Economic and demographic risks for pay-as-you-go pension schemes: Defined Benefit versus Defined Contribution

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Structure

Motivation

Public pension systems are usually financed on a pay-as-you-go (PAYG) basis where pensions for retirees are paid by the contributions of the working-age population.

- As a result of an increase in life expectancy, pensions are paid over a longer time horizon. Also, a decrease in birth rate makes pension system unsustainable. (SUSTAINABILITY)
- A common trend in European countries has been a wave of parametric or even structural reforms, by changing the formula to calculate the pension from a DB to a DC scheme (Whitehouse 2012). (FAIRNESS)
- According to European Commmission, pension systems can be expected to deliver adequate pensions to future generations of retirees. (ADEQUACY)

Aim of the paper

- To analyse, from a theoretical point of view, how different pension designs (DB versus DC) react to economic and demographic risks (by means of population projections, salary growth, replacement rate...) that affect the financial sustainability of pension scheme.
- To design different strategies (Risk-sharing mechanisms - RSs), that involve changes in the key variables of the system (indexation of pensions, contribution rate) to restore the sustainability.
- To analyse different designs of pension systems (DB and DC) in terms of Sustainability, Adequacy and Fairness.

Structure

Introduction

According to OECD (2015), there are three challenges for pension systems:

- Adequate income for pensioners in the retirement phase.
- A fair level of benefits in relation to the contributions paid (actuarial fairness)
- Sustainable pension system in the long run.

Introduction

DC PAYG pension systems (also called NDCs) have some positive features:

- High level of transparency and a degree of credibility.
- Better relationship benefit-contribution (fairness).
- NDC's face the population ageing more or less automatically.

However these schemes do not guarantee sustainability, due to the PAYG nature (Valdés-Prieto (2000) and Palmer (2013)), or secure an adequate level of benefits.
This research analyses how different pension designs (DB versus DC) react in terms of sustainability, adequacy and fairness. Also, after restoring sustainability through ABMs we explore adequacy and fairness.

Structure

The steady state

In the steady state, the income from contributions at time t, C_t, and the pension expenditures P_t are given as follows:

$$C_t = \overbrace{\pi}^{\text{Cont rate}} \sum_{x=x_0}^{x_r-1} \overbrace{W_t^x}^{\text{Wages}} \overbrace{N_t^x}^{\text{Working pop}} = C_{t-1}(1+g)(1+n) \tag{1}$$

$$P_t = \sum_{x=x_r}^{\omega-1} \underbrace{P_t^x}_{\text{Pensions}} \underbrace{N_t^x}_{\text{Retired pop}} = P_{t-1}(1+g)(1+n) \tag{2}$$

where,
x_0 is the entry age into the labour market, and x_r represents the retirement age.
$\omega - 1$ is the maximum life span for an individual.
g and n are the growth of salaries and population respectively.

The steady state

Remark

When π is chosen such that $C_0 = P_0$:

$$\pi = \frac{\sum_{x=x_0}^{x_r-1} W_0^x N_0^x}{\sum_{x=x_r}^{\omega-1} P_0^x N_0^x}$$

In the steady state, the liquidity ratio is then equal to 1 for any choice of replacement rate and indexation rate:

$$LR_t = \frac{C_t + F_t^-}{P_t} = \frac{C_0 + \overbrace{(C_0 - P_0)}^{=0}(1+i)^t \frac{\left(\frac{(1+g)(1+n)}{1+i}\right)^{t+1} - 1}{\frac{(1+g)(1+n)}{1+i} - 1}}{P_0} = 1$$

A more general case: Dynamic OLG model

- Population is dynamic: entries and mortality change over time;
- Growth of wages, indexation of pensions and notional rate are time-dependent;

$\rightarrow$ The PAYG liquidity indicator is no longer equal to one.

$$LR_t = \frac{C_t + F_t^-}{P_t}, \tag{3}$$

where
C_t and P_t represent the total income from contributions and pension expenditures at t.
F_t^- represents the value of the buffer fund at t before new contributions and benefits are included.
$\Rightarrow$ Indexation and contribution rate can be adjusted to attain liquidity.

Risk sharing mechanism

- Let $\beta_t \in [0, 1]$ be the time-dependent risk-sharing coefficient between the contributors and the pensioners;
- Let D_t be the difference between income and expenditures, that is, $C_t - P_t$
- The government can share the burden between the contributors and pensioners as follows:
  - $\beta_t D_t$ is the share of the surplus/deficit borne by the contributors, and
  - $(1 - \beta_t) D_t$ is the share of the surplus/deficit borne by the pensioners.

Risk sharing mechanism (Ctd)

Table: Overview of variables pre Risk Sharing

	Pre Risk-Sharing
Contribution rate	π_{t-1}
Income from contributions	$C_t^* = \pi_{t-1} \sum_{x=x_0}^{x_r-1} W_t^x N_t^x$
Indexation rate	λ_t^*
Pension expenditures	$P_t^* = P_t^{x_r} N_t^{x_r} + \sum_{x=x_r+1}^{\omega-1} P_{t-1}^{x-1} (1+\lambda_t^*) N_t^x$
Liquidity ratio	$LR_t^* = \frac{C_t^*}{P_t^*}$

π_{t-1} corresponds to the contribution rate in the previous period
λ_t^* corresponds to the indexation rate according to the legislation.

Risk sharing mechanism (Ctd)

Table: Overview of variables post Risk Sharing

	Post Risk-sharing
Contribution rate	$\pi_t = \pi_{t-1}(1+\alpha_t^{\pi})$
Income from contributions	$C_t = \pi_t \sum_{x=x_0}^{x_r-1} W_t^x N_t^x$
Indexation rate	$\lambda_t = (1+\lambda_t^*)(1+\alpha_t^{\lambda}) - 1$
Pension expenditures	$P_t = P_t^{x_r} N_t^{x_r} + \sum_{x=x_r+1}^{\omega-1} P_{t-1}^{x-1}(1+\lambda_t) N_t^x$
Liquidity ratio	$LR_t = \frac{C_t}{P_t}$

α_t^{π} (resp. α_t^{λ}) is the rate of increase of the contribution rate (resp. indexation rate) after risk-sharing.

Risk-Sharing Result

Proposition (Risk-sharing)

The automatic balancing mechanisms related to the contribution rate, α_t^{π}, and related to the indexation rate, α_t^{λ}, are represented as follows:

$$\alpha_t^{\pi} = \beta_t \left(\frac{1 - LR_t^*}{LR_t^*} \right), \tag{4}$$

$$\alpha_t^{\lambda} = \beta_t + (1 - \beta_t) \frac{C_t^* - P_t^{x_r} N_t^{x_r}}{P_t^* - P_t^{x_r} N_t^{x_r}} - 1, \tag{5}$$

Risk-Sharing Result (Ctd)

Corollary (Particular cases: $\beta_t = 0$ and $\beta_t = 1$)

- *When the risk-sharing coefficient* $\beta_t = 0$ (4) *and* (5) *become:*

$$\alpha_t^{\pi} = 0,$$
$$\alpha_t^{\lambda} = \frac{C_t^* - P_t^{x_r} N_t^{x_r}}{P_t^* - P_t^{x_r} N_t^{x_r}} - 1.$$

- *Alternatively, when the risk-sharing coefficient* $\beta_t = 1$ (4) *and* (5) *become:*

$$\alpha_t^{\pi} = \frac{1 - LR_t^*}{LR_t^*},$$
$$\alpha_t^{\lambda} = 0.$$

Structure

Hypotheses

Data and assumptions

- Individuals join the labour market at age 20
- Fixed retirement age is 65
- Population structure and salary growth: Belgium data
- Mortality: Historical from HMD and prospective tables for the future
- Immigration: Entries are assumed to happen only at age 20
- Contribution rate for both DB and DC coincides with the balanced contribution rate for the DB scheme in 2016
- No minimum or maximum pensions are considered.
- The risk-sharing mechanisms are symmetric, that is, no funds are accumulated after introducing the RSs.

Pension schemes studied

DB:

$$P_t^{x_r} = 60\% \cdot \frac{\sum_{x=x_0}^{x_r-1} W_{t-x_r+x}^{x} \prod_{j=t-x_r+x+1}^{t} (1+g_j)}{x_r - x_0}$$

DC individual:

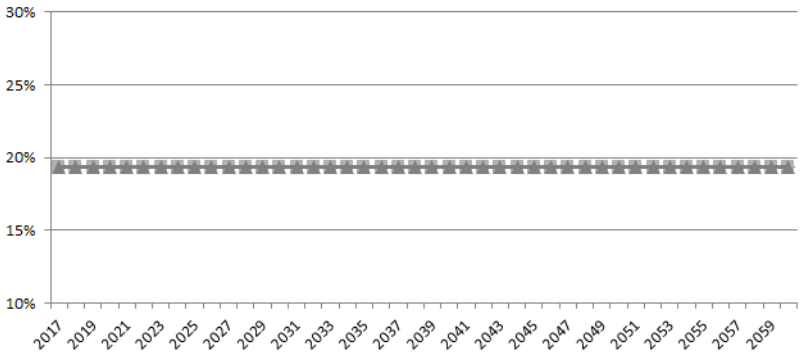
$$P_t^{x_r} = \frac{NC_{indiv,t}^{x_r}}{a_{x_r;t}} = \frac{\sum_{x=x_0}^{x_r-1} \pi_{t-x_r+x} W_{t-x_r+x}^{x} \prod_{i=t-x_r+x+1}^{t} (1+nr_i)}{a_{x_r;t}}$$

DC with inheritance gains:

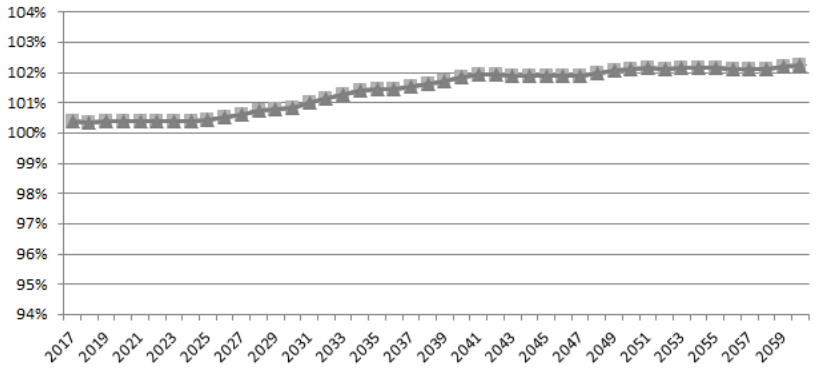
$$P_t^{x_r} = \frac{NC_{cohort,t}^{x_r}}{a_{x_r;t} N_t^{x_r}} = \frac{\sum_{x=x_0}^{x_r-1} \pi_{t-x_r+x} W_{t-x_r+x}^{x} N_{t-x_r+x}^{x} \prod_{i=t-x_r+x+1}^{t} (1+nr_i)}{a_{x_r;t} N_t^{x_r}}$$

Numerical example: No RS

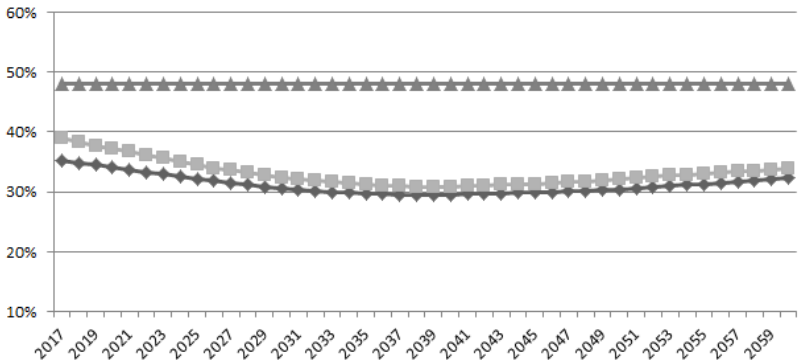
a) Contribution rate



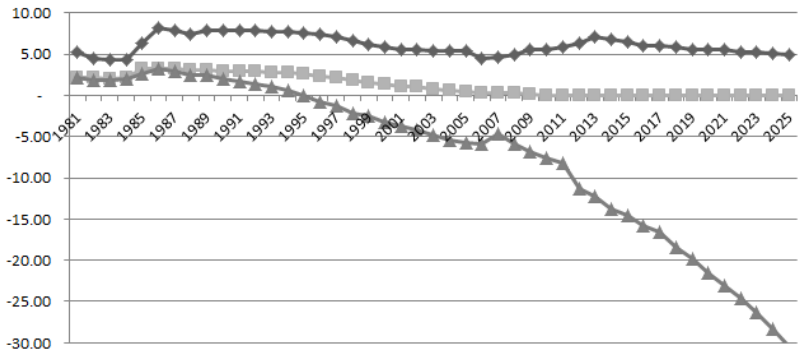
b) Indexation rate



c) Replacement rate at 65

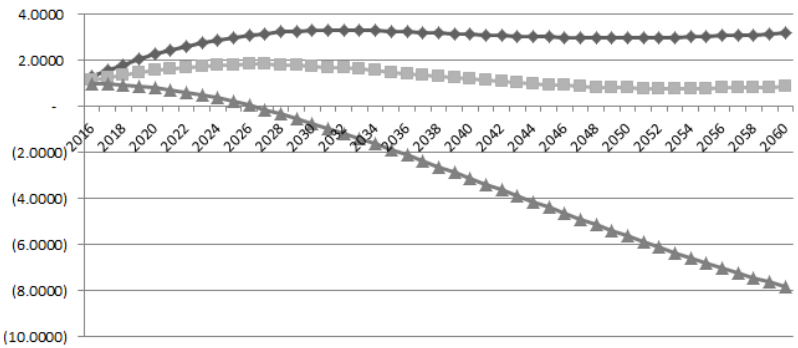


d) Actuarial fairness

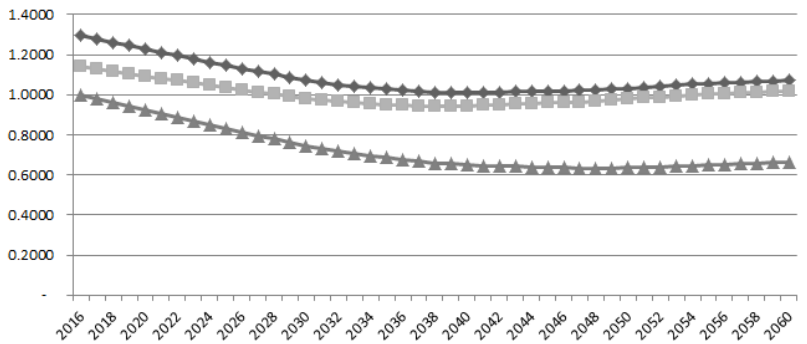


Numerical example: No RS - Liquidity

a) Liquidity rate with fund



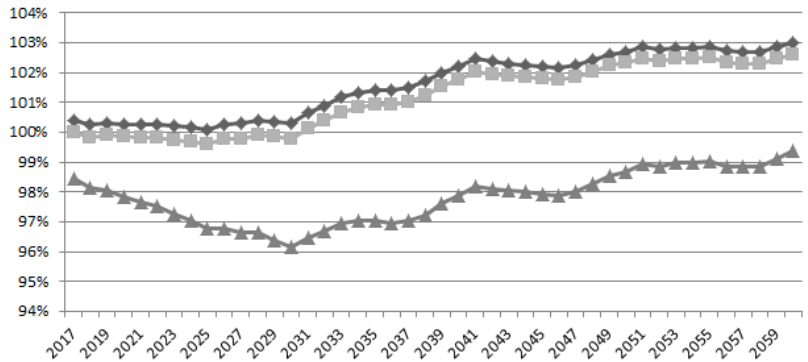
b) Liquidity rate without fund



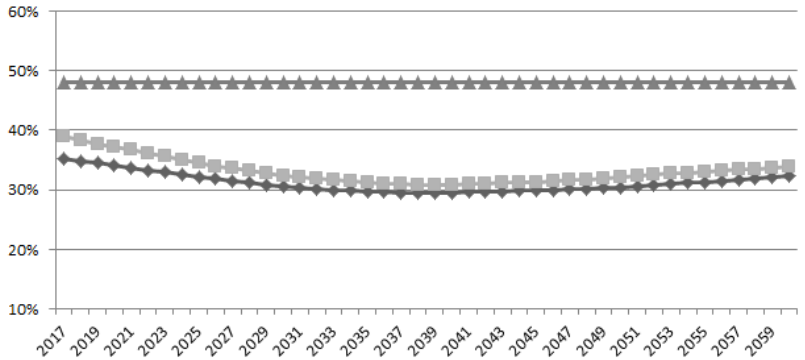
- The DB scheme is highly in deficit!
- The DC start accumulating surplus very early on.

Numerical example: RS on the indexation rate

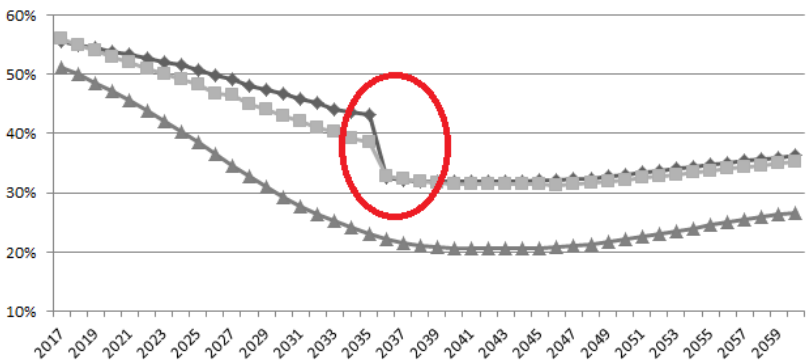
a) Indexation rate



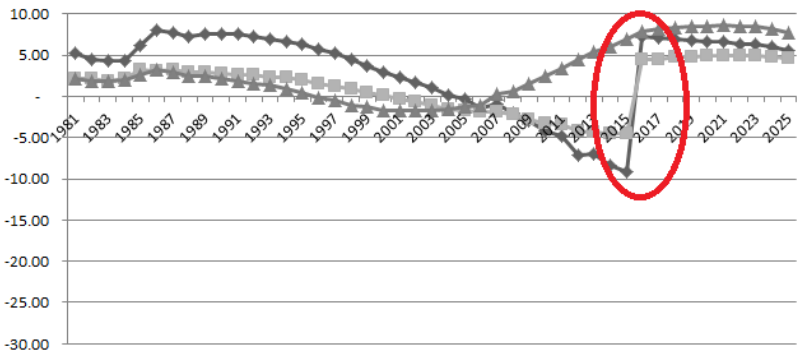
b) Replacement rate at 65



c) Replacement rate at 85



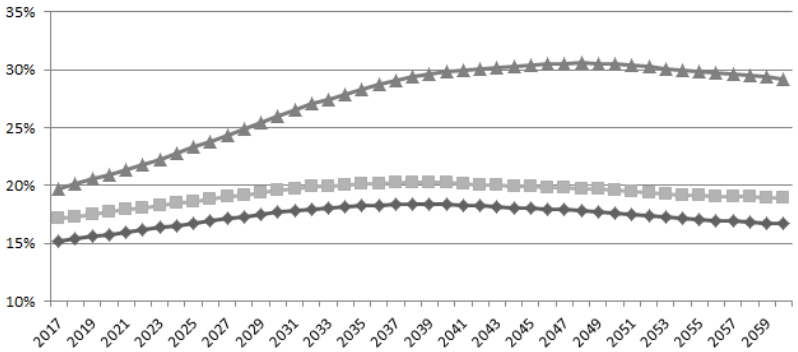
d) Actuarial fairness



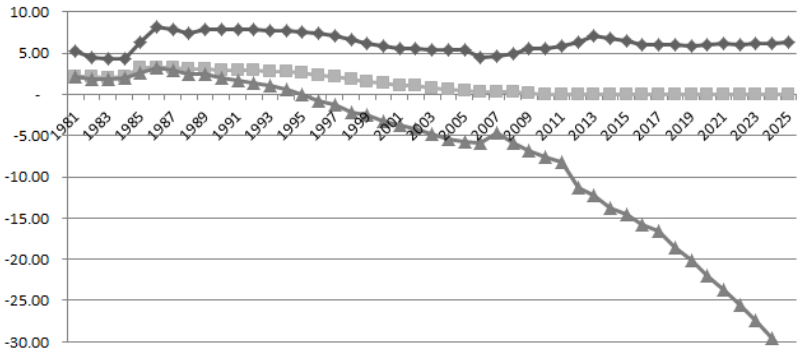
DC-indiv DC-inheritance DB

Numerical example: RS on the contribution rate

a) Contribution rate



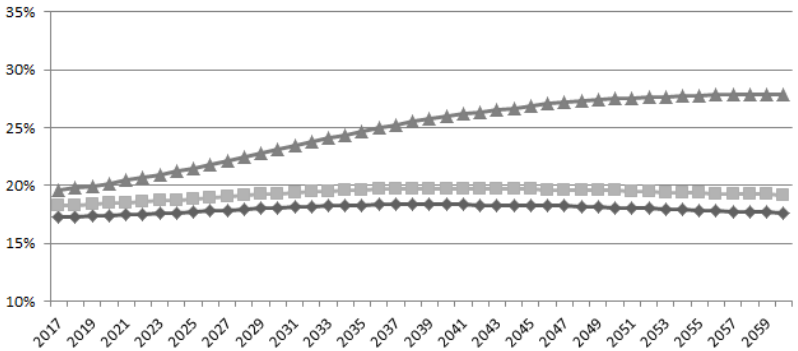
b) Actuarial fairness



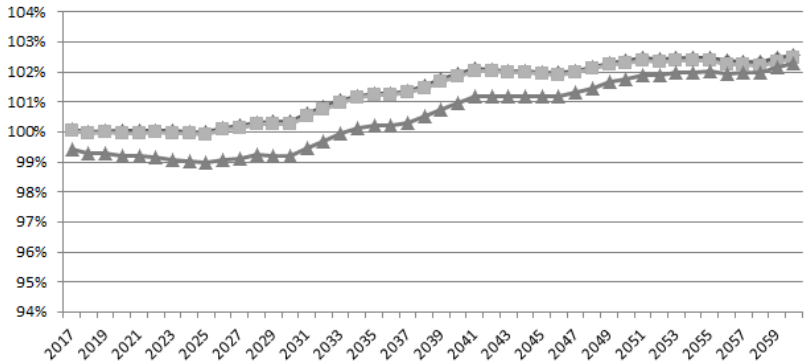
The replacement rates do not change as we do not alter the indexation

Numerical example: RS 50%-50%

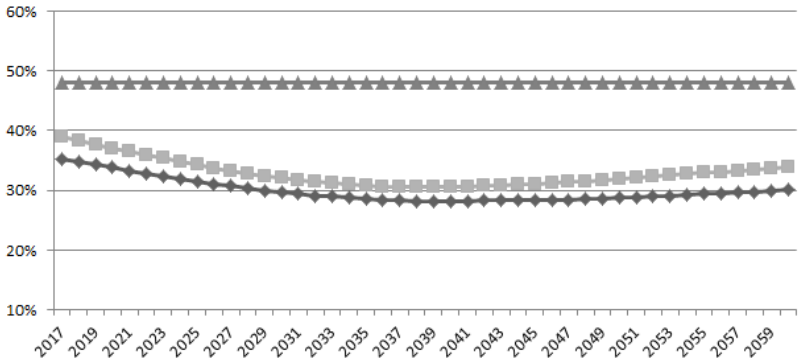
a) Contribution rate



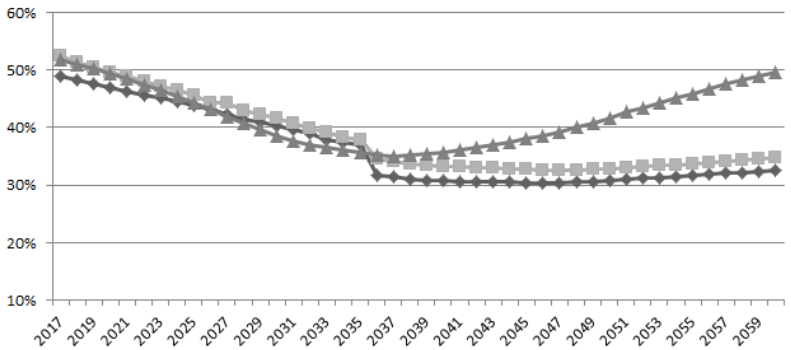
b) Indexation rate



c) Replacement rate at 65



d) Replacement rate at 85



DC-indiv DC-inheritance DB

Structure

Concluding comments

- The challenge of balancing sustainability and adequacy are becoming more important in most countries. Structural reforms from DB to DC also open the debate on fairness.
- This paper presents a **flexible** risk-sharing mechanism on the contribution and indexation rate.
- In general, in terms of adequacy it seems that the DB pension system is better for the individuals. However the DC scheme performs better in terms of fairness and sustainability.
- However, if we adjust the indexation rate in order to attain sustainability $\rightarrow$ the DC with inheritance and DB have comparable fairness and adequacy properties.

Further research

- Analyse the consequences of different shocks into the DB and DC pension schemes.
- Study different combinations of mechanism involving other variables such the retirement age and replacement rate
- Optimal share of risk which guarantee intra en inter generational fairness.

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Thanks

Thanks for your attention

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