

Actuarial Fairness When Longevity Increases: An Evaluation of the Italian Pension System

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This study analyses the actuarial characteristics of the Italian pension system throughout its transition from defined benefit (DB) to notional defined contribution (NDC) rules, taking into account expected increasing longevity. Computations rely on ad hoc projected cohort mortality tables based on a limit survival scenario depicted by demographic experts. Most workers retiring in the coming years, whose pension is partly computed according to DB rules, will receive more-than-actuarially fair pensions. However, the generosity of the pension system has been significantly reduced for them by a recent reform that tightened early retirement eligibility requirements. Disability benefits remain (extremely) generous when claimed before age (57) 60. Steady-state NDC pensions, due to dynamic efficiency, are less than actuarially fair. They further deviate from actuarial fairness due to the specific rules, based on historical mortality, adopted by the Italian law for computing and updating benefits while facing increasing longevity. Cohort mortality projections should be used to handle longevity changes in NDC schemes.

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Introduction

In the last two decades, population ageing and low economic growth have undermined the financial stability of several pay-as-you-go defined benefit (DB) pension schemes. Some countries (including Italy, Latvia, Poland and Sweden) have reacted to the crises by retaining their pay-as-you-go financing method, but replacing their DB with a notional defined contribution (NDC) pension system. An NDC scheme consists of an individual account system to which contributions are earmarked and interests notionally paid; at retirement, the notionally accumulated sum is converted into the pension taking into account life expectancy, that is, incorporating actuarial fairness.

An ideal actuarially fair pension scheme is characterised by both actuarial fairness and actuarial fairness at margin. Actuarial fairness guarantees that, for each individual, the discounted sum of contributions paid during the working career is equal to the discounted sum of expected benefits received during retirement. Actuarial fairness at margin ensures

that, for each individual, any supplementary contributions to be paid in case of postponed retirement will correspond to additional pension benefits.^{1,2}

An NDC scheme cannot guarantee the two above described ideal actuarial conditions; however, it should satisfy the weaker conditions of *quasi*-actuarial fairness, and *quasi*-actuarial fairness at margin.³ These conditions recognise that, in a dynamic efficient economy, only a funded DC pension scheme can guarantee pure actuarial fairness.⁴ Since an NDC system is pay-as-you-go financed, its equilibrium rate of return is given by the wage bill growth rate.⁵ Moreover, an NDC scheme should broadly allow for differences in life expectancy across different population groups within a cohort.⁶

According to official European demographic projections, life expectancy at age 65 for the EU-27 countries is expected to increase by about five years by 2060.⁷ Implementations of *quasi*-actuarially fair NDC systems need to guarantee that life expectancy used to compute the annuity at retirement is as close as possible to actual, *ex post*, residual life.⁶ Palmer⁸ has suggested three procedures to handle increasing longevity in NDC schemes.⁹ The first procedure consists in forming a committee of demographic experts in charge of the analysis of long-run scenarios and the publication of official cohort projections. Revisions are gradual, and only occur when changes in long-run trends are documented. They always apply to non-retired cohorts and are increasingly small as cohorts approach retirement. The second procedure consists in estimating cohort life tables based on historical cross-sectional data. In this case, periodical adjustments are necessary to avoid producing systematically more-than-actuarially fair annuities. The third procedure envisages the use of recent cross-sectional survival data to compute annuities at retirement and to regularly adjust the pensions of all retirees on the basis of more updated data.

In 1995, the Italian pension system was reformed and an NDC scheme was introduced to replace the previous unsustainable DB scheme. The 1995 reform (known as the “Dini” reform) set up a transitional phase towards the new rules lasting almost 30 years. Transition rules were partly modified by a subsequent reform in 2011 (“Monti-Fornero” reform). In the coming two decades, pensions will be partly computed according to the old rules; consequently, their actuarial features will still depend on the characteristics of the former DB scheme. Moreover, (N)DC pension benefits are computed on the basis of updated cross-sectional mortality tables, while benefits of retired individuals are unaffected by longevity changes occurring during retirement. A comparison between

¹ Legros (2006).

² A formal definition of these actuarial concepts is provided in the section “Actuarial indicators”. In the literature, actuarial fairness is often named actuarial fairness “on average”, to stress that in contrast to the notion of actuarial fairness at margin, it takes into account the whole career profile of the agent, without focusing on the last years of work (Legros, 2006, p. 211) In this paper, we use the term actuarial fairness as synonymous for actuarial fairness on average.

³ Holzmann (2006).

⁴ See, e.g. Lindbeck (2006); Holzmann (2006).

⁵ See Samuelson (1958); Aaron (1966).

⁶ Disney (2004).

⁷ EPC-WGA (2011).

⁸ Palmer (2006).

⁹ See also Bengtsson and Keilman (2003).

these pension rules and the above suggested procedures indicates that the Italian NDC pension system may violate actuarial principles if longevity continues to rise.

Similar issues are likely to arise for other countries that have introduced NDC pension systems, such as Poland, which adopts alike pension rules to counteract longevity improvements.¹⁰ Sweden has also adopted a similar approach; nevertheless, this country has introduced an automatic long-run correction mechanism (called pension-debt adjustment mechanism) which indexes downward notional capital of workers and benefits if actual and expected longevity differ.¹¹ Benefits of Latvians are instead calculated from projected cohort mortality tables prepared by demographic experts.¹²

Various studies analysed the actuarial characteristics of the Italian pension system after the 1995 reform. Ferraresi and Fornero¹³ and Fornero and Castellino¹⁴ rely on a representative agent approach and show that the former DB scheme was extremely generous, whereas the future NDC will be almost actuarially fair. These findings have been largely confirmed by microsimulation models.¹⁵ Marano *et al.*¹⁶ point out that the NDC formula departs from actuarial fairness if one accounts for the interaction between old-age and social assistance provisions. Other studies quantify the extent of within-cohort redistribution of the Italian NDC pension system induced by differential mortality by gender, education, income¹⁷ and regions.¹⁸ Most of the cited studies assume static mortality; none of them incorporate cohort mortality tables. To our knowledge, the effects of the 2011 reform on the actuarial characteristics of the Italian pension system have not been analysed yet.

The contribution of this paper is twofold. First, extending Ferraresi and Fornero¹³ and Fornero and Castellino,¹⁴ we analyse the actuarial features of the Italian pension system accounting for dynamic mortality. We compare the Italian pension rules with the first procedure suggested by Palmer⁸ to counteract increasing longevity in NDC schemes. In addition, we evaluate the impact of the 2011 pension reform on the actuarial characteristics of the Italian pension system. To these aims, we build ad hoc projected cohort- and gender-specific mortality tables based on a limit survival scenario depicted by demographic experts.

The paper proceeds as follows. The next section illustrates the institutional framework, the subsequent section describes the projected life tables. The latter sections describe the model and the actuarial indicators. The sixth section shows the main results, the penultimate section provides a sensitivity analysis with respect to some key model assumptions and the final section concludes. Three appendices describe pension projections, detailed results and mortality forecasts methodology.

¹⁰ See Chlon *et al.* (1999).

¹¹ Palmer (2000).

¹² Palmer *et al.* (2006).

¹³ Ferraresi and Fornero (2000).

¹⁴ Fornero and Castellino (2001).

¹⁵ See Borella and Coda Moscarola (2006); Marano *et al.* (2012).

¹⁶ Marano *et al.* (2012).

¹⁷ Mazzaferro *et al.* (2012).

¹⁸ Caselli *et al.* (2003).

Institutional framework

To improve the social security budget, an impressive sequence of reforms was introduced in Italy during the 1990s and the 2000s.¹⁹ Most of these changes were designed to be effective in the short run by acting on specific parameters of the existing system, such as the minimum retirement age. Law No. 335/1995, which was designed instead to improve the budget in the long run, replaced the existing DB scheme with an NDC one.

In line with its long-run view, the 1995 law classified workers into three groups: the oldest, the middle-aged and the youngest. The oldest are those workers who, at the time of the reform, had accrued more than 18 years of seniority. They were unaffected by the reform. The middle-aged are those who had accrued less than 18 years of seniority by the end of 1995. Their pension is computed according to a mixed (pro-rata, PR henceforth) system where old and new rules are combined in proportion to the number of years worked up to and after 1995. The youngest, to whom the new system fully applies, are those who started working after 1995. Recently, Law No. 214/2011 extended the PR system to the oldest. The pension of this group of workers is thus computed according to a mixed system (extended *pro-rata*, DB-PR henceforth) where old and new rules are combined considering the number of years worked up to and after 2011.

About two-thirds of the workforce is insured with the Istituto Nazionale della Previdenza sociale (INPS), the main social security institution in Italy. The Fondo Pensioni Lavoratori Dipendenti (FPLD) is the largest INPS pension scheme, enrolling almost all employees in the private sector. Separate schemes with different pension rules exist for the self-employed, civil servants and other categories of workers. The development of voluntary-based second and third pillars has been recently encouraged; both participation and contributions remain however modest.²⁰ Considering the complexity of the framework generated by the reforms, in this study we focus on the FPLD fund.

Male (female) workers can claim an old-age pension at age 66 (62, progressively increasing to 66 by 2018) once 20 years of seniority have been accrued. By 2021, in compliance with a recent EU Commission recommendation, the minimum retirement age for the old-age pension will be raised to 67. Early retirement has been severely restricted by the 2011 reform; it can be claimed by males (females) who accumulate 42 (41) years and one month of seniority.²¹

The DB benefit is computed as the product of three factors: pensionable earnings, seniority and annual return. Pensionable earnings are the average wage of the last years of work. The number of years to include in the computation of pensionable earnings was progressively increased from 5 to 10 by the reforms of the 1990s. Seniority includes the number of years of regular contribution to the scheme, as well as years of notional contribution spent during out-of-work periods (e.g. unemployment spells, maternity leaves and military service). Total seniority is topped at 40 years. Annual return is a decreasing function of pensionable earnings, equal to 2 per cent for a large part of the earnings distribution. Payroll taxes grew from 19 per cent in 1967 (the first relevant year for our simulation) to 33 per cent

¹⁹ Pension expenditure grew from 7.4 per cent of GDP in 1970 to 14.9 per cent in 1992 (Brugiavini and Galasso, 2004).

²⁰ According to COVIP (2011), 24.1 per cent of workers have adhered to supplementary pension funds and assets are 4.6 per cent of GDP.

²¹ Eligibility conditions are linked to life expectancy.

(9.19 per cent, that is, about 28 per cent of the total, are paid by the employee). Pensions are price-indexed.²²

The DC old-age/early retirement pension for a worker retiring at age x is computed as:

$$P(x)^{DC-OLD} = \left[\alpha_a w_a + \sum_{i=1}^{a-1} \alpha_i w_i \prod_{j=i}^{a-1} (1 + \bar{g}_j) \right] \delta_x, \quad (1)$$

where α_i and w_i are payroll tax rate and wages when seniority is i , a is seniority at retirement and \bar{g}_j is the geometric mean of nominal GDP growth rate in the 5 years preceding the year in which seniority is j . The amount in square brackets is the nominally accrued fund at retirement. δ_x is the conversion coefficient for retirement at age x , defined as:

$$\delta_x = \left(\frac{\sum_{s=mf}^{\Omega-x} \frac{dir_{x,s} + ind_{x,s}}{2} - k}{2} \right)^{-1}, \quad (2)$$

$$dir_{x,s} = \sum_{t=0}^{\Omega-x} \frac{\ell_{x+t,s}}{\ell_{x,s}} (1 + g_f)^{-t}, \quad (3)$$

$$ind_{x,s} = \theta_s \sum_{t=0}^{\Omega-x} \frac{\ell_{x+t,s}}{\ell_{x,s}} \left(1 - \frac{\ell_{x+t+1,s}}{\ell_{x+t,s}} \right) (1 + g_f)^{-t} \Theta_{x+t,s} a_{x+t+1}^W, \quad (4)$$

$$a_{x+t+1}^W = \sum_{\tau=1}^{\Omega-x-t+\varepsilon_s} \frac{\ell_{x+t+\tau-\varepsilon_s,-s}}{\ell_{x+t+1-\varepsilon_s,-s}} (1 - q_{x+t+\tau-\varepsilon_s,-s}^{ved}) (1 + g_f)^{-\tau}, \quad (5)$$

where $\ell_{x+t,s}/\ell_{x,s}$ is the gender- s -specific conditional survival probability from age x to age $x+t$; Ω is the maximum life span, g_f is the long-run expected GDP growth rate; θ_s is the fraction of the annuity paid to the widow(er) ($\theta_s = \theta \times c^{et}$, where $\theta = 0.6$ and c^{et} is a earning-related reduction factor, set equal to (0.7) 0.9 if s is (fe)male); Θ is the age-and-gender-specific probability to be married.²³ a_{x+t+1}^W is the expected present value of a unitary annuity paid to the widow(er) at time $x+t+1$; ε is the age difference between pensioner and his/her widow(er) ($\varepsilon_s = +3(-3)$ if $s = m(f)$); $-s$ is the gender of the widow(er); q^{ved} is the age-and-gender-specific probability for the widow(er) to remarry.²⁴ k is an actuarial adjustment factor that takes into account the number of pension payments made to the retiree each year.²⁵ Differences in death probabilities between genders are averaged out (see Eq. 2). The retirement age x is flexible between 62 and 70 (before the 2011 reform: between age 57 and 65). According to the current legislation, conversion coefficients have to be revised every three years, to incorporate updated mortality tables and new GDP growth rates projections; before 2007 the temporal validity of the coefficients was equal to 10 years.

²² A formal description of the DB and PR pension formulas is provided by Fomero and Castellino (2001).

²³ ISTAT (2007).

²⁴ ISTAT (2006).

²⁵ Formally, $k = 0.5 - (6/13n)$, where n is the number of (anticipated) pension payments made to the retiree each year. Currently, $k = 0.4615$ since $n = 12$ (NVSP, 2006).

Disability and survivor pensions are also financed through social security contributions. Disability benefits (*pensione di inabilità*) are paid to claimants who, after medical screening, result to be in the permanent and total impossibility of doing any kind of work activity (Law No. 222/1984). Additional requirements to claim this benefit are five years of enrolment to INPS and at least three years of contributions in the previous five. The disability benefit is computed first applying either DB (prior to the 2011 reform)/DB-PR, PR or DC rules, as established for the old-age/early retirement pension. To the benefit computed in this way, a “contributory bonus”—equal to the years of contributions from the age of claiming to the age of 60—is then added. If the claimant is younger than 57, the favourable conversion coefficient for retirement at age 57 is applied.

The DC disability pension claimed at age x is given by²⁶:

$$P(x)^{DC-DIS} = \left\{ \left[\alpha_a w_a + \sum_{i=1}^{a-1} \alpha_i w_i \prod_{j=i}^{a-1} (1 + \bar{g}_j) \right] + \left[\frac{\sum_{i=1}^5 w_{a-i}^*}{5} 0.33(60-x) \right] \right\} \delta_{\max\{x,57\}}, \quad (6)$$

where the amount in the first set of square brackets is the nominally accrued fund when the person becomes disabled (see Eq. 1), and w_i^* is the (appropriately adjusted) wages in the preceding 5 years). The amount in the second set of square brackets is the “contributory bonus”.

Survivor benefits are paid to the worker’s (*pensione indiretta*) or old-age, early retirement and disability beneficiary’s (*pensione di reversibilità*) relatives, including the widow(er), minor or disabled children, children in full-time education or, in particular cases, even parents or brothers and sisters. The payment amount of survivor benefits depends on the number of recipients and on their earnings. The deceased worker needs to meet the minimum contribution requirements established for the disability pension; see above.

Projected cohort mortality tables

A sizeable downward trend in old-age mortality has taken place in Italy since the 1970s. In the last 40 years, life expectancy at age 60 (e_{60}) gained nearly six years.²⁷ Currently, e_{60} is about 22 years for males and 26 years for females. The greatest improvements for the future are expected for the oldest old, that is, individuals aged 80 and over. In a context characterised by further progress in the prevention and cure of diseases and by firmly-rooted life styles able to promote “successful ageing”, younger cohorts are expected to live longer than older ones.²⁸

The future mortality evolution will be influenced by tendencies that emerge in the last phase of life. Two theories contrast on this point. According to the theory of “compression of

²⁶ Throughout the paper, the symbol x defines the age at which the individual leaves the labour force, regardless of the specific exit route which he or she may use (i.e. either old-age/early retirement or disability pension).

²⁷ Caselli *et al.* (2003); ISTAT (2010).

²⁸ Christensen *et al.* (2009).

mortality,”²⁹ life expectancy cannot exceed the limit of 85 years and, as many more people gain years of life, there will be a process of concentration of their deaths in a narrow interval astride this threshold. The theory of “expansion of mortality”³⁰ on the contrary, points out that the recorded maximum life span will continue to increase.³¹ This last theory is backed up by statistics regarding the maximum life span gradually reached by persons who have died in the last 30 years in developed countries, and by the observed decline in mortality of the oldest old (i.e. aged 80 years and more).

In this study, we develop a deterministic forecast for the Italian cohorts 1945–2000 which relies on the theory of expansion of mortality. In this framework, characterised by a limit scenario where the whole survival curve is shifted towards higher ages, life expectancy will continue to rise in the future.³² To build limit life tables—that is, the life tables of the selected limit scenario³³—set in the distant future, we follow the indications provided by recent interdisciplinary studies which have depicted the most important traits for human survival.³⁴ Cohort forecasts are obtained by computing period age-specific death probabilities on the forecast time frame: we connect period tables with limit life table; in the first years of the projections, our tables reflect the characteristics of current mortality, while for farther projection years, they progressively come closer to those of the limit scenario.

Projected cohort mortality tables typically cover a very long period of time (e.g. our limit life tables are set around year 2150). A scenario approach like the one we adopt is particularly suitable to account for such a long-run time frame. Alternative approaches—including the stochastic Lee and Carter³⁵ model—are instead often preferred for short- and mid-time projections.^{36,37} In our exercise, we corroborate the actuarial findings based on our projected life tables with alternative results based on the long-run probabilistic mortality projections for Italy recently implemented by the United Nations.^{38,39} By exploiting alternative percentiles of the UN probabilistic forecasts, we also account for the impact of projection uncertainty on the actuarial indicators.

Table 1 compares the estimated life expectancy at birth (e_0) and at age 65 (e_{65}) with the corresponding statistics provided by the most recent official projections.^{40,41} The table

²⁹ See, e.g. Fries (1983, 1989).

³⁰ Myers and Manton (1984); Olshanski *et al.* (1993); Robine and Cheung (2008).

³¹ See Wilmoth and Lundstrom (1996); Wilmoth (2000).

³² Kannisto (1996).

³³ Tabeau *et al.* (2002); Booth and Tickle (2008).

³⁴ See Robine *et al.* (2006).

³⁵ Lee and Carter (1992).

³⁶ Li and Gerland (2012).

³⁷ Lee and Carter (1992) assume that the sensitivity of the logarithm of the age-specific mortality rate to the time trend is constant over time (See p. 660 in Lee and Carter, 1992). This is a strong assumption in very long-term forecasts.

³⁸ Raftery *et al.* (2012).

³⁹ The UN mortality projections represent part of the probabilistic population projections for all countries. They are carried out in two steps. In the first step, probabilistic projections of life expectancy at birth are based on a Bayesian hierarchical model (Raftery *et al.*, 2013). In the second step, these life expectancies are converted into age-specific mortality rates using extended model life tables (Li and Gerland, 2012). See UN (2012) for details. The UN mortality projections stretch up to 2100 and thus allow to reconstruct mortality tables for cohorts 1945–1980. Cohorts born after 1980 are not extinct in 2100.

⁴⁰ ISTAT (2008).

Table 1 Predicted period life expectancy at birth (e_0) and at age 65 (e_{65}): our tables vs official tables

Forecast/Year	Males				Females			
	2030		2050		2030		2050	
	e_0	e_{65}	e_0	e_{65}	e_0	e_{65}	e_0	e_{65}
Our tables	83.0	20.8	86.6	23.4	88.2	25.0	91.5	27.8
ISTAT (2008)—high	84.0	21.9	86.8	24.1	89.1	25.8	91.6	27.9
ISTAT (2008)—main	82.2	20.5	84.5	22.2	87.5	24.4	89.5	26.0
ISTAT (2008)—low	80.2	19.0	81.9	20.2	85.7	22.9	87.2	24.1

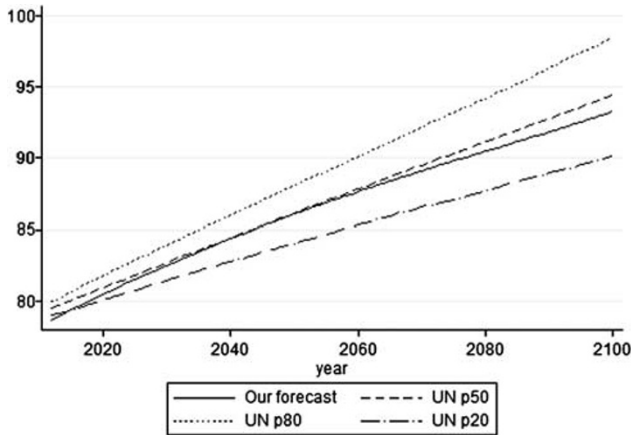


Figure 1. Predicted period life expectancy at birth: our tables vs United Nations tables—percentiles 20, 50 and 80.

indicates that our forecasts lie between ISTAT-main and ISTAT-high mortality scenarios. Figure 1 contrasts our estimated e_0 with corresponding values from the UN projections—percentiles 20, 50 and 80; it highlights that our projections are very close to those obtained by the United Nations, median values. Finally, Figure 2 shows our forecasted survival curves by cohort for males; a similar figure can be drawn for females. The figure highlights two typical characteristics of the mortality process of younger cohorts: the “rectangularisation” of life tables, that is, deaths are concentrated around a narrower interval of age, and the increase in life span. As a consequence of these improvements, males e_{60} is expected to increase from 23.1 years (cohort 1945) to 27.1 years (cohort 1970), up to a striking 31.4 years (cohort 2000).⁴²

⁴¹ At an intermediate step, our approach forecasts periodic life tables, which can be compared with those obtained by official forecasts. It should be pointed out, however, that the methodological approaches used in a very long-term forecast and in standard demographic forecasts (which usually cover a period of 30–50 years) are extremely different. Therefore, a formal comparison between the two tables cannot be conducted.

⁴² No official cohort mortality tables for the overall population exist in Italy. There exist two cohort tables (called RG48 and IP55, pertaining to the 1948 and 1955 cohorts) used by Italian insurance companies to compute

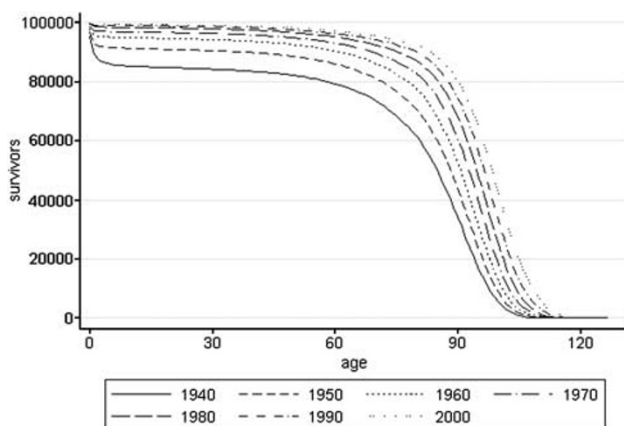


Figure 2. Projected survival curves by cohort: males.

Representative agents

We consider a set of representative agents subjects to either DB/DB-PR, PR or (N)DC pension rules. Each analysed individual represents a typical employee born in a given year, of a given gender and occupation (blue or white-collar). Agents are characterised by a stylised working career, described by an age at enrolment, a lifetime wage profile and a set of alternative retirement ages. The main features of the working career (e.g. age of entry into the labour market) are kept constant across cohorts to better highlight the impact of both normative and mortality changes on the actuarial indicators.

Based on empirical evidence obtained from the Bank of Italy's survey of household's income and wealth (SHIW), we assume that white-collar workers enrol into the pension scheme at age 24, while blue-collar workers enrol at age 22 if female, or at age 20 if males. We further assume that, once enrolled, agents keep contributing to the same scheme until retirement.⁴³ Given our assumptions, agents become eligible to claim old-age or early retirement benefits between the ages of 62 and 67; specific eligibility varies with gender, occupation and year of birth.⁴⁴

premiums. They refer to the annuitant population and correct for self-selection. Owing to self-selection of healthier individuals, the annuitants' life expectancy is longer than the whole population's.

⁴³ Using the SHIW data (various cross-sections) we compute the average age of entry into the labour market by gender and occupation. To avoid overestimation of accrued seniority at retirement, we account for an average period of 3 years spent out of the labour market and not compensated by notional contributions (see the section "Institutional framework"). This figure has been computed by Belloni and Alessie (2009), exploiting INPS micro data.

⁴⁴ Specifically, male blue-collar workers are eligible at age 62, female blue-collar workers at age 63 (cohorts 1950–1951 at age 62), female white-collar workers at age 65 (cohorts 1950–1951 at age 62, cohort 1952 at age 63), male white-collar workers at age 66. We additionally consider "late" male white-collar workers, who enroll at age 28. Differently from the other stylised workers, these agents become eligible for the old-age benefits (at age 67, or at age 66 if born in 1950–1954) with less than 40 years of accrued seniority. We will show that the

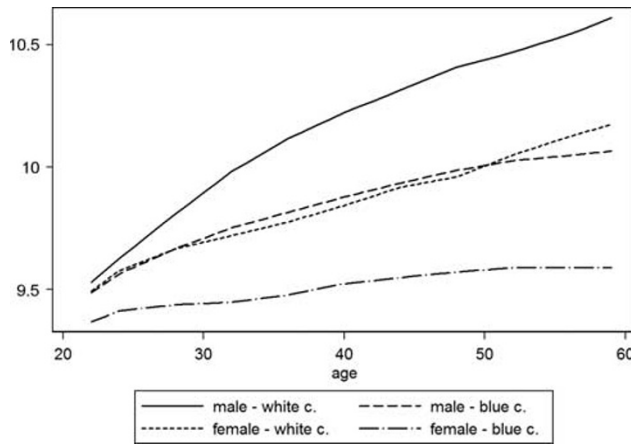


Figure 3. Estimated age–wage profiles by gender and occupation.
Note: log-wages (2009 euros); cohort 1950.

Lifetime wage profiles are obtained as predictions from a random effects model for individual wages estimated on the Italian administrative data *Estratti Conto INPS*, a panel data set that covers the period 1985–1997 and includes 1/365 of the Italian private sector workforce. In the wage model, the log of wages is regressed against an age spline, a variable capturing the cohort effect, a set of year, sector and area of work dummies. The model is estimated separately by gender and occupation (blue- and white-collar workers). Figure 3 displays the estimated lifetime wage profiles: among the four groups, male white-collar workers have the steepest and highest profile while female blue-collar workers have the less dynamic careers and are the poorest. Owing to self-selection problems, the estimation samples only include individuals younger than age 60; above age 59, we assume that wages grow with age at a rate equal to the growth rate estimated at ages 55–59.⁴⁵

Given these stylised careers, each representative agent is assigned to a specific pension regime. Table 2, for example, reports assigned pension regime and retirement years by cohort for male white-collar workers. It shows that agents born between 1945 and 1953 are subject to the DB-PR rules, since in 1995 they had accumulated 18 years of contributions or more. Depending on retirement age (given our assumptions, male white-collar workers acquire eligibility at age 66) and cohort, these agents claim pension benefits between year 2012 and 2023. Agents born between 1954 and 1970 are subject to the PR rules and retire between 2020 and 2040. Finally, agents born in 1971 or later are subject to the DC rules and

effect of the pro rata extension on the actuarial indicators depends on whether the individual has reached the threshold of 40 years of seniority at retirement (see the section “Institutional framework”).

⁴⁵ Following Heckman and Robb (1985) and Kapteyn *et al.* (2005), we assume that wages differ across cohorts due to the macroeconomic conditions when individuals enter into the labour market. These conditions are summarised by productivity growth and are approximated by GDP per capita. This means that the age–wage profiles illustrated in Figure 3 shift upward (or downward) by cohort, incorporating historical and projected GDP growth. Including cohort effects in the wage model allows for a consistent estimate of the age–wage profiles. Additional details are provided upon request.

Table 2 Pension regime and retirement years by cohort: male white-collar workers

Cohort	Start	Sen.1995	Regime	Retirement years		
				Age 66	...	Age 70
1945	1969	26	DB-PR	—		2015
...
1953	1977	18	DB-PR	2019		2023
1954	1978	17	PR	2020		2024
...
1970	1994	1	PR	2036		2040
1971	1995	0	DC	2037		2041
...
2000	2024	0	DC	2066		2070

Notes: Start=enrolment year; sen.1995=seniority accrued at the end of 1995; regime: DB-PR=extended pro rata, PR=pro rata, DC=notional defined contribution.

retire in 2037 or later. Agents can claim disability benefits at younger ages if qualified (see the section “Institutional framework”). A similar categorisation of workers is obtained for the other types of agents.

Historical and projected values of key macroeconomic indicators such as GDP growth rates, inflation rates and long-run (10 years’ maturity) government bond interest rate are used in the computation of pension benefits and corresponding actuarial indicators (see the next section). In our main macroeconomic setting, the projected long-run real GDP growth rate (g_f , see the section “Institutional framework”) is equal to 1.5 per cent and the long-run riskless interest rate (r , see the next section) is equal to 2 per cent.⁴⁶ The implied spread ($r-g_f=0.5$ percentage points) is coherent with a dynamic efficient economy, although it envisages a limited dominance of the financial market with respect to the pay-as-you-go system. In a sensitivity analysis we consider alternative macroeconomic settings where the spread between these two macroeconomic variables is wider.

Finally, in our simulations we consider three alternative normative scenarios: baseline 2011 (B_{2011}), baseline 1995 (B_{1995}) and *quasi*-actuarial benchmark (AB). The first two incorporate actual pension rules. Scenario B_{2011} considers current pension rules, while scenario B_{1995} accounts for pension rules existing right after the 1995 reform. Differently from the former, the latter scenario: (i) considers DB (instead of DB-PR) pension rules and (ii) assumes a temporal validity of conversion coefficients equal to 10 (instead of 3) years (see the section “Institutional framework”). To compute conversion coefficients in scenarios B_{2011} and B_{1995} , we exploit the cross-sectional versions of our projected cohort mortality tables. The AB scenario considers hypothetical cohort- and gender-specific conversion coefficients, formally defined as

$$\delta_{x,s}^{co} = (dir_{x,s}^{co} + ind_{x,s}^{co})^{-1}, \quad (7)$$

where $dir_{x,s}^{co}$ and $ind_{x,s}^{co}$ are defined in Eqs (3–4) and computed using cohort-*co* mortality rates.

⁴⁶ A very similar value for the GDP growth rate has been adopted in recent long-run EPC-WGA pension projections (EPC-WGA, 2011) and in most of the Italian pension expenditure projections (MEF, 2009, 2011).

Actuarial indicators

We compute two actuarial indicators: the present value ratio (PVR) and the implicit tax/subsidy rate (TAX). The former is used to evaluate actuarial fairness while the latter measures actuarial fairness at margin. Both of them require the computation of social security wealth (SSW). The SSW for retirement at age x , computed at the beginning of the working career, is given by:

$$SSW(x) = -PVC(x) + PVB(x) + PVW(x), \quad (8)$$

where the three components represent the actuarial present value of: contributions (PVC), retirement and disability benefits including survivor benefits (PVB), and survivor benefits paid before retirement to the deceased worker's widow(er) (PVW). They are defined as:

$$PVC(x) = \sum_{j=1}^a \alpha_j \hat{w}_j^* \frac{\ell_{e+j-1,s}^c}{\ell_{e,s}^c} (1+r)^{-j+1}, \quad (9)$$

$$PVB(x) = P(x) \sum_{j=a+1}^{\Omega-e} \frac{\ell_{e+j-1,s}^c}{\ell_{e,s}^c} (1+r)^{-j+1} \times \left[1 + \theta_s \left(1 - \frac{\ell_{e+j,s}^c}{\ell_{e+j-1,s}^c} \right) (1+r)^{-1} \Theta_{e+j-1,s} a_{e+j}^W \right], \quad (10)$$

$$PVW(x) = \theta_s \sum_{j=5}^a P(e+j-1)_{SC}^{RE-OLD} \frac{\ell_{e+j-1,s}^c}{\ell_{e,s}^c} \times \left(1 - \frac{\ell_{e+j,s}^c}{\ell_{e+j-1,s}^c} \right) (1+r)^{-j} \Theta_{e+j-1,s} a_{e+j}^W, \quad (11)$$

where α_j and \hat{w}_j^* are respectively payroll tax rate (see the section “Institutional framework”) and wages (at constant prices as predicted by the wage model; see the previous section) when accrued seniority is j , e is the age at which the employee starts contributing to the scheme, a is the number of years of seniority accrued at retirement or when claiming a disability pension, c is the cohort, r is the riskless interest rate,⁴⁷ while the other symbols are defined in the section “Institutional framework”. $P(x)$ is defined as follows:

$$P(x) = \gamma_x P(x)_{SC}^{RE-OLD} + (1 - \gamma_x) P(x)_{SC}^{RE-DIS}, \quad (12)$$

where RE is the pension regime (either DB/DB-PR, PR or DC, depending on cohort and type of agent), SC is the normative scenario (B_{2011} , B_{1995} or AB), OLD and DIS are old-age/early retirement and disability formula respectively, while $\gamma_x=1$ if the individual at age x is eligible

⁴⁷ We approximate r with the long-run (10 years' maturity) government bond interest rate. See Queisser and Whitehouse (2006) for a discussion of the appropriate discount rate.

for old-age/early retirement and 0 otherwise.⁴⁸ Under the assumption of continuous working careers, $x=e+a$. As mentioned in the section “Institutional framework”, the legislation on survivor benefits envisages a variety of possible beneficiaries and pension amounts. In Eqs (10–11) for simplicity we assume that, among the relatives of the deceased worker/retiree, survivor benefits are only paid to the widow(er); this is in line with what is established by law in the computation of the conversion coefficients (see Eq. 2). Financial flows are annual and anticipated.

The PVR for retirement at age x , computed at the beginning of the working career, is given by:

$$PVR(x) = \frac{PVB(x) + PVW(x)}{PVC(x)} \quad (13)$$

showing how much the system returns to the worker for each euro paid. A pension system is defined to be actuarially fair if $PVR(x)=1$ (i.e. $SSW(x)=0$ in Eq. 8). A pension system is defined to be *quasi-actuarially* fair if $PVR(x)=1$ when $r=g_f$.

The TAX for retirement at age x , computed at the beginning of the working career, is given by:

$$TAX(x) = \frac{-ACC(x)}{\hat{w}_{a+1}^* (\ell_{e+a,s}^c) (1+r)^{-a} / \ell_{e,s}^c}, \quad (14)$$

where \hat{w}_{a+1}^* is the expected wage for the following year in case of postponed retirement, as predicted by the wage model described in the previous section, while the numerator is called *accrual* and is defined as:

$$ACC(x) = SSW(x+1) - SSW(x). \quad (15)$$

If retirement is postponed by one year, the SSW varies due to two reasons. First, it decreases because of additional contributions to pay. Second, it varies due to the difference in the present values of pension benefits associated with the alternative retirement options. The sign of this difference is undefined because a shorter retirement period is generally associated with a higher pension benefit. In Eq. (14), the accrual is normalised with respect to the expected wage for the additional year of work. A pension system is defined actuarially fair at margin if $TAX(x)=0$. A pension system is defined to be *quasi-actuarially* fair at margin if $TAX(x)=0$ when $r=g_f$. If $TAX(x)>0$ the pension system imposes an implicit taxation on the continuation of the working activity; if $TAX(x)<0$ it instead penalises early retirement.

Results

To compute PVR and TAX in alternative normative scenarios, we forecast appropriate conversion coefficients for future retirement years. These coefficients are reported in Appendix A. In scenarios B_{2011} and B_{1995} , coefficients are expected to decrease considerably, as

⁴⁸ Therefore, the SSW for retirement ages at which the agent is not eligible for old-age or early retirement is computed conditional on being eligible for disability.

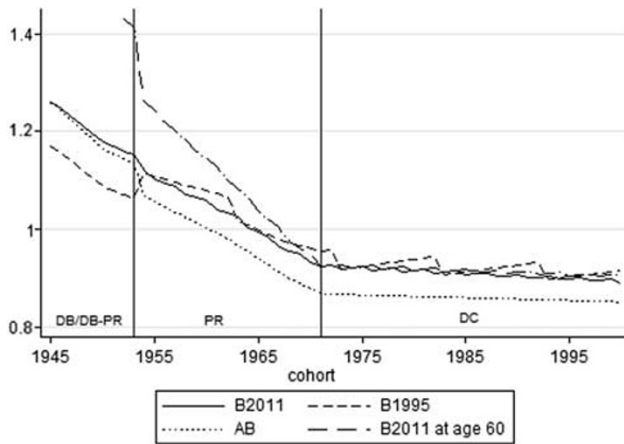


Figure 4. PVR by cohort: male white-collar workers, alternative scenarios.
 Note: B_{2011} : current pension rules; B_{1995} : 1995 pension rules; AB : quasi-actuarial benchmark; retirement at age 67, B_{2011} at age 60: current pension rules and retirement allowed at age 60; $g_f=0.015$, $r=0.02$.

a consequence of the increased longevity; this especially occurs at older retirement ages and in the first years of the simulation (see Table A1). Cohort- and gender-specific conversion coefficients (scenario AB , Table A2) would be very heterogenous, with lower values expected for younger cohorts and females. Finally, a comparison between coefficients in scenarios B_{2011} and AB (see Table A3) shows that the former coefficients are higher than the latter by 5 to 10 percentage points for males and by 11 to 14 points for females.⁴⁹

Actuarial fairness

Figure 4 reports the PVR by cohort for male white-collar workers retiring at age 67 (i.e. the future old-age retirement age, see the section “Institutional framework”). In addition to the normative scenarios B_{2011} , B_{1995} and AB , the figure reports the case of hypothetical early retirement at age 60 (B_{2011} at age 60); this case is reported to highlight the impact on the indicator of the stricter eligibility conditions introduced by the 2011 reform.⁵⁰ The results for other agents and macroeconomic assumptions are described in the next section.

The DB-PR system turns out to be extremely generous, providing male white-collar agents with much more than actuarially fair benefits: employees born in 1945–1953 receive in terms of social security benefits up to 126 per cent of what they paid in terms of contributions during their working career (PVR=1.26 for cohort 1945, scenario B_{2011}).⁵¹ Their PVR would

⁴⁹ Notice that the differences between the two scenarios decrease over time for males, while they remain almost constant for females. This different pattern can be explained by differences in our mortality projections between genders: although the rate of growth of life expectancy at old ages over cohorts is higher for males than for females, it declines faster for the former than for the latter gender.

⁵⁰ Given our assumptions, male white-collar workers are eligible for early retirement at age 66. Without the 2011 reform, the same workers would have been eligible for early retirement at age 60.

reach an even higher value, up to 1.4, if they could claim benefits at age 60 as permitted before the 2011 reform (B_{2011} at age 60, cf. with PVR=1.1 scenario B_{2011} cohort 1953).⁵²

Throughout the transitional phase towards the DC rules (cohorts 1954–1970), the PVR exhibits a decreasing trend due to the increasing weight of the DC quota in the computation of pension benefits of younger cohorts. For workers born after 1964, the system is less than actuarially fair. The stricter eligibility rules introduced in 2011 have a strong negative impact on the PVR for cohorts in the PR regime.

For workers born in 1971 or later, the PVR ranges between 0.89 and 0.93, indicating that the steady-state DC regime is less than actuarially fair. This result is attributed to dynamic efficiency in NDC schemes.¹⁴ Noticeably, the PVR is 4–6 percentage points higher in scenario B_{2011} than in scenario *AB*. This difference is the result of two counteracting effects, which stem from the specific rules adopted by the Italian law to handle increased and heterogeneous longevity. For one thing, pension computation disregards cohort effects in mortality; benefits of retirees are kept unchanged regardless of longevity changes occurred during retirement. This effect widens the gap between these two scenarios. For another, current pension rules penalise males by not accounting for their lower life expectancy, thus reducing this gap (for females, the difference in the PVR between scenarios B_{2011} and *AB* is much higher than for males, ranging between 10 and 13 percentage points: the two effects cumulate for females). Additional computations that violate dynamic efficiency (obtained setting $r = g_f = 0.015$; results not reported) show that the PVR for the DC cohorts ranges between 1.05 and 1.09; this indicates that future DC pensions are expected to be more than *quasi*-actuarially fair (see the previous section).

Finally, Figure 4 shows that the PVR by cohort is characterised by an irregular course. Periodical adjustments of the conversion coefficients, implemented to counteract increased longevity, generate discontinuities in the indicator, revealing pension income redistribution between adjacent cohorts. Making revisions more frequent limits but does not eliminate this issue (cf. scenario B_{2011} and B_{1995} , i.e. revisions every 3 years vs 10 years). The PVR has a smooth course in the *AB* scenario, where longevity increases are anticipated.

Figure 5 highlights the actuarial characteristics of disability benefits. It reports the PVR by claiming age (50 to 67) for male white-collar workers born in 1962, scenario B_{2011} . These agents become eligible for early retirement at age 66; between age 50 and 65, we assume that they are eligible to claim disability benefits (see the section “Institutional framework”). The figure shows very high PVR for younger claiming ages, for example, at age 50, PVR=1.95. It also shows a decline in the PVR with age,

⁵¹ Notice that the PVR decreases by cohort even for cohorts in the old DB scheme (scenario B_{1995}). This is due to the increase in the payroll tax rate experienced by younger DB cohorts during their working career.

⁵² Figure 4 also points out that the pro rata extension (from DB to DB-PR) introduced in 2011 increased the generosity of the pension system for cohorts 1945–1953 (cf. B_{2011} and B_{1995}). This partly compensates the negative effect on the indicator of stricter eligibility conditions imposed by the same reform (B_{2011} vs B_{2011} at age 60). Such an increase in the PVR is explained with the feature of the DB-PR scheme of rewarding contributions paid during the whole working career; on the contrary, seniority was topped at 40 years in the former DB scheme (see the section “Institutional framework”). Notice that the value of the actuarial indicators for *late* male white-collar workers—claiming an old-age pension with 36 years of seniority—is almost unaffected by the implementation of the pro rata extension (see Appendix B).

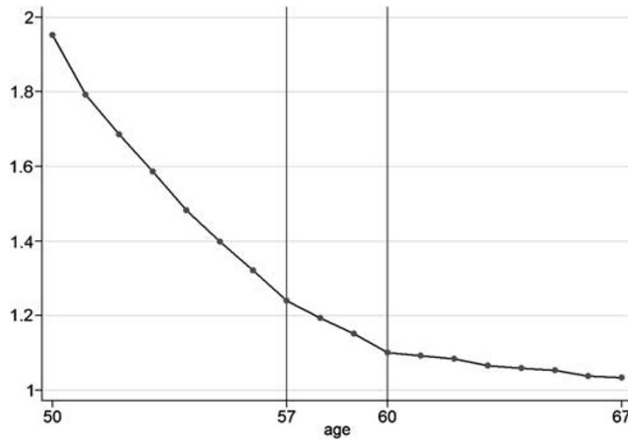


Figure 5. PVR by claiming age: male white-collar workers, cohort 1962.

Note: Scenario B_{2011} ; cohort 1962 is aged 50 in 2012 and is subject to PR pension rules; $g_f=0.015$, $r=0.02$; these agents become eligible for early retirement at age 66; between age 50 and 65, we assume that they are eligible to claim disability benefits.

characterised by two kinks at ages 57 and 60. As described in the section “Institutional framework”, until age 60 disability pensions grant a “contributory bonus” and, up to age 57, their DC component is computed applying the favorable conversion coefficient established for age 57 (e.g. the PVR at age 50 would be equal to 1.74, instead of 1.95, if the coefficient for age 50 was applied). The size of these two “extra bonuses” diminishes as claiming age approaches 57. Between ages 57 and 59, only the “contributory bonus” applies; for higher claiming ages, disability and old-age/early retirement benefits coincide, since no “extra bonus” is granted to disability benefits.⁵³

Actuarial fairness at margin

Figure 6 shows the TAX by cohort for male white-collar workers retiring at age 67. In the DB-PR scheme, the indicator reaches a value of 0.58 (scenario B_{2011}), which represents a strong financial incentive to claim pension benefits.^{54,55} The application of PR pension rules progressively reduces the implicit taxation of continuing working. In the steady state, the TAX ranges between 0.05 and 0.07 (excluding the spikes, see later), which is a very low value. Nevertheless, the implicit taxation is not eliminated. DC pensions are therefore less

⁵³ The PVR at age 60 in Figure 5 is thus equal to that reported in Figure 4 for cohort 1962, scenario B_{2011} at age 60. Up to age 59, the shape of the PVR by age is similar across the analysed cohorts. For retirement ages equal to 60 and above, the PVR decreases with the retirement age in the DB-PR and PR schemes, while it is almost constant with respect to it in the DC scheme (see Table B1).

⁵⁴ Brugiavini (1999).

⁵⁵ Figure 6 also highlights that the pro-rata extension generates a relevant reduction in the TAX for older cohorts (cf. B_{2011} and B_{1995}). As explained in footnote 52, the DC scheme allows for accumulation of pension rights beyond the 40th year of work.

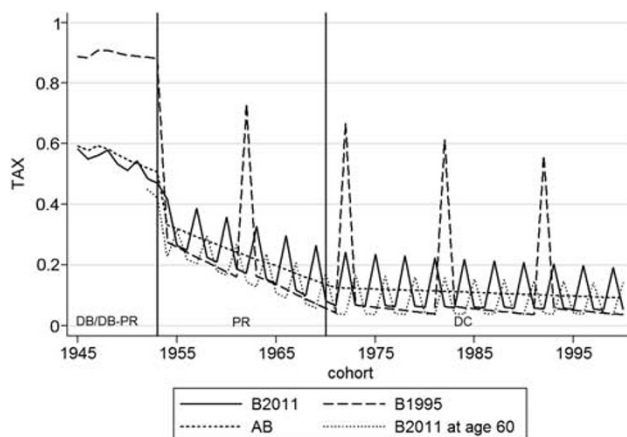


Figure 6. TAX by cohort: males white-collar workers, alternative scenarios.

Note: see Figure 4.

than actuarially fair at margin: due to dynamic efficiency, it is optimal to retire at minimum requirements and invest the accumulated wealth in the financial market.

Finally, Figure 6 shows that the TAX is characterised by big spikes—equal to 14–17 percentage points—in the years preceding the revision of the conversion coefficients. An individual deciding in those years to work longer faces a very strong cut in his or her SSW. As expected, the more frequent the revision of the coefficients, the lower the generated spikes of taxation (cf. scenarios B_{2011} and B_{1995}); however, spikes only disappear in scenario AB .

Sensitivity

In this section, we summarise the findings for alternative mortality projections, types of agent—see appendix B for details—and macroeconomic settings.

Figure 7 compares the PVR by cohort for male white-collar workers retiring at age 67 computed using our mortality forecasts (see Figure 4, scenario B_{2011}) with the corresponding values computed exploiting the probabilistic mortality projections for Italy implemented by the United Nations—percentiles 50, 80 and 20 (see the section “Projected cohort mortality tables”).⁵⁶ The PVR computed using our life tables is 1–6 percentage points lower than that computed with the UN tables—median.⁵⁷ Projection uncertainty has a small impact on the

⁵⁶ The whole set of results based on the UN life tables is available from the authors upon request.

⁵⁷ These differences are not large. Consider that the UN longitudinal projections are more optimistic than ours with respect to the future evolution of life expectancy, especially at older ages. For instance, according to our tables, e_{65} for males born in 1960 is equal to 22.1 years; the corresponding value according to the UN tables—median is equal to 24 years. Notice that these differences are not at odds with what reported in Figure 1, which refers to cross-sectional e_0 .

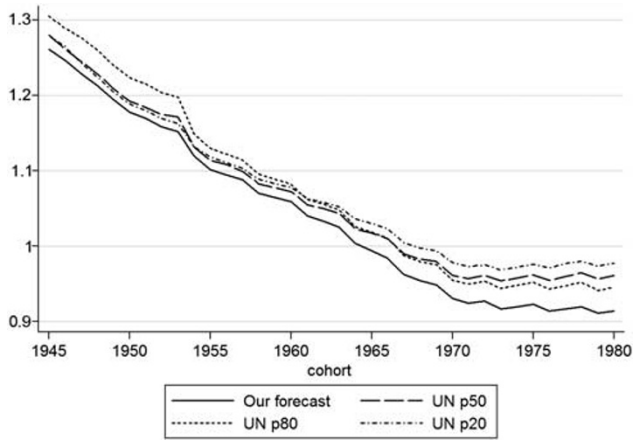


Figure 7. PVR by cohort: male white-collar workers, alternative mortality forecasts.
 Note: scenario B_{2011} ; retirement at age 67; $UN\ p50$, $UN\ p80$, $UN\ p20$: United Nations probabilistic projections—percentiles 50, 80 and 20; $g_f=0.015$, $r=0.02$.

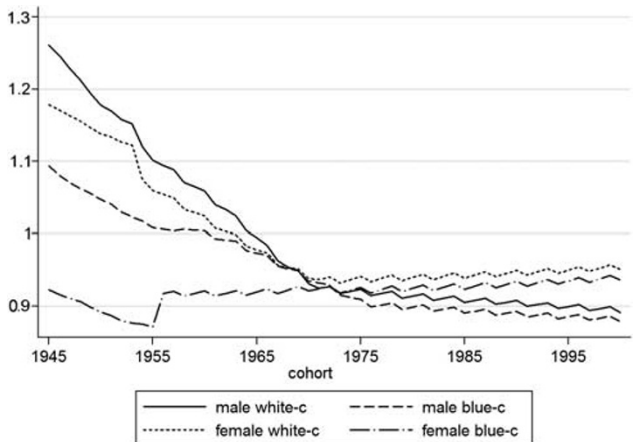


Figure 8. PVR by cohort at age 67: current legislation, different agents.
 Note: scenario B_{2011} ; $g_f=0.015$, $r=0.02$.

PVR: for most of the cohorts, the difference in the PVR, UN percentiles 80 vs 20, is lower than 4 percentage points; the maximum difference is equal to 6 percentage points, cohort 1980. This is an important finding, since our mortality projections are deterministic.

Our simplified within-cohort analysis largely confirms previous results from microsimulation models.⁵⁸ Figure 8 compares the PVR by cohort at age 67 for male, females, blue- and

⁵⁸ See Marano *et al.* (2012); Borella and Coda Mascarola (2006).

Table 3 Sensitivity analysis with respect to g_f and r : descriptive statistics

	B_{2011}		B_{1995}		AB	
	PVR	TAX	PVR	TAX	PVR	TAX
<i>Cohort 1945 (DB)</i>						
Mean	119.8	59.8	111.2	88.7	119.4	60.7
Sd	19.4	3.5	18.1	1.5	19.3	3.4
Percentile 25	103.3	57.3	95.8	87.6	103.0	58.2
Percentile 50	115.7	59.8	107.4	89.0	115.4	60.7
Percentile 75	133.3	62.4	123.9	90.0	133.0	63.2
<i>Cohort 2000 (NDC)</i>						
Mean	78.4	9.3	80.5	7.7	74.7	12.8
Sd	14.6	5.6	14.9	5.8	14.1	5.1
Percentile 25	66.7	4.8	68.7	3.0	63.1	8.6
Percentile 50	79.2	8.8	81.4	7.3	75.5	12.4
Percentile 75	90.1	13.6	92.7	12.1	85.2	16.8

Note: Percentage points; male white-collar workers retiring at age 67; $r \in [0.01, 0.03]$, $g_f \in [0.005, 0.025]$, $r > g_f$.

white-collar workers. In the DB-PR scheme, the highest PVR is found for white-collar workers (steeper age–wage profiles), whereas the lowest is found for blue-collar workers (flatter profiles). This result is attributed to the DB pension formula, which only accounts for the last wages before retirement. Since individuals with steeper age–wage profiles are typically also the richer, the DB system is known to redistribute resources in a “perverse” way.⁵⁹ In the DC scheme, the highest PVR is found for (longer-living) female workers.¹⁷

The heterogeneous effects of the normative changes implemented in 2011 are worth mentioning. Previous studies report $PVR > 1$ for almost all workers in the DB scheme retiring at younger (pre-2011) retirement ages.⁶⁰ Figure 8 shows instead $PVR < 1$ for older cohorts of female blue-collar workers. More generally, our computations highlight that the DB-PR scheme is less than actuarially fair ($PVR < 1$, see Table B1) for workers who retire at later ages and whose age–wage profiles is approximately flat.

Finally, we run a robustness check of main findings with respect to alternative macroeconomic conditions: we draw vectors $[g_f, r]$ from a bivariate continuous uniform distribution— $g_f \in [0.005, 0.025]$, $r \in [0.01, 0.03]$ —and recompute PVR and TAX accordingly. The qualitative effect of the two macroeconomic variables on the indicators can be determined *a priori*: $\partial PVR / \partial r < 0$, $\partial PVR / \partial g_f \geq 0$, $\partial TAX / \partial r > 0$, $\partial TAX / \partial g_f \leq 0$.⁶¹ Table 3 reports summary statistics of this exercise for male white-collar workers retiring at age 67, cohorts 1945 (DB) and 2000 (DC), alternative scenarios (B_{2011} , B_{1995} , AB). The median PVR (TAX) are lower (higher) than in the base case, since in most drawn vectors $r - g_f > 0.5$ per cent. The interquartile range is quite

⁵⁹ Coda Moscarola and Fornero (2009).

⁶⁰ See e.g. Borella and Coda Moscarola (2006).

⁶¹ $\partial PVR / \partial r < 0$: both PVB+PVW and PVC (see equation 8) decrease if r increases, but the impact on the former is stronger than on the latter; $\partial PVR / \partial g_f \geq 0$: if g_f increases PVB+PVW increases due to an increase in $P(\cdot)$ in the DC scheme; $\partial TAX / \partial r > 0$: r is the opportunity-cost to stay at work; $\partial TAX / \partial g_f \leq 0$: g_f is the opportunity-cost to retire in the DC scheme.

small for the TAX (e.g. $62.4 - 57.3 = 5.1$ percentage points, 1945 cohort, scenario B_{2011}). In the DC scheme, $PVR < 1$ and $TAX > 0$ in almost all the cases. Qualitatively, the results found for the base macroeconomic setting remain valid for a wide range of macroeconomic conditions. A noticeable exception occurs however for the $PVR = 1945$ cohort scenario B_{1995} , which is lower than one in more than 25 per cent of the cases.

Conclusions

This study analyses the actuarial characteristics of the Italian pension system throughout its transition from DB to NDC rules, taking into account expected increasing longevity. Computations rely on ad hoc projected cohort mortality tables based on a limit survival scenario depicted by demographic experts.

Most workers retiring in the coming years, whose pension is partly computed according to the DB rules, will receive more-than-actuarially fair pensions. However, the generosity of the pension system has been significantly reduced for them by a recent reform which tightened eligibility requirements for early retirement. As a consequence of these normative changes, those workers who retire at later ages and whose age–wage profiles is approximately flat will receive less-than-actuarially fair benefits. Disability benefits remain (extremely) generous when claimed before age (57) 60.

Steady-state NDC pensions, due to dynamic efficiency, are less than actuarially fair (at margin). They further deviate from actuarial fairness due to the specific rules adopted by the Italian law to handle expected increasing and heterogeneous longevity: pensions computation disregards cohort effects in mortality and benefits of retirees are kept unchanged regardless of longevity changes occurred during retirement. Periodical revisions of the pension formula, implemented to counteract increased longevity, generate sizeable redistribution between cohorts as well as strong financial incentives to retire in the year preceding each revision. The use of unisex pension rules favors longer-living females and penalise males.

Cohort mortality projections should be used to handle longevity increases in NDC schemes. This would avoid actuarial shortcomings and related cohort redistribution stemming from alternative procedures based on historical mortality, such as the one implemented in Italy.

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Appendix A

Forecasted conversion coefficients

Table A1 Legislated and forecasted conversion coefficients (percentage points) by retirement age and year: current legislation

Age	<i>Retirement year (life tables)</i>					
	<i>1995–09</i>	<i>2010–12</i>	<i>2019–21</i>	<i>2028–30</i>	<i>2040–42</i>	<i>2049–51</i>
	<i>(ISTAT90)</i>	<i>(ISTAT02)</i>	<i>(2018)</i>	<i>(2027)</i>	<i>(2039)</i>	<i>(2048)</i>
57	4.720	4.419	4.169	4.029	3.866	3.758
58	4.860	4.538	4.276	4.128	3.956	3.843
59	5.006	4.664	4.390	4.234	4.052	3.932
60	5.163	4.798	4.511	4.345	4.153	4.027
61	5.334	4.940	4.640	4.464	4.261	4.127
62	5.514	5.093	4.777	4.590	4.375	4.233
63	5.706	5.257	4.922	4.724	4.496	4.346
64	5.911	5.432	5.077	4.867	4.625	4.466
65	6.136	5.620	5.244	5.020	4.762	4.594
66	—	—	5.422	5.183	4.909	4.787
67	—	—	5.613	5.358	5.066	4.937
68	—	—	5.818	5.546	5.235	5.032
69	—	—	6.040	5.749	5.417	5.200
70	—	—	6.278	5.964	5.612	5.381

Note: First two columns show coefficients applied respectively to the retirement periods 1995–2009 and 2010–12 (Law No. 335/95 and Law No. 247/07); following columns show forecasted conversion coefficients for selected retirement years (retirement ages 57–62 are displayed for comparison with first column); coefficients are computed using forecasted cross-sectional life tables for the year indicated in italics at the top of each column.

Table A2 Forecasted conversion coefficients (percentage points) by retirement age and gender—selected cohort: AB scenario

Age	Cohort					
	Males			Females		
	1950	1970	1990	1950	1970	1990
57	4.044	3.769	3.557	3.925	3.627	3.375
58	4.140	3.851	3.629	4.014	3.701	3.437
59	4.240	3.939	3.706	4.108	3.779	3.503
60	4.347	4.031	3.787	4.208	3.862	3.571
61	4.459	4.128	3.872	4.313	3.949	3.643
62	4.578	4.231	3.961	4.425	4.041	3.719
63	4.704	4.339	4.056	4.543	4.137	3.800
64	4.837	4.454	4.156	4.668	4.240	3.884
65	4.978	4.575	4.262	4.802	4.348	3.973
66	5.129	4.705	4.374	4.943	4.464	4.068
67	5.290	4.842	4.494	5.094	4.586	4.169
68	5.462	4.989	4.621	5.256	4.717	4.276
69	5.647	5.146	4.757	5.429	4.857	4.390
70	5.845	5.315	4.902	5.613	5.006	4.511

Table A3 Forecasted conversion coefficients: percentage deviation between current legislation (Table A1) and AB scenario (Table A2)

Age	Retirement year									
	Males					Females				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
57	10.5	8.1	7.9	6.6	6.5	14.1	12.0	12.3	11.7	12.5
58	10.5	8.1	7.9	6.6	6.5	14.1	12.0	12.4	11.8	12.6
59	10.4	8.0	7.8	6.5	6.7	14.1	12.1	12.5	11.8	12.7
60	10.4	8.0	7.8	6.4	6.3	14.0	12.1	12.5	11.9	12.8
61	10.3	7.9	7.8	6.4	6.3	14.1	12.1	12.6	11.9	12.8
62	10.3	7.9	7.7	6.3	6.2	14.1	12.2	12.6	12.0	12.9
63	10.2	7.8	7.7	6.2	6.1	14.1	12.2	12.7	12.0	12.9
64	10.2	7.8	7.6	6.1	6.1	14.1	12.2	12.7	12.0	13.0
65	10.2	7.7	7.6	6.1	6.0	14.1	12.2	12.8	12.0	13.0
66	—	7.7	7.5	6.0	7.2	—	12.2	12.8	12.1	14.5
67	—	7.6	7.5	5.9	7.2	—	12.2	12.8	12.1	14.6
68	—	7.6	7.4	5.8	5.7	—	12.1	12.8	12.1	13.2
69	—	7.5	7.4	5.7	5.7	—	12.1	12.8	12.1	13.2
70	—	7.4	7.2	5.6	5.6	—	11.9	12.8	12.1	13.3

Appendix B

Table B1 PVR by selected cohort and retirement age—alternative normative scenarios and types of worker

Cohort/Scheme		Retirement age					
		55	57	60	63	65	67
		<i>Male white-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	117.0
1950	DB/DB-PR	—	—	—	133.5	122.0	108.7
1955	PR	—	143.9	126.6	121.4	113.3	110.9
1960	PR	149.3	133.2	114.0	110.7	109.1	108.0
1965	PR	130.3	116.6	105.5	104.5	100.1	99.8
1970	PR	118.6	106.4	94.1	94.7	95.3	96.1
1975	DC	113.4	101.8	93.7	94.7	91.6	92.3
1980	DC	114.9	103.2	91.5	92.3	93.0	93.8
1985	DC	112.4	101.0	92.7	93.6	90.7	91.2
1990	DC	113.7	102.2	90.8	91.4	92.0	92.6
1995	DC	111.5	100.3	91.9	92.7	89.8	90.2
2000	DC	112.7	101.4	90.1	90.6	91.0	91.4
		<i>Late male white-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	119.9
1950	PR	—	—	—	121.8	118.3	115.7
1955	PR	—	136.5	119.8	115.9	108.3	106.5
1960	PR	141.5	125.4	106.5	104.6	103.8	103.5
1965	PR	122.4	108.7	98.5	99.0	95.1	95.6
1970	PR	118.8	105.8	92.7	93.7	94.5	95.4
1975	DC	116.1	103.4	94.2	95.2	91.9	92.6
1980	DC	117.6	104.8	92.0	92.8	93.4	94.1
1985	DC	115.1	102.6	93.3	94.1	91.1	91.7
1990	DC	116.4	103.9	91.3	91.9	92.4	93.0
1995	DC	114.2	101.9	92.5	93.2	90.3	90.7
2000	DC	115.4	103.1	90.7	91.1	91.5	91.9
		<i>Male blue-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	92.8
1950	DB/DB-PR	—	—	—	113.7	100.8	89.5
1955	DB/DB-PR	—	156.1	131.1	109.9	97.7	86.9
1960	PR	143.4	128.7	110.9	106.4	104.0	102.2
1965	PR	129.2	116.5	105.9	103.5	98.7	97.7
1970	PR	120.4	109.0	97.4	96.6	96.3	96.2
1975	DC	108.5	98.6	92.5	93.5	90.2	90.9
1980	DC	109.8	99.8	90.2	90.9	91.5	92.2
1985	DC	107.4	97.7	91.4	92.2	89.2	89.7
1990	DC	108.6	98.9	89.5	90.1	90.5	91.1
1995	DC	106.5	97.0	90.6	91.3	88.5	88.8
2000	DC	107.6	98.1	88.9	89.3	89.7	90.1

Table B1 (continued)

Scenario: *B*₁₉₉₅

Cohort/Scheme		Retirement age					
		55	57	60	63	65	67
		<i>Female white-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	109.6
1950	DB/DB-PR	—	—	—	131.1	119.7	106.4
1955	PR	—	139.9	123.2	117.8	109.7	106.6
1960	PR	144.8	129.9	111.5	108.0	106.0	104.4
1965	PR	128.2	115.3	104.6	103.4	98.9	98.2
1970	PR	119.2	107.4	95.3	95.9	96.3	96.9
1975	DC	114.6	103.4	95.7	96.8	93.5	94.1
1980	DC	116.5	105.3	94.0	94.9	95.6	96.4
1985	DC	114.4	103.5	95.7	96.9	93.9	94.6
1990	DC	116.2	105.2	94.2	95.3	96.0	96.9
1995	DC	114.4	103.7	96.0	97.2	94.6	95.3
2000	DC	116.3	105.5	94.8	95.9	96.7	97.6
		<i>Female blue-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	81.8
1950	DB/DB-PR	—	—	—	104.6	91.4	79.7
1955	DB/DB-PR	—	142.2	117.6	102.0	89.5	78.4
1960	PR	133.4	119.2	102.3	98.1	95.8	93.8
1965	PR	122.0	109.9	100.1	98.1	93.4	92.3
1970	PR	117.0	106.2	95.3	95.0	94.9	94.9
1975	DC	110.4	100.5	94.5	95.5	92.1	92.5
1980	DC	112.2	102.3	92.9	93.7	94.2	94.9
1985	DC	110.2	100.5	94.6	95.6	92.5	93.1
1990	DC	111.9	102.2	93.1	94.0	94.6	95.3
1995	DC	110.2	100.8	94.9	95.9	93.2	93.8
2000	DC	112.0	102.5	93.6	94.6	95.3	96.1

Scenario: *B*₂₀₁₁

Cohort/scheme		Retirement age					
		55	57	60	63	65	67
		<i>Male white-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	126.1
1950	DB/DB-PR	—	—	—	133.0	124.9	117.8
1955	PR	—	143.9	124.3	117.8	113.7	110.2
1960	PR	146.1	129.3	114.3	110.0	107.2	105.9
1965	PR	130.7	115.9	103.7	101.4	100.9	99.4
1970	PR	116.5	104.5	94.8	94.3	93.6	93.1
1975	DC	114.2	101.4	92.2	92.0	91.6	92.3
1980	DC	113.3	100.7	91.5	91.3	91.8	91.4
1985	DC	112.4	101.0	91.8	91.5	91.0	90.5
1990	DC	112.6	100.3	91.1	90.8	90.3	90.7
1995	DC	111.8	99.7	90.5	90.1	90.5	89.9
2000	DC	111.1	99.9	90.7	90.3	89.7	89.1

Table B1 (continued)

Cohort/scheme		Retirement age					
		55	57	60	63	65	67
		<i>Late male white-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	120.3
1950	PR	—	—	—	119.5	115.7	111.6
1955	PR	—	136.5	117.3	112.0	108.6	105.8
1960	PR	138.1	121.2	106.9	103.9	101.8	101.3
1965	PR	122.8	108.0	96.6	95.7	96.0	95.2
1970	PR	116.5	103.7	93.5	93.3	92.8	92.3
1975	DC	116.9	103.0	92.7	92.5	91.9	92.6
1980	DC	115.9	102.3	92.0	91.7	92.2	91.7
1985	DC	115.1	102.6	92.3	92.0	91.4	90.9
1990	DC	115.3	101.9	91.6	91.3	90.7	91.2
1995	DC	114.5	101.3	91.0	90.6	91.0	90.4
2000	DC	113.7	101.6	91.3	90.8	90.2	89.5
		<i>Male blue-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	109.4
1950	DB/DB-PR	—	—	—	121.3	112.5	104.7
1955	DB/DB-PR	—	151.9	128.0	114.9	107.4	100.8
1960	PR	140.8	125.4	111.2	105.8	102.4	100.4
1965	PR	129.6	115.9	104.3	100.8	99.4	97.3
1970	PR	118.5	107.3	98.0	96.2	94.8	93.5
1975	DC	109.3	98.3	91.1	90.8	90.2	90.9
1980	DC	108.2	97.4	90.2	89.9	90.4	89.8
1985	DC	107.4	97.7	90.5	90.1	89.6	89.0
1990	DC	107.6	97.0	89.8	89.4	88.8	89.3
1995	DC	106.8	96.4	89.2	88.8	89.1	88.5
2000	DC	106.0	96.6	89.4	89.0	88.4	87.8
		<i>Female white-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	117.9
1950	DB/DB-PR	—	—	—	130.2	121.7	113.8
1955	PR	—	139.9	121.0	114.4	110.0	105.9
1960	PR	141.8	126.2	111.8	107.3	104.2	102.4
1965	PR	128.6	114.6	102.8	100.4	99.6	97.8
1970	PR	117.0	105.4	96.1	95.5	94.7	93.8
1975	DC	115.4	103.1	94.3	94.1	93.5	94.1
1980	DC	114.9	102.7	94.0	93.8	94.5	94.0
1985	DC	114.4	103.5	94.7	94.7	94.3	93.9
1990	DC	115.1	103.2	94.6	94.6	94.2	95.0
1995	DC	114.8	103.1	94.5	94.5	95.3	95.0
2000	DC	114.6	103.9	95.3	95.5	95.3	95.1

Table B1 (continued)

Scenario: *B*₂₀₁₁

Cohort/scheme		Retirement age					
		55	57	60	63	65	67
<i>Female blue-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	92.2
1950	DB/DB-PR	—	—	—	106.2	97.2	89.1
1955	DB/DB-PR	—	138.1	114.4	101.4	93.9	87.1
1960	PR	130.7	116.0	102.6	97.5	94.2	92.1
1965	PR	122.4	109.2	98.5	95.3	94.1	91.9
1970	PR	115.0	104.4	96.0	94.6	93.4	92.1
1975	DC	111.2	100.1	93.1	92.7	92.1	92.5
1980	DC	110.7	99.9	92.9	92.6	93.1	92.5
1985	DC	110.2	100.5	93.6	93.4	92.9	92.3
1990	DC	110.8	100.3	93.4	93.3	92.8	93.4
1995	DC	110.5	100.2	93.3	93.3	93.9	93.5
2000	DC	110.3	101.0	94.2	94.3	93.9	93.6

Scenario: *AB*

Cohort/scheme		Retirement age					
		55	57	60	63	65	67
<i>Male white-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	125.8
1950	DB/DB-PR	—	—	—	132.6	124.0	116.5
1955	PR	—	136.7	119.2	112.6	108.8	105.7
1960	PR	138.0	123.1	108.9	104.6	102.2	100.3
1965	PR	122.4	109.4	98.1	96.0	94.9	93.9
1970	PR	108.1	96.9	88.2	87.9	87.9	87.9
1975	DC	105.2	94.4	86.1	86.2	86.3	86.5
1980	DC	105.0	94.3	86.0	86.0	86.1	86.2
1985	DC	104.8	94.2	85.8	85.8	85.9	85.9
1990	DC	104.6	94.1	85.7	85.7	85.7	85.7
1995	DC	104.4	93.9	85.5	85.5	85.4	85.4
2000	DC	104.2	93.8	85.3	85.2	85.1	85.1
<i>Late male white-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	119.9
1950	PR	—	—	—	115.3	110.8	107.0
1955	PR	—	128.6	111.8	106.4	103.4	101.0
1960	PR	129.2	114.4	101.0	98.1	96.6	95.3
1965	PR	113.6	101.0	90.6	89.9	89.6	89.4
1970	PR	107.8	96.0	86.7	86.8	86.9	87.1
1975	DC	107.7	95.9	86.6	86.6	86.7	86.8
1980	DC	107.5	95.8	86.4	86.4	86.5	86.6
1985	DC	107.3	95.7	86.3	86.3	86.3	86.3
1990	DC	107.1	95.6	86.2	86.1	86.1	86.1
1995	DC	106.9	95.5	86.0	86.0	85.9	85.8
2000	DC	106.8	95.4	85.9	85.7	85.6	85.5

Table B1 (continued)

Cohort/scheme		Retirement age					
		55	57	60	63	65	67
<i>Male blue-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	109.1
1950	DB/DB-PR	—	—	—	121.0	111.8	103.8
1955	DB/DB-PR	—	150.8	127.2	113.7	106.0	99.4
1960	PR	133.9	120.1	106.5	101.1	98.1	95.5
1965	PR	122.4	110.3	99.4	96.0	94.1	92.4
1970	PR	111.0	100.5	92.0	90.4	89.5	88.7
1975	DC	100.7	91.5	85.1	85.1	85.1	85.2
1980	DC	100.3	91.2	84.8	84.8	84.7	84.8
1985	DC	100.1	91.1	84.6	84.5	84.5	84.5
1990	DC	99.9	91.0	84.4	84.4	84.3	84.3
1995	DC	99.7	90.8	84.3	84.2	84.1	84.1
2000	DC	99.5	90.7	84.1	84.0	83.9	83.8
<i>Female white-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	117.5
1950	DB/DB-PR	—	—	—	129.6	120.5	112.2
1955	PR	—	131.1	114.3	107.3	103.1	99.2
1960	PR	131.3	117.8	104.1	99.4	96.6	93.9
1965	PR	117.2	105.3	94.4	91.8	90.2	88.7
1970	PR	104.7	94.3	85.7	85.0	84.5	84.0
1975	DC	102.1	92.1	84.0	83.7	83.4	83.2
1980	DC	101.9	92.0	84.0	83.7	83.5	83.2
1985	DC	101.7	92.0	83.9	83.6	83.4	83.2
1990	DC	101.5	91.9	83.9	83.6	83.4	83.2
1995	DC	101.2	91.8	83.8	83.5	83.3	83.1
2000	DC	101.0	91.6	83.7	83.4	83.3	83.1
<i>Female blue-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	92.0
1950	DB/DB-PR	—	—	—	105.8	96.3	87.9
1955	DB/DB-PR	—	136.7	113.4	99.7	91.9	84.9
1960	PR	121.5	108.6	95.7	90.5	87.4	84.5
1965	PR	112.1	100.9	90.7	87.5	85.5	83.6
1970	PR	103.8	94.1	86.3	84.8	83.9	82.9
1975	DC	98.3	89.5	83.0	82.5	82.2	81.8
1980	DC	98.2	89.5	83.0	82.6	82.2	81.9
1985	DC	97.9	89.3	82.9	82.5	82.2	81.8
1990	DC	97.7	89.3	82.9	82.5	82.2	81.8
1995	DC	97.5	89.2	82.8	82.4	82.1	81.8
2000	DC	97.3	89.0	82.7	82.3	82.0	81.8

Notes: percentage points; in italics: only if eligible for disability; —: retirement year is <2012; scenario: B_{2011} : current pension rules; B_{1995} : 1995 pension rules; AB: quasi-actuarial benchmark; scheme: DB=defined benefit, DB-PR=extended pro-rata, PR=pro-rata, DC=notional defined contribution; $g=0.015$, $r=0.02$.

Table B2 TAX by selected cohort and retirement age—alternative normative scenarios and types of worker

<i>Cohort/scheme</i>		<i>Retirement age</i>					
		55	57	60	63	65	67
<i>Scenario: B₁₉₉₅</i>							
<i>Male white-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	88.2
1950	DB/DB-PR	—	—	—	50.2	88.5	88.7
1955	PR	—	55.6	19.5	20.2	25.1	25.5
1960	PR	72.4	48.6	16.8	16.9	17.1	17.4
1965	PR	67.9	43.7	9.2	9.2	12.5	13.3
1970	PR	64.9	37.0	4.9	5.2	5.3	5.5
1975	DC	63.0	36.5	2.6	2.6	5.6	5.8
1980	DC	62.8	35.9	3.9	4.0	4.0	4.1
1985	DC	61.7	36.4	2.8	2.7	5.4	5.4
1990	DC	61.5	35.9	4.0	4.0	3.9	3.8
1995	DC	60.5	36.4	2.9	2.7	5.0	5.0
2000	DC	60.3	35.9	4.0	3.8	3.7	3.5
<i>Late male white-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	54.9
1950	PR	—	—	—	23.3	23.2	23.2
1955	PR	—	50.6	14.7	15.0	19.9	20.3
1960	PR	67.2	43.8	11.7	11.9	12.1	12.3
1965	PR	63.0	38.7	4.5	4.5	7.9	8.2
1970	PR	61.7	35.8	3.6	3.8	3.9	4.0
1975	DC	60.6	36.3	2.4	2.3	5.2	5.4
1980	DC	60.4	35.7	3.7	3.7	3.8	3.8
1985	DC	59.4	36.3	2.6	2.4	5.0	5.1
1990	DC	59.2	35.8	3.8	3.7	3.7	3.6
1995	DC	58.3	36.2	2.8	2.5	4.7	4.7
2000	DC	58.1	35.8	3.7	3.6	3.5	3.3
<i>Male blue-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	111.9
1950	DB/DB-PR	—	—	—	111.2	111.5	112.0
1955	DB/DB-PR	—	108.6	110.4	111.3	111.6	112.1
1960	PR	90.0	65.0	30.6	31.4	32.1	32.9
1965	PR	83.8	56.8	20.3	20.9	24.9	25.8
1970	PR	79.3	47.1	13.0	13.8	14.3	14.9
1975	DC	73.9	39.8	3.5	3.8	7.7	8.3
1980	DC	73.7	39.0	5.0	5.4	5.7	6.0
1985	DC	72.2	39.7	3.6	3.8	7.2	7.6
1990	DC	72.0	39.0	5.0	5.3	5.4	5.6
1995	DC	70.6	39.6	3.8	3.7	6.9	7.1
2000	DC	70.4	39.0	5.0	5.2	5.2	5.2

Table B2 (continued)Scenario: *B*₁₉₉₅

Cohort/scheme		Retirement age					
		55	57	60	63	65	67
		<i>Female white-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	94.7
1950	DB/DB-PR	—	—	—	48.5	92.8	94.2
1955	PR	—	54.6	19.1	18.7	24.1	24.7
1960	PR	69.9	47.8	15.0	15.1	15.2	15.3
1965	PR	67.3	42.8	6.9	6.5	9.8	9.7
1970	PR	65.7	36.0	1.9	1.4	1.0	0.5
1975	DC	63.9	35.3	-1.0	-1.9	0.9	0.5
1980	DC	63.6	34.5	0.2	-0.6	-1.3	-2.1
1985	DC	62.4	35.0	-1.4	-2.6	-0.1	-0.9
1990	DC	62.0	34.2	-0.4	-1.4	-2.3	-3.4
1995	DC	60.9	34.6	-2.0	-3.4	-1.3	-2.3
2000	DC	60.6	33.8	-1.1	-2.4	-3.5	-4.8
		<i>Female blue-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	123.0
1950	DB/DB-PR	—	—	—	123.6	123.6	123.5
1955	DB/DB-PR	—	116.4	70.4	124.1	124.1	124.0
1960	PR	92.9	65.2	28.4	28.4	28.5	28.5
1965	PR	86.0	55.4	16.2	15.8	19.7	19.8
1970	PR	81.1	43.8	7.0	6.9	6.7	6.3
1975	DC	77.0	38.7	-0.9	-1.8	1.8	1.4
1980	DC	76.8	37.6	0.5	-0.3	-1.0	-1.9
1985	DC	75.1	38.3	-1.5	-2.8	0.3	-0.6
1990	DC	74.8	37.3	-0.3	-1.4	-2.5	-3.8
1995	DC	73.3	37.8	-2.2	-3.8	-1.3	-2.6
2000	DC	72.9	36.8	-1.2	-2.7	-4.1	-5.8

Scenario: *B*₂₀₁₁

Cohort/scheme		Retirement age					
		55	57	60	63	65	67
		<i>Male white-collar</i>					
1945	DB/DB-PR	—	—	—	—	—	57.6
1950	DB/DB-PR	—	—	—	49.2	52.6	50.6
1955	PR	—	79.0	31.3	35.5	24.8	26.1
1960	PR	82.4	49.5	16.5	17.5	18.7	35.2
1965	PR	68.0	43.9	10.6	11.6	27.7	13.6
1970	PR	64.3	50.0	17.8	20.8	6.6	7.8
1975	DC	75.5	36.6	3.6	4.6	5.6	23.4
1980	DC	62.4	36.7	3.9	4.8	20.4	5.9
1985	DC	61.7	47.4	15.3	17.8	5.1	6.0
1990	DC	71.9	36.5	3.8	4.5	5.2	20.7
1995	DC	60.6	36.6	4.0	4.6	18.2	5.2
2000	DC	59.9	46.1	14.0	16.0	4.6	5.2

Table B2 (continued)

Cohort/scheme		Retirement age					
		55	57	60	63	65	67
<i>Scenario: B₂₀₁₁</i>							
<i>Late male white-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	52.2
1950	PR	—	—	—	25.6	37.3	27.1
1955	PR	—	74.0	26.5	30.3	19.6	20.9
1960	PR	77.2	44.7	11.5	12.5	13.6	30.2
1965	PR	63.1	38.9	5.9	6.9	23.1	8.5
1970	PR	61.2	47.9	15.6	18.4	5.1	6.3
1975	DC	72.1	36.4	3.4	4.3	5.2	21.8
1980	DC	60.1	36.5	3.7	4.5	18.9	5.6
1985	DC	59.4	46.3	14.1	16.5	4.8	5.6
1990	DC	68.7	36.3	3.5	4.2	4.9	19.3
1995	DC	58.3	36.4	3.8	4.3	16.9	4.9
2000	DC	57.8	45.0	13.0	14.8	4.3	4.9
<i>Male blue-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	90.4
1950	DB/DB-PR	—	—	—	78.3	81.6	79.9
1955	DB/DB-PR	—	108.0	70.4	73.6	70.3	71.7
1960	PR	100.8	66.0	30.3	32.1	33.8	54.9
1965	PR	83.9	57.0	21.8	23.5	44.2	26.2
1970	PR	78.6	62.5	28.9	33.6	15.8	17.6
1975	DC	90.0	39.9	4.7	6.2	7.7	33.7
1980	DC	73.2	40.0	5.0	6.4	28.7	8.3
1985	DC	72.2	54.0	20.6	24.6	6.9	8.3
1990	DC	85.3	39.8	4.8	5.9	7.0	29.9
1995	DC	70.7	39.9	5.0	6.1	25.9	7.5
2000	DC	69.9	52.3	18.9	22.5	6.5	7.6
<i>Female white-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	63.1
1950	DB/DB-PR	—	—	—	50.5	55.0	53.8
1955	PR	—	79.0	31.6	35.2	23.8	25.3
1960	PR	80.4	48.9	14.7	15.8	16.9	35.4
1965	PR	67.4	43.0	8.4	9.2	27.1	10.1
1970	PR	65.2	50.5	16.5	19.5	2.4	3.2
1975	DC	77.8	35.4	0.1	0.4	0.9	21.4
1980	DC	63.2	35.4	0.2	0.3	18.1	0.1
1985	DC	62.4	47.4	13.1	15.3	-0.5	-0.2
1990	DC	73.7	34.9	-0.6	-0.9	-0.7	17.3
1995	DC	61.0	34.9	-0.7	-1.0	14.7	-2.0
2000	DC	60.2	45.5	10.8	12.5	-2.2	-2.4

Table B2 (continued)Scenario: B₂₀₁₁

Cohort/scheme		Retirement age					
		55	57	60	63	65	67
<i>Female blue-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	97.5
1950	DB/DB-PR	—	—	—	85.1	88.0	85.4
1955	DB/DB-PR	—	116.4	76.4	79.0	74.8	75.5
1960	PR	104.7	66.3	28.1	29.1	30.4	54.1
1965	PR	86.1	55.7	17.8	18.8	42.3	20.2
1970	PR	80.3	61.6	25.8	30.5	8.4	9.6
1975	DC	94.8	38.8	0.5	1.0	1.8	31.7
1980	DC	76.2	38.8	0.5	0.8	26.3	0.9
1985	DC	75.1	54.5	18.2	21.8	-0.1	0.3
1990	DC	89.7	38.2	-0.6	-0.7	-0.5	25.8
1995	DC	73.4	38.1	-0.7	-1.0	21.6	-2.1
2000	DC	72.4	52.1	15.1	18.0	-2.5	-2.8

Scenario: AB

Cohort/scheme		Retirement age					
		55	57	60	63	65	67
<i>Male white-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	58.5
1950	DB/DB-PR	—	—	—	52.1	53.2	54.1
1955	PR	—	58.1	26.5	29.2	30.2	31.5
1960	PR	69.7	52.0	21.6	22.9	24.0	25.2
1965	PR	65.9	46.4	15.5	16.8	17.9	19.5
1970	PR	62.2	40.6	10.0	11.3	12.3	13.4
1975	DC	61.0	39.3	8.7	9.9	10.8	11.8
1980	DC	60.5	39.1	8.5	9.6	10.4	11.4
1985	DC	59.9	38.9	8.3	9.3	10.1	10.8
1990	DC	59.4	38.8	8.1	9.0	9.6	10.2
1995	DC	58.9	38.7	8.0	8.6	9.1	9.7
2000	DC	58.4	38.5	7.6	8.2	8.6	9.1
<i>Late male white-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	53.2
1950	PR	—	—	—	30.3	31.3	32.5
1955	PR	—	53.1	21.8	24.0	25.0	26.2
1960	PR	64.5	47.1	16.6	17.9	18.9	20.1
1965	PR	61.1	41.5	10.8	12.1	13.2	14.4
1970	PR	59.3	39.1	8.4	9.6	10.6	11.7
1975	DC	58.8	38.9	8.2	9.3	10.2	11.2
1980	DC	58.3	38.7	8.0	9.1	9.9	10.8
1985	DC	57.8	38.5	7.9	8.8	9.5	10.3
1990	DC	57.3	38.4	7.7	8.6	9.1	9.7
1995	DC	56.8	38.3	7.6	8.2	8.6	9.1
2000	DC	56.4	38.2	7.2	7.7	8.2	8.6

Table B2 (continued)

Scenario: AB

Cohort/scheme		Retirement age					
		55	57	60	63	65	67
<i>Male blue-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	91.3
1950	DB/DB-PR	—	—	—	81.2	82.2	83.5
1955	DB/DB-PR	—	<i>103.4</i>	<i>71.4</i>	73.0	74.1	75.5
1960	PR	86.6	68.5	35.8	38.0	39.8	41.7
1965	PR	81.4	59.7	27.2	29.4	31.2	33.1
1970	PR	75.9	51.0	18.7	20.8	22.5	24.4
1975	DC	71.2	43.2	10.8	12.7	14.3	16.0
1980	DC	70.4	43.0	10.5	12.2	13.7	15.3
1985	DC	69.7	42.8	10.2	11.8	13.2	14.6
1990	DC	69.1	42.6	10.0	11.5	12.7	14.1
1995	DC	68.4	42.4	9.8	11.2	12.3	13.5
2000	DC	67.8	42.3	9.6	10.9	12.0	13.1
<i>Female white-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	65.3
1950	DB/DB-PR	—	—	—	54.7	57.0	58.9
1955	PR	—	57.8	28.3	30.2	31.7	33.4
1960	PR	66.6	52.3	22.3	24.0	25.2	26.7
1965	PR	64.5	47.0	16.3	17.7	18.9	20.1
1970	PR	62.0	41.5	10.5	11.7	12.6	13.6
1975	DC	60.8	40.2	9.2	10.2	11.0	11.9
1980	DC	60.1	40.1	9.0	9.9	10.6	11.4
1985	DC	59.4	39.9	8.8	9.6	10.3	10.9
1990	DC	58.7	39.8	8.7	9.4	10.0	10.5
1995	DC	58.0	39.7	8.6	9.2	9.7	10.2
2000	DC	57.3	39.6	8.5	9.0	9.5	9.9
<i>Female blue-collar</i>							
1945	DB/DB-PR	—	—	—	—	—	99.6
1950	DB/DB-PR	—	—	—	89.3	89.8	90.5
1955	DB/DB-PR	—	<i>111.6</i>	<i>78.7</i>	79.8	80.5	81.3
1960	PR	88.3	70.0	36.5	38.4	39.9	41.7
1965	PR	82.2	60.1	26.7	28.7	30.3	32.1
1970	PR	76.0	50.2	17.0	19.0	20.6	22.4
1975	DC	72.5	44.8	11.3	13.1	14.5	16.0
1980	DC	71.6	44.6	11.1	12.7	13.9	15.3
1985	DC	70.7	44.4	10.9	12.3	13.4	14.6
1990	DC	69.8	44.2	10.6	11.9	12.9	14.0
1995	DC	68.9	44.0	10.4	11.6	12.5	13.5
2000	DC	68.0	43.9	10.3	11.3	12.1	13.0

Notes: percentage points; in italics: only if eligible for disability; —: retirement year is <2012; scenario: B_{2011} : current pension rules; B_{1995} : 1995 pension rules; AB: quasi-actuarial benchmark; scheme: DB=defined benefit, DB-PR=extended *pro-rata*, PR=*pro-rata*, DC=notional defined contribution; $g_j=0.015$, $r=0.02$.

Appendix C

Mortality forecasts: Methodology

The first step needed for the projection consists in converting the indication of the experts on the human being limit characteristics³⁴ into an appropriate survival function. Following previous studies,⁶² we model the trend in endogenous mortality $q_{end}(x)$ by means of a Weibull model. This generates a process of mortality of an initial closed contingent of individuals of the same age according to the following survival function:

$$\ell(x) = \exp \left[- \left(\frac{x-a}{m} \right)^b \right], \quad x \geq a; a \geq 0; b, m > 0. \quad (C.1)$$

The derivative of (C.1) provides the corresponding function of deaths that corresponds to the Weibull statistical distribution

$$f(x) = \begin{cases} \frac{b}{m} \left(\frac{x-a}{m} \right)^{b-1} \exp \left[- \left(\frac{x-a}{m} \right)^b \right], & x \geq a; a \geq 0; b, m > 0, \\ 0 & \text{otherwise} \end{cases}$$

where we interpret $f(x)dx$ as the fraction of components of an initial contingent that are eliminated at age $[x, x+dx)$. Parameters a, b, m have been set consistently with the envisaged characteristics of the limit scenario, which are: $e_0=109.4$ years, life span about 125 years, minimum life equal to 70 years, median age at death equal to 109 years.⁶³ The Weibull distribution is widely used in life data analysis due to its versatility;⁶⁴ in particular the three-parameters type permits fairly effective control of important features of the survival reference scenario, such as life expectancy at birth, the Lexis point, the median age at death and also the threshold below which mortality is considered avoidable. They are all functions of the parameters in Eq. (C.1).⁶⁵ Specifically, we set $a=70, b=7.5$ and $m=45$.

We then build the limit probabilities of dying due to exogenous or accidental causes $q_{eso}(x)$, that is, accidents, traumas, etc. We first select a group of developed countries for which detailed and updated statistic on causes of death are available.⁶⁶ Focusing on accidental causes of death, we then construct an empirical function of minimum mortality by age (Nizard and Vallin, 1970): that is, for each age, we select the minimum level of mortality observed in these countries. Finally, we fit a fifth degree polynomial, which provides the analytical form of $q_{eso}(x)$, to the empirical function obtained in this way.

⁶² See e.g. Duchêne and Wunsch (1993); Maccheroni (1998).

⁶³ Reference is made to the international workshops “Human longevity, individual life duration and growth of oldest-old population”, International Union Scientific Study of Population (IUSSP), Montpellier, October 2000 (see Robine *et al.*, 2006) and “Health, ageing and work. Strategies for the new welfare society in the larger Europe”, 2nd Geneva Association Health and Ageing Conference, Trieste, October 2004. The recorded and officially confirmed longest life span is that of J. L. Calment, who died at the age of 122 (Wilmoth and Robine, 2003).

⁶⁴ See Dugan *et al.* (2005); Maccheroni (1998);

⁶⁵ Johnson and Kotz (1970).

⁶⁶ In details: Norway, Holland, Belgium, Spain, France, Finland, Italy, Great Britain, Sweden, Austria, Canada, USA, Australia, Japan, New Zealand.

Table C1 Limit life table: survivors from 100,000 live births

Age_x	ℓ_x	Age_x	ℓ_x	Age_x	ℓ_x
0	100,000	40	99,831	85	98,985
1	99,997	45	99,799	90	98,242
5	99,992	50	99,768	95	95,017
10	99,983	55	99,735	100	85,236
15	99,968	60	99,695	105	67,726
20	99,948	65	99,642	110	42,180
25	99,923	70	99,566	115	15,306
30	99,894	75	99,454	120	1,980
35	99,863	80	99,280	125	40

The limit probabilities of dying $q_{lim}(x)(x=0, 1, \dots)$ is obtained as the suitably smoothed sum of (the discrete version of) the original components $q_{end}(x)$ and $q_{eso}(x)$. The abridged limit survival function is shown in Table C1.

Forecasts are then obtained as follows:

1. By establishing a time frame for the scenario provided by $q_{lim}(x)$ in relation to the recorded Italian mortality trends. A procedure based on the logit model⁶⁷ is used: the limit survival function $\ell_{lim}(x)$ obtained from $q_{lim}(x)$ is taken as standard and, using the reconstructed and observed survival functions⁶⁸ $\ell_{x,t}(t = 1945, 1946, \dots, 1998)$, the historical series of parameters a_t and b_t of the following relationship are estimated by ordinary least squares:

$$Y_{x,t} = a_t + b_t Y_x^{lim}, \tag{C.2}$$

where Y_x^{lim} is the logit of the limit life table and $Y_{x,t}$ is the logit obtained from the observed $\ell_{x,t}$. Linear trend extrapolations are performed on the historical series of a_t and b_t in order to obtain new time sequences for parameters a_t^* and b_t^* (to establish if and when $a_t^* \rightarrow 0$ and $b_t^* \rightarrow 1$ when t diverges). In our case, these results are obtained when $t=2143$ for females and when $t=2170$ for males. On the basis of (C.2), it is then possible to obtain the sequence of projected life tables that reflect the characteristics of the limit situation in the period of time that stretches from 1999 to the two previously defined extremities of time.

2. By linking the mortality models obtained as explained above with the ongoing process of evolution of mortality. The gap between current and limit mortality is bridged by assuming a type of evolution that reflects the theory of expansion of mortality.⁶⁹ This step is carried out in two phases. In the first one, we define the evolution of mortality resulting from the most recent trends. In the age groups where the mortality trend is decreasing, the evolution of mortality is obtained by extrapolating the recent observed historical series of $q_{x,t}$ with a conventional exponential model.⁷⁰ In the groups where mortality is growing—that is, between age 25 and 35, the so-called “accident hump”—a logistic model has been

⁶⁷ See Brass (1971).

⁶⁸ Maccheroni and Locatelli (1999).

⁶⁹ Myers and Manton (1984)

⁷⁰ See Pollard (1987); Booth and Tickle (2008)

fit and extrapolated. We empirically found that extrapolating these trends after year 2050 would generate an anomalous age pattern of mortality; moreover, this pattern would be incompatible with the postulated evolution of mortality towards the limit scenario. Consequently, for these ages we envisage a stationary mortality situation starting from around year 2050. In the second phase, we synthesise the projections for each year by averaging the results of the two mortality models (the logit C.2 and the exponential model). The average assigns gradually increasing linear weights to the life tables projected obtained from the logit (C.2) and decreasing linear weights to those obtained with the exponential model. The resulting projected life tables, therefore, initially take into account recent mortality trends and gradually assume the characteristics of the limit life table.

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