PENSION REFORM, RETIREMENT AND LIFE-CYCLE UNEMPLOYMENT

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Abstract

The labor market effects of pension reform stem from retirement behavior and from job search and hours worked of prime age workers. This paper investigates the 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 provide some analytical results and use a computational model to demonstrate the economic and welfare impact of recent pension reform in Austria.

JEL Code: D58, D91, H55, J26, J64.

Keywords: pension reform, retirement, job search, life-cycle unemployment.

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1 Introduction

With only few exceptions, industrial countries rely on pay-as-you-go (PAYG) 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 at the same time to keep 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 important distortion concerns the tendency towards early retirement. Although a general shift in preferences may have led people to retire earlier for other reasons, early retirement is importantly induced by the large participation tax rates on continued work as is extensively 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 U.S. The retirement decision is an example of a discrete labor supply response on the extensive margin that can be characterized by participation tax

[1] For 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).

rates in the sense of Saez (2002), Immervoll et al. (2007), Kleven and Kreiner (2006), as well as Fisher and Keuschnigg (2007) 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. It would be misleading, though, to ignore other important repercussions.

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 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). Fenge and Werding (2004) computed those tax rates for Germany. 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. The *net* effect of PAYG contributions thus depends on the size of the implicit tax rate on job search which is similar to the one on current earnings as mentioned before.

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 interaction among them. Based on a small analytical model, we first clarify the key concepts of implicit 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 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 re-

[2] We employ a generalized OLG model in the tradition of Blanchard (1985) but extended with demographic and life-cycle structure, see the Appendix. Recently, Heijdra and Romp (2007, 2008) have developed a stylized, but analytically solvable model of a similar nature for the analysis of aging and pension reform.

cent 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 the main 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 of the Beveridge type by benefits of the Bismarkian type that are linked to past earnings or contributions. This can be understood as bringing several occupational groups such as civil servants who basically 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 the implicit tax is 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

[3] See Knell, Koehler-Toeglhofer and Prammer (2006), Hofer and Koman (2006), and OECD (2005), for an insightful description and discussion of pension reform in Austria. Research in the European Commission provides an international comparison of pension growth and its decomposition into several explanatory factors due to demographic and economic adjustments, see European Commission (2006).

age, this scenario raises the pension level permanently whenever people retire later, and cuts it when they prematurely retire at earlier ages.

The paper proceeds as follows. We first present an analytical core model in section 2 that clarifies important concepts and derives already some basic results. Section 3 shortly describes the structure of the computational model, with more details stated in the appendix. Section 4 shortly reviews recent pension reform in Austria, defines the policy scenarios in numerical terms, and discusses the quantitative results. Section 5 concludes.

2 Labor Market Incentives

2.1 A Simple Model

To clarify basic concepts and derive key insights, we first consider a stylized core model. Workers live for two periods. Labor is the only input into a linear production technology. The labor market for young workers is competitive. They are thus paid a gross wage equal to the marginal product $W = 1$. Agents are fully employed but work a variable number of hours. In the second period, they decide about their preferred retirement date which introduces an extensive margin of aggregate labor supply. People remain active for some time and switch to retirement for the rest of life. Old workers are subject to unemployment risk. When search effort results in a job match, workers and firms bargain over a wage and thereby split the job surplus among them.[4] To keep the model as simple as possible, we abstract from unemployment benefits so that the reservation wage is zero. Bargaining results in a gross wage of $w < 1$.

Life-time utility is assumed linear in consumption and separable in disutility of work related effort. Present and future consumption, C_1 and C_2, are perfect substitutes so that people do not care about the timing but only about the present value of consumption. The interest factor $R = 1 + r$ is equal to one plus a constant rate of time preference:

$$\begin{aligned} V &= [C_1 - \varphi(l)] + \frac{1}{R}[C_2 - x \cdot \zeta(s) - \phi(x)], \\ C_1 &= (1-t)\, l - S, \qquad (1) \\ C_2 &= x \cdot (1-t)\, we + (1-x) \cdot P + RS. \end{aligned}$$

[4]Except for the influence of the pension system, our static search model follows Boone and Bovenberg (2002).

Hours worked, l, result in a utility cost $\varphi(l)$. All types of utility costs are assumed convex increasing. Gross earnings are reduced by pension contributions levied at a proportional rate t. Private savings S augment future consumption by RS. Agents remain active during a part x of the second period and supply one unit of labor. A part e of them is employed, the remaining part $u = 1 - e$ of the unemployed are left without earnings. Conditional on being active, the expected wage is $(1-t)\,we$. Workers are retired during a part $1-x$ of the second period and obtain a pension P per capita. We refer to x as the retirement date.

Second period utility increases with consumption C_2 but is reduced by the disutility from two types of labor market activities. Agents incur a utility cost $\zeta(s)$ from job search with intensity s. This effort cost is incurred only during the active part x, giving total effort cost $x\zeta(s)$. Search effort determines their individual probability $e = sf$ to locate a suitable job. With probability $1-e$, they remain unemployed. This probability depends on individual search effort s and a term f that reflects labor market tightness and is taken as given by individuals. By the law of large numbers with independent risks, the individual probability of finding a job will be equal to the aggregate employment rate. Since the mass of each generation is also assumed to be one, aggregate labor supply of the young is l and of the old xe. Finally, life-time utility is progressively reduced by $\phi(x)$ when the retirement date x increases. The increasing aversion to postpone retirement may be due to deteriorating health and other reasons.[5] As the last line in (1) indicates, postponing retirement means earning labor income and paying contributions over a longer period and consuming pension benefits over a shorter period of time.

Adding production closes the model. The labor market for young workers is assumed competitive. Firms make zero profits and pay a wage equal to exogenous productivity equal to one. In contrast, market frictions lead to some unemployment in the second period. Old workers can be hired only in a matching market. Only a fraction x of them participates in the labor market. Each one searches with intensity s for a job. Hence, the mass of effective job searchers is sx. Firms place v vacancies. A matching function $M(sx, v)$ represents search frictions, implying that a fraction q of vacancies is filled and a fraction f of effective searchers locates a job. These fractions correspond to individual probabilities. When M is linear homogenous and quasiconcave, one can deduce $f'(\theta) > 0 > q'(\theta)$ where $\theta \equiv v/(sx)$ is market tightness equal to the

[5] This way of modeling retirement follows Cremer and Pestieau (2003), for example.

number of open positions per effective job searcher. The probabilities f and q are determined in equilibrium and are taken as given by individual agents.

After a successful hire, a worker adds 1 to the firm's revenues. He gets a wage w which leaves a job rent $1-w$ to the firm. The firm would thus like to hire more workers but can obtain them only with probability q for each vacancy. It must further incur a cost κ per vacancy. When the expected job rent exceeds the cost per vacancy, the firm creates more jobs and posts vacancies. As the market becomes increasingly tight, the hiring probability declines until profits $\pi = [(1-w)\cdot q - \kappa]\cdot v$ get exhausted. The zero profit condition $(1-w)\cdot q(\theta) = \kappa$ determines market tightness and thereby also fixes the probability $f(\theta)$ that the marginal search effort yields a job offer. While f is fixed in market equilibrium, the individual success probability is $e = sf$ when the worker spends total effort s. Hence, the employment rate and, thereby, the unemployment rate $1-sf$ depend on individual incentives which, in turn, reflect the pension system's implicit tax rate τ^S on job search, to be defined below.

The wage determines the firm's job surplus $1-w$. A workers' job surplus net of taxes amounts to $\left(1-\tau^S\right)w$ and determines search incentives. Since the implicit tax rate does not depend on the wage (see next subsection), the wedge $1-\tau^S$ is a constant and plays no role in wage negotiation. The worker's gross surplus is w since, by assumption, unemployment neither yields a replacement income nor utility from leisure. The joint surplus of the match is equal to the marginal product of labor, $w+(1-w)=1$. Given a bargaining power ξ of workers, the firm and worker agree on a wage that maximizes the Nash product $w^{\xi}\cdot(1-w)^{1-\xi}$. Bargaining thus yields a fixed wage that is an average of labor productivity and the worker's fallback position of zero. The worker's job rent before taxes is $w=\xi$ and the firm's rent is $1-w=1-\xi$.

2.2 Implicit Tax Rates

How the pension system affects labor market incentives depends on the specific rules of how one's pension is calculated. A rather general rule that nests a number of alternatives is

$$P = m(x)\left[tlR^p + twex\right] + p_0. \tag{2}$$

As a first case, setting $m=0$ yields a Beveridge type system with a flat pension p_0 that is unrelated to past earnings or contribution payments. The contribution rate t and the flat pension

p_0 must be chosen to equate aggregate revenues and spending to balance the system. Second, a standard Bismarkian type PAYG system with a tax benefit link emerges from setting $p_0 = 0$, $R^p = 1$ and $m(x) = m_0$. The pension is linked to past earnings by the rule $P = m_0 [tl + twex]$. It fails to provide strong incentives to postpone retirement beyond the simple fact that paying contributions over a longer time period accumulates more pension entitlements. There is no actuarial adjustment of the pension size that would reflect the shorter benefit duration. A third case would provide an actuarial adjustment of the conversion factor $m = 1/(1-x)$ such that the increase in pension size appropriately reflects the shorter benefit duration when retirement is postponed. Gruber and Wise (2005) have much emphasized the need for such actuarial adjustment in order to eliminate the large disincentives for continued work. The final reference case is a fully capital funded system with $p_0 = 0$, $R^p = R$ and $m(x) = 1/(1-x)$. Contributions earn the market rate of interest, and pensions are adjusted in an actuarially fair way to take account of the length of the retirement period. Substituting this investment based pension rule $(1-x)P = t[lR + wex]$ into (1) shows that life-time wealth becomes independent of the parameters of the pension system, $C_1 + C_2/R = l + wex/R$. Provided that pension funds earn the same rate of return as private households do, a fully funded system would provide a perfect substitute for private savings. Since it does not change private wealth, it remains fully neutral with respect to labor market incentives.

Substituting the budgets (1) and (2) into the value function yields life-time utility,

$$\begin{aligned} V &= \max_{l,s,x} \; (1-t)\,l - \varphi(l) + V_2/R, \\ V_2 &= x(1-t)\,we + (1-x)\,P - x\zeta(s) - \phi(x), \quad e = s \cdot f, \\ P &= m(x)\,[tlR^p + twex] + p_0. \end{aligned} \tag{3}$$

Life-time utility is maximized by choosing hours worked in the first period and job search as well as a retirement date in the second period. The relevant first order conditions are

$$\begin{aligned} \varphi'(l) &= 1 - \tau^L, \quad \tau^L \equiv t \cdot [1 - (1-x)\,m \cdot R^p/R] < t, \\ \zeta'(s) &= f \cdot \left(1 - \tau^S\right) w, \quad \tau^S \equiv t\,[1 - (1-x)\,m], \\ \phi'(x) &= (1-t)\,we - \zeta - P + (1-x) \cdot dP/dx, \\ dP/dx &= t \cdot \left[mwe + m' \cdot (lR^p + wex)\right]. \end{aligned} \tag{4}$$

Working more hours l in the first period boosts earnings which get taxed with a statutory rate t. However, in recognizing the tax benefit rule the individual knows that higher contributions today 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, $\tau^L \leq t$. Without a tax benefit link ($m = 0$), contributions are fully perceived as a tax, $\tau^L = t$. At the other extreme end, the investment based system not only pays interest on contributions ($R^p = R$) but also adjusts in an actuarially fair way the conversion factor $m = 1/(1-x)$ to correctly reflect the length of the retirement period. As a result, the implicit tax on current earnings becomes zero, $\tau^L = 0$. This is just another statement of the fact that the investment based system does not affect life-time wealth.

Consider next the incentives for job search of older workers near retirement. Marginally increasing search effort raises the probability sf of finding a job by f. The worker compares the alternatives of accepting a job versus remaining unemployed. In case a job is found, he can get a disposable wage $(1-t)\,w$ relative to no income during unemployment. However, the contribution payments add to pension entitlements at rate m 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 implicit tax on job search is only $\tau^S < t$. Again, the implicit tax is much reduced when the conversion factor is actuarially adjusted and set at $m = 1/(1-x)$ to reflect the length of the retirement period. Since there is no interest within the second period, actuarial adjustment alone would suffice to fully eliminate the implicit tax τ^S. Comparing the two implicit taxes shows that $\tau^L > \tau^S$ under a PAYG system that does not pay interest on contributions ($R^p = 1$). This statement explains the finding in empirical calculations of implicit tax rates which always turn out higher for younger workers and decline as the date of retirement approaches.[6]

The simple definitions of implicit tax rates on hours worked and job search yield another important insight. Policies that raise the retirement age x *without* adjusting the conversion factor m 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 inflates the implicit taxes τ^L and τ^S on work effort and job search when m is fixed. When contributions are paid over a longer time horizon and pensions are

[6] See Feldstein and Samwick (1992), Disney (2004) and Fenge and Werding (2004), among others.

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 retirement date is optimally chosen when the marginal utility 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, $(1-t)\,we-\zeta$. The opportunity cost is the foregone pension P that an individual could have consumed during that time instant. The opportunity cost, however, is reduced by $(1-x)\cdot dP/dx$ if pension payments over the remaining retirement time were increased. In a PAYG system with a tax benefit link, pensions are increased because the extra contribution payments twe raise the assessment base of the pension calculation and result in a pension increase of $m\cdot twe$. However, fiscal sustainability improves because people will collect pensions over a shorter time span when they retire later. Individuals can be compensated for those savings by an increase in the conversion factor m' which raises their pension. In both ways, a PAYG system with a tax benefit link can reduce the opportunity cost of continued work and thereby contain the tendency towards early retirement. We can now show that a PAYG system that adjusts the conversion factor in an actuarially fair way, i.e. setting it at $m=1/(1-x)$ which yields $(1-x)\,m'=m$, is entirely neutral with respect to the retirement decision. The pension rule $P=mt\,(lR^p+wex)$ therefore results in $(1-x)\,dP/dx=twe+P$. The increase in pension benefits during the remaining retirement period exactly compensates the individual for all savings to the pension system that result from postponed retirement. The individual optimality condition would be the same as without a pension system, $\beta\phi'(x)=we-\zeta$.

The same statements can be phrased in terms of an implicit tax on continued work in the sense of Gruber and Wise. This effective tax corresponds to the definition of participation tax rates in the analysis of discrete labor supply responses as in Immervoll et al. (2007), Kleven and Kreiner (2006) and Saez (2002). To see this, write the retirement condition as

$$\phi'(x)=\left(1-\tau^R\right)we-\zeta,\quad \tau^R\equiv\left[\tau we+P-(1-x)\,dP/dx\right]/(we)\,, \tag{5}$$

where τ^R collects all changes in the tax benefit system resulting from a marginal increase in the retirement date. As was noted before, the contribution rate would be fully perceived as a tax if pensions were flat in the absence of a tax benefit link ($m=0$). With $dP/dx=0$ in this case, the implicit tax $\tau^R=t+P/we$ would amount to the sum of the contribution and the replacement rate! It would thus be very high as the literature mentioned above has pointed out. A PAYG system with a full tax benefit link and an actuarial adjustment of the conversion factor, giving $(1-x)\,dP/dx = twe + P$ as noted above, or a fully capital funded system with individual savings accounts, could reduce the implicit tax rate to zero.

3 An Overlapping Generations Model

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. 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 must be supported by 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. The Appendix shortly describes the key parts of the computational model.

In the model, households search for jobs, supply variable hours worked if employed, and endogenously choose retirement. 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 mortality risks that increase with age, reflecting usual demographic patterns. Capital accumulation results from intertemporal investment decisions of domestically owned firms. In contrast to a competitive output market, the labor market is subject to matching frictions leading to involuntary unemployment. Compared to Section 2, the calibrated model includes a rich pattern of life-cycle earnings, savings and consumption. It includes the separate budgets of general government, unemployment insurance and the earnings linked pension system. The Appendix describes how pensions are linked to past earnings and thereby determine the implicit tax rates on labor market activities of prime age workers. Taxes and pensions also imply a participation tax (implicit retirement tax) of more senior workers. Tables 1 and 2 summarize.

Table 1: Model Parameters

Production		
r	0.050	annual real interest rate
g	0.018	growth rate labor productivity
δ	0.100	depreciation rate of capital
σ^K	0.800	elasticity of capital labor substitution
Households		
σ	0.350	intertemporal elasticity of substitution
ν_l	0.200	intensive labor supply elasticity
ν_s	0.200	job search elasticity
ϵ_u	1.803	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 *)
N^R/N^W	0.331	retiree worker ratio
Welfare System		
ρ^u	0.550	replacement rate unemployment benefits
ρ^P	0.732	*net* replacement rate 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
$\mu'(x)$	0.032	sensitivity pension discount/supplement
τ^R	0.736	implicit participation/retirement tax
P^{tot}	12.825	gdp share pension expenditure
Z^P	2.561	gdp share pension deficit

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. *) Retirement date corresponds to the share of active workers in the semi-retire d group.

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 and Carlstrom (1999) and Altig et al. (2001) for a discussion of other more standard parameters. The wage elasticity of hours worked refers to intensive labor supply in (A.5) and is set at a low value $v_l = .2$, reflecting the empirical consensus reviewed in Immervoll et al. (2007) and Blundell and MaCurdy (1999). A one percent wage increase thus leads to a 0.2 percent 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 $\nu_s = \varphi'_S/(s\varphi''_S) = .2$ 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 Boersch-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: 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 *)	6	7	8
population share	n	0.191	0.189	0.181	0.163	0.139	0.097	0.039	0.002
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	-0.008	-0.102	-	-	-
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	$\bar{a}$	9.215	11.732	12.285	11.433	10.678	9.025	8.649	8.448
marg.prop.cons.	mpc	3.703	4.986	6.039	7.322	8.740	11.569	12.624	13.069

Legend: mpc marginal propensity to consume out of life-time wealth, $n^a = N^a/N$ population shares. *) The participation rate in the semi-retired group is 20 p.c., the unemployment rate refers to the active part only.

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. 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 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.

4 Pension Reform in Austria

4.1 Recent Policy Initiatives

Pension reform in Austria is particularly interesting for several reasons.[7] The Austrian pension system was subject to a large imbalance 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, 2003b). 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 December 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 (see Table 1). Clearly, recent pension reform in Austria was among the more courageous and far reaching in Europe, resembling much of what we have analyzed in the preceding section. Furthermore, early retirement and low labor market participation of older workers were particularly widespread phenomena in 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. Ac-

[7] Pension reform in Austria is discussed, among others, in OECD (2005), European Commission (2004 and 2006a,b), Knell et al. (2006), Felderer et al. (2006) and Hofer and Koman (2006).

cording 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 percent 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 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 (40-50 years old) 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 their older colleagues 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, 2006b). 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. Contribution rates were fully harmonized to a uniform statutory rate of 22.8%. The personal contributions of farmers and self-employed are subsidized with co-payments financed out of general tax.

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 first consider the impact of a general change in retirement preferences. We scale down the shift parameter in the retirement cost function to an extent that the average retirement age increases by roughly 2 years in long-run equilibrium. This would reverse about two thirds of the decline in average retirement age that occurred in Austria since the early 70s. In subsection 4.3, 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 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 percent 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 percent 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%. 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. We consider the consequences of such a further step to gauge the importance of retirement incentives.

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 any deficits or surpluses are covered out of general tax revenue by an adjustment of the wage tax rate.

4.2 Impact of Retirement Trend

Table 3 reports the long-run impact of a shift in preferences leading to delayed retirement of about two years. Obviously, the direct consequence is an increase in aggregate labor supply on the extensive margin. The expansion of the labor force by 3.7%, without any further reaction, raises the worker retiree ratio and thereby more than halves the deficit of the PAYG system. Even though later retirement leads to higher per capita pensions, the reduction in the number of retirees dominates.[8] The lower deficit together with a growing wage tax base creates room for a substantial tax cut. Lower tax rates stimulate hours worked and job search activities of prime age workers which magnifies the aggregate labor supply response, leading to a total increase of 5.5%. Labor income tax rates are reduced by a factor of .89 for all age groups. Tax rates on prime age workers are down by 2.2 to 3.3 percentage points while the tax load on pensioners falls between 1.7 to 3 points. People are thus not only working longer on average, but also search more intensively for jobs if they are unemployed. The aggregate unemployment rate therefore shrinks by more than half a point. In an open economy with a fixed real interest rate, investment and output all expand in line with aggregate labor supply by the same relative amount, giving a long-run level effect on GDP of 5.5%.

In an earnings based system, higher earnings at younger ages increase benefits during retirement. However, when people retire later, pension rules lead to even higher per capita benefits to compensate for paying contributions longer and claiming benefits over a shorter period. The net pension replacement rate substantially increases from 73 to 78% of the last net of tax salary. Of course, the higher pension is consumed over a shorter period when retirement is postponed.

[8] The participation tax rate τ^R measures not only the net fiscal burden to the individual of a marginal increase in the retirement date, but also the net fiscal gain to the public sector. A high participation tax rate thus means that the fiscal balance strongly improves when retirement occurs later.

At the margin, however, the opportunity cost of retirement is increased by a higher replacement rate which leads to a slightly higher implicit retirement tax in the sense of Gruber and Wise.

Table 3: Retirement Trend, Long-Run

Scenarios	ISS		Retire
Absolute Values:			
Wage Tax, scaling	1.000	ϕ	0.885
Contribution Rate	0.170	t^s	0.170
Implicit Pension Tax *)	0.135	$\hat{t}_3^s$	0.137
Implicit Retirement Tax	0.736	τ^R	0.754
Retirement Date	0.200	x	0.400
Pension Repl. Rate	0.732	ρ^P	0.780
Unemployment Rate	0.065	$\bar{u}$	0.059
Pension Def., % GDP	2.561	Z^P	0.929
Pension Spend., % GDP	12.825	P^{tot}	11.176
Percentage Changes:			
Labor Force		N^W	3.689
Labor Demand		L^D	5.471
Gross.Dom.Prod., GDP		F	5.471

Legend: *) Implicit tax on group 3 (41-50years).

A final interesting result refers to the employment prospects of younger and older workers. Tables 1 and 2 show that older workers near retirement face an unemployment rate of 11.6% which is way above the average rate of 6.5% in Austria. This above average unemployment rate much erodes the expected wage income obtained from active work and, in our model, represents some incentive to retire early. The question is whether postponed retirement and, thus, the associated increase in labor market participation, necessarily leads to an even higher unemployment rate among older workers. Our model says no. Conditional on labor market participation, older workers face much improved incentives for job search due to substantially reduced wage taxation which contributes to a lower unemployment rate in this age group as well. However, the reduction in the unemployment rate among older workers is much smaller than for younger age groups. In contrast, the unemployment rate among younger workers falls by roughly 0.8 percentage points.

4.3 Economic Impact of Recent Reform

We now investigate the effects of Austrian pension reform as discussed in section 4.1. The policy scenarios in the last four columns of Table 4 must be understood cumulatively, one on top of the other. Section 4.3.6 below discusses the generational and aggregate welfare effects.

4.3.1 Lengthening Assessment Period

We first turn to the extension of the assessment period to entire life-time earnings, giving a uniform value of the tax benefit link $m^a = m$ for all groups, instead of the initial pattern shown in Table 2. To avoid an unintended change in the generosity of pensions, 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 tax benefit coefficient is raised from zero to 0.017 for the youngest age 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. In our simulations, the policy initiative cuts the implicit tax rate from the youngest age group of people in their twenties by 3 percentage points, from 17 to about 14%. At the same time, the reduction of the accrual rate imposes a larger implicit tax on older workers in their best 15 years of earnings. For example, the active part of age group 5, corresponding to people in their early sixties, has actually received an implicit subsidy on their contributions equal to 10.2% of earnings, reflecting the deficit of the system and the remarkable generosity of pensions. The subsidy is turned into an effective tax of 3.5% as a result of the reduction in the tax benefit coefficient. The effective subsidy to the fourth age group, the 50 to 60 year olds, is similarly turned into an effective tax of 8.3%. Consequently, the labor market activity of these groups is discouraged. This part of the Austrian reform package should thus have not so much encouraged work incentives on average, but rather incentives of younger workers at the expense of older ones.

Table 4: Parametric Pension Reform, Long-Run

Scenarios	ISS		Length	Harm	Index	Fair
Absolute Values:						
Wage Tax, scaling	1.000	ϕ	1.004	0.987	0.976	0.940
Implicit Pension Tax i)	0.135	$\hat{t}_3^s$	0.113	0.105	0.106	0.107
Implicit Retirement Tax	0.736	τ^R	0.756	0.743	0.744	0.709
Retirement Date	0.200	x	0.196	0.216	0.214	0.288
Pension Repl. Ratio	0.732	ρ^P	0.765	0.772	0.771	0.795
Unemployment Rate, %	6.467	$\bar{u}$	6.469	6.334	6.285	6.116
Pension Def., % GDP	2.561	Z^P	2.554	2.374	2.152	1.663
Pension Spend., % GDP	12.825	P^{tot}	12.811	12.635	12.411	11.916
Net For. Ass., % GDP	-19.500	D^F	-17.155	-21.290	-15.962	-29.604
Percentage Changes:						
Labor Force		N^W	-0.071	0.288	0.260	1.632
Labor Demand		L^D	-0.296	0.645	0.717	2.669
Gross.Dom.Prod., GDP		F	-0.296	0.645	0.717	2.669
Aggr. Consumption		C	-0.254	0.662	1.001	2.628
Aggr. Assets		A	0.351	0.296	1.353	0.665
Welfare changes, % GDP						
Present Generations		EV^O	-0.081	0.179	0.096	0.792
Future Generations		EV^Y	-0.029	0.121	0.147	0.471
Aggregate Gains		EV	-0.110	0.300	0.242	1.263

Legend: i) Implicit tax on age group 3 (41-50years); Scenarios: 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.

The changes in the implicit tax component of PAYG contributions is reflected in the labor supply response documented in Figure 1. While Figure 1 shows the cumulative impact of the complete reform, the life-cycle pattern is clearly dominated by this first scenario. In our model, hours worked of active generations depend on the real wage net of *effective* tax rates. The Figure illustrates how the lengthening of the calculation period reduces effective taxes and thus stimulates hours 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 30s, and -3.6% for the still active workers in their 60s.

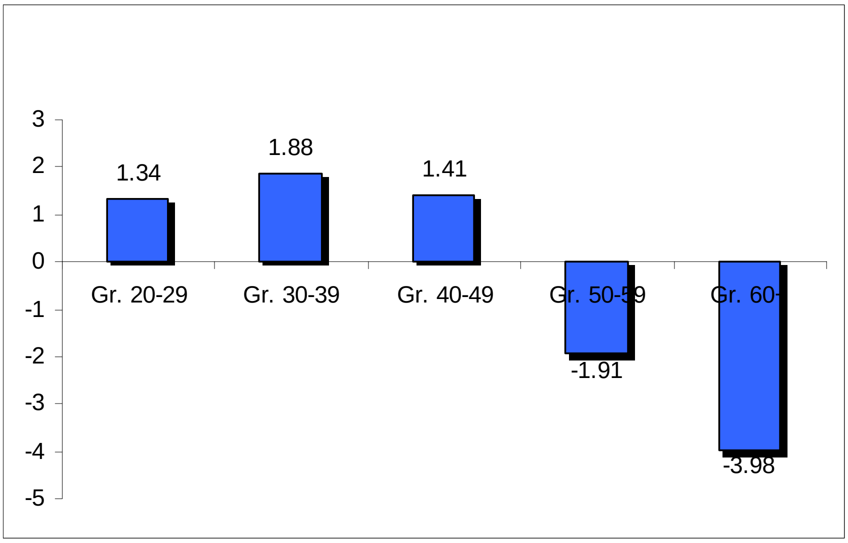

Fig. 1: Life-Cycle Labor Supply, Percent Changes

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 count for future pensions. 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 4, the rate of unemployment among the 30-40 years old shrinks by -0.14% while it increases for workers in their 50s and 60s by +.32% in both groups.

The unemployment rates in Figure 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 4 remains unchanged.

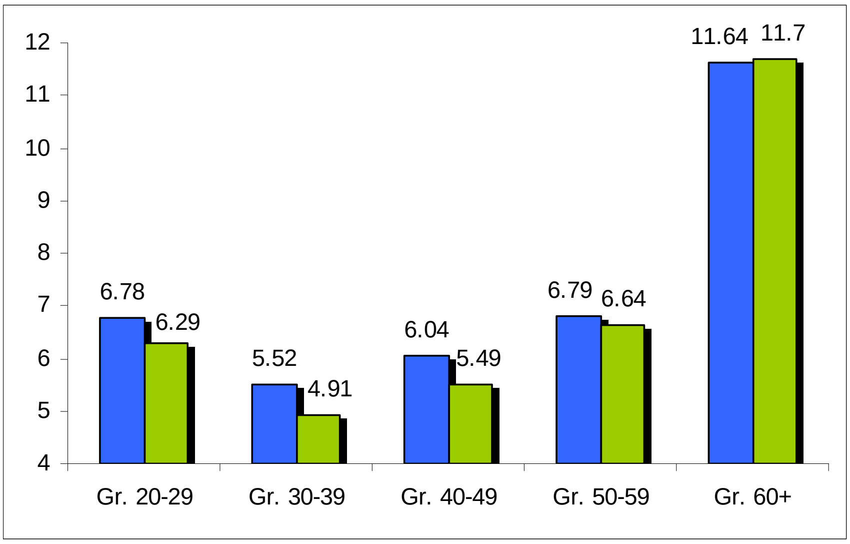

Fig. 2: Life-Cycle Unemployment, Absolute

4.3.2 Strengthening Tax Benefit Link

An important element of Austrian pension reform was to subject certain groups of the population such as civil servants and farmers who have largely received flat pensions, to the earnings linked 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 pension at the start of retirement when individual behavior is kept constant. 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 4 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 implicit 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_p' in the implicit retirement tax in A.5). 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 (term μ_w' times wage base in A.5).

The results in Table 4 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 .36 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 rather than a cut in per capita pensions, 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 beyond the mere participation effect and boost GDP by 0.6%.

4.3.3 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 onwards, 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 4 reports the long-run results from eliminating wage indexation of pensions. Labor market incentives on 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 on 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 GDP effect from .65 to .72%. The outcome, however, hinges on the system already exhibiting some degree of actuarial fairness in the initial state. If late retirement were not rewarded with pension supplements, then a devaluation of pension claims could have no effect on the retirement decision. This would avoid the early retirement effect and result in a somewhat larger GDP gain.

Another interesting point is the significant increase in life-cycle savings. The transition from wage to price indexation leads to a relative 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 1.35% higher in the long-run. In a small open economy, the interest rate and thus capital intensity are internationally determined and are 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 almost 20% is reduced by almost 4 percentage points of GDP.

4.3.4 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 4 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.

Introducing more actuarial fairness has two immediate effects. It substantially reduces the participation tax rate from 74 to 71%. When people on average retire later, they collect larger benefits which significantly raises the pension replacement rate. Table 4 shows that the policy initiative, by inducing late retirement, boosts the participation rate in 5, corresponding to the 60 to 70 years old, from 21 to 29%. Higher old age participation expands the labor force by about 1.8%, 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 which amounts to -4.1%. The large decline in the dependency ratio obviously is a key factor to restore financial 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 12.4 to 11.9% of GDP. These savings shave off half a percentage point of GDP from the PAYG deficit. The corresponding 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 ends up being slightly higher, but the effect on the total effective tax rates on work and job search are dwarfed by the cut in wage taxes. The lower wage tax stimulates significantly 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, and the total effect on aggregate labor supply and GDP rises from .7 to 2.7%.

Table 4 also points to important repercussions of pension reform for 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 growth 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.

To sum up, 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.

4.3.5 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

5 shows how the long-run impact of policy 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 4. 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 gains is reduced from 2.7 to 2.3%. Interestingly, the halving of the search elasticity has much less impact. To gauge the size of this parameter value, we compute in a separate exercise that an increase in the replacement ratio of unemployment benefits equal to 10% would raise the unemployment rate 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 effect of 2.54 instead of 2.7% in the long-run.

Table 5: Sensitivity Analysis

Base Case Parameter Values $v_l = .2$, $v_s = .2$ and $\epsilon_r = .8$	ISS		Base Case	Hours $v_l = 0$	Search $v_s = .1$	Retire $\epsilon_r = .4$
Absolute Values:						
Wage Tax, scaling	1.000	ϕ	0.940	0.944	0.942	0.962
Retirement Date	0.200	x	0.288	0.292	0.288	0.243
Unemployment Rate, Gr.1, %	6.780	u^1	6.289	6.312	6.421	6.428
Unemployment Rate, av., %	6.467	$\bar{u}$	6.116	6.160	6.219	6.220
Pension Def., % GDP	2.561	Z^P	1.663	1.700	1.676	1.968
Pension Spend., % GDP	12.825	P^{tot}	11.916	11.948	11.930	12.225
Net For. Ass., % GDP	-19.500	D^F	-29.604	-30.772	-29.183	-21.417
Percentage Changes:						
Hours Worked, Gr.1		l^1	1.338	0.001	1.333	1.229
Hours Worked, av.		$\bar{l}$	0.515	0.000	0.503	0.436
Labor Force		N^W	1.632	1.698	1.622	0.796
Gross.Dom.Prod., GDP		F	2.669	2.336	2.540	1.476
Aggr. Consumption		C	2.628	2.163	2.513	1.629

Legend: (Base) Base case results, (Hours) Fixed hours of work, (Search) Low job search intensity, (Retire) Low retirement elasticity.

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 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 much 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.

4.3.6 Generational Welfare Effects

We compute the intergenerational and aggregate welfare effects of policy reform in terms of equivalent variations of life-time wealth. Since we analytically aggregate individual agents into different life-cycle groups, we can state the generational welfare effects per capita of eight different preexisting age groups and of all new generations born at dates after the policy shock, as is shown in Figure 3. To obtain the aggregate welfare effect at the date of the policy change, we first compute for each scenario the complete equilibrium time paths, starting from historical conditions and ending up with long-run equilibrium values. We then add the equivalent variations of all presently living generations and convert this wealth measure into a permanent income stream of equal present value which can be compared to other flows. We thus obtain in Table 4 the welfare change EV^O of present generations, expressed in percent of GDP. To obtain the welfare change EV^Y of future generations, we add the discounted equivalent variations of *new* agents born in the period following the policy shock or later, and appropriately weigh them by their population weights at birth. To express the welfare change in percent of GDP as in Table 4, we again convert the resulting amount of wealth into permanent income with equal present value. Adding up the two numbers gives the aggregate welfare change of present and future generations. Note that the numbers plotted in Figure 3 are expressed per capita and in percent of life-time wealth while the numbers in Table 4 are aggregate values in percent of GDP.

There are several reasons for welfare changes in our model with a frictional labor market, but perfectly competitive output and capital markets. To interpret the welfare results, we must also keep in mind our focus on labor income taxes and the pension system while other tax revenue is raised lump-sum. As a rough guideline, policies will yield welfare gains if they succeed to stimulate hours worked, job search, and old age participation (late retirement) since they are suppressed by effective tax wedges on these behavioral margins. Of course, labor market activities are most directly enhanced by reducing the respective labor tax wedges. Furthermore, since the bargaining power of workers is assumed to be larger then the matching elasticity of job search, equilibrium unemployment is inefficiently high. Policies thus yield first order welfare gains if they succeed to cut back involuntary unemployment.

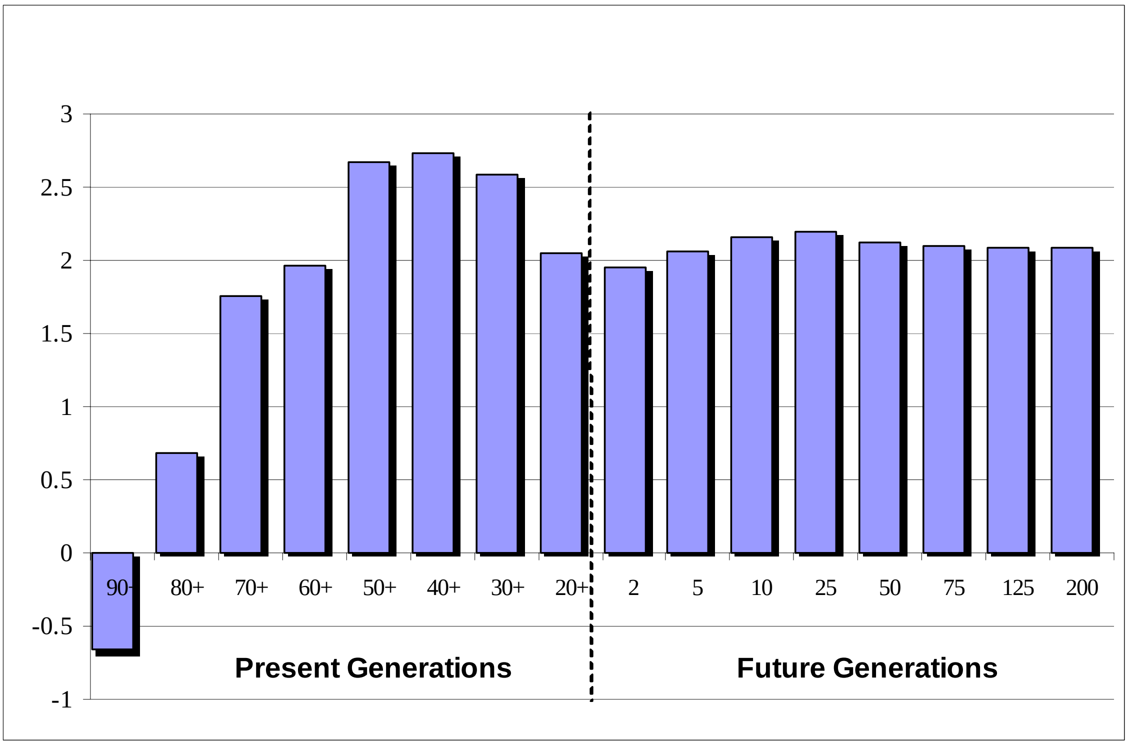

Fig. 3: Generational Welfare Changes

The aggregate welfare results in Table 4 show that the gains to present and future generations are largely balanced. Given the anticipated problems with fiscal sustainability, it was imperative to reform the Austrian pension system in a way that would not make it more generous. We translated this requirement into our policy scenarios such that pensions per capita remained constant for given behavior, and could increase only as a result of induced behavioral changes. Table 4 shows that the lengthening of the calculation period mainly shifts labor market incentives from old to young workers without a systematic *net* effect. The net welfare effect is rather negligible and even slightly negative, reflecting the small but negative impact on employment. Strengthening the tax benefit link, in contrast, promises moderate welfare gains. The first two elements of reform, extension of the calculation period and system harmonization, yield welfare gains that are reasonably balanced across present and future generations. The cumulative welfare gain of the present population is equivalent to a permanent income stream of 0.18% of GDP while the corresponding gain to future generations is somewhat smaller and amounts to 0.12%. Moving from wage to price indexation without compensating measures is a strategy to restore sustainability by shifting the burden on retirees whose pensions will increasingly fall behind wage earnings. While the replacement rate at retirement date should not be too different, it increasingly declines over the remaining life-time. Adding this measure therefore shifts the welfare gains in Table 4 away from present generations to future ones.[9] Finally, introducing more actuarial fairness reverses this intergenerational redistribution so that the total reform again benefits current generations relatively more than new generations arriving after the policy shock. The aggregate welfare gain of the total reform amounts to 1.3% of GDP.

Figure 3 gives a more detailed account of intergenerational redistribution. The bars represent the equivalent variation of a given population group in percent of life-time wealth and per capita. The bars to the left of the vertical line show the gains per capita of the eight age groups that coexist at the date of the policy shock.[10] The bars to the right list the gains per capita of future generations that are born at the dates indicated on the axis. Due to slow capital accumulation along with continuing wage increases, the welfare gains of future generations still grow beyond the per capita gains of the youngest age group living at the date of the policy shock. Since intertemporal prices don't change in an open economy, the welfare gains of presently living

[9] This result most likely overstates the welfare losses to current generations since we have not yet found a way to model grandfathering schemes that would protect the (net of tax) pension incomes of current retirees. Actual pension reform includes prolonged transitional periods to phase in the changes and allow current generations to continue under the old rules. While limiting the losses to old generations, such phasing in would much delay the efficiency gains of reform.

[10] Taking these gains in absolute terms, rather than in percent of life-time wealth, multiplying by the size of each group, adding up, converting into an annuity stream, and expressing this stream in percent of GDP gives an aggregate welfare gain of 0.79% of GDP as listed in Table 4. Multiplying the equivalent variations corresponding to the bars on the right with the size of new cohorts arriving at dates after the policy shock, discounting them back to the present, adding up and converting into a permanent income stream yields a gain of 0.47% of GDP.

generations are felt in a change in wealth over the remaining life-time that comes from two sources. First, the induced investment boom leads to an immediate rise in share prices and to windfall gains in the value of the capital stock. All existing age groups share in these windfall gains in proportion to their share in overall financial assets. Since age asset profiles are hump-shaped, windfall gains are most important for age groups 3 to 4 , corresponding to people in their forties and fifties, and least important for the youngest and oldest parts of the population. The second source is the change in human wealth, consisting of discounted incomes from net labor earnings, pensions as well as other public transfers, corrected for the utility costs of generating these earnings. The earlier analysis found that the positive effects of pension reform in terms of hours worked and unemployment, are mostly with younger workers while workers near retirement face actually a substantial decline in net earnings due to shorter working time and somewhat higher unemployment. For this reason, the gains of the mixed age group are already smaller than those of prime age workers. Also, the mixed group corresponding to people in their sixties benefits from higher pensions only to the extent that they spend their time in retirement. Consequently, the rise in per capita pensions weigh much less than for full time retirees in the following age group.

The rapid decline in welfare gains of still older age groups is due to the declining importance of windfall gains on financial asset holdings and to the lagging pension growth due to the move to price indexation. The last group has basically no assets left, and is hit the worst from price indexation.[11] Since this group corresponding to people in their nineties make up only 0.2% of the entire population (see Table 2), this welfare loss per capita can hardly be of any importance for aggregate results. Our analysis thus promises significant aggregate welfare gains, equal to almost 1.3% of GDP as our central estimate, and implies almost a Pareto-improvement. It should not be impossible to make the reform a true gain for virtually all population groups by a slow phasing in of the move to price indexation in order to protect the currently old generations. Note finally that the aggregate welfare gain is markedly smaller than the long-run increase of consumption or GDP as reported in Table 4. Not only does it take account of the additional effort costs and foregone leisure to generate larger wage earnings and consumption, it also appropriately reflects the slow transition with smaller short-run gains.

[11] As mentioned before, the loss to the oldest age group may be due to our inability in accounting for grandfathering rules.

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 by 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 reform promises significant aggregate welfare gains equivalent to about 1.3% of GDP annually. This calculation takes account of the slow transition and the opportunity costs of leisure in generating higher wage earnings. The main sources come from the introduction of larger pension supplements and discounts for increased actuarial fairness, and the harmonization of the system. Harmonization subjects a larger share of the population to the earnings linked pension rules and reduces the share that receives flat pensions unrelated to past earnings. Sixth, the greatest sensitivity of our results lies 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. Finally, we point out that the aggregate welfare results might be overstated to some extent by our inability so far to take account of grandfathering rules that are designed to slowly phase in the reforms. Slow phasing in implies that new rules would apply only to future generations while a large part of present generations could continue under the old rules. We conjecture that slow phasing in would delay the efficiency gains of the reform and slow down the transition, leading to smaller short-run gains that will be felt in a lower total welfare gain aggregated over all generations. However, these grandfathering rules will also protect the old generations from the welfare losses that we have recorded in our simulations, and might possibly make the reform a Pareto improvement, although with smaller gains to transitional generations.

Appendix: The Simulation Model

This appendix highlights those parts of the model which facilitate a more precise interpretation of the simulation results. Jaag et al. (2007) provide a complete documentation. The model is based on the 'probabilistic aging' concept introduced by Grafenhofer et al. (2006). It is a generalization of Gertler (1999) who first introduced a simple life-cycle structure into the 'perpetual youth' OLG model of Blanchard (1995) by allowing for a stochastic transition from work to retirement. Our model distinguishes not two, but eight different groups of workers and retirees and therefore yields a much closer approximation of the life-cycle. The mortality and life-cycle transition rates for each group together determine the demographic structure. Agents are symmetric within each group and heterogeneous across groups. In particular, they differ in the length of time they spend in a given age state. Each age group is analytically aggregated so that the aggregate economy can be parsimoniously represented with a relatively small number of state variables. In calibrating the model, an age group is assigned the average characteristics of a group of cohorts as shown in Table 2. The period length of the model is a calender year, allowing for realistic short and long-run dynamics.

We consider here only the decision of the 'mixed group' of people in their 60s which consists of workers and retirees. We approximate endogenous retirement by assuming that agents in the mixed group are, in any period, working a fraction x of their time endowment and spend a fraction $1-x$ in retirement. Retiring later raises the share of work income and correspondingly reduces the share of pensions in total income. Younger groups exclusively receive wage income ($x=1$) while older groups are fully retired ($x=0$) and earn pensions only. Total pension income $P+p_0$ is taxed at rate t^p and consists of an earnings linked part P and a flat basic pension p_0. Workers are endowed with θ efficiency units of labor, earning a wage w per unit or w^n net of wage taxes and social security contributions. Working l hours, agents earn $lw^n\theta$ when employed with probability $1-u$ ($=e$ in section 2). When unemployed with probability u ($=1-e$ in section 2), they get unemployment benefits $\left(b^U lw^n+b_0\right)\theta$ which are partly indexed to net wages (giving a fraction b^U of the 'last' net wage income) and partly constant in real terms. We assume that a fraction $1-\varepsilon$ of workers finds a job instantaneously, while ε of them must search in a matching market. They locate a job with probability sf where s is search effort and f reflects market tightness. The life-cycle specific unemployment rate consists of the unsuccessful job searchers as a share of the active work force in a given age group. Members of the mixed group thus obtain an average income[12]

$$\begin{aligned}
\bar{y} &= x\cdot y+(1-x)\cdot(1-t^p)(P+p_0),\\
y &= (1-u)\cdot lw^n\theta+u\cdot\left(b^U lw^n+b_0\right)\theta,\\
w^n &= (1-t^w-t^s)\,w,\quad u=(1-sf)\,\varepsilon.
\end{aligned}\tag{A.1}$$

Given that active wage income is larger than net pension income, $y>(1-t^p)(P+p_0)$, agents can increase their average income by working a larger part x in their mixed age period and spending a smaller part in retirement. This income gain from postponing retirement is offset by a progressively increasing disutility cost $\varphi_R(x)$.

Agents save and accumulate assets A to smooth consumption C and accumulate pension entitlements P under the rules of an earnings linked pension system:

$$\begin{aligned}
\gamma GA_{t+1} &= R_{t+1}\left[A+\bar{y}+z-C\right],\\
GP_{t+1} &= \mu_w(x)\cdot m\cdot\left(1-u+b^1u\right)wl\theta+\mu_p(x)\cdot P.
\end{aligned}\tag{A.2}$$

Agents earn average work related income $\bar{y}$ and receive government transfers z. Further, $G>1$ is a growth factor reflecting labor productivity growth, R is one plus the interest rate, and γ

[12] The average income at date t of a person belonging to age group a with life-cycle history α would be $\bar{y}^a_{\alpha,t}$. To concentrate on essential insights, we suppress indices and write $\bar{y}$. See Jaag et al. (2007) for a precise notation.

is the survival rate, equal to one minus the mortality rate, and reflects the existence of reverse life-insurance as in Blanchard (1985). Pension entitlements P_{t+1} next period are equal to today's stock plus some additions. They grow with new entitlements in the amount of $\mu_w \cdot m$ times current wage income. In Austria, a part b^1 of the base for unemployment benefits is also included in the pension assessment base.

Retirement incentives are controlled by the functions μ_w and μ_p. Positive derivatives serve to compensate the agent with pension supplements for longer contribution payments ($\mu_w' m$ times wage base) and foregone pension benefits ($\mu_p' P$). The specifications $\mu_w(x) = \mu^1 \left(x - x^R\right) + \mu_w^1$ and $\mu_p(x) = \mu^1 \left(x - x^R\right) + \mu_p^1$ capture a range of possible cases. Retiring at the "statutory retirement age", $x = x^R$, yields a regular pension. The slope μ^1 rewards late retirement with extra benefits and punishes early retirement with pension discounts. Prime age workers ($x = 1$) accumulate pension claims as in (A.2) except that $\mu_w = \mu_p = 1$.

In any period, agents make a sequence of decisions. They (i) choose labor market participation ('retirement date' x), (ii) search for employment with intensity s if a job is not immediately available, (iii) choose hours of work l, (iv) bargain over a wage w when a job is found, and (v) choose consumption and savings. Preferences are given by recursive CES utility. The intertemporal elasticity of substitution is $\sigma = 1/(1-\rho)$ and β is a subjective discount factor. The agent's optimization problem is[13]

$$\begin{aligned} V_t^a &= \max \left[\left(C - x\bar{\varphi}\theta - \varphi_R(x)\right)^\rho + \gamma\beta \left(G\bar{V}_{t+1}^a\right)^\rho \right]^{1/\rho}, \\ \bar{V}^a &\equiv \omega^a V^a + (1-\omega^a) V^{a+1}, \\ \bar{\varphi} &= \varepsilon\varphi_S(s) + (1-u)\varphi_L(l). \end{aligned} \tag{A.3}$$

In any period t, agents stay in the current age state with probability ω^a but switch to the next state of age with probability $1-\omega^a$, giving rise to an expected utility $\bar{V}_{t+1}^a$. The assumption of separable effort costs, $\varphi_R(x)$ of postponing retirement, $\varphi_S(s)$ of job search, and $\varphi_L(l)$ of hours worked, excludes income effects on work related effort and greatly facilitates the analysis.

At each date, agents consume a fraction of life-time resources. Much like in standard life-cycle models, the marginal propensity to consume out of total wealth increases when agents move to the next age state and the end of life becomes more probable. To illustrate labor market

[13] To avoid cluttered notation, we index age groups only when absolutely necessary.

behavior, it is useful to define an implicit pension tax $\hat{t}^s$ and subsidy s^u to unemployment,

$$\hat{t}^s \equiv t^s - \frac{\mu_w(x)}{x} m\gamma \frac{\tilde{\lambda}_{t+1}}{R_{t+1}}, \quad s^u \equiv (1 - t^w - t^s) b^U + \frac{\mu_w(x)}{x} b^1 m\gamma \frac{\tilde{\lambda}_{t+1}}{R_{t+1}}, \tag{A.4}$$

where $\tilde{\lambda}$ is the present value of future benefits per unit of accumulated entitlement P. For prime age workers, $\mu_w/x = 1$. This term enters only in the semi-retired group to capture retirement incentives which might reward prolonged contribution payments with higher pension benefits.

The optimality conditions for labor market behavior are derived in Jaag et al. (2007),

$$\begin{aligned}
\varphi_L'(l) &= \left(1-\tau^L\right) w, \quad \tau^L \equiv \hat{t}^s + t^w - \frac{u}{1-u}\cdot s^u, \\
\varphi_S'(s) &= f\cdot\left[\left(1-\tau^S\right) wl - b_0 - \varphi_L(l)\right], \quad \tau^S \equiv t^w + \hat{t}^s + s^u, \\
\varphi_R'(x) &= \left(1-\tau^R\right)(1-u)\, wl\theta - \bar{\varphi}\theta, \\
\tau^R &\equiv t^w + t^s - \frac{u}{1-u}\frac{b}{wl} + \frac{(1-t^p)\left(\bar{P}+p_0\right)}{(1-u)\, wl\theta} \\
&: -\left[\mu_w'\cdot m\left(1+\frac{u}{1-u}b^1\right) + \mu_p'\cdot\frac{\bar{P}}{(1-u)\, wl\theta}\right]\frac{\gamma\tilde{\lambda}_{t+1}}{R_{t+1}}.
\end{aligned} \tag{A.5}$$

The rules of social insurance importantly affect the incentives to engage in labor market activities. Hours worked are chosen by equating marginal utility cost with the effective net wage. On top of the marginal wage tax t^w, the *effective* tax rate τ^L is increased by the implicit pension tax $\hat{t}^s$ defined in (A.4). Working more hours today expands the current assessment base and thereby augments future pension benefits, depending on the tax benefit link $m\mu_w/x$ (or m for prime age workers). The present value of future benefits is captured by the shadow price $\tilde{\lambda}_{t+1}$. This additional return strengthens work effort by reducing the tax component $\hat{t}^s$ implicit in the statutory contribution rate t^s. The effective tax on hours worked is reduced to the extent that unemployment benefits are indexed to net earnings. Given benefit indexation at rate b^U, a higher net salary also raises the benefit should the agent become unemployed, showing up in a higher unemployment subsidy s^u. Depending on the factor b^1 in (A.2), higher earnings also add to the pension assessment base during periods of unemployment, resulting in higher pension benefits in the future. This extra gain shows up in a higher unemployment subsidy and a lower effective tax rate on intensive labor supply.

Search effort raises the probability sf of successfully locating a job by f at the margin which increases the expected income gain from obtaining a job. The condition for job search thus compares this marginal expected benefit with the marginal utility cost of search. The effective tax rate τ^S collects all fiscal barriers against job search that are related to gross earnings wl. On top of the wage tax, the effective tax rate consists of the implicit pension tax, and is thus reduced by the value of future pension benefits that are tied to current earnings. Unemployment benefits, both lump-sum and earnings related, reduce incentives for job search. The earnings related part shows up in a higher effective rate τ^S via the unemployment subsidy. The effective tax is also inflated by the fact that periods of unemployment are included in the assessment base and create additional future pension benefits. The unemployment subsidy and the effective tax rate are higher for this reason as well.

The optimal retirement date is found when the marginal utility cost of prolonged participation balances the present value of net income gains. In the absence of the public sector, the instantaneous gain from another year of work would be $(1-u)\,wl\theta - \bar{\varphi}\theta$. The participation tax rate τ^R summarizes all fiscal benefits and costs of postponing retirement and expresses them as a share of gross earnings $(1-u)\,wl\theta$. It consists of the sum of the statutory tax rates $t^w + t^s$, and is reduced by the replacement rate of unemployment benefits if the worker remains unemployed (third term in A.5). In fact, unemployment is an often chosen pathway to retirement. In the model, unemployment compensation helps to contain early retirement, although at a cost to the unemployment insurance scheme. Further, the participation tax is importantly increased by the pension replacement rate which reflects the opportunity cost of continued work in terms of forgone net pensions.

The last two terms in the numerator reflect the degree of actuarial fairness in the pension formula. The opportunity cost of continued work is reduced (increased) by the marginal change in future benefits due to pension supplements (discounts) when the agent marginally retires later (earlier). The present value of these future gains (or losses) are captured by the shadow price $\tilde{\lambda}$. In the absence of government, the participation tax is zero, $\tau^R = 0$. When there are no earnings related pensions (i.e. no tax-benefit link, $m = \bar{P} = 0$), no other taxes ($t^p = t^w = 0$), and no unemployment insurance ($b = 0$), the effective tax is $\tau^R = t^s + p_0/\left(wl\theta\right)$ as in a Beveridge type system. Being the sum of the statutory contribution and pension replacement rates, it tends to be high. Strengthening actuarial fairness by compensating for prolonged contribution payments, $\mu_w' > 0$, and foregone benefits, $\mu_p' > 0$, greatly reduces the participation tax.

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