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ABSTRACT

In response to the challenges of increasing longevity, an obvious policy response is to gradually increase the statutory eligibility age for public pension benefits and to shut down pathways to early retirement such as special rules for women. This is, however, very unpopular. As an alternative, many countries have introduced “flexibility reforms” which allow combining part-time work and partial retirement. A key measure of these reforms is the abolishment of earnings tests. It is claimed that these reforms increase labor supply and therefore, also the sustainability of pension systems. We show that these claims may not be true in the circumstances of most European countries.

To this end, we employ a life-cycle model of consumption and labor supply where the choices of labor force exit and benefit claiming age are endogenous and potentially separate. Earnings tests force workers to exit the labor market when claiming a pension. After abolishing the earnings test, workers can claim their benefits and can keep on working, potentially increasing labor supply. Our key result is that the difference between exit and claiming age strongly depends on the actuarial neutrality of the pension system and can become very large. Abolishing an earnings test as part of a “flexibility reform” may therefore create more labor supply but at the same time, reduce the average claiming age when adjustments remain less than actuarial, thereby worsening rather than improving the sustainability of public pension systems.

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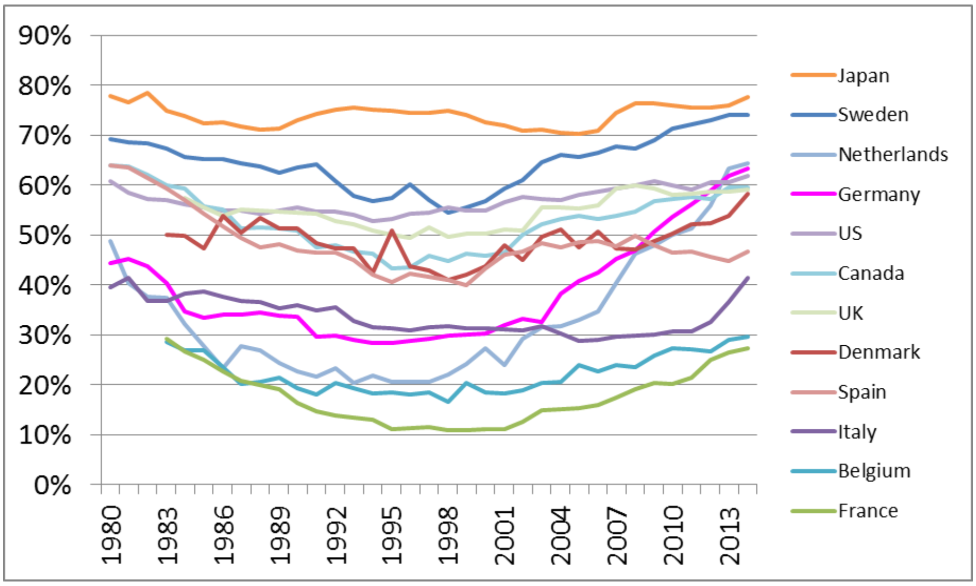
1. Introduction

Living longer is a great achievement of modern societies but has posed major challenges to policy makers as they struggle to keep the social security systems sustainable. As a consequence, much attention has been given to labor supply at older ages since working longer helps to decrease a pension system's dependency ratio. Many countries have introduced gradual increases of the statutory eligibility age and shut down pathways to early retirement. This has, among other factors (Coile et al., 2018), led to a striking reversal around the year 2000 of the long-term trend to ever earlier retirement observed since the 1970s (Figure 1).

Figure 1 – Labor force participation among men 60-64



Source: OECD Employment Data (2017)

Nevertheless, the percentage of individuals who retire early is still large, regardless of the statutory eligibility age implemented. Except for Sweden, all European countries depicted in Figure 1 feature less than 65% labor force participation among men aged 60-64. In France, Belgium, Italy and Spain the majority of men in this age range have already retired. In Germany, which has experienced the strongest reversal in labor force participation, the actual average retirement age is about 62.1 years, more than 3 years earlier than the current statutory eligibility age which is 65 years and 3 months (Börsch-Supan et al., 2017; OECD, 2015). This observation is in line with the many incentives left which create early retirement, in particular earnings tests and less than actuarial adjustment factors to the benefits claiming age.

In addition, backlashes against further reforms have become very large. Increasing the eligibility age for public pensions and increasing the penalties for early retirement are especially unpopular policies. Politicians consider them as the “third rail in politics”, referring to the high-voltage rail in the subway which gives a fatal jolt to those who touch it (Safire 2007, Lynch and Myrskyl 2009). Some countries have even introduced new pathways to early retirement (e.g. Germany) and re-instated earlier eligibility ages for women (e.g. Poland).

As a substitute for increasing the eligibility age and the penalties for early retirement, “flexibility reforms” have become a favorable policy (Graf et al., 2011; Huber et al., 2013; Sonnet et al., 2014; Börsch-Supan et al., 2017). They introduce partial retirement, a combination of part-time work and partial pension benefit receipt by relaxing constraints such as earnings tests which often impose very tight maximum hours constraints on working after the earliest eligibility age for public pensions.

While “flexibility” sounds desirable and abolishing constraints has intuitive appeal to policy makers and the populace in general, this paper argues that such reforms may backfire. We show with a general life-cycle model that abolishing an earnings test as part of a “flexibility reform” may create more labor supply but at the same time, will reduce the average claiming age when adjustments remain less than actuarial, thereby worsening rather than improving the sustainability of public pension systems.

The key element of flexibility reforms is the abolishment of an existing earnings test. Earnings tests are a specific form of means-testing and impose an upper limit on earnings while receiving a pension. In their most stringent form, earnings tests force workers to exit the labor market when claiming a pension. In contrast, without an earnings test, workers could claim their benefits and continue working, thus potentially increasing labor supply. Earnings tests have been abolished in a few countries (e.g. in the US, Canada and the UK) quite some time ago. Norway has been the most recent European country to follow their example. Table 1, however, shows that many European countries still have earnings tests for individuals who retire before the statutory eligibility age (SEA), e.g. France or Germany, with different limits and different rules (Social Security Administration, 2014).

Table 1 – Adjustments to retirement age and earnings tests across selected countries

	Adjustment rate	Earnings tests
Australia	-[1]	Pension is means tested against any income above AUD 4,200/7,500 p.a. (singles/couples); 50% withdrawal rate;
Austria	4.2%	Before SEA: when earnings are above a ceiling of 290 € per month, the pension is fully withdrawn; After SEA: no limit
Belgium	- [2]	Before SEA: when annual earnings are above 7,793€ (single) or 11,689 € (dependent child) per year, the pension is reduced by the amount that exceeds the limit. If annual earnings are 25% above the limit, the pension is fully withdrawn for as long as the additional income is higher than the ceiling; After SEA: when earnings are above 22,509 € (single) or 27,379 € (dependent child) per year, the pension is reduced by the amount that exceeds the limit. If annual earnings are 25% above the limit, the pension is fully withdrawn for as long as the additional income is higher than the ceiling. For a retiree older than 65 with at least 42 years of contribution, the ceiling is lifted entirely
Canada	0.6%	No limit
Denmark	- [3]	Before SEA: no public pension receipt possible, therefore no conflict between public pension benefits and additional income; After SEA: full basic pension (795€ per month or 9,540€ per year, which is equivalent to around 17% of average earnings) is reduced at a rate of 30% against earned income, if work income exceeds 40,518€ per year (approx. ¾ of average earnings)
Finland	4.8%	No limit
France	5.0%	No limit for full pension recipients; workers are eligible for full public pension benefits if they fulfil either both a minimum contributory record (in 2014: 41.25 years for people born in 1953) and the minimum legal pension age (61 years and two months) or the age of 66 years and two months
Germany	3.6%	Before SEA: for drawing full pension payments the limit is one-seventh of the reference base (i.e. 3,060€ per year or 255€ per month respectively); for drawing a partial pension the ceiling is dependent of the partial pension level, i.e. 1,483€ per month (1/3 partial pension), 1,112€ per month (1/2 partial pension), 741€ per month (2/3 partial pension), multiplied with the individual earnings points in the year before pension claiming; After SEA: no limit
Italy	1 – 2%	No limit
Japan	8.4%	Up to age 69. Threshold differs for ages 60–64 and 65–69; marginal withdrawal rate is 50%.
Netherlands	- [4]	Before SEA: no public pension receipt possible, therefore no conflict between public pension benefits and additional income; After SEA: no ceiling on additional earnings for public pension recipients
New Zealand	- [5]	No limit

Norway	3.8-4.7%	No limit
Spain	2-3% /6.5%- 8%	Until 2013 work and pension were incompatible except under the partial retirement program.
Sweden	4.1-4.7%	No limit
UK	5.4%	No limit
US	5.0-6.67%	Limits between 62 and SEA; after SEA: no limits

[1] In Australia there are no adjustment rates implemented. [2] In Belgium, there is no actuarial reduction in the pension calculation in case of early retirement. However, the pension of the early retirees can be incomplete if they have worked less than 45 years. [3] In Denmark, early claiming of pension benefits is not possible. [4]In the Netherlands, it is not possible to claim public pensions before the SEA. Early retirement is financed either by private savings or by occupational pensions. [5] In New Zealand, there are no adjustment rates implemented. Sources: Queisser & Whitehouse (2006), Blundell et al. (2016) and Börsch-Supan et al. (2017).

Table 1 also shows how diverse and relatively small adjustment factors are between countries. These adjustment factors link the pension benefit to the age at which individuals begin claiming pension benefits. They are crucial elements of a pension system to understand the beneficial or harmful effects of flexibility reforms since they reduce benefits by a certain percentage ("adjustment rate") when an individual claims pension benefits earlier than the statutory eligibility age, and increase benefits when claiming benefits is postponed after the statutory eligibility age. If an individual's choice of claiming age should be neutral to the sustainability of the pension system, these adjustment factors must be actuarially neutral, i.e., they should equalize the present discounted value of pension benefits across all permissible claiming ages. Depending on age and life expectancy, actuarial adjustment rates are between 6.5 and 8 percent (Börsch-Supan, 2004; Queisser & Whitehouse, 2006; Werding, 2007 and 2012; Gasche, 2012; OECD, 2015). In most European countries, however, they are substantially lower (Table 1).

This paper employs a life-cycle model of rational consumption and labor supply choices in order to study the interaction between earnings tests and actuarial adjustments during the window of retirement when workers are allowed to choose their retirement age.[1] A key feature of our model is that households may decide separately on their claiming age R and their exit age from the labor force X $(R \gtreqless X)$, subject to the rules and parameters of the pension system. The main aim of the paper is to study the reaction of these two potentially separate ages R and X to the

[1] In this paper, we do not take into account time inconsistent decision making. See our concluding sections and Börsch-Supan et al. (2016) which provides a discussion and models designed for this case. Time inconsistent behavior will strengthen our results about early claiming since time inconsistent individuals tend to prefer receiving benefits as soon as possible. We also abstract from other behavioral mechanisms such as norms and anchoring because our focus is on the incentives created by adjustment factors and earning tests.

parameters of the pension system and other determinants driving the retirement decision. Among the parameters of the pension system, we focus on the adjustment factors which link the pension benefit to the chosen claiming age. Other determinants influencing the retirement behavior include declining health, declining productivity, increasing appreciation of leisure versus consumption, and fixed costs of working.

Our contribution to the literature combines four aspects. First, we model the three decisions: to claim benefits, to choose working hours (intensive margin of labor supply) and to exit the labor force (extensive margin) as separate decisions in a unified life-cycle framework. This is crucial in order to understand partial retirement. Second, we offer several alternative mechanisms that create the abrupt jump in the hours' supply to zero when exiting the labor force, including a minimum hours constraint generated by fixed time costs of working. This is important in order to understand the incentives to keep on working. Third, we do not restrict our analysis to the effects of abolishing an earnings test on labor supply but also predict the implications for the financial sustainability of a prototypical public pay-as-you-go pension system. Fourth, we extend this analysis from the actuarially neutral case to the case of distortive adjustment factors which are more typical for the pension systems in Europe as compared to the US. Taken together, these four aspects are essential to better understand in which institutional setting a reform towards more flexibility will not only boost labor supply but also strengthen the financial sustainability of pension systems.

We show that the difference between exit and claiming age strongly depends on the preference for consumption versus leisure and can become very large. This is in line with previous literature and our intuition on how workers tend to react to stimuli that affect their preferences for consumption, leisure and savings. There are, however, also interaction effects that are more complex and not covered by the existing literature. Most importantly, the difference between exit and claiming age strongly depends on the actuarial neutrality of the pension system. We show, for instance, that abolishing an earnings test will reduce the average claiming age when adjustments are less than actuarial, hence worsening rather than improving the sustainability of public pension systems. This effect is not compensated by the increase in labor supply.

Our model provides a unified framework which nests and explains a host of empirical findings which have been provided by the literature. There is a large empirical literature which has concentrated its efforts on identifying the effects of the abolishment of earnings tests on labor supply. Studies such as Friedberg (2000), Tran (2002), Gustman and Steinmeier (2008), Michaud (2008), Haider and Loughran (2008), Friedberg and Webb (2009) and Engelhardt and Kumar

(2009) for the US, Baker and Benjamin (1999) for Canada, Disney and Smith (2002) for the UK, Shimizutani and Oshio (2013) for Japan, and Brinch et al. (2012) and Hernæs and Jia (2013) for Norway show that the abolishment of an earnings test has led to an increase in labor supply.

There is a substantial body of evidence showing that smaller than actuarially neutral adjustments exert large incentives to claim benefits earlier than the statutory eligibility age and that this has significantly contributed to the early retirement visible in Figure 1 (e.g. Gruber and Wise, 1999 and 2004; Blondal and Scarpetta, 1999; Börsch-Supan, 2000).

Our model is in the tradition of several theoretical models that have studied the abolishment of the earnings test in the Anglo-Saxon countries on labor supply (Gustman and Steinmeier, 2008; French, 2005; Benítez-Silva and Heiland, 2007; Michaud, 2008; Fehr and Uhde, 2014; Kudrna and Woodland, 2011). With one exception, these papers do not address the implications for the financial sustainability of the public pay-as-you-go pension systems and they take place in an actuarially neutral pension system.

The closest paper to ours is Gustman and Steinmeier (2008) which models the distinction between claiming and exiting the labor force in a very rich dynamic programming model. This model includes heterogeneity of workers' preferences and job characteristics in order to obtain a good fit to US data. While Gustman and Steinmeier implicitly consider the parameters of the US Social Security system, they do not vary them except for the abolishment of the earnings test. Hence, their analysis refers to a largely actuarial neutral institutional environment which is in stark contrast to the situation in Europe.

Regarding the claiming decision, Gustman and Steinmeier (2008) show that the abolishment of the earnings test increases the share of married men who claim their benefits by about 10% between the early and normal retirement ages. Gruber and Orszag (2003), Song (2004) and Song and Manchester (2007) also find evidence that loosening the earnings test accelerates the claiming of benefits among the eligible population.[2]

Regarding labor supply, many papers claim that the increase in labor supply due to the abolishment of an earnings test stems mostly from the intensive margin, i.e., the decision of working more hours than before, e.g. Disney and Smith (2002), Engelhardt and Kumar (2009),

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[2] Michaud (2008) finds no significant evidence on an impact on the claiming age after the elimination of earnings tests.

Friedberg (2000), Song (2002), Tran (2002), Hernæs et al (2016) or Hernæs and Jia (2013). Others find that the positive effect is mainly generated on the extensive margin, i.e., by an increase in labor force participation, e.g. Baker and Benjamin (1999), Tran (2002), Engelhardt and Kumar (2009), Hernæs et al (2016), Heræes and Jia (2013), Michaud (2008), Friedberg and Webb (2009).[3] Our theoretical model is designed to distinguish between the two margins.

Our paper is also related to the literature about means-testing pension benefits against assets (Bütler et al., 2016; Chomik et al., 2015; Fehr and Uhde, 2014; Woodland, 2016). In contrast to our study which investigates earnings tests, these studies concentrate on wealth tests when applying for pension benefits. More specifically, Kudrna and Woodland (2011) and Tran and Woodland (2014) focus on the Australian superannuation scheme and examine the impact of means-testing on the incentives of individuals to save and work, on government financial commitments and on the distributional effects on the welfare of individuals.

Finally, our paper also relates to the literature on minimum hours constraints (e.g., Gustman and Steinmeier, 2004; Gielen, 2009). We generate such a constraint through fixed time costs of working.

The paper is organized as follows. In Section 2, we present our model. Section 3 describes the calibration strategy and our computational solution method. The analysis of our results and sensitivity analyses are presented in Section 4. It includes a prototypical "flexibility reform" which looks promising from a political point of view but is likely to fail in securing the sustainability of a pay-as-you-go pension system. Section 5 concludes the paper.

2. The model

Since we want to focus on the households' labor supply decisions in a complex pension system, we will operate in a partial equilibrium framework in which wages and interest rates are exogenously fixed.[4] Our model can be thought of as the household sector plus the pension system

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[3] Song (2004), Song and Manchester (2007) and Gruber and Orszag (2003) find no significant effects of the abolishment of the earnings test on employment and/or hours worked in the US.

[4] We will thus disregard the general equilibrium effects of abolishing an earnings test on wages and interest rates. Woodland (2016) provides a general equilibrium analysis of means testing and other forms of taxation. While the wage effects are small, the interest rate effects are larger but not in the focus of this labor-supply oriented paper.

in the well-known general equilibrium framework developed by Auerbach and Kotlikoff (1987). Regarding the household model, we need to extend this typical neoclassical set-up by an endogenous retirement decision (extensive margin: labor force participation) in addition to the choice of labor supply (intensive margin: working hours). Regarding the pension system, we need additional detail by modeling earnings tests and adjustment factors as bonuses for late retirement and penalties for early retirement. Since the main goal of our study is to explain the mechanism and reaction of individuals to earnings tests and different adjustment factors, we abstain from any distributional considerations, e.g. regarding differences by gender, occupational groups or any other differentiable forms between individuals.

2.1 Household consumption and leisure

We begin with the traditional set-up of how households choose between consumption and leisure. Households of age j gain utility from consumption c_j and leisure l_j according to a CES-type per-period utility function given by

$$\boldsymbol{u(c_j, l_j) = \frac{1}{1-\theta}\left[c_j^{\phi_j} * l_j^{1-\phi_j}\right]^{1-\theta}}, \tag{1}$$

where ϕ_j denotes the utility weight of consumption versus leisure and can be modeled as age-dependent (see Section 3.2). Risk aversion is described by the parameter θ.

Households are neoclassical life-cyclers with perfect foresight. They solve a von Neumann-Morgenstern (VNM) expected utility maximization program over the entire life-cycle which lasts for a maximum of J years. The life-time maximization problem of a cohort is therefore given by:

$$\boldsymbol{max \sum_{j=1}^{J} \beta^{j-1} \sigma_j \, u(c_j, l_j)}, \tag{2}$$

where β is the pure time discount factor, $\beta = \frac{1}{1+\rho}$. In addition to pure discounting, households discount future utility with their unconditional survival probability, σ_j, expressing the uncertainty about the time of death. We do not include intended bequests in our model and assume that accidental bequests resulting from premature death are taxed away by the government at a confiscatory rate and used for otherwise neutral government consumption.

The household's disposable non-asset income y_j is

$$\boldsymbol{y_j = h_j w_j (1 - \tau) + p_j}, \tag{3}$$

which has two components. The first term of the right-hand side reflects labor income (hours worked, $h_j = 1 - \boldsymbol{l}_j$, multiplied by the net wage, w_j, each age specific) while the second term is pension income.

Denoting total assets by a_j, maximization of the household's intertemporal utility is subject to a dynamic budget constraint given by

$$\boldsymbol{a_{j+1} = a_j(1 + r) + y_j - c_j}. \tag{4}$$

In this traditional set-up, labor supply (working hours) may decline at the intensive margin if the parameters in the utility function change. There is, however, no sudden retirement (withdrawal from the labor force at the extensive margin). Retirement is typically assumed to be exogenously dictated by a mandatory retirement age *R* at which individuals must stop working and will begin receiving pension benefits. This implies that $p_j = 0$ for $j \leq R$ and $h_j = 0$ for $j>R$ in equation (3). We will deviate from this traditional set-up in the following section.[5]

2.2 The retirement decision

Modern pension systems deviate from this rigid set-up. First, most pension systems have a window of retirement defined by an earliest and a latest eligibility age $R_E \leq \overline{R} \leq R_L$ which bracket the statutory or "normal" eligibility age $\overline{R}$. Workers have the choice to retire within this window which we need to model. Second, "flexibility reforms" permit combinations of work and pension benefit receipt both before and after the statutory retirement age. In this case, "retire" refers to two separate decisions, namely to stop working at age *X* and to begin receiving pension benefits at age *R*. Both decisions are influenced by common determinants such as institutional parameters and the individual's preferences. Earnings tests and mandatory retirement may enforce $R = X$. In other institutional settings, however, *R* may be earlier or later than *X*. If workers have saved sufficiently, they may want to stop working before they receive pension benefits ($X<R$). In turn, many retirees want to continue some limited engagement with their work place ($R<X$). We therefore need to model two separate decisions – claiming benefits and exiting the labor force – in a life-cycle setting.

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[5] Our model does not include liquidity constraints for the sake of simplicity and clarity. The influence of imperfect capital markets on retirement and claiming choices is complex and the subject of another paper in preparation.

The decision to begin claiming benefits at age R is heavily influenced by the parameters of the pension system. This will be described in the Subsection 2.3. Modeling the decision to leave the labor force completely at age X, the extensive margin of labor supply, is more difficult. Common sense tells us that the choice of the labor force exit age X is mainly driven by the aging process which is characterized by declining productivity, declining health, increasing value of leisure, and/or a combination thereof. Since these are on average continuous and slow-moving processes, the sudden downward jump in labor supply associated with retirement requires an additional mechanism such as a fixed cost of working which makes it unattractive to supply small amounts of labor.

We offer several mechanisms. First, productivity may rise to a peak well before retirement and then decline with age. In a neo-classical world, hourly wages then evolve as

$$w_j = \overline{w}\varepsilon_j, \tag{5}$$

where ε_j is age-specific labor productivity. As ε_j declines, individuals receive lower wages and reduce their labor supply.

Second, the value of leisure relative to consumption may increase with age. This is expressed by a decrease of the parameter ϕ_j in the utility function (1) with age. Accordingly, the household weighs consumption less in the later, rather than the earlier, stages of life. The opposite evolution applies to leisure. In response, individuals will reduce their labor supply in later ages.

Third, time costs of work $\vartheta(h_j, j)$ may increase with age. These time costs represent the effect of declining health on the disutility of work (Börsch-Supan & Stahl, 1991). This effect may be non-linear, increasing with the number of hours worked:

$$\vartheta(h_j, j) \;=\; \chi_j \left(1 - \frac{1}{(1+h_j)^{\xi}}\right), \tag{6}$$

where χ_j increases with age (i.e., worsening health). We insert these costs of work into the household's decision program by linking leisure and work hours following French (2005):

$$l_{t,j} = 1 - h_j - \vartheta(h_j, j). \tag{7}$$

Since the labor supply of households is bound by $0 \leq h_{t,j} \leq 1$, the non-negativity condition drives individuals to stop working. As soon as $\vartheta(h_j, j) > 1 - h_j$, workers will exit the labor force at a well-defined exit age *X*.

These three mechanisms are likely to work in parallel. Unfortunately, there is little solid evidence for their quantification. While there is plenty of quantifiable evidence that health declines with age, there is little evidence of how to translate declining health into related time costs of work (the $\vartheta(h_j, j)$ function) or a shift in the labor-leisure tradeoff (the decrease of ϕ_j). The evidence on productivity decline is also mixed. While aggregate studies show rising and then declining productivity with age (e.g. Altig et al., 2001), micro-econometric estimates show flat age-productivity profiles in the relevant age range $R_E \leq \bar{R} \leq R_L$ (e.g. Börsch-Supan & Weiss, 2016; Göbel & Zwick, 2009). Our approach is therefore to define synthetic age profiles of ϕ_j, ε_j and χ_j which represent a benchmark case plus an upper and lower bound for each mechanism. We will then map out all combinations and check the robustness of the key results. The parameters of ϕ_j, ε_j and χ_j will be chosen in the calibration process to ensure that labor force exit falls into the retirement window $[R_E, R_L]$ for the benchmark case. This will be detailed in Subsection 3.2 below.

2.3 The pension system

The institutional background for the retirement decision is a contributory pay-as-you-go (PAYG) system which promises defined benefits that are strictly earnings-related. This corresponds to the pension systems in the large Continental European countries, e.g. France, Germany and Italy.[6] In a first setting, contributions are due until R-1, pension benefits are paid from the claiming age R onwards. We will slightly modify this setting in Subsection 4.2 when we study a prototypical flexibility reform. We model the relation between earnings and benefits in the form of earnings points. In each working year, earnings points reflect the labor income position of a worker at age *i* relative to the average earnings $\overline{wh}$. Earnings points are accumulated during the entire work life:

$$s_R = \sum_{i=0}^{R-1} \frac{w_i h_i}{\overline{wh}}. \tag{8}$$

[6] These countries have large PAYG systems while the role of fully funded occupational and private pensions is still fairly limited. We therefore do not model 2nd and 3rd pillar pensions in this paper.

Life-time earnings points depend on the claiming age, the hours of work supplied (intensive and extensive margin) and their valuation (hourly wage). Pension benefits p_R for an individual claiming benefits at age R are given by three multiplicative components:

$$p_R = \bar{q}\ s_R\, \omega_R \qquad\qquad \text{for } R \geq R_E. \qquad (9)$$

$\bar{q}$ is the base pension amount for one earnings point when a worker is retiring at the statutory eligibility age $\overline{R}$; s_R are the accumlated earnings points according to (8); finally, ω_R is an adjustment factor which links pension benefits to the actual claiming age R.

Adjustment factor ω_R are actuarially neutral if the present discounted value (PDV) of participating in the pension scheme is independent of the benefit claiming age R: [7]

$$PDV_t(R) = \sum_{j=R+1}^{\infty} \bar{q}\ s_R\, \omega_R\ \sigma_{t+j,j} \left(\frac{1}{1+r}\right)^j - \sum_{j=0}^{R} \tau_{t+j} w_{t+j}\, \sigma_{t+j,j} \left(\frac{1}{1+r}\right)^j \qquad (10)$$

$$= \text{constant for all } R \in [R_E, R_L].$$

The resulting actuarially neutral adjustment factors are a function of the assumed interest rate, r, and the survival probabilities, σ_j. Pension systems providing flat benefits independent of the individual retirement age (i.e., $\omega_R = 1$ for all R) are not actuarially neutral since they redistribute income from late retirees to early retirees who receive the same benefit over a longer time, thereby creating particularly strong incentives for workers to retire early. As we have seen in Table 1, many countries feature adjustment factors that are constant over a large range of claiming ages R and are lower than actuarially neutral.[8]

We therefore model this adjustment in a linear fashion where the steepness of the adjustment is driven by a single adjustment rate ω. If the household claims its pension at the statutory eligibility

[7] See Queisser and Whitehouse (2006) for a detailed discussion on this definition.

[8] The actuarial neutral adjustment rate at age 65 is about 6.3% for the average of France, Germany and Italy underlying the calibration described in Section 3.

age $\overline{R}$, there is no deduction or premium, ω_R=1. For one year of earlier retirement, benefits are reduced by ω percent while benefits are increased by ω percent for one year of later retirement:[9]

$$\omega_R = 1 + (R - \overline{R})\omega. \tag{11}$$

The decision to begin claiming benefits at age R is heavily influenced by the size of the adjustment rate ω. If ω is very small, rational individuals will choose R=R_E. If ω is very large, rational individuals will choose R=R_L. If ω is actuarially neutral, individuals are indifferent when to claim and R is not well defined.

The contribution rate to the system, τ, is computed to balance the PAYG system. Revenues are the product of the contribution rate τ and the wage bill $\sum_{j=1}^{R-1} w_j h_j NW_j$, where the number of workers of age j is denoted by NW_j. Expenditures are the sum of the products of pension benefits p_j and number of pensioners NP_j. The budget-balancing contribution rate is thus given by

$$\tau = \sum_{j=1}^{R} w_j h_j NW_j \,/ \sum_{j=R+1}^{J} p_j NP_j. \tag{12}$$

3. Partial equilibrium and calibration

3.1 Computational algorithm

The optimal paths of consumption and labor supply (average hours worked) are computed using the algorithm developed by Ludwig (2006) which is a further development of the procedures initially proposed by Auerbach and Kotlikoff (1987). The life-cycle of a household ranges from the entrance in the labor market at age 15 until a maximum of 100 years. The solution of the life-cycle optimization is solved recursively by taking initial guesses for variables at last age and policy variables. Then, the model is solved backwards using recursive methods by applying first order methods and appropriately handling the constraints. Decisions of individuals are computed yielding the new values for aggregate variables. This procedure delivers new guesses for the vectors of consumption, hours worked, claiming age, labor force exit age, assets

[9] Some countries have two adjustment rates: ω_{ER} for retirement before the statutory "normal retirement age" and ω_{LR} for retirement thereafter. Adjustment factors are only one way to link pension benefits to the claiming age. It fits well with earnings point, notional defined contribution and similar pension systems. Other mechanisms include age-varying benefit accrual rates.

and the new contribution rate. Following this, we update the initial (old) guesses and repeat the same method until we reach convergence of the model towards the partial equilibrium. This equilibrium is achieved when the initial guesses and the final new values for aggregate variables have sufficiently converged.

Labor costs – here modeled as time costs – depend on hours worked and tend to increase with age as they simulate the burden of older workers to remain in the labor market. We loop forward in order to calculate savings and assets applying the budget constraint (4). Labor market exit age is simply the age at which the hours worked reach zero. We constrain the exit age to be at most age 85. We do not allow the household to re-enter the labor market.

The endogenous decision of retirement (claiming age) is a second step of the algorithm step. To solve it and calculate the pension claiming age, we use an outer loop that searches the claiming age which maximizes the household's utility, taking into account the adjustment factors that provide incentives for earlier or later retirement. In the earnings test scenario, hours are set to zero after claiming for pensions and the claiming age coincides with the labor market exit age. If there is no earnings test, we allow the decision on hours worked to be independent of the optimal claiming age R.

3.2 Calibration

The benchmark case of the model is calibrated such that claiming and exit ages correspond roughly to the values observed in the large Continental European countries such as France, Germany and Italy for the cohorts retiring about now. This was around 65 years for men and 63 years for women in 2014 (OECD, 2015), associated with relatively low adjustment rates ω of about 3.5% to 4% per year which are common in these countries. In our policy experiments, the outcomes of different pension system parameters also relate to these early baby boomer cohorts.

We use the average mortality rates across the EU countries from 1960 until 2014 as reported by Eurostat (2016). The main behavioral parameters are summarized in Table 2 and chosen by reference to other studies. The sensitivity of our results to the choice of these parameters is studied in Subsection 4.4.

Table 2 – Parameter calibration

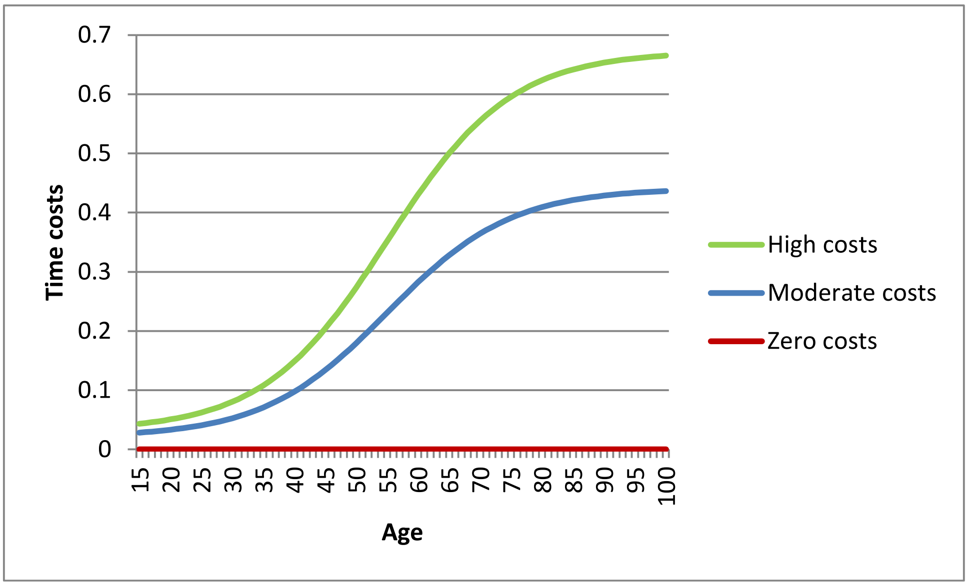
Parameter	Values
Discount rate (ρ)	0.02
Risk preference (θ)	2
Consumption weight (ϕ_j)	[0.55; 0.65]
Interest rate (r)	0.04
Cost function parameter (ξ)	15
Age dependent maximal attained cost – at age 80 (χ_j)	0.41
Earliest claiming age (R_E)	60
Latest claiming age (R_L)	72
Replacement rate at age 65 ($\bar{q}$)	0.6
Adjustment rates (ω)	[0%: 7%]

The discount rate ρ is assumed to be 0.02 (Frederick et al., 2002), smaller than the interest rate r_t of 4% (i.e., more patient households). The risk preference parameter θ is assumed to be 2, which makes the household slightly risk averse and lies in the middle of estimates in the literature – between 1 and 5 – (Bansal & Yaron, 2004; Browning et al., 1999; Cecchetti et al., 2000). The weight of consumption in the utility function, ϕ_j, ranges between 0.55 and 0.65 (French, 2005). Its dependence on age will be specified below (Figure 4).

We set the retirement window from $R_E = 60$ until $R_L = 72$. Age 60 is the earliest eligibility age in many countries (OECD, 2015). While there is no corresponding value for Continental European countries, we assume 72 as the latest possible claiming age in accordance with US Social Security regulations. We set the base pension amount $\bar{q}$ such that the replacement rate is 60% at the statutory eligibility age. This value is close to the average replacement rate across the three large aging countries in Continental Europe (France, Germany and Italy). Depending on the policy experiment, we assume different values for the adjustment rates ranging from ω =0% to ω =6.3% (see equation 11).

We calibrate the three aging mechanism described in Subsection 2.2 such that the claiming age for the benchmark case is within the retirement window. First, fixed costs are assumed to have two components: χ_j, which is age-dependent, and the ratio $\frac{\chi_j}{(1+h_j)^{\xi}}$. We assume that χ_j linearly increases over time until a maximum value of 40% of total time available for the household when reaching age 80. At the highest possible retirement age, costs can reach around 37% of total time available, which is normalized to 1. The age profile of this cost function for $h_j = 1$ is shown in Figure 2 (moderate scenario). However, since they depend also on hours worked, costs never reach such high values. Due to the ratio in the cost function, the calibrated value of $\xi = 12$, and the decisions of households on leisure and consumption, the cost function will never attain the maximum cost value at any age but will asymptotically approach it for higher working hours.[10] As an alternative scenario (see Subsection 4.2), we also consider a cost profile that increases to a maximum value of 62% of total time available (high costs scenario in Figure 2).

Figure 2 – Time costs of working



Source: own computations. Note that this figure displays fixed costs functions over age for $h_j = 1$.

Second, we define life-course productivity profile ε_j. The steepest case is based on the procedures developed by Altig et al. (2001) and Fullerton and Rogers (1993) and is adapted to Germany where suitable panel data is available. We use all waves from 1984 until 2013 of the German Socio-Economic-Panel (GSOEP) and calculate the productivity profile according to:

$$\varepsilon_j = e^{\zeta_0 + (g+\zeta_1)j + \zeta_2 j^2 + \zeta_3 j^3}, \tag{13}$$

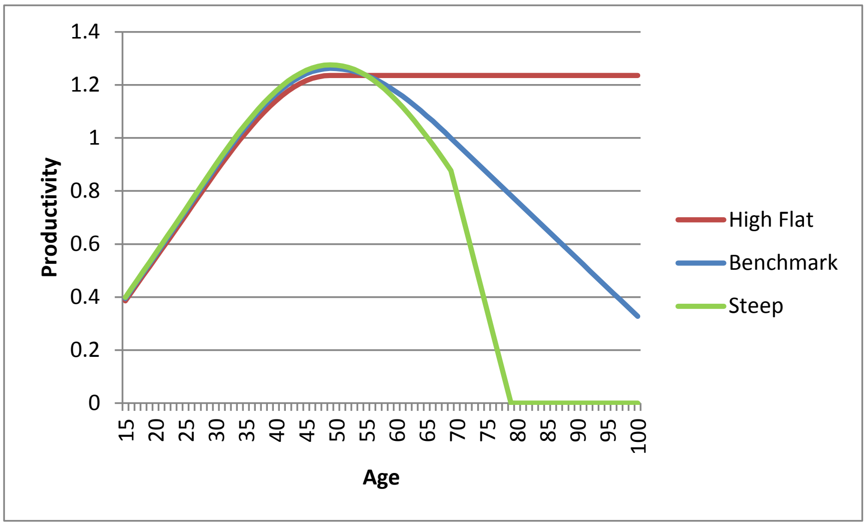
where j stands for age and g is the constant rate of technological progress. The ζ coefficients are calculated according to the following procedure (Altig et al., 2001). First, hourly wages are regressed on fixed-effect dummies, age-cubed and interactions between age, age-squared and other demographic variables. Second, the coefficients obtained from the previous regression are

[10] Note that with a value of ξ=12, the cost function quickly approaches zero when hours worked are small. We use this shape of the cost function to avoid discrete jumps in fixed costs at $h_j = 0$. Instead, the function smooths the costs function for values of hours worked close to zero. These assumptions of fixed costs lead to a more realistic hours profile and of course, they also shape retirement decisions of households – this is discussed in the sensitivity analysis in Subsection 4.3.

used to generate predicted life-cycle wage profiles. The coefficients of equation (13) are estimated from the simulated data. The resulting productivity profile ε_j is used in equation (5) to determine individual life-cycle wage profile. It is depicted in Figure 3.

As an alternative productivity scenario, we assume a profile, in which productivity increases with age until it stabilizes after reaching the maximum productivity around age 50. Our benchmark scenario is a compromise between these two profiles.

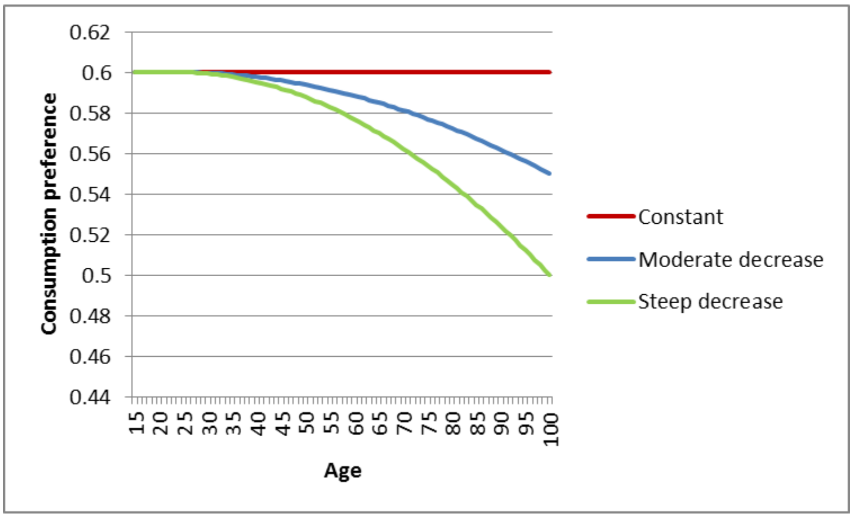
Figure 3 – Different age productivity profiles



Source: own computations.

The third aging mechanism is declining preferences of consumption, see Figure 4. These profiles range from constant preferences to steep decreasing ones. The decline can be of 0.05 (moderate decrease) or 0.10 (steep decrease). For instance, in the case of initial preferences of 0.6, we assume that they could decrease until reaching values between 0.55 or 0.5 at the end of life. This assumption is independent of productivity, meaning that we would either have declining productivity profiles or declining preferences of consumption to mimic the aging process.

Figure 4 – Decreasing weight on consumption



Source: own computations.

4. Results

We structure our results in four subsections. First, we discuss the benchmark case in detail (Subsection 4.1). It shows that abolishing an earnings test may undermine the financial sustainability of a PAYG pension system rather than strengthening it. Subsection 4.2 shows that the same conclusion holds for some forms of "flexibility reforms" in Europe and the US. We then investigate the sensitivity of our results. Subsection 4.3 combines alternative specifications of the retirement mechanisms defined at the end of the preceding section while Subsection 4.4 investigates the sensitivity of our results with respect to other key model parameters in Table 2.

In each subsection, our focus is on the interaction between earnings tests and actuarial adjustments. The figures and tables shown have therefore two dimensions: whether the pension system imposes a strict earnings test or not, and how large the adjustment rates are, ranging from 0% to 6.3% per year earlier or later than the statutory eligibility age. The figures and tables then show the resulting claiming and labor force exit ages (which coincide in the case of a strict earnings test).

With respect to the earnings test, we study three scenarios:

- *Strict earnings test:* the pension system rules out any additional earnings after claiming pension benefits so that individuals have to exit the labor force after claiming a pension;

- *No earnings test:* the pension system permits any amount of additional earnings; individuals can choose different claiming and exit ages; after claiming age, neither are contributions due nor will the individual accumulate earnings points.
- *Flexibility reform:* Subsection 4.2 modifies the no earnings test scenario with respect to the latter rule: contributions will be due on earnings and earnings points can be accumulated after claiming age.

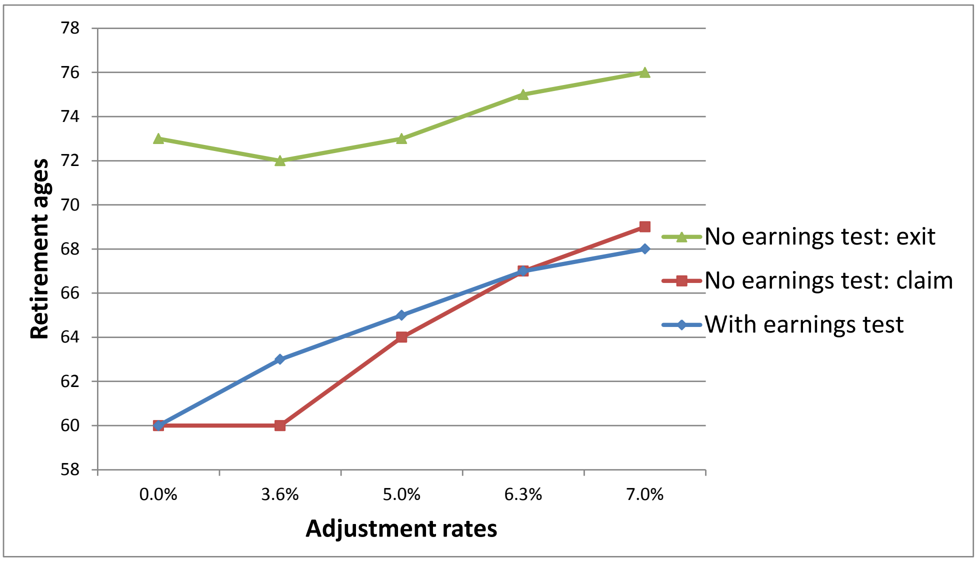
4.1. Analysis of the benchmark case

The benchmark case is defined by moderate time costs of working as depicted in Figure 2, an age-productivity profile that mildly declines in later stages of life as depicted in Figure 3 and a moderately decreasing weight of consumption in the utility function starting at $\phi = 0.6$ as depicted in Figure 4.

Figure 5 provides a general overview of our main results based on this benchmark case. It shows that the benefit claiming and labor market exit ages are very different depending on the maintenance or abolishment of an earnings test. For low adjustment rates (i.e., below actuarial values), this difference is particularly large. If an earnings test is imposed and adjustment rates are small but positive, individuals retire early but claim benefits later than in the no earnings test scenario. As adjustment rates increase, the gap decreases. The two lines intersect for actuarially neutral adjustment rates. In conclusion, less than actuarially neutral adjustment rates create incentives for early claiming/retirement. This is a well-known result (Gruber and Wise, 1999). Early claiming leads to more years of benefits to be paid by the system which threatens its sustainability.

The key point of our analysis is that abolishing an earnings test is not a substitute for making adjustment factors neutral. If moving from an earnings test system to a no earnings test system should have the aim of maintaining the same age of retirement/claiming as previously and additionally increase labor supply, it fails to achieve that aim as long as adjustment factors are too small. The aim is achieved only when the pension system also introduces at least actuarially neutral adjustment factors. As Figure 5 shows, imposing or not imposing an earnings test will not influence the choice of claiming age if the adjustment rate is actuarially neutral but increase labor force participation, hence also increasing the sustainability of pension systems.

Figure 5 – Retirement decisions with and without earnings test



Source: own calculations.

Tables 3 to 5 depict in a more detailed way the main results summarized in Figure 5. Table 3 shows retirement decisions for the earnings test scenario depending on adjustment rates and preferences for consumption over leisure, whereas Table 4 and Table 5 show the choices of the benefit claiming age and the labor force exit age in absence of an earnings test, respectively. As noted earlier we refer to "retirement age" when X=R and distinguish "claiming age" from "labor market exit age" otherwise.

In the earnings test scenario (Table 3), low adjustment rates, ω, create early retirement choices. Since claiming age and exit age are equal, individuals tend to retire even before the statutory eligibility age in a pension system when adjustment rates are low. Adjustment rates of 0% induce, independently of the value assumed for preferences for consumption, retirement at the earliest possible age – here age 60. The reason is that there are no financial penalties for early retirement at all. For $\omega = 3.6\%$ and ϕ = 0.55/0.60, the resulting retirement ages are 61/63, respectively. These are the retirement ages observed in the German data which may serve as a benchmark for the effects of abolishing an earnings test. For $\omega \geq 5\%$, Table 3 shows relatively late retirement ages of 67 and later monotonically increasing with the magnitude of the adjustment rates and the associated penalties for early retirement/premia for later retirement, respectively. Table 3 shows that individuals react very sensitively to the adjustment rates, especially when the weight of consumption in the utility function is high.

Table 3 – Retirement age R as a function of actuarial adjustment – earnings test

	Actuarial adjustment rate (ω)				
Initial level of utility weight of consumption (ϕ)	**0%**	**3.6%**	**5%**	**6.3%**	**7%**
Low (0.55)	60	61	64	68	69
Middle (0.60)	60	63	65	67	68
High (0.65)	60	64	67	68	69

Source: own calculations.

If there is no earnings test, claiming age R (Table 4) and labor market exit age X (Table 5) differ. For low values of the adjustment rate $\omega \leq 3.6\%$, workers' claiming age is earlier than in the scenario with an earnings test (around age 60) because the longer period of retirement is not penalized by sufficiently low benefits. In fact, early claiming is even more extreme than in the earnings test case since claiming is detached from exit from work force. Hence, decisions on claiming are mainly dependent on the financial incentives created by the penalties/premia generated by the adjustment rates and are less dependent on the consumption/leisure trade-off. If adjustment rate become large ($\omega > 5\%$), workers shift their claiming age to very late ages around 67-70 in order to benefit from higher pension payments. The optimal claiming age depends on ω_R relative to the discount rate including mortality risk.

Table 4 – Claiming age R as a function of actuarial adjustment – no earnings test

	Actuarial adjustment rate (ω)				
Initial level of utility weight of consumption (ϕ)	**0%**	**3.6%**	**5%**	**6.3%**	**7%**
Low (0.55)	60	60	65	69	69
Middle (0.60)	60	60	64	67	69
High (0.65)	60	60	65	68	70

Source: own calculations.

Regarding exit age decisions, households work until the utility from consumption is dominated by the utility of leisure and labor costs. As Table 5 shows, labor force exit age X is decoupled from the benefit claiming age R in Table 4. Exit ages are mostly higher than claiming age, which means that workers request their pension benefits but keep working for some more years before exiting the labor market. The duration of labor supply beyond claiming age strongly depends on the preference for consumption, expressed by the parameter ϕ. The higher the preference for consumption, the longer workers remain in the labor force. Moreover, it depends on total income (wages plus pensions). The higher the preference for consumption, the longer individuals work and receive wages along with pensions.

The difference between claiming and exit ages diminishes with increasing adjustment rates which results from labor costs and decreasing consumption preferences with age. Otherwise, the impact of the adjustment rates on exit ages has no general pattern since exit ages are only indirectly affected by them. This is in stark contrast to claiming ages which are directly dependent on the adjustment rates.

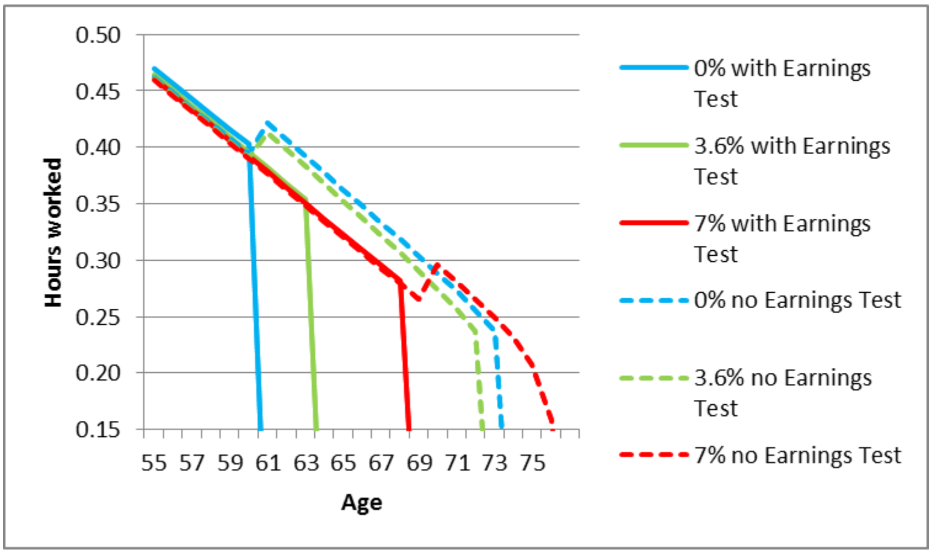
Table 5 – Exit age X as a function of actuarial adjustment – no earnings test

	Actuarial adjustment rate (ω)				
Initial level of utility weight of consumption (ϕ)	**0%**	**3.6%**	**5%**	**6.3%**	**7%**
Low (0.55)	69	69	70	67	67
Middle (0.60)	73	72	73	75	76
High (0.65)	85	79	79	85	85

Source: own calculations.

Figure 5 and the subsequent tables have shown retirement and labor force exit ages. They represent the extensive margins of labor supply. We now turn to the intensive margin (hours worked if participating, Figure 6). The product of both margins (total labor volume) is a key variable for a PAYG system since it directly determines a country's overall wage bill from which proportional contributions are paid.

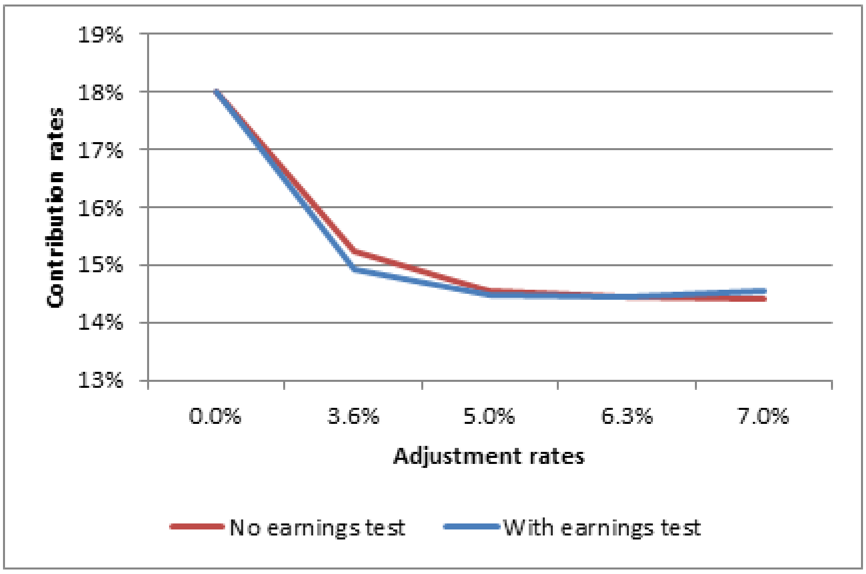
Figure 6 – Labor supply for different adjustment rates with and without earnings test



Source: own calculations.

Figure 6 shows that abolishing an earnings test has positive impacts on total labor volume in terms of both margins. Labor force exit ages are shifted to older ages and hours are increased relative to the scenarios with an earnings test imposed. It would be premature, however, to conclude that this higher labor volume helps to stabilize PAYG pension systems by lowering contribution rates. As we have seen in Figure 5, claiming age decreases when the adjustments rates are smaller than actuarially neutral. This increases pension expenditures and thus contribution rates. The combined effect is show in Figure 7. It shows that contribution rates are higher after the abolishment of an earnings test for low adjustment rates and decrease only for adjustment rates that are actuarially neutral (around 6.3%) or higher.

Figure 7 – Contribution rates with and without earnings test



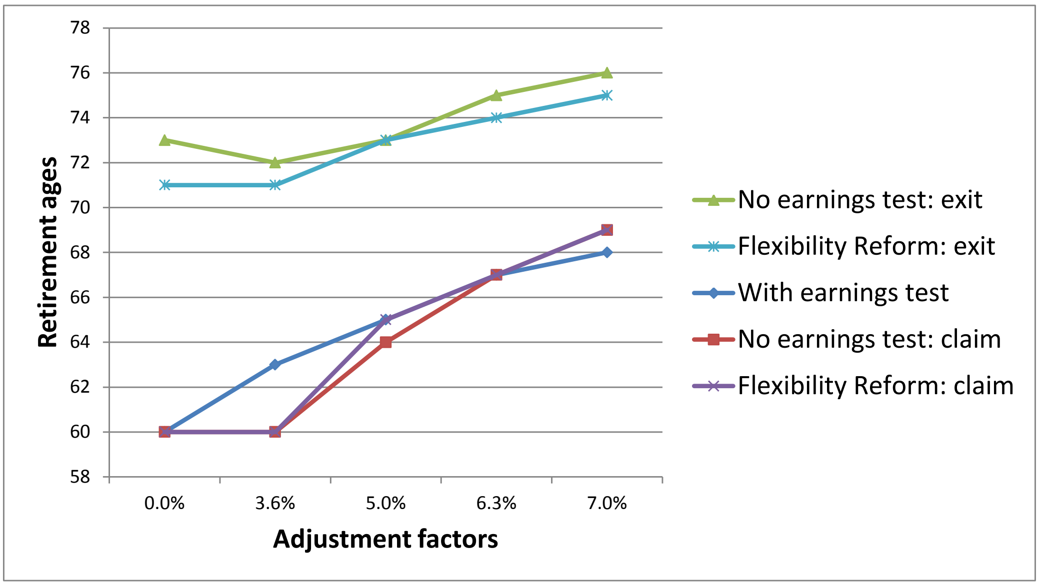
Source: own calculations.

4.2. Flexibility reform and partial retirement

Some recent "flexibility reforms" and "partial retirement" proposals entail a slightly modified scenario of how benefits are calculated when individuals keep working after having claimed pension benefits. Examples are the abolition of the earnings test in 2000 in the US (Social Security Administration, 2008) and the proposal for a "*Flexi-Rente*" announced by the German government (Bundesgesetzblatt, 2016). These reforms abolish the strict earnings test but depart from the scenario presented in the previous subsection by collecting pension points after claiming pensions which is not permitted in traditional systems without an earnings test. This modification allows individuals to increase their pension benefits after claiming. On the one hand, this creates even larger incentives to work longer since besides receiving wages individuals also receive higher pension benefits in the end – a double incentive. On the other hand, however, net wages are lower due to contributions to the pension system.

While the double incentive has an intuitive appeal to many policy makers, this subsection shows that these proposals have the same negative impact on claiming ages and sustainability of the pension system when they are applied to the existing public pension system with less than actuarially neutral adjustment factors. Figure 8 parallels Figure 5 and provides an overview of the results based on the same benchmark parameters as in the preceding subsection.

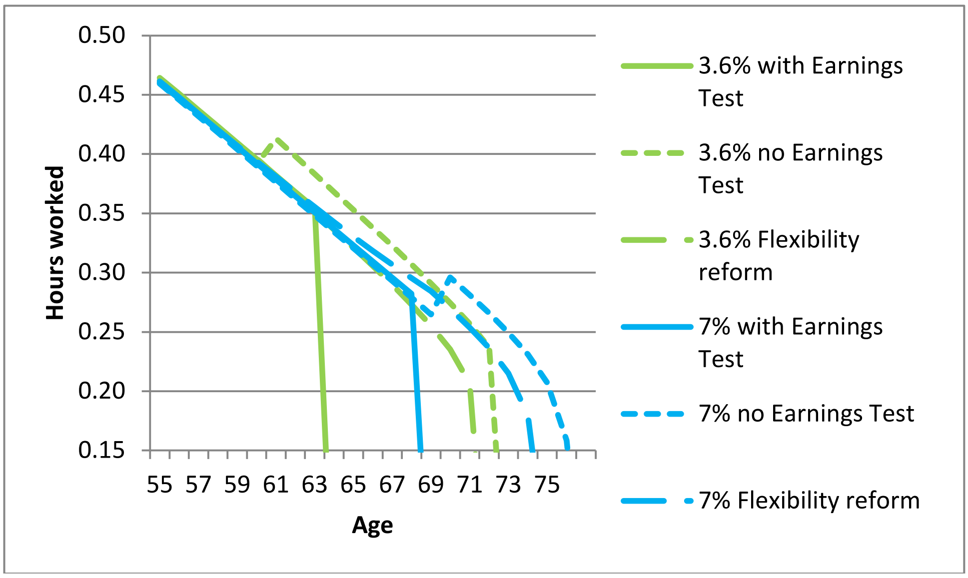
Figure 8 – Retirement decisions under a flexibility reform



Source: own calculations.

The flexibility-reform in Figure 8 generates slightly later claiming ages but earlier labor force exit ages compared with the abolishment of the earnings test depicted in Figure 5. At the same time, individuals also work less intensively under a flexibility reform compared to the traditional scenario without an earnings test (Figure 9).

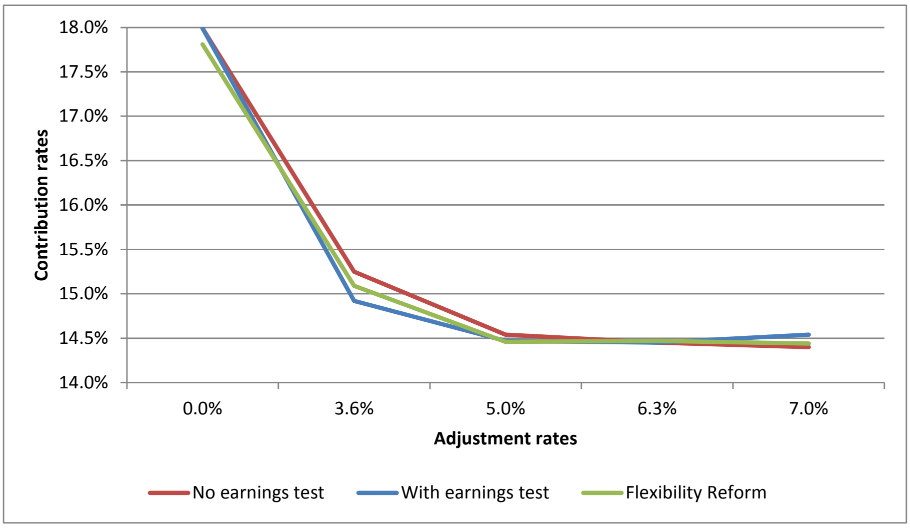
Figure 9 – Labor supply under a flexibility reform



Source: own calculations.

The total effect on the pension system is shown in Figure 10 in terms of the contribution rate. It is in between the two cases shown in the preceding subsection (earnings test imposed and traditional scenario without an earnings test). The contribution rate is slightly lower after a flexibility reform than after simply abolishing an earnings test if the adjustment rates are lower than actuarially neutral. This poses incentives for earlier claiming in order to benefit from higher net wages after claiming. In turn, the higher total income (wages and pensions) changes the labor/leisure trade-off and makes workers leave the labor force earlier than in the straight no-earnings test scenario. The pension system faces two opposite effects. On the one hand, after claiming, workers can still contribute the pension system benefits through more contributions until later in life which increases receipts to the system. On the other hand, the pension claims of retirees will be higher which increases expenditures. If adjustment rates are actuarially neutral, there is no effect on the contribution rate. If they are higher than actuarially neutral, contributions rates are slightly higher than in the traditional scenario without an earnings test since the costs of the additional pension benefits outweigh the additional contributions.

Figure 10 – Contribution rates under a flexibility reform



Source: own calculations.

In summary, keeping contributions active when working even after claiming benefits as part of a flexibility reform is less harmful in terms of the financial sustainability to the simple abolishment of an earnings test when adjustment rates are less than actuarially neutral – but the effect on the financial sustainability is still negative. As was the case for the simple abolishment of an earnings test, a flexibility reform is not a substitute for making adjustment rates actuarially neutral.

4.3 Sensitivity to alternative retirement mechanisms

This subsection investigates whether these harmful effects occur also under different assumptions about the aging process of which we have no good evidence. We simulate systematically all non-benchmark assumptions presented in Subsection 3.2 and show that they yield similar behavior of individuals when faced with the abolishment of an earnings test. Since the flexibility reform presented in the preceding subsection is an intermediate case, we only show the difference between the more extreme cases of Subsection 4.1.

We separate the sensitivity analyses into two sets of scenarios. The first set changes the assumptions on the evolution of productivity during the life-cycle under different fixed costs profiles, representing higher or lower effects of declining health on the disutility of work (Table 6). The second set examines different age-dependent preferences on consumption and leisure under different fixed costs profiles (Table 7). We start by comparing vertically the different productivity scenarios (see light grey boxes in Table 6, results displayed in Figure 11). We then compare scenarios horizontally (dark grey boxes in Table 6, results displayed in Figure 12).

Table 6 – Scenarios with different productivity profiles and fixed cost levels

Productivity	Time costs of working		
	Zero	**Moderate**	**High**
Flat	Appendix	Figure 11	Appendix
Moderate	see Figure 12	Benchmark in Section 4.1	Figure 12
Steep	Appendix	Figure 11	Appendix

Finally, we compare vertically the different preference scenarios (see light grey boxes in Table 7, results displayed in Figure 13). The more extreme scenarios are relegated to an appendix.

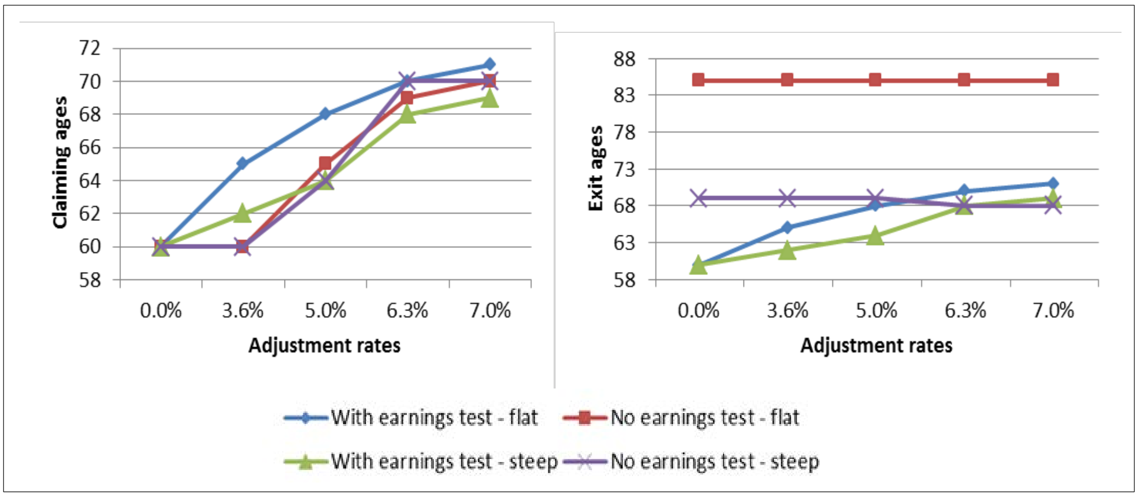
Table 7 – Scenarios with different consumption preferences and fixed cost levels

Consumption preferences	Time costs of working		
	Zero	**Moderate**	**High**
Flat	Appendix	Figure 13	Appendix
Moderate	Figure 12	Benchmark in Section 4.1	Figure 12
Steep	Appendix	Figure 13	Appendix

The first set of sensitivity analyses addresses the different productivity profiles (flat and steep decline). As referred to in Subsection 3.2, different strands of literature show that productivity may present different shapes with age. Börsch-Supan and Weiss (2016) show that productivity tends to not decrease with age. This profile is presented as the flat productivity profile. The other two experiments refer to the estimated benchmark productivity profile and to an even steeper productivity profile ("steep decrease") where the decline on productivity is stronger after age 50 (Figure 3 in Subsection 3.2).

Figure 11 shows that the abolishment of an earnings test with less than actuarial neutral adjustment rates leads to large differences in claiming ages between scenarios with and without an earnings test. Under a flat or steep declining productivity profile and for low adjustment rates, the claiming age is always higher in the earnings test scenario than in the no earnings test scenario (except for adjustment rates of 0% since the incentives for very low values lead to the earliest possible claiming age).

Figure 11 – Claiming and exit ages with and without earnings test (different productivity profiles)

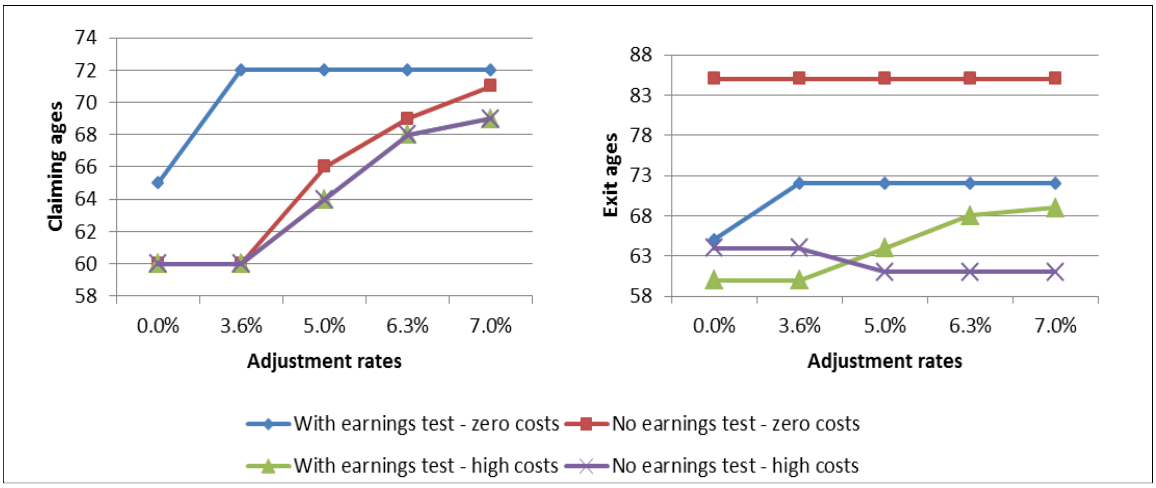


Source: own calculations.

These outcomes are in accordance with the benchmark scenario and support the claim that individuals tend to claim earlier under the no earnings test scenario when adjustment factors are not actuarially neutral. Only for very high adjustment rates, this pattern turns around and claiming ages in the no earnings test scenario are equal or higher than in the earnings test case. As can be seen in Figure 11, this happens in the steep scenario with adjustment rates of 5%. In the flat-productivity simulation, this intersection occurs only for very high adjustment rates. For the flat productivity profile, individuals exit the labor force very late in life because of the constant, high wages at older ages that incentivizes individuals to work longer.

When analyzing the effect of different fixed cost profiles on the outcomes of the model (Figure 2), we again obtain the same patterns as we did in the benchmark case. For fixed costs equal to zero ("zero costs"), the differences in claiming ages are large: individuals claim much earlier in the scenario without an earnings test. The intersection occurs, again, only for very high adjustment rates. In the case of high fixed costs ("high costs"), retirement and claiming ages are identical.

Figure 12 – Claiming and exit ages with and without earnings test (different fixed costs profiles)



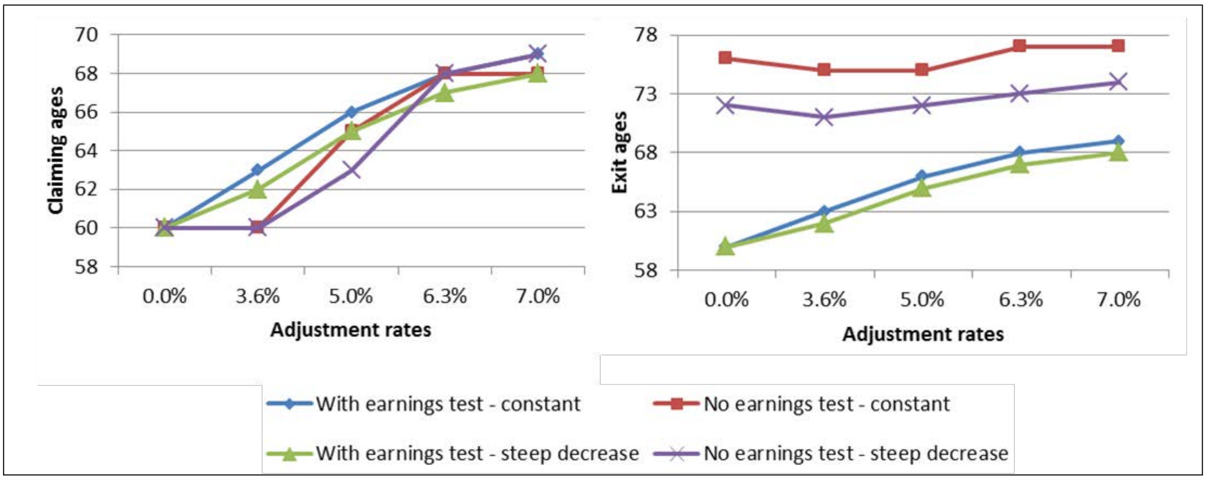
Source: own calculations.

Two main types of labor force exit behavior are observed when no earnings tests are imposed. While fixed costs of zero lead to very late exit ages, high fixed costs lead to early exit ages. For the highest fixed costs considered (62% of total available time), exit ages become substantially lower (age 61/64) because decreasing health conditions represented by the fixed costs of work force workers to exit the labor market much earlier. In some cases, workers even exit labor force before claiming their pensions. These individuals finance their retirement consumption temporarily with the savings which they have accumulated during their working lives.

Retirement ages in the earnings test scenario are quite sensitive to the fixed costs of working. This is not the case for claiming ages when no earnings tests are in place. Claiming ages remain relatively stable whereas the corresponding exit ages decline substantially. This can lead to some very particular cases where the claiming age after flexibilization is higher than the retirement age before flexibilization. However, this is a very specific situation which results from the higher sensitivity of individuals under an earnings test to fixed costs. This happens because individuals do not have as much degrees of freedom as they had when no earnings test was imposed. We conclude from this analysis that individuals released from the restriction of an earning test first prefer to reduce the number of years in the labor force and change their claiming age only when necessary.

We now turn to Figure 13 and the third alternative to model the aging process, namely different trajectories of how the relative preference for leisure versus consumption increases with age, modelled by a declining ϕ_j in the utility function (1). Fixed costs and productivity are set to the benchmark values, i.e. fixed costs are 41% of total available time and productivity is assumed to decline moderately after age 50. We compare the two extreme cases presented in Figure 4 of Subsection 3.2. The first case entails constant preferences during the life-cycle while the second case comprises a decrease that is steeper than in the benchmark case. As it was the case in our earlier sensitivity analyses, claiming ages decrease when abolishing an earnings test and the adjustment rates are not actuarially neutral. These results do not change qualitatively when different slopes of increasing leisure preferences are assumed. In the case of a steep decrease, the intersection takes place between adjustment rates of 5% and 6.3% (Figure 13). When preferences are flat, the intersection occurs for an adjustment rate of 6.3%. Exit ages are also affected by the abolishment of an earnings test, being considerably later than before, as it would be expected. Figure 13 shows that this effect is slightly larger when preferences are constant over the life course than with steeply increasing preferences for leisure, again in line with intuition.

Figure 13 – Claiming and exit age decisions with and without earnings test (different consumption preferences)



Source: own calculations.

In summary, this subsection has shown that the patterns of outcomes and the main messages are preserved when more extreme assumptions about the process of aging and the mechanisms for retirement are assumed.

4.4. Sensitivity to other model parameters

As explained in Subsection 3.2, our calibration roughly targeted the actual average age of labor market exit in the large Continental European countries. In this section, we investigate how our results change if different preference and rate price parameters are chosen. We focus on the outcomes of retirement decisions for adjustment rates of 0%, 3.6% and 6.3%.

The first part of the analyses assumes that households are less risk averse, namely $\theta = 1$ rather than $\theta = 2$. Individuals are less concerned about large income shocks and therefore save less. Results are shown in Table 8. Retirement ages under an earnings test are usually lower for all consumption preferences and adjustment rates. For values close to the actuarially neutral adjustment rate, the claiming age is equal or slightly higher than the retirement age under earnings tests. The predictions regarding the impact of the abolishment of an earnings test on individuals' behavior remain unchanged to the benchmark case.

Table 8 – Sensitivity analysis for θ=1 and r=4% and ρ=2%

	Earnings test			No earnings test (Claim)			No earnings test (Exit)		
	Actuarial adjustment rate (ω)			Actuarial adjustment rate (ω)			Actuarial adjustment rate (ω)		
Utility weight of consumption (ϕ)	**0%**	**3.6%**	**7.0%**	**0%**	**3.6%**	**7.0%**	**0%**	**3.6%**	**7.0%**
Low (0.55)	60	60	69	60	66	69	66	62	59
Middle (0.60)	60	60	69	60	60	69	69	68	62
High (0.65)	60	61	69	60	60	72	71	71	70

Source: own calculations.

Table 9 shows the sensitivity to our assumptions regarding interest rates. A lower interest rate makes individuals work longer in order to compensate for the loss of interest income from their savings. They will therefore retire much later even when an earnings test is implemented. With a low non-actuarially neutral adjustment rate, an earnings test yields very early retirement. Abolishing the earnings test makes most individuals claim their pension earlier, but at the same time they leave the labor force later than in our main scenario in Subsection 4.1. These results might be interpreted as an indication of the younger generations' behavior if current low interest rates were to persist in the longer run.

Table 9 – Sensitivity analysis for θ=2 and r =3% and ρ=2%

	Earnings test			No earnings test (Claim)			No earnings test (Exit)		
	Actuarial adjustment rate (ω)			Actuarial adjustment rate (ω)			Actuarial adjustment rate (ω)		
Utility weight of consumption (ϕ)	**0%**	**3.6%**	**7.0%**	**0%**	**3.6%**	**7.0%**	**0%**	**3.6%**	**7.0%**
Low (0.55)	60	64	70	60	62	72	76	75	85
Middle (0.60)	60	66	71	60	62	72	85	85	85
High (0.65)	60	67	72	60	63	72	85	85	85

Source: own calculations.

For a higher interest rate, we can observe the same results (Table 10). The patterns observed in the benchmark case now occur already for lower adjustment rates. For instance, for initial values of consumption preferences of 0.6, abolishing an earnings test no longer leads to earlier claiming ages for an adjustment rate of 3.6%. This means that the adjustment rate which equates the claiming ages in the two types of pension systems is now lower than in the benchmark case.

The exit age is also slightly lower than in the benchmark case. This is due to higher returns on savings that can make up for lower number of years at work force.

Table 10 – Sensitivity analysis for θ=2 and r =5% and ρ=2%

	Earnings test			No earnings test (Claim)			No earnings test (Exit)		
	Actuarial adjustment rate (ω)			Actuarial adjustment rate (ω)			Actuarial adjustment rate (ω)		
Utility weight of consumption (ϕ)	**0%**	**3.6%**	**7.0%**	**0%**	**3.6%**	**7.0%**	**0%**	**3.6%**	**7.0%**
Low (0.55)	60	60	67	60	60	67	66	65	63
Middle (0.60)	60	60	67	60	60	68	69	69	66
High (0.65)	60	62	67	60	60	68	60	60	67

Source: own calculations.

In summary, the central conclusions drawn in the benchmark case also hold if different preference and cost parameters are assumed. For lower than actuarially neutral adjustment rates, workers tend to claim their pension earlier rather than later when an earnings test is abolished, worsening the financial sustainability rather than improving it. Exit ages, however, will occur later in life, increasing total labor volume.

5. Conclusions

Increasing dependency ratios in aging societies pose a threat to the financial sustainability of pension systems. Policy makers have faced this challenge with several reforms. Among them, increasing the statutory eligibility age is effective but very unpopular. Alternative reforms, particularly if sold to the public under the label of increasing flexibility, are more popular. It is essential to understand how these measures affect labor supply and retirement behavior. These behavioral effects are complex since flexibilization drives a wedge between claiming pension benefits and exiting the labor force. In the best case, more labor supply creates additional resources to finance the pension system; in the worst case, however, such “flexibility reforms” do harm to the sustainability of pension systems because the added flexibility allows individuals to claim pension benefits earlier. It is thus crucial to take behavioral reactions into account.

In order to shed some light on this topic, we built a life-cycle model of saving and labor supply under a PAYG pension system that allowed us to study the incentive effects of a pension system on three distinctive decisions of workers: when to claim benefits, how many hours to work (intensive margin) and when to exit the labor force (extensive margin). Several key parameters shape these decisions, mainly institutional parameters such as the adjustment factors to the actual claiming age and the existence of an earnings test, and preference parameters such as the consumption/leisure trade-off which may change with age.

Workers tend to exit early from the labor force when an earnings test is enforced. Lifting this restriction appears to be a good way to keep older workers in the labor force and make pension systems more sustainable. The key result of this paper is that this aim is achieved if and only if adjustment factors are actuarially neutral. This result also holds when individuals who keep working after claiming benefits continue to contribute to the pension system with associated benefit increases. This is the case for some flexibility reforms which have actually been enacted, e.g. in Germany and the US. If pension benefits are not actuarially neutrally linked to the claiming age, abolishing an earnings test is indeed harmful to the financial sustainability of a pension system.

These conclusions are derived from a theoretical model. Like any model, one may criticize its underlying assumptions, specifications and parameter choices. We have performed a series of sensitivity analyses to ascertain that results are robust under different parameter choices and alternative specifications of the retirement mechanism. The results are also corroborated by the few empirical studies on recent flexibility reforms (Graf et al., 2011; Huber et al., 2013; Börsch-

Supan et al. 2015a, 2015b, 2017). They also explain the results from the much larger empirical literature on the abolishment of the earnings tests in the US, Canada and the UK.

Our predictions can intuitively be understood as follows. If there is no earnings test, the decisions of when to claim a pension and when to exit the labor force ages are detached. The decision to claim a pension is essentially driven by the adjustment factors which balance additional contributions to be paid by individuals with additional pension benefits later on. Low adjustment factors create incentives for workers to claim early. This incentive is strengthened once the earnings test has been abolished because individuals can now combine their pension benefit with additional wage income. Early claiming, however, means additional years of benefits that have to be financed by the pension system, threatening its sustainability.

The gap between claiming and labor force exit age shrinks with higher adjustment factors. If they are actuarially neutral, having or not an earnings test will not influence the decision on claiming age but will provide higher labor supply until later in life. Only in this case, abolishing an earnings test meets the aim of policy makers to strengthen the financial sustainability of a pension system.

Abolishing an earnings test must therefore carefully be contemplated by policy makers. Understanding the interplay of the benefit computation with the claiming age right is essential to avoid worsening the financial sustainability of pension systems. Flexibility per se is no substitute to fixing a pension system that creates early retirement incentives due to adjustment factors that are lower than actuarially neutral.

Permitting workers to keep contributing to the system in order to earn additional earnings points leads to less harm done to the pension system than simply abolishing the earnings test. The key condition for actually improving the financial sustainability, however, is again an actuarially neutral linkage between benefits and claiming age.

As always, models abstract from many aspects of real life. Hence several caveats apply. Our model refers to the typical 1st pillar PAYG systems in Continental Europe. We therefore do not include in our model fully funded 2nd and 3rd pillar pensions. Especially occupational pensions based on defined benefits create their own strong retirement incentives. They differ between professions and need to be accounted for in empirical work, see e.g. the studies in Gruber and Wise (2004). Many of their incentives are analogous to the effects described in this paper.

Another issue is heterogeneity. Individuals may differ in their time preference and life expectancy, thus react differently to the incentives created by homogenous adjustment factors and earnings tests. Examples are differences across cohorts and between women and men. Qualitatively, however, our results would remain.

As already mentioned, our modelling approach is based on fully rational individuals, abstracting from behavarioral mechanisms such as those created by time inconsistent decision making. Such behavior would strengthen our key result of earlier claiming under low actuarial adjustments since time inconsistent individuals prefer receiving benefits as soon as possible.

Norms and anchoring mechanism, in turn, will reduce the short-run elasticity with respect to law changes such as the abolishment of earnings tests. Norms or anchoring are therefore likely to weaken our results but will not influence the direction of our predicted effects.

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Appendix

This appendix shows the results for the extreme scenarios not described in Subsection 4.3.

Scenarios with different productivity profiles and fixed cost levels

Productivity	Time costs of working		
	Zero	Moderate	High
Flat	**Scenario A-1**	see Figure 6	**Scenario A-2**
Moderate	see Figure 7	Benchmark in Section 4.1	see Figure 7
Steep	**Scenario A-3**	see Figure 6	**Scenario A-4**

Scenarios with different consumption preferences and fixed cost levels

Consumption preferences	Time costs of working		
	Zero	Moderate	High
Flat	**Scenario A-5**	see Figure 8	**Scenario A-6**
Moderate	see Figure 7	Benchmark in Section 4.1	see Figure 7
Steep	**Scenario A-7**	see Figure 8	**Scenario A-8**

Scenario A-1 (productivity: flat; fixed costs: zero)

phi=0.55	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	72	60	85	60	85
$\omega = 3.6\%$	72	60	85	63	85
$\omega = 6.3\%$	72	70	85	71	85

phi=0.60	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	72	60	85	60	85
$\omega = 3.6\%$	72	60	85	63	85
$\omega = 6.3\%$	72	70	85	71	85

phi=0.65	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	72	60	85	60	85
$\omega = 3.6\%$	72	60	85	63	85
$\omega = 6.3\%$	72	70	85	70	85

Scenario A-2 (productivity: flat; fixed costs: high)

phi=0.55	With Earnings Test	No Earnings Test		Flexibility Reform	
$\omega = 0\%$	60	60	64	60	61
$\omega = 3.6\%$	60	62	60	60	60
$\omega = 6.3\%$	68	68	60	68	60

phi=0.60	With Earnings Test	No Earnings Test		Flexibility Reform	
$\omega = 0\%$	60	60	67	60	63
$\omega = 3.6\%$	60	60	66	60	63
$\omega = 6.3\%$	67	67	63	67	63

phi=0.65	With Earnings Test	No Earnings Test		Flexibility Reform	
$\omega = 0\%$	60	60	69	60	67
$\omega = 3.6\%$	61	60	69	60	66
$\omega = 6.3\%$	68	68	66	68	66

Scenario A-3 (productivity: steep; fixed costs: zero)

phi=0.55	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	62	60	76	60	76
$\omega = 3.6\%$	69	60	76	61	75
$\omega = 6.3\%$	71	69	77	68	76

phi=0.60	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	63	60	77	60	76
$\omega = 3.6\%$	69	60	76	61	76
$\omega = 6.3\%$	71	69	77	68	77

phi=0.65	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	64	60	77	60	77
$\omega = 3.6\%$	70	60	77	61	76
$\omega = 6.3\%$	71	69	77	68	77

Scenario A-4 (productivity: steep; fixed costs: high)

phi=0.55	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	60	60	59	60	58
$\omega = 3.6\%$	60	60	58	60	58
$\omega = 6.3\%$	68	68	58	68	58

phi=0.60	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	60	60	63	60	61
$\omega = 3.6\%$	60	63	61	60	61
$\omega = 6.3\%$	68	68	61	68	61

phi=0.65	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	60	60	66	60	63
$\omega = 3.6\%$	60	60	65	60	63
$\omega = 6.3\%$	68	68	63	68	63

Scenario A-5 (fixed costs: zero; consumption weight: flat)

phi=0.55	With Earnings Test	No Earnings Test		Flexibility Reform	
$\omega = 0\%$	65	60	85	60	85
$\omega = 3.6\%$	72	60	85	62	85
$\omega = 6.3\%$	72	69	85	70	85

phi=0.60	With Earnings Test	No Earnings Test		Flexibility Reform	
$\omega = 0\%$	66	60	85	60	85
$\omega = 3.6\%$	72	60	85	62	85
$\omega = 6.3\%$	72	69	85	70	85

phi=0.65	With Earnings Test	No Earnings Test		Flexibility Reform	
$\omega = 0\%$	67	60	85	60	85
$\omega = 3.6\%$	72	60	85	62	85
$\omega = 6.3\%$	72	69	85	70	85

Scenario A-6 (fixed costs: high; consumption weight: flat)

phi=0.55	With Earnings Test	No Earnings Test		Flexibility Reform	
$\omega = 0\%$	60	60	63	60	60
$\omega = 3.6\%$	60	61	59	60	60
$\omega = 6.3\%$	68	68	59	68	60

phi=0.60	With Earnings Test	No Earnings Test		Flexibility Reform	
$\omega = 0\%$	60	60	65	60	63
$\omega = 3.6\%$	60	60	64	60	63
$\omega = 6.3\%$	68	68	62	68	62

phi=0.65	With Earnings Test	No Earnings Test		Flexibility Reform	
$\omega = 0\%$	60	60	68	60	66
$\omega = 3.6\%$	61	60	67	60	65
$\omega = 6.3\%$	68	68	65	68	65

Scenario A-7 (fixed costs: zero; consumption weight: steep)

phi=0.55	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	64	60	85	60	85
$\omega = 3.6\%$	71	60	85	62	85
$\omega = 6.3\%$	72	69	85	70	85

phi=0.60	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	65	60	85	60	85
$\omega = 3.6\%$	72	60	85	62	85
$\omega = 6.3\%$	72	69	85	70	85

phi=0.65	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	66	60	85	60	85
$\omega = 3.6\%$	72	60	85	62	85
$\omega = 6.3\%$	72	69	85	70	85

Scenario A-8 (fixed costs: high; consumption weight: steep)

phi=0.55	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	60	60	58	60	58
$\omega = 3.6\%$	60	60	58	60	58
$\omega = 6.3\%$	68	68	58	68	58

phi=0.60	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	60	60	64	60	62
$\omega = 3.6\%$	60	63	61	60	61
$\omega = 6.3\%$	68	68	61	68	61

phi=0.65	**With Earnings Test**	**No Earnings Test**		**Flexibility Reform**	
$\omega = 0\%$	60	60	66	60	64
$\omega = 3.6\%$	60	60	65	60	64
$\omega = 6.3\%$	68	68	63	67	64