Rethinking the Contribution-Benefit Linkage in Pay-As-You-Go Retirement Systems Based on Algerian Case

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In Pay-As-You-Go systems, retirement benefits result from the multiplication of the reference wage by the contribution duration by an annuity rate. This formulation can undergo some adjustments to ensure sustainability within a changing environment. In this paper, we showed that the current contribution-benefit linkage might generate a large gap between individuals in terms of profitability and thus in terms of wealth accumulation over long periods. Considering the possible career scenarios in the Algerian retirement system, we found that return rates vary from 9.6% to 13.2%. To reduce inequality, we propose a new retirement benefit formula partially based on the actuarial fairness principle.

Keywords: retirement, PAYG, equality, IRR, scenario, Algeria.

INTRODUCTION

From an individual perspective, pensions are an efficient way to prevent late-life risks and smooth consumption over the life cycle (Barr & Diamond, 2006; Bovenberg & Van Ewijk, 2011a). For governments, they represent a tool to alleviate poverty among the elderly through funded, unfunded Pay-As-You-Go (PAYG), hybrid, or multi-pillar schemes. Indeed, pension systems design in a given country depends on a set of economic, political, cultural, and social circumstances (Bovenberg & Van Ewijk, 2011b). Experience suggests that a *perfect* pension system filling all objectives in all situations does not exist (Barr, 2002). Thus, policymakers must prioritize some aspects compared to others when designing a pension system. PAYG retirement systems are more efficient than funded systems in reducing poverty (Cousins, 2007; Weyland, 2009), but are more sensitive to demographic risks. In such situations, state intervention is necessary (Barr & Diamond, 2006) to correct financial imbalances and keep poverty reduction on target.

In recent decades, population aging weakened the efficiency of state intervention in maintaining the financial balance of pension systems and resulted in lowering their generosity. Following the World Bank [WB] report in 1994 (WB, 1994), many reforms worldwide were imple-

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mented to lighten the load on the classical PAYG schemes, mainly by introducing additional funded pillars. Indeed, a multi-pillar system is the most suitable for a multi-objectives strategy (Holzman & Hinze, 2005). Some countries, such as Mexico, have experienced a shift from the PAYG to a fully-funded system. Under fully funded systems, the linkage of pension benefits to contributions obeys actuarial fairness based on financial market return rates and life expectancy evolution. What a retiree receives during retirement is proportional to the contributions accumulated during his working career (Castanheira & Galasso, 2011). Within the PAYG defined benefits systems, the current working generation contributes to the current generation of retirees against a promise to receive pension benefits once at retirement (Barr & Diamond, 2006). Keeping these promises relies on the volume of contributions that future working generations will be able to pay. In some circumstances, maintaining the income-outcome balance will require a few adjustments, mainly by asking future workers for more contributions or making future retirees receive less than promised. Such parametric reforms result in a sort of inequality between the successive generations (Morris, 2022; Piirits & Võrk, 2019; Miles & Iben, 2000). On the other hand, various types of inequality can rise within the same generation, and different types and sources of inequality exist. Unequal wages and unequal employment chances translate directly into unequal retirement benefits (Klos et al., 2022; Castanheira & Galasso, 2011).

Although the literature had addressed most inequality sources in PAYG systems, issues related to the system design and the way pension benefits are linked to contributions were not considered. In PAYG systems, the first pension benefit equals the product of the replacement rate by the reference wage. The replacement rate refers to the years of contribution multiplied by an annuity rate. For example, 40 contributed years with an annuity rate of 2% result in a replacement rate of 80%. Usually, the reference wage corresponds to the final salary. This formulation, even though very common in defining pension benefits under the PAYG system, remains very debatable since its definition does not obey well-defined rules.

The first objective of this paper consists of studying pension inequalities due to the classical design of PAYG retirement systems referred to here as “systemic inequalities” that are considered from an actuarial fairness point of view. To this end, we use the Algerian public retirement system of salaried workers as a case study. Assuming that wages are equal for all workers aged x in time t and that contribution rates for retirement are constant over time, we estimate and compare the internal return rate (IRR) of all the possible scenarios of contribution-retirement. High dispersion of the IRRs distribution translates as an inequality.

The use of the IRR for pension valuation within PAYG systems dates back to Samuelson (1958) and Aaron (1966). It remains widely used for analyzing pension generosity (Diseny, 2006; Reznik et al., 2009; Ben Brahem, 2009; Luthen, 2016), studying inter- and intra-generational redistribution (Klos et al., 2022), and comparing PAYG and fully funded systems returns (Turner, 1998). Because PAYG systems, unlike funded plans, do not obey financial market investments, using the IRR for its evaluation seems inappropriate. However, such a tool is very performant in comparing the value of the perceived benefits against the paid contributions. Indeed, the IRR in PAYG systems translates as the demographic and economic returns (Galasso, 2019; Settergren & Mikula, 2005;

Brunner 1996). When the population and salaries grow over time, retirement benefits will be more generous in the future, meaning a high IRR. But, when the population is decreasing or is aging and salaries are stable or are decreasing, one would expect future benefits to be less generous.

The second objective of this paper is to propose a new approach for linking retirement benefits to contributions aiming at reducing inequalities and improving fairness. Then, we propose a new retirement formula using simple models based on the final wage, the years of contribution, and the retirement age.

Section 2 starts with a short overview of the Algerian PAYG retirement system for the salaried workers, followed by a presentation on the definition of the possible contributions-benefits scenarios. Then, we expose and implement the methodology of estimating the IRRs for the different scenarios, and we discuss inequalities due to the classical way of linking benefits to contributions. In Section 3 we propose a new method to link benefits to contribution while reducing inequality. We present and discuss our results in Section 4. Finally, we end with a Conclusion.

THE PROBLEM OF SYSTEMIC INEQUALITY

To analyze the inequalities related to the classical method of linking benefits to contributions in PAYG retirement systems, we estimate the IRR for all the possible contribution-retirement scenarios within the system. As previously said, high dispersion of the IRR translates as an inequality. We consider the Algerian retirement system for salaried workers managed by the "*Caisse Nationale des Retraites (CNR)*" as a case study. For simplification reasons, only men, who constitute more than 83% of the direct pensioners of the CNR, are considered. First, we give a short overview of the Algerian retirement system. Then, we define all the possible scenarios, present the methodology for estimating the IRR, and analyze the results.

Overview of the Algerian retirement system

The retirement system in Algeria is composed of three schemes, one for military personnel, one for the high ranking civil servants and government staff, and one for the workers in the civil sector. The latter comprises two sub-schemes: one for the salaried employees that is managed by "*La Caisse Nationale des Retraites (CNR)"* and one for the self-employed workers that is managed by "*La Caisse d'Assurance Sociale des Non-Salaries (CASNOS)"*. The CNR covers almost 90% of the retirees of the civil scheme. This article focuses on the salaried employees' regime only.

In the salaried workers scheme, which this paper focuses on, the statutory retirement age is 60 years old. The first retirement benefit is calculated by:

$$\boldsymbol{RB_x} = \boldsymbol{2.5\%} * \boldsymbol{n} * \underline{\boldsymbol{W}}_{[\boldsymbol{x-5},\boldsymbol{x}[} \tag{1}$$

With:

- RB_x is the retirement benefit paid to a newly retired person;
- x represents the age of retirement;
- n refers to the years of contribution, with 15 years as a minimum to open the right to a retirement pension and 32 years as a maximum;
- $\underline{W}_{[x-5,x[}$ is the average wage of the 5 years before retirement (final wage); for simplification issues, it is noted as w^*.

Interested readers can refer to Flici and Planchet (2020) for a more detailed overview of the Algerian retirement system.

Defining the possible scenarios

Since we are not willing to consider the effect of the year of retirement on pension inequality, all the hypothetical retirees considered here are supposed to retire in the same year (even though they are of different ages), which is supposed to be 2020. Then, the possible scenarios for a contribution-retirement career have been defined based on two variables:

a) The duration of contribution, which varies from 15 to 40 years;

b) The age of retirement, which goes from 50 to 70 years;

Even if the statutory retirement age is 60 years, many options have allowed getting retired starting from the age of 50 years. Also, many workers remain occupied beyond 60 and even 65 years in some cases (Flici & Planchet, 2020).

The combination of the two variables gives a total of 26x21 = 546 scenarios. Some constraints have been imposed:

a) The age of starting contributing is between 18 and 55 years;

b) The year of starting contributing to be later than 1977;

The first constraint comes from the interaction between the minimum required years of contribution (15 years) and the maximum age for retirement, i.e. 70 years. The second constraint relies on the fact that the mortality data of Algeria, which is used here as a survival function in the contribution-retirement cycle, is only available starting from 1977.

After removing the impossible combinations, the final number of scenarios is 483.

Assumptions

The IRR represents the discount rate which allows equalizing the sum of the expected contributions and that of the expected retirement benefits at a given time *t*. Time *t* is assumed to be the year of starting work within each scenario, and IRR(i) to be the IRR corresponding to the i^{th} scenario ranging from 1 to 483. All payments are supposed to occur at the beginning of the year. The contributions for retirement are paid annually as a part of the annual wages. Wages are assumed to evolve linearly with time and follow a quadratic function over age. The base wage used in calculating the first retirement benefit is the average of the last five years' salary. Then, retirement benefits are annually revaluated with a factor (1+*rev*).

For each scenario, we estimate the payment schedule of the contributions and the expected retirement benefits. We adopt some hypotheses about the different parameters involved in the retirement system:

a) Wages

Since we are not addressing the effect of wage inequality here, all workers aged *x* in year *t* receive the same salary. Assuming that wages will keep growing in the future, linearly, following their historical evolution, implies that the average wage (noted $\underline{w}$) at the time (*t*+1) equals the average wage at the time (*t*) multiplied by an evolution factor (1+*wgr*), with *wgr* denoting the *wages growth rate*. This can be written as:

$$\underline{w}_{t+1} = \underline{w}_t * (1 + wgr) \qquad (2)$$

We note that, for each scenario, the average wage of the first year of contribution $\underline{w}_{(t=1)}$ is assumed to equal to 1.

On the other hand, wages vary with age. Flici and Planchet (2020) used the distribution of salaries by large age intervals provided by the household income survey by the Algerian Office of National Statistics [ONS] in 2011 (ONS, 2014). Unfortunately, no data is available for more recent years. Here, the age distribution of wages is assumed to remain the same for the whole period of analysis.

Flici and Planchet (2020) fitted the crude distribution of wages by large age intervals with a quadratic function, which allowed them to estimate the wage pattern by detailed ages ranging from 18 to 64. Here, the same function is used to extend the wage pattern until the age of 69 years. However, our variable of interest becomes the ratio of the wage at age *x* and time *t* on the average wage at year *t* (noted as $\frac{w_{x,t}}{\underline{w}_t}$) instead of $w_{x,t}$. This can be written as follows:

$$w_{x,t} = \underline{w}_t * (a + b * x + c * x^2) \qquad (3)$$

Combining Equations 2 and 3 allows for estimating the year-to-year evolution of wages at all ages. That gives:

$$w_{(x+1,t+1)} = w_{(x,t)} * (1 + \frac{(b+c+2*c*x)}{(a+b*x+c*x^2)}) * (1 + wgr) \qquad (4)$$

With:
a=0.5244, *b*=0.0196, and *c*=- 0.00016.

The annual wage growth rate is assumed to keep at 9.5%. For more details, see Flici and Planchet (2020).

b) Contributions

Workers pay the contributions for retirement as a part of the contribution to social security. Since late 2015, the contribution rate for retirement (CRR) has equaled 18.25% shared between the insured person himself (6.75%), the employer (11%), and the government (0.5%). Historically, the CRR evolved from 5% in 1985 to 11% in 1991 and 12.5% in 1998. Then it underwent successive revisions in 1999, 2000 and 2006, taking it up to 14%, 16%, and 17.25%, respectively.

Since we do not aim to address the effects of parametric reforms on pension inequality in this article, the CRR is assumed to be constant at 18.25% over the 1977-2019 period. Thus, we can calculate the the annual contribution to retirement (CR) as follows:

$$CR_{x,t} = w_{x,t} * CRR \qquad (5)$$

Additionally, the contribution period is assumed to be continuous and concentrated toward the end of the working age. Also, it is not assumed to be limited to 32 years as it is currently regulated, but can reach 40 years.

c) Survival functions

The payment of contributions and retirement benefits is conditional on surviving to the payment dates. Longevity is assumed to keep improving at different paces for males and females on one side and the global population and the retirees on the other side.

Because of the unavailability of specific life tables for the insured population in Algeria, we assume the mortality of the contributing workers is similar to that of the global population. To this end, we use the coherent forecast of Flici (2021) as a survival function during the contribution phase. For the payment phase, we use the retirees-specific prospective life tables estimated by Flici and Planchet (2019) based on the mortality data of the CNR for males and females aged 50 years and older.

Estimating the IRR passes through discounting contributions and benefits to a unique time reference, in our case the year of starting work. Two different survival functions are used for this issue, one specific to the contribution phase and another one to the retirement phase. Considering $q^g_{x,t}$ to be the age-specific mortality rate of the global population at age *x* and year *t* and $q^e_{x,t}$ to be the mortality rate for the retired population, we can estimate the probability to survive from the first age of contribution (x) to any age of the contribution phase ($x+n$) as follows:

$$_{n}p_{x,t} = \prod_{m=x,k=t}^{x+n-1,t+n-1} (1 - q^{g}_{m,k})$$

Similarly, the probability of surviving from the first age of contribution (x) to any age($x+s$) of the retirement phase, with $x+r$ is the age of retirement and $s > r$, can be written as:

$$_{s}p_{x,t} = {}_{r}p^{g}_{x,t} \prod_{m=x+r,k=t+r}^{x+s-1,t+s-1} (1 - q^{e}_{m,k})$$

d) Retirement benefits

The first retirement benefit is calculated as follows:

$$RB_r = 2.5\% * n * w * \quad (6)$$

With:

r: The age of retirement;

w^*: represents the final wage averaged on the last 5 years ($(w^* = \frac{1}{5}\sum_{z=r-5}^{r-1} w_z)$;

n: The duration of contribution;

Then, the retirement benefit of the next year is calculated by applying an annual revaluation rate (*rev*) of 5% (Flici & Planchet, 2020). It gives:

$$RB_{r+1} = RB_r * (1 + rev)$$

Estimating the IRR by scenario

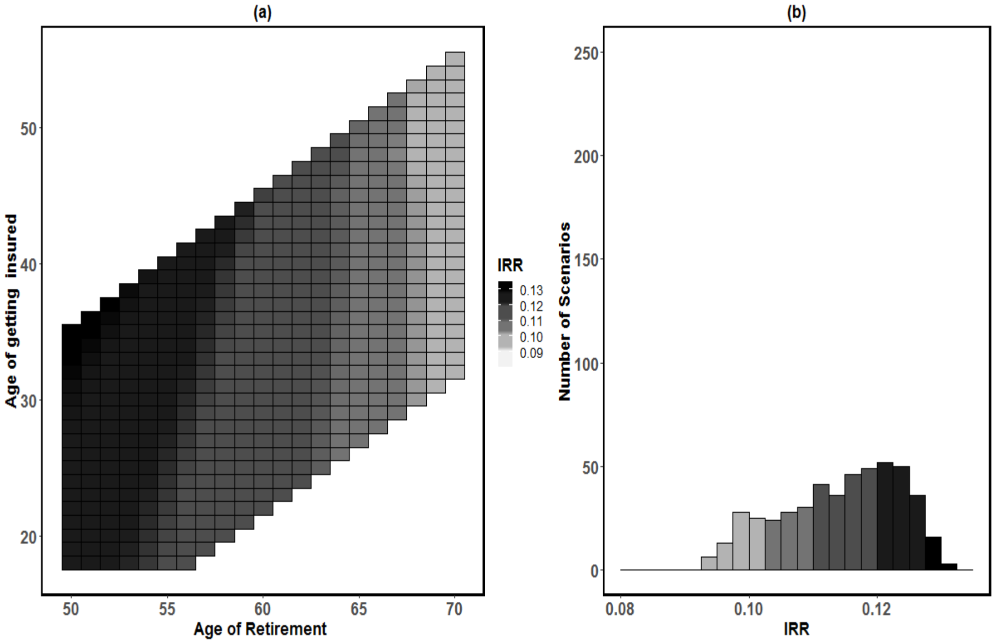
Following the definition of the IRR, it represents the discount rate, which equalizes the sum of the expected contributions (SEC) and the sum of the expected retirement benefits (SERB). Considering the year of starting work as the reference year for all the financial flows within a retirement contract, we can write:

$$\sum_{m=x,k=t}^{x+r-1,t+r-1} \boldsymbol{CR_{m,k}} * {}_{m-x,k-t}\boldsymbol{p^{g}_{x,t}} * (\boldsymbol{1} + \boldsymbol{irr})^{-(\boldsymbol{k}-\boldsymbol{t})} = \sum_{l=x+r,v=t+r}^{x+s-1,t+s-1} \boldsymbol{RB_{l,v}} * {}_{l-x-r,v-t-r}\boldsymbol{p^{e}_{x+r,t+r}} * (\boldsymbol{1} + \boldsymbol{irr})^{-(\boldsymbol{v}-\boldsymbol{t})} \quad (7)$$

The IRR of each scenario was estimated through an optimization problem using the *optimx* package under R. The obtained results are shown in Figure 1.

The results show the high variability of the IRR by scenario. Even if the average IRR is 11.49%, the minimum and maximum are 9.59% and 13.21%, respectively. The standard deviation of the IRR distribution is equal to 8.77E-03. The lowest IRR is associated with the following scenario: start working (contribution) at age 51 and retire at age 70 with 19 years of contribution. On the other hand, those who began contributing at age 35 and retired at age 50 have the highest IRR. This difference of 3.62% in terms of the IRR can lead to huge disparities in wealth accumulation over the long run. For example, in 30 years, a return rate of 1% generates 34% of the initial investment.

Figure 1
IRR Vs. age of starting contributing and retirement age. The subplot (a) shows the IRRs in the function of the year of starting contribution and the retirement age. The subplot (b) shows the distribution of the scenarios according to their IRR.



In the next section, we propose and evaluate new ways to calculate retirement benefits to reduce the gap in terms of IRR as much as possible while keeping the calculation method simple, understandable, and easily implementable.

THE PROPOSED MODELS

To reduce the inequalities generated from the design of the PAYG systems, a new formulation is proposed partially based on the actuarial fairness between the paid contributions and the expected retirement benefits. To this end, we simplify the actuarial relationship in Equation 7 using generalized linear models (GLM).

First pension benefit Vs. Final wage

We start by writing the first term of Equation 7 as a function of the final wage w^* and the second term as a function of the first retirement benefit (RB_r**)**. This leads to write:

$$A * w^* = B * RB_r \tag{8}$$

A and B resulted from dividing the two parts of Equation 7 by w^* and RB_r and are named "*coefficient of contributions*" and "*coefficient of retirement benefits*", respectively. The first retirement benefit can simply be obtained by:

$$RB_r = w^* * \frac{A}{B} \tag{9}$$

Simplifying the Contributions – benefits equation

Next, we model the first retirement benefit using GLMs. We compare two models. The first model (noted as L1) tries to write the ratio of the first retirement benefit on the final wage as a linear function of the duration of contribution (n). The second one, noted as L2, (the current system is labeled L0) considers the retirement age (r) in addition to n. The three models -including the current one- are written as:

$$L0: \frac{RB_r}{w^*} = 2.5\% * n$$

$$L1: \frac{RB_r}{w^*} = a_1 + a_2 * n$$

$$L2: \frac{RB_r}{w^*} = b_1 + b_2 * n + b_3 * r$$

The proposed models attempt to make the IRRs resulting from the different scenarios converge to a central value better than under the current system. Thus, the models are compared based on the concentration of the obtained IRRs around the mean. We use the interquartile and inter-decile ranges to measure the dispersion of the IRRs distribution under each model.

Eliminating the extreme scenarios

Since the proposed models rely partially on the actuarial fairness equation, the resulting IRRs might strongly converge to the central IRR. However, some scenarios consistently lead to aberrant IRRs, far below or above the mean. In such a case, it will be necessary to introduce some requirements for getting retired, such as a minimum duration of contribution or minimum retirement age.

RESULTS AND DISCUSSION

The two GLMs models have been estimated using the *lm* function under R. The estimated models can be written as:

$$L1: \frac{RB_r}{w^*} = 32.9\% + 3.05\% * (n - 15)$$

$$L2: \frac{RB_r}{w^*} = 14.55\% + 2.83\% * (n - 15) + 1.97\% * (r - 50)$$

The resulting SSEs (sums of squared errors) equal 8.08 and 1.36 for L1 and L2, respectively.

Figure 2

$\frac{RB_r}{w^*}$ *Vs. duration of contribution. The subplot (a) shows the fit of* $\frac{RB_r}{w^*}$ *using the model L1. The subplot (b) shows the fit based on the model L2.*

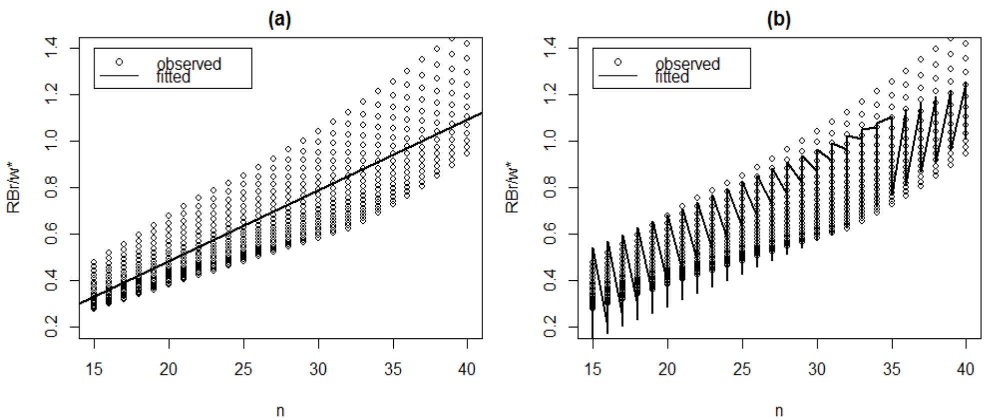


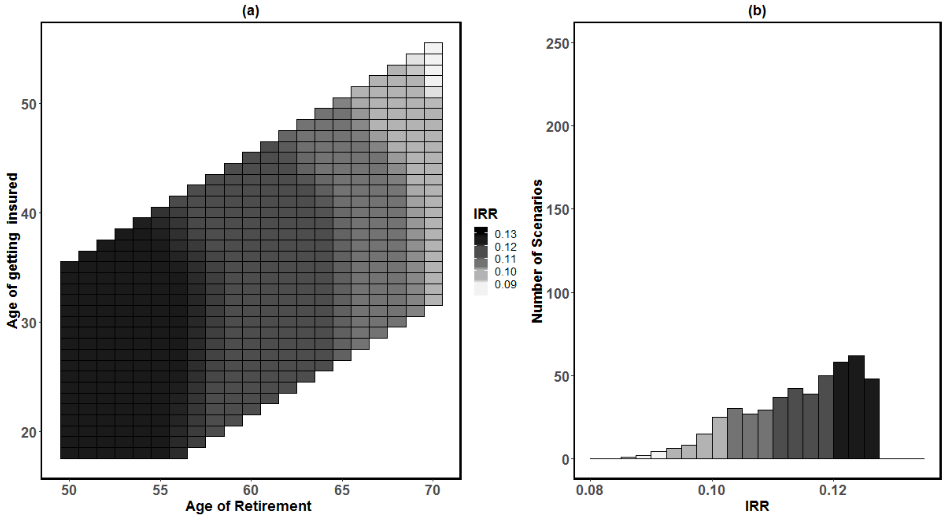
Figure 2 compares the observed ratio $\frac{RB_r}{w^*}$ to the fits obtained using models L1 and L2.

According to the results, the model L1 provides a replacement rate of nearly 33% for the required 15 years of contribution plus 3% for each additional year beyond this minimum. The current system would lead to a slightly higher replacement rate (37.5%) for the same contribution period. On the other hand, 32 contributed years would provide a replacement rate of 84.76% against 80% under the current system. The model L2 provides merely 15% of a flat-rate replacement augmented by nearly 2.8% for each contributed year beyond 15 years and 2% for each delayed year beyond the minimum retirement age of 50 years. According to the model L2, retiring at age 60 with 20 contributed years would result in a replacement rate of 48.4% against 50% under the current system. However, for a retirement age of 60 years and 32 years of contribution, an 82.36% replacement rate is provided, which is a little higher than the 80% provided by the current system.

Comparing the two models based on the goodness-of-fit does not answer the research question we are addressing in this article, which is ensuring more equality in terms of profitability. Instead, we prefer using dispersion measures for such comparison. Figures 3 and 4 show the new distributions of the different scenarios according to their IRR.

Figure 3

IRR Vs. age of starting contributing and retirement age (model L1). The subplot (a) shows the IRR according to the year of starting contribution and the retirement age. The subplot (b) shows the distribution of the scenarios according to the IRR.



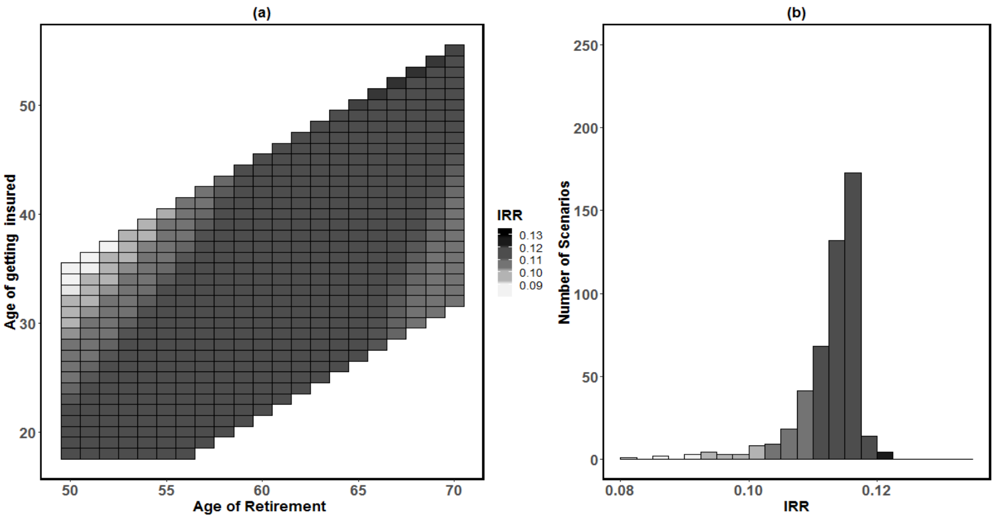
Figures 1 and 3 show high similarity, meaning that the model L1 does not reduce the dispersion of the IRRs compared to the current situation (model L0). Table 1 exposes this comparison with more evidence. The variances of the two distributions are almost similar, with 7.7e-05 and 7.55e-05 for L0 and L1, respectively. Compared to model L0, the minimum and maximum of the IRR distribution have slipped down but without affecting the mean, the median, and the interquartile and interdecile ranges of the distribution.

Table 1
The dispersion characteristics of the IRRs distribution under the different models

	L0	L1	L2
Max(%)	13.21	12.73	12.42
Min (%)	9.59	8.81	8.10
Mean (%)	11.49	11.49	11.45
Variance	7.70E-05	7.55E-05	2.79E-05
Q10 (%)	10.15	10.24	10.91
Q25 (%)	10.82	10.84	11.32
Q50 (%)	11.60	11.66	11.60
Q75 (%)	12.20	12.21	11.74
Q90 (%)	12.56	12.51	11.78

The model L2 allowed a large portion of the scenarios to converge toward the central IRR. As shown in Table 1, the variance of the distribution of IRRs fell to 2.79e-05. 80% of the examined scenarios result in an IRR ranging from 10.9% to 11.8%, while 50% of them lead to an IRR between 11.32% and 11.74%. Consequently, the interquartile distance narrowed to only 30% compared to its value under model L0. Also, results show that 60% of the IRRs range between 11.25% and 11.75%.

Figure 4
IRR Vs. age of starting contributing and retirement age (model L2). The subplot (a) shows the IRR according to the year of starting contribution and the retirement age. The subplot (b) shows the distribution of the scenarios according to their IRR.



What remains evident is that model L2 has significantly reduced the dispersion of the IRRs, which means better equality in terms of profitability for the retirees. Under some scenarios, however, even with model L2, excessively high or low IRRs are still obtained. In 10% of cases, IRR is above 11.8% and it is below 11% in nearly 12% of the examined scenarios. Eliminating these extreme scenarios returns to setting some eligibility conditions about the retirement age and the duration of contribution. To this end, we have to define a targeted IRR variation range. For example, if the targeted variation range is [11%, 12%], we will need to eliminate all the contribution-retirement scenarios leading to an IRR outside the defined interval.

Figure 5 shows the distribution of IRR as a function of the retirement age and the duration of contribution. Such visualizations would help greatly in deciding about the conditions to impose as a requirement for accessing retirement. Imposing a minimum contribution period of 20 years will cap the IRRs at 11.85% against 12.42% for 15 years. Figure 6 shows the distribution of the IRRs by the retirement age after eliminating the periods of contribution shorter than 20 years.

Figure 5
IRR Vs. retirement age (subplot a) and Vs. duration of contribution (subplot b), under model L2

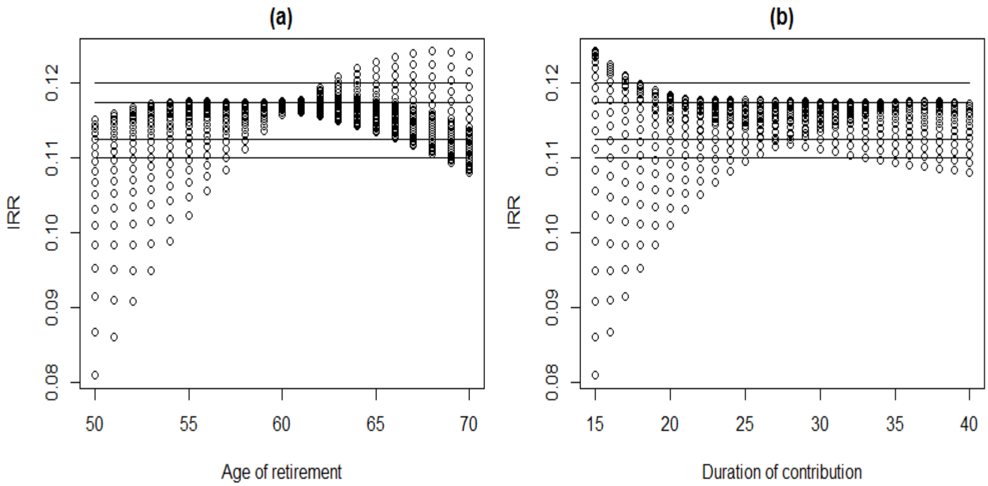
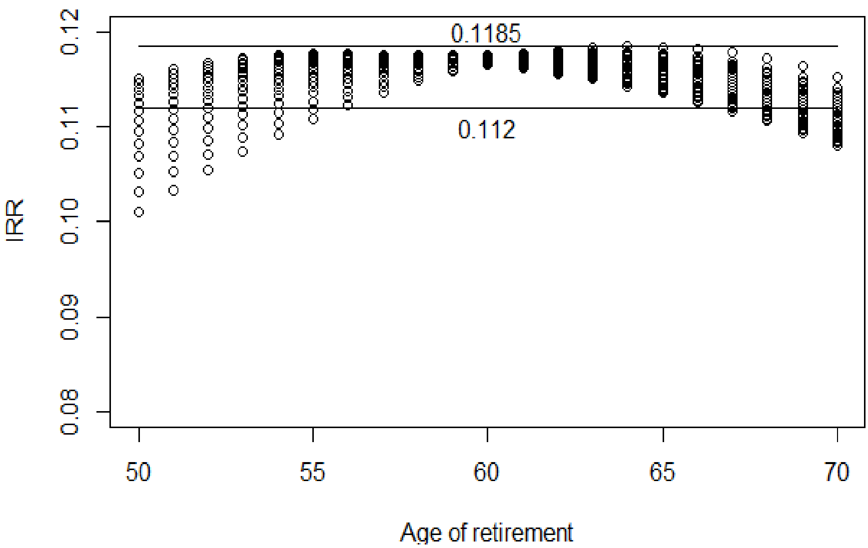


Figure 6
IRR Vs. retirement age for a duration of contribution of 20 years or longer



On the other hand, eliminating the IRRs below a fixed minimum (11.2% as an example) returns to impose a retirement age constraint, which must vary from 56 to 66 years old. Then, we can improve the concentration of the IRRs by making the retirement age close to 60 years. In the best scenario, retiring at age 60 with at least 20 years of contribution would result in an IRR ranging from 11.66% to 11.76%. Similarly, for a targeted IRR range of [11%, 12%], the duration of contribution required for getting access to retirement needs to be set at 18 years or longer with a retirement age from 56 to 68 years. Different combinations are also possible depending on the target range of the IRR.

CONCLUSION

Poverty-reducing is the ultimate objective behind maintaining the long-run financial sustainability of a retirement system. In Pay-As-You-Go retirement systems, pension benefits are defined based on the reference wage, the duration of contribution, and an annuity rate. Following economic and demographic changes, a readjustment of the pension parameters becomes necessary to keep the system sustainable. Such a formulation, as its parametric adjustment, can weaken the contribution-benefit linkage and, most importantly, distort equality between individuals within the system.

In this article, we have shown how the retirement formula in PAYG systems can lead to huge inequalities between the different contribution-retirement scenarios taken from the profitability point of view. Firstly, we defined all the possible combinations allowed in the Algerian retirement system considering the retirement age and the duration of contribution. We assumed that: 1) there is an automatic contribution to social security when starting working, 2) the contribution period is continuous and concentrated to the end of the working career, 3) all individuals aged x during the year t gain identical salaries, and 4) contribution rates are constant throughout the analysis. We assumed wages to keep growing in the future at 9.5% annually. The different contribution-retirement scenarios led to internal return rates (IRRs) varying between 9.6% to around 13.2% and an average value of 11.5%. Such a min-max gap of 3.6% might result in a significant gap in wealth accumulation over long periods.

The main objective of this article was to propose a new contribution-benefit linkage formula allowing a reduction of these observed inequalities. The idea was to use the actuarial fairness equation connecting the paid contributions and the expected retirement benefits and to derive a simplified expression of the first retirement benefit as a function of the final wage, the contribution duration and, eventually, the retirement age. To this end, we evaluated and compared two generalized linear models (GLMs). The first model relies on the duration of contribution to explain the ratio of the first pension benefits. The second one includes the retirement age in addition to the contribution duration.

Compared to the model solely based on the years of contribution, the one considering the retirement age decreased the dispersion of the IRRs distribution and narrowed the interquartile distance to only 30% of its initial length. Also, under the second model, a large proportion of the scenarios had an IRR between 11.2% and 11.85%. Then, regulating the requirements to access retirement will disallow the contribution-retirement careers leading to IRRs outside the desired interval. In our case, imposing 20 years as a minimum for the contribution duration and encouraging retirement at age 60 or nearly would help concentrate further the IRR toward 11.7% for all the retirees.

The methodology proposed in this paper can be generalized to other countries and contexts. In addition to its efficiency in reducing pension inequality, it represents a practical tool for defining the contribution-benefit linkage in PAYG retirement systems and designing parametric reforms. Indeed, the current practice regarding pension reforming suggests generally postponing the retirement age or reducing the annuity rate to balance the future incomes and outcomes of the system. Usually, a set of reform scenarios are considered to select the most favorable one. However, acting this way, there is a risk of not including the best possible reform combinations in the comparison process. Our method allows us to define the adequate re-parametrization of the system for any changes in the economic and demographic environments and a given (targeted) return rate.

In the end, it is worth recalling that this article did not address the effect of wage disparity on pension inequality nor that of parametric reforms. Also, we note that our findings build on a high inflation case, which implies a high salary evolution. Thus, the gap between the minimum and maximum return rates is high enough to make a significant difference regarding wealth accumulation over long periods. The proposed methodology needs further assessment in a low salary evolution context.

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Sažetak

PROMIŠLJANJE O POVEZANOSTI DOPRINOSA I NAKNADA U MIROVINSKIM SUSTAVIMA MEĐUGENERACIJSKE SOLIDARNOSTI NA TEMELJU PRIMJERA ALŽIRA

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U sustavima međugeneracijske solidarnosti (Pay-As-You-Go), mirovine proizlaze iz množenja referentne plaće s trajanjem doprinosa i stopom anuiteta. Ova se formulacija može podvrgnuti određenim prilagodbama kako bi se osigurala održivost u okruženju koje se mijenja. U ovom smo radu pokazali da trenutna veza doprinosa i naknada može stvoriti veliki jaz između pojedinaca u smislu profitabilnosti, a time i u smislu akumulacije bogatstva tijekom dugih razdoblja. Uzimajući u obzir moguće scenarije karijere u alžirskom mirovinskom sustavu, otkrili smo da stope povrata variraju od 9,6% do 13,2%. Kako bismo smanjili nejednakost, predlažemo novu formulu za mirovine koja se djelomično temelji na načelu aktuarske pravednosti.

Ključne riječi: umirovljenje, sustav međugeneracijske solidarnosti (PAYG), jednakost, IRR, scenarij, Alžir.