PUBLIC PENSION SYSTEM SUSTAINABILITY

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Abstract
Since many years the pensions debate has played a fundamental role in the political program of many countries of the world. The public PAYG pension schemes have faced a crisis due from one hand to the aging population for which the pension must be paid for a long time, and from the other hand the stoppage in economic growth has slowed down the flow of contribution revenue. In this work it is analyzed the sustainability of a PAYG pension scheme, after the introduction of a funded component to balance the PAYG part when the ratio between contributors and pensioners is decreasing. Risk indicators are presented to assess the sustainability of the scheme. The aim is to find the optimal share of the funding component, in order to maximize the sustainability indicators.

Keywords: demographic risk, public pension system, sustainability.


1. Introduction
Pension schemes can be classified, according to the financing method, into pay-as-you-go (PAYG) and funded. In a PAYG scheme retired generation's pensions is financed by contributions paid by current working-age generation. By contrast, in a funded scheme, the contributions of each generation are invested into a fund and the accrued amount is used towards meeting the benefits upon retirement. In Europe, public pension schemes are generally managed as PAYG while private are funded.

To be in balance, a PAYG pension scheme needs equilibrium between the contribution income and the pension expenditure. In many developed countries this balance has begun to fail due to the decrease in fertility rates and the increase in life expectancy that have reduced the share of active populations. The situation will be worse when the generation of the baby boomers will be retired in the next years.

In the last decades many governments, in particular in Europe, have implemented reforms in the public pension system. Some countries adopted some reforms like increasing the pensionable age, raising the contribution rates and limiting the generosity of retirement benefits; these reforms are usually called in the literature “parametric” (see also Disney 2000; Haberman and Zimbidis 2002).
Others countries, like Sweden, Italy, Latvia and Poland introduced Notional Defined Contribution NDC systems, which are financed on a PAYG basis, but where the pension is linked to the contributions paid during the working life, with a notional account for each participant (see Auerbach and Lee 2009; Settergren 2001; Settergren and Mikula 2005; Holzman et al. 2012). These schemes are “actuarially fair” because there is a direct link between the paid contributions and received benefits.

Another possibility to reform public pension system is the privatization. But, as pointed out in Fajnzylber and Robalino (2012), a transition process from PAYG to funding has high transition costs because a generation pays twice the pension. Diamond (2002) and Diamond and Orszag (2005), investigate the social security reforms and the social security policies in order to restore the long-term sustainability. Andersen (2012) addresses the fiscal sustainability of public policies when the demography is changing. Grech (2013) analyses the sustainability of pension reforms in Europe. Holzmann (2013) provide an exhaustive review of different pension reforms worldwide.

Melis and Trudda (2012a, 2012b) study the sustainability of a PAYG pension fund also with the introduction of a funded component. The model is applied to the pension fund of Italian Professional Orders. Devolder and Melis (2015) study the financing of a public pension scheme in a stochastic framework. They introduce a funded component and develop a model to find the optimal share to invest in both systems. Godínez-Olivares et al. (2016) propose an automatic balancing mechanism to restore the sustainability of a PAYG pension system in order to calculate the optimal path of the contribution rate, age of retirement and indexation of pensions. Attias et al. (2016) analyze the Italian pension system in terms of adequacy, by proposing a reform based on the introduction of a fully funded component, when the population is stable.

In this paper we present a mixed model for a public pension scheme with the introduction of a funded component in order to analyze the future sustainability. For the PAYG part we adopt an NDC scheme, i.e. without the accumulation of resources, but with defined contribution. A funded component is introduced and it is analyzed how the financial sustainability varies with the partial accumulation of amount into a fund invested on capital markets.

2. The model

The model describes a pension scheme for a social security system in a discrete time with an age structured population. The population is closed to migration.

2.1. Population

Let $N(x,t)$ be the population aged $x$ at time $t$, $\alpha$ is the entry age into the scheme, $\pi$ is the age of retirement and $\omega$ is the extreme age (See Fig. 1).
The population evolves as follows for each age:
\[ N(x,t) = N(x-1,t-1) \cdot p_{x-1,1} = N(x-t,0) \cdot p_{x-t,1} \]  \hspace{1cm} (1)
where \( p_{x-1,1} \) is the probability that a member aged \( x-1 \) is alive after one year.
If \( N_{\alpha,t} \) is the number of people aged \( \alpha \) at time \( t \), the cohort of the new entrants evolves as follows:
\[ N_{\alpha,t} = N_{\alpha,t-1} \cdot (1+d) = N_{\alpha,0} \cdot (1+d)^t \]  \hspace{1cm} (2)
where \( d \) is the rate of increasing of the new entrants.

2.2. Contributions
The total contribution \( C(t) \) is calculated as follows:
\[ C(t) = \gamma \sum_{x=\alpha}^{\pi} N(x,t) \cdot w(x,t) \]  \hspace{1cm} (3)
where \( \gamma \) is the contribution rate, \( w(x,t) \) indicates the average wage for a person aged \( x \) at time \( t \).

2.3. Wages
The wage function \( w(x,t) \) evolves as follows:
\[ w(x,t) = w(x,t-1) \cdot (1+g) = w(x,0) \cdot (1+g)^t \]  \hspace{1cm} (4)
where \( g \) is the annual growth of income.

2.4. Pensions
The total pensions are calculated by the following equation:
\[ P(t) = \sum_{x=\pi}^{\omega-1} N(x,t) \cdot b(x,t) \]  \hspace{1cm} (5)
where \( b(x,t) \) is the average pension for people aged \( x \) at time \( t \).
The pension is the sum of two components, the former calculated with the PAYG system and the latter calculated with the funding system:
\[ b(x,t) = b_r(x,t) + b_p(x,t) \]  \hspace{1cm} (6)
After the retirement we assume that pensions are indexed at the rate \( g \):
\[ b(\pi+1,t+1) = b(\pi,t) \cdot (1+g) \]  \hspace{1cm} (7)
Let us consider the generation retiring at time \( t \).

The funded component \( b_F(x, t) \) is calculated by capitalizing on the contributions paid during the working life at the rate of return of the fund.

Indicating with \( A_F(\pi, t) \) the amount accumulated in the funded scheme by a member of age \( \pi \) at time \( t \) we have:

\[
A_F(\pi, t) = \gamma \cdot \sum_{x=1}^{\pi-1} w(x, t - \pi + x)(1 + i)^{(\pi-x)}
\]

(8)

Indicating with \( A_p(\pi, t) \) the notional amount accumulated in the NDC system by a member of age \( \pi \) at time \( t \) at the rate \( j \) we have:

\[
A_p(\pi, t) = \gamma \cdot \sum_{x=1}^{\pi-1} w(x, t - \pi + x)(1 + j)^{(\pi-x)}
\]

(9)

Let us consider that a share of the contributions \( a \) (with \( 0 \leq a \leq 1 \)) is invested in funding and the fraction \( 1-a \) is invested in PAYG.

For the PAYG component we calculate the value of the pension at time of retirement by multiplying the total contributory accrued amount by the annuity factor \( TC(x, t) \), the transformation coefficient (see Janssen and Manca 2006) for a member aged \( x \) at time \( t \):

\[
b_F(\pi, t) = (1-a)A_F(\pi, t) \cdot TC(\pi, t)
\]

(10)

For the sake of simplicity we consider that all people retire at the same age \( \pi \).

For the funded component we have:

\[
b_F(\pi, t) = aA_F(\pi, t) \cdot TC(\pi, t)
\]

(11)

The average pension is:

\[
b(\pi, t) = TC(\pi, t)[aA_F(\pi, t) + (1-a)A_p(\pi, t)]
\]

(12)

The pension balance is:

\[
C(t) - P(t).
\]

(13)

If a component is capitalized every year then \( aC(t) \) is invested into the fund, while \((1-a)\) is used to pay PAYG pensions.

Then we will have the recursive formula of the fund:

\[
F(t) = F(t-1)(1+r(t)) + aC(t) - P_F(t)
\]

(14)

where \( r(t) \) is the return rate of the amount invested in the fund and \( P_F(t) \) indicates the total funded pensions paid at time \( t \).

Without the accumulation into the fund, the general formula for the evolution of the system will be:

\[
Y(t) = Y(t-1)(1+\theta(t)) + C(t) - P(t)
\]

(15)

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1 The notional rate \( j \) is usually set by law.

2 The total pensions paid at time \( t \) is the sum of the total PAYG and funded pensions at time \( t \): \( P(t) = P_{PAYG}(t) + P_F(t) \).
where \( Y(t) \) is the overall balance and \( \theta(t) \) is the rate of the cost of public debt (positive or negative).

If we accumulate the amount \( aC(t) \) into a fund, then the total balance will be:

\[
Y(t) = Y(t-1)(1 + \theta(t)) + F(t) + (1-a)C(t) - P_{PAY}(t)
\]

(16)

3. Numerical applications

This section presents a numerical example of the model above applied to a pension system. Italian data from ISTAT (Italian National Institute of Statistics) are used. We take into account only the data from dependent workers.

The following assumptions are adopted:

- the pension is calculated with the NDC pension system for people starting to work after 1996, while for people starting before 1996 pension is calculated using the mixed method, the so called pro rata. Until 1996, the defined benefit DB formula is used and the pension is calculated by multiplying the pensionable earnings, i.e. the mean of the earnings obtained over the final years of work, revalued at a given rate, by the number of years of contributions accrued in the DB system;
- Italian mortality tables 2015 (source ISTAT);
- for new entrants fixed entry age \( \alpha = 25 \), retirement age \( \pi = 66 \);
- the inflation rate is fixed at 1.5%;
- the contribution rate is fixed at 25%;
- the last transformation coefficients (2016) have been employed;
- salaries are appreciated at rate of inflation;
- benefits are calculated with the mixed method;
- the return on assets is fixed at 2%;
- the rate of cost of public debt is fixed at 1%;
- the notional rate is fixed at 1.5%.

The pension scheme balance is projected for 50 years. We first consider the case of \( a = 0 \), without the accumulation into the fund. The obtained results are summarized in Figures 2-6.
Figure 2 shows the projection of the total contributions received by the pension system. As it is possible to observe, there is an initial increase, but after 16 years there is a decrease in the total inputs. At the same time, by looking at Figure 3, we can see that in the same period of time there is an increase in the total pensions paid by the system. This situation causes a financial instability to the scheme because the system in the long run is not able to pay pensions without the public intervention to cover the pension liabilities.

Figure 4 shows the projection of the *liquidity ratio*, the ratio of the total contributions to the total pension. This relation is considered as an indicator of the liquidity of the system. For a system in equilibrium this value must be over 1. As we can see also this indicator is going to decrease after 16 years. Figure 5 shows the pension balance, i.e. the difference between the total contributions received and the total pensions paid, which reflects the same problem for the system.
Fig. 4. Ratio contribution received on total pension paid years 2013-2062
Source: own elaborations.

Fig. 5. Pension balance – difference between total contributions received and pension paid years 2013-2062
Source: own elaborations.

Fig. 6. Replacement rate years 2013-2062
Source: own elaborations.

In order to measure the level of individual performance, we calculate the replacement rate, the ratio of the first pension received to the last wage earned before the retirement. Figure 6 shows the projection of this indicator. As we can see, replacement rate is going to decrease, stabilizing slightly above 50%.

We must stress that we consider only full careers, i.e. 40 years of contribution. If, instead, you do consider the unemployment and delayed entry into the working world, the replacement rate will be even lower, about 40%.

Then we consider the case in which a fraction $a$ of the contributions is invested into a fund. We calculated the overall balance for different values of $a$ in order to
find the number of years it will get the balance of the system and a state of autonomy, without the intervention of the state to cover the negative balance. Our findings is that the minimum \( a \) that makes the system sustainable is \( a = 0.04 \), for which the balance is positive after 27 years. The results are shown in Fig. 7.

![Overall balance years 2013-2062](image)

**Fig. 7.** Overall balance for \( a = 0.04 \) – years 2013-2062
Source: own elaborations.

### 4. Results and conclusion

In this paper we introduced a funded component in order to improve the sustainability of a public pension system, i.e. the capability of the scheme to cover the pension liabilities in the long run, given the actual and future demographic scenario. The model has been applied to a fund with the features of the Italian public pension system.

For the public budget, if there is set aside a part of the contributions, after a number of years it will get the balance of the system and a state of autonomy, without the intervention of the state to cover the negative balance of social security. The minimum component to be allocated according to the assumptions used in the simulations of new contributors, interest rate and cost of debt is 4% of the contributions, which ensures an overall positive balance after about 27 years. On the other hand, at the level of individual performance, the replacement rate increases with the introduction of a capitalization component, but not significantly.

We must emphasize that in the paper hypothesis we consider only full careers, i.e. 40 years of contribution, as the purpose of the study is to assess the impact of the introduction to the public system of a capitalization component. If, instead, you do consider this, given the unemployment and delayed entry into the working world, the replacement rate will be even lower, about 40%.

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References


