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THE LABOR MARKET EFFECT OF DEMOGRAPHIC CHANGE: ALLEVIATION FOR FINANCING SOCIAL SECURITY

Abstract

The paper shows the effect of demographic change on per capita burden of financing a PAYG social security system in the standard OLG model with a frictional labor market. Rising longevity and decreasing fertility both induce a rise in the employment level via increased capital accumulation and job openings. Simulations of the theoretical model show that this labor market effect indirectly crowds out part of the initial demographic shock's direct impact on per capita financing burden. This holds true for the generation at the period of impact as well as for the following generations.

JEL-Codes: H55, J11, E24

Keywords: Demographic change, PAYG public pensions, unemployment, tax burden

1 Introduction

Demographic change implies altering societal structures and causes economies to face new economic conditions. The current and ongoing debate is much about its effect on economic key indicators as productivity, savings and pension spending (see for instance *The Economist*, 2014, pp. 18-20). Most worries are about the drop in labor supply, because fewer new born individuals lead to a smaller workforce later on. This mainly affects the institutions of social security systems, directly as well as indirectly (see Schmähl, 1990, p. 160). The direct effect is driven by the ratio of retired individuals to working age population and increases the per capita burden of financing pensions and other tiers of social security. The indirect effect evolves due to the close interdependencies between the labor market and the social security system. A higher rate of employment also means an increased relative number of contributors.

A vast literature exists on the consequences of population aging with respect to its induced adjustment effects on the social security system in overlapping generations (OLG) frameworks (see for instance Auerbach and Kotlikoff, 1987; Bräuninger, 1996; Cipriani, 2014; Jimeno et al., 2008; Meijdam and Verbon, 1997). These papers mainly discuss the above described direct effect of demographic change. None of these papers, however, take into account induced feedback effects from the macroeconomic labor market conditions on the social security system. In general, existing models usually assume perfect competition on the labor market so that changes in absolute employment are only due to adjusting workforce or individual hours of labor supplied. Demographic change then affects the social security system adversely as per capita burden for its financing increase. In settings with imperfect labor markets though, potentially further contributors are available, namely the unemployed. If demographic change induces labor demand, the relative number of contributors rises.

Evidence for rising labor demand through increasing longevity and decreasing mortality is given by de la Croix et al. (2013) who integrate equilibrium unemployment, resulting from labor market frictions, into the standard OLG model (see also Keuschnigg and Keuschnigg, 2004). Their focus is on pension system reforms and the incentives to work for individuals with different ages. They show that inter alia a higher optimal retirement age, induced by demographic change, causes a relatively lower rise in cost of public pension (in % of GDP) in the case of labor markets with frictions than in the case of perfect labor markets. As cost for a given pension scheme depend only on demographic variables (or more general: the number of beneficiaries), it does not give any information about potential changes of per capita financing burden of contributors. The overall importance of rising cost is set into perspective if per capita financing burden reacts differently (or less strong) to demographic change. The paper in hand ties up to this point.

Applying a standard OLG model with frictions on the labor market, it can be shown that the direct effect of demographic change on relative per capita contributions to the social

security system is cushioned by the endogenous labor market response. The first young generation which experiences the permanent demographic shock faces higher tax rates than the following generations. This is due to the continuing adjustment of the employment rate. Nevertheless, the stronger the effective labor market adjustment, the stronger is also the alleviation for the first young generation. The strength of this indirect effect of demographic change is dependent on the assumptions about the costs which firms face for opening a vacancy. Within the model of this paper, cost per vacancy develop subproportionally to the wage rate. In comparison to the case of constant cost per vacancy, this approach avoids a potential overstatement of the labor market effect.

The paper is organized as follows. Chapter 2 develops the model. Chapter 3 presents the calibration and the related simulation results. Conclusions are drawn in chapter 4.

2 The model

The basic structure of the model refers to the standard OLG framework developed by Samuelson (1958) and Diamond (1965). It is extended by an imperfect labor market as in Pissarides (2000), though in a reduced form. Time is discrete and the economy is closed. A representative household exists for each living generation as well as a representative firm for the companies. Households have perfect foresight, do not leave bequests and supply labor inelastically. Life-time uncertainty is offset by a perfect insurance market. Frictions on the labor market are implemented by a standard matching technology. The wage level then is determined by Nash bargaining about the surplus that is generated accordingly by an additional individual employed. Furthermore, firms do not decide directly about the level of employment but express their demand for labor through posting vacancies. Expenditures for the social security system are threefold: unemployment support, regular retirement payments and health care expenditures.

2.1 Demographics

The population of the economy consists of two generations: the young and the old. A new born generation lives for sure one period but survives only for a fraction of the second period. Individuals work in the first period and enjoy retirement in the second period. The mass of young individuals in the population is denoted by $Z_{y,t}$ and the mass of old individuals by $Z_{o,t}$. Total population Z_t is then equal to

$$Z_t = Z_{y,t} + Z_{o,t} \quad (1)$$

The young individuals can be distinguished by their labor market status. The group of the young therefore divides into the employed N_t and the unemployed U_t

$$Z_{y,t} = N_t + U_t \quad (2a)$$

$$= (n_t + u_t)Z_{y,t} \quad (2b)$$

Percentage shares in the total labor force of employed individuals and unemployed individuals are represented by n_t and u_t . The size of a new generation is determined by

$$Z_{y,t} = (1 + x_t)Z_{y,t-1} \quad (3)$$

with $x_t \geq -1$ reflecting the total population's growth rate from period $t-1$ to period t . A negative value describes a shrinking population, a positive value a growing population. Aging is implemented by introducing uncertainty about the length of life time via a deterministic survival probability $0 \leq \pi_t \leq 1$. It is interpreted as surviving only the fraction π_t of the second life period. Equation (1) then is rewritten as

$$Z_t = Z_{y,t} + \pi_t Z_{y,t-1} \quad (4a)$$

$$= Z_{y,t-1}(1 + x_t + \pi_t) \quad (4b)$$

Alternatively, a rise in the households' subjective discount rate on time could be interpreted as aging. It bases on the intuition that more weight is put on the second period of life time when expected lifespan increases. However, the introduction of uncertainty about the length of life time as described in equation (4a) requires a mechanism that distributes unused assets when an individual dies. It is here assumed that households are selfish and do not leave bequests. Instead, individuals save in annuities which are offered by insurance companies and offset the risk of life-time uncertainty.

2.2 Labor market flows

Flows on the labor market are described by a matching function $M_t(V_t, Z_{y,t})$ which depends technically on the total numbers of vacancies V_t and the total number of job seekers $Z_{y,t}$. Assuming a Cobb-Douglas form for M_t , employment is determined by

$$N_t = M(V_t, Z_{y,t}) = \mu V_t^\gamma Z_{y,t}^{1-\gamma} \quad (5)$$

with $0 < \mu < 1$ indicating the general matching efficiency and $0 \leq \gamma \leq 1$ indicating the elasticity of matching with respect to vacancies. In per young capita terms, equation (5)

reads as

$$n_t = \mu v_t^\gamma \quad (6)$$

Because all new born individuals are initially unemployed, the total number of job-seekers at beginning of period t is given by $Z_{y,t}$. The ratio of vacancies to the number of the young, v_t then also depicts the tightness of the labor market, defined as ratio of vacancies to job-seekers. Dividing the matching function by the number of vacancies in turn yields the probability q_t that a vacant job position can be filled

$$q_t = \frac{M_t}{V_t} = \frac{n_t}{v_t} = \mu v_t^{\gamma-1} \quad (7)$$

The probability of finding a job p_t is then defined as

$$p_t = \frac{M_t}{Z_{y,t}} = n_t = \mu v_t^\gamma \quad (8)$$

Matching takes place once at the beginning of a new period and is thus always successful. If a job-worker pair is formed, it does not break up again and lasts until the end of the period when all job positions are resolved and individuals enter regular retirement. If no job-worker pair is formed, individuals do not get another chance to find a job and stay unemployed for the whole period. It follows that flows on the labor market are characterized by the flow from unemployment into employment only. The current setting does not allow for transitions from out-of-the-labor-force into unemployment or employment as well as for job separations. Thus, employment in period t is solely determined by equation (6).

The representation of the labor market flows here differs from the standard representation in search and matching models with respect to two important characteristics. First, individual households and firms do not face idiosyncratic job separation risks. Households work for one period only, and successful matches do not break up again until the beginning of the retirement period. Thus, the probability of job destruction is assumed to reach certainty for each period. Pissarides (2000) defines the change in unemployment during a (small) time interval as the difference between the mean number of those workers who enter unemployment and those who leave unemployment (see Pissarides, 2000, p. 9). Therefore, the second difference lies in the interpretation of labor market flows which are to be interpreted here rather as stocks than as real flows. The unemployment rate is a purely deterministic expression and simply defined as the difference between the initial number of job seekers and those who find a job at the beginning of the period

$$U_t = Z_{y,t} - p_t Z_{y,t} \quad (9a)$$

$$u_t = 1 - n_t \quad (9b)$$

2.3 Representative household

All individuals in the economy belong to a representative household. There is one representative household for each age group. Each young individual inelastically supplies one unit of labor such that no specification about participation decisions is required. Furthermore, it is assumed that individuals take only into account the effects of their own behavior on the total utility of the representative household. These restrictions lower the degree of complexity and result in the equivalence of the optimization program of a representative household and that of a single individual. If employed, individuals earn the gross wage w_t the share τ_t of which is taxed away. If unemployed, individuals receive unemployment benefits $b_t^u = \rho^u w_t$. The overall income is used to finance consumption $c_{y,t}$ and to build up savings s_t . Thus, the flow budget constraint reads as

$$c_{y,t} + s_t = w_t(1 - \tau_t)n_t + b_t^u u_t \quad (10)$$

If individuals reach the retirement age, they stop working and use their savings s_t and the retirement benefit b_t^i to finance consumption $c_{o,t+1}$ in the second period of their life-time. The flow budget constraint of the retirement period is then given by

$$c_{o,t+1} = \frac{1 + r_{t+1}}{\pi_{t+1}} s_t + b_{t+1}^i \quad (11)$$

Following Diamond (1965), $1 + r_{t+1}$ describes the return on income invested in firms' securities, with r_{t+1} representing the rental rate per unit of capital. It is assumed that firms offer only simple loans with a maturity of one period after issuing.

Life-time uncertainty is offset by insurance companies which offer securities promising fixed payments in the retirement period. Following the interpretation of the survival probability π_t as reflecting the average individual length of the second life-time period, the payments could be visualized as annuities that are paid at regular fractions of the respective time period. For the formal implementation of such an insurance it is assumed that the insurance companies are risk neutral and operate on competitive private annuity markets (see also Yakita, 2001, p. 636; Cipriani, 2014, p. 253). The yield of the security then amounts to $\frac{1+r_{t+1}}{\pi_{t+1}}$.

The representative household optimizes life-time utility over both periods by choosing the optimal level of consumption when being young, $c_{y,t}$ and when being old, $c_{o,t+1}$. The time preference is expressed by a subjective discount factor β . Assuming that utility, $U(\cdot)$ is additive, separable and logarithmic, the representative household of generation t maximizes the per young capita objective function

$$x_t^H = U(c_{y,t}) + \beta \pi_{t+1} U(c_{o,t+1}) \quad (12a)$$

$$= \ln(c_{y,t}) + \beta \pi_{t+1} \ln(c_{o,t+1}) \quad (12b)$$

with respect to the inter-temporal budget constraint

$$c_{y,t} + \pi_{t+1} \frac{c_{o,t+1}}{1+r_{t+1}} = w_t(1-\tau_t)n_t + b_t^u u_t + \pi_{t+1} \frac{b_{t+1}^i}{1+r_{t+1}} \quad (13)$$

Optimizing lifetime utility by the standard Lagrange method results in the Euler equation

$$\frac{c_{o,t+1}}{\beta c_{y,t}} = 1 + r_{t+1} \quad (14)$$

The left hand side constitutes the inter-temporal marginal rate of substitution of consumption in period $t+1$ for consumption in period t , whereas the right hand side depicts the marginal rate of transformation for capital. The latter one describes the rate at which individuals may shift consumption between the periods.

2.4 Representative firm

The firms in the economy use a Cobb-Douglas technology for production with the two input factors capital, K_t and labor, N_t . All workers are equally efficient and do not differ in their productivity. In per young capita variables, the production function can be written as

$$f(k_t, n_t) = A k_t^\alpha n_t^{1-\alpha} \quad (15)$$

with $A > 0$ denoting the total-factor-productivity and $0 \leq \alpha \leq 1$ denoting the elasticity of production with respect to capital.

The firms issue securities to obtain the required capital for production. For one unit of capital investment, firms pay an interest of r_t . Capital depreciates at the rate δ . The marginal cost for one worker amounts to w_t and the cost for opening a vacancy amounts to $a = h w_t^m$. It is reasonable to assume that developments on the labor market also influence hiring costs. If hiring is labor-intensive, a lower unemployment rate may cause higher costs for opening and maintaining vacancies. The parameter $h > 0$ is used for scaling while the parameter $0 \leq m \leq 1$ determines the proportionality of costs per vacancy to the wage rate.

To maximize profits in period t , the representative firm decides about the optimal amount of capital K_t and the optimal number of vacancies V_t . Employment is implicitly determined through the bargained wage, posted vacancies and the matching function. The firm's per young capita objective function is

$$x_t^F = f(k_t, n_t) - (r_t + \delta)k_t - w_t n_t - a v_t \quad (16)$$

with $n_t = q_t v_t$. Following standard Lagrange optimization, the first order condition with

respect to k_t is

$$f_{k_t} = r_t + \delta \quad (17)$$

and the first order condition with respect to v_t is

$$\frac{\partial x_t^F}{\partial n_t} \frac{\partial n_t}{\partial v_t} = a \quad (18a)$$

$$q_t = \frac{a}{f_{n_t} - w_t} \quad (18b)$$

The second first order condition states that in optimum the cost per vacancy has to be equal to the expected net return from hiring an additional worker $\frac{\partial y_t^F}{\partial n_t}$ times the marginal change in employment by posting an additional vacancy $\frac{\partial n_t}{\partial v_t}$. The first order condition determines uniquely the amount of posted vacancies and thus, via the matching function, the level of employment, implying the bargained wage rate w_t . This result is equivalent to the formulation of Pissarides (2000) where in equilibrium the present discounted value of expected profit from an occupied job equals the ratio of hiring costs and the probability of filling a vacancy Pissarides (2000, pp. 12 and 75), though the general settings are different in the current formulation. In equilibrium the marginal productivity of labor must be equal to the wage rate plus the average costs of a vacant job

$$f_{n_t} = w_t + \frac{a}{q_t} \quad (19)$$

The optimality condition for the firm's number of vacancies requires that the labor market flows of hiring employees and finding employers have to compensate each other in equilibrium

$$p_t = q_t v_t \quad (20a)$$

$$a v_t = (f_{n_t} - w_t) n_t \quad (20b)$$

By substituting the optimality conditions (17) and (20b) into the profit function (16), it is possible to explain the distribution of profits in equilibrium

$$x_t^F = f(k_t, n_t) - f_{k_t} k_t - w_t n_t - (f_{n_t} - w_t) n_t \quad (21)$$

The marginal value product of labor is, on one hand, used to pay the wage bill of workers, and, on the other hand, it is used to cover the cost for posting vacancies. The application of Euler's Theorem proves that no excess profits are left in equilibrium so that $x_t^F = 0$. This result implies that there is no room for paying dividends if a stock market was present in the current setup. The firm faces only direct costs for buying capital, paying labor and posting

job offers, but there are no adjustment costs for capital, labor or vacancies. Without adjustment costs, the capital investment supply of households as well as the investment demand from firms are perfectly elastic. Furthermore, in the current setup the employment in the next period does not depend on the current level of vacancies as the firms do not have to maintain job vacancies over a couple of periods. This is due to the assumption that each jobs exists for one period only. Thus, no inter-temporal aspect enters the optimization problem of the firm. Maximizing the firm's value is therefore equivalent to maximizing per period profits. The value of a firm is then simply equal to its replacement value, in fact the value of its capital endowment.

2.5 Wage bargaining

Wages are determined by potentially asymmetric general Nash bargaining. Bargaining takes places between the representative household and the representative firm. This approach is applied by several authors of which Shi and Wen (1994, 1997) and Domeij (2005) have to be mentioned. They use a representative household utility function to integrate jointly the different agents, the unemployed and the workers. In doing so, it is assumed that all individual decisions are concerned only with the maximization of the representative household's total utility. Intractable dynamic programming problems are avoided and individual risks are smoothed out (see Shi and Wen, 1994, p. 2). With respect to wage determination, bargaining between a matched worker and the firm can be reinterpreted then as a bargaining process taking place between the representative household (on behalf of the matched worker) and the firm (see Liu and Zeng, 2008, p. 783, fn. 12). The optimal wage level maximizes the net returns from a job match. In fact, this is the respective value that is placed on an additional unit of labor employed in household's utility and in firm's profit (see also Shi and Wen, 1994, p. 8; Shi and Wen, 1997, p. 1754; Domeji, 2005, p. 629; de la Croix et al., 2013, p. 110). The bargaining power of the representative household is denoted by η and the bargaining power of the representative firm is denoted by $(1 - \eta)$. The per young capita Nash bargaining problem then is given by

$$\max_{w_t} \left(\frac{\partial x_t^H}{\partial n_t} \right)^\eta \left(\frac{\partial x_t^F}{\partial n_t} \right)^{1-\eta} \quad (22)$$

The responsiveness of the household's life-time utility with respect to $n_{y,t}$ results to be

$$\frac{\partial x_t^H}{\partial n_t} = \frac{\partial U(c_{y,t})}{\partial c_{y,t}} \frac{\partial c_{y,t}}{\partial n_t} = U_{c_{y,t}} w_t (1 - \tau_t - \rho^u) > 0 \quad (23)$$

The derivative is strictly positive, indicating a positive utility gain for the representative household if relatively more individuals are employed. The firm's responsiveness of profit

with respect to $n_{y,t}$ reads as

$$\frac{\partial x_t^F}{\partial n_t} = f_{n_t} - w_t > 0 \quad (24)$$

so that the optimal wage level then is determined by solving the maximization problem (22), which yields

$$w_t = \eta f_{n_t} \quad (25)$$

This representation of the bargained wage level is different to the first version of the bargaining problem described in Pissarides (2000). The reservation wage does not show up here explicitly, because the bargaining agents know on one hand that the reservation wage will be below the bargained wage every time. Furthermore, in contrast to Pissarides (2000), the agents in the current setup do not face an infinite time horizon or job-separation risks. Households live for two periods and are thus only confronted with simple two period dynamic optimization. As only young people work, there is no need for discounting or considering future expectations in bargaining, neither for households nor for firms.

2.6 Social security system

All expenditures for social security are financed via a pay-as-you-go system, implying inter-generational transfers. The respectively young generation finances unemployment benefits, retirement benefits and expenditures for general public health care. No debt is taken and no governmental consumption exists.

Unemployment benefits are defined by $b_t^u = \rho^u w_t$, and retirement payments by $b_t^i = \rho^i w_t$. Both are proportional to the real wage rate via their respective replacement rates, ρ^i and ρ^u . Per capita health care expenditures b_t^h are assumed to develop proportional to the per capita GDP, $g_t = F_t(N_t, K_t)/Z_t$, with constant share ρ^h . Differences in the respective age groups' causation of health care expenditures are reflected by the two parameters $\varepsilon_y + \varepsilon_o = 1$.

The social security system's budget balances solely via the income tax rate τ_t , which is levied on the gross wage w_t

$$\tau_t w_t N_t = b_t^u U_t + b_t^i Z_{o,t} + b_t^h (\varepsilon_y Z_{y,t} + \varepsilon_o Z_{o,t}) \quad (26)$$

With help of equation (25) the budget constraint appears to be

$$\tau_t = \rho^u \frac{u_t}{n_t} + \rho^i \frac{\pi_t}{n_t(1+x_t)} + \rho^h \frac{n_t}{\eta(1-\alpha)} \frac{1+x_t}{1+x_t + \pi_t} \left[\frac{\varepsilon_y}{n_t} + \frac{\varepsilon_o \pi_t}{n_t(1+x_t)} \right] \quad (27)$$

Considering the partial derivative of τ_t with respect to n_t , it can be seen that a higher relative

level of employment has a decreasing impact on the total tax rate

$$\frac{\partial \tau_t}{\partial n_t} = -\frac{1}{n_t^2} \left(\rho^u + \rho^i \frac{\pi_t}{1+x_t} \right) < 0 \quad (28)$$

In subsequent chapter this opposing effect of the employment rate is referred to as the labor market effect (induced by demographic change). With respect to the health care's share in burdens to the social security system, it appears that the labor market effect cancels out. On one hand, it can be clearly seen that a rising employment rate lowers the per capita contributions of employed individuals through a higher share of contributors. On the other hand, though, this isolated favorable effect on households' income is crowded out through the respective proportional rise of GDP and its related rise in employment, as it is assumed that costs for health care rise with GDP per capita on a one-to-one basis. Finally, only changes in the exogenous demographic parameters lead to an adjustment of health care expenditures (in contrast to the other both tiers of the social security system).

2.7 Capital market equilibrium

An equilibrium on the capital market requires that the supply of capital coincides with the demand for capital. Thus, the capital market equilibrium balances

$$s_t Z_{y,t} = K_{t+1} \quad (29a)$$

$$s_t = \frac{K_{t+1}}{Z_{y,t+1}} (1+x_{t+1}) \quad (29b)$$

$$\frac{s_t}{(1+x_{t+1})} = k_{t+1} \quad (29c)$$

with k_{t+1} describing the capital intensity per young individual in period $t+1$. The savings of period t determine the capital stock used by the firm in period $t+1$.

3 Simulation

The simulation of the developed model shows that demographic change may indirectly crowd out part of its own direct effect on per capita financing burden. The strength of this effect depends on the technical assumptions about the evolvement of cost per vacancy. In turn, the burden levied on the young individuals to finance the social security system is dependent on the labor market conditions. This chapter presents at first the calibration of the model. It then shows the effect of demographic change on per capita burden of financing a PAYG social security system. Finally, it illustrates how the model economy behaves for different assumptions about the sensitivity of cost per vacancy with respect to changes in the wage level.

3.1 Calibration

Table (1) presents the applied parameter values: the household's subjective discount rate β , the output elasticity of capital α , the depreciation rate δ , the matching elasticity of vacancies γ , the bargaining power of workers η , the survival probability of individuals π , the fertility rate x , the replacement rates ρ^i , ρ^u and ρ^h , the respective generations' share in public health care expenditures ε_y and ε_o , the technology parameters A and μ , and the costs for posting a vacancy with scaling parameter h and proportionality parameter m .

The subjective discount rate is chosen to represent a 4% annual discount rate on time. This is equivalent to a time discount factor around 0.3 for a time span of 30 years. The output elasticity of capital takes the customary value of 1/3. For the depreciation rate it is assumed that any machine or building has to be renewed for sure after one period. Nash bargaining is symmetric such that the share in the surplus of a job match equals 0.5 for both, workers and firms. The matching elasticity of vacancies and unemployed individuals is given a value of 0.5 each. The survival probability may be reinterpreted as a parameter indicating the average length of the period of retirement relative to the obligatory length of the average working period for full benefits. Therefore, the initial π takes the plausible value of 0.3. Assuming a fertility rate around 1.4, the initial value of x is chosen to be 0.3. With respect to replacement rates, ρ^i takes a value of 0.40 and ρ^u takes a value of 0.5. Replacement rates for health care are to be interpreted differently than replacement rates for unemployment and retirement benefits. Health care benefits are earmarked and cannot be transformed into consumption of other goods. Therefore, these benefits do not explicitly show up in the utility function or the two budget constraints. Health in the current modeling framework is not seen as an autonomous good which can be consumed. Rather it is assumed that "health" causes costs which have to be shouldered by the society. In fact, it can be reinterpreted as any arbitrary service provided by public authorities with the characteristic that the service' degree of provision is not linked to its source of finance (wage income in the model's setup). Here, the costs for health care are tied to the development of production

Table 1: Calibration

Parameter	Value	Parameter	Value
α	0.33	A	100
β	0.30	η	0.50
δ	1.00	γ	0.50
m	0.50	μ	0.90
h	6.40		
π	-0.30	ρ^i	0.40
x	0.30	ρ^u	0.50
ε_y	0.33	ρ^h	0.08
ε_o	0.66		

output in the modeled economy, setting a value of 0.08 for ρ^h . As the old cause higher expenditures for health than the young, ε_y takes a value of 1/3 and ε_o takes a value of 2/3.

The parameters determining the labor market situation are calibrated to yield an unemployment rate of about 9% in the initial steady state. For this, successful matching efficiency is assumed to reach 90% while total factor productivity and marginal vacancy costs are fixed at values of 100 and $a = 6.4w^{0.5} = 45.84$. A and a are used to ensure a reasonable level of unemployment in the initial steady state (compare Cahuc and Zylberberg, 2004, p. 535).

3.2 The labor market effect

The basic demographic scenario is described by a mutual fall in fertility from -0.30 to -0.35 and a rise in life-expectancy from 0.30 to 0.35. Table (2) summarizes the simulation results for the case of subproportional cost per vacancy.

The model economy is in a steady state prior to the demographic shock, which occurs in period t . In period $t + 6$ the economy almost completely accomplishes its adjustment reaction. The new steady state is characterized by a higher capital intensity, a higher employment rate, higher per capita financing burden of social security, higher vacancy costs, a less tight labor market and lower rental rates for capital. Most importantly, looking at the transition of the total tax rate τ , the labor market effect defined in equation (28) becomes visible. Due to the once-and-for-all demographic shock, the per capita financing burden jumps up from 0.34 in period $t - 1$ to 0.39 in period t . As it will be seen later, this jump would be even higher if the labor market would not react anyhow to the demographic shock and its related rise in capital supply. However, due to a continuing labor market adjustment (in contrast to fixed demographic exogenous variables), the tax rate already decreases in period $t + 2$ and continues decreasing until it reaches its new steady state value in $t + 6$. This trajectory shows that demographic change induces labor market reactions which in turn lead to a salvation of increased financing burden.

Table 2: Simulation results - subproportional cost per vacancy

Time	k	n	τ	a	v	r^*
t-1	3.30	0.91	0.34	45.84	1.01	0.089
t	3.52	0.92	0.39	46.26	1.03	0.088
t+1	3.79	0.92	0.38	46.74	1.05	0.086
t+2	3.93	0.93	0.38	46.98	1.07	0.086
t+3	4.00	0.93	0.38	47.10	1.07	0.085
t+4	4.03	0.93	0.38	47.16	1.07	0.085
t+5	4.05	0.93	0.37	47.19	1.08	0.085
t+6	4.06	0.93	0.37	47.20	1.08	0.085
∞	4.06	0.93	0.37	47.22	1.08	0.085

* annual value

What role do the both single parts of the demographic shock, x and π play for the final results? A simple drop in the fertility rate has similar effects as an identical scenario with a perfect labor market where shrinking fertility implies a proportional drop in labor supply. In a perfect labor market, labor supplied and labor employed are identical. Under imperfect labor markets, both variables' values may differ from each other. Then, a drop in fertility does not have a direct effect on labor employed but on the future size of the workforce. The employment of the input factor labor is not automatically decreased, but the input factor labor becomes just more scarce. If a firm then wants to maintain its current level of production, it has to increase search efforts to hire the same amount of labor as before. In other words, it becomes harder for the firm to fill vacancies. In the model setup, increasing search efforts of firms are equivalent to posting more vacancies. Accordingly, it implies a higher probability to get hired what directly translates into a lower rate of unemployment.

A single increase of life expectancy, π induces the individuals to increase their savings as the returns on annuities shrink. The higher amount of savings in the economy is equivalent to a rise in the supply and use of capital in the production process. It induces the marginal product of capital to decrease and that of labor to increase. To satisfy the induced higher labor demand, firms have to open additional vacancies. The labor market gets less tight and it becomes easier for unemployed individuals to get hired. Thus, a simple rise in longevity exhibits the same quantitative reaction as the combined shock or a single fall in fertility.

A decrease in fertility and an increase in life expectancy work into the same direction with respect to the height of the tax rate. The demographic shock gives rise to a feedback effect on the tax rate, because a higher employment rate works into the initial demographic shock's opposite direction. The final effect on the tax rate depends on the relative strength of the direct demographic shock compared to its indirect effect via the employment rate.

3.3 The cost per vacancy effect

Applying a sensitivity analysis shows that shocks in parameter values do not exhibit implications on the functioning of the labor market effect. The most sensitive reaction of the initial steady state values (ss table (2)) can be observed for single shocks in the values of the matching efficiency, μ and the bargaining power of workers, η . However, the main findings with respect to the labor market effect are not altered when considering the same demographic scenario as before but starting from an adjusted initial steady state. Therefore, it is abstained from reproducing the complete sensitivity analysis here. Instead, it is considered how sensitive the labor market effect is affected by changing the assumptions about the height of cost per vacancy. It can be shown that simulation results concerning the rate of employment may be biased if vacancy costs are constant.

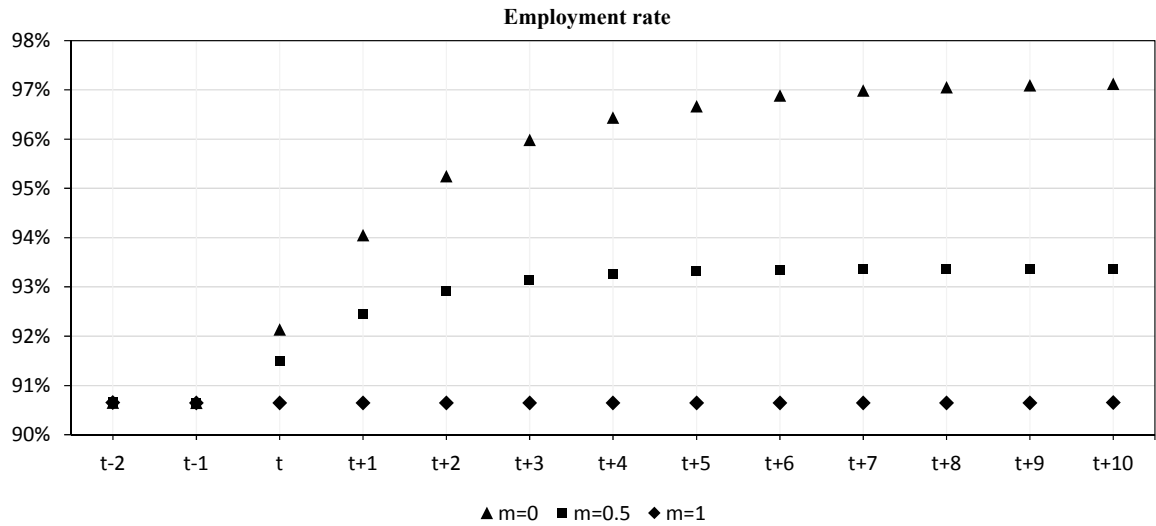


Figure 1: Reaction of employment rate when demographic shock occurs in period t .

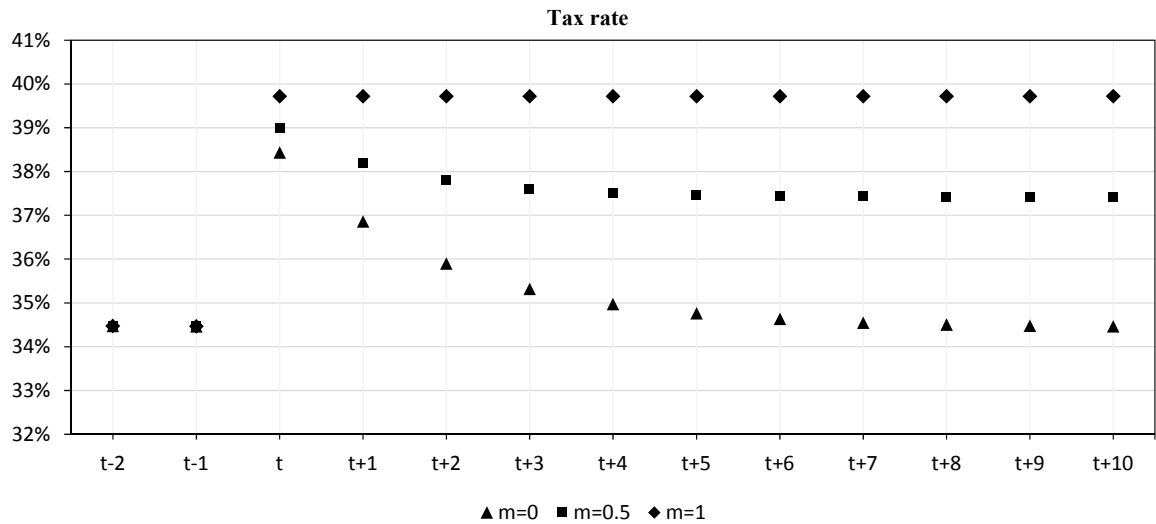


Figure 2: Reaction of tax rate when demographic shock occurs in period t .

Figures (1) and (2) illustrate the main findings. If cost per vacancy develop proportionally to the wage rate ($m = 1$), no labor market effect occurs and thus, no salvation for per capita burden of financing social security burden arises. The reasoning behind this result is straightforward and is best seen in equation (20b). In the optimum, the cost for posting vacancies has to be equal to profits from employing workers. If demographic change induces labor demand, but opening an additional vacancy is as expensive as the expected profit from hiring an additional worker, the induced labor demand is completely crowded out and no labor market effect occurs. In contrast, if cost per vacancy stay constant ($m = 0$), hiring an additional worker becomes relatively cheaper. The firm posts additional vacancies until the total cost for posting vacancies is again equal to total profits from employing workers. If hiring costs are variable and develop subproportionally to wages ($m = 0.5$), the incentive for

posting additional vacancies is lower, but still existent. It becomes clear that the assumption about the endogeneity of vacancy costs is crucial when explaining the effects of demographic change on the labor market and its further impact on financing social security. If the labor market reacts less sensitive to demographic change, the burden on the social security system is also crowded out less strong.

4 Conclusion

Demographic change affects the institutions of social security systems directly as well as indirectly. On one hand, it adversely impacts the old-age dependency ratio. On the other hand, it induces a favorable employment effect on the labor market so that increasing pressures on financing social security are partially crowded out.

The paper aims at visualizing these fundamental mechanisms and focuses on the impact of demographic change with respect to employment and per capita tax burden. The model in the paper makes use of an OLG framework with finite life-time and imperfect labor markets. Frictions on the labor market are implemented via matching and bargaining though the setting is deterministic and job-specific separation risks are not taken into account. Crucial for the derivation of wages via Nash bargaining is the assumption that individuals care only about the representative household's total utility. This allows for bargaining between the representative firm and the representative household.

Two effects are worked out in the paper: the alleviating labor market effect of demographic change and the cost per vacancy effect. Demographic change and employment have opposing influences on the per capita financing burden of social security. A higher employment rate lowers them while demographic change increases them. As demographic change itself induces the unemployment rate to shrink, it then crowds out part of its own direct impact on the per capita financing burden of social security. The cost per vacancy effect is the stronger the less sensitive these costs react to changes in the wage rate. Wage indexation proves to have important technical implications on the final simulation outcome. Especially the value of the employment rate appears to be biased upwards in the case of constant cost per vacancy.

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