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Career breaks, broken pensions? Long-run effects of early and late-career unemployment spells on pension entitlements

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Abstract

Unemployment periods and other career breaks have long-term scarring effects on future labour market possibilities, permanently affecting workers' retirement income and standard of living as pensioners. Previous literature has focused on the impact of job loss on working careers with little attention to its impact on pension wealth, particularly the extent to which longevity heterogeneity amplifies unemployment scars. This paper investigates the effect of single and multiple unemployment spells on the lifetime pension entitlements of earnings-related contributory pension schemes, considering the timing and duration of breaks, alternative lifecycle labour earnings profiles, scarring and restoration effects on labour market re-entry, the existence of pension credits and pension accruals for periods spent outside the labour market, longevity heterogeneity, and the accumulation and decumulation redistributive features of the pension scheme. Pension entitlements are estimated using a backward-looking simulation approach based on the actual Portuguese public pension system rules and stylized labour market profiles identified in the SHARE Job Episodes Panel data using a sequence analysis. Longevity heterogeneity is modelled using a stochastic mortality model with a frailty model. Our results show that the timing and duration of unemployment periods is critical, that scarring effects amplify pension wealth losses, that minimum pension provisions, pension credits and pension scheme redistributive features can partially mitigate the impact of unemployment periods on future entitlements, and that the presence of positive correlation between lifetime income and longevity career breaks can amplify the asymmetry in the distribution of pension entitlements across income groups.

Key words: Longevity heterogeneity; pension credits; pension entitlements; restoration effects; scarring effects; unemployment breaks

JEL codes: J26; J64; H55; H23

1. Introduction

In earnings-related pension schemes, benefits are closely linked to individual employment histories, wages and contributions. Unemployment periods and other voluntary or involuntary career breaks (e.g., part-time employment, layoff, termination of fixed-term contracts, parental leave, childbearing, childrearing, illness/disability, studying, military service, housekeeping without raising children or general inactivity periods) have long-term scarring effects on future labour market possibilities and earnings, permanently affecting workers' retirement income and the pension system financial sustainability. The literature on the implications of job loss is growing but has mostly concentrated on either the short-term or the permanent and persistent effects of job loss on working careers and therefore on

future (nominal and real) wages, particularly when compared to workers in similar full-career work (see, e.g., Burda and Mertens, 2001; Beblo and Wolf, 2002; Manning and Petrongolo, 2008; Bucheli *et al.*, 2010; Schmieder *et al.* 2014; Edler *et al.*, 2015; Heisig, 2015; Paul, 2016; Heisig and Radl, 2017), future labour market possibilities and job quality (e.g., Arulampalam, 2001; Gregg, 2001; Dieckhoff, 2011) and labour market re-entry wages ('scarring' effects), the negative psychological and physical health consequences for affected workers (e.g., Noelke and Beckfield, 2014), subsequent unemployment chances (path-dependency), the retirement decision (Chan and Stevens, 2004), loss of psychosocial assets, social withdrawal, family disruption and lower levels of children's attainment and well-being (see, e.g., Brand (2015) for a recent review).

Empirical evidence suggests that unemployment breaks are the type of career interruption that is more harmful to an employee's future wage prospects and, consequently, to pension benefits (e.g., Mincer and Ofek, 1982; Albrecht *et al.*, 1999; Bruce and Schuetze, 2004; Cooper, 2014; Schmieder *et al.*, 2014; Heisig and Radl, 2017). This is usually explained by lower human general or firm-specific capital accumulation¹, negative signalling effects, lower labour force attachment or matching theory (Mincer and Polachek, 1974; Jovanovic, 1979; Mincer and Ofek, 1982; Oesch and Baumann, 2015; Paul, 2016). Little research has been dedicated to identifying and quantifying the effects of early or late job separation on the lifetime pension entitlements of displaced workers considering not only the timing and duration of breaks and reemployment wage patterns but also the institutional settings of the pension scheme that may mitigate or amplify the effects in retirement incomes in old-age.

The magnitude of the impact of shorter and more fragmented careers on pension entitlements is expected to depend, first, on the type, frequency, timing and duration of unemployment periods and corresponding scarring and restoration effects. According to the human capital theory, the higher the concentration of human capital investment in early ages is, the higher lifetime earnings will be and the lower both the risk and the duration of unemployment spells will be (Becker, 1975, 1985; Mincer and Ofek, 1982; D'Addio, 1998). The timing of employment breaks on the individual income profile matters because skills, knowledge and experience change over time and they are valued differently in the labour market. The duration of unemployment is determined by individuals' search effort, and job acceptance decisions, the random arrivals of job offers as well as the generosity of unemployment benefit and assistance programmes. An individual who is unemployed longer is expected to face different labour demand (e.g., receive less and potentially different job offers), the longer the duration of unemployment, because of skill depreciation or stigma (Machin and Manning, 1999). In addition, workers may accept different jobs and lower wages the longer they are unemployed, i.e., they may have a declining reservation wage the longer they have been out of work.² Some authors find a catch-up effect (also called 'restoration effect') of human capital following an unemployment-break

¹Discontinuities in the employment profile or temporary downgrading to part-time employment are expected to cause wage cuts since they imply an interruption in the accumulation of human capital as well as a depreciation of human capital stock built up in the past. This is because technical progress and innovations in the work process may cause human capital acquired in previous years of employment to become obsolete after an employment-break, particularly if this know-how is not preserved and updated during the career break. On the job, workers often acquire job-specific and organization-specific skills that are not necessarily transferable to other companies. Outside the labour market, previously acquired skills, when not regularly exercised, are subject to processes of atrophy and depreciation. Consequently, a new position where these skills are not valued will likely pay a lower wage, at least initially, until the worker acquires the skills that are valued by the new employer. Additionally, the longer a worker is out of work, the more his or her firm-specific skills depreciate, making the worker less valuable to a new employer. This situation again translates into receiving a lower initial wage at a new job. However, if the career interruption is due to training periods, positive wage effects are expected, i.e., the overall wage changes may be split into two components, a missing experience effect and an additional productivity-related effect.

²Several studies suggest that past unemployment spells may raise negative expectations on the side of the employer regarding the actual productivity or motivation of the potential employee, translating into lower wages (see, e.g., Albrecht *et al.*, 1999).

that may partly offset the depreciation of human capital and mitigate re-employment wage cuts (see, e.g., Mincer and Ofek, 1982; Cooper, 2014; Schmieder *et al.*, 2014).³ The restoration effect is expected to be stronger in the early and middle stage compared to the late employment period and the shorter the unemployment spell.

Second, the impact of unemployment spells on pension entitlements depends on the design of pension schemes (e.g., the redistributive nature of the DB benefit formula, the precise definition of pensionable earnings, the eligibility criteria for basic and minimum old-age pensions, the uprating rate for pensions in payment, minimum pensions) and on other fiscal (e.g., pensions taxation) or social security policies (e.g., unemployment benefits) that mitigate earnings losses either by compensating directly for career interruptions or by minimizing the reduction in the accumulation of human capital. For instance, most (public) earnings-related pension systems of OECD countries grant pension rights through pension credits and pension accruals for periods spent outside the labour market for reasons that are considered commendable (e.g., maternity/paternity, unemployment, care duties) and derived pension rights (e.g., survivor's pensions). In some cases, the accrual of pension rights is made through contributions deducted from benefits received during career breaks or through the purchase of pension rights by means of voluntary contributions. Pension credits may be granted in the form of assumed career years (e.g., Portugal, Spain), pension points (e.g., France, Germany) or social security contributions credited to the individual (e.g., Sweden) or a combination of them (EC, 2017). The effectiveness of pension credits in counteracting employment breaks depends on the duration of leave, the pensionable earnings base (e.g., earnings immediately prior to break, reference earnings, unemployment or childcare-related benefits, minimum wage (MW)) and the ways in which those parameters count towards pension entitlements (e.g., best years of earnings vs. full career in benefit calculation formulae). In many cases, pension credits are linked to the receipt of unemployment or childcare benefits and are, thus, subject to time limits and/or other conditionality conditions such as participation in training and activation programmes. Additional factors such as heterogeneity in longevity by education or lifetime income levels (highly correlated with the probability of job displacement) and the life expectancy gap carry an implicit tax/subsidy mechanism that may amplify or compress the impact of job loss on pension entitlements (Ayuso *et al.*, 2017a, b, 2020; Bravo *et al.*, 2020).

Despite its relevance, little research has been done to estimate the impact of career breaks on pension benefits and/or on the probability of not fulfilling vesting period conditions. In this paper, we contribute to the literature by investigating the effect of single and multiple unemployment spells on lifetime pension entitlements. We consider both the timing (beginning, middle or end of contribution career) and the duration of breaks (1–5 years) to assess their differential impact on pension entitlements. One of the main contributions of the paper is to compare the magnitude of pension wealth losses for displaced workers that can recover and return to the labour market with little or no reemployment wage penalty with that of workers who suffer permanent scarring effects. Another important contribution is to examine the extent to which pension credits and pension accruals granted for unemployment spells can mitigate the long-term pension wealth losses for displaced workers. To assess whether the redistributive features of pension schemes amplify or minimize the impact of contribution gaps on pension entitlements, we consider several layers of earnings profiles in the simulation process. In addition, to measure the effect of post-interruption wages on pension entitlements and the significance of restoration effects, we considered alternative (convergent, divergent) earnings profiles to investigate the interaction between the negative scarring effects and the positive restoration influence following job displacements.

In terms of data and methods, the employment histories in the Survey of Health, Ageing and Retirement in Europe (SHARE) Job Episodes Panel data, the time series of aggregate labour market data for Portugal and a sequence analysis technique are used to identify stylized labour market profiles

³Workers can recover earnings and, subsequently, pension losses resulting from career breaks if they can prolong their working lives afterwards. The interaction between the negative scarring effects and the positive restoration effect following job displacements remains an open empirical question.

and to assist in the simulation of hypothetical future pension entitlements. We use a ‘typical cases’ method design to define representative career paths resembling the most frequent individual career breaks and adopt a backward-looking simulation approach based on the actual Portuguese public pension system rules to compute initial benefits. Portugal is a particularly interesting case to study since it was one of the countries that was more severely impacted by the economic and financial crisis (unemployment rates reached a record high of close to 20% in 2013) and has been particularly active in reforming its complex earnings-related pension system over the past three decades to address financial sustainability problems, with little focus on pension adequacy (OECD, 2019). Contrary to previous studies that have focused on the impact of job loss on the initial pension benefit or on the replacement rate, in this paper, we innovate and compute the lifetime income (pension wealth) losses for displaced workers. This process involves using stochastic mortality models combined with a frailty model to estimate the cohort life expectancy at retirement and the duration of the pension decumulation phase. We compute pool average and group-specific annuity factors to investigate to what extent heterogeneity in longevity by income level mitigates or amplifies the long-term consequences of unemployment spells, counteracting the pension scheme redistributive features and goals.

Our simulation results, summarized in Section 4, show that: (i) unemployment spells can have severe, persistent and long-term effects on the future standard of workers as pensioners; (ii) the negative impact of single unemployment spells of different duration is modest for low-, average- and medium- to high-earning workers if on the labour market re-entry the reemployment wage is not penalized and scarring effects are insignificant; (iii) for workers with ascending wage profile, the impact of job loss on pension entitlements is more significant; (iv) the longer the duration of the unemployment spell, the more negative the consequences, irrespectively of the timing of the job loss, the wage profile and the magnitude of scarring and restoration effects on labour market re-entry; (v) pension credit mechanisms mitigate partially the scarring effects of longer unemployment periods on pension outcomes; (vi) abstracting from longevity heterogeneity, the redistribute nature of the pension system mitigates the effect of job loss on pension entitlements for low-income groups. However, the redistributive effect of heterogeneity in longevity not only neutralizes the redistributive intentions but also creates additional distortions in the distribution of pension entitlements across income groups; (vii) the impact of job loss is more severe when job displacement is followed by a lower trajectory for future earnings after re-engagement; (viii) scarring effects are less severe for unemployment spells occurring late in the contribution career and can be minimized in the presence of restoration effects; (ix) persistent (multiple) unemployment spells are more harmful to pension entitlements when compared to single-break shocks. The implicit tax/subsidy mechanism embedded in the longevity risk insurance mechanism of pensions generates unintended redistribution from low-income groups to high-income groups, extending (and amplifying) the income asymmetries beyond retirement age, challenging the design of pension schemes and counteracting the objectives of recent reform approaches.

Previous empirical research examining the influence of employment breaks on pension benefits is scarce. Using data for Germany, Potrafke (2012) and Potrafke and Steiner (2007) concluded that pension losses due to career interruptions in the early and middle employment periods differ and that the negative effects of late unemployment spells are relatively small. Similar results were obtained by Beblo and Wolf (2002) that concluded that while the 3-year break right at the beginning of the employment career may have minor impact on re-employment wages, postponing the interruption by 10 years raises the re-employment wage penalty significantly. Arulampalam (2001) claims, on the contrary, that unemployment early in a worker’s career might endanger young workers’ future labour market possibilities. Geyer and Steiner (2014) analysed the impact of employment histories, pension reforms and changing demographics on the future level of gross public pensions across birth cohorts in Germany using a microsimulation model. The authors concluded that the cohort effects vary greatly between region, gender and education, but the largest effects can be observed in younger cohorts in East Germany and for the low educated. The simulation results show that policy reforms and higher cumulated unemployment spells are expected to substantially reduce the pension levels for East German men and women, and that for West German men, a small reduction of average pension is

anticipated among younger birth cohorts, whereas for West German women, pensions are expected to increase or remain stable due to increasing labour market participation of younger cohorts.

El Mekkaoui *et al.* (2011) evaluated the impact of different employment-breaks on pension benefits for French private-sector workers and concluded that by compensating for some career accidents, the French legislation allows individuals to receive, in some cases, the same level of social security pension that they would have received with a smooth, professional path. In an assessment of the impact of shorter and more fragmented careers on mandatory public and private pension entitlements in OECD countries, considering pension credits, OECD (2015) concludes that pension credits in earnings-related pension systems mitigate the effects on pension benefits of workers with interrupted work histories, but they are not sufficient to fully offset contribution shortfalls. The investigation assumes, however, that pension entitlements are forward-looking in the sense that model pension rules of the base year will apply throughout the career until workers reach the standard pension age.

The literature dealing with this subject highlights the specific situation of women and suggests that the impact on pension benefits of discontinuous employment careers tend to be very different, in sign and size, for women and men (see, e.g., Beblo and Wolf, 2002; Arun *et al.*, 2004; Malo and Munoz-Bullon, 2008; D'Addio, 2012).⁴ Women that have children and give up their job lose their own income, and if they decide to re-join the labour force, they frequently find themselves accepting lower wages and facing poor career development opportunities. Ultimately, they also face lower pension benefits but live longer on average (Ayuso *et al.*, 2017a, b, 2020). Pension crediting of these periods is therefore crucial to mitigate the negative effects of delayed, shorter or interrupted careers on pension benefits.

The structure of the remaining of this paper is as follows: Section 2 provides a brief overview of the Portuguese pension system and discusses the way pension benefits are computed. Section 3 describes the data and the theoretical framework adopted in this study, including the simulation design approach, the stochastic mortality models used to forecast cohort life expectancy and to compute the pension wealth by income level. Section 4 reports and discusses the empirical results on the effect of job loss on pension entitlements taking into account: (i) the duration of breaks; (ii) the timing of breaks; (iii) the lifetime path of contribution records; (iv) the existence of single vs. multiple breaks; (v) different layers of earnings profiles; (vi) the impact of unemployment spells on reemployment wages; (vii) the influence of restoration effects; (viii) the mitigating effect of pension credit mechanisms; and (ix) the impact of longevity differentials. Section 5 discusses the main policy implications of this study and concludes.

2. Institutional background

2.1 Portugal's pension system

The Portuguese pension system is based on three pillars of differing importance: the dominant earnings-related old-age state pension system (first pillar), the occupational pension provision (second pillar) and the personal pension provision (third pillar). The first pillar combines an earnings-related, defined benefit (DB), mandatory public scheme, comprising two separate but convergent schemes⁵: (i) a private-sector workers scheme (general social security scheme – RGSS) and (ii) a civil service pension scheme (CGA) covering public servants enrolled before December 2005 (Bravo, 2018; European Commission, 2018).⁶ Nearly three-quarters of people older than 65 received a pension from the RGSS in 2019. Contributory state pensions are financed on a pay-as-you-go (PAYG) basis by social

⁴Empirical evidence suggests that Employment-breaks due to child-raising have greater policy relevance than caregiving periods, not only because of their longer duration but also due to their early onset which more critically impacts on women's future labour market biographies and pension entitlements. As the number of children rises, so does the overall duration of employment breaks.

⁵Lawyers and solicitors (CPAS) and older bank employees are covered by minor special systems.

⁶The scheme has been closed to new entrants since 2006 and new civil servants contribute to the general scheme. Yet, the CGA will continue to operate for most of the 21st century. Although rules have converged, except for the pre-2006 entitlements those who became civil servants before 2006 continue in the old scheme.

contributions paid by both the employer and employee, complemented by a small fraction of the value-added tax (social VAT).⁷ Additionally, the state system includes non-contributory means-tested first-tier pension benefits, top-up minimum contributory benefits and several targeted assistance programmes, fully funded by general taxes. The state pension scheme comprises old age, early retirement, disability and survivors' pensions (OECD, 2019). Occupational pension schemes and accident insurance form the second pillar. Voluntary occupational pension plan coverage in Portugal is low compared to other OECD countries and has been relatively stable for the past 10 years. As of 2019, only 2.5% of Portugal's workforce is covered by occupational plans. Contributions to occupational pension plans are mostly from employers. Benefits are in the form of lump-sum (maximum one-third) and annuity payments. The third pillar, personal pension provision, is voluntary and consists of various private personal funded schemes (in the form of open pension funds or retirement savings plans) and a residual publicly funded scheme. There is a Social Security Trust Fund (FEFSS), currently managing around €20 billion in assets, financed through a fraction of social security contributions, the sale of public assets and from returns on investments. In recent years, Portugal has implemented numerous (temporary and permanent) short-term fiscally driven parametric pension reforms aimed at reducing pension expenditures, with little margin for addressing income adequacy concerns.⁸ The PAYG DB scheme links old-age pension benefits with past earnings. Eligibility requires a minimum of 15 years of contributions. There is a common time-dependent statutory retirement age $x_r(t)$ for both men and women which, from 2015 onwards, is automatically adjusted every year according to life expectancy developments as follows:

$$x_r(t) = 66 + \frac{m_t}{12} \quad (1)$$

with

$$m_t = \frac{2}{3} \left[\sum_{j=2015}^{t-1} 12 \times (\dot{e}_{65,j-2} - \dot{e}_{65,j-3}) \right], \quad (2)$$

where m_t denotes the number of months to be added to the statutory retirement age (rounded to the nearest integer) and $\dot{e}_{65,t}$ is the complete period life expectancy at age 65 in year t . The retirement age $x_r(t)$ in equation (1) is measured in years. As of 2019, the normal retirement age was 66 years and 5 months.⁹

2.2 Pension benefit computation

Pension benefits are based on an individual's entire earnings history as follows:

$$P_t^{x_r(t)} = RE_t^{x_r(t)} \times AC_t^{x_r(t)} \times SF_t \times (1 \pm b_{x_r(t)}^{\%}), \quad (3)$$

⁷Contributions amount to 11% of gross earnings for employees and 23.75% of the payroll for employers. For the self-employed, they range between 29.6% and 34.75% (when workers have management functions). From the overall social security contribution rate, 20.21% finance old-age benefits, 4.29% are allocated to disability pensions and 2.44% finance survivor's pensions.

⁸Parametric reforms include: (i) the introduction of a sustainability factor in the pension formula; (ii) an increase in the statutory retirement age; (iii) moving from best years to lifetime average earnings; (iv) a new indexation mechanism linked to prices and real GDP growth; (v) the introduction of bonuses for late retirement and penalties for early retirement; (vi) freezing early-retirement regimes; (vii) nominal pension cuts; and (viii) means-testing for non-contributory benefits; (ix) convergence of rules between RGSS and CGA regimes.

⁹The normal age of retirement can be reduced by 4 months for each year of contributions exceeding 40 years when the beneficiary turns 65 years old with a 65-year threshold. Workers can retire at age 60 with full pension if they contributed for at least 48 calendar years (46 calendar years if contributory employment began before age 15).

where $P_t^{x_r(t)}$ denotes the initial pension benefit, $RE_t^{x_r(t)}$ is the monthly reference earnings or pensionable salary, $AC_t^{x_r(t)}$ is the global accrual rate¹⁰, SF_t is the sustainability factor and $b_{x_r(t)}^{\%}$ is the percentage penalty (bonus) for early (postponed) retirement, all at time t . Mathematically, $RE_t^{x_r(t)}$ is computed as follows:¹¹

$$RE_t^{x_r(t)} = \frac{1}{14} \left[\frac{1}{x_r(t) - x_0} \left(W_t^{x_r(t)} + \sum_{x=x_0}^{x_r(t)-1} W_{t-x_r(t)+x}^x \prod_{j=t-x_r(t)+x+1}^t (1 + g_j) \right) \right], \tag{4}$$

where x_0 is the contributory career entry age, W_t^x denotes the annual age and time-dependent salaries for ages $x = x_0, \dots, x_r(t)$ at time $t > 0$ and g_t is the rate of growth of the revalorization index¹² between year $t - 1$ and year t .

The pension system grants workers pension rights through pension credits and pension accruals for periods spent outside the labour market (e.g., unemployment) but the protection is linked to the receipt of a social insurance benefit and is subject to time and amount limits and/or other conditions such as participation in training and activation programmes.¹³ In addition, the amount of pension is often calculated from a smaller reference wage, resulting in lower future pension entitlements.¹⁴ Minimum pension benefits are 30% of the reference earnings or a monthly guaranteed amount fixed according to the length of the insured’s contribution career, whichever is greater. Maximum pension benefits are 92% of reference earnings. Early retirement at age $x_r(t)$ is possible with 40 years of contributions for every insured person aged at least 60¹⁵ or in case of long-term unemployment. There are, however, two cumulative penalties for early retirement. First, a general reduction based on a so-called sustainability factor linked to period life expectancy developments at age 65 and computed as follows:

$$SF_t = \frac{\dot{e}_{65,2000}}{\dot{e}_{65,t-1}}. \tag{5}$$

On top of that, a reduction of 0.5% is applied for each month of early retirement preceding the insured’s statutory retirement age, i.e., $b_{x_r(t)}^{\%} = 0.5\% \times k$, where k denotes the number of months of anticipation with regards to $x_r(t)$. There are bonuses¹⁶ for those who defer retirement and remain in the

¹⁰For those with 15–20 years of earnings, the pension accrues at 2% of the earnings base per year of contributions. For those with more than 20 years of contributions, the accrual rate ranges between 2% and 2.3%, depending on the level of the reference wage. The schedule for the accrual rate depends on individual earnings relative to the value of a social support index (Indexante dos Apoios Sociais – IAS). The IAS is an income base pecuniary amount that serves as a reference to Social Security in Portugal for computing workers’ contributions, pension benefits and other social assistance benefits. It was created in 2006 with a value equal to the minimum wage (MW) but has since then been disconnected, representing in 2019 only 72.6% of the MW. Each tier of earnings accrues pension at a different rate. Accruals stop after 40 years of contributions.

¹¹Before 2002, the reference earnings measure was determined by the best 10 years of the last 15 years of earnings. Since 2002, the reference earnings used to compute the pension was extended and became lifetime average earnings from 2017 on, gradually considering the career-best 40 annual earnings. Reference earnings of those who started work before 2002 will gradually be determined by the full-career wage from a weighted average (pro-rata) on the best 10 of the last 15 years and lifetime-average earnings. For workers with more than 40 years’ contributions, only the best 40 count in the benefit formula.

¹²Past earnings are updated by applying a mix of earnings and prices index (75% of the consumer price inflation excluding housing, 25% earnings growth, whenever earnings growth is higher than the CPI), subject to a maximum real increase of 0.5%.

¹³The entitlement to pension credits is not subject to means-testing.

¹⁴For instance, the unemployment benefit corresponds to 65% of the reference wage (average insured’s earnings of the first 12 months of the last 14 months prior to unemployment). The duration of benefits depends on the insured’s age and the number of months with registered earnings since the last unemployment spell and ranges between 150 and 540 days.

¹⁵As long as that contribution record is completed by age 60.

¹⁶The bonus ranges between 0.33% and 1% according to career length. However, pension benefits, including a bonus for late retirement, are capped at 92% of the reference wage, reducing the incentives to postpone retirement.

labour market beyond $x_r(t)$. There are detailed automatic rules for uprating pensions in payment, considering both the evolution of consumer prices and real GDP growth. The indexation rules are redistributive if we deprecate heterogeneity in longevity (Ayuso *et al.*, 2017a, b, 2020). Pension benefits are subject to taxation. The general taxation regime of public pension schemes in Portugal may be classified as EET for employees and employers, i.e., a pure Fisher–Kaldor–Meade expenditure (consumption, cash-flow) tax regime in which only consumption (not saving and capital income) is taxed.¹⁷

3. Materials and methods

3.1 Empirical data on labour market histories

The employment histories collected in the third release of the Survey of Health, Ageing and Retirement in Europe (SHARE) Job Episodes Panel are used to find groups of workers with ‘interrupted’ and ‘full’ careers and to identify patterns for the frequency, the timing and the duration of career breaks across birth cohorts. The Job Episodes Panel release 7 is based on SHARE Waves 3 and 7 (see Brugiavini *et al.* (2019) for methodological details). The stylized labour market profiles are then used to simulate hypothetical future pension entitlements. To identify the typical patterns of employment histories based on retrospective data, particularly labour market transitions, we apply a sequence analysis technique to measure the similarity between different career paths. The concept of sequence analysis is illustrated in Figure 1.

For each individual in the dataset, two possible states are differentiated: full-time employment (state ‘J’), and part-time employment, unemployment, retirement from work or general inactivity (state ‘N’). In this paper, we are focused on the impact of single status changes between employment and non-employment or part-time employment on pension entitlements. The dataset comprises a total of 508 individuals (57% of which are men) followed through time corresponding to a total of 34,724 person-year observations. In Figure 2, we plot the labour market sequences of individual persons’ job episodes for men and women included in the dataset. We can observe that for both sexes the episodes of not working or working part-time are more common and frequent at the beginning and at the end of working life, although they can be frequent at the middle of the working career, particularly for women.

For most worker’s, the duration of non-employment spells is relatively short when compared to periods of full-time work, but for the female population, the episodes of not working are both more frequent and have longer duration, particularly for older cohorts. For women, interrupted careers are usually the outcome of initial voluntary withdrawal from employment in childbearing and childrearing periods, part-time employment and reduced returns to the labour market at later stages of their life course. Episodes of non-employment later in the working life often end up in premature retirement. The episodes of non-employment affect individual pension entitlements in three ways as described in the previous section. First, they negatively affect the lifecycle reference earnings. Second, they reduce the global accrual rate (replacement rate). Third, they may end up in premature retirement with reduced pension levels due to the significant early retirement penalties. We can also observe that the labour market entry age and the effective retirement age have been increasing for younger cohorts. The data show that the labour participation of women is higher for younger birth cohorts. Figure 3 plots state occupancies by age and sex, including information on censored cases.

The employment rates of men are higher than those of women for all ages, which combined with differences in wage levels translate into differences in the life course labour income gap and future pension entitlements. Figure 4 plots the Kaplan–Meier estimator of the survivor function of the job duration by sex (solid line), together with the corresponding 95% confidence intervals (dashed line). The results from the SHARE sample show that the duration of a job spell is generally higher for men than for women. The median duration of a full-time job spell is 445 months against 325 months for women. At the end of 2018, the aggregate average duration of an unemployment spell

¹⁷See Bravo (2016, 2018) for a detailed discussion on the taxation of pensions in Portugal.

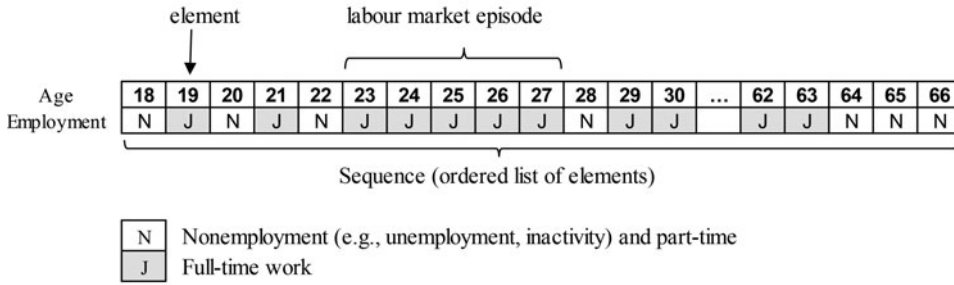


Figure 1. Conceptual diagram of a sequence of labour market episodes. Source: Author’s preparation based on Brzinsky-Fay et al. (2006).

in Portugal was almost 30 months, with almost half (47%) of the unemployed out of work for more than 1 year, 30% were jobless for more than 2 years, 21% were unemployment for more than 3 years and 16% for more than 4 years.¹⁸

Over the last 40 years, the composition of employment and the determinants of wages have changed remarkably in Portugal mirroring a significant improvement in education levels for those in employment, an increasing proportion of women labour participation, a radical transformation in the specialization pattern of the Portuguese economy, a reduction in the firm size and the ageing of the working population. Figure 5 shows the base nominal wage distribution in Portugal in 2017. The growing density close to the MW is explained by recent policy intervention targeting the elimination of wages paid at a rate below the MW and the growing prevalence of the MW as a result of nominal increases in the MW above the nominal average wage (AW).

3.2 Simulation design approach

The computation of pension entitlements requires detailed individual information on both accrued entitlements as well as estimates of expected pension accruals until retirement, which depend on labour market histories, earnings profiles and the timing of retirement. Since there is no dataset publicly available in Portugal that includes the required information and the SHARE Job Episodes Panel data are considered insufficient, we use a ‘typical cases’ method design and define representative career paths which deviate from a full-time continuous career because of unemployment breaks. Sample or typical cases are often used for the assessment of public policies. The stylized labour market profiles identified in the previous section are used to assist in the design and computation of hypothetical future pension entitlements. First, we describe the typical cases considered in the simulation study, together with the assumptions. Next, we compute the pension entitlements for benchmark working life courses that are not affected by employment breaks. This will serve later to analyse the impact of different types of career breaks on pension wealth. In our study, the baseline full-career representative case refers to a 27-year-old childless individual born on 1 August 1952, entering the labour market on 1 August 1979 and retiring on 1 January 2019 at the current statutory retirement age of 66 years and 5 months after completing a 40-year continuous contributions career without breaks or reduced activity periods, having received during his whole career the observed MW. The computed pension entitlements are based on the current (2019) Portuguese RGSS pension rules and take into consideration pension credits. We adopt a backward-looking approach and assume that existing rules and parameters of the year 2019 were applied throughout the career until workers reach the statutory retirement age.

We conducted a systematic analysis on the effect of job loss on pension entitlements and simulated the influence of: (i) single or multiple breaks; (ii) short and long duration breaks (1–5 years); (iii)

¹⁸Source data obtained from Statistics Portugal.

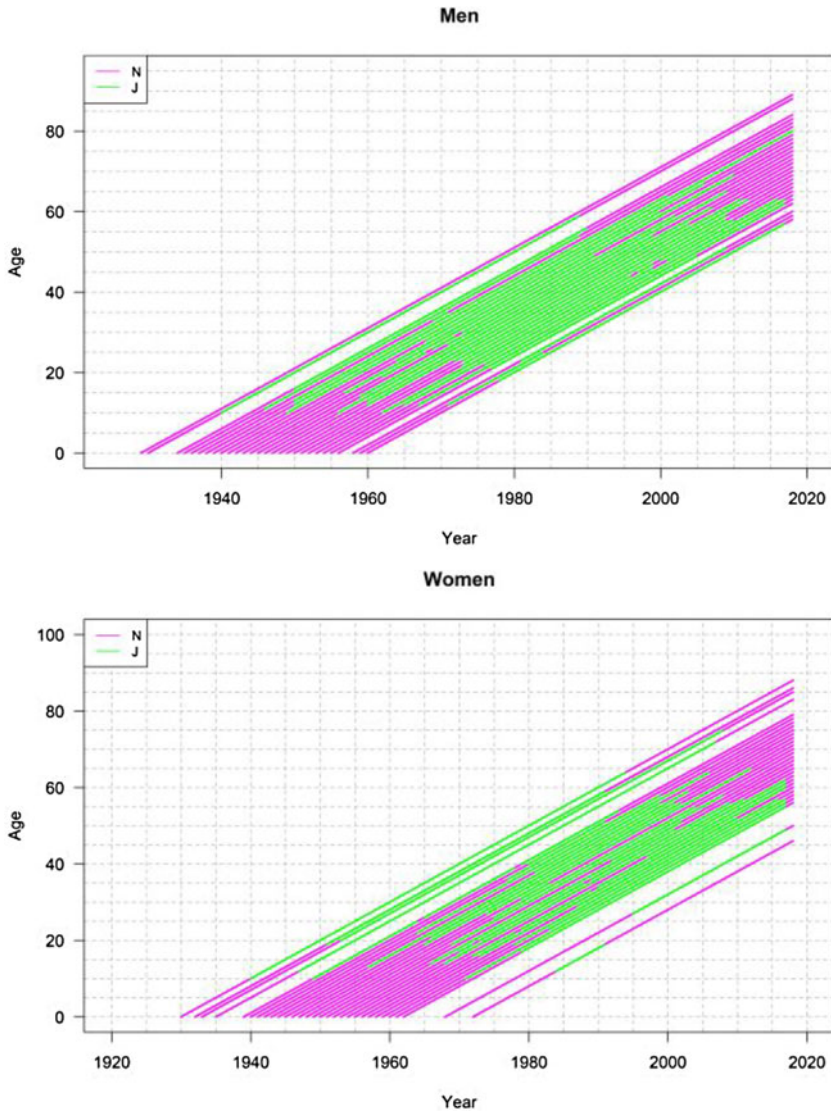


Figure 2. Labour market sequences of individual persons' job episodes, Portugal.

Source: Original estimates based on SHARE Job Episodes Panel data release 7.

Notes: State 'J' denotes full-time work episodes, whereas state 'N' denotes part-time or non-employment episodes. Only individuals with at least one job spell have been considered.

employment breaks occurring at the beginning (between ages 30 and 35), in the middle (between ages 40 and 45) and at the end (between ages 61 and 66) of the contribution career; (iv) breaks for low, average and high earners; (v) breaks for flat and ascending earnings profiles; (vi) post-interruption convergent and divergent earnings profiles, scarring and restoration effects. In assessing the influence of the timing employment breaks on pension benefits, three different career phases (early, middle and late) are distinguished. We considered the possibility of single breaks at the beginning (between ages 30 and 35), in the middle (between ages 40 and 45) and late in the contribution career (between ages 61 and 66), together with combined multiple breaks.

Five layers of earnings profiles for wages earned throughout the entire contribution career proxying the wage distribution (as represented in Figure 5) were considered to assess the redistributive features

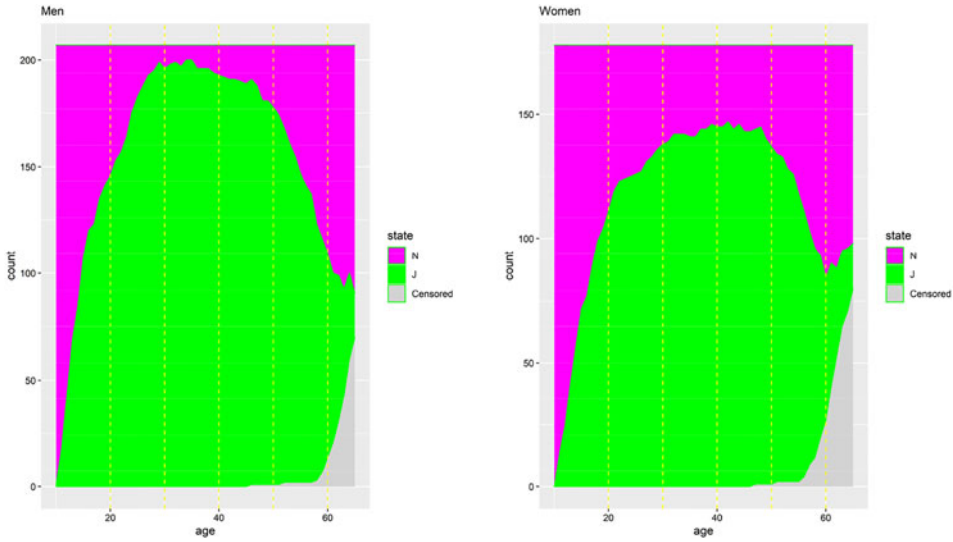


Figure 3. State occupancies by age and sex, Portugal.

Source: Original estimates based on SHARE Job Episodes Panel data release 7.

Notes: State ‘J’ denotes full-time work episodes, whereas state ‘N’ denotes part-time or non-employment episodes. Only individuals with at least one job spell have been considered.

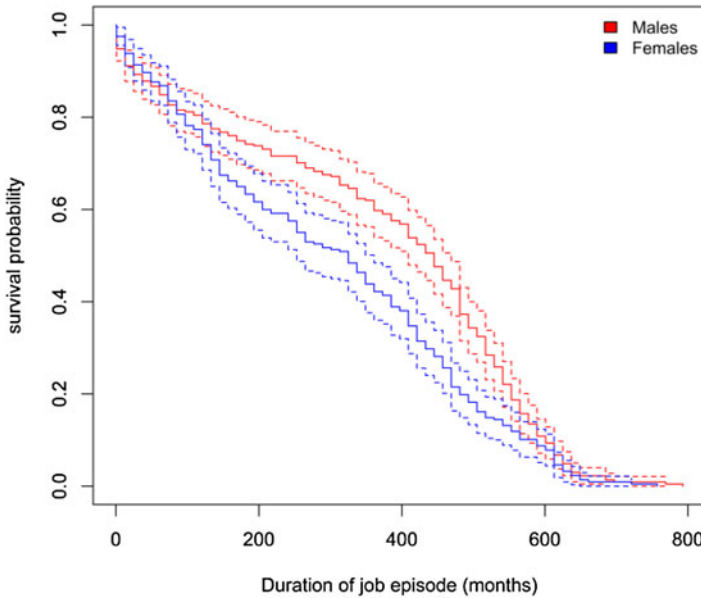


Figure 4. Kaplan–Meier estimator of job duration, by sex.

Source: Original estimates based on SHARE Job Episodes Panel data release 7.

Notes: The solid (dashed) lines represent the median estimator (95% confidence limits). Only individuals with at least one job spell have been considered.

of the pension scheme: (i) a ‘low earnings’ flat profile, with reference earnings matching the observed national nominal MW, currently (2019) amounting to €8,400; (ii) an AW profile, with reference earnings equal to the AW (currently amounting to €13,334); (iii) two ‘middle-to-high earnings’ profiles (2 and 3 times the AW); (iv) a ‘high earnings’ profile (6 times the AW). The time series of MW and AW aggregate data was obtained from Statistics Portugal. Additionally, an ascending wage profile has been simulated for all earnings profiles assuming the worker starts with the MW or one of the four multiples of the AW and experiences throughout life an annual salary raise of 2% above

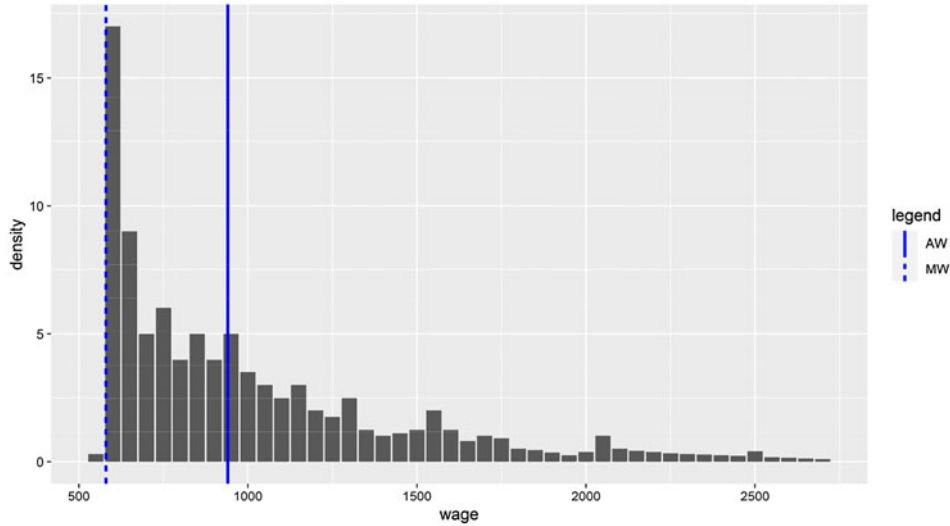


Figure 5. Base wage distribution in Portugal, 2017.
 Source: Author’s preparation based on data obtained from Statistics Portugal.
 Notes: MW = minimum nominal wage; AW = average nominal wage.

the annual benchmark growth. To simplify, we assume in this case that the earnings progress is linear and not concave as is frequently observed. In Figure 6, we represent the six layers of annual earnings profiles considered in this study over the period 1979–2018.

To assess the effect of post-interruption wages on pension entitlements and the significance of restoration effects, we considered three alternative profiles: (i) a baseline scenario in which we assume that after an unemployment spell, the reemployment wage equals that of a full-career worker; (ii) a ‘divergent earnings’ profile, in which the reemployment wage is reduced by 10% per year of job displacement when compared to that of a full-career worker; (iii) a ‘convergent earnings’ profile, in which the reemployment wage is reduced by 10% per year of job displacement but then catches-up with the baseline earnings in 5 years. To isolate the empirically simulated results from penalties or bonuses due to early or late retirement, respectively, we assume individuals retire at the statutory retirement age so that pension entitlements are computed at the full accrual rate. Other studies frequently combine early or late retirement with compensated and uncompensated unemployment or inactivity spells, a methodological option that does not allow discerning the specific effect of job loss on pension entitlements, even if breaks and expected pension losses could induce a change in labour supply behaviour or the retirement behaviour. The rate of payroll contributions is assumed constant in the calculations, as observed in Portugal over the last three decades.

3.3 Stochastic mortality modelling and calibration

To estimate the pension wealth corresponding to each pension benefit cash flow stream, we first forecasted the cohort life expectancy at the statutory retirement age for the total Portuguese population. We assumed the dynamics of mortality rates is well captured by a log bilinear Lee–Carter (LC) model under a Poisson setting (Brouhns *et al.*, 2002; Renshaw and Haberman, 2003). Despite numerous extensions, this model has proven to be robust in long-term projection exercises and is still the benchmark model at Statistical Offices around the world, including Statistics Portugal (see, e.g., Booth and Tickle (2008), Hunt and Blake (2014) for recent reviews). The log bilinear Poisson LC model assumes that

$$D_{x,t} \sim \text{Poisson}(\mu_x(t)E_{x,t}) \text{ with } \mu_x(t) = \exp(\alpha_x + \beta_x \kappa_t), \tag{6}$$

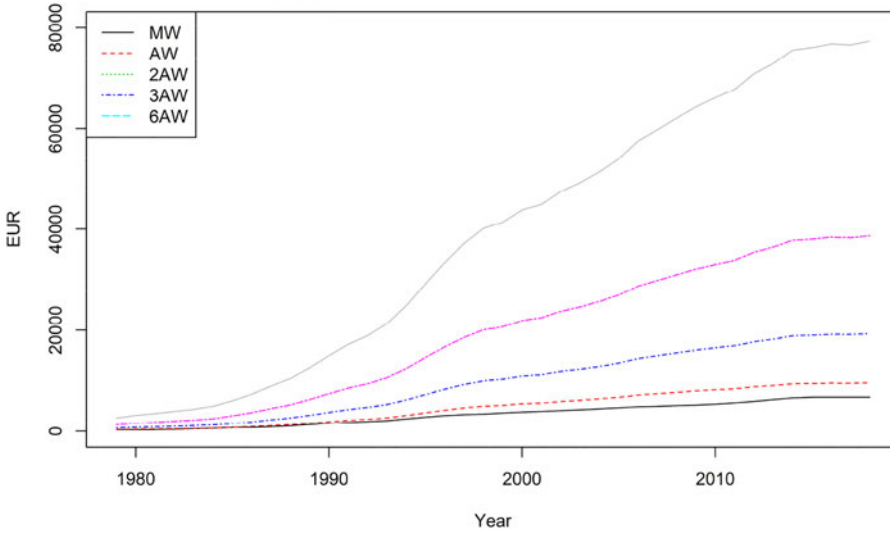


Figure 6. Portugal, lifecycle labour earnings profiles, 1979–2018.
 Source: Author’s preparation based on observed minimum (MW) and average (AW) nominal wages time series data obtained from Statistics Portugal.

where $\mu_x(t)$ denotes the observed force of mortality at age x during year t , $D_{x,t}$ is the number of deaths recorded at age x during year t , from those exposed-to-risk $E_{x,t}$, α_x denotes the general shape of the mortality schedule, β_x represents the age-specific patterns of mortality change and κ_t represents the time trend. To forecast the mortality rates, we first calibrate the LC model to the total Portuguese population using data from 1980 to 2015 and for ages 60–95 for estimation. Data on deaths and exposures are obtained from the Human Mortality Database (2019). Parameter estimates are obtained using ML methods and an iterative method for estimating log-bilinear models developed by Goodman (1979), considering the usual identification constraints. Formally, we estimate parameters α_x , β_x and κ_t by maximising the log-likelihood derived from the model (PLC)

$$\ln V(\alpha, \beta, \kappa) = \sum_{t=t_{min}}^{t_{max}} \sum_{x=x_{min}}^{x_{max}} \{D_{x,t}(\alpha_x + \beta_x \kappa_t) - E_{x,t} \exp(\alpha_x + \beta_x \kappa_t)\} + c, \tag{7}$$

where $\alpha = (\alpha_{x_{min}}, \dots, \alpha_{x_{max}})'$, $\beta = (\beta_{x_{min}}, \dots, \beta_{x_{max}})'$, $\kappa = (\kappa_{t_{min}}, \dots, \kappa_{t_{max}})'$ and c is a constant. We then assume that vectors α_x and β_x remain constant over time and forecast future values of κ_t using a standard $ARIMA(p, d, q)$ univariate time series model. Box–Jenkins methodology (identification-estimation-diagnosis) is used to generate the appropriate ARIMA time series model using a proprietary routine written in R. An $ARIMA(1, 1, 0)$ with drift (differenced first-order autoregressive) model has been found appropriate to describe the dynamics of the time index κ_t in the Portuguese total population and subsample considered, i.e.,

$$\Delta \kappa_t = \mu + \phi \Delta \kappa_{t-1} + \epsilon_t, \quad \epsilon_t \sim N(0, \sigma_\epsilon^2), \tag{8}$$

where $\Delta \kappa_t = \kappa_t - \kappa_{t-1}$ and the drift μ , AR(1) ϕ and volatility parameters σ are estimated using ML methods from our data (see Table 1 for results).

We tested and confirmed the model residuals for normality properties using the Jarque Bera normality test. Finally, we complete the dynamic lifetables using the simple and efficient method

Table 1. Parameter estimates for ARIMA(1, 1, 0) time series model for κ_t

Coefficients	Estimate	Std. error	z value	Pr(> z)
Drift (μ)	-0.666817	0.095456	-6.9856	2.836e-12***
AR(1) (ϕ)	-0.568701	0.136894	-4.1543	3.263e-05***

Source: Author's computations; Notes: $\hat{\sigma}_\epsilon^2 = 0.8147, AIC = 96.48$; Estimation window: 1980–2015; Significance codes: '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1, ' ' 1.

proposed by Denuit and Goderniaux (2005). The method consists of fitting the following log-quadratic model by OLS:

$$\ln(\hat{q}_x(t)) = a_t + b_t x + c_t x^2 + u_x(t), \quad u_x(t) \sim N(0, \sigma_u^2) \tag{9}$$

to age-specific mortality rates observed at older ages, separately for each calendar year t , with two additional constraints: (i) $q_\omega(t) = 1$; (ii) $(\delta/\delta x)q_\omega(t)|_{x=\omega} = 0$. We are then equipped to compute complete cohort life expectancies at the retirement age using

$$e_x^c(t_0) = \frac{1}{2} + \sum_{n=1}^{\omega-x_r(t)} \exp\left(-\sum_{j=0}^{d-1} \exp(\alpha_{x+j} + \beta_{x+j}\kappa_{t_0+j})\right). \tag{10}$$

3.4 Estimating pension entitlements by socio-economic group

Previous studies have used the ratio between the gross pension benefit of a job displaced worker and that of a full-career worker or the deviations in replacement rates to measure the impact of employment breaks on pension entitlements (e.g., El Mekkaoui *et al.*, 2011). Although these indicators are interesting, they do not appropriately measure the impact of broken careers on pension entitlements and household's wealth. The concept of replacement rate is consistent with lifetime consumption smoothing and a proxy for pension adequacy but it is only a partial indicator of pension entitlements since it assesses only how well older people can maintain their pre-retirement levels of consumption once they stop working (in a narrow sense since income other than wages and pensions is not considered).¹⁹ In this paper, we follow a different approach and assume that the pension wealth, i.e., the actuarial present value at the normal retirement age $x_r(t)$ of future pension benefits, is a better measure of pension entitlements and household's wealth. We estimate the impact of shorter and more fragmented careers on pension entitlements by computing the pension wealth $PW_t^{x_r(t)}$ at $x_r(t)$.

$$PW_t^{x_r(t)} = P_t^{x_r(t)} \ddot{a}_{x_r(t)}^{\pi, r} \tag{11}$$

where $P_t^{x_r(t)}$ denotes the initial annual pension benefit (monthly pension payable 14 times per year) computed according to (3) and $\ddot{a}_{x_r(t)}^{\pi, r}$ is a life annuity due factor, computed using the cohort expected survival probabilities (${}_k p_{x_r(t)}^c$), the (automatic) uprating rate for pensions in payment (π) and the discount rate (r).

¹⁹First, replacement rates do not consider the contributory effort made by employees (and employers) and/or their longevity heterogeneity, i.e., intra-generational fairness and equity considerations are ignored. Second, the replacement rate is a historical measure since one needs to wait until retirement to be able to compute them. Third, it is not a prospective measure since it does not give information on the impact of future changes in pension system rules. Fourth, it is an individual measure and thus may not be representative of the whole population. Fifth, replacement rates have no direct link with poverty in the sense that a pension system may replace 100% of previous income and yet not be enough to reduce the risk-of-poverty. Sixth, the replacement rate may not be representative for the analysis, for instance in those cases where the individual goes through a non-employment period just before retirement. Finally, replacement rates are a single point-in-time indicator, they do not take longevity into account and how it affects lifetime transfers to the individual.

$$\ddot{a}_{x_r(t)}^{\pi,r} = \sum_{k=0}^{\omega-x_r(t)} \left(\frac{1+\pi}{1+r}\right)^k \times {}_kP_{x_r(t)}^c \tag{12}$$

with

$${}_kP_{x_r(t)}^c = \prod_{u=0}^{k-1} (1 - q_{x_r(t)+u,t+u}), \tag{13}$$

where ω denotes the life table highest attainable age. In computing (annuity), we use the annual potential GDP growth rate as the discount rate (EC, 2018). The annuity factor estimated for the three brackets of the automatic pension indexation mechanism is 21.67 for the lower pensions, 20.38 for the middle bracket and 19.77 for those in the top pension bracket, i.e., abstracting from mortality differentials, the pension gradient gradually compresses as people age during retirement.

Previous studies have, however, concluded that socio-economic differences in longevity have important distributive and efficiency effects. This facet is because longevity heterogeneity modifies the redistributive features of pension schemes, since part of the income redistribution may be amplified, neutralized or even reversed by mortality differentials (Ayuso *et al.*, 2017a, b).²⁰ To evaluate the extent to which the impact of broken careers on pension entitlements is amplified by longevity heterogeneity, we used the simple but popular frailty differential mortality model. This model includes an age-specific, time-specific and group-specific mortality multiplier $\lambda_{x,t,g}$ by which the actual mortality of each socio-economic group $q_{x,t,g}$ differs from that of a given homogeneous common life table $q_{x,t,g}^S$. Formally, the 1-year group-specific mortality rate for a given individual aged x at time t , $q_{x,t,g}$ is given by:

$$q_{x,t,g} = \begin{cases} \lambda_{x,t,g} \times q_{x,t,g}^S, & \lambda_{x,t,g} \times q_{x,t,g}^S \leq 1 \\ 0, & \text{otherwise} \end{cases}. \tag{14}$$

The multiplier $\lambda_{x,t,g}$ to be estimated, describes the group relative life expectancy. For instance, for $0 < \lambda_{x,t,g} < 1$ individuals belonging to this group have an above-average life expectancy, whereas for $\lambda_{x,t,g} > 1$ individuals have a below-average life expectancy. Given the frailty parameter, the k -year group-specific survival probability is expressed as

$${}_kP_{x_r(t)}^{c,g} = \prod_{u=0}^{k-1} (1 - \lambda_{x_r(t)+u,t+u,g} \times q_{x_r(t)+u,t+u}^S). \tag{15}$$

We calibrated the frailty differential mortality model to match the life expectancy gap between the lower and higher educated in Portugal (as a proxy for lifetime income) estimated by Majer *et al.* (2011) – 3.8 and 3.0 years for men and women, respectively – and computed the corresponding group-specific annuity factors for the three brackets of pension indexation obtaining the following values for the low $\ddot{a}_{x_r(t)}^{\pi,r,low} = (19.39; 18.32; 17.81)$ and high $\ddot{a}_{x_r(t)}^{\pi,r,high} = (23.98; 22.44; 21.72)$ life expectancy groups, respectively. When compared to the average life expectancy group, we can observe that longevity heterogeneity translates into an implicit tax/subsidy of roughly 10%, slightly higher for the low pension indexation bracket.

²⁰One way to cope with the uncertainty in future mortality improvements is to share the longevity risk between the annuity provider and the annuitant (see, e.g., Bravo and Silva, 2006; Alho *et al.*, 2013; Bravo and El Mekkaoui de Freitas, 2018; Bravo, 2019).

4. Results

In this section, we analyse the simulation results of unemployment spells on pension entitlements taking into account: (i) the duration of breaks; (ii) the timing of breaks; (iii) the lifetime path of contribution records; (iv) the existence of single vs. multiple breaks; (v) different layers of earnings profiles; (vi) the impact of unemployment spells on reemployment wages; (vii) the influence of restoration effects.

4.1 Baseline case

In Table 2, we report the results for the baseline scenario in which the gross pension entitlements of a full-career worker are compared with those of a worker experiencing single unemployment spells of different duration occurring at the beginning (Panel A), middle (Panel B) or end (Panel C) of the contribution career. Unemployment spells are here defined as uninterrupted years in which an individual was unemployed. The actual DB rules for computing the initial pension benefit were considered, including those referring to pension credits for unemployment benefits. We assumed that after the break, there were no reemployment wage penalties or restoration effects. The baseline PW for a full-career worker is expressed in thousands of EUR. The values in Panels A, B and C denote the percentage loss in PW due to unemployment breaks. In every table and panel, column 2 refers to MW earners, whereas columns 3–6 refer to multiples of AW earners.

The impact on pension entitlements of single unemployment spells of different duration occurring early in the contribution career is not very significant for low-, average- and medium- to high-earning workers. Relatively to a full-time worker, the PW losses range between -0.44% (for a 1-year break faced by MW earners) and -3.32% (for a 5-year break experienced by high – 6AW – earners). The relatively small impact is explained by both the DB pension formula and the mitigating effect of pension credits. The pension formula effect stems from the transitional rule by which pensions are calculated by a weighted average (pro-rata) of the previous method (best 10 out of the last 15 contribution years) and the current lifetime (40-year) reference earnings method. Those for which the DB pension formulae include a significant component based on the best years are protected from unemployment periods occurring outside the pension calculation reference period. The mitigating effect of pension credits (limited to periods of benefit percipiency and capped by a relatively low amount – 2.5 times the IAS) results from the fact that time spent in unemployment is credited as insured period and considered as equivalent to paid employment. The effect of early contribution years on initial pension benefits is also highly dependent on the rules used for uprating past wages.

As expected, for all wage profiles, the longer the duration of the unemployment break, the higher the negative impact on pension entitlements. This result is observed irrespectively of the timing of the job loss. This element is mostly explained by the reduced shock-absorbing effect of pension credits for longer unemployment spells, which cover unemployment insured periods only since in the baseline scenario we are assuming that on the return to the job market the reemployment pay will be the same of that of a full-career worker. The gross pension entitlements of a worker who earns the baseline AW throughout life and interrupts his career for 1–5 years early in his contribution history would decrease by an amount ranging between -0.47% and -3.12% relative to a full-career worker (Table 2, Panel A). For the same representative worker, the pension wealth losses for breaks occurring later in the worker's contribution history are slightly higher and range between -0.50% and -3.93% (Panel B) and between -0.56% and -4.80% (Panel C) relative to a full-career worker for 1–5 years breaks occurring at the middle or end of the contributory career, respectively. This result is mostly explained by the transitional rule of the DB pension formula which penalizes more heavily breaks occurring later in the contribution career.

Our results also show that the effect of job loss on pension entitlements is less severe, the lower the income and the contribution amount of workers. This occurs because of the explicit and implicit redistributive mechanisms embedded in the Portuguese public PAYG schemes, particularly the DB

Table 2. Pension entitlement losses for single unemployment spells of different duration and timing for alternative earnings profiles

	Earnings profiles				
	MW	AW	2 AW	3 AW	6 AW
Baseline PW	127.2	229.2	428.1	636.8	1,217.4
Panel A: Beginning of the contribution career					
1-year	-0.44	-0.47	-0.47	-0.47	-0.54
2-year	-1.07	-1.08	-1.08	-1.11	-1.22
3-year	-1.68	-1.71	-1.71	-1.74	-1.88
4-year	-2.35	-2.38	-2.38	-2.42	-2.57
5-year	-3.07	-3.12	-3.13	-3.16	-3.32
Panel B: Middle of the contribution career					
1-year	-0.46	-0.50	-0.50	-0.51	-0.54
2-year	-1.09	-1.20	-1.20	-1.27	-1.34
3-year	-1.75	-2.02	-2.03	-2.14	-2.23
4-year	-2.42	-2.95	-2.95	-3.09	-3.19
5-year	-3.32	-3.93	-3.94	-4.09	-4.20
Panel C: End of the contribution career					
1-year	-0.54	-0.56	-0.56	-0.55	-0.59
2-year	-1.35	-1.38	-1.38	-1.47	-1.54
3-year	-2.32	-2.38	-2.39	-2.54	-2.62
4-year	-3.45	-3.53	-3.53	-3.72	-3.82
5-year	-4.70	-4.80	-4.81	-5.01	-5.12

Source: Authors' calculations; Assumptions: (i) No reemployment wage penalty; (ii) No restoration effects; (iii) Pension credits considered. Notes: Baseline pension wealth (PW) in EUR1,000; All other values correspond to the percentage reduction in PW due to unemployment breaks; Earnings profiles: MW, minimum wage; AW, average wage.

pension benefit calculation rules, notably the progressive schedule for the accrual rate mechanism described above, the existence of minimum contributory pensions and the progressive nature of the automatic mechanism for uprating pensions in payment. For instance, for a 5-year break occurring at the middle of the contribution history, the pension wealth losses would be -3.32% for an MW earner whereas for a high earner (6AW) the losses amount to -4.20% . Table 3 reports the results for the baseline scenario of single unemployment spells of different duration but now considering ascending wage profiles. To isolate for the impact of job loss in ascending careers, we continue to assume no reemployment wage penalties or restoration effects and account for pension credits. The baseline PW is now naturally higher than before due to higher contribution amounts.

Compared to a baseline earning profile, the results show that the impact of job loss on pension entitlements for workers with ascending wage profile is lower for breaks taking place at the beginning and middle of the contribution history but significantly higher for breaks occurring close to retirement. For instance, for a 5-year break occurring at the end of the contribution history, the pension wealth losses would now range between -10.76% for an MW earner and -12.81% for a high earner. These results show that in the absence of reemployment wage penalties or restoration effects, workers with increasing wage profiles are better equipped to mitigate the effect of unemployment breaks occurring early in the contribution history but are increasingly impacted if they take place later in life. This differential impact is mostly explained by the compounding effect of the uprating mechanism for past wages and the DB transitional rule formula. The effect of unemployment periods on pension entitlements continues to be higher for medium- to high-income earners and lower for MW earners, and to be positively correlated with unemployment duration.

4.2 Reemployment wage penalties and restoration effects

In Table 4, we report the impact on pension entitlements of single unemployment spells of different duration considering a 10% reemployment wage penalty per year of job displacement. In the short-term, unemployment periods imply a direct income loss that can be partially offset by pension credit

Table 3. Pension entitlement losses for single unemployment spells of different duration and timing for ascending earnings profiles

	Earnings profiles				
	MW	AW	2 AW	3 AW	6 AW
Baseline PW	228.2	387.4	744.6	1,109.2	2,191.6
Panel A: Beginning of the contribution career					
1-year	-0.26	-0.28	-0.31	-0.35	-0.40
2-year	-0.64	-0.65	-0.71	-0.75	-0.83
3-year	-1.06	-1.08	-1.10	-1.14	-1.23
4-year	-1.40	-1.44	-1.52	-1.54	-1.65
5-year	-1.86	-1.91	-1.98	-1.99	-2.11
Panel B: Middle of the contribution career					
1-year	-0.39	-0.40	-0.52	-0.58	-0.67
2-year	-0.93	-1.03	-1.20	-1.28	-1.42
3-year	-1.59	-1.75	-1.95	-2.02	-2.20
4-year	-2.33	-2.55	-2.76	-2.82	-3.03
5-year	-3.13	-3.41	-3.47	-3.65	-3.88
Panel C: End of the contribution career					
1-year	-1.56	-1.59	-1.63	-1.70	-1.82
2-year	-3.14	-3.36	-0.82	-3.86	-4.06
3-year	-5.26	-5.79	-5.89	-6.38	-6.65
4-year	-8.20	-8.60	-8.90	-9.25	-9.55
5-year	-10.76	-11.80	-12.03	-12.51	-12.81

Source: Authors' calculations; Assumptions: (i) No reemployment wage penalty; (ii) No restoration effects; (iii) Pension credits considered. Notes: Baseline pension wealth (PW) in EUR1,000; All other values correspond to the percentage reduction in PW due to unemployment breaks; Earnings profiles: MW, minimum wage; AW, average wage.

mechanisms. In the long-run, unemployment periods deteriorate future labour market possibilities and thus have severe long-term consequences on pension entitlements. As expected, compared to the baseline scenario, the impact of career breaks becomes much more significant when we assume that job displacement is followed by a lower trajectory for future earnings after re-engagement, particularly for breaks occurring early in the contribution history. Unemployment spells registered early in the contribution career followed by a 'divergent earnings' profile have a compounding effect that amplifies pension wealth losses that can only be partially mitigated by pension credits and other redistributive mechanisms. For instance, for a 3-year break occurring at the beginning of the contribution history, the relative pension wealth losses suffered by an AW earner are now -27.13% (almost 16 times higher than that in the case of an equivalent break with no reemployment wage penalty) or -23.87% if the same break takes place in the middle of the contribution career. The importance of scarring effects on gross pension entitlements is comparatively less severe for unemployment spells occurring late in the contribution career since the number of earnings and contribution years affected (and the subsequent compounding effect) is smaller, and the current DB pension formula is likely to exclude them at the time of initial pension computation. Similar results were obtained for workers with an ascending wage profile and breaks occurring early in the contribution career, with pension losses being slightly higher for breaks taking place close to retirement.²¹

Not surprisingly, for baseline MW earners, unemployment spells have a marginal effect on gross pension entitlements even when we assume that job displacement is followed by a lower trajectory for future earnings and breaks are long. This result is explained by the joint effect of MW legislation preventing wages to fall below a certain threshold, by the way unemployment insurance benefits are computed, namely the existence of a lower bound that roughly approximates the MW, by the effect of minimum pension provisions for contributory pensions that offer a floor for pension benefits, by pension credits and by the redistributive nature of the indexation rules for pensions in payment.

²¹Owing to space constraints, these results are not included in the paper but they can be obtained from the authors upon request.

Table 4. Pension entitlement losses for single unemployment spells of different duration and timing considering for reemployment wage penalties

	Earnings profiles				
	MW	AW	2 AW	3 AW	6 AW
Baseline PW	127.2	229.2	428.1	636.8	1,217.4
Panel A: Beginning of the contribution career					
1-year	-0.44	-10.09	-10.14	-10.12	-10.15
2-year	-1.07	-19.19	-19.20	-19.22	-19.24
3-year	-1.77	-27.13	-27.17	-27.32	-27.33
4-year	-2.55	-34.60	-34.62	-34.64	-34.66
5-year	-3.40	-41.07	-41.37	-41.41	-41.48
Panel B: Middle of the contribution career					
1-year	-0.32	-8.78	-8.82	-8.91	-9.05
2-year	-0.87	-16.72	-16.87	-16.98	-17.18
3-year	-1.59	-23.87	-24.10	-24.21	-24.46
4-year	-2.42	-30.30	-30.57	-30.67	-30.95
5-year	-3.32	-35.92	-36.35	-36.44	-36.75
Panel C: End of the contribution career					
1-year	-0.54	-1.61	-1.64	-1.79	-1.94
2-year	-1.35	-2.56	-2.71	-2.92	-3.12
3-year	-2.32	-3.42	-3.64	-3.88	-4.12
4-year	-3.45	-4.17	-4.45	-4.70	-4.96
5-year	-4.70	-4.81	-5.12	-5.39	-5.65

Source: Authors' calculations; Assumptions: (i) No restoration effects; (ii) Pension credits considered; (iii) Baseline wage profiles.

Notes: Baseline pension wealth (PW) in EUR1,000; All other values correspond to the percentage reduction in PW due to unemployment breaks; Earnings profiles: MW, minimum wage; AW, average wage.

As before, the effect of job loss on pension entitlements continues to be more significant, the higher the labour income level and the longer the unemployment spell, here aggravated for longer career breaks for which the earnings scarring effect is more relevant since the reemployment wage is substantially reduced. In Table 5, we report the impact on pension entitlements of single unemployment spells of different duration considering the existence of a reemployment wage penalty per year of job displacement followed by a 'convergent earnings' profile in which wages catch-up with the baseline earnings (full-career worker) in 5 years.

Compared to the previous divergent earnings scenario, the impact of unemployment periods on pension entitlements is much lower when on labour market re-entry wages quickly recover to the previous baseline path. For instance, for a 3-year unemployment period occurring at the beginning of the contribution history, the relative pension wealth losses suffered by a two times AW earner reduce from -27.17% when scarring effects are permanent to just -2.47% when scarring effects are transitory, and future labour market possibilities are not severely deteriorated. For MW earners, restoration effects have little significance. Similar conclusions were obtained in the case of ascending wage profiles, although with more substantial pension wealth losses.

4.3 Multiple unemployment breaks

Previous studies have documented a persistence phenomenon in unemployment frequency, i.e., an individual who has experienced unemployment in the past is more likely to suffer from similar negative labour market experiences in the future and have lower re-employability. To quantify the long-term effect of unemployment persistence on pension entitlements, in Table 6, we report the results for the impact of multiple unemployment spells of different duration for representative workers with alternative earnings profiles, considering for (Panel A) or excluding (Panel B) scarring effects. We ignore restoration effects and consider for pension credits. In both Panels, columns 2–6 now represent the pension wealth losses of a representative worker with baseline earnings profile experiencing unemployment periods of 1–5 years three times (at the beginning, middle and end of the

Table 5. Pension entitlement losses for single unemployment spells of different duration and timing considering for reemployment wage penalties and restoration effects

	Earnings profiles				
	MW	AW	2 AW	3 AW	6 AW
Baseline PW	127.2	229.2	428.1	636.8	1,217.4
Panel A: Beginning of the contribution career					
1-year	-0.44	-0.71	-0.77	-0.83	-0.89
2-year	-1.07	-1.51	-1.64	-1.71	-1.78
3-year	-1.77	-2.30	-2.47	-2.52	-2.59
4-year	-2.55	-3.13	-3.31	-3.35	-3.40
5-year	-3.40	-3.98	-4.18	-4.20	-4.22
Panel B: Middle of the contribution career					
1-year	-0.32	-0.83	-0.86	-0.98	-1.10
2-year	-0.87	-1.81	-1.93	-2.10	-2.25
3-year	-1.59	-2.87	-3.06	-3.23	-3.41
4-year	-2.42	-3.99	-4.22	-4.38	-4.55
5-year	-3.32	-5.14	-5.38	-5.54	-5.69
Panel C: End of the contribution career					
1-year	-0.50	-1.46	-1.50	-1.65	-1.80
2-year	-1.26	-2.42	-2.57	-2.78	-2.99
3-year	-2.28	-3.34	-3.57	-3.82	-4.06
4-year	-3.36	-4.17	-4.45	-4.70	-4.96
5-year	-4.70	-4.81	-5.12	-5.39	-5.65

Source: Authors' calculations; Assumptions: (i) Pension credits considered; (ii) Baseline wage profiles.

Notes: Baseline pension wealth (PW) in EUR1,000; All other values correspond to the percentage reduction in PW due to unemployment breaks; Earnings profiles: MW, minimum wage; AW, average wage.

contribution career) during the contribution career. For instance, the pension wealth of an AW earner experiencing three times a 2-year unemployment period – one at the beginning, one at the middle and a final one close to retirement – is reduced by -3.87% compared to that of a full-career worker assuming no reemployment penalties.

As expected, the impact of multiple unemployment breaks on pension entitlements is now more severe when compared to that of single-break spells, even when one assumes there is no wage penalty on labour market re-entry. When the long-term scarring effects of persistent unemployment spells are considered, the pension wealth losses are massive. For instance, an AW earner experiencing three times a 4-year unemployment period loses nearly half (-48.66%) of his pension wealth when compared to that of a full-career if the labour market re-entry is made with penalties (Panel B). The results in Table 6 evidence that the pension entitlements of MW earners are, in this case, less protected in the event of longer total unemployment periods (>10 years). This detail is because according to Portuguese pension system rules, the minimum pension benefit for contribution periods of less than 30 years is reduced to 80% of that of a worker with more than 30 years of contributions, lowering the corresponding old-age safety net. Consequently, the pension wealth of MW earners experiencing multiple unemployment spells of 4 years every time will be 10.85% lower than that of full-career counterparts. The effect of job loss on PW continues to be higher for medium- to high-income earners and lower for low (MW) earners and the higher the duration of unemployment periods. Similar results were obtained in the case of ascending wage profiles.

4.4 Longevity heterogeneity implicit tax/subsidy

Analysing whether the consequences of job loss are asymmetric among different socioeconomic groups is a topic of great relevance. To examine to what extent longevity heterogeneity translates into an implicit tax/subsidy that counteracts the redistributive objectives of the pension scheme such that unemployment periods penalize more heavily the pension entitlements of the poorest, we recomputed the pension wealth assuming MW earners belong to the low life expectancy group,

Table 6. Pension entitlements losses for multiple unemployment spells of different duration

	Earnings profiles				
	MW	AW	2 AW	3 AW	6 AW
Baseline PW	127.2	229.2	428.1	636.8	1,217.4
Panel A: Excluding scarring effects					
1-year	-1.38	-1.54	-1.67	-2.04	-2.39
2-year	-3.81	-3.87	-4.10	-4.59	-5.07
3-year	-6.03	-6.13	-6.73	-7.28	-7.82
4-year	-10.85	-10.97	-11.58	-12.13	-12.67
5-year	-15.16	-15.87	-16.64	-17.17	-17.73
Panel B: Considering scarring effects					
1-year	-1.38	-19.29	-19.32	-19.48	-19.82
2-year	-3.81	-34.11	-34.63	-34.68	-35.18
3-year	-6.03	-44.77	-45.40	-46.95	-47.83
4-year	-10.85	-48.66	-53.81	-56.74	-57.87
5-year	-15.16	-51.65	-62.19	-62.32	-63.90

Source: Authors' calculations; Assumptions: (i) No restoration effects; (ii) Pension credits considered; (iii) Baseline wage profiles.

Notes: Baseline pension wealth (PW) in EUR1,000; All other values correspond to the percentage reduction in PW due to unemployment breaks; Earnings profiles: MW, minimum wage; AW, average wage.

AW-2AW earners represent the pool average and 3AW-6AW earners belong to the high life expectancy group. Table 7 reports the results for the baseline scenario in which the pension entitlements of a full-career worker with pool average longevity are compared with those of workers belonging to the low and high life expectancy groups experience single unemployment spells of different duration. Columns 3-4 in Panels A, B and C replicate those in Table 2.

We note that the pension wealth gap between the high and low life expectancy groups is 48.5 thousand EUR for an AW earner, but the magnitudes of the implicit tax/subsidy can be significantly higher for top income levels. Consider first low-income and longevity individuals (MW earners). We can observe that compared to a full-career pool average longevity individual, the impact of unemployment spells of different duration on pension entitlements is now more severe irrespectively of the timing of breaks. For instance, a 3-year break occurring at the beginning of the contribution history generates now PW losses 7.2 times higher (-12.08%) than that of an equivalent spell for a pool average longevity worker.

Contrarily, for high-income and longevity individuals (3AW-6AW earners), we can observe that compared to a full-career pool average longevity individual, the impact of unemployment spells of different duration on pension entitlements is now much less severe, with the increased longevity prospects more than compensating for the contribution gaps generated by career breaks. For instance, a 3-year break occurring at the middle of the contribution history generates now PW relative «gains» (+6.98%) for a 6AW earner when compared to a pool average longevity individual experiencing the same shock. This result shows that despite the explicit and implicit redistributive structure of the Portuguese public PAYG schemes (e.g., progressive nature of the accrual rate schedule, minimum pension provisions, progressive uprating rate) promising higher replacement rates for lower income earners, the redistributive effect of heterogeneity in longevity not only neutralizes the redistributive intentions but also creates additional distortions in the distribution of pension entitlements across income groups. Stated differently, our results show that the redistributive effects of heterogeneity in longevity on pension entitlements carry an implicit tax/subsidy mechanism in the provision of insurance that aggravates the negative impact of career breaks on pension entitlements for low-income groups but alleviates its impact for high-income and longevity groups when compared to the average longevity group. The long-term scarring effects of unemployment spells tend to be more significant for low lifetime income (and education) groups. Additionally, the potential positive restoration effects following an unemployment-break that could potentially offset the depreciation of human capital and help mitigating the impact on re-employment wages tend to be stronger for highly educated groups. In the presence of positive correlation between lifetime income (and education) and longevity, the

Table 7. Pension entitlement losses for single unemployment spells of different duration and timing with longevity heterogeneity

Baseline PW by LE	Earnings profiles				
	MW	AW	2 AW	3 AW	6 AW
Low LE	113.9	205.2	384.9	572.6	1,097.1
Average LE	127.2	229.2	428.1	636.8	1,217.4
High LE	140.8	253.7	471.4	701.3	1,337.6
Panel A: Beginning of the contribution career					
1-year	-10.90	-0.47	-0.47	9.45	9.13
2-year	-11.46	-1.08	-1.08	8.69	8.35
3-year	-12.08	-1.71	-1.72	7.97	7.63
4-year	-12.78	-2.38	-2.38	7.22	6.90
5-year	-13.55	-3.12	-3.13	6.42	6.11
Panel B: Middle of the contribution career					
1-year	-10.79	-0.50	-0.50	9.39	9.00
2-year	-11.29	-1.20	-1.20	8.45	8.01
3-year	-11.92	-2.02	-2.03	7.45	6.98
4-year	-12.67	-2.95	-2.95	6.38	5.92
5-year	-13.48	-3.93	-3.94	5.29	4.83
Panel C: End of the contribution career					
1-year	-11.05	-0.56	-0.56	9.30	8.87
2-year	-12.17	-1.38	-1.38	8.18	7.70
3-year	-13.80	-2.38	-2.39	6.95	6.43
4-year	-15.78	-3.53	-3.53	5.62	5.09
5-year	-16.91	-4.80	-4.81	4.20	3.66

Source: Authors' calculations; Assumptions: (i) No reemployment wage penalty; (ii) No restoration effects; (iii) Baseline wage profiles.

Notes: Baseline PW by life expectancy (LE) in EUR1,000; All other values correspond to the percentage reduction in PW due to unemployment breaks; Earnings profiles: MW, minimum wage; AW, average wage.

economic and social welfare considerations that are commonly used to rationalize the redistributive nature of pension schemes (e.g., reducing the income disparity observed during working lives, compensating for incomplete insurance periods and fluctuating incomes, counterbalancing the better access of higher-income groups to occupational and voluntary private pension provisions that often enjoy generous tax treatment) are perverted by the longevity risk insurance mechanism that generates unintended redistribution from low-income groups to high-income groups, extending (and amplifying) the income asymmetries beyond retirement age. This outcome challenges the design of pension schemes and counteracts the objectives of recent reform approaches strengthening contributory principles, reducing the progressivity of the contribution-benefit formula and often creating an automatic link of future pensions to average period life expectancy (e.g., through initial pension benefit computation, by indexing the statutory retirement age and/or the qualifying conditions, by adjusting the penalties (bonuses) for early (late) retirement to years of contributions to retirement age, by replacing traditional NDB public PAYG schemes with NDC schemes, by conditioning pension indexation or modifying the annual account indexation rate in NDC schemes).

4.5 The mitigating effect of pension credits

To evaluate the offsetting capacity of pension credits and pension accrual for paid unemployment periods on pension wealth losses caused by career breaks, Table 8 reports the pension entitlements for single unemployment spells of varying duration in the contra-factual scenario in which pension credits are excluded from the computation of DB benefits. These results compare with that reported in Table 2. As expected, the negative impact of unemployment periods on pension entitlements is now higher, particularly for breaks experienced by MW and AW earners occurring at the beginning or in the middle of the contribution career, and for unemployment periods covered by paid unemployment insurance.

Table 8. Pension entitlement losses for single unemployment spells of different duration and timing for alternative earnings profiles in the absence of pension credits

	Earnings profiles				
	MW	AW	2 AW	3 AW	6 AW
Baseline PW	127.2	229.2	428.1	636.8	1,217.4
Panel A: Beginning of the contribution career					
1-year	-0.82	-0.84	-0.86	-0.88	-0.89
2-year	-1.64	-1.66	-1.68	-1.77	-1.82
3-year	-2.29	-2.39	-2.45	-2.47	-2.59
4-year	-3.06	-3.13	-3.18	-3.27	-3.31
5-year	-3.78	-3.92	-3.96	-4.01	-4.09
Panel B: Middle of the contribution career					
1-year	-1.01	-1.04	-1.06	-1.11	-1.15
2-year	-2.03	-2.10	-2.17	-2.19	-2.23
3-year	-3.07	-3.18	-3.23	-3.32	-3.45
4-year	-4.12	-4.28	-4.31	-4.36	-4.42
5-year	-5.17	-5.38	-5.40	-5.50	-5.63
Panel C: End of the contribution career					
1-year	-0.54	-0.56	-0.56	-0.55	-0.59
2-year	-1.35	-1.38	-1.38	-1.47	-1.54
3-year	-2.32	-2.38	-2.39	-2.54	-2.62
4-year	-3.45	-3.53	-3.53	-3.72	-3.82
5-year	-4.70	-4.80	-4.81	-5.01	-5.12

Source: Authors' calculations; Assumptions: (i) No reemployment wage penalty; (ii) No restoration effects; (iii) Baseline wage profiles. (iv) Pension credits excluded from the computation of pension benefits.

Notes: Baseline pension wealth (PW) in EUR1,000; All other values correspond to the percentage reduction in PW due to unemployment breaks; Earnings profiles: MW, minimum wage; AW, average wage.

Relatively to the baseline scenario (Table 2), the PW losses for a 3-year break experienced by an AW earner at the middle of the contribution career are now almost 40% higher than that suffered when pension credits and pension accrual are considered. For unemployment spells occurring close to retirement, the offsetting capacity of pension credits is irrelevant. The elimination of pension credits does not significantly modify the redistributive features of the Portuguese public pension schemes.

5. Discussion and conclusion

Pension systems have a central role in (almost entirely) replacing labour income after retirement, in securing adequate living standards in old age and in protecting people from poverty. In Bismarckian pension schemes, in which benefits are closely linked to wages and contributions, following a compulsory professional insurance principle, individual employment histories determine the level of pensions workers receive when they reach retirement age. Everything else constant, the higher a worker's individual pensionable earnings and the more continuous his career, the higher the pension benefits will be. Over the last three decades, several waves of pension reforms planned to ensure the long-term financial sustainability of pension systems in the face of major demographic (population ageing) and economic changes (social and technological changes in labour markets) have brought and will continue to bring major changes in the living conditions for pensioners. Although these reform measures may have contributed to addressing the fiscal sustainability problem, it is crucial to assess their effect in terms of pension adequacy since social or political sustainability challenges will likely emerge in countries with a steep reduction in the generosity of pensions.

Increasingly workers experience single or multiple (voluntary or involuntary) interruptions to their occupational careers at some point of time. These events have a long-term scarring effect on future labour market possibilities, particularly for younger workers, and thus will permanently affect their retirement income and standard of living as pensioners. Previous literature investigated the economic (and social) implications of job loss extensively, particularly the negative and persistent effect of job

displacement on lifetime wages. Yet, evidence on the consequences of job loss on pension entitlements remain scarce or with a narrow focus on replacement rates at retirement age, depreciating the effect of longevity differentials and pension system redistributive mechanisms on pension wealth. In this study, we have therefore examined to what extent is the build-up of pension entitlements in earnings-related contributory pension schemes protected in the event of job loss, using a comprehensive measure of lifetime income that better captures the repercussions of job displacement on retiree's standard of living. This is a topic of great interest for workers, employers and policymakers since the trend away from standard full-time permanent employment relationships (that enjoy enhanced labour and social security protection) towards non-standard more flexible work arrangements and recent unemployment benefit and pension system reforms reducing the social protection of workers and increasingly sharing labour market, longevity and capital market risks with workers are likely to increase the direct and indirect effects of job loss on pension entitlements.

Our results show that unemployment spells can have severe, persistent and long-term effects on the future standard of workers as pensioners. Using a backward-looking simulation approach based on the actual Portuguese public pension system rules and labour market wage trajectories, we conclude that relatively to a baseline representative full-career worker, the negative impact of single unemployment spells of different duration on pension entitlements is modest for low-, average- and medium- to high-earning workers if on the labour market re-entry, the reemployment wage is not penalized and scarring effects are insignificant. In this particular case, the earlier in the working career the job displacement occurs, the lower the pension wealth losses. This finding is mostly explained by both the transitional DB pension formula (under which pensions are calculated by a weighted average of the best 10 out of the last 15 and lifetime (40-year) contribution years) and the mitigating effect of pension credits. As soon as the transitional rule phases out and lifetime income becomes the norm, the effect of early, more frequent and longer job displacements on pension wealth is expected to increase and additional public measures besides offering pension credits have to be put in place to cushion their negative effect on the future labour market and pension outcomes of young workers. For workers with ascending wage profile, the impact of job loss on pension entitlements is higher, particularly for breaks experienced by high-earners close to retirement, with losses in PW exceeding 10%. We conclude that in the absence of scarring effects, given the current DB transitional rule formula, workers with increasing wage profiles are better equipped to mitigate the effect of unemployment breaks occurring early in the contribution history but are increasingly impacted if they take place later in life. This scenario is likely to reverse as the transitional formula phases out, and unemployment leaves young workers with long-term scars.

Our results demonstrate that the longer the duration of the unemployment break, the higher the negative impact on pension entitlements. This result is observed irrespectively of the timing of the job loss, the wage profile (baseline, ascending) and the magnitude of scarring and restoration effects on labour market re-entry. This arises because of the reduced shock-absorbing capacity of pension credits for longer unemployment spells, which only cover unemployment insured (short-term) periods. Increasing the coverage of unemployment benefits and pension credit mechanisms is one option to minimize the effect of longer unemployment periods on pension outcomes, but this has to be weighed against adding incentives that lead to a lower probability of returning to a formal job.

Our results also show that, abstracting from longevity heterogeneity, the effect of job loss on pension entitlements is less severe, the lower the income and the contribution amount of workers. This is because of the explicit and implicit redistributive mechanisms embedded in the Portuguese public PAYG schemes, particularly the progressive schedule for the accrual rate computation, the existence of minimum pension provisions and the progressive nature of the automatic mechanism for uprating pensions in payment. We conclude that the impact of job loss is much more severe when job displacement is followed by a lower trajectory for future earnings after re-engagement, particularly for breaks occurring early in the contribution history, i.e., unemployment leaves young workers with long-term scars. This is because unemployment spells have a compounding effect that amplifies pension wealth losses that can only be partially mitigated by pension credits and other redistributive mechanisms. The

importance of scarring effects on pension wealth is comparatively less severe for unemployment spells occurring late in the contribution career since the number of earnings and contribution years affected is smaller, and the pension formula is likely to exclude them at the time of initial pension computation. Additionally, in many countries, there are provisions that allow workers that lose their close to statutory retirement age to apply for early retirement, possibly with penalties. For MW earners, scarring effects have little marginal effect on gross pension entitlements even for long unemployment periods. This is owing to the combined effect of MW legislation preventing wages from falling below a certain threshold, lower bounds for insurance benefits, minimum pension provisions, pension credits and the redistributive nature of the indexation rules for pensions in payment. Our results also demonstrate that average and high-earners scarring effects can be minimized in the presence of restoration effects, i.e., if on labour market re-entry wages quickly recover to the previous baseline path. For MW earners, restoration effects have little significance. Similar conclusions were obtained in the case of ascending wage profiles, although with more considerable pension wealth losses. As expected, we conclude that persistent (multiple) unemployment spells have a more severe effect on pension entitlements when compared to single-break shocks, particularly when one assumes scarring effects on labour market re-entry are important and restoration effects are minimal. Our results also show that the pension entitlements of MW earners are, in this case, less protected in the event of longer total unemployment periods because of reduced old-age safety net minimum pension provisions.

One important contribution of this study is to conclude that the pension wealth consequences of job loss are asymmetric among different socioeconomic groups. Our results show that longevity heterogeneity by lifetime income group translates into an implicit tax/subsidy that counteracts the redistributive objectives of the pension scheme, with unemployment periods penalising the pension entitlements of the poorest more severely. Redesigning the pension schemes to address the effects of heterogeneity in longevity on pension schemes' objectives and outcomes and to reduce the aggregate tax/subsidy effect is becoming an increasingly critical issue. To counteract heterogeneity in longevity, interventions can be envisaged at the accumulation, annuitization and decumulation phases, including applying differential social contribution rates, accrual rates or uprating indices by socioeconomic group, implementing a two-tier contribution scheme of individual and flat-rate allocation to individual accounts, having different statutory retirement age by socioeconomic group or using group-specific annuity factors for benefit computation (see Ayuso *et al.*, 2017a, b, 2020 for a detailed discussion of the policy options).

Finally, we conclude that for MW and AW earners experiencing short-term (<3 years) unemployment spells at the beginning or in the middle of the contribution career, pension credit mechanisms are an effective way of mitigating the negative impact of job loss on pension entitlements. For unemployment spells occurring close to statutory retirement age, the offsetting capacity of pension credits is irrelevant. Pension credits do not significantly alter the redistributive features of the pension scheme. Further research is needed to examine the differential impact of non-employment spells on the pension entitlements of men and women accounting for cohort effects. The research literature suggests that the impact on pension benefits of discontinuous employment careers tend to be very different, in sign and size, for women and men and that for women the unemployment scars add to the effects of employment-breaks due to child-raising or caregiving periods. Further research is also needed to identify and investigate alternative policy measures for mitigating the long-term consequences of job loss on pension wealth that are aligned with labour market policies and societal redistributive objectives.

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