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ABSTRACT

The change in economic and sociodemographic reality, characterized by a continuous increase in longevity, the consequences of the economic crisis, and the lack of adequate adjustments of social security retirement pension systems everywhere, entails risks for workers and the social security systems themselves. Many reforms of public pension systems have been carried out in recent years, based on modifying system parameters and structural changes. Some reforms aim at increasing capitalization in the determination of the final pension through a life annuity to complement the public retirement pension as a second retirement income. Against the background of the change of agents' behaviors throughout the life cycle and the presence of an adverse selection problem in the annuities market, we describe in this paper a two-step mixed pension system that tries to solve the pressure that increasing longevity is putting on pension schemes to provide adequate and sustainable pensions for all. In our two-step mixed system, when workers reach their ordinary retirement age they receive a term annuity generated by their previous capitalized savings to be replaced by a social security defined contribution (DC) pure life annuity when the so-called grand age is reached. The analysis is carried out from an individual perspective, through the internal rate of return (IRR) that workers will receive after ordinary retirement in both schemes compared with the one they would get with the same contributions in the current situation. We also analyze some possible transition strategies to the new system.

INTRODUCTION

The objective of social security systems can be defined as protecting workers against old age and related risks, with which they cannot cope individually. Globally, conventional mixed pension systems are based, at least, on a two-pillar structure with a first pillar being the conventional social security, pay-as-you-go (PAYG) scheme that provides a public retirement pension that is complemented with the second pillar being a life annuity, generated by a fully funded, employer-sponsored scheme.

In many countries, though not necessarily the United States, a third pillar based on individual savings allows workers to expect another life annuity from a fully funded pension plan (or from other savings alternatives). In the United States, by contrast, the three-pillar structure includes Social Security, a public or private defined benefit (DB) plan that typically provides a life annuity, and an employer-sponsored DC plan in which employees define their contributions to the plan but not necessarily the benefit amount nor a specific retirement-income product or strategy.

In recent years, however, fewer and fewer workers—at least in the United States—have a DB plan and there is effectively only a two-pillar pension system: Social Security and DC plans in which the individual may or may not choose to use a life annuity for all or part of their retirement-income plan. It is also common for U.S. retirees to use systematic withdrawals from their retirement accounts based on individual savings.

Ultimately, each country has its own mix of schemes in varying proportions so that the resulting replacement ratios that can be attributed to each scheme also differ. What is common to all systems everywhere is that all benefits are received during the entire retirement period in a mostly simultaneous and sometimes complementary way. We will name this type of conventional complementary system the "standard system" in our analysis.

Thus, many countries have included the complementarity of public and private pensions in their pension systems, seeking that the income social security grants to pensioners, coming from the PAYG system, be supplemented with income generated by a private defined-contribution-funded system (Herce et al. 2017).

For income security reasons, the income that complements the public system should be a life annuity similar in amount to social security benefits (Galdeano et al. 2018). This obliges the providers of the product and/or the benefit holders to be strongly exposed to longevity risk, because as life expectancy increases regularly in most countries, the value of the periodic income will be reduced, given the premium paid *ex ante* by the beneficiary. It is therefore necessary to make a relevant saving effort, a careful planning of such effort, and a sound risk assessment to adequately complement for life and the equally life-long provision of social security, from retirement age to death.

Mitchell et al. (1999) show that life annuities in the United States are between 15 and 25 percent lower, in terms of wealth obtained, than those purchased using overall population mortality tables. Finkelstein and Poterba (2000) also show that life annuities in the United Kingdom, which are taken out by sixty-five-year-old men, are between 10 percent and 15 percent lower, in terms of wealth obtained, than those purchased using ordinary overall population mortality tables. Note that the problem that occurs when adverse selection and overweighted mortality combine in the case of life annuities is reduced significantly in the case of term annuities.

We can say that this standard system suffers several problems. First, annuities entail a severe problem of adverse selection (see Blake et al. 2008; Domínguez et al. 2018; Herce and del Olmo 2013; Whitehouse and Zaidi 2008; Morales and Larraín 2017), and thus they become unduly expensive. On the other hand, the kind of longevity insurance offered by social security is unsustainable, because the system has barely changed the retirement age since its creation, when life expectancy at birth was around forty years, and around ten years at age sixty-five.

In this paper we present what we call a two-step mixed pension system, in which contributions are paid as in the standard system but benefits are received by steps: a DC term annuity from retirement until what we call grand age (the "old age" that historical social security systems fixed at inception) and a social security notional defined contribution (NDC)[1] life annuity afterward.[2] Thus, a two-step mixed pension system is based on a deferred foundation in which both benefits, obtained from the term annuity and from the notional DC annuity, never are received at the same time. In fact, benefits from personal savings start to work from the moment of retirement until the grand age, because they don't have to guard against longevity in the same way that current alternatives such as Qualified Longevity Annuity Contracts (QLAC) must. On the other hand, from the grand age moment, an annuity is paid by the social security pillar based on active workers' contributions.

The two-step pension system solves two major problems: the adverse selection problem in private pensions and the pension adequacy problem in public pensions. Social security, in particular, will continue to be PAYG-based, but it will have to pay actuarially adjusted benefits for a shorter period, thus managing more efficiently the longevity risk and reaching sustainability.

As previously noted, workers' and employers' contributions are assumed to be the same as in the standard model, while benefits since retirement are restricted to be at least as good as in the standard model. Our quest is therefore for those conditions under which retirees improve under the two-step system with respect to the standard system.

The two-step mixed pension system is based on the need to adapt pension schemes (public and private) to the longevity-induced behaviors of individuals,[3] and responds to those financial needs that workers cannot cope with individually.

DESCRIPTION OF THE TWO-STEP MIXED PENSION SYSTEM

Pension systems are structured in two main flows: During the contribution phase, individuals contribute a part of their salary until retirement age. During the retirement stage, they receive a total lifetime pension from the system, generated from retirement until death. This general scheme runs everywhere, regardless of the system, either as a pure public PAYG system, a funded system, or a mixed system.

Taking into account the demographic risks and the fact that most of the implemented reforms seek to make the system sustainable, mainly through reduction in the amount of pensions, this implies a problem of adequacy of benefits and, therefore, a strong risk of impoverishment for retired people.

The two-step system that we propose considers a period of active life, from the beginning of working life to the moment of retirement (chosen with sufficient flexibility); and a retirement period that is divided into two steps: one from ordinary retirement age to the grand age and another one from that grand age until the individual's death.

During the active stage, contributions will be paid both to a DC-funded scheme and to a reinvented NDC social security scheme. It is important to mention that, in our analysis, these levels of contributions will be the same in the two-step system as in the standard system. Thus, the annual contribution made by individuals is divided into two parts:

- A part of the contribution generates a term actuarial income that the worker will receive from the moment he or she retires to the grand age.

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- The other part of the contribution finances a pension generated by a social security scheme based on NDC accounts, consisting of a life annuity that pays a monthly income from the grand age until the individual's death.

Therefore, when people retire in the two-step mixed system, they will receive a term income, based on capitalization rules, from the retirement age they have freely chosen until the grand age, after which they will receive a retirement pension financed through an NDC account PAYG method, until death.

Grand age will be fixed by law, while ordinary retirement age can be chosen (within limits) by workers. Some workers cannot keep their jobs beyond a certain age and may be forced to retire earlier, drawing on accumulated savings for their living until they reach grand age. These savings already will be there, because they were made compulsory during standard working ages by the design of the two-step system. The fact that ordinary retirement can be chosen adds efficiency to this decision by workers until social security intervenes.

This ordering of contribution and benefit flows solves several crucial aspects of the pension arithmetic and workers' behavior, namely:

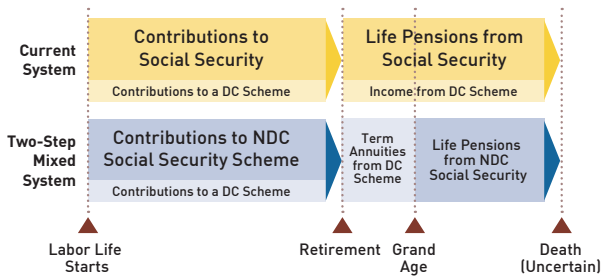
- During the first retirement step, between the ordinary retirement age and the grand age, a term annuity or retirement income based on private capitalization is paid. Because of this, each worker, duly informed and according to his or her long-term savings achieved, will be best positioned to choose the retirement age he or she wants.[4] Temporary incomes ideally will be insured through actuarial products and, because they do not cover a lifetime period (but are limited up to the grand age), longevity risk gets effectively capped and efficiently covered until grand age. Term annuities are not designed to cover ordinary longevity risk, which increases enormously after grand age and which is, clearly, more expensive to hedge, so insuring longevity to that point increases the efficiency of the plan. During retirement phase one, from ordinary retirement age to grand age, there is only a unique benefit stemming out of accumulated savings. This entails the risk of capital loss of this fund at retirement. Because benefits must be insured, annuitants also could choose to insure capital accumulation during working years, obviously at a cost for the annuitant. Failing this, other mechanisms could be imposed upon savers to protect both assets and income after retirement. Flexible retirement is also a way to protect against capital losses.
- Secondly, during phase two, which occurs between the grand age and the death event, retired people receive a retirement pension from social security, which, by definition, is structured by an annuity obtained with strict actuarial criteria. As a reminder, this pension is financed through the PAYG method and the scheme in this second step is equivalent to a public system with notional DC individual accounts, namely a NDC scheme.

This way of presenting the sequence of contributions and benefits combined in time, is what allows us to talk about the reinvention of social security (Herce and del Olmo 2013).

If this kind of radical reform were to be adopted, it would be important to warn workers and the general public that the retirement income to be received after ordinary retirement until grand age is not a social security benefit. This benefit stems out of a previous saving effort that has been imposed upon workers for decades under certain conditions. This also would prevent political manipulation of such a reform because it makes perfect information about every worker's achieved saving level available, allowing them to decide their optimal retirement age based on their own circumstances. Explaining the role that a reinvented social security plays in a two-step system and the crucial distinction between ordinary retirement age and grand age is not a trivial effort, and it would involve a significant communication effort by the government. Above all, it is crucial to be able to explain to society how expensive and tricky it is to insure against longevity when longevity turns extreme for so many.

Figure 1 compares the standard model with the two-step mixed system that we propose. It shows the contributions and benefits for each scheme in a crude illustration of the actual numbers we have assumed for the standard system. It also shows the rearrangements that contributions and benefits must undergo in order to implement the two-step idea without net losses for individuals.

Figure 1 STANDARD SYSTEM VERSUS TWO-STEP SYSTEM



Source: Authors' calculations

COMPARATIVE ANALYSIS OF THE STANDARD SYSTEM AND THE TWO-STEP SYSTEM IN TERMS OF INDIVIDUAL FINANCIAL SOLVENCY

There are two basic periods: capital accumulation, which goes from x_0 (age of access to a first job) to x_r (retirement age) and the period of decumulation, which takes place from x_r to ω.

Consider the following:

- Funded capital $C_F^{x_r}$ can be supplemented with other wealth sources—a house, for instance. Individuals decide the financial strategy depending on their previous saving decisions.
- In the two capital computations, actuarial tables haven't been used. These will be used for computing benefits after retirement age x_r .
- This analysis assumes an overlapping generations model with four periods, where steady state is defined as:
  $x_o = x_{r-1}$, $x_g = x_{r+1}$ *and* $\omega = x_{g+1}$

ACCUMULATION PERIOD

Through a mixed system structured by an NDC and by a funded pillar (FDC), with the same accumulation period for the standard system and in the two-step system. Both systems share the following information:

π_N = Contribution rate in NDC pillar.

π_F = Contribution rate in funding pillar.

$C_F^{x_r}$ = Funded capital obtained through the FDC pillar at retirement age x_r

$C_N^{x_r}$ = Notional capital obtained through the NDC at retirement age x_r

These capitals are respectively given by:

a. Notional Part (NDC):

$$C_N^{x_r} = \sum_{x=x_0}^{x_{r-1}} \pi_N \times W(x) \times \left(\prod_{y=x}^{x_{r-1}} (1+r_y)\right) \quad (1)$$

Where:
$W(x)$ = Salary at age x
r_y = Notional rate applied at age y (between y and $y + 1$)

For initial wage $W(x_0) = 1$ and r the notional rate of the NDC, β the constant inflation rate, and k the increase salary rate we have:

$$C_N^{x_r} = \pi_N \left[(1+r)^2 + (1+\beta) \times (1+k) \times (1+r)\right] \quad (2)$$

For the canonical choice (steady state) $(1+r) = (1+d) \times (1+\beta)$,

Where:
d is the rate of demographic increase.

b. Funded part (FDC):

$$C_F^{x_r} = \sum_{x=x_0}^{x_{r-1}} \pi_F \times W(x) \times \left(\prod_{y=x}^{X_{r-1}} (1+f_y)\right) \quad (3)$$

Where:
$W(x)$ = Salary at age x

f_y = Financial rate of return at age y (between y and $y + 1$)

If i is the technical interest rate of the insurer:

$$C_F^{x_r} = \pi_F \left[(1+i)^2 + (1+\beta) \times (1+k) \times (1+i)\right] \quad (4)$$

DECUMULATION PERIOD

In the standard system, each of the two capital amounts is converted into a pure life annuity, following the NDC technique or the funding insurance technique. In the two-step system, the funded capital is converted into a term annuity, which will provide retirement income between the retirement age x_r and the grand age x_g, being the notional capital deferred until age x_g and then converted into a life annuity, and a proper social security pension, between grand age x_g and death.

In relation to mortality, a few other hypotheses are needed:

1. We have not assumed mortality before retirement age.
2. We have assumed that, after retirement, p is the probability of survival from retirement age to grand age.
3. We have assumed that the mortality rate used by the insurer is given by $p^* = p \times (1 + \alpha)$ with $\alpha > 0$ and α being a safety coefficient. Loading applied by the insurer (commission) on life annuity is g.

The price of the life annuity (indexed) is then given by:

$$a_{x_r}^F = \frac{1}{1-g} \times \left[1 + \frac{p(1+\alpha)(1+\beta)}{(1+i)}\right]$$

Standard system

In the standard system, total retirement income is generated by two different life pensions, one coming from funded scheme and the other coming from the NDC Social Security scheme.

a. The funded part in the standard system:

First pension benefit at retirement age is:

$$R_F^{x_r} = \frac{C_F^{x_r}}{a_{x_r}^F}; \; R_F^{x_r} = \pi_F \times \frac{\left[(1+i)^2 + (1+\beta) \times (1+k) \times (1+i)\right]}{\frac{1}{1-g} \times \left[1 + \frac{p(1+\alpha)(1+\beta)}{(1+i)}\right]} \quad (5)$$

The next pension is computed with the following expression:

$$R_F^{x_r+1} = R_F^{x_r} \times (1+\beta) \quad (6)$$

b. The notional part in the standard system:

$$R_N^{x_r} = \pi_N \times \frac{[(1+r)^2 + (1+\beta) \times (1+k) \times (1+r)]}{1+p\ \frac{1+\beta}{1+r}} \quad (7)$$

The next pension is computed with the following expression:

$$R_N^{x_r+1} = R_N^{x_r} \times (1+\beta) \quad (8)$$

Two-step system

In the two-step system, there are also two pension flows, one coming from the funded pillar and received from x_r to x_g and another one coming from the NDC pillar that is received from x_g to death.

a. Founded part (at retirement age) in the two-step system:

$$R_F^{*x_r} = \pi_F \times \frac{[(1+i)^2 + (1+\beta) \times (1+k) \times (1+i)]}{\frac{1}{1-g}} \quad (9)$$

$$R_N^{*x_r} = 0$$

b. Notional part (at grand age) in the two-step system where the notional capital at grand age becomes:

$$C_N^{x_g} = C_N^{x_r} \times \frac{1+r}{p}$$

$$= \pi_N \times \frac{1+r}{p} \times [(1+r)^2 + (1+\beta) \times (1+k) \times (1+r)]$$

$$R_N^{*x_g} = \pi_N \times \frac{1+r}{p} \times [(1+r)^2 + (1+\beta) \times (1+k) \times (1+r)] \quad (10)$$

$$R_F^{*x_g} = 0$$

Table 1 shows the pension computations in each system.

We now compare both systems, from an individual point of view, though the internal rate return (IRR).

In the standard system, the IRR is solution of the following equation:

$$C = C_N + C_F = R^{x_r} + \frac{p}{1+IRR} \times R^{x_{r+1}} \quad (11)$$

The solution is given by:

$$IRR = \frac{p \times R^{x_r}\ (1+\beta)}{C - R^{x_r}}$$

In the two-step system, we have:

$$C = C_N + C_F = R^{*x_r} + \frac{p}{1+IRR^*} R^{*x_{r+1}} \quad (12)$$

Table 1

PENSIONS IN EACH SYSTEM IN THE OVERLAPPING GENERATION MODEL WITH FOUR PERIODS, AND WITH STEADY STATE

Age	Pensions in the Standard Complementary System	Pensions in the Two-Step System
x_r	$R_F^{x_r} + R_N^{x_r} = R^{x_r}$	$R_F^{*x_r}$
$x_g = x_{r+1}$	$(R_F^{x_r} + R_N^{x_r})(1+\beta) = R^{x_r+1}$	$R_N^{*x_g}$

Source: Authors' calculations

The solution is given by:

$$IRR^* = \frac{p \times R^{*x_r+1}}{C - C_F}$$

And the main question is how to compare these two IRRs. So, we will try to find conditions under which the two-step system IRR* is higher than standard IRR.

Assuming capital amounts at retirement are known, it is not necessary to work with the contribution rate, so we can concentrate on what happens only after retirement provided capitals in both situations are the same.

First, sensibility analysis is the best way to compare the interest rate i and the notional rate r. So, we consider the following cases:

Case 1. Without management fees in funding and using the same survival probabilities in the notional and the funding cases.

$IRR^* > IRR$ if and only if: $\frac{p \times R^{*x_r+1}}{C - C_F} > \frac{p \times R^{x_r}\ (1+\beta)}{C - R^{x_r}}$

Or: $R^{*x_r+1}\ (C - R^{x_r}) > R^{x_r}\ (1+\beta)\ (C - C_F)$

Taking into account the following values:

a. $R_N^{*x_r+1} = C_N \times \frac{1+r}{p}$

b. $R^{x_r} = R_F^{x_r} + R_N^{x_r} = \frac{C_F}{\left(1+p\ \frac{1+\beta}{1+i}\right)} + \frac{C_N}{\left(1+p\ \frac{1+\beta}{1+r}\right)}$

We obtain:

$$C_N \frac{1+r}{p}\left[C_F + C_N - \frac{C_F}{1+p\ \frac{1+\beta}{1+i}} - \frac{C_N}{1+p\ \frac{1+\beta}{1+r}}\right] > \left(\frac{C_F}{1+p\ \frac{1+\beta}{1+i}} + \frac{C_N}{1+p\ \frac{1+\beta}{1+r}}\right)(1+p)C_N$$

Or:

$$\frac{1+r}{p}\left[C_F \frac{p\ \frac{1+\beta}{1+i}}{1+p\ \frac{1+\beta}{1+i}} + C_N \frac{p\ \frac{1+\beta}{1+r}}{1+p\ \frac{1+\beta}{1+r}}\right] > \left(\frac{C_F}{1+p\ \frac{1+\beta}{1+i}} + \frac{C_N}{1+p\ \frac{1+\beta}{1+r}}\right)(1+\beta) \quad (13)$$

Finally:

$$\frac{C_F\frac{1+r}{1+i}}{1+p\frac{1+\beta}{1+i}}+\frac{C_N}{1+p\frac{1+\beta}{1+i}}>\frac{C_F}{1+p\frac{1+\beta}{1+i}}+\frac{C_N}{1+p\frac{1+\beta}{1+i}} \quad (14)$$

Getting the final condition that:

$$\frac{1+r}{1+i}>1 \quad (15)$$

for the two-step IRR to be larger than the classical IRR.

Result 1. It can be appreciated that the relation between the IRR will be independent of the proportion C_F/C_N and then, without fees paid and using the same life table for notional and funding computations, in terms of IRR for both systems:

If $r > i$, then the two-step system is better in terms of individual IRR.

If $i > r$, then the standard system is better in terms of individual IRR.

Case 2. With management fees paid on the annuity and using different survival probabilities in the notional and the funding case.

$i \neq r\ ;\ p^* \neq p\ ;\ g \neq 0$

The condition on the two IRRs is still the same:

$$R_N^{*x_r+1}\ (C-R^{x_r})>R^{x_r}\ (1+\beta)\ (C-C_F)$$

But the way to compute R^{x_r} is now different:

$$R^{x_r}=R_F^{x_r}+R_N^{x_r}=\frac{C_F(1-g)}{1+p^*\frac{1+\beta}{1+i}}+\frac{C_N}{1+p\frac{1+\beta}{1+r}} \quad (16)$$

Getting now:

$$C_N\frac{1+r}{p}\left[C_F+C_N-\frac{C_F(1-g)}{1+p^*\frac{1+\beta}{1+i}}-\frac{C_N}{1+p\frac{1+\beta}{1+r}}\right]>\left(\frac{C_F(1-g)}{1+p^*\frac{1+\beta}{1+i}}+\frac{C_N}{1+p\frac{1+\beta}{1+r}}\right)(1+p)C_N$$

Or:

$$\frac{1+r}{p}\left[C_F\times\frac{p^*\frac{1+\beta}{1+i}+g}{1+p^*\frac{1+\beta}{1+i}}+C_N\times\frac{p\frac{1+\beta}{1+r}}{1+p\frac{1+\beta}{1+r}}\right]>\left(\frac{C_F(1-g)}{1+p^*\frac{1+\beta}{1+i}}+\frac{C_N}{1+p\frac{1+\beta}{1+r}}\right)(1+\beta)$$

Or:

$$\frac{C_F\left(\frac{p^*}{p}\times\frac{1+r}{1+i}(1+\beta)+g\times\frac{1+r}{p}\right)}{\left(1+p^*\frac{1+\beta}{1+i}\right)}>\frac{C_F(1-g)(1+\beta)}{1+p^*\frac{1+\beta}{1+i}}$$

Finally:

$$\frac{p^*}{p}\times\frac{1+r}{1+i}(1+\beta)+g\times\frac{1+r}{p}>(1-g)(1+\beta) \quad (17)$$

Or:

$$\frac{p^*}{p}\times\frac{1+r}{1+i}>1-g-\frac{g}{p}\times\frac{1+r}{1+\beta} \quad (18)$$

If $\frac{1+r}{1+i}>\frac{p}{p^*}\left(1-g-\frac{g}{p}\times\frac{1+r}{1+\beta}\right)$ then, the two-step system is better.

But if $\frac{1+r}{1+i}<\frac{p}{p^*}\left(1-g-\frac{g}{p}\times\frac{1+r}{1+\beta}\right)$ then, the standard system is better.

This can be written as a condition on the IRR as follows:

$$\text{If}\quad 1+i>\frac{(1+r)\frac{p^*}{p^*}}{1-g-\frac{g}{p}\times\frac{1+r}{1+\beta}}$$

Then, IRR in the standard system > IRR in the two-step system.

In particular, if $p^* > p$ and $g > 0$ then $\partial_1=\frac{p^*}{p}>1$ and:

$$\partial_2=\frac{1}{1-g-\frac{g}{p}\times\frac{1+r}{1+\beta}}>1$$

So if $1+i>(1+r)\times\partial_1\times\partial_2$, then, IRR of the standard system > IRR of the two-step system.

Result 2. The i must be very large to compensate for extra longevity (to cope with adverse selection) and for the fees paid. The condition is independent of the relative level of the two capitals under both systems, C_F and C_N.

On the other hand, and although the results on IRRs are independent of the relative level of the capital, the two types of capital at retirement (notional capital, C_N, and funding capital, C_F) should be roughly equivalent to assure some continuity in the levels of retirement income during the transition from the funded income to the NDC income under the two-step system.

The condition is that:

$$R^{*x_g}=R^{*x_g-1}\ (1+\beta) \quad (19)$$

And in the four-period model, $x_g = x_r + 1$:

$$R^{*x_r}=C_F;\ R^{*x_r+1}=C_N\frac{1+r}{p} \quad (20)$$

The condition $R^{*x_r+1}=R^{*x_r}\ (1+\beta)$ becomes:

$$C_N\frac{1+r}{p}=C_F(1+\beta)\ \text{ or }\ \frac{C_F}{C_N}=\left(\frac{1+r}{1+\beta}\right)\left(\frac{1}{p}\right) \quad (21)$$

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Result 3. **In the two-step system, if it is desirable to maintain continuity in pensions, the ratio set between the capital amount obtained by the funded pillar and the notional accounts pillar must be a function of the notional rate, the growth of wages, and the probability of survival.**

EMPIRICAL ANALYSIS

The conclusions obtained above will be matched with two examples. The following graphics show IRR change in relation with the changes in other parameters. Table 2 shows the basic parameters.

Case 1. Without considering fees in the funding and using the same life expectancy as the notional and the funding with the interest rate i different from notional rate r.

Case 2. It is interesting to explore the general case with fees included in the funding and using the different life table from the notional and the funding with interest rate i different from notional rate r.

Case 1 is shown in figure 2. We use different values of i to show the effect on IRR in the standard system and in the two-step system. The IRR of the standard system is higher than the IRR in the two-step system only when the interest rate exceeds the value of the notional rate. This extreme case, however, is not realistic.

Case 2 is shown in figure 3. Using different interest rate values, and verifying that even in cases where the interest rate is higher than the notional rate, the IRR of the two-step system can be higher than the IRR of the standard system. Only in cases in which the interest rate is more than twice the notional rate, the IRR of the standard system is higher.

From an individual perspective, the IRR is better, under the assumptions adopted, for the two-step system than for the standard system. This improvement is due to the superior profitability of a term annuity over that of the pure life annuity.

Workers can face inadequate savings in their DC plans, and they frequently lack employment opportunities beyond age sixty-five, or face disability and family caregiving needs. These problems, however, should be addressed by other standard welfare and care programs rather than social security and, in any case, they are less significant because some compulsory dedicated saving always should exist. Above all, because of the two-step system design, they should not reduce the social security benefit after grand age.

Now, we present other numerical examples, based on the parameters assumed in table 2, where capital amounts ensure continuity of benefits in the two-step system.

Table 2

BASIC PARAMETERS CONSIDERED

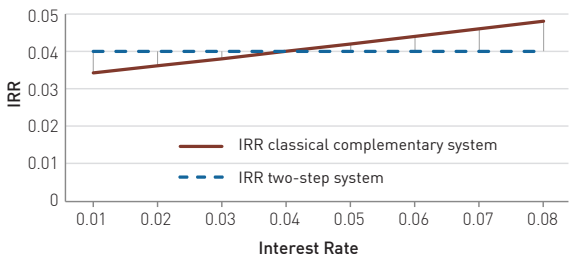
Initial Salary		$W(x_0)$	1	
Constant inflation rate		β	0.02	
Increase of salary		k	0.01	
Total capital		C	1000	
			Case 1	Case 2
Actuarial parameters	Increase in probability	∂	0	0.021
	Probability (loaded)	p^*	0.95	0.97
	Demographic increase	D	0.08	
	Probability (effective)	p	0.95	
NDC parameters	Contribution rate	μ_n	0.8	
	Notional rate	r	0.04	
DC parameters	Contribution rate	μ_f	0.2	
	Life annuity fee	g	0	0.0125

Source: Authors' calculations

Figure 2

CASE 1, FEES NOT INCLUDED, NOTIONAL LIFE EXPECTANCY, NON-NOTIONAL INTEREST RATE

IRR with r=0.04 and with different values of i

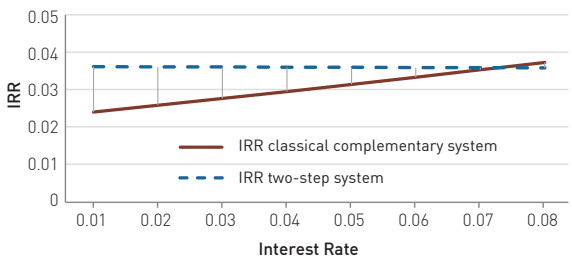


Source: Authors' calculations

Figure 3

CASE 2, FEES INCLUDED, NON-NOTIONAL LIFE EXPECTANCY AND INTEREST RATE

IRR with r=0.04 and with different values of i

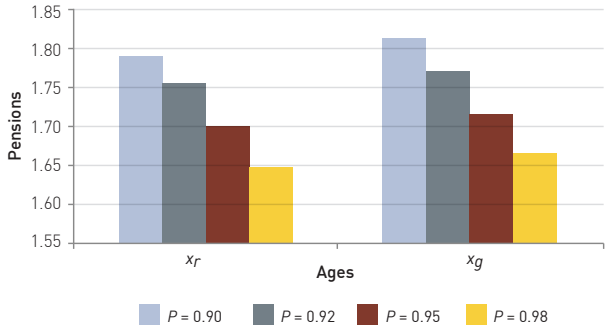


Source: Authors' calculations

Figure 4

REDUCTION IN AMOUNT OF PENSIONS AS SURVIVABILITY PROBABILITY INCREASES

First (at x_r) and second pension (at x_g) with r=0.02 and β=0.01 and different probabilities

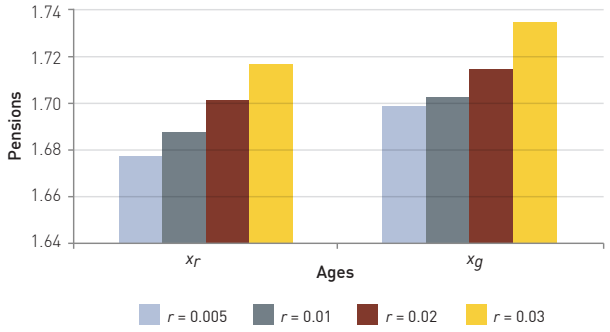


Source: Authors' calculations

Figure 5

AMOUNTS OF PENSIONS INCREASE AS THE NOTIONAL RATE INCREASES FOR GIVEN VALUES OF SURVIVAL PROBABILITY AND INFLATION RATE

First (at x_r) and second pension (at x_g) with β=0.01 and P=0.95 and different values of r

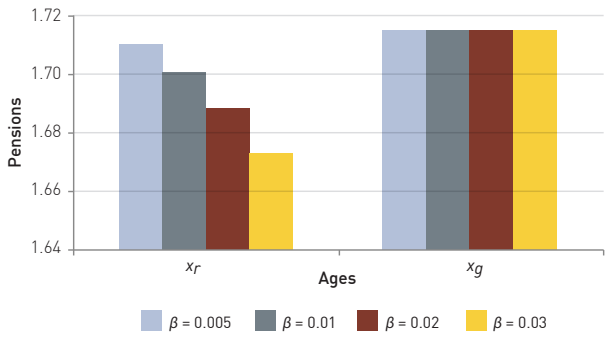


Source: Authors' calculations

Figure 6

PENSIONS ARE REDUCED IN VALUE AS INFLATION INCREASES, GIVEN SURVIVAL PROBABILITY AND NOTIONAL RATE

First (at x_r) and second pension (at x_g) with r=0.02 and P=0.95 and different values of β



Source: Authors' calculations

Figure 4 shows how the amounts of pensions are reduced as survival probability increases.

Figure 5 shows how the amounts of pensions increase as the notional rate increases for given values of survival probability and inflation rate.

Finally, figure 6 shows how pensions are reduced in value as the inflation rate increases, given the survival probability and notional rate. Note that in figure 6 the amount of pension at x_g is constant.

CONCLUDING REMARKS

Commonly, the standard system has two pension schemes: a social security (PAYG albeit NDC), scheme, and a fully funded (compulsory) DC scheme. In a way, this setup represents well many advanced countries' pension arrangements. Many other countries, where social security DB schemes are prevalent and DC pension arrangements are complementary and voluntary, however, are marching toward that kind of total pension setup through continuous reforms.

All pension systems, however, are far away from having fully adapted to the increase of life expectancy that all nations have witnessed in past hundred years, just after social security was invented in continental Europe.

Our two-step model can be applied both in countries where DB or DC plans prevail, and above all in countries where social security is the dominant system providing retirement incomes. Our simulations are set under the restriction that resulting retirement incomes are at least as good as they were before the introduction of the two-step model.

Workers decide (within limits) when to retire, informed about the income they will obtain after retirement and until they reach grand age. This income would be paid as a term annuity against their lifelong savings, compulsorily, for that purpose. This funding arrangement preferably should be employer-sponsored, but it also could be strictly personal or mixed. In any case, it should be a DC plan. By being able to choose their retirement age, workers can avoid or cope better with risks of unemployment and the like at later ages. Once they reach the legal grand age, retirees will start receiving income from social security under an NDC PAYG scheme. This social security income fully or partly could replace the term annuity in that situation.

Our two-step system proposal tries to put pensions in line with the social, demographic, and economic reality of the twenty-first century. Its concept is simple, and amounts to a kind of reinvention of social security. We still consider ordinary retirement around age sixty-five, although workers should have

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the ability to decide when to retire or whether to retire at all, as long as they are aware of their savings to that point and how to handle term annuities until grand age, because social security would not begin before that point. This is why we call this total pension scenario the two-step system.

In the two-step mixed system, workers can choose their ordinary retirement age, at which time they will receive a term annuity equivalent to a retirement pension and stemming out of previously accumulated and dedicated saving. This freedom to choose helps to accommodate risky situations that workers may face at advanced ages as work opportunities shrink and health problems tend to become more acute. Later, at grand age, social security benefits will begin. At this point, it is important to realize that the introduction of the grand age deadline does not alter necessarily workers' capacity to quit the labor market, and it may actually favor later retirement by able workers.

Many factors may help to decide how the grand age should be set. Using biometric criteria, the remaining life years at age sixty-five in 1900, should be equivalent in most advanced countries, to more than eighty years. This analysis was based on more conservative estimates, but historical European social security systems originally did exactly this: protected workers from their grand age until death.

In our view, this arrangement is more effective and more efficient than standard pension practice everywhere. Because term annuities are cheaper than life annuities, they suffer from far less adverse selection, and they don't need longevity adjustments that are expensive.

Our numeric results show that the two-step system has a higher IRR than the standard system for workers, and that only under rather exceptional conditions would it be the otherwise. The economy also would profit because of the larger availability of long-term saving and more active mature workers. This is subject to identical savings efforts during working years to both systems.

When considering transitions from the standard system to the two-step system, we must remember that our simulations assume identical saving plus contribution efforts, equivalent to current ones in advanced societies. So transitional costs could be relatively small and easy to compensate with transitional benefits.

To ease transition from the standard system to the two-step system, some behavioral economics tricks can be used, besides transparency and awareness policy. Individuals must be led to "think slow" (Kahneman 2011) about the role social security plays in insuring them during their later years. That's why in the two-step system, social security must come last. This frees individuals from insuring themselves against the longevity risk that occurs after grand age. Education about longevity, insurance, and pensions is fundamental to the successful transition from the current situation to the two-step system.

For social security, the two-step system provides short-term benefit first, and a long-term sustainable solution after some time. Year after year, the obligation of social security will shrink as more workers enter the new system and their benefit years begin at grand age, not before. Some baby boomers even could be part of this transition, if the new system is adopted. On the other hand, the first-step DC scheme is sustainable by definition, even if some of its parameters may need to be adjusted with time as longevity increases and its term benefits have to be kept adequate with time. DB schemes also could fit this pattern, although sustainability would be more expensive to obtain than with DC schemes. DB schemes, however, are clearly in retreat and should not be privileged in this kind of transition.

Another concern is who to let move from the standard system to the two-step system. Many alternatives exist, but they share a dividing age line among current workers. However, a crucial element appears in this scenario. That is the fact that the NDC social security life annuity could well be higher than the DB social security it would replace.

Lastly, but not least important is the question of where to place the grand age. The grand age is the cornerstone of the two-step system design and almost everything depends on its choice. To reassure the reader, we aren't saying that the grand age should be set at eighty or older. In fact, in our computations, this age has been set at seventy-five. Two other things are important about this variable. First, it should be set so that the aggregate balance of the NDC social security scheme, that continues to be of a PAYG nature, reaches and keeps a proper balance between its income and expenditure flows over time. Second, and closely related to the previous one, this age should be regularly reassessed to keep proper relation to life expectancy.

Comparing a full replacement of a PAYG social security system with a fully funded DC social security system, this reinvention of social security entailed by the two-step mixed system promises far lower transitional costs and has an easy-to-understand rationale, if properly explained.

As we have shown, the two-step mixed system has a superior efficiency to the standard mixed system, which means that part of the transition costs can be paid for more easily. The details of more developed transition paths and strategies are left for further research by the authors.

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ENDNOTES

1. Notional accounts are designed to mimic a DC plan, where the pension depends on contributions and investment returns. Pension contributions are tracked in accounts that earn a rate of return. However, in notional accounts, the return that contributions earn is a notional one, set by the government, not the product of investment returns in the markets.
2. We have opted for a DC scheme instead of a DB scheme, but our design could be equally applicable to the latter. Everywhere, DC schemes are replacing DB because of their superior efficiency for the provider.
3. We refer to longevity as phenomenon and to all implied effects that longevity has over people's behavior. For example, and from a life cycle point of view, people with longer life expectancies tend to finish their studies later, which also tends to influence decisions such as the age of starting to work or the age of forming a family.
4. Taking into account their individual saving decisions and possibilities and based on their own circumstances, workers decide their retirement age knowing that their term annuity is determined by the achieved saving level. However, partial retirement (combined with part-time work) is an interesting option, and is compatible with the two-step system philosophy.

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