RETIREMENT AGE UNDER UNEQUAL LONGEVITY AND WORK CAPACITY

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Retirement Age under Unequal Longevity and Work Capacity [1]

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Abstract: Retirement ages are rising in many countries to offset the challenges of population ageing, but people's capacity to work for more years in their later working life is unclear and unequal. If low-skilled workers enter the labour market earlier, work in more arduous jobs, and die earlier, a uniform increase in the statutory retirement age can disproportionately hurt them. This paper shows analytically how a two-sided actuarial adjustment in a PAYG pension system can protect workers retiring early due to arduous careers while preserving incentives to work longer and support financial sustainability. A simulation calibrated to Belgium accounts for income-related differences in premature mortality and longevity to estimate the cost of compensating arduous work and the pension adjustments needed for budget neutrality. The simulations suggest that the pension gain for compensated workers in the lowest income quintile is about three times the pension loss in the highest quintile, with this ratio varying with mortality and longevity gaps.

JEL classification: D63*,* D64*,* H55*,* I38
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1. Introduction

A central challenge for pension systems is to ensure an adequate standard of living for retirees while maintaining financial sustainability in the face of population ageing. As longer working lives become necessary to finance pensions, an important policy question arises: how can we encourage individuals to remain in the labor market longer without penalizing those whose health or working conditions prevent them from doing so?

People's capacity to work for more years in their later working life (>50 years) is unequal. The empirical evidence shows a social gradient in that working life expectancy. Parker et al (2020) analysis included adults aged 50 years and older from six waves (2002-13) of the English Longitudinal Study of Ageing (ELSA), with linked mortality data. Healthy working life expectancy was defined as the average number of years expected to be spent healthy (no limiting long-standing illness) and in paid work (employment or self-employment) from age 50 years. Population subgroups with the longest healthy working life expectancy were the self-employed (11·76 years [95% CI 10·76-12·76]) or those with non-manual occupations (10·32 years [9·95-10·69]), and those with a tertiary education (11·27 years [10·74-11·80]).

The central premise of our article is that occupations differ significantly in terms of their level of hardship, and that the most demanding jobs are disproportionately held by lower-qualified, lower-paid workers. These individuals typically enter the labor market at an earlier age and experience a more

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rapid deterioration in their working capacity due to physical strain, psychosocial stress, and greater job insecurity. As a result, there are strong equity arguments for allowing them to retire earlier. Fleurbaey et al. (2016) argue that accounting for inequalities in longevity is fair, as these differences are largely driven by factors for which individuals can hardly be considered responsible. This provides a strong welfare argument for setting a relatively early retirement age, as raising the retirement age disproportionately affects individuals with shorter life expectancies. In the OECD a group of 15 countries provide access to pension provisions for hazardous or arduous jobs for a large number of jobs and another group of 8 countries to a limited number of jobs (OECD 2023). Obviously, longevity differences also reflect non-occupational factors, including unemployment, pre-existing health, and circumstances preceding labour-market entry (Vandenberghe, 2023). A hardship pension mechanism should therefore be understood as compensating for the consequences of arduous work, not as addressing all sources of inequality in life expectancy.

To make longer working lives in response to population ageing socially acceptable and to address a fundamental equity/fiscal sustainability trade-off, we propose two adjustments: (i) allowing early labour-market entrants to retire earlier without requiring a longer career, and (ii) allowing shorter careers for workers in arduous occupations or with lower work capacity. We develop a concrete mechanism to implement both adjustments, estimate their budgetary cost, and show how they can be financed through targeted reductions in the highest pensions. We estimate who benefits and who loses from the reforms and quantify their respective gains and losses. We leave the welfare implications of the reforms to further research (see Conclusion).

To implement the early starters adjustment, we introduce a *normal retirement age* and a *two-sided actuarial adjustment* that accounts retrospectively for career length and prospectively for expected time in retirement. To address the working capacity adjustment, we assign a fixed arduousness compensation to each income quintile, while leaving its distribution within each quintile to the social partners. We assume that the compensation declines with income, reflecting the idea that workers in arduous occupations who already receive substantial wage compensation are less likely to require additional pension compensation.[3]

We are aware of the difficult *identification issue*. Some factors such as income, education and lifestyle correlate with both health and occupations and may be the main drivers of bad health, rather than bad health being the result of hazardous or arduous jobs. While life expectancy differs by broad occupational groups, a large part of occupational differences in life expectancy is related to socio-economic factors that are not caused by working conditions. However, even when socio-economic factors are controlled for, the differences in health status and life expectancy across occupational groups remain significant. There is convincing evidence of some working conditions negatively affecting health, sometimes with some delays (working at night, working under physical strain, working under high safety risks). To account for unequal declining capabilities to work until retirement ages and for immediate or delayed health risks caused by working conditions, we should adjust working life requirement to working life capability.[4]

[3] This addresses the wage compensation differential argument. For example, a highly paid night-shift worker in the chemical industry would be less likely to qualify for hardship-related retirement benefits than a low-paid worker exposed to similarly demanding working conditions

[4] Real-world implementation would require empirical evidence identifying which careers warrant differentiated retirement conditions and how arduous work affects longevity and employability. Such evidence would determine the appropriate extent of early retirement. The paper instead examines the mechanism's functioning and quantitative implications conditional on these parameters.

As Kolsrud et al. (2024) argue, reducing pensions for individuals who retire before the statutory retirement age is often inequitable because those leaving the labor market early tend to be among the most disadvantaged. Using Swedish microdata, they show that early retirees generally have lower lifetime wealth, poorer health, and shorter life expectancy. These findings underscore the importance of accounting for arduous working conditions and different working life capacity in pension design.

Another issue concerns the *appropriate intervention*. Some economists, following in the footsteps of Viscusi (1983), consider that occupational risk is internalised in wages (compensating wage). In principle, arduous jobs might already compensate workers through higher wages, which matters when deciding whether an additional pension intervention is warranted. But the empirical evidence on compensating differentials is quite mixed, and modern work (using panel data rather than cross-section data) emphasizes labour-market frictions and selection limiting the wage compensation (Lavetti ,2023). Poor working conditions tend to coexist with low wages while impediments to labour mobility might result in limited options for workers in unhealthy and low-paid jobs to move into some offering better conditions.

Free wage bargaining is considered to lead employers to compensate for increased risk with increased pay to attract workers. This analysis has been strongly criticised by other authors (Dorman 2009). Put simply, it ignores the reality that compensation for risk is highly variable and incomplete in practice: some workers are largely compensated for increased risk, others are partially compensated and finally some are not compensated at all and sometimes even penalised in the sense that "they are stuck in bad jobs that are worse in both respects".[5] A good job allows you to 'buy' good health (Burgard & Lin 2013).

In the United States, a study estimates that between 10% and 38% of the differences in longevity between socio-demographic groups are associated with different working conditions linked to the matching of workers with different levels of education in jobs with different levels of exposure to risks (Goh et al., 2015). Similar results were obtained in the Netherlands (Volkers et al 2007). A more rapid deterioration in work capacity was observed in workers with low levels of education, suggesting a greater deleterious effect of work on this occupational category (Berger et al 2022). Based on European SHARE data on self-assessed health, Baurin and Hindriks (2019) show that compared with teachers, farmers and construction workers are 41% less likely to report good health, metalworkers and surface technicians 35% less likely, and police officers and protective services 20% less likely. Using O*NET measures of working conditions, to construct a career-long indicator of physical arduousness for individuals aged 50 and over in 26 European countries, Vandenberghe (2025) reveals a life-expectancy gap between the least and most arduous careers of around 4–4.2 years. Differences in healthy life expectancy are even larger, ranging from 6.9 to 9.1 years. All these studies come up with the same problem, which is the phenomenon of "selection by health". People in good physical and mental health are more likely to get good jobs with good working conditions. People in poor health are more likely to find themselves out of work or in jobs that are more exposed to health risks. Based on a meta-analysis, Paul & Moser (2009) point out that 34% of the unemployed suffer from psychological problems, compared with 16% of the employed population.

Compensating for unequal longevity is another important objective of a fair pension system. Differences in life expectancy across socioeconomic groups imply that workers with shorter lives, who are often exposed to more demanding working conditions and lower lifetime earnings, receive pension

[5] Dorman and Boden (2021) present a methodical deconstruction of the myth of wage compensation for arduous and dangerous jobs. Kalleberg (2011) describes the growing dualization of employment in the United States, with “high pay safe jobs”; and “low pay harmful jobs”.

benefits for fewer years than those who live longer. Based on Belgian population microdata, Feliciangeli et al (2025), find variation of about 20% in the survival probabilities around the retirement age of 65 across socio-economic groups. Case and Deaton (2021, 2023) show that the education gap in life expectancy is widening is the US. Without corrective mechanisms, a uniform retirement age and benefit formula can therefore generate implicit redistribution from disadvantaged to more advantaged groups (Sánchez-Romero 2024). Incorporating unequal longevity into pension design can improve both equity and the perceived legitimacy of the system while preserving its financial sustainability.

The paper is organized as follows. Section 2 presents the pension framework, while Section 3 introduces the two-sided actuarial adjustment rate. Section 4 describes the preferential accrual rate. Section 5 calibrates the model to the Belgian context and introduces the budget constraint ensuring that policy costs are matched by revenues. Section 6 presents the simulation results, focusing on the effects of alternative retirement age policies and longevity risks on pension gains and losses. Section 7 concludes.

2. The Pension framework

Most public pension (on a pay-as-you-go basis) records pension entitlements, expressed in euros (or in points), accumulated throughout an individual's career. The account is opened at the start of the career, and each year's gross earnings (possibly subject to a cap) generate additional pension rights through an accrual rate. This rate is approximatively defined as the target replacement rate divided by the length of the reference career. Before new rights are added, previously accumulated entitlements are indexed in line with nominal wage growth (or inflation). At retirement, the total accumulated and indexed entitlement is converted into an annual pension using an age-dependent conversion coefficient. After retirement, the pension amount is adjusted annually through a revaluation coefficient.[6]

For an individual retiring in year T, the pension rights evolve through three successive phases: before retirement t<T, at retirement t=T and after retirement as follows:

$$P_t = \begin{cases} (1+r_t)P_{t-1} + a_t w_t, & \text{for } t < T, \\ \pi_T P_T, & \text{for } t = T, \\ (1+r_t)P_{t-1}, & \text{for } t > T. \end{cases}$$

Where for each year t, P_t is the annual pension, r_t the indexation rate, a_t is the accrual rate, w_t is the pensionable wage and π_T is the actuarial rate. In simple terms, the accrual rate determines the amount of pension entitlement accumulated each year, while the indexation (or revaluation) rate determines how these accumulated rights evolve over time. These two parameters are the main policy levers available to ensure the financial balance of the pension system. Baurin and Hindriks (2023) show that reforms affecting indexation and accrual rates have very different efficiency and equity effects when addressing the cost of population ageing. Indexation reform is fairer because it spreads the aging adjustment costs across a broader range of generations, including current and future retirees, whereas the accrual reform only concerns the future retirees. Indexation reform is also more effective in

[6] Point system uses point costs and point values to convert the accumulated points at retirement age into a pension benefit. Notional Defined Contribution (NDC) systems use notional contribution as accrual rate and notional interest as indexation rate, as well as annuity rate to convert the notional capital into a pension annuity at retirement age.

balancing the budget because its impact is immediate, whereas the accrual reform unfolds gradually as it rolls over across successive cohorts of workers, with individuals progressively accumulating pension rights under the new accrual rates.

The actuarial adjustment rate

The actuarial rate π_T is an age conversion rate rather than the general actuarial conversion of a pension account into an annuity. The key idea is that an actuarially neutral pension adjustment changes the annual pension when the retirement age changes so that the expected present value of pension benefits (pension wealth) remains unchanged. Suppose P_T is the annual pension when retiring at the age T, and an individual instead retires early at $R < T$. The actuarially neutral early-retirement pension satisfies $P_R = \pi_R P_T$ with $\pi_{R,T} = L_T/L_R$ where $L_R > L_T$ are the expected pension longevity at ages $R < T$. Because someone retiring at $R < T$ is expected to receive benefits for longer, $\pi_{R,T} < 1$: early retirement implies a lower annual pension, but the reduction is actuarially neutral because the expected (discounted) pension wealth is unchanged.

Rather than calculating π_T separately for everyone's longevity risk, we calculate it using the average longevity of the population:

$$\pi_{R,T}^{pool} = \frac{\sum_{t=T+1}^{\infty} {}_t p_T^{pool}}{\sum_{t=R+1}^{\infty} {}_t p_R^{pool}}.$$

Where ${}_t p_T^{pool}$ and ${}_t p_R^{pool}$ are the probability of surviving t years after retirement ages T and R. Therefore, workers with different longevity risks are pooled and charged a common rate based on average longevity risks when retiring early at age $R < T$. This is consistent with the current practice of actuarially fair systems, where contributions are pooled and individuals who die earlier subsidize the pensions of those who live longer, and benefits are typically based on average life expectancy.[7]

This creates implicit redistribution across longevity groups: individuals with shorter-than-average longevity receive pension benefits for fewer years, while those with longer-than-average longevity receive them for more years. Two features of our pension policy will mitigate that implicit redistribution: the normal pension age and the arduous work compensation.

Following Schokkaert et al. (2020), instead of a uniform statutory retirement age T, we define a *normal pension age*, T_i which depends on the completion of a "normal" career length. If L_{T_i} denotes the expected pension longevity when retiring at the normal retirement age T_i, and L_R the expected pension longevity at the actual retirement age R, then an actuarially neutral adjustment factor can be defined as:

$$\pi_{R,T_i} = \frac{L_{T_i}}{L_R} \leq 1 \quad \text{for } R \leq T_i$$

The actuarial adjustment factor π_{R,T_i} is defined as the ratio of expected pension longevity at the normal retirement age T_i to expected pension longevity at the actual retirement age R, $\pi_{R,T_i} = \frac{L_{T_i}}{L_R}$. This adjustment ensures actuarial neutrality by keeping expected (discounted) pension wealth

[7] Note that if high-income earners, who receive larger pension benefits, also tend to outlive the average, these "regressive" actuarially fair systems risk becoming financially unbalanced.

constant across retirement ages. In this framework, actuarial corrections depend both on career length and chronological age. It represents a *two-sided actuarial adjustment* based on prospective pension longevity and retrospective working longevity.

This two-sided actuarial adjustment has two noteworthy properties, beyond offsetting the budgetary cost of retiring before the normal pension age.

First, *retrospectively*, the actuarial adjustment rate is intrinsically linked to the age at which an individual enters the labor market. Since the normal pension age is defined by the completion of a normal (uniform) career length, individuals who start working earlier also reach their normal pension age earlier. Consequently, a low-educated worker who begins working five years before a high-educated worker can retire five years earlier without any actuarial penalty.

Second, *prospectively*, the actuarial penalty associated with one year of retirement before the normal pension age is smaller for individuals who started their careers earlier. Consider a normal career length of 45 years and an average life expectancy of 20 years at age 65 (recall that longevity risks are pooled and based on average longevity). A worker entering at age 18 reaches the normal pension age at 63. If this worker retires at age 62—one year before the normal pension age—the conversion rate is 22/23, corresponding to an actuarial reduction of 4.35%. Conversely, a worker entering at age 23 reaches the normal pension age at 68. Retiring at age 67 yields a conversion rate of 17/18, implying an actuarial reduction of 5.56%. Thus, the actuarial penalty associated with one year of anticipation is about 25% larger for someone who started working five years later.

The same reasoning applies to postponed retirement: the actuarial premium for working beyond the normal pension age is larger for individuals who entered the labor market later. We regard this feature as desirable because it provides stronger incentives for highly educated workers, who typically begin their careers later, to extend their working lives, while imposing weaker incentives on less educated workers, who generally start working at younger ages.

Suppose that average longevity at age 65 increases from 20 to 22 years. For a worker who entered the labour market at age 20, the conversion coefficient for retiring one year before the normal pension age then increases from 20/21 to 22/23. As a result, the actuarial reduction falls from 4.77% to 4.35%. In other words, increases in longevity mechanically reduce the actuarial penalty for early retirement. One way to neutralise this effect is to adjust the reference career length in line with gains in life expectancy.[8]

Now consider the actuarial adjustment rate would be differentiated by income group to reflect differences in life expectancy (see Quinby and Wettstein, 2024). At first glance, such differentiation may appear justified: if low-income workers have a shorter life expectancy at age 65 than high-income workers, one might argue that actuarial adjustments should be based on group-specific life expectancies. However, this approach would have the unintended consequence of imposing larger actuarial penalties on low-income workers who retire before their normal pension age. To illustrate, consider two workers who both enter the labor market at age 20 and complete a full career by age 65. If the first worker has a remaining life expectancy of 16 years at age 65, the conversion coefficient for retiring one year early is 16/17, whereas it is 20/21 for a worker with a remaining life expectancy of 20

[8] In some countries, including Denmark, Estonia, Greece, Italy, and the Slovak Republic, the retirement age rises one-for-one with life expectancy, thereby keeping the expected duration of retirement constant. In others, including Finland, the Netherlands, Portugal, and, from 2026, Sweden, the adjustment is more gradual: the retirement age increases by two-thirds of the gain in life expectancy, maintaining a stable ratio between years spent working and years in retirement (OECD, 2023)

years. The corresponding actuarial reduction is therefore 5.89% for the former, compared with 4.77% for the latter. In other words, basing the conversion rate on group-specific longevity would require individuals with shorter life expectancy to bear larger penalties for early retirement.

This runs counter to our objective. If anything, stronger incentives to postpone retirement should apply to individuals with longer life expectancy rather than to those with shorter life expectancy. For this reason, we propose using the actuarial rate based on average life expectancy. Besides avoiding undesirable distributional effects, this approach is also considerably simpler to implement.

Moreover, linking the normal pension age to career length rather than to chronological age already partially accounts for differences in longevity. Individuals who enter the labor market at younger ages are disproportionately represented among lower-income groups and tend to have shorter life expectancy. Because they also reach their normal pension age earlier, the proposed system partly compensates for the socioeconomic longevity gap without requiring group-specific conversion rates.

3. Preferential accrual rate

We now consider an additional adjustment for workers in arduous occupations/with limited working life capacity, allowing the required career length to be reduced without penalty. This adjustment neutralizes both the actuarial correction of early retirement and the loss of pension entitlements associated with completing a shorter career.

For example, consider a worker who enters the labor market at age 20 and retires at age 64, one year before the normal pension age, under a system based on a full career of 45 years. In the absence of an arduous work adjustment, this worker would face two separate reductions. First, the shorter career would reduce pension entitlements by 1/45. Second, retiring one year before the normal pension age would trigger an actuarial penalty of 4.77%. The purpose of the adjustment is to compensate for both effects.

To achieve these objectives, we propose applying a preferential accrual rate to years worked in arduous occupations and workers with limited working capacity. This allows those workers to retire earlier without a reduction in pension benefits. Let n_t denote the number of years of career credit granted to a worker employed in an arduous occupation throughout an entire career. The objective is that such a worker can retire n_t years before completing the reference career without any loss of pension.

For a career requirement N_t and a replacement rate ρ_t , the accrual rate is given by $a_t = \frac{\rho_t}{N_t}$. The arduous work accrual rate is the standard accrual rate multiplied by an arduousness coefficient. We call it the preferential accrual rate $\mathring{a}_t$. This preferential accrual rate evolves over time as a function of changes in the reference career N_t, the target replacement rate ρ_t , the credited years n_t, and the actuarial rate π_t, which itself varies with demographic developments.

$$\mathring{a}_t = a_t \left(\frac{N_t}{N_t - n_t}\right) \pi_t^{-1}$$

The first correction $\frac{N_t}{N_t - n_t}$ compensates for the reduced career length of $N_t - n_t$ years, and the second correction π_t^{-1} offset the actuarial penalty for early retirement. The actuarial rate is calculated as the ratio of life expectancy at the completion of the reference career to life expectancy at the retirement age corresponding to an adjusted career length of $N_t - n_t$ years.[9] For workers with mixed careers, the preferential accrual rate is applied only to fraction of career exposed to arduous occupations, while the standard accrual rate a_t applies to the rest of the career.

The budgetary cost of the arduous work compensation will be estimated based on the share of occupations recognized as arduous and their distribution across the income distribution.

Table 1 indicates the *preferential* accrual rate for different normal pension ages and different levels of arduousness, assuming a reference career of N_t =45 years, a target replacement rate of ρ_t =60%, and an average pension longevity of L_T =20 years at age T=65. The preferential accrual rate increases with both the number of compensated years and the normal pension age. In this example, it ranges from 7% (1.42/1.33) for one compensated year with a normal pension age of 63 to 33% (1.78/1.33) for four compensated years with a normal pension age of 67.

Table 1. Preferential accrual rate.

Compensated years (*n*)	Normal retirement age (NRA) 63	64	65	66	67
0	1.33	1.33	1.33	1.33	1.33
1	1.42	1.43	1.43	1.43	1.44
2	1.52	1.52	1.53	1.54	1.55
3	1.62	1.63	1.64	1.65	1.66
4	1.73	1.74	1.75	1.77	1.78

The preferential accrual rate increases with the normal retirement age, as expected retirement duration declines with later retirement. Consequently, the actuarial adjustment for early retirement becomes more stringent, requiring a higher accrual rate to compensate. For a worker expected to live to age 80, advancing retirement by one year increases pension benefits by 5.8% when normal retirement age is 63, compared with 7.6% when it is 67.

4. Model calibration to Belgium

5.1 Normal retirement age (NRA)

Retirement depends on completing a uniform reference career rather than reaching a statutory age. We infer the labour market entry age from the educational composition of each wage quintile. For simplicity, we assume individuals complete their education on time, enter the labour market immediately, and experience no career interruptions (or that any interruptions are fully credited toward the reference career). This yields the earliest age at which a full career is completed.

The first step is to determine the educational composition of the Belgian working-age population. Although education data are available for the entire population, they are not well suited for our

[9] Recall that the conversion coefficient depends on the age at which an individual enters the labour market. Since the arduousness coefficient is designed to compensate for the cost of early retirement, this coefficient varies with the age at which the career begins.

purpose because they include many individuals aged 15 or over who have not yet completed their education, while older cohorts are less representative of the current and future workforce.

We therefore use Statbel data for individuals aged 25–54, for whom educational attainment is largely complete. In this group, 14.5% have a low level of education (lower secondary or no diploma), 36.5% have completed upper secondary education, and 49% hold a higher education degree. As the data do not distinguish between bachelor's and master's degrees, we assume these groups are of equal size, assigning 24.5% to each.

The second step is to allocate individuals across wage quintiles. Using Statbel data on average gross earnings by education level, we assign each educational group to the wage distribution so that the implied average earnings closely match the observed averages.

We assume that university graduates are absent from the first quintile, as the average starting salary of a university graduate (€2,845; Jobat) exceeds the upper bound of that quintile (€2,650 gross). We also assume that individuals with no diploma are absent from the top quintile. In contrast, bachelor's degree holders are distributed across all quintiles, reflecting their average starting salary (€2,585) and greater wage dispersion. We further assume that the educational composition of the 25–54 age group is representative of the workforce.

Although these allocations are necessarily approximate, the implied average wage for each education group differs from the corresponding Statbel average by only €38 to €94, suggesting that the calibration provides a reasonable fit.

The average labour market entry age in each quintile is calculated as the weighted average of the entry ages associated with each education level. We assume the earliest possible career start: age 18 for individuals with at most an upper secondary diploma, age 21 for bachelor's graduates, and age 23 for master's graduates. The corresponding normal retirement age is then obtained by adding a uniform 45-year reference career, assuming all career interruptions are fully credited.

Table 2 : Career entry age and normal retirement age (NRA)

Wage quintile	Monthly wage (€)	Career entry age	Normal retirement age (NRA)
1	2 280	18.6	63.6
2	2 938	19.1	64.1
3	3 547	19.7	64.7
4	4 258	20.6	65.6
5	6 946	22.4	67.4

With a uniform retirement age at 65, the initial pension longevity gap is 8 years. Accounting for differences in career entry ages through the normal retirement age reduces this gap by half, to 4 years. This retirement age correction is budget-neutral because earlier retirement for early labour-market entrants is offset by later retirement for those who enter the labour market later. In fact, the adjustment to the retirement age is likely to have a positive budgetary impact, as higher-income individuals, who receive larger pension payouts, also tend to live longer than the average individual.

5.2 Cost of early retirement age (ERA)

We assume that exposure to arduous work decreases with income. In the baseline scenario, eligible workers receive three years of early retirement in Q1, two years in Q2, one year in Q3, and none in Q4–Q5.

For each eligible worker, the budgetary cost consists of the additional pension benefits paid during the compensated years and the contributions forgone over the same period. Workers in non-arduous occupations retire upon completing the reference career, while those in arduous occupations retire earlier by the number of compensated years assigned to their income quintile. We assume that workers retire at the earliest possible age, consistent with empirical evidence (Seibold, 2021; Rabaté et al., 2024).

We use the replacement rates reported by the OECD in *Pensions at a Glance 2023* for Belgium. The replacement rate is 67.5% for a worker earning half the average wage, 43.4% at the average wage (€3,832 gross per month), and 29.2% at twice the average wage. Linear interpolation between these reference points gives estimated replacement rates for each income quintile, ranging from approximately 63% in Q1 to 32% in Q5. The decline in replacement rates with income reflects the redistributive design of the Belgian pension system. Low earners benefit from a minimum pension and minimum pension rights per year of career, while pensionable earnings are capped at a statutory wage ceiling (€71,520 in 2022).[10]

For social security contributions, we distinguish between employee and employer contributions. Employees contribute 13.07% of their gross remuneration. Average employer social security contributions amount to 24.92% in the private sector, and 24.82% for contract workers in the public sector.[11]

Given the diversity of contribution regimes, and the fact that our data are limited to annual wages, we assume a uniform employee contribution rate of 13.07% and ignore additional remuneration components. This is likely to lead to a slight underestimation of employee contributions. For employers, we use an average contribution rate of 25%, slightly above the observed rates, to partially offset the exclusion of other remuneration elements from the calculation.

The annual budgetary cost for compensated workers consists of the pension paid during the compensated year (32% to 63% of the worker's average gross wage, depending on income) plus forgone employee (13.07%) and employer (25%) social security contributions. Overall, the cost ranges from 70.07% in Q5 to 101.07% in Q1 of the gross wage.

Table 3 reports the budgetary cost per eligible worker by income quintile. The total cost is highest in Q1 because workers receive three years of early retirement credits. On a per-year basis, however, the cost rises with income, from about €28,000 in Q1 to €36,000 in Q3. Although replacement rates decline with income, the resulting reduction in pension costs is more than offset by the higher social security contributions forgone on higher wages.

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[10] In addition, pension rights accrue during certain non-working periods—such as unemployment, illness, disability, parental leave, and career breaks—through *assimilated periods* based on a notional wage.

[11] We exclude statutory workers in the public sector (around 50% of the public workforce) from our analysis because their pension scheme differs substantially from that of the rest of the workforce. There is limited employer contribution, and more generous accrual rates (preferential *tantièmes*) based on end-of-career earnings rather than lifetime earnings. These preferential *tantièmes* have historically served as a form of compensation for arduous working conditions in the public sector.

Table 3 : Cost of early retirement age (ERA)

Quintile	Annual cost (% gross wage)	ERA credits (in years)	Total unit cost (in €)
1	101	3	82 968
2	93	2	65 639
3	85	1	36 212
4	80	0	0
5	70	0	0

The total expected cost of early retirement is

$$C(n_q, \sigma_q) = \sum_{q=1}^{3} M_q \, S_{T,q} \, \sigma_q \, n_q c_q$$

Where for each quintile *q=1,2,3*

M_q is the number of workers;

$S_{T,q}$ is the probability of surviving to retirement age T;

σ_q is the share of workers eligible for arduous work compensation;

n_q is the number of credited years of early retirement for eligible workers;

c_q is the annual budgetary cost of one credited year of early retirement;

5.3 Financing of ERA

We now turn to the financing of this early retirement policy (n_q, σ_q). Since the expenditure is incurred gradually over time, we propose a financing mechanism that is similarly spread over time, keeping revenues and costs aligned. The financing of arduousness compensation is concentrated on higher-income workers. Specifically, only individuals in the top two income quintiles contribute through an implicit tax on pension rights accrued on earnings above a threshold. This contribution is collected throughout retirement, as pension benefits are paid.

The threshold is set at the lower bound of the fourth quintile, corresponding to an annual gross wage of €46,248 (12 × €3,854). We calibrate the implicit tax rate to fully finance the cost of early retirement for arduous work. Early retirement is limited to the bottom three income quintiles, while the implicit tax applies only to the top two. Using income-specific replacement rates, we translate the tax into the corresponding reduction in pension benefits for higher-income workers. The tax rate is then set so that the expected cumulative pension reduction in the top two quintiles exactly offsets the total cost of early retirement in the bottom three.

The total financing revenue generated by applying the tax rate τ to the portion of pension benefits exceeding the lower-bound pension threshold of the fourth pension decile *P°* is

$$F(\tau) = \tau \sum_{q=4}^{5} M_q \, S_{T,q} \, L_{T,q} \, (P_q - P°)$$

Where for each quintile *q=4,5*

M_q is the number of workers;

$S_{T,q}$ is the probability of surviving to retirement age T;

$L_{T,q}$ is the average duration of pension payments after retirement age;

P_q is the average annual pension.

P° is the lower-bound pension of the fourth income quintile, i.e. the pension threshold above which the financing rate applies.

The budget balance is

$$F(\tau) = C(n_q, \sigma_q)$$

Therefore, for any early retirement policy (n_q, σ_q) the equilibrium implicit tax $\tau(n_q, \sigma_q)$ is

$$\tau(n_q, \sigma_q) = \frac{\sum_{q=1}^{3} M_q \, S_{T,q} \, \sigma_q \, n_q c_q}{\sum_{q=4}^{5} M_q \, S_{T,q} \, L_{T,q} \, (P_q - P°)}$$

It follows directly from this equation that the implicit tax rate decreases with the pension longevity of high-income workers $L_{T,q}$ (with *q=4,5*) and with their survival probability $S_{T,q}$ relative to that of low-income workers.

5.4 Accounting for longevity gap and pre-retirement mortality

Before running the simulations, we account for mortality differences across income groups, considering both life expectancy after retirement and pre-retirement mortality risk. Pre-retirement mortality reduces the cost of early retirement because no compensation is paid to workers who die before retirement. Differences in post-retirement longevity also allow the financing burden to be spread over the longer retirement periods of higher-income groups.

The simulation parameters are reported in Table 4. Mortality differentials and pre-retirement mortality risks are based on Eggerickx et al. (2020. Baseline retirement duration is measured conditional on survival to retirement and before early retirement credits.

Table 4 : Pre-retirement mortality and retirement duration

Quintile	Life expectancy	Pension duration (at NRA)	ERA credits (in years)	Early mortality < 65 (in %)
1	81.4	17.8	3	20.8
2	83.4	19.5	2	15.6
3	85.4	20.73	1	10.4
4	87.4	21.81	0	7.8
5	89.4	22.05	0	5.2

Before any intervention, the life expectancy gap between Q1 and Q5 is 8 years. Accounting for differences in labour-market entry ages through the normal retirement age reduces the pension duration gap to 4 years. Allowing earlier retirement for low-income workers further reduces this gap to just 1 year, conditional on survival to retirement.

5. Simulation results

6.1 Baseline policy scenario

Using the calibration parameters from Section 5, we estimate the annual cost of arduousness compensation under different arduousness and taper rates. The **arduousness rate** is the share of workers eligible for compensation in Q1 (reference group), while the **taper rate** measures how this share declines across income quintiles. Eligible workers receive three, two, and one years of pension anticipation in Q1, Q2, and Q3, respectively.

Table 5 reports on the resulting annual cost and the corresponding share of eligible workers (coverage rate). The annual cost ranges from €161 million to €1,127 million as the coverage rate increases from 3% to 25% of the workforce.

Table 5: Annual cost (in millions €) and coverage rate (*in brackets in %*)

Taper rate Arduousness rate	10%	30%	50%
10%	225 *(5)*	191 *(4)*	161 *(3)*
20%	451 *(10)*	383 *(8)*	323 *(6)*
30%	676 *(15)*	574 *(12)*	484 *(10)*
40%	902 *(21)*	766 *(17)*	646 *(13)*
50%	1127 *(25)*	957 *(21)*	807 *(16)*

Interestingly, for our baseline scenario of $n_1 = 3, n_2 = 2, n_3 = 1,$ (three, two, and one years of pension anticipation in Q1, Q2, and Q3, respectively), the implicit tax rate $\tau(n_q, \sigma_q)$ ranges from 3% to 25% as the coverage rate increases from 3% to 25%.

Table 6 : Implicit tax rate (in %)

Taper rate Arduousness rate	10%	30%	50%
10%	5	4	3
20%	10	8	7
30%	15	12	10
40%	20	17	14
50%	25	21	18

We can translate the implicit tax rate into the corresponding reduction in pension for higher-income workers. The implicit tax rate is set so that the expected cumulative pension reduction in the top two quintiles exactly offsets the total cost of early retirement in the bottom three. The implicit tax applies only to the portion of pension benefits exceeding the lower-bound pension threshold of the fourth pension decile *P°*.

Table 7: Expected pension loss (in %) – baseline scenario.

Taper rate	10%		30%		50%	
Arduousness rate	Q4	Q5	Q4	Q5	Q4	Q5
10%	0.5	2.2	0.4	1.8	0.3	1.6
20%	0.9	4.4	0.8	3.7	0.7	3.1
30%	1.4	6.5	1.2	5.5	1.0	4.7
40%	1.8	8.7	1.6	7.4	1.3	6.2
50%	2.3	10.9	1.9	9.3	1.7	7.8

The pension reductions remain modest as long as the share of arduous occupations is kept within a reasonable range. For example, with an arduousness rate of 30% in Q1 and a taper rate of 50%, the pension reduction is 1.0% in the fourth quintile and 4.7% in the fifth. These relatively small reductions reflect differences in mortality across income groups. Because higher-income individuals receive pensions over a longer expected period, the cost of compensation can be spread over more pension payments, resulting in a smaller annual pension reduction. At the same time, higher pre-retirement mortality among lower-income workers reduces the fiscal cost of compensating for arduous work, as some eligible workers die before reaching retirement.

As for the low-income group, the expected pension gain from the compensation is as follows

Table 8: Expected pension gain (in %) - baseline scenario

Taper rate	10%			30%			50%		
Arduousness rate	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
10%	1.7	0.9	0.4	1.7	0.7	0.2	1.7	0.5	0.1
20%	3.4	1.8	0.8	3.4	1.4	0.5	3.4	1.0	0.2
30%	5.1	2.8	1.2	5.0	2.1	0.7	5.0	1.5	0.4
40%	6.7	3.7	1.6	6.7	2.9	0.9	6.7	2.1	0.5
50%	8.4	4.6	1.9	8.4	3.6	1.2	8.4	2.6	0.6

The expected pension gain measures the average value of early retirement policy (n_q, σ_q) for individuals in the first three income quintiles Q1-Q3. It depends on both the arduousness rate and the taper rate, which determines how eligibility declines across quintiles $\sigma_1 > \sigma_2 > \sigma_3$.

Under an arduousness rate of 30% in the first quintile and a taper rate of 50%—the expected pension gain is 5.0% in the first quintile, 1.5% in the second, and 0.4% in the third. The much smaller gain in the third quintile reflects its lower eligibility rate: only 7.5% of workers qualify, compared with 30% in the first quintile.

These average gains, however, conceal much larger benefits for eligible workers. Conditional on receiving arduousness compensation, the pension gain rises to 17% in the first quintile, 10% in the second, and 5% in the third.

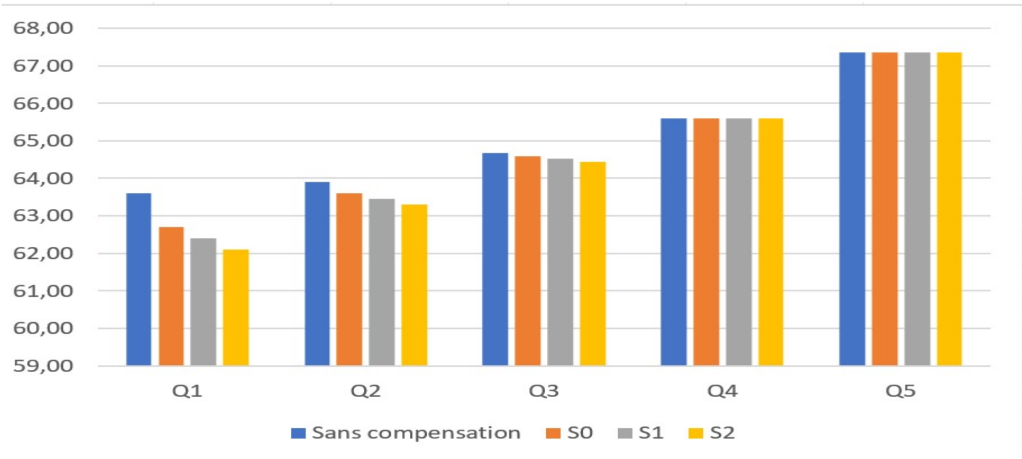
6.2 Alternative ERA scenarios

So far, we have varied eligibility rates within and across income quintiles. We now fix the eligibility rates at 30% in the first quintile, 15% in the second, and 7.5% in the third. We then compare three policy scenarios that differ in the number of years of pension anticipation granted to eligible workers.

In **Scenario 0** (least generous), eligible workers receive three years of pension anticipation in the first quintile, two years in the second, and one year in the third. In **Scenario 1** (intermediate), they receive four, three, and two years, respectively. Finally, in **Scenario 2** (most generous), the corresponding values are five, four, and three years. For each scenario, we compute the resulting retirement ages and the associated pension gains and losses.

Figure 1 illustrates the expected retirement ages under the three early-retirement scenarios (S0, S1, and S2), using the average career entry ages reported in Table 1. For each income quintile, we report both the average retirement age without compensation, and the expected retirement age with the various early-retirement scenarios S0,S1 and S2, with a 30%, 15% and 7,5% eligibility probability in Q1, Q2, and Q3, respectively.

Figure 1. Expected Retirement Age - alternative ERA scenarios



Under the no-compensation scenario (blue chart), only the *normal* retirement age (NRA) applies, with earlier retirement among lower-income workers reflecting their earlier entry into the labour market. Interestingly, the normal-age correction allows Q1 workers to retire four years earlier than Q5 workers.

Under scenarios S0–S2, retirement ages vary both within and across Q1–Q3, reflecting differences in eligibility for arduousness compensation.

Figure 2 reports pension gains and losses as percentages of pension benefits under the alternative policy scenarios. These gains and losses vary with the generosity of the arduousness compensation and reflect differences in life expectancy across income quintiles. Mortality rates, reported in Table 4, are held constant across scenarios. Pension gains apply only to workers eligible for arduousness compensation, while pension losses apply only to those who survive to retirement.

Figure 2. Pension gains (if compensated) and losses (%) -alternative ERA scenarios

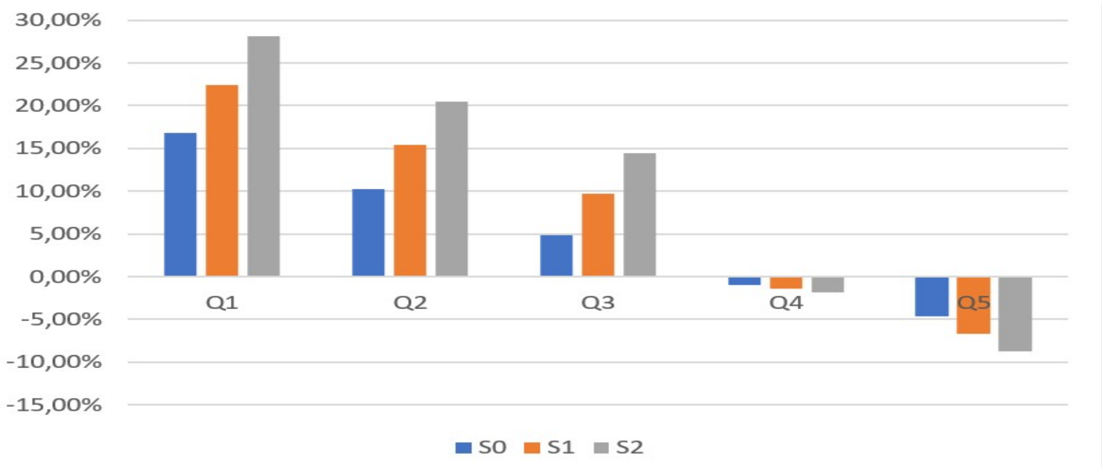
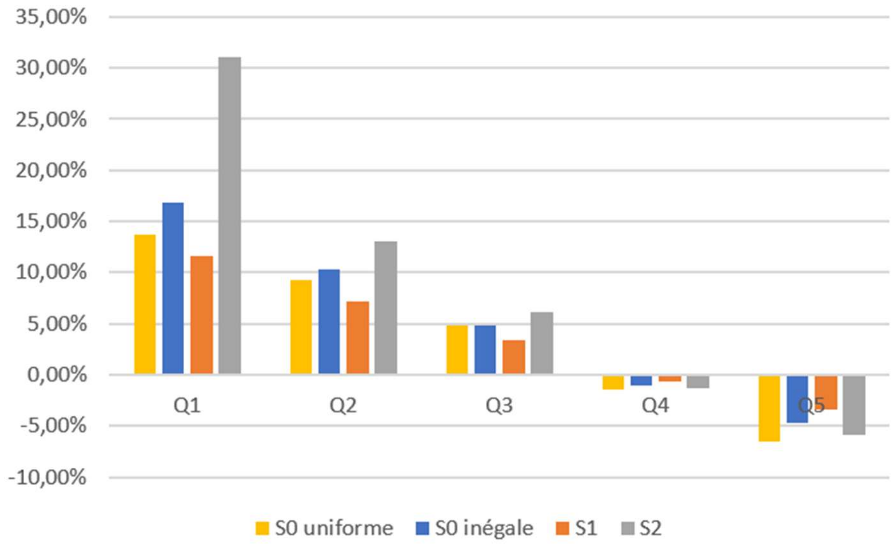


Figure 2 shows that, regardless of the generosity of the early retirement policy—from three years of early retirement in S0 to five years in S2—the pension gain for compensated workers in the lowest income quintile is approximately three times the pension loss in the highest quintile. These relatively small pension losses reflect differences in mortality across income groups. Because higher-income individuals have longer expected periods in retirement, the cost of arduousness compensation can be spread over more pension payments, resulting in a smaller annual pension reduction. At the same time, higher pre-retirement mortality among lower-income workers reduces the fiscal cost of arduousness compensation, as some eligible workers die before reaching retirement.

6.3 Alternative longevity and mortality risks

We now vary the demographic parameters to assess their impact on relative pension gains and losses, while keeping the retirement policy unchanged. Figure 3 illustrates pension gains and losses under the same arduousness compensation scheme—three years of early retirement in Q1, two years in Q2, and one year in Q3. The normal retirement age is unchanged. In S0-uniform, pre-retirement mortality is set to zero and life expectancy is uniformly 85.4 years. In S0-unequal, both pre-retirement mortality and life expectancy vary across income quintiles, as reported in Table 4.

Figure 3 Pension gains (if compensated) and losses (%) – alternative mortality risks



Comparing the two scenarios, unequal mortality and longevity increase the pension gain for low-income workers. The reason is that, conditional on survival to retirement, three years of early retirement represent a larger increase in expected pension duration for a worker with a shorter remaining life expectancy. For example, reducing the retirement age in Q1 from 63.6 to 60.6 years generates a larger proportional increase in expected pension duration for a worker expected to live to 80 than for one expected to live to 85.

For higher-income workers, longer expected retirement durations allow the cost of arduousness compensation to be spread over more pension payments, thereby reducing the proportional pension loss. In addition, higher pre-retirement mortality among lower-income workers reduces the overall cost of compensation, further limiting the pension adjustment required at the top of the distribution.

In Scenario S1, we increase the longevity gap by 10% by increasing life expectancy by 10% for all income groups, while keeping pre-retirement mortality unchanged from S0-unequal. The resulting longer expected retirement duration reduces the relative pension gain for low-income workers. At the same time, the pension loss at the top decreases because the compensation cost is spread over more pension payments.

In Scenario S2, we instead reduce the longevity gap by 10%, through an equal proportional reduction in life expectancy across all income groups, while keeping pre-retirement mortality unchanged. Relative to S0-unequal, the pension gain for low-income workers doubles, while the pension loss at the top remains broadly unchanged.

6. Conclusion

In this article, we propose a two-sided actuarial adjustment based on prospective pension longevity and retrospective working longevity. Beyond ensuring that early retirement is budget neutral, the two-sided actuarial adjustment has two key properties. First, retrospectively, the normal pension age depends on career entry age: workers who start earlier can retire earlier without an actuarial penalty. Second, prospectively, the actuarial penalty for each year of early retirement is smaller for workers who entered the labour market earlier. Accounting for earlier labor market entry among low-income workers allows them to retire four years earlier than high-income workers, thereby reducing the pension longevity gap by 50%. This provides the first compensation to workers with limited capacity to work longer. The second compensation is to reduce the career length of workers exposed to arduous and hazardous occupations to account for declining capabilities to work until retirement ages and for immediate or delayed health risks caused by working conditions. There is no consensus on how to define hazardous or arduous jobs and so we delegate that decision to social partners with a fixed envelope. We considered alternative scenarios varying both the overall share of workers in arduous occupations and its distribution across income quintiles. In each case, the reform was designed to be budget-neutral, with the additional pension rights financed through reductions in the highest pensions. The results show that targeting arduousness compensation towards lower-income workers requires only modest pension reductions at the top of the income distribution. For example, granting hardship compensation to 30% of workers in the first income quintile, 15% in the second quintile, and 7% in the third quintile would imply a pension reduction of 1.0% for the fourth quintile and 4.69% for the fifth quintile.

These results suggest that a targeted hardship scheme can be implemented without imposing large adjustments on higher-income retirees, who are also more likely to receive retirement income from complementary sources such as occupational pensions, private savings, and accumulated wealth. Supporting this interpretation, Kolsrud et al. (2023), using Swedish data, show that consumption declines more sharply following retirement among low-income households than among high-income households. More importantly, they show how consumption (observable metric) can be a key metric for evaluating welfare effects of pension reforms. Their analysis indicates that the welfare cost of providing late-career incentives is higher the larger the drop in consumption *when retired* for early retirees relative to late retirees.

Several limitations should be acknowledged. Our analysis relies on simplifying assumptions regarding the identification of arduous occupations, its distribution across income groups, and the financing mechanism. Consequently, the quantitative estimates should be interpreted as illustrative rather than as precise policy predictions. Future research could relax these assumptions by incorporating richer administrative data on working conditions, health, and lifetime earnings, thereby providing a more comprehensive assessment of the costs and distributional effects of our compensation policy. The quantitative pension gain and loss estimate from the reforms need to be translated into a welfare implication.[12] Kolsrud et al. (2024) provides a framework that allows for a simple and transparent welfare analysis of pension reforms to go beyond consumption/income implications when evaluating the equity of pension reforms. The key objective is to assess the welfare implications of reallocating pension resources from better-off individuals to individuals with fewer resources, who face a higher risk of premature mortality and shorter pension durations.

In OECD (2023), the role of various policies (other than old-age pensions) in addressing hazardousness and arduousness of jobs as well as shorter working life capacity is analysed, namely: health and safety regulations; communication; reskilling measures and age management; and, disability insurance. Vandenberghe (2026) argues that existing retirement, disability, sickness, and unemployment schemes already generate substantial de facto differentiation in effective/implicit retirement ages. Our contribution is to provide a quantitative illustration of the redistributive and financial implications of these various early retirement pathways;

Our analysis focused on hardship/limited working capacity compensation through earlier retirement and, to a limited extent, on reducing longevity inequalities by linking the pension age to the career start age. An alternative approach is proposed by Diakité and Devolder (2022), who adjust pension benefits according to income to equalize implicit rates of return across socioeconomic groups. In our

[12] We thank Frank Riedel for this useful reminder.

simulations, this effect is incorporated implicitly through actual replacement rates, which decline from 63% in the first income quintile to 32% in the fifth, reflecting Belgium's pension ceilings and minimum pension provisions.

Similar income-related benefit structures exist in other countries. For example, Social Security replacement rates in the United States decline from 90% to 32% and 15% across successive earnings brackets, while the corresponding rates in Switzerland are 84%, 56%, and 33%. As evidence of widening socioeconomic differences in life expectancy continues to accumulate (Bosworth et al., 2016; Bravo et al., 2021; Walczak et al., 2021; Vandenberghe, 2022), the treatment of longevity inequalities has become an increasingly important issue in pension design.

An alternative approach is to link pension entitlements directly to limited work capacity, which may be associated with both shorter working lives and lower life expectancy. This principle is already reflected, to some extent, in several countries through disability insurance and incapacity pensions. In France, for example, pension rules provide earlier access to retirement and adjust pension entitlements for individuals with disabilities, recognising their typically shorter life expectancy. A similar rationale applies to workers with a history of asbestos exposure, who face an elevated risk of cancer and are therefore allowed to claim their pension before the statutory eligibility age (Bosio et al., 2024).

The aim of our retirement policy proposal is, ultimately, to organize the social compensations of our current pension system in a transparent, objective and targeted way, by means of common and simple rules, which today vary considerably from one pension scheme to another. Illustration of poor targeting is to condition early retirement to long careers (as for instance in Belgium, France, Germany and Belgium). Recent evidence suggests mistargeting: individuals with longer careers tend to have higher, rather than lower, life expectancy (Börsch-Supan et al., 2022; Aubert, 2024).

A final point relates to spillover across social insurance programmes. The literature documents sizeable spikes in inflows into unemployment insurance (UI) and disability insurance (DI) at ages when workers gain access to these programmes, suggesting that many older workers use them as pathways to early retirement (Haller and Staubli,2024). Restricting access to UI and DI can therefore substantially increase employment rates among older workers before the early-retirement age.

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