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# On the redesign of PAYG Retirement Systems: towards more generational and inter-generational equality


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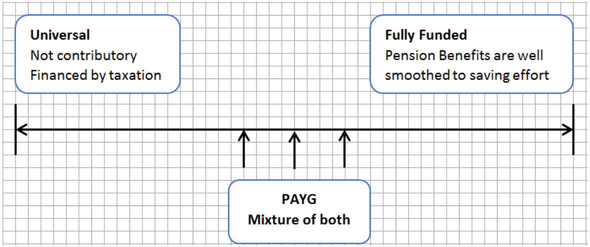
# Motivation

- PAYG retirement system tries to combine two objectives, i.e., Poverty alleviation and smoothing retirement benefits to saving efforts (Bovenberg and Van Ewijk, 2011a)




- This combination is arbitrarily defined in the midway between the two according to a set of cultural, historical, political factors (Bovenberg and Van Ewijk, 2011b)

# Motivation

- Retirement benefits in PAYG system are defined in function of :
  1. number of years of contribution
  2. an annuitization rate for each year of contribution
  3. The reference wage : final wage / average wage
  4. A penalty associated to each anticipated year before the normal age of retirement
- The final formula is fixed in an arbitrary way in order to keep the system sustainable.
- Such a practice (formula) is widely used over the world event arbitrary defined;
- That said, no technical formula behind;
- That may lead to some (huge) inequalities;

Our objective is :

- To visualize these inequalities;
- To adjust the retirement formula to reduce inequalities under economic and demographic evolution.
- We consider the Algerian male retirees (CNR) for a case study.

# Definition of inequality

- Inequality in our case is defined from the investment Return point of view (IRR);
- A working-Retirement career is taken as an investment cycle;
- Equality means that all individual within the system are supposed to benefit proximate IRRs;
- IRR is usually used to evaluate the overall generosity of a retirement system (Ben Brahem, 2009; Diseny, 2006; Reznik et al., 2009; Luthen, 2016);
- Here, IRR is used to compare the generosity of the system towards different retirement scenarios;

# Outline of the Talk

- Motivation
- Objective
- The Algerian pension system
- IRR as a measure of inequality
- The scenarios
- Optimization problem : Centering the IRRs
- GLM models : definition and estimation
- Final Results
- Concluding remarks

# Algerian Retirement System

- Type of Regimes
  1. Salaried workers regime (Caisse Nationale des Retraaites CNR)
  2. self-employed and employers regime (CASNOS)
- Salaried workers retirement regime
  - Age of retirement is 60 for men and 55 for women, but still flexible;
  - 15 years of contributions are required to access to retirement;
  - 32 years of contribution give access to full retirement, a replacement rate of 80%;
  - The final wage is averaged on the last (or best) 5 years wages during the working career;
- The first retirement benefit $RB_x$:

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

  - x: Age of retirement, n: years of contribution, $W_x$: salary at age x
- The $RB$ is annually upgraded by $rev = 5\%$ to smooth inflation.

# Evaluating inequalities within the Algerian PAYG system

- We define all the possible scenarios for working-retirement careers;

1. Age of starting work : 18 to 55
2. Year of retirement : 2015 to 2030
3. Number of years of contribution : 15 to 40
4. The total number of scenarios : 8120

We assume:

- All workers contribute for retirement;
- working career is continuous and is concentrated to the end of working age;
- Wages are equal for all workers aged $x$ during the year $t$

# IRR calculation : Whatś needed

- We set the age of getting into the contribution system as a time origin for the evaluation;
- The expected contributions and retirement benefits are to be discounted to this origin;
- The required information are:

- The present value of future contributions;
  - The age-time wage evolution;
  - The evolution of contribution rate for retirement;
  - The surviving function - Global population prospective life table;
- The present value of future retirement benefits;
  - The final wage (last five years average wage)
  - The annual revaluation rate of pension benefits (5%)
  - The surviving function - Retirees specific prospective life tables;

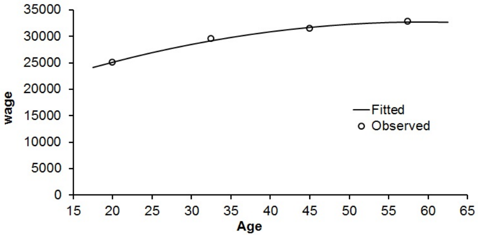
# Wage evolution

- Time evolution of the average salary by 9.5 % according to its evolution from 1990 to now

$$\bar{W}_{t+n} = \bar{W}_t * (1 + 9.5\%)^n$$

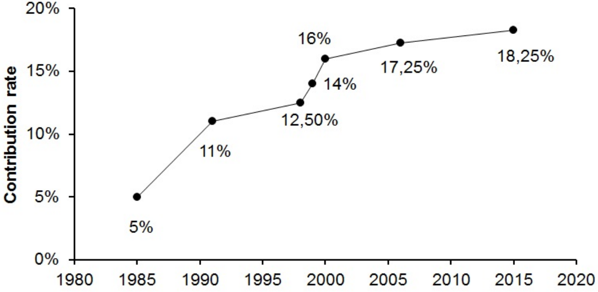
- A quadratic evolution over age (Workforce survey, ONS, 2011):

$$W_{(x,t)} = \bar{W}_t * (a + b * x + c * x^2)$$



# Evolution of contribution rates

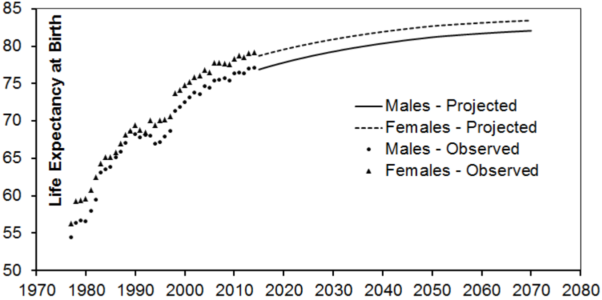
- Contribution rate for retirement has evolved from 5% in 1985 to 18.25% starting in 2016;




- We assume it to remain at 18.25 % in the future;

# Survival function - Contribution phase

- We use a global population mortality forecast (Flici, 2016) as an estimate of the surviving function during the contribution phase;

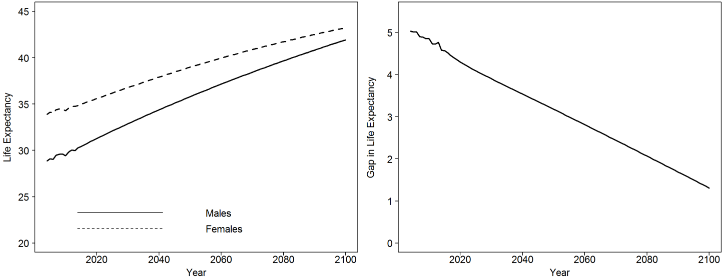




- Flici, F. 2016. Coherent mortality forecast for the Algerian population, Conference paper, Samos Conference on Actuarial Science and Finance.

# Survival function - payment phase

- We use the retirees specific prospective life tables (Flici and Planchet, 2019) as an estimate of the surviving function during the payment phase.




(a) (b)


- Flici, F. and Planchet, F. 2019. Experience prospective life tables for the Algerian retirees, Risks, 7 : ??:??.

# Calculate the IRR for each scenario

- for each scenario $i$, $IRR_i$ is calculated through an optimization problem.

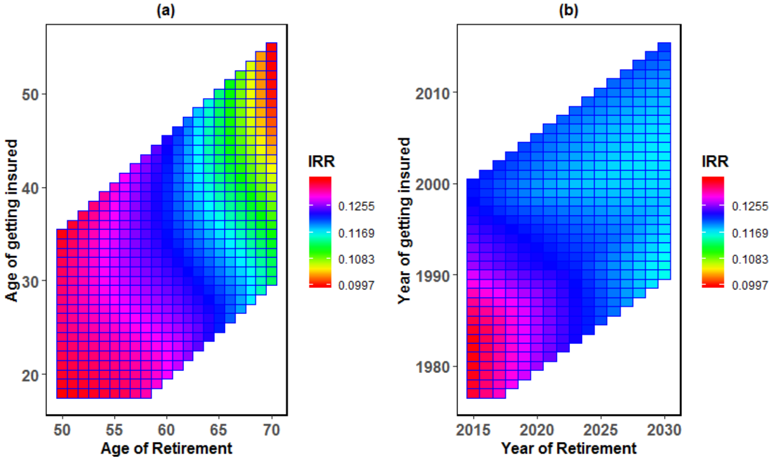
$$\sum_{m=x,k=t}^{x+r,t+r} CR_{m,k} * {}_{m-x,k-t}P^{g}_{x,t} * (1+irr)^{(r-k)} - \sum_{l=x+r,v=t+r}^{x+s,t+s} RB_{l,v} * r, rP^{g}_{x,t} * {}_{s-r,s-r}P^{e}_{x+r,t+r}$$

$$*(1+irr)^{-(v-t-r)} = 0$$

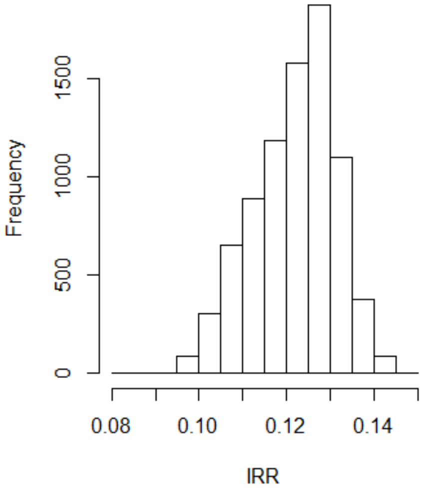
- With:
  - Annual Contribution for Retirement: $CR_{m,k} = W_{(m,k)} * CRR_t$
  - $P^g$, $P^e$ denote respectively the surviving probability issued from the Global population life tables and the Experience life table for retirees
  - $RB_{l,v}$ is the first retirement benefit calculated by: $2.5\% * n * (\frac{1}{5}\sum_{x-5,t-5}^{x-1,t-1} W_{m,k})$

# Results: IRR Vs Age Vs Year

- The average IRR is 12.05% varying in between 9.8% and 14.43%.



# Density plot: The distribution of scenarios Vs IRR



# How to deal with such inequality????

- The gap between the min IRR and the max IRR is evaluated at around 4.63%
- such a gap is supposed to results in a wider gap in term of wealth accumulation during the whole working-retirement cycle;

- The Question is:
  - How to reduce the IRR dispersion? or :
  - How to make all the working-retirement scenarios converging towards the average IRR?

- The solution can be:
  - by adjusting the retirement formula?
  - How?

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# Adjusting the retirement formula : The proposed model

- Our idea is:
  - To assume a common IRR for all the scenarios as a target;
  - To estimate the deserved retirement benefit time distribution;
  - We write the present value of future retirement benefits in function of the first retirement benefit (RB);
  - Then, we try to link $RB$ to finale wage ($W^*$) using generalized linear models GLM;
- recall that:

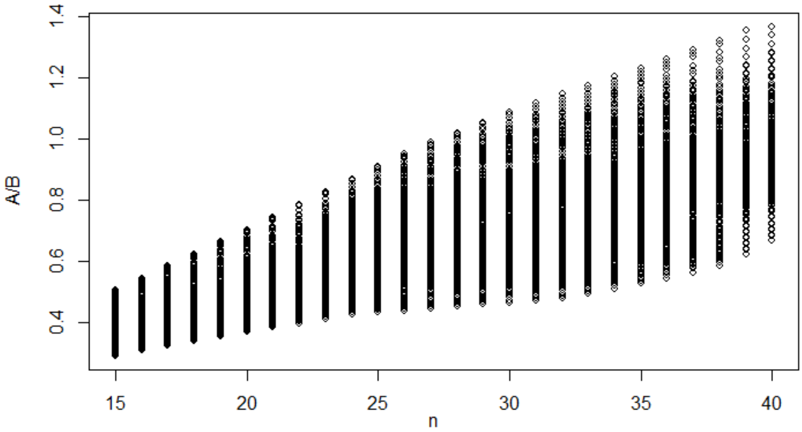
$$\sum_{m=x,k=t}^{x+r,t+r} CR_{m,k} * {}_{m-x,k-t}P^{g}_{x,t} * (1+irr)^{(r-k)} = \sum_{l=x+r,v=t+r}^{x+s,t+s} RB_{l,v} * r, rP^{g}_{x,t} * {}_{s-r,s-r}P^{e}_{x+r,t+r} * (1+irr)^{-(v-t-r)}$$

- We set:

$$A * w^* = B * RB_t => RB_t = \frac{A}{B} * w^*$$

- Now, letś visualize $\frac{A}{B}$ in function of $n$

# A/B Vs number of years of contribution



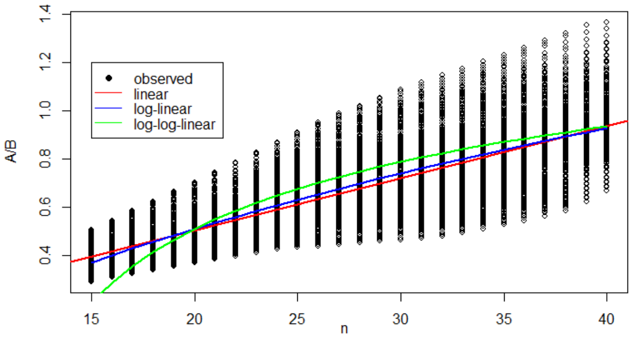
# Linking RB to final wage using GLM

- 3 models will be compared

- $\frac{\hat{A}}{B} = a_1 + b_1 * n$
- $\exp\left(\frac{\hat{A}}{B}\right) = a_2 + b_2 * n$
- $\exp\left(\exp\left(\frac{\hat{A}}{B}\right)\right) = a_3 + b_3 * n$

n : number of years of contributions

# Models evaluation




- The linear model provides the lowest SSE (Sum of Squared Errors):

$$Model(1) : RB = W^{*} * (7.17\% + 2.17\% * n)$$

# What if we want to improve the model : adding new variables

- Two variables model: years of contribution $(n)$ + age of retirement $(x)$
- Three variables model: years of contribution $(n)$ + age of retirement $(x)$ + year of retirement $(t)$

| | 2 variables GLM | 3 Variables GLM |
|---|---|---|
| model | $\frac{\hat{A}}{B} = a_4 + b_4 * n + c_4 * x$ | $\frac{\hat{A}}{B} = a_5 + b_5 * n + c_5 * x + d_5 * t$ |
| log model | $\exp\left(\frac{\hat{A}}{B}\right) = a_6 + b_6 * n + c_6 * x$ | $\exp\left(\frac{\hat{A}}{B}\right) = a_7 + b_7 * n + c_7 * x + d_7 * t$ |

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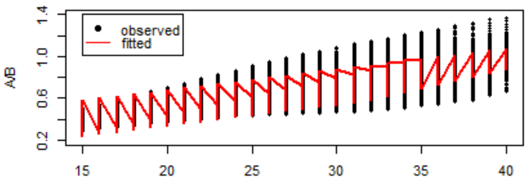
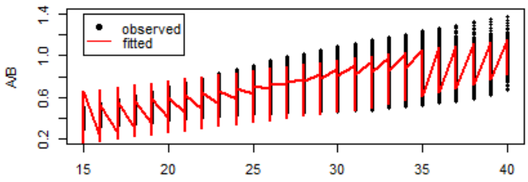
# Model comparison

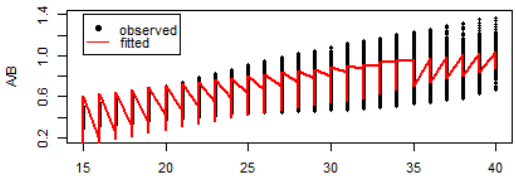
$$\frac{\hat{A}}{B} = a_4 + b_4 * n + c_4 * x$$



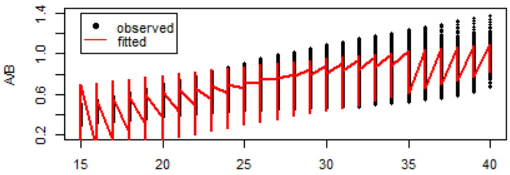

$$\frac{\hat{A}}{B} = a_5 + b_5 * n + c_5 * x + d_5 * t$$




$$\exp\left(\frac{\hat{A}}{B}\right) = a_6 + b_6 * n + c_6 * x$$

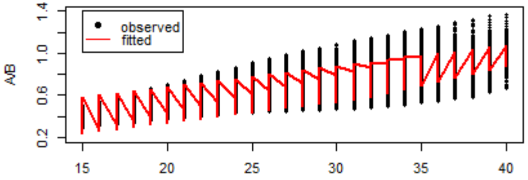



$$\exp\left(\frac{\hat{A}}{B}\right) = a_7 + b_7 * n + c_7 * x + d_7 * t$$

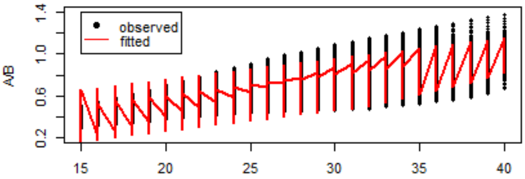


# Model comparison

$$\frac{\hat{A}}{B} = a_4 + b_4 * n + c_4 * x$$

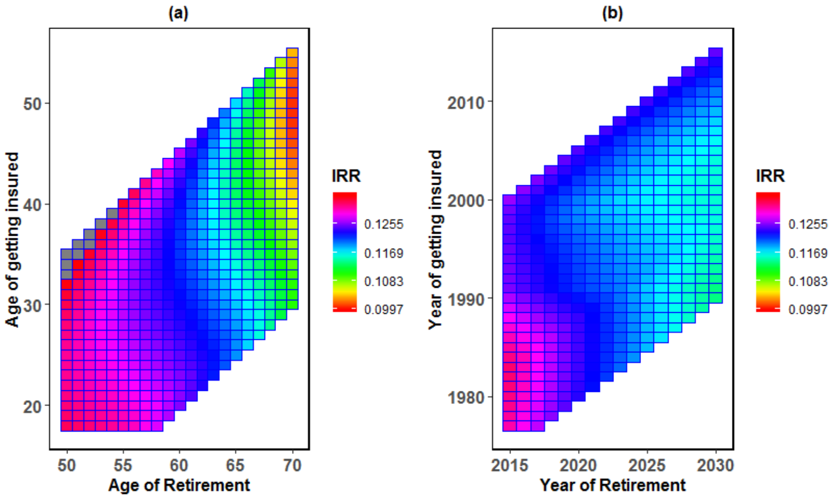



$$\frac{\hat{A}}{B} = a_5 + b_5 * n + c_5 * x + d_5 * t$$

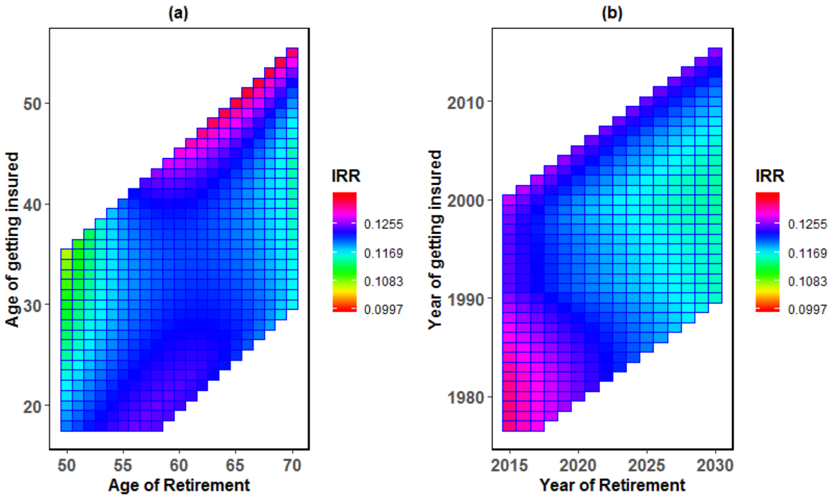



- The best models are:
  - $\frac{\hat{A}}{B} = 41\% + 2\% * (n - 15) + 1.75\% * (x - 60)$ (Model (2))
  - $\frac{\hat{A}}{B} = 33.5\% + 2 * \% * (n - 15) + 1.75\% * (x - 60) + 1\% * (t - 2015)$ (Model (3))

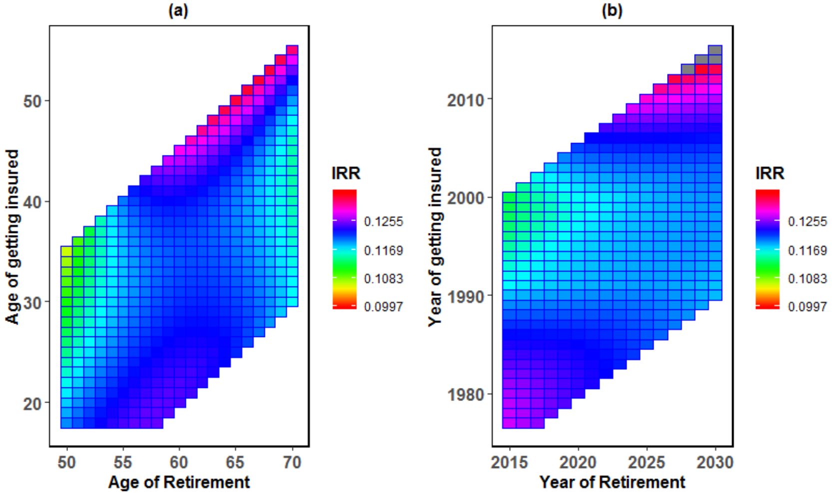
# IRR plot : Model(1)



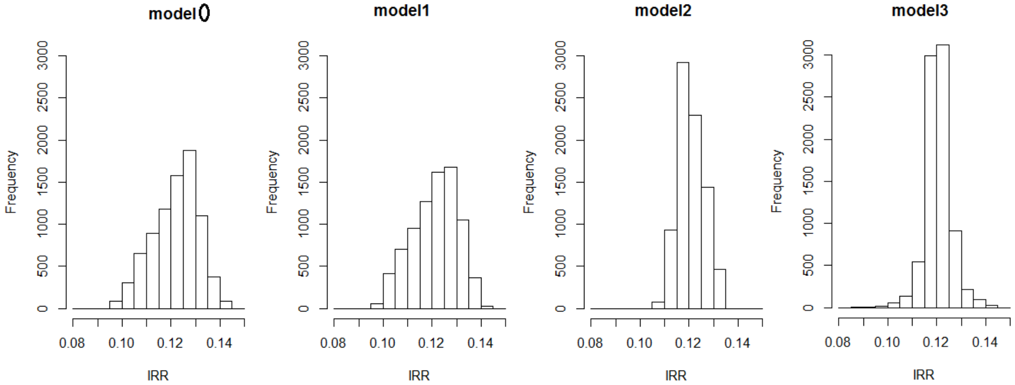
# IRR plot : Model (2)



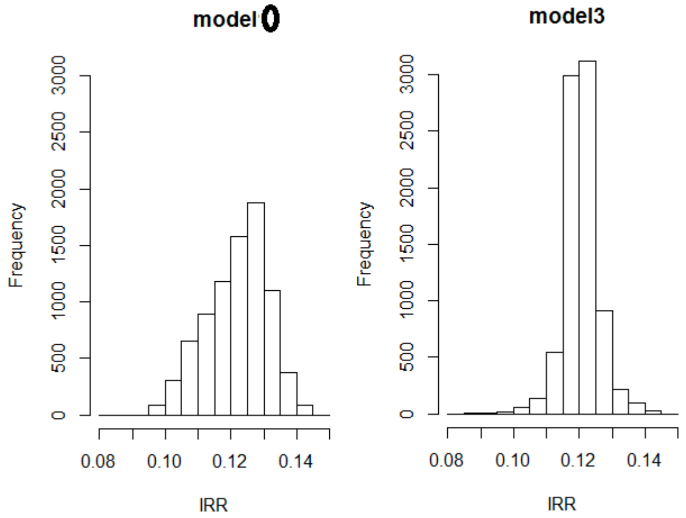
# IRR plot : Model (3)



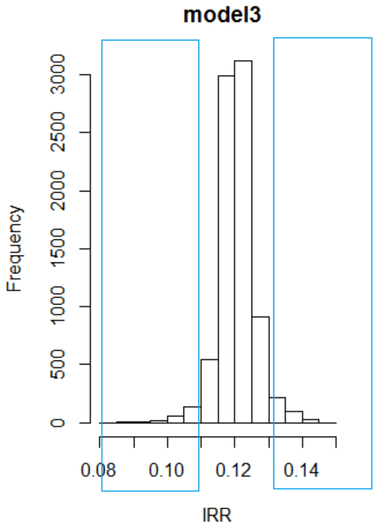
# Scenarios Vs IRR : model comparison



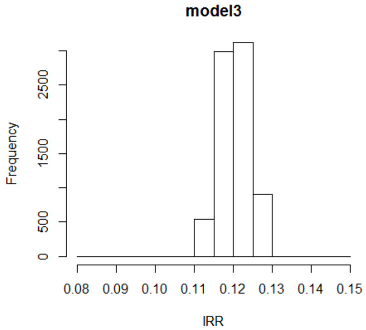
# Scenarios Vs IRR : model comparison

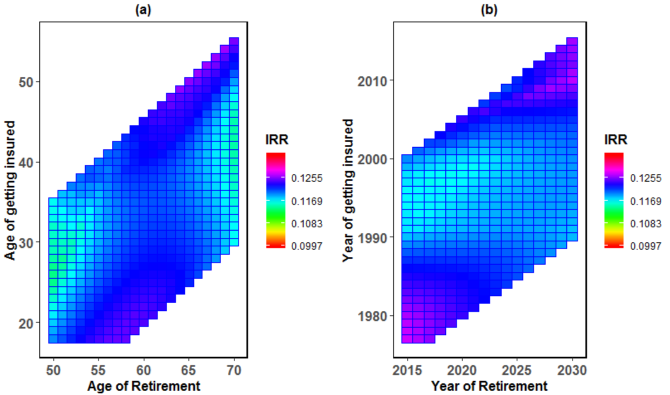


# Scenarios Vs IRR : model comparison



# Eliminating extreme scenarios



# Main recommendations

- There are mainly two points to highlight:
  - Set the minimum years of contribution for getting retired at 25 years or higher;
  - a big part of the inequality is due to the revision of revision of the CRR from 5% to 11% in 1991. Thus, some adjustment is needed between the generations having started contributing after 1991 and those before;

# Conclusion

- As a conclusion:
  - The classical PAYG retirement formula can lead to important inequalities regarding the individual IRR;
  - We have proposed a new formula allowing to reduce inequalities while considering the past and future improvement in demographic and economic factor;
  - However, some regulation is needed to eliminate the extreme scenarios;
- Further ways for research
  - Extend the model to male-female populations;
  - Consider the case of steady time wages evolution;
  - Consider the case of wages inequality;

Thank you for your attention !

Enjoy your stay in Cape Town

- If you have any remarks : farid.flici@cread.dz

Actuarial Demography Team