

Pension reform, retirement, and life-cycle unemployment

Christian Jaag · Christian Keuschnigg ·
Mirela Keuschnigg

Published online: 14 April 2010
© Springer Science+Business Media, LLC 2010

Abstract This paper investigates the labor market impact of four often proposed policy measures for sustainable pensions: strengthening the tax benefit link, moving from wage to price indexation of benefits, lengthening calculation periods, and introducing more actuarial fairness in pension assessment. We consider the impact on three margins of aggregate labor supply, retirement behavior, job search, and hours worked. We provide some analytical results and use a computational model to demonstrate the economic impact of recent pension reform in Austria. Reducing the distortion in the retirement decision by introducing pension supplements and discounts conditional on the chosen retirement date promises the largest gains. We also find that the pension reform is far from sufficient to offset the fiscal implications of projected demographic change in Austria.

Keywords Pension reform · Retirement · Job search · Life-cycle unemployment

JEL Classification D58 · D91 · H55 · J26 · J64

Financial support by NetSpar and, on previous research grants, by the Austrian National Science Fund (No. P14702) and the Swiss National Science Foundation (No. 1214-066928) is gratefully acknowledged. The paper was presented at the Netspar pension workshop in Utrecht in January 2008, the IIPF 2008 congress in Maastricht, and at the Technical University of Vienna. We thank our discussants Ben J. Heijdra and Sergi Jimenez-Martin, seminar participants, Johannes Berger and Ludwig Strohner for very constructive comments. We are particularly grateful to two anonymous referees and the editor, Ruud A. De Mooij, for very helpful suggestions.

C. Jaag
Swiss Economics and University of St.Gallen, Abeggweg 15, 8057 Zürich, Switzerland
e-mail: Christian.Jaag@swiss-economics.ch

C. Keuschnigg (✉) · M. Keuschnigg
University of St.Gallen (IFF-HSG), CEPR, CESifo, Varnbühlstrasse 19, 9000 St.Gallen, Switzerland
e-mail: Christian.Keuschnigg@unisg.ch

M. Keuschnigg
e-mail: Mirela.Keuschnigg@unisg.ch

1 Introduction

With only few exceptions, industrial countries rely on pay-as-you-go (PAYG) pension systems where the contributions of active workers must pay for the benefits of old generations in retirement. The trends in population aging and labor market participation have put pressure on pension systems. Preserving living standards of retired citizens and keeping the system financially sustainable requires formidable adjustments. In the absence of reform, pension spending will grow to unprecedented levels. Sustainability can be restored with three basic measures, or a combination of them: (i) reduce benefit levels, (ii) raise contribution rates or other taxes, (iii) raise the statutory and effective retirement age. The common denominator of these reforms is that, from an individual perspective, the ratio of contributions paid and benefits received over one's life-time will deteriorate substantially. Depending on the specific design and rules of the system, it will thus be considered as a much less attractive and reliable means to assure one's own living standard during retirement.¹ Contributions will be increasingly perceived as taxes, even in a system with a clear tax benefit link, and must be expected to discourage work effort and job search. Instead of dampening and partly offsetting the demographic reduction of the workforce, the induced behavioral response may instead exacerbate demographic trends if the system is not carefully (re-)designed to preserve labor market incentives.

What are exactly the adverse labor market incentives that we think to be particularly harmful? Weil (2006) recently argued that tax distortions from financing PAYG pensions are probably the most important channel through which aging will affect aggregate output. Arguably, the most severe distortion concerns the tendency toward early retirement. Although a general shift in preferences may have led people to retire earlier for other reasons, early retirement is induced by the large participation tax rates on continued work as is documented in the Gruber and Wise (1999, 2004, 2005) worldwide project and subsequent updates. Börsch-Supan and Schnabel (2000) and Börsch-Supan (2000) provide evidence for Germany, and Samwick (1998), among others, for the US. The retirement decision is an example of a discrete labor supply response on the extensive margin that can be characterized by participation tax rates in the sense of Saez (2002), Immervoll et al. (2007), Kleven and Kreiner (2006), as well as Fisher and Keuschnigg (2010) in the context of pension reform. Hofer and Koman (2006) calculated these tax rates for the Austrian pension system. Many economists consider the retirement margin the most important behavioral response to pension reform.

The second distortion concerns the intensive labor supply response, i.e. hours worked and effort on the job of prime age workers. In the absence of a tax benefit link, contributions are fully counted as a labor tax without any individually perceived benefit associated to those contributions. In this case, social security contributions discourage intensive labor supply just like a wage income tax. However, if there is an operative tax benefit link, earning more today raises pension benefits during retirement which encourages labor earnings. Since more earnings are associated with

¹For a highly selective list of recent reviews of social insurance and pension reform, see Pestieau (2006), Diamond and Orszag (2005), Feldstein (2005), Fenge and Pestieau (2005), Diamond (2004), Bovenberg (2003), Lindbeck and Persson (2003), and Feldstein and Liebman (2002).

higher pension benefits, the implicit tax on current earnings is lower than the statutory contribution rate, as was first pointed out by Feldstein and Samwick (1992). The econometric estimates of Disney (2004) imply that men are not very responsive to a variation in the effective contribution tax while women's activity rates are highly adversely affected which is consistent with much of the empirical labor supply literature.

A third distortion from PAYG pension financing arises from job search and unemployment; see Krueger and Meyer (2002) for a review of the empirical evidence. The incentives to search for and accept an employment opportunity are reduced by all the taxes paid on the salary and by unemployment benefits and assistance payments lost upon giving up non-employment. One can define a participation tax which can be large since it consists of the *sum* of wage taxes and foregone transfers during unemployment. The pension contribution rate further adds to this large participation distortion. However, an extra benefit from accepting an employed income is that it raises the contribution base for future pensions. Hence, the tax benefit link reduces the tax component of the contribution rate and thereby strengthens incentives for job search.

Although the impact of pension reform on labor market incentives seems straightforward in principle, there are sometimes non-trivial interactions that may generate quite negative consequences as well. As an example, raising the retirement age and at the same time keeping statutory contribution rates constant will, in fact, increase the implicit tax on active workers. They must pay contributions over a longer period and accordingly receive benefits over a shorter period of life which makes the system more unfavorable from an individual perspective. Obviously then, they will perceive a larger share of their contributions as a tax on work effort and job search. Sometimes, by its very design, pension reform can have uneven effects on life-cycle employment and earnings. A number of countries have recently prolonged the calculation period for the pension assessment base, e.g. by including not only the best five but rather the best ten years of past earnings, or even the entire life-time employment history. This initiative means that the implicit tax rate will be cut for younger cohorts of workers, with beneficial consequences for their labor market incentives, but not for older workers who were already covered by the tax benefit link. By explicitly considering the typical life-cycle unemployment incidence, we can also address another question often ignored in pension reform: what are the gains from postponed retirement when older people are subject to an above average unemployment risk? How does such reform affect the employment prospects of younger workers?

The central contribution of this paper is to shed light on the labor market incentives from parametric pension reform and on the possible interactions among them. Based on a small analytical model, we first clarify the key concepts of effective tax rates on three behavioral margins, i.e. hours worked, job search, and choice of retirement date. The analytical part also serves to make the most basic reactions of our computational model more transparent. Then we employ the much more detailed, calibrated model to obtain quantitative magnitudes of behavioral responses in general equilibrium.² One of the most novel and policy relevant features of the computational model

²We employ a generalized OLG model in the tradition of Blanchard (1985) but extended with demographic and life-cycle structure; see the technical appendix in Jaag et al. (2009). See also Jaag (2009). Recently,

is that it captures the life-cycle incidence of unemployment. We can thus contrast the differential unemployment experience of younger workers early in their career with the labor market status of older workers near retirement. This feature is particularly relevant since policies to raise the average retirement age may have much less potential if unemployment among older workers is excessive and many of them might not find appropriate jobs (see the discussion in OECD 2005). Based on key behavioral elasticities reflecting the consensus of recent econometric research, we find the labor market impact of pension reform in Austria to be quantitatively substantial but unevenly distributed over the life cycle.

The Austrian pension system and its recent reform provides a useful showcase because it includes key reform strategies that are considered in many other countries as well.³ In investigating the potential consequences of reform, we consider four often discussed scenarios. We first explore the consequences of lengthening the calculation period for pension assessment. Several countries, Austria among them, have reformed their pension rules to include the entire life-time earnings rather than only the best five or ten years of earnings which will usually coincide with the last phase of work life. Such a reform essentially means that the last periods count much less in determining the pension level while earlier years weigh more heavily. Labor market incentives are shifted from old to young workers. The impact is reinforced if workers in addition receive a notional interest (equal to the wage growth rate) on their earnings that enter in the pension assessment base. Second, we investigate a strengthening of the tax benefit link. The scenario replaces flat pension benefits (Beveridge system) by earnings linked benefits (Bismarkian system). This can be understood as bringing several occupational groups such as civil servants who received pensions largely unrelated to past earnings, into a harmonized, earnings linked system. The overall benefit level is thereby kept constant. Given constant statutory contribution rates, it will be shown that effective tax rates are reduced on several margins of work.

Third, we study the consequences of moving from wage indexation of pension benefits to price indexation. The scenario means that pension benefits will grow slower than wage earnings of active workers so that the replacement rate declines during retirement. Obviously, this strategy of restraining the growth in pension spending puts the burden on retirees. We will argue, however, that it has actually quite important consequences for implicit taxes and labor market incentives of the active workforce as well. Finally, and most importantly, we study the impact of incentives for postponed retirement by strengthening actuarial fairness of the system; see Gruber and Wise (1999 and 2005). When a normal benefit level is attained at the statutory retirement age, this scenario raises the pension level permanently whenever people retire later, and cuts it when they prematurely retire at earlier ages.

Heijdra and Romp (2008, 2009) have developed a stylized, but analytically solvable life-cycle model with demographic structure, and discuss the impact of aging and pension reform on the endogenous retirement margin in a perfect labor market. This paper investigates, in addition to retirement incentives, the impact of pension reform on prime age labor supply and life-cycle unemployment. For this purpose, we also develop a richer institutional modeling of the pension system, including the tax benefit link between today's contributions and future pension income.

³See Keuschnigg and Keuschnigg (2004), Knell et al. (2006), Hofer and Koman (2006), and OECD (2005), for an insightful description and discussion of pension reform in Austria.

Simulation results from a detailed computational general equilibrium model suggest that recent pension reform in Austria could add around 2.7% of GDP in the long-run. The major gains in terms of aggregate consumption and GDP stem from strengthening actuarial fairness by raising pension supplements for late retirement, and from pension harmonization by including a larger part of the population in the earnings linked system. The reform shifts labor market activity in terms of hours worked and employment rates from old to younger prime age workers. While the unemployment rate in the most senior part of the workforce of 60 years plus remains virtually unchanged, it declines by roughly half a percentage point among younger workers, leading to a decline in the aggregate unemployment rate from 6.5 to 6.1%. The gains in labor market prospects are rather unevenly distributed over the life cycle.

Finally, we investigate to which extent pension reform is effectively able to offset the impact of projected aging in Austria which is expected to double the old age dependency ratio until 2050 and to increase population size by roughly 10%. We first simulate the economic consequences of aging in the absence of pension reform when the government follows a passive strategy of raising wage tax rates to achieve fiscal balance. Depending on the age income class, tax rates must be increased by 8 to 14 percentage points. Taking account of the behavioral response and the demographic change in the workforce, effective employment, and GDP would decline by about 10%. Implementing the pension reform could reduce this loss by 40% and cut down the employment loss to 6%, compared to the equilibrium in the absence of aging and pension reform. While the specific policy scenario is probably subject to some uncertainty, the simulation results indicate that pension reform in Austria is far from enough to cope with the fiscal impact of the projected demographic change.

The paper proceeds as follows. We first present an analytical core model in Sect. 2, define effective tax rates on three labor market margins and show how they depend on the parameters of the pension system. The last part turns to the main features of the computational model. Section 3 shortly reviews recent pension reform in Austria, defines the policy scenarios in numerical terms, and discusses the quantitative results. We also investigate the potential sensitivity of the results. Section 4 simulates an aging scenario and discusses to which extent pension reform is successful to cope with the projected demographic change. Section 5 concludes.

2 Labor market incentives

To clarify basic concepts and derive key insights, we first consider a stylized core model. We investigate the basic analytics of demographic change when there are only two age groups. To provide a perspective on the aging scenarios in the last section of the paper, we derive a simple formula showing how the contribution rate of a PAYG pension system must increase for a given replacement rate when the old age dependency ratio rises. The following subsection derives simple formulas for the effective tax rates on hours worked, job search, and the retirement decision based on intertemporal optimization and shows how pension reform changes these rates and thereby affects labor market incentives.

2.1 Analytics of aging

The quantitative analysis is based on a generalized overlapping generations (OLG) model with eight different age states and population groups. The period length is one year. Depending on the chosen demographic and aging parameters (mortality rates and transition rates to consecutive age groups), the model includes different classes of OLG models as special cases. In this section, we highlight the key demographic aspects by collapsing the model into two age states and, correspondingly, two age groups (see Gertler 1999). The total population thus consists of young and old agents, $N = N^1 + N^2$. The demographic structure evolves according to⁴

$$\begin{aligned} N_{t+1}^1 &= \omega N^1 + n, \\ N_{t+1}^2 &= \gamma N^2 + (1 - \omega) N^1, \\ N_{t+1} &= N + [n - (1 - \gamma) N^2]. \end{aligned} \quad (1)$$

The transition rate $1 - \omega$ from the young to the old state and the mortality rate $1 - \gamma$ of old agents are constant. For simplicity, we assume that the mortality risk sets in only in the second age state. In a demographic steady state, births just replace the outflow due to death, $n = (1 - \gamma) N^2$. The inverse of the transition rates correspond to the duration in the young and old age states, $T^1 = 1/(1 - \omega)$ and $T^2 = 1/(1 - \gamma)$. With stationary demographics, we can compute the old age dependency ratio δ which turns out to be equal to the ratio of time spent in retirement over time spent in the active state:

$$\delta \equiv \frac{N^2}{N^1} = \frac{1 - \omega}{1 - \gamma} = \frac{T^2}{T^1}. \quad (2)$$

The dependency ratio is determined by the two parameters. In a stationary state, the age structure of the population is $N^1 = N/(1 + \delta)$ and $N^2 = N\delta/(1 + \delta)$, leading to an inflow of new born agents equal to $n = (1 - \gamma) N^2 = (1 - \gamma) N\delta/(1 + \delta)$.

Aging means that expected life-time and, thus, time spent in the old age state T^2 increases. In other words, the survival rate γ rises. Given the same duration in the young state, the dependency ratio δ increases. This implies population growth at the “old end”. Inevitably, the population share of old agents rises, and that of young, active workers becomes smaller. Denoting the per capita earnings of the young by y and the per capita pension of the old by p , the budget constraint of the PAYG pension system is

$$t \cdot y N^1 = p \cdot N^2 \quad \Rightarrow \quad t = \frac{p}{y} \cdot \frac{N^2}{N^1} = \rho^p \cdot \delta. \quad (3)$$

When the pension replacement rate $\rho^p = p/y$ is kept constant and the dependency ratio δ rises due to aging, the contribution rate t must necessarily increase in the tax rate. Section 4 provides a quantitative analysis of aging and its impact on public finances. Higher taxes and social security contributions are harmful to employment

⁴As a convention, we use the time index only when we refer to periods different from t .

and income. If this is to be avoided, one could raise the retirement date. Postponed retirement in the individual life cycle corresponds to a larger participation rate in the cross-section of the old population. When the participation rate among older workers rises, a larger part of the population contributes to the system and a smaller part collects a pension. The next subsection introduces endogenous labor market participation among the old which is interpreted as the result of a retirement decision. In particular, we show how the effective tax rates on the three margins of aggregate labor supply are affected by pension reform in an earnings linked system.

2.2 Labor market behavior

Old workers A key aspect of an earnings linked system is the accumulation of entitlements. When a worker stays active in age group a , she acquires pension claims $P_{t+1}^a = R^P [m^a \cdot e^a w l^a + P^a]$ where R^P is the return factor of the PAYG system. Earnings reflect the employment rate e^a , hours worked l^a , and the wage rate w . Current earnings add to existing claims at rate m^a , and thus augment benefits after retirement. Given the tax benefit link parameterized by m^a , higher earnings today translate into better benefits tomorrow. A fully retired person receives a constant annuity $P_{t+1}^2 = P_t^2$. However, depending on the chosen retirement date, part of the old are still active. We interpret retirement as a labor market participation decision. Average income then amounts to $c^2 = x \cdot y^2 + (1 - x) \cdot P^2$, where y^2 is active earnings, P^2 refers to pension benefits, and x is the participation rate among the old.⁵

Depending on retirement choice, people in the second group partly acquire new claims and partly consume benefits based on previously accumulated entitlements. The fact that people already withdraw benefits from their account can be modeled by scaling the return R^P by a factor μ which slows down the accumulation of benefits. The scaling factor depends on the retirement date x and, therefore, on the rate at which benefits are withdrawn and contribution payments are denied. This allows, in the context of our model, a consistent modeling of retirement incentives. We show below that we can appropriately define the incremental factor μ as in a capital funded system which would be neutral on all margins.⁶ Given the return adjustment, entitlements accumulate by

$$P_{t+1}^2 = \mu(x) R^P [m^2 \cdot e^2 w l^2 + P^2]. \quad (4)$$

We now show how the tax benefit link established by the accumulation of pension entitlements determines the effective tax rates on the different margins of aggregate

⁵This way of modeling retirement follows Cremer and Pestieau (2003), for example. In our richer model, total labor market behavior follows from a sequence of decisions within a given period, i.e. (i) participation/retirement, (ii) job search, and (iii) hours worked. By backward induction, participation behavior anticipates the income and welfare resulting from subsequent choice of job search and hours worked.

⁶A useful parameterization is $\mu(x) = \mu_1 \cdot (x - x_R) + \mu_2$ where μ_2 is set to replicate a given replacement rate. This would also be the return adjustment when retirement occurs at the statutory date x_R . Early retirement and, thereby, a lower participation rate $x < x_R$, reduces the return factor μ and leads to pension discounts, postponed retirement leads to pension supplements in the sense of Gruber and Wise (2005). The slope μ_1 captures the strength of the participation incentives.

labor supply. To reflect the tax benefit link, individual labor market activity must be derived from intertemporal optimization. Since our focus is on labor market behavior, and since the impact of pension reform on life cycle savings is well understood, we abstract here from consumption/savings decisions and assume infinitely elastic intertemporal substitution.⁷ Agents then care only about the present value of consumption, not the timing over the life cycle. The subjective discount rate must then be equal to the interest rate r , giving a discount factor equal to $1/R$ where $R = 1 + r$. Further, current utility is assumed to be separable between consumption and effort costs of labor market behavior. All effort costs are convex increasing in their argument. The Bellman equation of expected life-time utility of an old agent is thus,

$$V(P^2) = \max_{l^2, e^2, x} c^2 - (x \cdot \varphi^2 + \varphi_X(x)) + \gamma V(P_{t+1}^2)/R, \quad \varphi^2 \equiv \varphi_E(e^2) + e^2 \varphi_L(l^2), \quad (5)$$

where average income c^2 and active earnings y^2 during old age are defined as

$$c^2 = x \cdot y^2 + (1 - x) \cdot P^2, \quad y^2 = e^2 \cdot (1 - t)wl^2 + (1 - e^2) \cdot b. \quad (6)$$

We allow for a constant unemployment benefit b which importantly determines the unemployment rate $1 - e^2$ among the old. As in Cremer and Pestieau (2003), among others, we assume that a larger participation rate due to prolonged labor market activity is increasingly costly to individuals, i.e. φ_X is convex increasing in x . Furthermore, conditional on participation, the employment rate e^2 reflects the individual job search effort, giving rise to convex increasing effort costs φ_E (see, for example, Boone and Bovenberg 2002). Finally, effort costs of hours worked are multiplied by $x e^2$ since they are incurred only if the individual is not retired *and* has a job.

Old agents choose a ‘retirement date’ x and, conditional on continued participation, job search and hours of work. Denote the shadow price of pension entitlements as $\lambda^2 \equiv dV^2/dP^2$ which, by the envelope condition, must satisfy $\lambda^2 = 1 - x + \mu(x)R^P \gamma \lambda_{t+1}^2/R$. The shadow price is the present value of future pension benefits per unit of entitlement P^2 .⁸ The optimality conditions for hours worked and job search are

$$\begin{aligned} \varphi'_L(l^2) &= (1 - \tau_L^2)w, & \tau_L^2 &\equiv t - m^2 \frac{\mu R^P}{x} \frac{\gamma \lambda_{t+1}^2}{R}, \\ \varphi'_E(e^2) &= (1 - \tau_E^2)wl^2 - \varphi_L^2, & \tau_E^2 &\equiv \tau_L^2 + \frac{b}{wl^2}. \end{aligned} \quad (7)$$

In the absence of tax, labor market activity is governed by $\varphi'_L = w$ and $\varphi'_E = wl^2 - \varphi_L^2$ where incentives for job search is reduced by the effort required on the job.

Working more hours boosts earnings which get taxed with a statutory rate t . However, in recognizing the tax benefit rule the individual knows that higher contributions

⁷ See the separate technical appendix in Jaag et al. (2009) for a full analysis.

⁸ The term $1 - x$ enters because the pension is consumed only during part $1 - x$ in the ‘mixed’ age state. The simulation model distinguishes several fully retired age states, giving a shadow value of the form $\lambda^a = 1 + \gamma \lambda_{t+1}^a/R$.

add to pension benefits that can be consumed during the retirement period $1 - x$. Taking account of this extra gain, individuals really consider only part of the statutory contribution rate as an implicit tax, $\tau_L^2 \leq t$. Without a tax benefit link ($m^2 = 0$), contributions are fully perceived as a tax, $\tau_L^2 = t$. At the other extreme, the investment based system awards entitlements only on the basis of actual contributions ($m^2 = t$), pays full interest on the individual account ($R^P = R$), and also adjusts the return factor μ in an actuarially fair to correctly reflect the length of the retirement period, $\mu = x/(\gamma\lambda_{t+1}^2)$. As a result, the effective tax rate on current earnings in (7) becomes zero, $\tau_L^2 = 0$. This simply reflects the fact that the investment based system does not affect life-time wealth. Substituting the parameters of the funded system into the shadow price yields $\lambda^2 = 1$. Hence, the value of entitlements does not depend on the parameters of the pension system when pension saving is a perfect substitute to private saving. A euro of extra contributions paid into a capital funded account generates a present value λ^2 of future pension benefits equal to one euro.

Consider next the incentives for job search of older workers near retirement. The worker compares the alternatives of accepting a job versus remaining unemployed. Marginally increasing search effort raises the probability e^2 of finding a job by 1. When a job is found and the agent supplies l^2 hours of work, she obtains an increase in expected disposable earnings equal to $(1 - t)wl^2 - b$. However, the labor earnings during the contribution period add to pension entitlements at rate m^2 that can be consumed during retirement. Hence, not all of the additional contributions are lost, only part of them are perceived as a tax. The effective net tax rate on earnings wl^2 on the job is only τ_L^2 . However, when accepting a job, the worker also loses unemployment benefits where the replacement rate is $\rho^u = b/(wl^2)$. Hence, the effective tax rate on job search amounts to the sum of the net tax rate on active earnings plus the replacement rate of unemployment benefits, $\tau_E^2 = \tau_L^2 + \rho^u$. For this reason, the effective tax rate is much higher than the one on hours worked. Again, a capital funded pension system would be neutral with respect to job search since $\tau_L^2 = 0$ in this case. Of course, a funded pension system cannot undo other distortions of the welfare state such as those associated with unemployment insurance, or with general wage taxes.

The simple definitions of effective tax rates on hours worked and job search yield another important insight. Policies that raise the retirement age x *without* adjusting the return factor μ and, therefore, without raising pension size over the remaining retirement period, may end up discouraging labor supply of the active workforce. For any given statutory contribution rate, a later retirement age (higher x in (7)) inflates the effective tax rates τ_L^2 and τ_E^2 on work effort and job search when μ is fixed. When contributions are paid over a longer time horizon and pensions are received over a shorter period of total life, workers get back less on their contributions and, therefore, perceive a larger fraction of them as a discouraging tax.

The optimality condition for retirement is

$$\phi'_X = y^2 - \varphi^2 - P^2 + (dP_{t+1}^2/dx)\gamma\lambda_{t+1}^2/R.$$

Noting $dP_{t+1}^2/dx = \mu' R^P [m^2 e^2 w l^2 + P^2]$ and defining the old age participation tax rate τ_X on continued work yields $\phi'_X(x) = (1 - \tau_X) e^2 w l^2 - \phi^2$ and⁹

$$\tau_X \equiv t + \frac{P^2 - (1 - e^2)b}{e^2 w l^2} - \mu'(x) R^P \left[m^2 + \frac{P^2}{e^2 w l^2} \right] \frac{\gamma \lambda_{t+1}^2}{R}. \quad (8)$$

The retirement date, and thereby the participation rate among the old, is optimally chosen when the marginal cost of continued work is offset by the marginal gain in life-time income, net of any work related utility cost. The marginal gain consists of the extra expected disposable earnings net of search costs, $y^2 - \phi^2$, where $y^2 = e^2(1 - t)w l^2 + (1 - e^2)b$. The opportunity cost is the foregone pension P^2 that an individual could have consumed during that instant of time. The opportunity cost, however, is reduced by $(\gamma \lambda^2/R) dP/dx$ in present value if the system rewards late retirement by pension supplements dP/dx over the remaining retirement period. In a PAYG system, postponed retirement generates a twofold fiscal gain to the system: (i) agents pay contributions for a longer time period, and (ii) they collect benefits over a shorter time span when they retire later. Individuals can be compensated for these two fiscal savings by an increase $\mu' R^P$ in the return factor which raises their pension. The pension supplements and discounts in response to a variation in the retirement date importantly reduce the opportunity cost of continued work and thereby contain the tendency toward early retirement. A capital funded system would compensate individuals in an actuarially fair way and would thus be fully neutral with respect to retirement choice if there are no other fiscal distortions such as general wage taxes or unemployment insurance. Setting $b = 0$, the capital funded system implies $m^2 = t$, $R^P = R$ and $\mu = x/(\gamma \lambda_{t+1}^2)$ as in the discussion following (7). Noting the pension supplement $\mu' = 1/(\gamma \lambda_{t+1}^2)$ and substituting into (8) yields $\tau_X = 0$.¹⁰ As argued above, one euro of contributions is worth one euro of additional pension benefits in present value, i.e. $\lambda^2 = 1$. Hence, with actuarially fair adjustment, the pension supplement has to be larger when remaining life-time is short (survival factor γ is small), and smaller if the marginal benefits must be paid over a longer time period (γ closer to unity).

The same statements are reflected in the definition of the old age participation tax rate on continued work along the lines of the Gruber and Wise program. The effective tax rate in (8) parallels the definitions in the discrete labor supply literature (e.g. Immervoll et al. 2007; Kleven and Kreiner 2006, and Saez 2002). In a system without participation incentives and in the absence of unemployment benefits ($\mu' = 0 = b$), the effective tax rate would amount to the sum of the contribution and the replacement rate, $\tau_X = t + \rho^p$, where the gross replacement rate is defined as $\rho^p = P^2/(w e^2 l^2)$. It would thus be very high as the literature on participation tax rates has pointed out. A PAYG system with an actuarial adjustment of the return factor, however, could reduce this high effective tax rate in a major way, and a fully capital funded system

⁹A referee pointed out that the dates of retirement from the labor market and of first time pension payment may not coincide. These issues should be explored more fully in future research.

¹⁰Of course, given other wage taxes and unemployment benefits, the participation tax would still be positive but the distortion would be unrelated to the pension system.

with individual savings accounts could, in principle, reduce it to zero if there are no other tax distortions unrelated to the pension system.

Young workers With some modifications, the same analysis also applies to agents in the first age group. Young workers stay in same age state with probability ω and transit to the next age state with probability $1 - \omega$, and thus expect a value $\bar{V}_{t+1}^1$ next period. Noting the assumption of this section that mortality risk starts only in the second age state ($\gamma^2 = \gamma$ and $\gamma^1 = 1$), we can write preferences by the Bellman equation:

$$\begin{aligned} V(P^1) &= \max_{l^1, e^1} c^1 - \varphi^1 + \bar{V}_{t+1}^1/R, \\ \bar{V}_{t+1}^1 &= \omega V_{t+1}^1 + (1 - \omega) V_{t+1}^2, \\ \varphi^1 &= \varphi_E(e^1) + e^1 \varphi_L(l^1). \end{aligned} \quad (9)$$

With probability ω , agents stay in the first age state with a value function $V_{t+1}^1 = V(P_{t+1}^1)$, and with probability $1 - \omega$ they switch the next state with value $V_{t+1}^2 = V(P_{t+1}^2)$, giving expected value $\bar{V}_{t+1}^1$ next period.

Prime age workers supply hours of work and search for jobs, earning expected income c^1 . If employed, they accumulate entitlements P^1 which determine their pension upon retirement in the subsequent age state,

$$c^1 = e^1 \cdot (1 - t)wl^1 + (1 - e^1) \cdot b, \quad P_{t+1}^1 = R^P [m^1 e^1 wl^1 + P^1]. \quad (10)$$

The worker's problem takes into account the implications of today's labor market activities for future pension income when old. Agents' optimization must also take account of the possible aging from this to the next period, implying that retirement in a probabilistic sense comes nearer. Therefore, the shadow price of current pension entitlements is $\lambda^1 \equiv dV^1/dP^1$ which gives an expected shadow price of the newly accumulated entitlements next period,¹¹ $\bar{\lambda}_{t+1}^1 \equiv \omega \lambda_{t+1}^1 + (1 - \omega) \lambda_{t+1}^2$. The optimality and envelope conditions are thus,

$$\varphi'_L(l^1) = (1 - \tau_L^1)w, \quad \varphi'_E(e^1) = (1 - \tau_E^1)wl^1 - \varphi_L^1, \quad \lambda^1 = R^P \bar{\lambda}_{t+1}^1/R, \quad (11)$$

with effective tax rates equal to

$$\tau_L^1 \equiv t - m^1 R^P \cdot \bar{\lambda}_{t+1}^1/R, \quad \tau_E^1 \equiv \tau_L^1 + b/(wl^1). \quad (12)$$

Some minor notational differences notwithstanding, the same interpretations as in the preceding section apply. However, due to discounting over a longer time span until retirement, effective tax rates tend to be higher for young workers than for older

¹¹When switching to old age from period t to $t + 1$, one inherits the same entitlements accumulated in period t . Hence, for this person P_{t+1}^1 if she is not aging, and P_{t+1}^2 if she is aging, are the same. For other agents who have already spent some time in a given age state, P^1 and P^2 are, of course, unrelated. See the technical appendix in Jaag et al. (2009) for a more detailed notation and analytical aggregation.

ones. They decline as retirement approaches, or becomes a more probable event in our model.¹² Further, if benefit assessment is based only on the best years of earnings rather than the entire history, the tax benefit link is much weaker for young agents ($m^1 < m^2$), leading to higher effective tax rates for young workers.

The comparison to the capital funded system shows that the distortions of an earnings linked PAYG system can be much reduced if it mimics the operation of a funded system. The funded system would be exactly neutral as in the previous subsection. To see this, note the shadow value in (11) equal to $\lambda^1 = \bar{\lambda}_{t+1}^1$ when $R^P = R$. Substituting $\lambda^2 = 1$ (see preceding section) yields $\lambda^1 = \bar{\lambda}^1 = \omega\lambda^1 + 1 - \omega$ and, therefore, $\lambda^1 = 1$. One euro contributed to a funded pension account yields a present value of future benefits equal to one euro. The effective tax rate is reduced to zero, $\tau_L^1 = 0$.

2.3 A quantitative model

In the remainder of the paper, we employ a computational model of the Austrian economy to investigate how pension reform in practice could affect labor markets, and how large the impact might possibly be. It is a generalization of Gertler (1999) who first introduced a simple life-cycle structure into the ‘perpetual youth’ OLG model of Blanchard (1985) by allowing for a stochastic transition from work to retirement. Stochastic transition creates a large heterogeneity with respect to life-cycle histories. However, the model can be analytically aggregated to a relatively small number of state variables describing the life-cycle stages of individuals.¹³ Despite the parsimonious state representation, the period length is a calendar year which allows for realistic short and long-run dynamics. Different from the preceding subsections, the computational model distinguishes not two, but eight different groups of workers and retirees and, therefore, yields a much closer approximation of the life cycle (see Table 2 below).

Savings and investment result from forward looking intertemporal choice in a small open economy with an internationally given real interest rate. Savings investment imbalances lead to an endogenously determined net foreign asset position which is reflected in a trade balance surplus or deficit. We assume that, prior to reform, the economy follows a balanced growth path. After reform is implemented, it enters a prolonged period of transition and eventually converges to a new balanced growth path. The model thus captures transitory as well as long-run effects of policy reform. Labor market behavior includes variable hours worked if employed, job search determining the life-cycle unemployment incidence, and variable retirement. The same trade-offs apply as in the preceding subsections, except for a richer institutional modeling of the pension system, unemployment insurance and the public sector.

Households save in their active phase of life to top up public pensions and sustain their consumption level during retirement. They are subject to life-cycle specific

¹²See Feldstein and Samwick (1992), Disney (2004), and Fenge and Werding (2004), among others.

¹³Aggregation is facilitated by two assumptions: preferences are symmetric within each group, i.e. independent of history, and additively separable in consumption and job related efforts. The separability assumption eliminates income effects in labor supply. Note, however, that the tax benefit link introduces intertemporal linkages in labor supply. Jaag et al. (2009) provide a complete documentation. The model is a variant of the ‘probabilistic aging’ concept introduced by Grafenhofer et al. (2006).

Table 1 Model parameters

Production		
r	0.050	annual real interest rate
g	0.018	growth rate labor productivity
δ^K	0.100	depreciation rate of capital
σ^K	0.800	elasticity of capital labor substitution
Households		
σ	0.350	intertemporal elasticity of substitution
ϵ_l	0.200	intensive labor supply elasticity
ϵ_u	1.804	elasticity unemployment rate
ϵ_r	0.800	semi-elasticity of retirement
ξ	0.750	bargaining power workers
η	0.500	matching elasticity workers
$\bar{u}$	0.065	aggregate unemployment rate
x	0.200	participation rate / retirement date ^a
δ^n	0.330	retiree worker ratio $\delta^n = N^R / N^W$
Welfare System		
ρ^u	0.550	replacement rate of unemployment benefits
ρ^P	0.732	net replacement rate of pension benefits
α	0.700	share earnings linked pensions
m	0.036	tax benefit link, last active group
g^P	0.004	pension growth rate/indexation
$\mu'(x)$	0.030	3 pc pension rise per additional year of work

Legend: $\mu(x) = (x - x^R)\mu^1 + \mu^2$, $\alpha = \bar{P}/(\bar{P} + p_0)$, $\rho^u = b/(w^n l)$, ϵ_u elasticity of unemployment rate w.r.t. replacement rate

^aRetirement date corresponds to share of active workers in group of 60–70 years old

mortality risks that increase with age, reflecting usual demographic patterns. Capital accumulation results from intertemporal investment decisions of domestically owned firms. The labor market is subject to matching frictions leading to involuntary unemployment. The calibrated model includes more institutional detail of the general government, unemployment insurance and the earnings linked pension system. The tax benefit link is weak for part of the population so that only 70% of pensions are earnings linked while the rest consists of flat benefits. Unemployment benefits are partly wage indexed. Household sector savings are invested in domestic firm values, government bonds and international bonds. Public debt amounts to about 63% of GDP in Austria, and net foreign debt is almost 20%. In all simulations below, we hold fiscal debt and real government consumption constant per capita.

For the sake of brevity, we discuss only the parameters governing life-cycle labor market behavior which is the most novel feature of our model. We refer to Altig et al. (2001) for a discussion of other more standard parameters. The wage elasticity of hours worked refers to intensive labor supply and is set at a low value $\epsilon_l = .2$, reflecting the empirical consensus reviewed in Immervoll et al. (2007) and Blundell

and MaCurdy (1999). A 1% wage increase thus leads to a 0.2% increase in hours worked.

The impact of the fiscal system on the unemployment rate is based on recent econometric evidence for OECD countries. The estimate of Scarpetta (1996) implies that a 10% increase in the replacement ratio of unemployment benefits leads to an unemployment rate higher by about 1.3 percentage points. This coefficient compares with an estimate of 1.7 in Layard et al. (1991), 1.1 in Nickel (1997) and roughly the same in Blanchard and Wolfers (2000). Holmlund (1998) reviews the literature. Setting the elasticity of the search effort cost at $v_s = \varphi'_S / (s\varphi''_S) = .2$ implies a long-run general equilibrium response of our model to a 10% increase in the replacement ratio equal to 1.8 (coefficient ϵ_u in Table 1) which is at the upper end of these estimates. This is meant to reflect the evidence in Daveri and Tabellini (2000) which implies a rather strong effect of labor taxes on unemployment. As part of our sensitivity analysis, we will check robustness with respect to a lower value of this elasticity.

Other important parameters determining search equilibrium are the matching elasticity of worker's search activity and bargaining strength. The vast majority of empirical studies estimates the elasticity of the matching function with respect to the unemployed around $\eta = .5$ (see Cahuc and Zylberberg 2004, pp. 520 and 534). In the absence of other direct information, we set the bargaining power of workers at $\xi = .75$. This means that the wage falls short of the marginal product of labor to a smaller extent, leaving only a relatively modest job rent to firms. In this case, the results of Hosios (1990) imply that equilibrium unemployment is inefficiently high, creating first order welfare gains from reducing the unemployment rate.

Finally, to parameterize retirement behavior, we rely on the estimates of Börsch-Supan (2000) for Germany. Given the similarity of pension systems, we take this semi-elasticity for Germany as representative for Austria as well. Börsch-Supan (2000) estimates that a decrease in benefits by 12% would reduce the retirement probability of the 60 years old from 39.3% to 28.1%. This amounts to a semi-elasticity of retirement equal to 0.93. However, this value decreases with age. For 64-year olds, it is estimated to be 0.45. These estimates are in line with Costa (1995) and Spataro (2005) who find values of 0.73 and 0.6, respectively. We set a base case value of $\varepsilon_r = 0.8$ and will reduce this value to half as part of our sensitivity analysis. Most other parameters in Table 1 reflect macroeconomic and institutional data for Austria.

Table 2 reports life-cycle information. The distribution of the population over age groups is based on mortality data. The survival rates importantly influence the marginal propensity to consume out of life-time wealth, and thereby life-cycle savings behavior. They increase strongly for very old age groups. As mortality rates rise and the end of life becomes a more probable event, agents wish to consume a larger fraction of their resources.¹⁴ Per capita assets are hump shaped and decline towards the end of the life cycle. Presumably reflecting the importance of seniority pay in Austria, the skill profile is rising over the entire earnings history. The pattern of net wages

¹⁴Heijdra and Romp (2008) have shown in an analytical model that consumption propensities rise with age, reflecting an increasing mortality rate. They also include life-cycle earnings profiles. In particular, they analyze an endogenous retirement decision as in this paper and allow for an early eligible retirement age. They show that many agents optimally bunch at this early retirement age. For this reason, the retirement elasticity might be lower in the aggregate which we address with a sensitivity analysis in Sect. 3.2.5.

Table 2 Life-cycle earnings and unemployment

Cohorts		20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99
Age Groups		1	2	3	4	5 ^a	6	7	8
population share	n	0.191	0.189	0.181	0.163	0.137	0.095	0.038	0.006
labor prod.	θ	1.500	1.859	2.114	2.308	2.340	–	–	–
net wage	w^n	0.566	0.525	0.499	0.480	0.499	–	–	–
wage tax rate	t^w	0.194	0.239	0.267	0.285	0.261	–	–	–
tax benefit link	m	0.000	0.000	0.011	0.036	0.036	–	–	–
eff.pens.contrib.	$\hat{t}^s$	0.170	0.170	0.135	–0.006	–0.104	–	–	–
unempl.rate	u	0.068	0.055	0.060	0.068	0.116	–	–	–
av. income	$\bar{y}$	0.820	0.948	1.024	1.070	0.865	0.793	0.779	0.734
per cap.assets	$\bar{a}$	9.025	11.490	12.031	11.198	10.458	8.839	8.471	8.274
marg.prop.cons.	mpc	3.709	4.988	6.040	7.319	8.678	11.312	11.815	13.064

Legend: mpc marginal propensity to consume out of life-time wealth, $n^a = N^a / N$ population shares

^aThe participation rate in the semi-retired group is 20 p.c., the unemployment rate refers to the active part only

additionally reflects the effect of progressive wage taxes. Finally, Table 1 reports an unemployment rate of 6.5% on average. This aggregate number hides a significant heterogeneity among different age groups. Life-cycle unemployment rates follow an inverse hump-shaped pattern. With 11.6%, the unemployment rate of people near retirement is about double the rate of prime age workers in their thirties when it is lowest with a rate of only 5.5%. The life-cycle pattern of the implicit contribution tax will be discussed below.

3 Pension reform in Austria

3.1 Recent policy initiatives

Recent pension reform in Austria was among the more courageous and far reaching in Europe.¹⁵ The pension system was subject to large imbalances and clearly unsustainable prior to reform. In 2000, Austria had the highest GDP share of pension spending in the EU15 equal to 14.5% and it was expected to increase to 18.1% in 2035 (European Commission 2003). Five years later, after several important reforms, the European Union projected a decline of pension spending by 1.2 percentage points, from 13.4% in 2004 to 12.2% in 2050. Pension spending in our model amounts to 12.8% of GDP which reflects the estimates based on legislation dating to the end of 2003. Contributions were far from sufficient to fully cover pension payouts, leading to a deficit of more than 2.5% of GDP to be financed out of general tax revenue. Early retirement and low labor market participation of older workers were particularly widespread in

¹⁵Recent reform is discussed, among others, by OECD (2005), European Commission (2004, 2006), Knell et al. (2006), Felderer et al. (2006), and Hofer and Koman (2006).

Austria. In 2003, the average retirement age was about 58 years, compared to statutory retirement age of 65 for men and 60 for women. The employment rate in the age group of 55–64 was thus a mere 28.8% in comparison to an average of 41% for the EU25 (European Commission 2007a). In contrast, participation rates among younger workers were European average or even better.

Austria runs a PAYG system that covers more than 90% of the labor force. Occupational pension schemes and individual capital funded pensions play only a rather minor role. The contribution rate amounts to 22.8% of gross salaries. Workers pay 10.25%, the remaining 12.55% are financed by employers. However, contributions are paid only up to an income ceiling. According to wage income statistics of 2005, wage income was 94.4 bn euro (3.769 mio cases). Incomes below the contribution ceiling account for 75% of the wage bill (70.4 bn euro or 3.471 mio cases). This would yield an effective statutory contribution rate of 17% (22.8×0.75). Pension levels are rather generous. They are assessed on the basis of individual past earnings where the first-time pension is given by the product of the (accumulated) accrual rate times the pension assessment base. Prior to the 2003 reform, two points could be added to the accrual rate for each year of earnings so that after 40 years of employment a maximum accrual rate of 80% of the assessment base was obtained. The Austrian pension formula thus results in a gross replacement rate equal to 64% of average earnings which implies a net of tax replacement rate of around 80% (European Commission 2007a).

Up to 2004, the assessment base consisted of an average of the best 15 years of earnings, meaning that younger workers could not influence their expected pension if they earned more. Calculating average earnings over a short period of time means that each year of eligible earnings weighs much more heavily in determining the pension. In our model, we capture this institutional feature by setting the tax benefit link m^a to zero for young workers and relatively high for older ones so that we replicate the observed average pension level at retirement. We interpret the participation rate of 0.2 as the average retirement age in group 5 (60 to 70 year olds). Given that wage profiles rise over the entire working life, the best 15 years of earnings would start with age 37 which corresponds to a share of 30% of time and earnings in this group. We thus set the value of m^a in group 3 (40 to 50 year olds) at $.3 \times .036 = .0108$ where the value for older workers equal to .036 is chosen relatively high to replicate the observed first time pension. For this reason, the contribution tax is equal to the full statutory contribution rate of younger workers while older ones get a significant subsidy; see Table 2. A subsidy to certain groups, especially to older workers, is not unusual (see the calculations in Feldstein and Samwick 1992). The subsidy in part reflects the generosity and substantial deficit of the Austrian system which results in higher taxes elsewhere. An extension of the assessment period to life-time earnings establishes a uniform level of the tax benefit link for all groups that would have to be reduced appropriately to yield the same starting pension. Such a change reduces the implicit tax of young workers while it raises the tax (or cuts the subsidy) of older ones.

Austria recently initiated several reforms in expectation of large imbalances of the system. The main reasons are an increase in life-expectancy by about 4.4 years, a fertility rate much below 2 until 2050, and a trend towards early retirement (European

Commission 2006). These developments are projected to lead to a doubling of the old age dependency ratio (ratio of people 65+ over ages 15 to 64), increasing from 25% in 2005 to 51% in 2050. In addition, the retirement age of men fell from more than 62 in the early 70s to 59 in 2003, or 58.8 as an average of men and women, in comparison to 61.3 for the EU15 (European Commission 2007b). To restore sustainability, the pension reforms of 2000, 2003, and 2004 introduced several measures that restricted or even abolished eligibility for early retirement, survivors and disability pensions. In 2000, some early retirement options were scrapped altogether. For the remaining schemes, the early retirement age was raised by 18 months up to 61.5 years for men and 56.5 for women. The pension schemes for all occupational groups were fully harmonized in 2004, implying a much reduced generosity of civil servant pensions.

On a more fundamental level, and with some extended phasing in period, Austrian reform of the PAYG system established individual pension accounts for all occupational groups and individuals born after 1955: (i) The assessment period is extended from the best 15 years to life-time earnings in 2004. At the same time, the accrual rate was reduced from 2 to 1.78% in 2003. According to the guiding formula 45/65/80, the pension system guarantees a pension equal to 80% of the assessment base after 45 insurance years at the standard retirement age of 65 years. (ii) Each year, 1.78% of individual earnings are added to the individual account as new entitlements. Accumulated entitlements are paid an implicit interest rate equal to the growth rate of average gross earnings. (iii) Relative to the statutory retirement age of 65, variable retirement is allowed within a pension corridor of ages 62 and 68. Pension discounts for each year of early and credits for each year of delayed retirement amount to 4.2% of the assessment base per annum. In the extreme cases, benefits can be reduced by 15% and increased by 12.6% relative to the normal pension that one would have received at the statutory retirement age. Entitlement is restricted to persons of at least 37.5 years of pensionable service. (iv) Existing pensions are inflation indexed. Previously, the system required that average pensions should have grown at the same speed as average wages, both net of social security contributions. Knell et al. (2006, p. 4) argued, however, that adjustment of average pensions reflected not much more than consumer price inflation as a result of ongoing changes in the composition of pensioners.

Our model is well suited to analyze the quantitative effects of many of these reform measures. In the next subsection, we investigate the potential consequences of four scenarios:

- (1) We analyze the extension of the calculation period for pension assessment from the best 15 years to the entire earnings history. At the same time, the accrual rate for entitlement accumulation is cut to an extent that keeps, in the absence of a behavioral response, the initial earnings linked pension fixed. In equilibrium, pension size will increase, should people start to work more and retire later and thereby acquire more entitlements.
- (2) Then we consider a strengthening of the tax benefit link. In our model, 70% of overall pension income initially stems from earnings linked pensions, the remaining part accrues in the form of flat benefits. We raise the share of earnings linked pensions to 80% and, taking initial labor market behavior as given, compensate by a cut in lump-sum benefits to keep total pension size constant. This scenario

is interpreted as a ‘harmonization’ of the system which subjects a larger part of the population to the same earnings based pension rules.

- (3) Wage indexation of pension benefits is replaced by price indexation. Although pensions were, in principle, increasing along with wages prior to reform, wage indexation was far from complete. We thus start from a situation where pensions were allowed to grow only by a quarter of the general wage growth rate. By moving to price indexation, this growth rate is reduced to zero so that pensions remain constant in real terms.
- (4) The final scenario refers to arguably the most important policy change in Austria, the increase in pension discounts and supplements for early and late retirement. In the simulation model, a postponement of retirement by one year (corresponding to an increase in the participation rate of age group 5, the 60 to 70 year olds, from 0.2 to 0.3) yields an increase in the first time pension equal to about 3%. To evaluate the importance of retirement incentives and in line with the government’s original intentions, we consider the impact of moving to a 4.2% pension adjustment with respect to one year of earlier or later retirement. The OECD (2005) has argued for even higher actuarial adjustments.

In all cases, the policy scenarios are not revenue neutral when the behavioral response kicks in, and result in larger or smaller deficits of the pension system. It is assumed that deficits or surpluses are covered out of general tax revenue by an adjustment of the wage tax rate.

3.2 Economic impact of reform

We now investigate the impact of pension reform as discussed in Sect. 3.1. The scenarios in the last four columns of Table 3 must be understood cumulatively, one on top of the other.

3.2.1 Lengthening the assessment period

We first turn to the extension of the assessment period to life-time earnings, giving a uniform tax benefit link $m^a = m$ for all groups, instead of the pattern shown in Table 2. To avoid an unintended change in pension generosity, we scale the level of the tax benefit coefficient such that, for *given* labor market behavior, it yields the same level of aggregate pension spending. To this end, the coefficient is raised from zero to 0.017 for the youngest group, and reduced from 0.036 to this same value for the oldest (partially) active group. In general equilibrium, pension levels will change to some extent in response to the induced labor market response. Any emerging deficit or surplus is offset by scaling the income tax on wages and pensions.

A reduction of the accrual rate generally weakens the tax benefit link and raises the implicit tax rates for older workers in their best 15 years of earnings. By way of contrast, the extension of the calculation period allows younger workers early in their career to participate in the tax benefit link which reduces the implicit tax character of their contributions, even though the statutory contribution rate remains constant.

The policy cuts the implicit contribution tax of the youngest group of people in their twenties by 3 percentage points, from 17 to about 14%. At the same time, the

Table 3 Parametric pension reform, long-run

Scenarios	ISS		Length	Harm	Index	Fair
<i>Absolute Values</i>						
Wage Tax, scaling	1.000	ϕ	1.004	0.987	0.976	0.940
Eff. Contrib. Rate	0.170	$\hat{t}_s^1$	0.141	0.136	0.137	0.137
Eff. Tax Hours	0.350	τ_L^1	0.321	0.314	0.312	0.306
Eff. Tax Empl.	0.682	τ_E^1	0.673	0.669	0.667	0.662
Eff. Participation Tax	0.735	τ_X	0.755	0.743	0.743	0.708
Retirement Date	0.200	x	0.196	0.216	0.214	0.289
Pension Repl. Ratio	0.732	ρ^P	0.765	0.773	0.772	0.795
Unemployment Rate, %	6.464	$\bar{u}$	6.467	6.333	6.282	6.114
Pension Def., % GDP	2.482	Z^P	2.475	2.298	2.069	1.586
Pension Spend., % GDP	12.747	P^{tot}	12.733	12.559	12.329	11.839
Net For. Ass., % GDP	-19.500	D^F	-17.154	-21.262	-15.827	-29.425
<i>Percentage Changes</i>						
Labor Force		N^W	-0.070	0.284	0.256	1.618
Labor Demand		L^D	-0.295	0.637	0.714	2.652
Gross.Dom.Prod., GDP		F	-0.295	0.637	0.714	2.652
Aggr. Consumption		C	-0.255	0.658	1.009	2.632
Aggr. Assets		A	0.359	0.300	1.405	0.698

Legend: Columns report cumulative effects. (Length) lengthening assessment period, (Harm) harmonization (extend coverage of earnings linked pensions), (Index) from wage to price indexation, (Fair) more actuarial fairness

reduction of the accrual rate imposes a higher contribution tax on older workers in their best 15 years of earnings. The active part of group 5, corresponding to people in their early sixties, actually received an implicit subsidy equal to 10% of earnings, reflecting the deficit and remarkable generosity of the system. The subsidy is turned into an effective tax of 3.4% as a result of the reduction in the tax benefit coefficient. The small subsidy to the fourth group, the 50 to 60 year olds, is similarly turned into an effective tax of 8.4%. Consequently, labor market activity of these groups is discouraged. This part of the Austrian reform should have not so much strengthened work incentives on average, but rather incentives of younger workers at the expense of older ones.

The changes in the implicit tax component of PAYG contributions triggers changes in labor supply. While Fig. 1 shows the cumulative impact of the complete reform, the life-cycle pattern is clearly dominated by this first scenario. Hours worked of active generations depend on the real wage net of *effective* tax rates. This total effective tax rate depends on the contribution tax but also on the change in the wage tax which is required to balance the fiscal budget. Since this first scenario is largely revenue neutral, the reduction in the effective tax on work (τ_L^1 in Table 3) is almost identical to the reduction in the implicit contribution tax ($\hat{t}_s^1$). The figure illustrates how the lengthening of the calculation period reduces effective taxes and thus stimulates hours

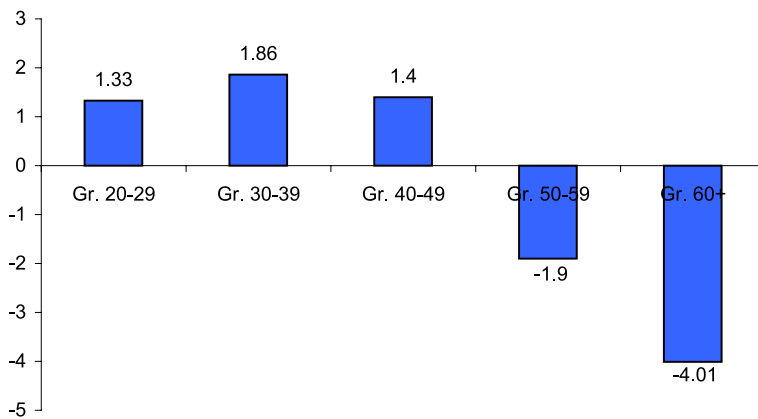


Fig. 1 Life-cycle labor supply, percent changes

worked and search activity of the young, and how it discourages labor supply of senior workers. The reduction in hours worked among the elderly is rather large in size, compared to the more modest but still substantial increases among the young. The isolated effect from extending the calculation period is +1.3% for people in their thirties, and −4% for older workers in their sixties.

Job search much depends on the strength of the tax benefit link which raises future benefits for any extra wage income created by switching into a job. In Austria, this channel remains relatively weak, however, since periods of unemployment to a large part also add to pension claims.¹⁶ The effective employment tax falls to a minor extent only. Compared to hours worked, the response of job search and unemployment rates is thus smaller. The effects are stronger for workers near retirement but are much discounted for people in their early career. Furthermore, the life-cycle pattern of the unemployment response reflects the fact that the policy initiative raises the tax on old and cuts it for younger workers, thereby shifting labor market incentives from the old to the young. If this scenario is viewed in isolation as in column ‘Length’ of Table 3, the rate of unemployment among the 30 to 40 year olds shrinks by −0.14 percentage points while it increases for workers in their 50s and 60s by +.32% in both groups. The unemployment rates in Fig. 2 reflect the additional influences of the other reform steps which scale down unemployment rates across the board. Therefore, in the end, the complete reform cuts unemployment rates of younger age groups substantially more than for older ones. Given the offsetting impact on younger and older workers, the aggregate unemployment rate in Table 3 remains unchanged.

3.2.2 Strengthening the tax benefit link

An important element of Austrian pension reform was to subject certain groups such as civil servants and farmers who have largely received flat pensions, to the earnings

¹⁶This aspect was not emphasized in Sect. 2, but is included in the simulation model. In (4) and (10), respectively, one would write $P_{t+1}^a = R^P[m^a[e^a + (1 - e^a)\beta]wl^a + P^a]$ if a fraction β of the earnings on the last job also count toward future pensions.

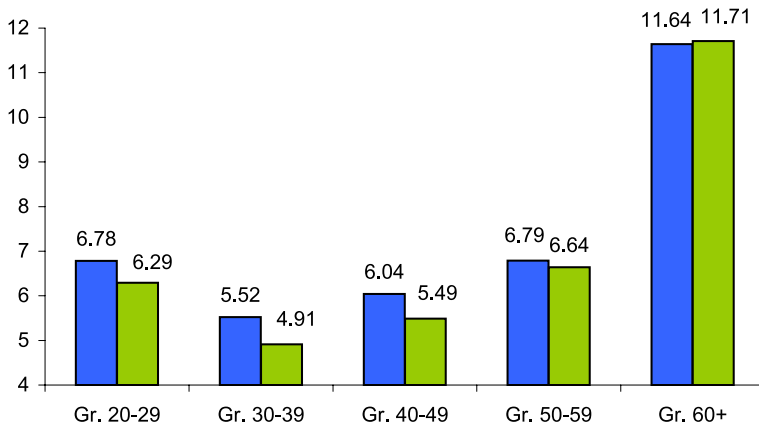


Fig. 2 Life-cycle unemployment rates, absolute

based rules of a ‘harmonized’ system. We can mimic this by assuming that the representative household receives a larger share of earnings linked pension income, and a correspondingly smaller share of a basic flat pension. We shift up accrual rates m and cut the flat pension subject to two constraints: (i) the share of the earnings linked pension is raised from 70 to 80%, and (ii) agents receive the same total pension at the start of retirement when individual behavior is kept constant. To achieve this, the uniform accrual rate m must thus be raised from 1.75 to 2.02% of expected wage income. To the extent that people respond with increased labor market activity to accumulate more pension entitlements, benefit levels may be higher in equilibrium. Column ‘Harm’ of Table 3 reports the cumulative impact when harmonization is imposed on top of lengthening the assessment period. The incremental effects are seen when comparing to column ‘Length’.

Strengthening the tax benefit link is an obvious efficiency improvement. The effective tax on hours worked is reduced across all age groups. The policy change also strengthens the incentives for job search because, with a stronger tax benefit link, the income gain from accepting employment translates into a larger increase in future pension benefits. Finally, the tax benefit link weakly boosts participation incentives of older workers, as is shown by a slightly reduced participation tax. Note that already in the initial equilibrium is the size of the pension to some extent sensitive to the retirement date. Since the size of the earnings linked part in total pension income is now larger, a given marginal delay in retirement translates into a larger future pension gain (term μ' in the implicit retirement tax in (8)). Workers are thus more keen to postpone retirement. Similarly, any given wage income translates into larger future pensions when the accrual rate m is higher. A given marginal delay in retirement and thereby marginally prolonged contribution payments again get rewarded with a higher present value of future pension income.

The results in Table 3 support these arguments. The retirement date is postponed which raises the participation rate from .196 to .216 and thereby augments the increase in the workforce by .35 percentage points. The number of pensioners and, therefore, the dependency ratio is correspondingly reduced so that sustainability of

the system improves. The small decline in pension spending, made possible by a smaller number of retirees, slightly reduces the deficit and creates room for a small wage tax cut which further magnifies labor market incentives. The increase in hours worked and the small reduction in the unemployment rate both reinforce effective labor supply (equal to labor demand L^D) beyond the mere participation effect and boost GDP by .9 percentage points to a total gain of 0.6%.

3.2.3 Moving to price indexation

The labor market impact of eliminating (the rather ineffective) wage indexation of pensions is not immediately apparent and reflects partly offsetting forces. Doing away with wage indexation has two direct effects. First, it reduces significantly the shadow price of pension entitlements. When pensions grow at a slower rate from the date of retirement onward, the present value of expected future pension income per unit of the starting pension must fall. Therefore, the value of additional pension benefits from working longer hours and generating more earnings at younger ages is much discounted. Such devaluation significantly raises the implicit tax component of PAYG contributions and thereby discourages job search and hours worked. Removing wage indexation simply makes the system less generous from an individual perspective. Even more importantly, the devaluation of pension entitlements due to the lower shadow price is likely to induce early retirement. If pension rules are already sensitive with respect to the retirement date, people can raise pension income upon retiring later. However, if the present value of the gains from obtaining a higher starting pension is reduced, people gain less from postponing retirement. The scenario thus holds a potential for early retirement. Second, when pensions grow slower than wages, they get relatively less generous during retirement. The resulting savings in aggregate pension spending are, after all, the main motivation for this policy change. If these savings come true, the lower deficit in the pension system would allow for wage tax cuts which would stimulate work, search, and old age participation.

Column 'Index' in Table 3 reports long-run results from eliminating wage indexation of pensions. Incentives of prime age workers change in offsetting ways. First, the pension savings reduce the PAYG deficit and allow for wage tax cuts. Second, the devaluation of entitlements when pensions grow slower after the date of retirement, increases the implicit pension tax. In our simulations, the first effect dominates and slightly stimulates hours worked and job search of prime age workers. As a third effect, the reduced shadow price of pension entitlements makes a delay in retirement less attractive. Therefore, the participation rate in group 5 slightly declines from 21.6 to 21.4 which reduces the labor force to a small extent. Nevertheless, due to the beneficial effects on labor market activity of prime age workers, abolishing wage indexation weakly stimulates effective labor demand and raises the impact on GDP from .64 to .71%.

Another interesting point is the significant increase in life-cycle savings. The transition from wage to price indexation leads to a decline of pension income of the very old, relative to wage income in active periods of work. The anticipation of lower pension growth during old age therefore leads to a considerable, offsetting increase in private savings to ensure old age living standards per capita. Compared to the initial equilibrium, aggregate private assets are by 1.4% higher in the long-run. In a

small open economy, the interest rate, and thus capital intensity are internationally determined and independent of domestic policy shocks. Therefore, investment simply parallels the increase in aggregate labor supply. Excess savings lead to increased capital exports in the form of international portfolio investments. In consequence, the country's net foreign debt of 21% of GDP is reduced by roughly 5 percentage points.

3.2.4 Increasing actuarial fairness

The most important element of Austrian pension reform may have been the revision of the pension formula to assure a larger degree of actuarial fairness. In our initial equilibrium, postponing retirement by one year raised a person's earnings linked pension by 3%. In this scenario, we raise—on top of the other reform elements—the pension increase to 4.2% per year as it was recently introduced in Austria. The last column of Table 3 reports the long-run results. Comparing to column 'Index' reveals the differential effect, while comparison to 'ISS' referring to the initial steady state shows the cumulative impact of the total package.

Increasing actuarial fairness has two immediate effects. It substantially reduces the participation tax rate from 74 to 71%. When people retire later, they collect larger benefits which significantly raises the pension replacement rate. Table 3 shows that the policy, by inducing late retirement, boosts the participation rate in age group 5, corresponding to the 60 to 70 year olds, from 21 to 29%. Higher participation expands the labor force by about 1.4% incrementally, or 1.6% in total. Since pensioners are a much smaller group to begin with, the same absolute change means a much larger percentage change of the number of retirees, equal to -4.1% . The large decline in the dependency ratio obviously is a key factor to restore fiscal sustainability of the system. Despite of the fact that per capita pensions are significantly larger as a result of late retirement supplements, the much lower take-up rate reduces aggregate spending from 12.3 to 11.8% of GDP. These savings shave off half a percentage point of GDP from the PAYG deficit. The fiscal savings finance a substantial tax cut. Tax rates on wage and pension incomes are scaled down by a factor of .94, implying a reduction in tax rates of up to 1 percentage point (or 1.7 points for the total reform) for top earners in their fifties.

Labor market behavior of prime age workers is mainly driven by effective wage and contribution tax rates. Given constant statutory contribution rates and a constant tax benefit link, the effective contribution tax is not much changed for prime age workers. Although lower taxes on pensions would imply a larger present value per unit of pension claim, these gains lie in the more distant future due to postponed retirement, and are thus discounted more heavily. For this reason, the effective contribution tax of the youngest age group does not change. The total effective tax rates on work and job search, however, are significantly lower due to the cut in wage taxes. The lower wage tax stimulates the labor market activity of prime age workers, and thus reinforces the extensive labor supply response on account of postponed retirement. The growth of the work force jumps from .26 to 1.6% as a result of late retirement incentives, while the total effect on aggregate labor supply and GDP rises from .7 to 2.6%.

Table 3 also points to important repercussions of pension reform on aggregate life-cycle savings. Postponed retirement which comes along with a significant increase in

the pension replacement rate, reduces the need for life-cycle savings for two reasons. First, the retirement period is shorter so that individuals need to save less to sustain living standards. Second, the higher pension replacement rate similarly reduces the need for private savings. While private consumption jumps from 1 to 2.6%, the increase in household sector financial wealth is reduced from 1.4 to 0.7%. The net foreign asset position accordingly deteriorates.

We do not report welfare results since the model cannot capture welfare gains from overcoming myopia and short-sightedness in life-cycle consumption behavior or the gains from insurance against the risks of aging and length of life. After all, these are important justifications for the existence of a mandatory system in the first place. Separate welfare calculations, reflecting mainly efficiency gains from reduced labor market distortions and intergenerational redistribution effects, show that most present and future generations would gain from the Austrian pension reform scenario.¹⁷ Since the pension replacement rate is kept roughly constant, the scenario distributes benefits and costs quite evenly across generations. The harmonization of the system and, in particular, the increase in pension supplements substantially reduce labor supply distortions and yield important efficiency gains. Since postponed retirement considerably improves fiscal balance, the reform allows to cut the distorting wage tax and thereby yields a second dividend. For these reasons, the Austrian pension reform scenario turns out quite beneficial for the majority of generations.

3.2.5 Sensitivity analysis

Given our focus on intensive and extensive margins of labor supply, hours worked, job search, and retirement, we want to check the robustness of results on those behavioral margins. Table 4 shows how the long-run impact of total pension reform changes when the model is calibrated on the same data base but with different behavioral elasticities. The base case column repeats the results from the last column of Table 3. Since the empirical literature finds a very low and in some cases insignificant wage elasticity of hours worked, we consider in the next column the case of fixed hours. We find that the long-run GDP gain is reduced from 2.7 to 2.3%. Interestingly, the reduction of the search elasticity has much less impact. We compute in a separate exercise that an increase in the replacement ratio of unemployment benefits equal to 10% would raise the unemployment rate in general equilibrium by about 1.4%, instead of 1.8% with the base case parameters listed in Table 1. Quite expectedly, a smaller job search elasticity somewhat dampens the impact on the unemployment rate which leads to a slightly lower GDP gain of 2.3 instead of 2.7% in the long-run.

Since the overall impact of the policy scenario is mainly dominated by induced retirement behavior, any change in the retirement elasticity is bound to have a larger effect. Halving the elasticity almost cuts in half the GDP gain as well. The main change comes from the impact on the workforce. With a lower elasticity, workers postpone retirement to a much lesser extent so that the participation rate among the

¹⁷ A referee pointed out the limitations of welfare calculations in our framework. However, the interested reader can find welfare results in the discussion paper version (CESifo DP 2163, 2007).

Table 4 Sensitivity analysis

Base Case Parameter Values $\epsilon_l = .2, \epsilon_u = 1.8$ and $\epsilon_r = .8$	ISS		Base Case	Hours $\epsilon_l = 0$	Search $\epsilon_u = 1.4$	Retire $\epsilon_r = .4$
<i>Absolute Values</i>						
Wage Tax, scaling	1.000	ϕ	0.940	0.944	0.942	0.962
Retirement Date	0.200	x	0.289	0.292	0.288	0.243
Unemployment Rate, Gr.1, %	6.780	u^1	6.290	6.314	6.422	6.428
Unemployment Rate, av., %	6.464	$\bar{u}$	6.114	6.158	6.217	6.217
Pension Def., % GDP	2.482	Z^P	1.586	1.623	1.599	1.887
Pension Spend., % GDP	12.747	P^{tot}	11.839	11.871	11.853	12.144
Net For. Ass., % GDP	-19.500	D^F	-29.425	-30.592	-29.002	-21.282
<i>Percentage Changes</i>						
Hours Worked, Gr.1		l^1	1.328	0.000	1.323	1.221
Hours Worked, av.		$\bar{l}$	0.513	0.000	0.501	0.435
Labor Force		N^W	1.618	1.683	1.608	0.790
Gross.Dom.Prod., GDP		F	2.652	2.318	2.523	1.470
Aggr. Consumption		C	2.632	2.163	2.516	1.637

Legend: (Base) base case results, (Hours) fixed hours of work, (Search) low job search intensity, (Retire) low retirement elasticity

60 to 70 years old increases only half as much compared to the base case. The fiscal gains are much reduced so that the possible wage tax cuts are substantially less generous. Consequently, the reduction in the unemployment rate is also smaller. The sensitivity analysis once again verifies that the retirement margin may be the most important channel for macroeconomic effects of pension reform especially if the degree of actuarial fairness is changed.

4 Aging and pension reform

A key policy question is whether recent pension reform in Austria is sufficient to assure long-term sustainability and what further steps might be required to offset the fiscal pressures due to aging. Demographic projections for Austria imply a major increase in the old age dependency ratio to 51% in 2050, mainly resulting from an increase in life-expectancy by about 4.4 years. At the same time, total population is expected to grow by 10% until then, despite of a low fertility rate. The main source is, of course, the growth at the ‘old end’ of the population as more and more people survive to very high ages. As a result, the weight of old people rises while the share of young groups must fall. The calculations in Sect. 2.1 illustrate this. We adjust the demographic model parameters to replicate projected population growth and the increase in the dependency ratio. Figure 3 shows the initial and long-run age structure of the population.

In Table 5, column ‘age’, we first compute the long-run economic consequences of demographic change when the existing pension system remains unreformed. The

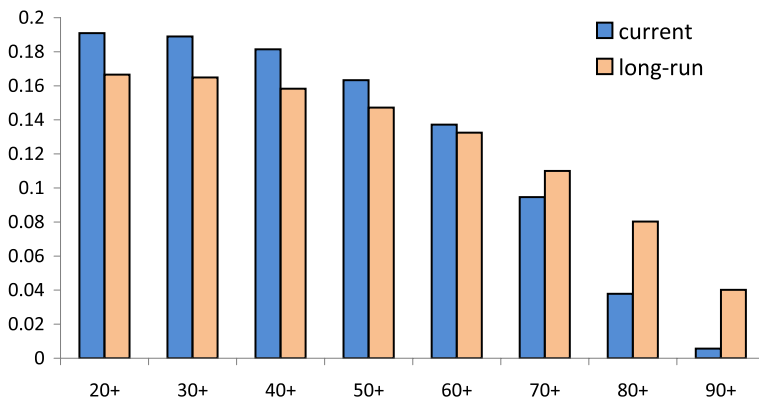


Fig. 3 Aging and population structure

earnings link determines the replacement rate which, by and large remains constant. The government is assumed to passively raise the wage tax rate to balance the budget, keeping government debt, and spending constant per capita. Equation (3) in Sect. 2.1 shows that a major tax increase is required. According to Table 5, the wage tax schedule must be scaled up by a factor of 1.5 which implies an increase in the tax rate of the youngest group by 10 percentage points, from 19 to 29%, and even more for people in their fifties at the peak of their career. Obviously, effective tax rates rise by a large extent on all margins. Even with moderate elasticities, this major tax increase must trigger a very detrimental impact on labor markets. In Table 5, the unemployment rate rises from 6.5 to 9%, hours worked fall by 3 to 4%, and given the relatively heavier taxation of active labor income, participation of older workers is discouraged and leads to somewhat earlier retirement. Demographic change, but also the lower participation in the group of 60 to 70 year olds, shrink the workforce by 4%. The negative impact is multiplied by detrimental labor supply responses (higher unemployment, less work when employed, and earlier retirement). Effective employment shrinks by 10%. In an open economy with a fixed interest rate, the level of GDP falls by the same amount. GDP per capita, however, declines even more dramatically, by 18% in the long-run, because GDP must be divided over a larger population.

We now ask to which extent recent pension reform can offset the detrimental impact of aging. We implement the complete pension reform package corresponding to the last column of Table 3. The differential impact relative to the post aging equilibrium is seen by comparing the columns 'PR' with 'Age'. The reform succeeds to substantially dampen the tax increase which is about 3 percentage points lower. We find the impact of the reform to be qualitatively the same but quantitatively larger than in Table 3. For example, GDP per capita grows by 2.6% in Table 3 while the reduction in per capita GDP as a result of aging is reduced by almost 4 percentage points. The unemployment rate falls from 9 to 8.3%, i.e. by 0.7 percentage points, which compares to 0.35 points in Table 3. While the reform succeeds to offset the negative consequences of aging to a substantial amount, it seems far from sufficient. Tax rates are still 7 to 10 points higher than prior to aging. Effective employment and the GDP level fall by roughly 6%. One of the reasons for the limited effects of the

Table 5 Aging and pension reform

Scenarios	ISS		Age	PR	PR+	PR++
<i>Absolute Values</i>						
Wage Tax, scaling	1.000	ϕ	1.494	1.376	1.283	1.140
Dependency Ratio	0.330	δ^n	0.526	0.489	0.447	0.432
Tax benefit link	0.036	m^5	0.036	0.020	0.020	0.016
Eff. Tax Hours	0.350	τ_L^1	0.443	0.383	0.366	0.346
Eff. Tax Empl.	0.682	τ_E^1	0.752	0.723	0.709	0.691
Eff. Participation Tax	0.735	τ_X	0.768	0.730	0.653	0.611
Pension Repl. Ratio	0.732	ρ^P	0.740	0.831	0.881	0.736
Retirement Date	0.200	x	0.137	0.261	0.409	0.463
Unemployment Rate, %	6.464	$\bar{u}$	9.056	8.296	7.813	7.141
Pension Def., % GDP	2.482	Z^P	10.113	7.967	6.434	3.534
Pension Spend., % GDP	12.747	P^{tot}	20.418	18.248	16.694	13.778
Net For. Ass., % GDP	-19.500	D^F	84.501	69.426	43.288	65.974
<i>Percentage Changes</i>						
Total population		N	10.000	10.000	10.000	10.000
Pensioners		N^R	52.969	45.708	36.990	33.790
Labor Force		N^W	-4.165	-1.771	1.103	2.158
Employment		L^D	-10.192	-5.935	-1.861	0.768
<i>Percentage Changes, per capita</i>						
GDP		F/N	-18.356	-14.486	-10.782	-8.392
Consumption		C/N	-17.624	-13.501	-10.095	-6.238
Assets		A/N	-0.975	1.230	1.255	7.799

Legend: Scenarios: Columns report cumulative effects. (Age) demographic change, (PR) total pension reform, (PR+) add participation incentives, (PR++) add reduction in tax benefit link (accumulation pension claims)

reform is that, in equilibrium, the net of tax replacement rate rises from 74 to 83% which keeps required taxes high.

Earlier results indicate that an increase in the effective retirement age seems to be a key strategy to cope with aging. Following the recommendation of the OECD, the next column PR+ further raises pension increments from 4.2 to 6% per year of postponed retirement. This measure succeeds to boost the participation rate in the group of 60 to 70 year olds to 40%. With more tax payers and fewer pensioners, the measure substantially improves public budget balance and allows for sizeable further wage tax cuts. Effective tax rates decline on all fronts and stimulate labor market activity. Hence, the decline in effective employment is reduced to 2%, a gain of 4 percentage points. The pension increments due to postponed retirement raise the net replacement rate to 88% which seems larger than what is usually considered desirable. Therefore, we scale down in the last column PR++ the tax benefit link by a factor of .8 to reduce the level of earnings linked pensions, keeping the flat basic pension (20% of overall pension spending) constant. The replacement rate thus falls

close to the initial level prior to aging and pension reform. This last measure brings further budget relief and allows for a lower wage tax burden. All in all, the tax rates exceed initial levels only by 2 to 4 points. This turns the loss in effective employment and GDP into a moderate gain of .8%. But this level needs to be divided over a larger population so that per capita GDP still shrinks by more than 8%. To sum up, recent pension reform in Austria is an important step to alleviate the economic consequences of aging but is far from enough to offset the required increase in taxes and the losses in per capita income.

5 Conclusions

This paper has analyzed recent pension reform in Austria, using a rich computational model of life-cycle labor supply, unemployment, and retirement. The model also includes in much detail the institutional features of the Austrian PAYG pension system that importantly determine the separate, effective (implicit) tax rates on three labor market margins. We can thus represent the actual parametric reform of the system in much detail. We record the following important results of our analysis. First, the reform promises a significant GDP gain, maybe around 2.7% in the long-run. GDP growth is mainly driven by expansion of labor inputs on the extensive and intensive margins that are complemented over time by parallel increases in capital inputs. Second, the total reform is likely to boost effective labor inputs on all three margins of labor market behavior. Calibrating the model with econometric estimates of the retirement elasticity, we find that retirement might be postponed on average by almost a year. The associated increase in aggregate labor supply is further magnified by more hours worked and declining unemployment of prime age workers. Third, the increase in hours worked and in aggregate employment rates is mainly concentrated among young prime age workers while people near retirement are hardly gaining or even loosing. While remaining active for more years, the reduction in hours worked could be interpreted as an increased demand for part-time employment of older workers. Fourth, postponed retirement boosts labor market participation of older workers and thus squeezes the dependency ratio on both sides by simultaneously raising the workforce and reducing the number of retirees. Pension spending and the PAYG deficit thus decline by almost 1% of GDP in the long-run. These savings could allow for a significant reduction in the wage tax burden in Austria which is perceived to be overly high by international comparison.

Fifth, the total pension reform is far from sufficient to offset the employment losses from projected aging in Austria which is expected to double the old age dependency ratio until 2050. In the absence of pension reform, and taking account of the equilibrium labor market responses, we quantify the long-run losses in effective employment at about 10% when the government passively raises wage taxes to achieve fiscal balance. Implementation of the pension reform would undo only about 40% of these losses. Significant further reform is required to cushion the economic impact of aging. Finally, we must emphasize that computational analysis is always sensitive to assumed parameter values which are often estimated with substantial uncertainty. The greatest sensitivity of our results seems to be in the assumed elasticity of retirement behavior. Different behavioral assumptions regarding the elasticities of job

search and hours worked are affecting not so much the aggregate results but might exacerbate the differential impact on young and old workers.

References

- Altig, D., Auerbach, A. J., Kotlikoff, L. J., Smetters, K. A., & Walliser, J. (2001). Simulating fundamental tax reform in the United States. *American Economic Review*, 91, 574–595.
- Blanchard, O. J. (1985). Debt, deficits and finite horizons. *Journal of Political Economy*, 93, 223–247.
- Blanchard, O. J., & Wolfers, J. (2000). The role of shocks and institutions in the rise of European unemployment: The aggregate evidence. *Economic Journal*, 110, S1–S33.
- Blundell, R. W., & MaCurdy, T. (1999). Labor supply: A review of alternative approaches. In O. Ashenfelter & D. Card (Eds.), *Handbook of labor economics*, Vol. 3A. Amsterdam: Elsevier.
- Boone, J., & Bovenberg, L. (2002). Optimal labour taxation and search. *Journal of Public Economics*, 85, 53–97.
- Börsch-Supan, A. (2000). Incentive effects of social security on labor force participation: Evidence in Germany and across Europe. *Journal of Public Economics*, 78, 25–49.
- Börsch-Supan, A., & Schnabel, R. (2000). Social security and declining labor force participation in Germany. *American Economic Review*, 88, 173–178.
- Bovenberg, L. A. (2003). Financing retirement in the European Union. *International Tax and Public Finance*, 10, 713–734.
- Cahuc, P., & Zylberberg, A. (2004). *Labor economics*. Cambridge: MIT Press.
- Costa, D. (1995). Pensions and retirement: Evidence from union army veterans. *Quarterly Journal of Economics*, 110, 297–319.
- Cremer, H., & Pestieau, P. (2003). The double dividend of postponing retirement. *International Tax and Public Finance*, 10, 419–434.
- Daveri, F., & Tabellini, G. (2000). Unemployment, growth and taxation in industrial countries. *Economic Policy*, 30, 49–104.
- Diamond, P. (2004). Social security. *American Economic Review*, 94, 1–24.
- Diamond, P., & Orszag, P. R. (2005). Saving social security. *Journal of Economic Perspectives*, 19, 11–32.
- Disney, R. (2004). Are contributions to public social security programmes a tax on employment. *Economic Policy*, 39, 267–311.
- European Commission (2003). *Report on the Austrian pension strategy 2002*. Republic of Austria.
- European Commission (2004). *Increasing the employment of older workers and delaying the exit from the labour market*. COM(2004) 146 final.
- European Commission (2006). *Report on the Austrian pension strategy 2005*. Republic of Austria.
- European Commission (2007a). *Adequate and sustainable pensions. Synthesis report 2006*. Directorate General for Employment, Social Affairs, and Equal Opportunities, Unit E.4.
- European Commission (2007b). *Indicators for monitoring the employment guidelines. 2007 compendium*. Directorate General for Employment, Social Affairs, and Equal Opportunities.
- Felderer, B., Koman, R., & Schuh, U. (2006). Investigating the introduction of NDCs in Austria. In R. Holzmann & E. Palmer (Eds.), *Pension reform. Issues and prospects for non-financial defined contribution schemes* (pp. 519–549). Washington: World Bank.
- Feldstein, M. (2005). Rethinking social insurance. *American Economic Review*, 95, 1–24.
- Feldstein, M., & Liebman, J. B. (2002). Social security. In A. J. Auerbach & M. Feldstein (Eds.), *Handbook of public economics* (Vol. 4, pp. 2245–2324). Amsterdam: Elsevier.
- Feldstein, M., & Samwick, A. (1992). Social security rules and marginal tax rates. *National Tax Journal*, 45, 1–22.
- Fenge, R., & Pestieau, P. (2005). *Social security and early retirement*. Cambridge: MIT Press.
- Fisher, W. H., & Keuschnigg, C. (2010). Pension reform and labor market incentives. *Journal of Population Economics*, 23, 769–803.
- Gertler, M. (1999). Government debt and social security in a life-cycle economy. *Carnegie-Rochester Conference Series on Public Policy*, 50, 61–110.
- Grafenhofer, D., Jaag, C., Keuschnigg, C., & Keuschnigg, M. (2006). *Probabilistic aging* (CESifo WP No. 1680).
- Gruber, J., & Wise, D. A. (Eds.) (1999). *Social security and retirement around the world*. Chicago: University of Chicago Press.

- Gruber, J., & Wise, D. A. (Eds.) (2004). *Social security and retirement around the world: Micro-estimation*. Chicago: University of Chicago Press.
- Gruber, J., & Wise, D. A. (2005). *Social security programs and retirement around the world: Fiscal implications* (NBER Working Paper 11290).
- Heijdra, B. J., & Romp, W. E. (2008). A life-cycle overlapping generations model of a small open economy. *Oxford Economic Papers*, 60, 89–122.
- Heijdra, B. J., & Romp, W. E. (2009). Retirement, pensions, and ageing. *Journal of Public Economics*, 93, 586–604.
- Hofer, H., & Koman, R. (2006). Social security and retirement in Austria. *Empirica*, 33, 285–313.
- Holmlund, B. (1998). Unemployment insurance in theory and practice. *Scandinavian Journal of Economics*, 100, 113–141.
- Hosios, A. J. (1990). On the efficiency of matching and related models of search and unemployment. *Review of Economic Studies*, 57, 279–298.
- Immervoll, H., Kleven, H. J., Kreiner, C. T., & Saez, E. (2007). Welfare reform in European countries: A microsimulation analysis. *Economic Journal*, 117, 1–44.
- Jaag, C. (2009). Education, demographics, and the economy. *Journal of Pension Economics and Finance*, 8, 189–223.
- Jaag, C., Keuschnigg, C., & Keuschnigg, M. (2009). *Pension reform, retirement and life-cycle unemployment: Technical appendix*. University of St. Gallen, www.iff.unisg.ch, page Research and Consulting/DP-Public Finance.
- Keuschnigg, C., & Keuschnigg, M. (2004). Aging, labor markets and pension reform in Austria. *Finanz-Archiv*, 60, 359–392.
- Kleven, H. J., & Kreiner, C. T. (2006). The marginal cost of public funds: Hours of work versus labor force participation. *Journal of Public Economics*, 90, 1955–1973.
- Knell, M., Koehler-Toeglhofer, W., & Prammer, D. (2006). *The Austrian pension system—how recent reforms have changed fiscal sustainability and pension benefits*. Austrian National Bank, DP.
- Krueger, A. B., & Meyer, B. D. (2002). Labor supply effects of social insurance. In A. J. Auerbach & M. Feldstein (Eds.), *Handbook of public economics* (Vol. 3, pp. 2327–2392). Amsterdam: Elsevier.
- Layard, R., Nickel, S., & Jackman, R. (1991). *Unemployment*. London: Oxford University Press.
- Lindbeck, A., & Persson, M. (2003). The gains from pension reform. *Journal of Economic Literature*, 41, 74–112.
- Nickel, S. (1997). Unemployment and labor market rigidities: Europe versus North America. *Journal of Economic Perspectives*, 3, 55–74.
- OECD (2005). *Aging and employment policies. Austria*. Paris: OECD.
- Pestieau, P. (2006). *The welfare state in the European Union. Economic and social perspectives*. Oxford: Oxford University Press.
- Saez, E. (2002). Optimal income transfer programs: Intensive versus extensive labor supply responses. *Quarterly Journal of Economics*, 117, 1039–1073.
- Samwick, A. A. (1998). New evidence on pensions, social security, and the timing of retirement. *Journal of Public Economics*, 70, 207–236.
- Scarpetta, S. (1996). Assessing the role of labour market policies and institutional settings on unemployment: A cross-country study. *OECD Economic Studies*, 26, 43–98.
- Spataro, L. (2005). Social security incentives and retirement decisions in Italy: An empirical insight. *Research in Economics*, 59, 223–256.
- Weil, D. N. (2006). *Population aging* (NBER WP 12147).