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Abstract

The demographic transition in industrialized countries poses challenges to the pension system which is essentially organized according to the pay-as-you-go principle in most countries. This paper aims at analyzing two proposals for pension reform in a theoretical model that endogenously explains the retirement and training decision of workers who are heterogeneous in ability. Because the economic benefits of motivating late retirement strongly depend on the employment prospects of workers near retirement age, the model includes the firms' employment decision at the extensive margin.

The first reform proposal, the implementation of individual retirement accounts, increases the workers' incentives to acquire skills and to postpone retirement. However, if the capital funded pillar of the pension system becomes strong, low-ability workers may not attain their optimal retirement age because firms refuse to employ them any longer. In a similar manner, the second reform proposal to increase the minimum retirement age may not work for low-ability workers if their separation date is determined by the firms before the minimum retirement age is achieved.

Keywords

Pension Reform, Endogenous Retirement, Human Capital Formation, Tax-Benefit Link, Individual Retirement Accounts, Minimum Retirement Age

JEL Classification

D91, H55, J24, J26, J31

1 Introduction

Starting from the "golden age of retirement" (Cremer and Pestieau (2000)), the demographic transition in industrialized countries poses challenges to the pension system and the economy as a whole (Bovenberg and Knaap (2005)). Declining fertility and increasing life expectancy give rise to prolonged demographic change that continuously changes the size and the composition of the labor force.[1] This topic has received much attention in recent years, mainly due to the expected sharp increase in the ratio of retirees per active worker. For example, in Switzerland, the ratio of people above 65 relative to the active population of age 20-64 is expected to increase from 30.1% in 2000 to 50.5% in 2060 (KommissionfürKonjunkturfragen (2005)).

The economic impact of this demographic change mainly derives from the reduction in aggregate labor supply and the impact on fiscal and social security budgets, necessitating either a significant reduction in old-age benefits, an increase in social security contribution rates, an increase in the minimum retirement age or other measures to improve labor market participation (Disney (2000)).[2] Börsch-Supan (2003) and Martín (2003) argue that in order to finance the current pension system, contributions and tax rates would have to rise substantially which reduces labor force participation of younger cohorts and destabilizes the pension system even more. For example, while the average contribution rate in the European Union was 16% in 2000, it will increase to 27% in 2050 if the present benefit rules are kept unchanged (EuropeanCommission (2001)).

The trend of declining labor force participation is aggravated by the fact that an increasing fraction of older workers decides to retire early (Conde-Ruiz and Galasso (2004)). The reason is that existing pension systems impose considerable negative accrual rates of pension wealth and thus provide economic incentives to leave the active population at younger and younger ages (Samwick (1998)). Gruber and Wise (2005) provide an extensive source on retirement behavior in industrialized countries. However, there is a second argument why labor force participation is low among older workers. In most industrial countries, the number of older workers in unemployment is disproportionately high which implies that the employment prospects of workers near retirement age are significantly reduced (Bingley and Lanot (2004)).

Besides its adverse effects on the pension system, population aging may induce individuals to invest more in their human capital if aging is accompanied with postponed retirement and longer working periods (Echevarría (2003)). According to consistent findings in the literature, human capital accumulation and economic growth are increased via these channels, possibly even without changes in the system of old-age provision.[3] However, most of the existing analysis of demographic change and pension reforms has been

[1] In the European Union, life expectancy at age 65 has increased by more than one year per decade since 1950 (Cremer, Lozachmeur, and Pestieau (2004)).

[2] Acording to Hines and Taylor (2005), the US Social Security trust fund will be empty in 2044. Martín (2003) uses a CGE model to analyze how pension reforms may alleviate the expected financial difficulties of current PAYG systems. In the long-run, the financial sustainability of pension systems may also be improved by immigration or family policy (Kirchgässner (2005)). However, Börsch-Supan (2003) argues that the decrease in the relative size of the economically active population cannot be balanced by higher capital intensity.

[3] Cf. de la Croix and Licandro (1999a), Kalemli-Ozcan, Ryder, and Weil (2000), Kalemli-Ozcan (2002), Boucekkine, de la Croix, and Licandro (2002), Soares (2005) and Echevarría (2004)

cast in a framework of flexible labor markets with endogenous labor supply.[4] Pension reform in the presence of labor market frictions (for example Keuschnigg and Keuschnigg (2004)) or with endogenous human capital formation (for example Jensen, Lau, and Poutvaara (2004)) is considered quite rarely.

This paper aims at closing this gap by developing a two-period partial-equilibrium model that analyzes the implications of two proposals for pension reform with a particular focus on retirement age and human capital formation. It is important to incorporate human capital formation into the analysis of pension reforms because extending the working life increases the return to education and thus fosters the workers' incentives to acquire skills (Trostel (1993)).

The contribution of this paper is twofold because the formal analysis of pension systems is extended in two important ways. First, we derive endogenously the worker's training intensity and the date of retirement which both depend on the individual ability of the worker. In line with Cremer, Lozachmeur, and Pestieau (2004) and Martín (2003), the retirement age increases with the worker's productivity which depends on initial ability and the level of training. Second, our model includes the employment decision of the firms that decide how long to continue production with the workers. The firms' employment decision can significantly affect the implications of pension reforms because workers and firms separate as soon as one party decides to leave the market. Hence, the effects of pension reforms strongly depend on the workers' employment prospects near retirement age. In a nutshell, there are two key questions considered in this paper: Starting from the current pension system of traditional pay-as-you-go, what is the impact of different pension reforms on the worker's incentives with respect to retirement age and human capital formation? And second, what are the actual effects of these pension reforms subject to the employment decision of the firms?

In a first step, we analyze the introduction of individual retirement accounts which imply to (partly) move the pension system from a pay-as-you-go towards a capital funded system. In aggregate, there is a double benefit from such a reform: reductions in labor market distortions at the extensive margin (retirement age) as well as increased human capital formation at the intensive margin (training intensity). Hence, the implementation of individual retirement accounts increases the workers' incentives to acquire skills and to postpone retirement. However, if the capital funded pillar of the pension system becomes strong and workers strive to significantly postpone retirement, low-ability workers may not attain their optimal retirement age because firms refuse to employ them any longer. In this case, the benefits of pension reform mainly accrue for high-ability workers while the benefits for low-ability workers are reduced once their employment prospects near retirement age are controlled for.

In a second step, we analyze an increase in the minimum retirement age without changing the fundamental nature of the pay-as-you-go system. Again, only high-ability workers may be affected because they are forced to stay inside the labor market until they have reached the minimum retirement age. In contrast, there may be no impact on low-ability workers if their separation date is determined by the firms before the minimum retirement age is achieved.

The paper proceeds as follows: the next section discusses the theory of old-age provision, labor

[4] Cf. Lindbeck and Persson (2003), Feldstein and Liebman (2002), Cutler, Poterba, Sheiner, and Summers (1990), Feldstein and Samwick (1999), Fehr (2000), Kotlikoff (2002) and Fehr, Jokisch, and Kotlikoff (2004).

supply and human capital formation. In Section 3, our partial-equilibrium model is developed and the decision problems of workers and firms are discussed. In Section 4 of this paper, we describe the current pension system with traditional pay-as-you-go and its implications for the workers' behavior with respect to retirement and training. In Sections 5 and 6, the two proposals for pension reforms are analyzed depending on the individual ability of the workers. Section 7 concludes.

2 Old-Age Provision, Labor Supply and Human Capital

2.1 Different Pension Systems

Two important arguments for the existence of social security systems are the myopia of those individuals who do not save adequately for their old-age provision and the asymmetric information between government and workers with respect to voluntarily chosen poverty (Feldstein (1985) and Kotlikoff, Spivak, and Summers (1982)).[5] According to Feldstein (1974), social security wealth is equal to "the present actuarial value of the social security benefits to which the current adult population will be entitled at age 65 minus the present actuarial value of the social security taxes that they will pay before reaching that age". Obviously, this term means not real wealth but corresponds to a claim on current and future taxpayers (Feldstein (1996)).

In general, there are two different concepts of old-age provision, namely the pay-as-you-go system and the capital funded system. Feldstein (2005a) and Keuschnigg (2005) provide an overview.

2.1.1 Capital Funding

With a capital funded pension system, the worker's contributions are paid into an individual account where they accumulate with interest until they are paid out during retirement in the form of actuarially fair pensions. The individual rate of return on one's own contributions corresponds to the market rate of interest, reduced by an administrative fee. Hence, every generation finances its old-age provision from its own savings accumulated during the previous working life (Feldstein (1974)). Because the pension system generates the same rate of return that workers could earn via private investments on the capital markets, there is no distortive tax involved. The contributions to the funded system simply replace private savings that would otherwise have been necessary to provide for old-age income.

In theory, old-age provision according to the capital funding principle constitutes a perfect substitute for private saving. Hence, a forced increase in social security will reduce private savings by an equal amount so that consumption, bequests, and aggregate savings will be unaffected (Barro (1974)). However, this offset between private and pension wealth may be less than one-for-one due to potential countereffects such as bequest motives, myopia, liquidity constraints and political risks (Bottazzi, Jappelli, and

[5] According to the empirical analysis by Reimers and Honig (1996), at least men behave myopically because they respond to current retirement benefits rather than to their social security wealth.

Padula (forthcoming)).[6] In a nutshell, the accumulated assets of pension funds are a major source of aggregate savings and can easily run up to 100 percent of GDP and more, depending on the size of contributions allocated to the system (Feldstein (1996)).

2.1.2 Pay-As-You-Go

The pay-as-you-go (PAYG) system rests on a so called inter-generational contract. In every period, the contributions of the current active population finance the pension entitlements of the retired population. In theory, the PAYG system constitutes a perfect substitute for private bequests (Barro (1974)). However, no capital stock is accumulated because old-age provision entirely rests on unfunded intergenerational transfers. Hence, private savings are crowded out because people save less if they need not to provide for their own old-age income (Feldstein (1974)).

Compared to capital funding, the PAYG system of old-age provision has two advantages: protection against the risk of inflation and protection against fluctuations of financial markets because the aggregate risk is diversified over generations (Diamond and Orszag (2005)).[7] With capital funding, the higher expected return on one's own contributions has to be balanced against the higher riskiness of these investments (Feldstein (1996)). The risks of PAYG only refer to long-run political factors, future demographic evolutions and the future of productivity and wages to which contributions and benefits are related (Miles, Timmermann, de Haan, and Pagano (1999)). The main drawback of the PAYG system is its dependency on the relative size of the active population (Kotlikoff (1996)). For example, if demographic changes raise the dependency ratio (i.e. the ratio of retirees per active worker), sustainability of the system demands either higher individual contributions, lower old-age benefits or an increase in the minimum retirement age (Disney (2000)).

In a nutshell, the primary costs of the PAYG principle are lower private savings and thus reduced capital accumulation (Feldstein (1985)). This theoretical conclusion is empirically confirmed by Samwick (2000) who uses a panel of countries over 25 years to analyze the effects of pension systems on aggregate savings. Another important cost is the deadweight loss of implicit taxation on labor supply at both the intensive and the extensive margins (cf. Section 2.2). Altogether, the optimal level of PAYG benefits solves a trade-of between protection against the risk of elderly poverty and distortions concerning private savings and labor supply (Feldstein (1985)). However, according to Feldstein (2005a), capital funded pension systems provide a better solution to this trade-off.

[6] Sheshinski and Weiss (1981) argue that the result of Barro (1974) strictly depends on the absence of uncertainty. Otherwise, an increase in social security will be only partially compensated by a decrease in private savings, which implies an increase in aggregate savings. There has been substantial research on the effect of social security on private savings. Although there is no agreement on the magnitude of this effect, most studies suggest that social security reduces the amount of private savings. Cf. for example Blinder, Gordon, and Wise (1981), Feldstein (1982) and Kotlikoff (1979).

[7] According to Sinn (2004), the PAYG pension system also works as insurance against the risk of not having children and as an enforcement device for ungrateful children who are unwilling to pay a pension to their parents .

2.1.3 Transition from PAYG to Capital Funding

Nearly all developed countries have adopted a pension system of the PAYG type. In general, pension systems are financed by a payroll tax levied on the labor income of the active population in order to finance the retirement benefits of the retired population. The size of these unfunded pension systems has increased over the last decades. In 1995, old-age provision absorbed 4.5% of GDP in the US, 13% in Italy, 16.5% in France and over 20% in Sweden (Galasso and Profeta (2002)).

Since the 1970's, various proposals for pension reform have suggested move the prevalent PAYG system (at least partially) towards a capital funded system of old-age provision.[8] According to these reform proposals, reallocating resources from the PAYG system to financial assets will eliminate many shortcomings of the current system. First, demographic changes will no longer affect the financial viability of the pension system. Second, the implementation of individual retirement accounts will reduce labor market distortions. And third, private savings and economic growth will be fostered which implies an increase in the present value of expected future consumption (Feldstein (2005b)).

However, it is widely accepted that shifting the current PAYG pension systems towards capital funding would not generally be neutral (Cremer and Pestieau (2000)). Feldstein (2005a) provides a list of four issues determining whether a shift from unfunded to funded systems of old-age provision will raise social welfare: (1) the costs of the transition process, (2) the level of administrative costs, (3) the riskiness of financial markets, and (4) the implications for the poorest workers at the bottom of the income distribution.

The magnitude of the transition costs is controversial in the literature. While Feldstein and Samwick (1999) and Lindbeck and Persson (2003) estimate moderate costs of moving from PAYG to capital funding, Miles, Timmermann, de Haan, and Pagano (1999) find rather high expenses. By simulating the effects of different pension reforms for Germany and Austria, Fehr (2000) and Keuschnigg and Keuschnigg (2004) conclude that all reforms redistribute towards future generations at the cost of currently active generations that have to "pay double".

Instead of moving from PAYG towards capital funding, Diamond and Orszag (2005) propose only slight changes within the current framework of traditional PAYG, namely a mixture of increased contributions and reduced benefits in order to restore the financial sustainability of the pension system. Imrohoroglu, Imrohoroglu, and Joines (1995) derive optimal social security replacement rates and associated benefits by means of an applied general equilibrium model. According to Boldrin, Dolado, Jimeno, Peracchi, Breyer, and Fernandez (1999) and Lindbeck and Persson (2003), an efficient pension system should be a mixture of PAYG and capital funded systems in order to diversify both political risks and the volatility of financial markets. However, if the initial system of old-age provision distorts endogenous labor supply and provides incentives to retire early, Bovenberg and Sorensen (2004) show that the introduction of compulsory retirement accounts can be Pareto-improving even in the presence of intragenerational heterogeneity.

[8] Cf. Feldstein (1996), Feldstein and Samwick (1999), Feldstein and Samwick (2002), Kotlikoff (1996) and Mitchell and Zeldes (1996).

2.2 Labor Market Effects of Old-Age Provision

2.2.1 Theoretical Implications of Pension Systems for the Retirement Age

The PAYG system generates an implicit tax on labor supply both at the intensive and the extensive margins (Keuschnigg (2005)). While labor supply at the intensive margin means the continuous decision how much to work during the active life, the extensive margin reflects a discrete labor supply choice by comparing costs and benefits of continuing work and postponing retirement by another period.

From an individual perspective, the rate of return on the contributions to the PAYG pension system is the internal rate of return equal to the sum of population and productivity growth rates which is below the real interest rate in a dynamically efficient economy (Feldstein (2005b)).[9] The demographic change with declining fertility and increasing life expectancy further reduces the rate of return to the PAYG system because it strictly depends on the relative size of the active population. The foregone interest margin is considered as an implicit tax on labor earnings which includes both the payroll marginal tax and foregone benefits (Cremer, Lozachmeur, and Pestieau (2004)). The size of this implicit tax is proportional to the difference between the market rate of interest on private savings and the rate of return on PAYG contributions. The implicit tax generates distortionary effects on labor supply of active workers, job search and unemployment.[10]

At the extensive margin, the implicit tax stems from the fact that most PAYG systems do not adjust the size of pension benefits in an actuarially fair way (Crémer and Pestieau (2003)). According to Lau and Poutvaara (2001b), the unfair adjustment of benefits can be interpreted as subsidization of early retirement. Indeed, the empirical evidence suggests a negative effect of pension contributions on employment and labor force participation (Scarpetta (1996)).

Whether contributions to a PAYG system are perceived as an implicit tax depends on whether pensions are linked to own past contributions or not. A PAYG system of the Beveridge type pays a flat pension that is uncoupled from own contributions. In this case, there is no tax-benefit link at all so that individuals must perceive their contribution rates as a 100% tax because they receive the same pension anyway (Feldstein (2005a)). In contrast, a PAYG system of the Bismarck type includes a tax-benefit link that relates the size of the pension to the size of one's own contributions in the past. However, contributions tend to be actuarially unfair so that old-age insurance yields a much lower return than private savings (Feldstein (2005a)). According to calculations for Germany, about 50% of the contribution is a tax on labor while the rest is a price for individually received services (Fenge and Werding (2003)).

Without changing the fundamental nature of the PAYG system, the implicit tax can be reduced by strengthening the individual tax-benefit link, i.e. by relating pensions more closely to one's own past contributions (Lindbeck and Persson (2003)). However, the capital funded system computes benefits in an actuarially fair way by definition. Hence, it provides the fullest possible tax-benefit link and thus avoids any type of implicit taxation. Moving to capital funding will not only raise aggregate capital

[9] This must hold at least in the long-run. Otherwise, intertemporal budget constraints would no longer be defined.

[10] Demmel and Keuschnigg (2000), Corneo and Marquardt (2000) as well as Keuschnigg (2004) demonstrate that unemployment increases with the level of implicit taxes.

accumulation, but should also eliminate implicit taxes on extensive and intensive labor supply and thereby yield important efficiency gains leading to lower unemployment, more human capital formation and higher incomes (Feldstein (2005b)).

2.2.2 Empirical Evidence

There is a considerable literature on the economics of old-age insurance arguing that there is indeed a small but significant impact of pension systems on the average age of retirement and the likelihood of going on pension.[11] For example, Stock and Wise (1990) suggest that increasing the minimum retirement age from 55 to 60 has reduced the probability of retirement before age 60 by over a third.

Influential work of Börsch-Supan (2000) and Börsch-Supan (2003) shows the importance of the extensive margin for Germany. Börsch-Supan (2000) estimates that a decrease of retirement benefits by 12% would decrease the retirement probability of the 60 year old from 39.3% to 28.1% for a given labor income. According to Gruber and Wise (2005), each year of later retirement should be rewarded by a 6% increase in future benefits for the system to be actuarially fair. Empirical evidence concerning the sensitivity of the extensive margin is summarized in Diamond and Gruber (1997) and Gruber and Wise (2005).

2.3 Employment Prospects of Older Workers

In industrialized countries, an increasing number of older workers leaves the labor force at younger and younger ages. For example, from 1950 to 1989 the labor force participation in the US has declined from 46% to 17% for men over 65 and from 87% to 67% for men between 55 and 64 (Lumsdaine and Wise (1990)). In some European countries (for example France and Italy), male labor force participation between 60 and 64 has fallen from above 70% in 1960 to below 20% in 2002 (Conde-Ruiz and Galasso (2004)).

For older workers, rates of job loss have significantly increased in recent years. In the US, the 3-year job loss rate for workers over age 55 has risen from 11% in 1981 to 16% in 1993 (Farber (1997)). According to Chan and Stevens (2001), losing a job has significant effects on future employment probabilities. Only 61% of displaced men and 55% of displaced women over age 50 are reemployed two years after a job loss. By using the National Longitudinal Study of Older Men, Diamond and Hausman (1984) confirm that older men face long periods of unemployment and increased retirement probabilities after a job loss. Furthermore, an empirical study by CongressionalBudgetOffice (1993) shows that about 50% of displaced workers over age 60 retire and thus leave the labor force.

The employment prospects of older workers strongly depend on the firms' incentives to hire and to employ workers near retirement age (Chan and Stevens (2001)). Unfortunately, firm behavior has received

[11] Cf. for example Blau (1994), Burtless and Moffitt (1985), Burtless (1986), Fields and Mitchell (1984), Hurd and Boskin (1984), Hall and Johnson (1980), Mitchell and Fields (1984), Rust and Phelan (1997), Samwick (1998), Mitchell and Phillips (2000), Crémer and Pestieau (2003) and Stock and Wise (1990). According to Samwick (1998), weak empirical results may be attributed to cross-sectional variation in retirement benefits.

much less attention in the retirement literature than the worker's decision to go on pension. However, profit-maximizing firms play an active role because they decide on the termination of production by comparing marginal benefits and marginal costs of employing workers for another time period (Hutchens (1999)). Hence, Hakola and Uusitalo (2005) conclude that it is important to consider retirement as a joint decision of workers and firms.

According to Bingley and Lanot (2004) and Heywood, Ho, and Wei (1999), there are three possible explanations why the labor market prospects of older workers are reduced compared to those of younger workers: (1) a decline in the worker's productivity over time, (2) a steep age-earnings profile due to delayed compensation schemes, and (3) an increase in the level of non-wage labor costs over time.

As suggested in his life-cycle model of human capital accumulation by Heckman (1976), the worker's productivity may decline because his human capital depreciates over time. On the one hand, older workers have more experience which generally increases productivity. But on the other hand, skills may decline with age after a certain point so that productivity is reduced (Johnson and Neumark (1997)). Furthermore, unexpected positive technology shocks may accelerate the skill depreciation of older workers, which implies that firm-sponsored retraining is more costly for older workers because the returns to this investment are recouped over a shorter period of time (Bartel and Sicherman (1993)). Hence, firms may use early retirement as a possible way to renew their workforce (Hakola and Uusitalo (2005)).

The empirical evidence concerning the relationship between age and productivity is mixed (Haltiwanger, Lane, and Spletzer (1999)). In their empirical study for manufacturing firms in France between 1994 and 1997, Crépon, Deniau, and Pérez-Duarte (2002) find that the productivity of older workers declines by about 10% on average. By using wages as a proxy for individual productivity, Kotlikoff and Wise (1989) conclude that the productivity of salesmen increases until age 52 and then declines by 16% until age 60. In a similar study for workers of a trading concern, Kotlikoff and Gokhale (1992) find that there is a productivity loss of nearly 20% compared to the productivity maximum at age 47. An overview is provided by Börsch-Supan, Duzgun, and Weiss (2005).

Concerning the second explanation for reduced employment prospects of older workers, optimal long-term labor contracts according to Lazear (1981) imply that low-tenure workers earn less than their productivity and high-tenure workers earn more than their productivity in order to alleviate the monitoring problems of firms. However, this upward-sloping wage profile of delayed compensation schemes introduces a new source of inefficiency because workers have an incentive to stay on the job past the efficient age of retirement (Lazear (1979)). Hence, firms need to limit the time period during which older workers receive wages above their productivity (for example by "mandatory retirement") (Leigh (1984)). This theoretical result is empirically confirmed by Daniel and Heywood (forthcoming) who find that indicators of delayed compensation are associated with a reduced likelihood of firms hiring older workers. Hence, delayed compensation schemes create incentives to minimize costs by terminating production with older workers (Heywood, Ho, and Wei (1999)).

With respect to the third explanation, Hutchens (1988) finds that newly hired older workers are clustered in a smaller set of occupations than newly hired younger workers and older workers in general.

Hence, firms employ older workers but dislike to hire them, which implies that job opportunities are diminishing with age. This result is empirically confirmed by Chan and Stevens (2001) and can be attributed to an increase in the level of non-wage labor costs over time. According to Straka (1992), employer contributions to health insurance negatively affect the employment prospects of older workers. Because the costs of health insurance are rising with age, the employment prospects of older workers are reduced compared to those of younger workers (Scott, Berger, and Garen (1995)).[12]

In our formal analysis, we focus on the third explanation. We assume that the fixed costs of production increase with the worker's age over the life-cycle, which implies that it is more costly for the firm to obtain the same output with an older worker than with a younger worker of the same initial ability.

2.4 Human Capital Formation

"Human capital" can be defined as knowledge, skills, attitudes, aptitudes, and other acquired traits contributing to production (Goode (1959)). According to Blundell, Dearden, Meghir, and Sianesi (1999), there are two main components of human capital with strong complementarity: early ability (whether acquired or innate) and skills acquired through formal education or training on the job. Human capital differs from other assets because it yields market returns only in proportion to the worker's supply of labor (Hall and Johnson (1980)). An extensive review of the theory of human capital is given by Cahuc and Zylberberg (2004).

2.4.1 The Investment in Human Capital

In his original approach, Becker (1964) develops a model of individual investment in human capital. In this view, human capital is similar to "physical means of production". According to Becker (1962), investing in human capital means "all activities that influence future real income through the embedding of resources in people". Human capital investments are expenditures on education, training, health, information, and labor mobility (Weisbrod (1966)). They involve initial costs (direct tuition expenditures and foregone earnings during schooling)[13] in order to gain a return on this investment in the future (Becker (1992)).[14]

An important stream of human capital literature deals with the life-cycle of earnings. At the intensive margin, the individual faces a trade-off between the costs of producing additional human capital and the benefits of increased earnings in the future. Models of human capital accumulation over the life-cycle can be attributed to two different branches: earnings maximizing models and utility maximizing models. While earnings maximizing models abstract from the labor-leisure choice problem and only analyze the

[12] With respect to the empirical analysis of Scott, Berger, and Garen (1995), Heywood, Ho, and Wei (1999) argue that the third explanation (increasing non-wage labor costs) cannot be easily disentangled from the second one (delayed compensation).

[13] Parsons (1974) distinguishes these major components of education costs.

[14] This return is based on two interrelated channels: increased earnings for the worker and higher productivity for the firm as well as increased employment probabilities (Bloch and Smith (1977)). Bloch and Smith (1977) indeed find a positive correlation of human capital and labor market employment. Also Mincer (1989) states that the probability of being unemployed decreases with the amount of education. In a nutshell, there are two key determinants of the return to education: the costs of education and the employment opportunities after education (Rephann (2002)).

trade-off between investment and income (for example Ben-Porath (1967)), utility maximizing models also incorporate the labor-leisure choice so that labor supply becomes endogenous to the model (for example Heckman (1976)).[15]

In a nutshell, Mincer (1970) and Mincer (1997) summarize the empirical evidence concerning the age-earnings profile of individuals. Earnings positively depend on the stock of human capital; the age-earnings profile is concave and at least for a long time upward-sloping. If human capital investment increases, the age-earnings profile becomes steeper and has its maximum later. Hence, human capital investments determine the shape of individual earnings over the life-cycle.

2.4.2 Implications of Pension Systems for Human Capital Formation

According to Echevarría (2003), the return to human capital investments is affected by the pension system if finite horizon economies are considered. With a tax-benefit link, the return to education is not restricted to increased labor incomes, but also extends to pensions during retirement. Hence, if workers decide on the optimal amount of human capital investments, they take into account not only the effect on future labor incomes but also on future retirement benefits (Echevarría and Iza (2005)).

Lau and Poutvaara (2001a) and Lau and Poutvaara (2001b) study the impact of social security incentives on human capital formation, arguing that actuarial fairness and a tight tax-benefit link increase human capital along with an increase in the retirement age. This is a common result in most theoretical analyses because postponed retirement lengthens the time period at the extensive margin over which individuals can appropriate the benefits from human capital investments, which translates into higher returns to education (Trostel (1993)). Hence, the return to education positively depends on the remaining active years. In a nutshell, postponed retirement raises aggregate human capital because higher returns to education are associated with increased human capital investments (Echevarría (2003)).

In their analysis of demographic transition and economic growth, Kalemli-Ozcan, Ryder, and Weil (2000) show in an OLG framework that augmented life expectancy gives rise to increased human capital formation. In a similar setup, de la Croix and Licandro (1999b) investigate an economy where the workers accumulate human capital as a function of their optimal schooling period. The effect of lower mortality rates on human capital formation is positive because the increased expected flow of future incomes will increase human capital per capita. The same result is obtained by Boucekkine, de la Croix, and Licandro (2002) under a setting with uncertain lifetime horizon and endogenous retirement age. Echevarría (2003) argues that an increase in life expectancy translates into higher growth rates by increased human capital formation only if demographic change is accompanied by simultaneous increments in the length of the working life. Hence, if there is a positive correlation between life expectancy and retirement age, an increase in life expectancy will foster the formation of human capital. For the UK, this result is empirically confirmed by Kalemli-Ozcan, Ryder, and Weil (2000).

[15] The difference between these two types of models is illustrated by Snow and Warren (1990) who explain that the income effect of higher wages (due to investments in human capital) on future labor supply may reduce realized future earnings. However, there are efforts to integrate these two branches, for example by Blinder and Weiss (1976). Weiss (1986) provides a review of the theoretical literature.

In a nutshell, because the PAYG pension system generates distortions in labor supply and thus provides incentives for early retirement, aggregate human capital is lower than with a capital funded system of old-age provision. The reason is that the PAYG system discourages human capital formation both directly and indirectly via the retirement age (Echevarría and Iza (2005)). Moving the pension system from PAYG towards capital funding eliminates the distortions in the labor market and thus increases the workers' retirement age and the investment in human capital (Feldstein (2005b)).

Furthermore, the positive relationship between retirement age and human capital accumulation also holds in the opposite direction. According to Hernoes, Sollie, and Strom (2000), education is an important determinant of the retirement age. A higher stock of human capital increases the retirement age because the worker's higher productivity implies increased labor incomes and makes labor supply more worthwhile compared to retirement. Hence, while early retirement is low among high-skilled workers, low-skilled workers may take the opportunity to retire at the lowest possible date.

Before analyzing two proposals for pension reform in Sections 5 and 6, we discuss the assumptions of our model (cf. Section 3) and the current pension system with traditional PAYG (cf. Section 4) in order to point out the analytical basis of comparison.

3 The Model

We consider a discrete-time model with two types of agents, namely workers and firms. In line with Feldstein (1985), there are two periods with fixed length. As modelled by Crémer and Pestieau (2003) and Lau and Poutvaara (2001b), the first period is fully active while the second period is endogenously split into a working subperiod and a retirement subperiod. In line with Lau and Poutvaara (2001a), the model allows for endogenous human capital formation that is limited to the first period. Production takes place in worker-firm pairs and no capital is needed.

At the beginning of period 1, each firm meets one worker whose individual ability is drawn randomly from a distribution that is common knowledge. In the second period, all workers are employed regularly until at least one party decides to separate, either the worker or the firm. In line with Acemoglu and Pischke (1999), there is no exogenous separation after the first period.[16] The remaining time of period 2 defines the length of the retirement subperiod. Altogether, the economy evolves over time as shown in figure 1. The model assumptions and the labor market decisions of firms and workers are described in the following subsections.

[16] Incorporating an exogenous separating probability as in Malcomson, Maw, and McCormick (2003) does not change our analytical results because we focus on the supply side of the labor market. For the workers who face the training decision in period 1, it is irrelevant whether their higher wages in period 2 are paid by their current or by another employer.

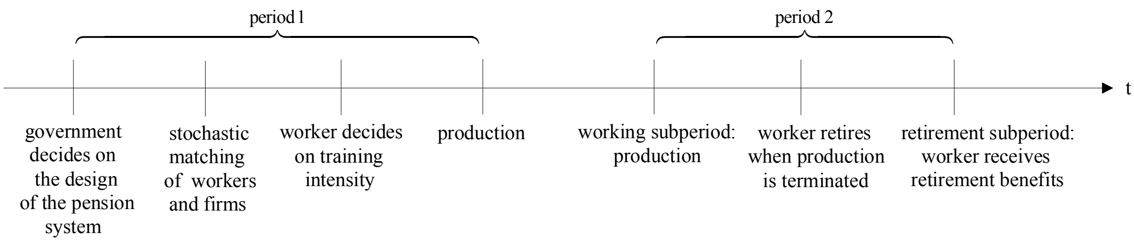

Figure 1: Evolution over Time

3.1 The Workers

By assumption, each worker meets one firm that can unambiguously observe the workers' ability.[17] In line with Crémer and Pestieau (2003) and Jensen, Lau, and Poutvaara (2004), there are two types of workers with individual ability $\theta_i = \{\theta_L, \theta_H\}$ at the beginning of period 1 and identical lifetime $(1+h)$. The length of period 1 is normalized to unity. The length of period 2 is equal to h and covers both a working and a retirement subperiod. In line with Malcomson, Maw, and McCormick (2003), workers are risk-neutral and maximize the sum of their discounted utilities over both periods:

$$U(\theta_i) = u_{1i} + \delta u_{2i} \tag{1}$$

The discount factor $\delta \equiv \frac{1}{1+r}$ with r as the market interest rate expresses the preference for current and future welfare. The higher δ, the higher is the weighting of the following periods and the lower is the preference for period 1.

In period 1, worker can invest in their stock of human capital.[18] In line with Lau and Poutvaara (2001a), the individual level of human capital depends on the amount of resources devoted to the process of educational production. As shown in equation (5), the training costs $\chi(e_i)$ disproportionately increase with the training intensity e_i. In line with the literature on human capital accumulation over the life-cycle, the training costs have to be borne by the worker.[19] Furthermore, the worker can transfer wealth from period 1 to period 2 by reducing his consumption c_{1i} and saving an amount s_{1i}.

[17] This assumption is in line with Boone and Bovenberg (2006). Furthermore, it is implicitly included into the whole literature on human capital and the life-cycle of earnings. Each worker offers his individual stock of human capital to the firms and is rewarded by a rental price per unit of human capital. Hence, we rule out asymmetric information (hidden knowledge). If the worker's productivity were not observed by the firm, there would be adverse selection as modeled e.g. by DeMeza and Webb (2001).

[18] This is an advancement compared to Martín (2003) who excludes human capital investments by assuming an exogenous distribution of education types.

[19] Most models that analyze the accumulation of human capital over the life-cycle completely concentrate on the investment decision of workers. Cf. for example Ben-Porath (1967) and Heckman (1976).

Altogether, the worker's utility in the first period is equal to[20]

$$u_{1i} = c_{1i} - \chi(e_i) \tag{2}$$

$$c_{1i} = (1-\tau)\, w_{1i} - s_{1i} \tag{3}$$

$$w_{1i} = \beta\theta_i \tag{4}$$

$$\chi(e_i) = \frac{(e_i)^2}{2} \tag{5}$$

In both periods, the worker's wage corresponds to the Nash bargaining solution of oligopolistic labor markets. According to Acemoglu (1997), the parameter $0 < \beta < 1$ indicates the (identical) bargaining power of workers concerning the division of output. Hence, there are labor market frictions because the worker's wage is below his marginal product (Masters (1998)). By defining the output good as numéraire and assuming an identical, linear one-to-one production function for the connection of output and labor (which is the only factor of production), the wage of worker i in period 1 depends on his productivity in the following manner: $w_{1i} = \beta\theta_i$. The net wage is equal to the difference between the wage w_i and the proportional contributions τw_i.

In period 2, the worker's productivity increases to $\theta_i' = (1 + e_i)\,\theta_i$ depending on the training intensity in the first period. Hence, in line with Lau and Poutvaara (2001a), there is no uncertainty about the return to education.[21] The labor income in period 2 is equal to the product of the worker's wage $w_{2i} = \beta\theta_i'$ and labor supply t_i. The worker endogenously determines t_i that defines the length of the working subperiod and thus the date of retirement. As defined in equation (10), there are effort costs of labor $\varphi(t_i)$ which increase with t_i (Crémer and Pestieau (2003)).[22]

[20] In line with Ben-Porath (1967), we do not analyze a more general utility function of workers. Note that the wage corresponds to the worker's labor income because labor supply is implicitly normalized to unity. By assumption, there are no effort costs of labor in period 1.

[21] Because e_i determines the amount of training in period 1 as well as the increased productivity in period 2, it constitutes the key determinant of the return to education as analyzed in the theory of human capital (c.f. Mincer (1974)).

The probability of a match in period 2 may explicitly depend on the worker's status of employment in period 1. Different matching probabilities can be justified by different frictions in searching for employment. Mincer (1989) empirically confirms that the probability of unemployment decreases with education. In this context, Brown and Kaufold (1988) stress that the possibility of unemployment reduces the expected return to education. In a nutshell, the worker's return to education is based on higher productivity as well as higher employment probability (Bloch and Smith (1977)). For simplicity, we assume no search frictions and thus the same matching probability for all workers.

[22] Mitchell and Fields (1984) stress that, in addition to the income opportunities as defined by the benefit rule, the worker's preferences for income relative to leisure are the most important determinant of the retirement age.

Hence, the worker's utility in the second period is equal to

$$
\begin{aligned}
u_{2i} &= c_{2i} - \varphi(t_i) + c'_{2i} &(6)\\
c_{2i} &= (1-\tau)\, t_i w_{2i} + R s_{1i} - s_{2i} &(7)\\
w_{2i} &= \beta \theta'_i &(8)\\
\theta'_i &= (1+e_i)\,\theta_i &(9)\\
\varphi(t_i) &= \frac{\gamma}{2}(t_i)^2 &(10)\\
c'_{2i} &= (h-t_i)\, b + s_{2i} &(11)\\
b &= m\,(t_i)\, k + n\,(t_i)\left[(1+p)\,\tau w_{1i} + \tau t_i w_{2i}\right] &(12)
\end{aligned}
$$

While c_{2i} denotes the period 2 consumption of worker i during the working subperiod, c'_{2i} refers to the level of consumption during the retirement subperiod. Consumption c_{2i} is composed of three parts: net labor income $(1-\tau)\, t_i w_{2i}$, private savings from period 1, and private savings s_{2i} from the working subperiod which reduce c_{2i} by transferring wealth to the retirement subperiod. Note that the amount of private savings s_{1i} is augmented by the factor $R = (1+r)$. In the retirement subperiod, consumption c'_{2i} is composed of private savings s_{2i} as well as old-age benefits b. The retirement subperiod has the length $(h-t_i)$ because it starts at date $(1+t_i)$ and continues until the worker dies at date $(1+h)$.

According to Keuschnigg (2006), old-age benefits are determined by the benefit rule as specified in equation (12). In general, they are composed of two parts. The first part refers to the pension system of the Beveridge type which pays a flat pension k uncoupled from own contributions. The second part refers to the Bismarck type and includes a tax-benefit link that relates the size of the pension b to the size of one's own contributions in periods 1 and 2. Social security contributions are equal to payroll taxes τ that are proportional to the worker's labor income. Note that the parameter p may be smaller than the market interest rate r. Whether contributions are actuarially fair depends on the parameters $m\,(t_i)$ and $n\,(t_i)$ that define to which extent individual benefits are adjusted in response to the retirement decision t_i.

Altogether, the total utility of a worker with ability θ_i is obtained by substituting equations (2) to (11) into equation (1):

$$
\begin{aligned}
U\,(\theta_i) &= (1-\tau)\,\beta\theta_i - \frac{(e_i)^2}{2} + \delta\left[(1-\tau)\, t_i \beta\,(1+e_i)\,\theta_i - \frac{\gamma}{2}(t_i)^2 + (h-t_i)\, b\right] &(13)\\
b &= m\,(t_i)\, k + n\,(t_i)\left[(1+p)\,\tau w_{1i} + \tau t_i w_{2i}\right]
\end{aligned}
$$

Note that private savings cancel out because they are increased and discounted by the same market interest rate r. Hence, they only represent transfers from one period to another without influence on total utility. In line with Lau and Poutvaara (2001a), total utility is separable in lifetime consumption and lifetime leisure.

3.2 The Retirement and Training Decision with Laissez-Faire (LF)

Without government interventions, there are no social security contributions and no old-age benefits. Hence, the parameters τ and b are equal to zero. Each worker maximizes the present value of his total utility (13) with respect to the decision variables t_i and e_i:

$$\max_{t_i,e_i} \beta\theta_i - \frac{(e_i)^2}{2} + \delta \left[t_i\beta\left(1+e_i\right)\theta_i - \frac{\gamma}{2}(t_i)^2 \right] \tag{14}$$

The first-order conditions (FOC) are the following:

$$t_i \quad : \quad \delta\beta(1+e_i)\theta_i = \delta\gamma t_i \tag{15}$$

$$e_i \quad : \quad \delta t_i \beta\theta_i = e_i \tag{16}$$

The FOC compare the marginal benefits (on the left hand side) and the marginal costs (on the right hand side) of an increase in t_i and e_i, respectively. Equation (15) represents the worker's optimization problem with respect to t_i. While the additional effort costs of labor are shown on the RHS, the increase in labor income is equal to $\beta(1+e_i)\theta_i$ which corresponds to the wage in the second period. In equation (16), each additional unit of training generates costs equal to e_i, but this investment makes the worker more productive and thus increases the labor income in period 2 by $t_i\beta\theta_i$.

Furthermore, equations (15) and (16) represent the optimal values $t_i = R^{LF}\left(e_i\right)$ and $e_i = R^{LF}\left(t_i\right)$ as a function of the other decision variable:

$$t_i = R^{LF}\left(e_i\right) = \frac{\beta\theta_i}{\gamma}\left(1+e_i\right) \tag{17}$$

$$e_i = R^{LF}\left(t_i\right) = \delta\beta\theta_i t_i \tag{18}$$

The optimality functions (17) and (18) are upward sloping in a (e_i, t_i)-diagram. Hence, retirement age and training intensity constitute complements concerning the worker's optimal choice of labor supply and human capital formation.[23] Additionally, both t_i and e_i positively depend on the individual ability θ_i. This theoretical result is in line with the empirical findings of Fields and Mitchell (1984) who suggest that those gaining more by postponing retirement will retire later. In figure 2, the two optimality functions are graphically illustrated for both ability types of workers.

In order to determine the optimal retirement age and the optimal training intensity for the worker

[23] This complementarity of ability and human capital formation is in line with Blundell, Dearden, Meghir, and Sianesi (1999).

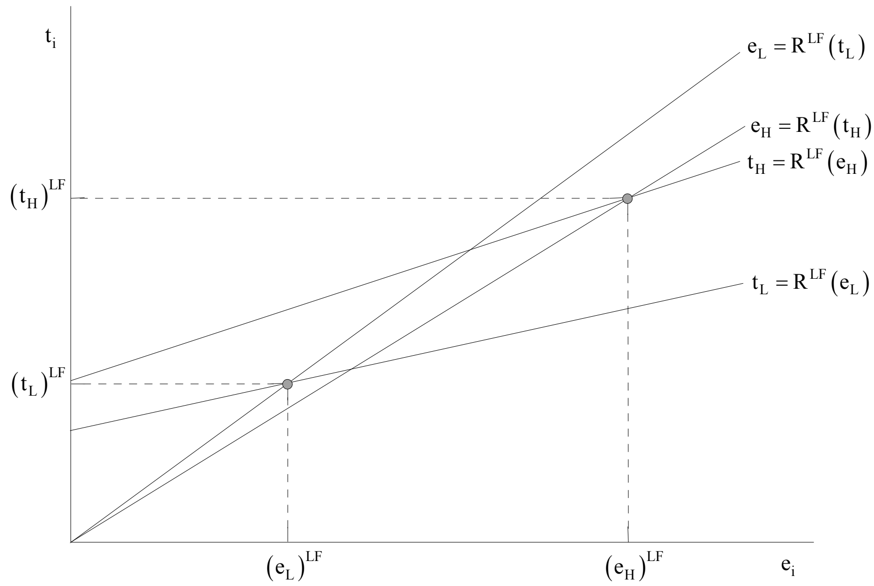

Figure 2: The Workers with Laissez-Faire

with ability θ_i, we have to combine the optimality functions (17) and (18):[24]

$$(t_i)^{LF} = \frac{\beta\theta_i}{\gamma - \delta\left(\beta\theta_i\right)^2} \tag{19}$$

$$(e_i)^{LF} = \frac{\delta\left(\beta\theta_i\right)^2}{\gamma - \delta\left(\beta\theta_i\right)^2} \tag{20}$$

With laissez-faire, the worker's optimal values for retirement age and training increase with the bargaining power β and the ability θ_i because these parameters determine the wage and thus the benefits of both training in period 1 and work in period 2.[25] This result is in line with Cremer, Lozachmeur, and Pestieau (2004) and Martín (2003) who suggest that workers with high productivity will retire later. Furthermore, both $(t_i)^{LF}$ and $(e_i)^{LF}$ increase with δ because an increase in δ is equivalent to a decrease in r. Hence, the additional income in period 2 is discounted less and thus weighted to a greater extent. As suggested by Lau and Poutvaara (2001a), the comparative statics are stronger for $(t_i)^{LF}$ than for $(e_i)^{LF}$ because the retirement age is affected both directly and indirectly via the impact on human capital. However, both variables decrease with γ because higher effort costs of labor imply that the net marginal benefits of work and education are reduced.

[24] The calculation of the optimal values for retirement age and training intensity with laissez-faire is presented in Appendix A. Concerning the following sections, the calculation of the optimal values proceeds in the same manner.

[25] Note that there are two opposite effects of individual ability on the retirement age, an income effect with negative correlation and a substitution effect with positive correlation (Jensen, Lau, and Poutvaara (2004)).

3.3 The Firms

As modeled by Malcomson, Maw, and McCormick (2003), firms are risk-neutral and maximize the sum of their discounted profits over both periods:[26]

$$\pi(\theta_i) = \pi_{1i} + \delta\pi_{2i} \tag{21}$$

In both periods, the firm's profit is equal to the difference between revenue and costs per worker. In period 1, the profit corresponds to the Nash bargaining solution:

$$\pi_{1i} = (1-\beta)\,\theta_i \tag{22}$$

In the second period, each firm decides how long production with the worker is continued. The firm leaves the market at the separation date t^F, which implies that production is terminated. Because the firm has to bear fixed costs of production $\psi\left(\theta_i, t^F\right)$, profits in period 2 are equal to

$$\pi_{2i} = t^F(1-\beta)(1+e_i)\,\theta_i - \psi\left(\theta_i, t^F\right) \tag{23}$$

$$\psi\left(t^F, \theta_i\right) = \frac{f}{2\theta_i}(t^F)^2 \tag{24}$$

As shown in equation (24), the fixed costs of production increase with t^F because non-wage labor costs are rising over time (cf. Section 2.3). Hence, it is more costly for the firm to obtain the same output with an older worker than with a younger worker of the same initial ability.

Altogether, total profits of a firm are obtained by substituting equations (22) to (24) into (21):

$$\pi(\theta_i) = (1-\beta)\,\theta_i + \delta\left[t^F(1-\beta)(1+e_i)\,\theta_i - \frac{f}{2\theta_i}(t^F)^2\right] \tag{25}$$

3.4 The Separation Decision of the Firms

The firm is not affected by the system of old-age provision which implies that it solves the same decision problem with laissez-faire and with a pension system, respectively. Hence, the firm always maximizes total profits in (25) with respect to the separation date t^F:

$$\max_{t^F}\,(1-\beta)\,\theta_i + \delta\left[t^F(1-\beta)(1+e_i)\,\theta_i - \frac{f}{2\theta_i}(t^F)^2\right] \tag{26}$$

The firm's FOC is equal to

$$\delta(1-\beta)(1+e_i)\,\theta_i = \delta\frac{f}{\theta_i}t^F \tag{27}$$

[26] The production function exhibits constant returns to scale. Hence, from the firm's point of view, the worker's ability can be interpreted as individual productivity. Note that there is no uncertainty because the probability of exogenous separation is zero.

Figure 3: The Separation Decision of the Firms

This FOC compares the marginal revenue (on the left hand side) and the marginal costs (on the right hand side) of an increase in t^F. While production in period 2 generates a marginal revenue equal to the Nash bargaining solution $(1-\beta)(1+e_i)\theta_i$, there are additional fixed costs that have to be borne by the firm. By solving the FOC (27) for t^F, we obtain the optimal separation date of the firm as a function of training intensity e_i (cf. figure 3):

$$t^F(e_i) = \frac{1-\beta}{f}(1+e_i)(\theta_i)^2 \tag{28}$$

Note that e_i corresponds to the optimal level of training chosen by the worker. In the case of laissez-faire, it is determined by the optimality function in equation (16). The optimal separation date of the firm increases with e_i and θ_i because the worker's productivity and thus the firm's profits are augmented. Hence, not only the worker's optimal retirement age (cf. Section 3.2) but also the firm's optimal separation date positively depend on the worker's productivity. In this context, Lazear (1979) suggests that the worker's education is positively correlated with the firm's age of mandatory retirement. However, $t^F(e_i)$ decreases with f because higher fixed costs of production make it is less profitable to employ the worker. Obviously, $t^F(e_i)$ decreases with β because the firm's output share is equal to $(1-\beta)$.

4 The Pension System

4.1 The Retirement and Training Decision with a Pension System

With a pension system, each worker has to pay contributions during his working life and receives retirement benefits b that depends on the type of the pension system. In general, each worker maximizes his total utility subject to the benefit rule defined by the system of old-age provision:

$$\max_{e_i,t_i} (1-\tau)\,\beta\theta_i - \frac{(e_i)^2}{2} + \delta\left[(1-\tau)\,t_i\beta\,(1+e_i)\,\theta_i - \frac{\gamma}{2}(t_i)^2 + (h-t_i)\,b\right] \tag{29}$$

$$s.t. \quad b = m\,(t_i)\,k + n\,(t_i)\left[(1+p)\,\tau w_{1i} + \tau t_i w_{2i}\right] \tag{30}$$

The FOC are the following:

$$t_i \quad : \qquad \delta\left[(1-\tau)\,\beta(1+e_i)\theta_i + (h-t_i)\,\frac{\partial b}{\partial t_i}\right] = \delta\left[\gamma t_i + b\right] \tag{31}$$

$$e_i \quad : \qquad \delta\left[t_i\,(1-\tau)\,\beta\theta_i + (h-t_i)\,\frac{\partial b}{\partial e_i}\right] = e_i \tag{32}$$

As in the situation with laissez-faire, the FOC compare the marginal benefits (on the left hand side) and the marginal costs (on the right hand side) of an increase in t_i and e_i, respectively. In equation (31), the marginal benefits of an increase in t_i are modified compared to (15). First, the wage for an additional unit of labor supply is decreased by the contributions τ. And second, if the retirement benefits are adjusted in response to the length of the working subperiod, b increases with t_i. Furthermore, the marginal costs on the RHS are increased because the worker forgoes the retirement benefits b during the additional unit of working time. In equation (32), the marginal benefits of an increase in e_i are modified compared to laissez-faire in (16). First, the additional labor income in period 2 is reduced by the contributions. And second, if the pension system contains a link between contributions and benefits, more training increases the level of benefits during the retirement subperiod.

Starting from the FOC (31) and (32), we can determine the implicit tax rates τ_t^* on labor supply at the extensive margin and τ_e^* on training intensity at the intensive margin:[27]

$$\begin{aligned}
(1-\tau_t^*)\,\beta(1+e_i)\theta_i &= (1-\tau)\,\beta(1+e_i)\theta_i + (h-t_i)\,\frac{\partial b}{\partial t_i} - b \\
\tau_t^* &= \tau + \frac{b - (h-t_i)\,\frac{\partial b}{\partial t_i}}{\beta(1+e_i)\theta_i}
\end{aligned} \tag{33}$$

$$\begin{aligned}
(1-\tau_e^*)\,\delta t_i\beta\theta_i &= \delta\left[t_i\,(1-\tau)\,\beta\theta_i + (h-t_i)\,\frac{\partial b}{\partial e_i}\right] \\
\tau_e^* &= \tau - \frac{(h-t_i)\,\frac{\partial b}{\partial e_i}}{t_i\beta\theta_i}
\end{aligned} \tag{34}$$

[27] According to Gruber and Wise (2005), the implicit tax on labor supply at the extensive margin is equal to the ratio of the change in the present value of retirement benefits and labor income.

Compared to the situation with laissez-faire in Section 3.2, both implicit tax rates indicate the degree of distortion with respect to the worker's retirement and training decision.

4.2 The Retirement and Training Decision with Traditional PAYG

With a PAYG system of old-age provision, social security contributions are not treated like private savings and benefits are not refunded from the stock of own savings (cf. Section 2.1.2). In most countries, the current PAYG pension system represents a mixture of the Beveridge type and the Bismarck type with actuarially fair adjustment of benefits. In the following, this mixture is analyzed in detail because it constitutes the analytical basis of comparison for evaluating the proposals for pension reform in Sections 5 and 6.

With the Beveridge type system, benefits are completely uncoupled from own contributions and independent of the length of the working life:[28]

$$b^{Beveridge} = k \tag{35}$$

However, benefits according to the Bismarck type depend on the worker's contributions during his working life and thus include a tax-benefit link:

$$b^{Bismarck} = \frac{\alpha}{h - t_i} \left[\tau\beta\theta_i + t_i \tau\beta \left(1 + e_i\right) \theta_i \right] \tag{36}$$

The benefits in (36) are actuarially adjusted because they are divided by $(h - t_i)$, the length of the retirement subperiod. In this context, the parameter α provides a measure of the tax-benefit link because it determines to which extent the retirement benefits depend on one's own contributions in the past. However, in contradiction to capital funding contributions of period 1 are not augmented by the market interest rate, which implies $p = 0$ in equation (30).

Altogether, we assume that the traditional PAYG system of old-age provision pays benefits equal to[29]

$$b^{PAYG} = b^{Beveridge} + b^{Bismarck} \tag{37}$$

The two parts of this benefit rule (37) focus on different socioeconomic goals. While the Beveridge part of the pension system provides a basic pension in order to prevent poverty, the Bismarck part pays earnings-related benefits in order to sustain the worker's previous standard of living (Jensen, Lau, and Poutvaara (2004)). In a nutshell, the flat pension $b^{Beveridge}$ represents the level of minimum pension which is also granted if the worker has never stayed inside the labor market.

[28] The latter property implies $m(t_i) = 1$ in the benefit rule (30).

[29] According to the propositions by Boskin, Kotlikoff, Puffert, and Shoven (1986), this two-pillar structure may be referred to as the "Boskin Proposal" (Huggett and Ventura (1999)).

Subject to (37), the FOC (31) and (32) are the following:

$$t_i \quad : \quad \delta\left[(1-\tau)\,\beta(1+e_i)\theta_i + \alpha\tau\beta\theta_i\frac{1+h\,(1+e_i)}{h-t_i}\right] = \delta\left[\gamma t_i + b^{PAYG}\right] \tag{38}$$

$$e_i \quad : \quad \delta\left[t_i\,(1-\tau)\,\beta\theta_i + \alpha t_i\tau\beta\theta_i\right] = e_i \tag{39}$$

Equation (38) represents the worker's optimization problem with respect to t_i. The two marginal benefits of extending the working subperiod are the additional net labor income $(1-\tau)\,\beta(1+e_i)\theta_i$ plus a second term which represents the increase in the level of retirement benefits. Obviously, this increase in the level of benefits depends on α, the strength of the tax-benefit link. On the left hand side in equation (39), there are two marginal benefits of an increase in e_i. First, more training generates additional net income in period 2. And second, the retirement benefits are augmented by the product of additional contributions in period 2 and the strength of the tax-benefit link.

As in Section 3.2, the FOC (38) and (39) represent the optimality functions $t_i = R^{PAYG}(e_i)$ and $e_i = R^{PAYG}(t_i)$ with traditional PAYG:

$$t_i = R^{PAYG}(e_i) = (1-(1-\alpha)\,\tau)\,\frac{\beta\theta_i}{\gamma}\,(1+e_i) - \frac{k}{\gamma} \tag{40}$$

$$e_i = R^{PAYG}(t_i) = \delta\,(1-(1-\alpha)\,\tau)\,\beta\theta_i t_i \tag{41}$$

Compared to the situation with laissez-faire in (17), the optimality function $t_i = R^{PAYG}(e_i)$ is affected twice. First, it is twisted downward because the marginal benefits of labor supply in period 2 are reduced by the factor $(1-(1-\alpha)\,\tau)$, that part of the retirement benefits which is not adjusted in an actuarially fair way. And second, it is shifted downward because the Beveridge part of the benefits is independent of the worker's past contributions. Furthermore, the optimality function $e_i = R^{PAYG}(t_i)$ is twisted upward because the marginal benefits of training are scaled down. These modifications of the optimality functions are illustrated in figure 4.

Combining equations (38) and (39) yields

$$(t_i)^{PAYG} = \frac{(1-(1-\alpha)\,\tau)\,\beta\theta_i - k}{\gamma - \delta\left[(1-(1-\alpha)\,\tau)\,\beta\theta_i\right]^2} \tag{42}$$

$$(e_i)^{PAYG} = \delta\,(1-(1-\alpha)\,\tau)\,\beta\theta_i\,(t_i)^{PAYG} \tag{43}$$

As with laissez-faire, the worker's optimal values for retirement age and training increase with the bargaining power β, the ability θ_i, and the discount factor δ while they decrease with γ, the effort costs of labor. Furthermore, $(t_i)^{PAYG}$ and $(e_i)^{PAYG}$ decrease with τ and k because these components of the pension system reduce the net marginal returns to labor supply and education. Hence, cutting the payroll tax rate or the Beveridge type benefits will, ceteris paribus, postpone retirement. This result is in line with Martín (2003) who suggests that especially the retirement age of low-skilled workers is distorted by the minimum pension as represented by the Beveridge part of the pension system. As suggested by Jensen,

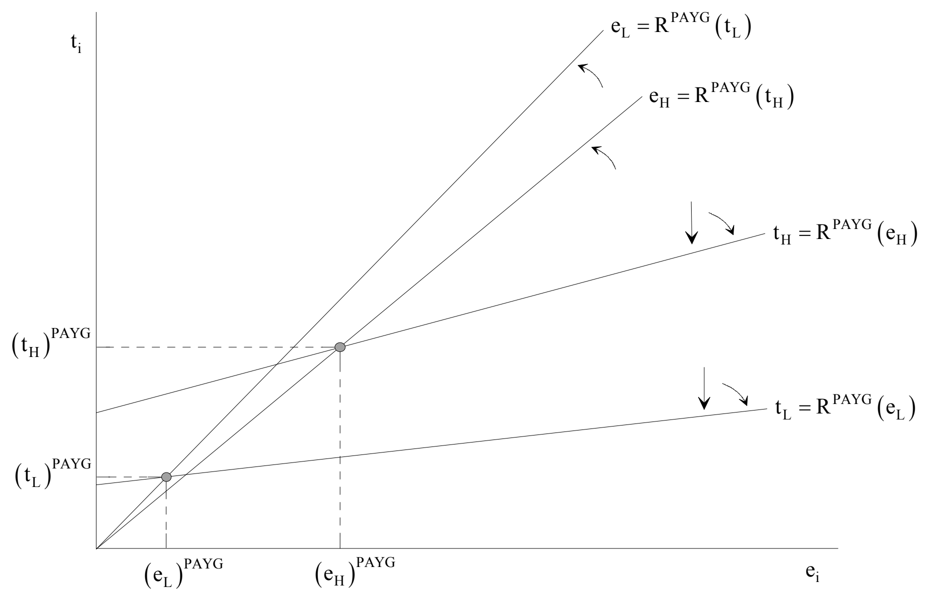

Figure 4: The Workers with Traditional PAYG

Lau, and Poutvaara (2004), strengthening the tax-benefit link implies an increase in the parameter α, which fosters human capital formation and increases the worker's retirement age.

With traditional PAYG, $(t_i)^{PAYG}$ and $(e_i)^{PAYG}$ are smaller than with laissez-faire because there is an implicit tax on extensive labor supply of older generations near retirement and on training intensity at the intensive margin:

$$(\tau_t^*)^{PAYG} = (1-\alpha)\tau + \frac{k}{\beta\left(1+(e_i)^{PAYG}\right)\theta_i} \quad (44)$$

$$(\tau_e^*)^{PAYG} = (1-\alpha)\tau \quad (45)$$

The implicit tax on labor supply in (44) is composed of two effects which are both generated by the pension system if there is no perfect tax-benefit link and the adjustment of benefits is not actuarially fair. First, for $\alpha < 1$ the tax-benefit link is imperfect because additional contributions do not fully translate into higher retirement benefits. And second, the Beveridge type component of the pension system implies that the individual labor income is reduced without proportionally increasing the level of retirement benefits. Hence, each worker forgoes benefits k by postponing retirement for another unit of time. In line with Crémer and Pestieau (2003), the implicit tax rate increases with k but decreases with θ_i.

As a borderline case, the traditional PAYG system manages to mimic the capital funded system of old-age provision. For $\alpha = 1$ and $k = 0$, the worker has the same incentives as with laissez-faire and chooses his optimal values for retirement age and training intensity according to (19) and (20). In this case, the implicit tax rates (44) and (45) are equal to zero and the pension system is referred to as neutral or actuarially fair (Cremer, Lozachmeur, and Pestieau (2004)). This result is in line with Lau and Poutvaara (2001b) who suggest that the best PAYG pension system is of the Bismarck type with actuarially fair adjustment of benefits.

4.3 The Current Situation with Traditional PAYG

Both workers and firms decide how long they want to produce in the second period. Depending on the worker's training intensity, the optimal separation date of the firm is described in equation (28). In period 2, the termination of production $(t_i)^*$ for ability type θ_i is defined by the smaller of the two values in (28) and (42) because then one party decides to leave the market and production is terminated:

$$(t_i)^* = \min\left\{(t_i)^{PAYG}, (t_i)^F\right\} \tag{46}$$

Subject to (41), it is the worker (and not the firm) who defines the end of production in period 2 if

$$\begin{aligned} (t_i)^{PAYG} &\leq (t_i)^F \\ (1-(1-\alpha)\tau) - \frac{1-\beta}{\beta}\frac{\gamma}{f}\theta_i &\leq \frac{k}{\beta(1+e_i)\theta_i} \end{aligned} \tag{47}$$

In the following analysis, we assume that the two ability types θ_L and θ_H satisfy the following condition:

$$(1-\tau)\frac{\beta}{1-\beta}\frac{f}{\gamma} < \theta_L < \frac{\beta}{1-\beta}\frac{f}{\gamma} < \theta_H \tag{48}$$

Hence, condition (47) is unambiguously satisfied for the ability type H, which implies that the separation date $(t_H)^*$ of ability type H corresponds to the worker's optimal retirement age in (42) (cf. figure 5):

$$(t_H)^* = (t_H)^{PAYG} = \frac{(1-(1-\alpha)\tau)\beta\theta_H - k}{\gamma - \delta\left[(1-(1-\alpha)\tau)\beta\theta_H\right]^2} \tag{49}$$

The strength of the tax-benefit link (α) determines whether (47) is also satisfied for the ability type L. If the tax-benefit link is weak (i.e. α is small), condition (47) is also satisfied for the ability type L. However, if the tax-benefit link is strong (i.e. α is large), it is the firm that determines the termination of production in period 2 because the optimality function $t_L = R^{PAYG}(e_L)$ moves upwards such that the firm's separation date $(t_L)^F$ falls below the worker's retirement age $(t_L)^{PAYG}$.

In the following, we assume that α is sufficiently small, which implies that also the separation date $(t_L)^*$ of ability type L corresponds to the worker's optimal retirement age in (42):

$$(t_L)^* = (t_L)^{PAYG} = \frac{(1-(1-\alpha)\tau)\beta\theta_L - k}{\gamma - \delta\left[(1-(1-\alpha)\tau)\beta\theta_L\right]^2} \tag{50}$$

Subject to this assumption, the traditional PAYG pension system is graphically illustrated in figure 5.

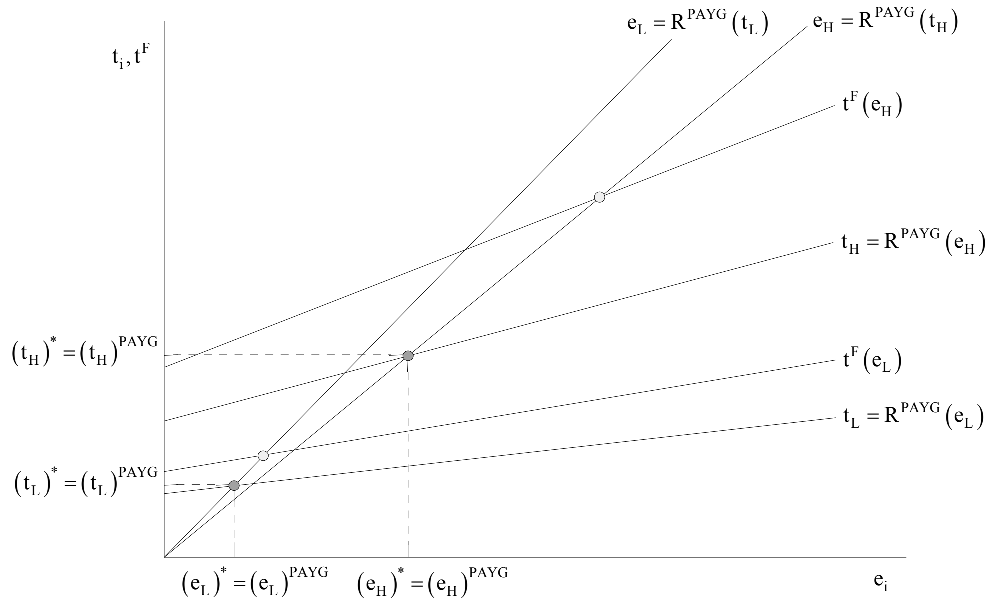

Figure 5: The Traditional PAYG Pension System

Because the retirement age corresponds to the worker's optimization, the training intensity of both ability types corresponds to the worker's optimal value in (43):

$$(e_H)^* = (e_H)^{PAYG} = \delta(1-(1-\alpha)\tau)\beta\theta_H(t_H)^{PAYG} \tag{51}$$

$$(e_L)^* = (e_L)^{PAYG} = \delta(1-(1-\alpha)\tau)\beta\theta_L(t_L)^{PAYG} \tag{52}$$

5 Pension Reform I: Implementation of Individual Retirement Accounts (IRA)

Policy discussions often propose to move from the traditional PAYG system to capital funding or at least to a mixed system comprising both a PAYG and a capital funded pillar (Kirchgässner (2005)). As discussed in Section 2.2.1, the capital funded system provides the fullest possible tax-benefit link and computes benefits in an actuarially fair way by definition. In a nutshell, it avoids any type of implicit taxation and thus constitutes a perfect substitute for private savings.

Retirement benefits according to capital funding are equal to

$$b^{CF} = \frac{1}{h-t_i}\left[R\tau\beta\theta_i + t_i\tau\beta(1+e_i)\theta_i\right] \tag{53}$$

Capital funding implies that the sum of all contributions during the working life is refunded as annuities after the retirement. The contributions of period 1 are augmented by the factor $R = (1+r)$.

Starting from the traditional PAYG system of old-age provision as discussed in Section 4.3, we analyze the implementation of individual retirement accounts and the impacts on labor supply and human capital formation. Individual retirement accounts represent the capital funded pillar of the pension system according to (53). Suppose that ω is the proportion of benefits generated by individual retirement accounts and thus a measure for the degree of capital funding of the pension system.[30]

Hence, total benefits b^{IRA} with individual retirement accounts are equal to

$$b^{IRA} = \omega b^{CF} + (1-\omega)\, b^{PAYG} \tag{54}$$

$$b^{PAYG} = k + \frac{\alpha}{h-t_i}\tau\beta\theta_i\left[1+t_i\left(1+e_i\right)\right] \tag{55}$$

5.1 The Retirement and Training Decision with Individual Retirement Accounts

Starting from (38) and (39), the worker's FOC are the following:

$$t_i \quad : \quad \delta\left[(1-\tau)\,\beta(1+e_i)\theta_i + (h-t_i)\left(\omega\frac{\partial b^{CF}}{\partial t_i} + (1-\omega)\,\frac{\partial b^{PAYG}}{\partial t_i}\right)\right] = \delta\left[\gamma t_i + b^{IRA}\right] \tag{56}$$

$$e_i \quad : \quad \delta\left[t_i\,(1-\tau)\,\beta\theta_i + (h-t_i)\left(\omega\frac{\partial b^{CF}}{\partial e_i} + (1-\omega)\,\frac{\partial b^{PAYG}}{\partial e_i}\right)\right] = e_i \tag{57}$$

The interpretation of the FOC is similar to the general decision problem in Section 4.1. However, the retirement benefits are composed of two parts that correspond to the different pillars of the pension system and are included by the weights ω and $(1-\omega)$, respectively. Applying the benefit rules (53) and (55) yields the optimality functions

$$t_i = R^{IRA}\left(e_i\right) = \left[1-(1-\omega)\,(1-\alpha)\,\tau\right]\frac{\beta\theta_i}{\gamma}\left(1+e_i\right) - (1-\omega)\,\frac{k}{\gamma} \tag{58}$$

$$e_i = R^{IRA}\left(t_i\right) = \delta\left[1-(1-\omega)\,(1-\alpha)\,\tau\right]\beta\theta_i t_i \tag{59}$$

The worker's optimality functions are graphically illustrated in figure 6. Compared to the situation with traditional PAYG in (40), the optimality function $t_i = R^{IRA}(e_i)$ is affected twice. It is twisted upward and shifted upward because both the tax-benefit link and the degree of actuarial adjustment are increased by the capital funded pillar of the pension system. Furthermore, $e_i = R^{IRA}(t_i)$ is twisted downward because the marginal benefits of training are augmented.

Combining (58) and (59) yields

$$\left(t_i\right)^{IRA} = \frac{\xi(\omega)\,\beta\theta_i - (1-\omega)\,k}{\gamma - \delta\left[\xi(\omega)\,\beta\theta_i\right]^2} \tag{60}$$

$$\left(e_i\right)^{IRA} = \delta\xi(\omega)\,\beta\theta_i\left(t_i\right)^{IRA} \tag{61}$$

[30] In fact, most PAYG systems determine the division of contributions rather than the division of benefits. In this case, ω is related to τ and the division of b^{IRA} is endogenously determined by the different returns to the capital funded pillar and the PAYG pillar of the pension system. Because the return to capital funding corresponds to the market rate of return and thus exceeds the return to PAYG, the proportion of benefits generated by individual retirement accounts is larger than ω (Feldstein (2005a)).

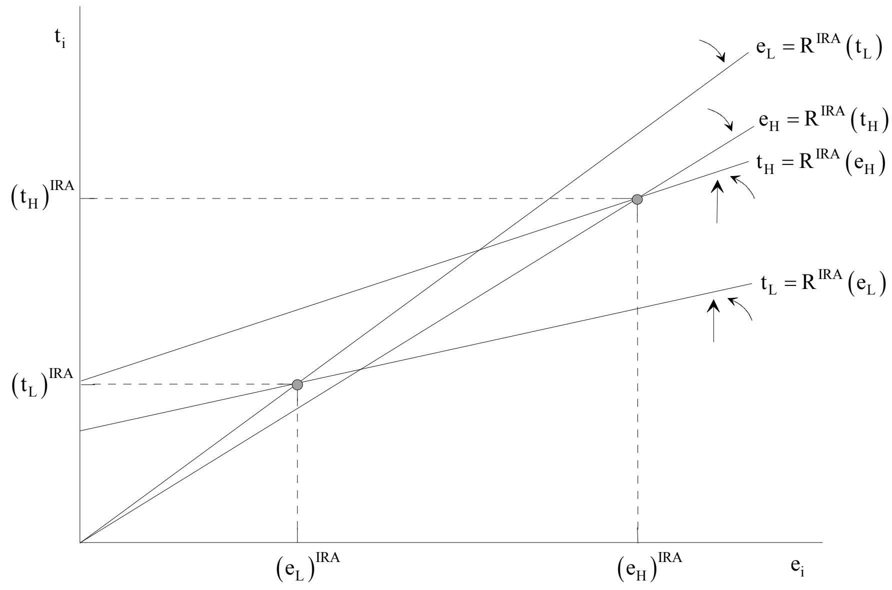

Figure 6: The Workers with Individual Retirement Accounts

with $\xi(\omega) \equiv 1 - (1-\omega)(1-\alpha)\tau$.

The implicit tax rates are equal to

$$(\tau_t^*)^{IRA} = (1-\omega)\left[(1-\alpha)\tau + \frac{k}{\beta\left(1+(e_i)^{IRA}\right)\theta_i}\right] \tag{62}$$

$$(\tau_e^*)^{IRA} = (1-\omega)(1-\alpha)\tau \tag{63}$$

The implicit tax rates $(\tau_t^*)^{IRA}$ and $(\tau_e^*)^{IRA}$ decrease with ω because distortions are reduced by moving towards capital funding. If there are no individual retirement accounts (i.e. $\omega = 0$), $(t_i)^{IRA}$ and $(e_i)^{IRA}$ are equal to the optimal values of the pure PAYG system according to (42) and (43). If the pension system is completely capital funded (i.e. $\omega = 1$), there are no distortions compared to the situation with laissez-faire:

$$\left.(\tau_t^*)^{IRA}\right|_{\omega=1} = (\tau_t^*)^{CF} = 0$$

$$\left.(\tau_e^*)^{IRA}\right|_{\omega=1} = (\tau_e^*)^{CF} = 0$$

5.2 The Effects of Individual Retirement Accounts

Similar to (46) for the traditional PAYG system, the termination of production in period 2 for ability type θ_i is defined by

$$(t_i)^* = \min\left\{(t_i)^{IRA}, (t_i)^F\right\} \tag{64}$$

Subject to (59), it is the worker (and not the firm) who defines the end of production in period 2 if

$$(t_i)^{IRA} \leq (t_i)^F$$
$$\xi(\omega) - \frac{1-\beta}{\beta}\frac{\gamma}{f}\theta_i \leq \frac{(1-\omega)k}{\beta(1+e_i)\theta_i} \tag{65}$$

Because of (48), this condition is unambiguously satisfied for the ability type H, which implies that the separation date $(t_H)^*$ of ability type H corresponds to the worker's optimal retirement age in (60) (cf. figure 7):

$$(t_H)^* = (t_H)^{IRA} = \frac{\xi(\omega)\beta\theta_H - (1-\omega)k}{\gamma - \delta[\xi(\omega)\beta\theta_H]^2} \tag{66}$$

The degree of capital funding (ω) determines whether (65) is also satisfied for the ability type L. If the capital funded pillar is weak (i.e. ω is small), condition (65) is also satisfied for the ability type L. In this case, the separation date of ability type L also corresponds to the worker's optimal retirement age in (60). However, if the capital funded pillar is strong (i.e. ω is large), it is the firm that determines the termination of production in period 2 because the optimality function $t_L = R^{IRA}(e_L)$ moves upwards such that the firm's separation date $(t_L)^F$ falls below the worker's retirement age $(t_L)^{IRA}$.

Because $(t_L)^{IRA} < (t_L)^F$ for $\omega = 0$ (this is the case of traditional PAYG) and $(t_L)^{IRA} > (t_L)^F$ for $\omega = 1$ (cf. Appendix B.2), there must be some critical level $\bar{\omega}$ such that for $\omega > \bar{\omega}$ the firm's separation date $(t_L)^F$ falls below the worker's retirement age $(t_L)^{IRA}$. Therefore, if the capital funded pillar is strong (i.e. $\omega > \bar{\omega}$), it is the firm that determines $(t_L)^*$, the termination of production in period 2. In this case, $(t_L)^F$ is obtained by substituting the optimality function (59) into equation (28) and solving for t.

Altogether, the separation date $(t_L)^*$ of ability type L is equal to

$$(t_L)^* = \begin{cases} (t_L)^{IRA} = \frac{\xi(\omega)\beta\theta_L - (1-\omega)k}{\gamma - \delta[\xi(\omega)\beta\theta_L]^2} & \text{if } \omega \leq \bar{\omega} \\ (t_L)^F = \frac{(1-\beta)(\theta_L)^2}{f - \delta\xi(\omega)\beta(1-\beta)(\theta_L)^3} & \text{if } \omega > \bar{\omega} \end{cases} \tag{67}$$

For $\omega > \bar{\omega}$, the implementation of individual retirement accounts is graphically illustrated in figure 7.

Furthermore, the training intensity of both ability types is determined by substituting the separation date into the optimality function (59). Hence, the level of training with individual retirement accounts is equal to

$$(e_H)^* = (e_H)^{IRA} = \delta\xi(\omega)\beta\theta_H(t_H)^{IRA} \tag{68}$$

$$(e_L)^* = \begin{cases} (e_L)^{IRA} = \delta\xi(\omega)\beta\theta_L(t_L)^{IRA} & \text{if } \omega \leq \bar{\omega} \\ (e_L)^F = \delta\xi(\omega)\beta\theta_L(t_L)^F & \text{if } \omega > \bar{\omega} \end{cases} \tag{69}$$

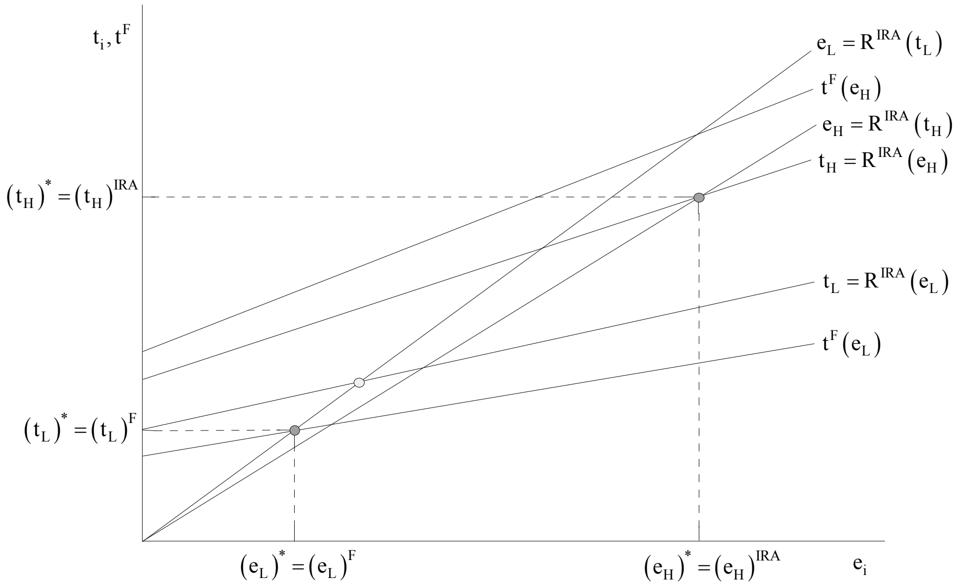

Figure 7: The Effecs of Individual Retirement Accounts

5.3 Interpretation

The introduction of individual retirement accounts implies that the implicit tax on labor supply and training is reduced. This can be seen by comparing the implicit tax rates with traditional PAYG in (44) and (45) and with individual retirement accounts in (62) and (63). As a consequence, human capital formation is increased and retirement is postponed. These results are in line with Lau and Poutvaara (2001a). However, concentrating on the worker's retirement and training decision in (60) and (61) and neglecting the production side of the economy may be misleading in evaluating the welfare gains of individual retirement accounts.

The effects of pension reforms also depend on labor market prospects of older workers near retirement age. These labor market prospects positively depend on the worker's ability. While high-ability workers indeed react to the introduction of individual retirement accounts according to (66) and (68), low-ability workers may be restricted by the firm's decision to terminate production. If the capital funded pillar of the pension system becomes strong, low-ability workers may not attain their optimal retirement age because firms refuse to employ them any longer. For $\omega > \bar{\omega}$, the separation date of ability type L is determined by $(t_L)^F$, which implies that the separation date increases to a much lower extent than suggested by the worker's optimal retirement age $(t_L)^{IRA}$.

Depending on the level of ω, the effects of strengthening the capital funded pillar for low-ability workers are as follows:

$$\frac{\partial (t_L)^*}{\partial \omega} = \begin{cases} \frac{\partial (t_L)^{IRA}}{\partial \omega} & \text{if } \omega \leq \bar{\omega} \\ \frac{\partial (t_L)^F}{\partial \omega} & \text{if } \omega > \bar{\omega} \end{cases} \tag{70}$$

The separation date $(t_L)^*$ unambiguously increases with ω because also the firm's optimal separation date $(t_L)^F$ positively depends on ω. The latter increases with ω because human capital formation is encouraged and so the firm can increase its profits by extending the time of production in period 2. However, the comparative statics of $(t_L)^{IRA}$ and $(t_L)^F$ are of different magnitude (cf. Appendix B.1):

$$0 < \frac{\partial (t_L)^F}{\partial \omega} < \frac{\partial (t_L)^{IRA}}{\partial \omega} \tag{71}$$

Hence, for $\omega > \bar{\omega}$, there is a gap between the optimal retirement age of low-ability workers and the actual separation date due to the firm's decision to terminate production. This gap increases with ω and has its maximum for $\omega = 1$. As a consequence, the ratio of retirees per active worker is reduced by less than suggested by the worker's incentives to go on pension.

For $\omega = 1$, the pension system is completely moved towards capital funding which implies that the worker has the same incentives as in the case of laissez-faire and chooses his optimal values for retirement age and training intensity according to (19) and (20). However, these values are not feasible once the separation decision of the firms is controlled for.

6 Pension Reform II: Increasing the Minimum Retirement Age (MR)

Postponed retirement is generally considered to be a key policy response to population aging because the ratio of retirees per active worker is reduced without changing the nature of the PAYG system (Lindbeck and Persson (2003)). In this context, EuropeanCommission (2001) concludes that increasing the effective retirement age to 65 will significantly limit the necessary increase in the social security contributions in the period between 2000 and 2050 (from 16% to 20.5% instead of 27%). Hence, a second proposal for pension reform refers to an increase in the minimum retirement age (for example Sayan and Kiraci (2001) and Gruber and Wise (2005)).

In our model, the minimum retirement age represents the lowest age of eligibility. Hence, workers are not allowed to choose a retirement age below the minimum retirement age $\bar{t}$. This lower bound $\bar{t}$ is identical for all workers and thus independent of their individual ability. In a nutshell, the minimum retirement age implies that workers face an additional restriction with respect to their retirement decision.

6.1 The Retirement and Training Decision with Minimum Retirement Age

In general, the decision problem of the workers remains the same as with traditional PAYG. Hence, the worker's optimal values for retirement age and training intensity are defined by (42) and (43). However, the retirement age must not fall below $\bar{t}$ which implies

$$(t_i)^{MR} = \max\left\{(t_i)^{PAYG}, \bar{t}\right\} \tag{72}$$

For $(t_i)^{PAYG} \leq \bar{t}$, the retirement restriction is binding for the ability type θ_i so that the worker's retirement age is equal to

$$(t_i)^{MR} = \bar{t} \tag{73}$$

In this case, the training intensity with $\bar{t}$ is described by the optimality function (41):

$$(e_i)^{MR} = \delta (1 - (1 - \alpha) \tau) \beta \theta_i \bar{t} = \bar{e}_i \tag{74}$$

6.2 The Effects of Increasing the Minimum Retirement Age

If the minimum retirement age is not binding (i.e. for $(t_i)^{PAYG} > \bar{t}$), the separation date is the same as with traditional PAYG in (49) for the ability type H and in (50) for the ability type L. However, if the retirement restriction is binding for the worker with ability θ_i, the termination of production in period 2 is defined by

$$(t_i)^* = \min \left\{ (t_i)^F, \bar{t} \right\} \tag{75}$$

Hence, it is the firm that defines the separation date if

$$(t_i)^F \leq \bar{t} \tag{76}$$

Altogether, the separation date for both ability types depends on the level of the minimum retirement age:

$$(t_i)^* = \begin{cases} (t_i)^{PAYG} & \text{if } \bar{t} < (t_i)^{PAYG} \\ \bar{t} & \text{if } (t_i)^{PAYG} \leq \bar{t} < (t_i)^F \\ (t_i)^F & \text{if } \bar{t} \geq (t_i)^F \end{cases} \tag{77}$$

For example, if the minimum retirement age $\bar{t}$ lies between the firm's separation dates for ability type L and H, i.e. $(t_L)^F < \bar{t} < (t_H)^F$, the situation for the ability types is the following (cf. figure 8):

$$\begin{aligned} (t_L)^{PAYG} &< (t_L)^F < \bar{t} \\ (t_H)^{PAYG} &< \bar{t} < (t_H)^F \end{aligned}$$

In this case, the termination of production $(t_H)^*$ for the high-ability worker is defined by the minimum retirement age:

$$(t_H)^* = \bar{t} \tag{78}$$

For the low-ability worker, the separation date $(t_L)^*$ is determined by substituting the optimality function (59) into equation (28) and solving for t:

$$(t_L)^* = (t_L)^F = \frac{(1 - \beta) (\theta_L)^2}{f - \delta (1 - (1 - \alpha) \tau) \beta (1 - \beta) (\theta_L)^3} \tag{79}$$

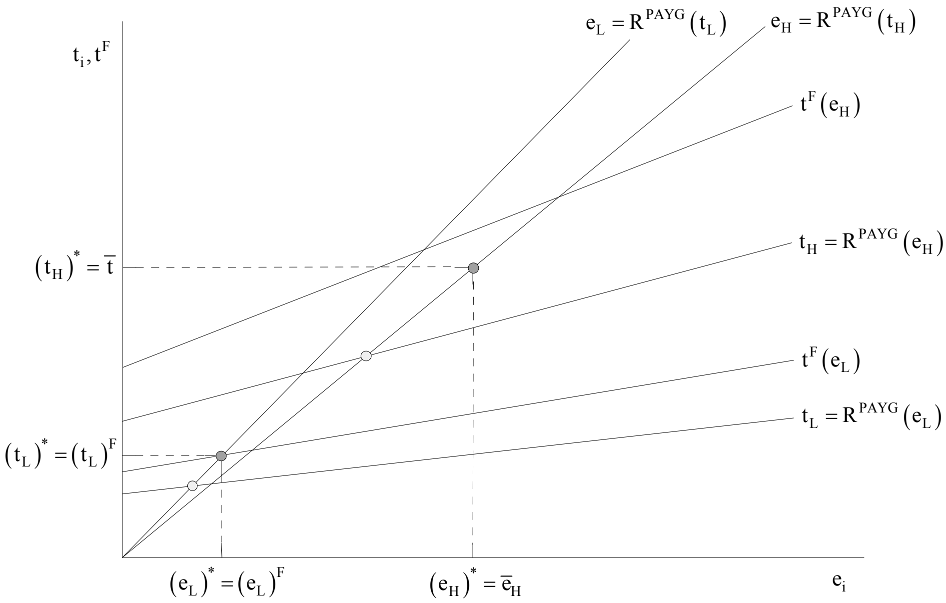

Figure 8: The Effects of Increasing the Statutory Retirement Age

This situation with $(t_L)^F < \bar{t} < (t_H)^F$ is graphically illustrated in figure 8.

According to (41), the worker's training intensity is equal to

$$(e_H)^* = \bar{e}_H \tag{80}$$

$$(e_L)^* = \delta\left(1 - (1-\alpha)\tau\right)\beta\theta_L (t_L)^F \tag{81}$$

6.3 Interpretation

Increasing the minimum retirement age aims at augmenting the labor force participation at the extensive margin. However, the effective implications of an increase in $\bar{t}$ are obtained by analyzing the comparative statics of (77):

$$\frac{\partial (t_i)^*}{\partial \bar{t}} = \begin{cases} 0 & \text{if } \bar{t} < (t_i)^{PAYG} \\ 1 & \text{if } (t_i)^{PAYG} \leq \bar{t} < (t_i)^F \\ 0 & \text{if } \bar{t} \geq (t_i)^F \end{cases} \tag{82}$$

These comparative statics show that the separation date $(t_i)^*$ is not affected if the minimum retirement age exceeds the optimal separation date of the firm. Hence, the effects of increasing the minimum retirement age are limited by the labor market prospects of older workers. As illustrated in figure 8, the situation $(t_L)^F < \bar{t} < (t_H)^F$ implies that only the separation date of high-ability workers is increased by raising $\bar{t}$:

$$\frac{\partial (t_H)^*}{\partial \bar{t}} = 1 \quad (83)$$

$$\frac{\partial (t_L)^*}{\partial \bar{t}} = 0 \quad (84)$$

In this case, high-ability workers are affected because they are forced to stay inside the labor market until they have reached the minimum retirement age. This is in line with the simulation results of Gruber and Wise (2002). By contrast, there is no impact on low-ability workers because it is the firm that decides to separate before the minimum retirement age is achieved. As in the case of individual retirement accounts, concentrating on the worker's retirement and training decision in (73) and (74) and neglecting the production side of the economy may be misleading in evaluating the welfare gains of pension reforms.

7 Conclusion

The demographic transition in industrialized countries poses challenges to the pension system which is essentially organized according to the PAYG principle in most countries. This paper presents a two-period partial-equilibrium model that systematically compares the implications of different pension reforms for the retirement behavior at the extensive margin. Starting from the current system of traditional PAYG, two proposals for pension reforms are analyzed which aim at compensating the adverse effects of demographic change on the relative size of the active population.

Our formal analysis is based on recent literature on old-age provision, but the model manages to explain endogenously both the date of retirement and the formation of human capital. It is important to incorporate the training decision into the analysis of pension reforms because extending the working life increases the return to education and thus fosters the workers' incentives to acquire skills. Furthermore, the model incorporates worker heterogeneity in ability which allows to analyze the implications of the pension system for different groups of workers. In line with Cremer, Lozachmeur, and Pestieau (2004) and Martín (2003), the retirement age increases with the worker's productivity which depends on initial ability and the level of training.

Compared to the situation with laissez-faire, the traditional PAYG pension system with an imperfect tax-benefit link creates an implicit tax on extensive labor supply of older workers near retirement and on training at the intensive margin. The weaker the tax-benefit link, the larger are the implicit tax components of the contribution rates and the more harmful are labor market distortions. In contrast, the capital funded system implies a zero implicit tax rate because it constitutes a perfect substitute for private savings.

The first reform proposal suggests to introduce individual retirement accounts in order to (partly) move from the prevalent PAYG towards a capital funded system of old-age provision. Indeed, increasing the size of the capital funded pillar of the pension system reduces the implicit tax on labor supply at the extensive margin. In line with Crémer and Pestieau (2003) and Lau and Poutvaara (2001a), this pension reform provides incentives for older workers to postpone retirement because a capital funded system rewards late retirement with an actuarial fair increase in subsequent pension benefits. A second benefit of capital funding follows from the labor market and refers to human capital formation. In line with Trostel (1993), the worker's ability to exploit more fully his labor potential at the extensive margin increases the returns to human capital investments. In particular, postponed retirement lengthens the time period over which individuals can appropriate the returns to education. In aggregate, there is a double benefit from the introduction of individual retirement accounts: reductions in labor market distortions at the extensive margin (retirement age) as well as increased human capital formation at the intensive margin (training intensity).

According to empirical estimates of Hernoes, Sollie, and Strom (2000), education is an important determinant of the retirement age. While early retirement is low among high-skilled workers, low-skilled workers tend to leave the labor force much earlier. One explanation could be that the retirement decision is essentially distorted for low-skilled workers (for example due to minimum pensions), which implies that the implementation of individual retirement accounts mainly affects the retirement of high-skilled workers (Martín (2003)).

In our model, the reduced impact of individual retirement accounts on low-ability workers stems from the firms' employment decision at the extensive margin. It is important to include the production side of the economy because the economic benefits of pension reforms strongly depend on the employment prospects of older workers near retirement age. In line with Lazear (1979), the firm's separation date increases with the worker's educational achievement. Hence, if the capital funded pillar of the pension system becomes strong and workers strive to significantly postpone retirement, low-ability workers may not attain their optimal retirement age because firms refuse to employ them any longer. Depending on the degree of capital funding, the benefits of this pension reform mainly accrue for high-ability workers while the benefits for low-ability workers are reduced once their employment prospects near retirement age are controlled for.

The second reform proposal suggests to increase the relative size of the active population by raising the minimum retirement age. Again, only high-ability workers may be affected because they are forced to stay inside the labor market until they have reached the minimum retirement age. In contrast, there may be no impact on low-ability workers if their separation date is determined by the firms before the minimum retirement age is achieved. This is in line with simulation results of Gruber and Wise (2002).

In our model, retirement and human capital formation are endogenously determined and depend on the individual ability of workers. Nevertheless, the model has been kept simple for expositional and calculational reasons. The theoretical results of our stylized model only allow for qualitative conclusions concerning the evaluation of pension reforms. In order to assess the quantitative magnitude of these effects, we would have to estimate the elasticities of the workers' retirement and training responses. However, the underlying insights into the model presented here are robust to various types of generalization. Hence, they constitute a promising basis for policy recommendations and for future research.

A Retirement and Training with Laissez-Faire

As shown in Section 3.2, the FOC with laissez-faire are the following:

$$\delta\beta(1+e_i)\theta_i = \delta\gamma t_i \tag{A1}$$

$$\delta t_i \beta\theta_i = e_i \quad \Leftrightarrow \quad t_i = \frac{e_i}{\delta\beta\theta_i} \tag{A2}$$

Solving (A2) for t and substituting the result into (A1) implies

$$\begin{aligned}
\delta\beta(1+e_i)\theta_i &= \frac{\gamma e_i}{\beta\theta_i} \\
\delta(1+e_i)\left(\beta\theta_i\right)^2 &= \gamma e_i \\
\delta\left(\beta\theta_i\right)^2 &= \left[\gamma - \delta\left(\beta\theta_i\right)^2\right] e_i
\end{aligned}$$

Solving for e_i yields

$$\left(e_i\right)^{LF} = \frac{\delta\left(\beta\theta_i\right)^2}{\gamma - \delta\left(\beta\theta_i\right)^2} \tag{A3}$$

By substituting $\left(e_i\right)^{LF}$ into equation (A2) we obtain

$$\left(t_i\right)^{LF} = \frac{\beta\theta_i}{\gamma - \delta\left(\beta\theta_i\right)^2} \tag{A4}$$

B Comparison of the Comparative Statics with Individual Retirement Accounts

For $\omega > \bar{\omega}$, $\left(t_L\right)^{IRA}$ increases with ω more rapidly than $\left(t_L\right)^{F}$:

$$\begin{aligned}
\frac{\partial\left(t_L\right)^F}{\partial\omega} &< \frac{\partial\left(t_L\right)^{IRA}}{\partial\omega} \\
\frac{\delta\tau\left(1-\alpha\right)\beta\left(1-\beta\right)^2\left(\theta_L\right)^5}{\left[f - \delta\xi\left(\omega\right)\beta\left(1-\beta\right)\left(\theta_L\right)^3\right]^2} &< \frac{\tau\left(1-\mu\right)\beta\theta_L\left[\gamma + \delta\left(\xi\left(\omega\right)\beta\theta_L\right)^2\right]}{\left[\gamma - \delta\left(\xi\left(\omega\right)\beta\theta_L\right)^2\right]^2}
\end{aligned}$$

By applying the definitions of $\left(t_L\right)^{IRA}$ and $\left(t_L\right)^{F}$ in (67), this inequality simplifies to

$$\delta\left[\left(t_L\right)^F\right]^2 < \delta\left[\left(t_L\right)^{IRA}\right]^2 + \left[\gamma - \delta\left(\xi\left(\omega\right)\beta\theta_L\right)^2\right]^2\gamma \tag{B1}$$

This condition is unambiguously satisfied for $\omega > \bar{\omega}$ because $\left(t_L\right)^F < \left(t_L\right)^{IRA}$.

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