Pension indexation and Intergenerational risk sharing in pay-as-you-go pension schemes

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Outline

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- 2. Optimization model
- 3. Numerical illustration
- 4. Conclusions

Reference :

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1. Motivation

A complicated combination for social security pension schemes in many countries :

DB + PAYG + Aging

3 main challenges to address simultaneously :

- *financial sustainability*
- *social adequacy*
- *fairness / equity*
    - *inter generation*
    - *intra generation*

Dependency ratio

	2022	2070
Be	**33,7**	**53,0**
NL	34,3	56,3
D	37,4	55,0
FR	38,2	57,8
SE	36,0	50,4
IT	40,8	65,5
EU	**36,1**	**59,1**

Demographic Dependency ratio = population 65+ / population 20-64

Aging report 2024

PAYG Equilibrium Equation

Incomes :

$A(t)$ = number of contributors at time t

$S(t)$ = mean salary

$\pi(t)$ = (implicit) contribution rate

$$IN(t) = A(t).\pi(t).S(t)$$

PAYG Equilibrium Equation

Outcomes :

$$B(t) = \text{number of retirees at time } t$$

$$P(t) = \text{mean pension}$$

$$\delta(t) = \text{benefit ratio} = \frac{P(t)}{S(t)}$$

↓

$$OUT(t) = B(t).P(t) = B(t).\delta(t).S(t)$$

PAYG Equilibrium Equation

Actuarial equilibrium :

$$IN(t) = OUT(t)$$

$$A(t).\pi(t).S(t) = B(t).P(t)$$

$$\pi(t) = \frac{B(t)}{A(t)} \cdot \frac{P(t)}{S(t)}$$

$$D(t) = \frac{B(t)}{A(t)} = \text{dependence ratio}$$

$$\delta(t) = \text{benefit ratio}$$

PAYG Equilibrium Equation

$$\pi(t) = \frac{\text{number of retirees}}{\text{number of contributors}} \times \frac{\text{mean pension}}{\text{mean wage}}$$

Demographic risk

Financing the system

Generation of active people

Social quality of the system

Generation of retirees

$$\pi(t) = D(t).\delta(t)$$

Automatic Adjustment Mechanism(AAM)

$$\pi(t) = \frac{B(t)}{A(t)} \cdot \frac{P(t)}{S(t)} = D(t) \cdot \frac{P(t)}{S(t)} = D(t) \cdot \delta(t)$$

Risk factor

- One equation
- 2 variables

Automatic Adjustment Mechanism :

In order to maintain financial sustainability
how to guarantee automatically this equilibrium
in case of change of D(t) (*! Aging effect* !)

The classical answer - DB or DC

$$\pi(t) = \frac{B(t)}{A(t)} \cdot \frac{P(t)}{S(t)} = D(t).\frac{P(t)}{S(t)} = D(t).\delta(t)$$

Risk factor

Constant in pure DC

Adjustment of δ

Social risk

Constant in pure DB

Adjustment of π

Financial risk

- **DB** : risks borne by the active workers

  (*sustainability challenge*)

- **DC** : risks borne by the retirees

  (*adequacy challenge*)

↓

- **Risk sharing** between generations ?

- Intermediate solutions between DB and DC ?

Literature

- General principles of Automatic Balance Mechanisms
  Vidal-Melia et al. (2009)
  Boado- Penas et al. (2020)

- Literature on risk sharing mechanisms in PAYG for given pension architecture
  Knell(2010)
  Godinez-Olivares et al.(2016 a / 2016 b)
  Alonso-Garcia et al. (2018a)
  Alonso-Garcia /Devolder (2019)

- Hybrid pension schemes
  Musgrave (1981)
  Schokkaert et al (2020)

In this paper , special focus on the indexation of pension as a potential automatic balance mechanism

Our proposal

Sharing the demographic and economic risks between generations in two ways (double automatic adjustment mechanism)

LEVEL 1 : **sharing the aging risk between workers and retirees**

$$\pi(t) = D(t).\delta(t)$$

A shock on the dependency ratio will affect jointly the benefit ratio and the contribution rate (*and not just the benefit ratio (DC) or just the contribution rate(DB)*) .

This first level will give us each year a mean benefit ratio $\delta(t)$
This mean benefit ratio is the consequence of decisions on pension :

- *for the new retirees (first pension / replacement rate)*
- *for the old retirees (revaluation/indexation of pension of the previous year)*

Our proposal

<u>LEVEL 2</u> : sharing the benefit risk between the new and the old retirees through adapted indexation

$$\delta(t)$$

$$\tilde{\delta}(t) \qquad \beta(t)$$

Replacement rate
New retirees

$$P(x_r, t) = \tilde{\delta}(t).S(t)$$

Sustainability factor
Old retirees

$$P(x, t) = P(x-1, t-1).\frac{S(t)}{S(t-1)}\beta(t)$$

Our proposal

LINK BETWEEN LEVEL 1 AND LEVEL 2 :

When the sustainability factor and the replacement rate are given ,
the mean benefit ratio can be computed for a given structure of population

Relation :

The cross sectional benefit ratio $\delta(t)$ represents the weighted average of the cohort –specific past replacement rates $\tilde{\delta}(.)$ modified by the successive sustainability factors $\beta(.)$

$$\delta(t) = \tilde{\delta}(t).l_{x_r,t} + \sum_{x=x_r+1}^{\omega} \tilde{\delta}(t-(x-x_r)).\left(\prod_{s=t}^{t-(x-(x_r+1))} \beta(s)\right).l_{x\ ,t}$$

Density of retirees by age

Our proposal

EXTREME CASES / LEVEL 1 :

Defined Benefit :

$$\delta(t) = \delta_0$$

$$\pi(t) = \delta_0 . D(t)$$

Defined Contribution :

$$\pi(t) = \pi_0$$

$$\delta(t) = \pi_0 / D(t)$$

Our proposal

PARTICULAR CASES / LEVEL 2 :

Protection of the old retirees :

$\beta(t) = 1$: full indexation

$\tilde{\delta}(t)$ to be adjusted to fulfill condition on $\delta(t)$

Solidarity between all the retirees :

$\tilde{\delta}(t) = \delta(t)$

$$\beta(t) = \frac{\delta(t)}{\delta(t-1)}$$

Protection of the new retirees :

$\tilde{\delta}(t) = \delta_0$: guaranteed initial replacement rate

$\beta(t)$ to be adjusted to fulfill condition on $\delta(t)$

2. Optimization model

Optimal risk sharing between workers and retirees (first level)
and between old and new retirees (second level)

Objective function : penalisation of the distance between the parameters and target values (*quadratic optimization – see Cairns (2000)*)

First level : relative stability of the benefit ratio and the contribution rate around equilibrium values

$$\min_{\pi(t),\delta(t)} \left(\rho_t . \left(\frac{\pi(t)}{\overline{\pi}} - 1 \right)^2 + (1-\rho_t).D(t).\left(\frac{\delta(t)}{\overline{\delta}} - 1 \right)^2 \right)$$

Weight-parameter

Democratic proportion
Between retirees and workers

Optimal first level

Solution :

$$\delta^*(t) = \bar{\delta}.\bar{\pi}.\frac{\rho_t.\bar{\delta} + (1-\rho_t).\bar{\pi}}{\rho_t.D(t).\bar{\delta}^2 + (1-\rho_t).\bar{\pi}^2}$$

$$\pi^*(t) = \delta^*(t).D(t)$$

Natural choice for the target :

Example : not deviate too much from initial values !

$$\bar{\delta} = \delta_0$$

$$\bar{\pi} = \pi_0$$

Optimal second level

Optimal risk sharing between workers and retirees (first level)
and between old and new retirees (second level)

<u>Second level : relative stability of the benefit ratio and the contribution rate around equilibrium values</u>

$$\min_{\pi(t),\delta(t)}\left(\eta_t.\left(\frac{\beta(t)}{\overline{\beta}(t)}-1\right)^2+(1-\eta_t).\frac{l_{x_r,t}}{\sum_{x>x_r} l_{x,t}}.\left(\frac{\tilde{\delta}(t)}{\overline{\tilde{\delta}}(t)}-1\right)^2\right)$$

Weight-parameter

Democratic proportion between the retirees

Optimal second level

Solution :

$$\beta^*(t)=\bar{\beta}(t)\frac{\eta_t\bar{\tilde{\delta}}(t)^2.l^2_{x_r t}+(1-\eta_t)\alpha(t).\bar{\beta}(t).D_{x_r,t}(\delta(t)-\bar{\tilde{\delta}}(t)l_{x_r,t})}{\eta_t\bar{\tilde{\delta}}(t)^2.l^2_{x_r t}+(1-\eta_t)\alpha^2(t).\bar{\beta}^2(t).D_{x_r,t}}$$

$$\tilde{\delta}^*(t)=\bar{\tilde{\delta}}(t)\frac{\eta_t\bar{\tilde{\delta}}(t).l_{x_r t}(\delta(t)-\alpha(t).\bar{\beta}(t))+(1-\eta_t)\alpha^2(t).\bar{\beta}^2(t).D_{x_r,t}}{\eta_t\bar{\tilde{\delta}}(t)^2.l^2_{x_r t}+(1-\eta_t)\alpha^2(t).\bar{\beta}^2(t).D_{x_r,t}}$$

$$\text{with}:\alpha(t)=\sum_{x=x_r+1}^{\omega}\tilde{\delta}(t-(x-x_r)).\left(\prod_{s=t}^{t-(x-(x_r+1))}\beta(s)\right).l_{x,t}$$

Natural choice for the target

$$\bar{\tilde{\delta}}_t=\delta_t \quad \text{(solidarity between retirees)}$$

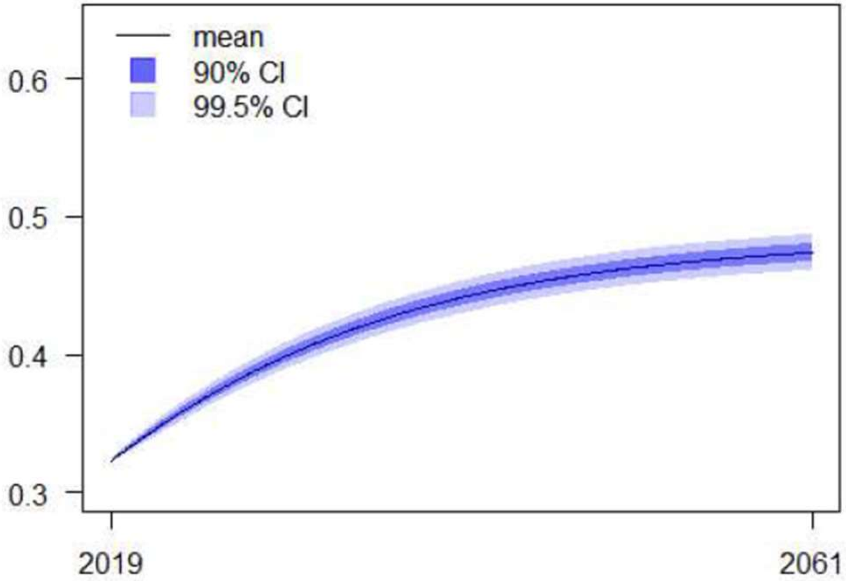
$$\bar{\beta}_t=1 \quad \text{(full indexation)}$$

3. Numerical illustration

Evolution of the dependency ratio

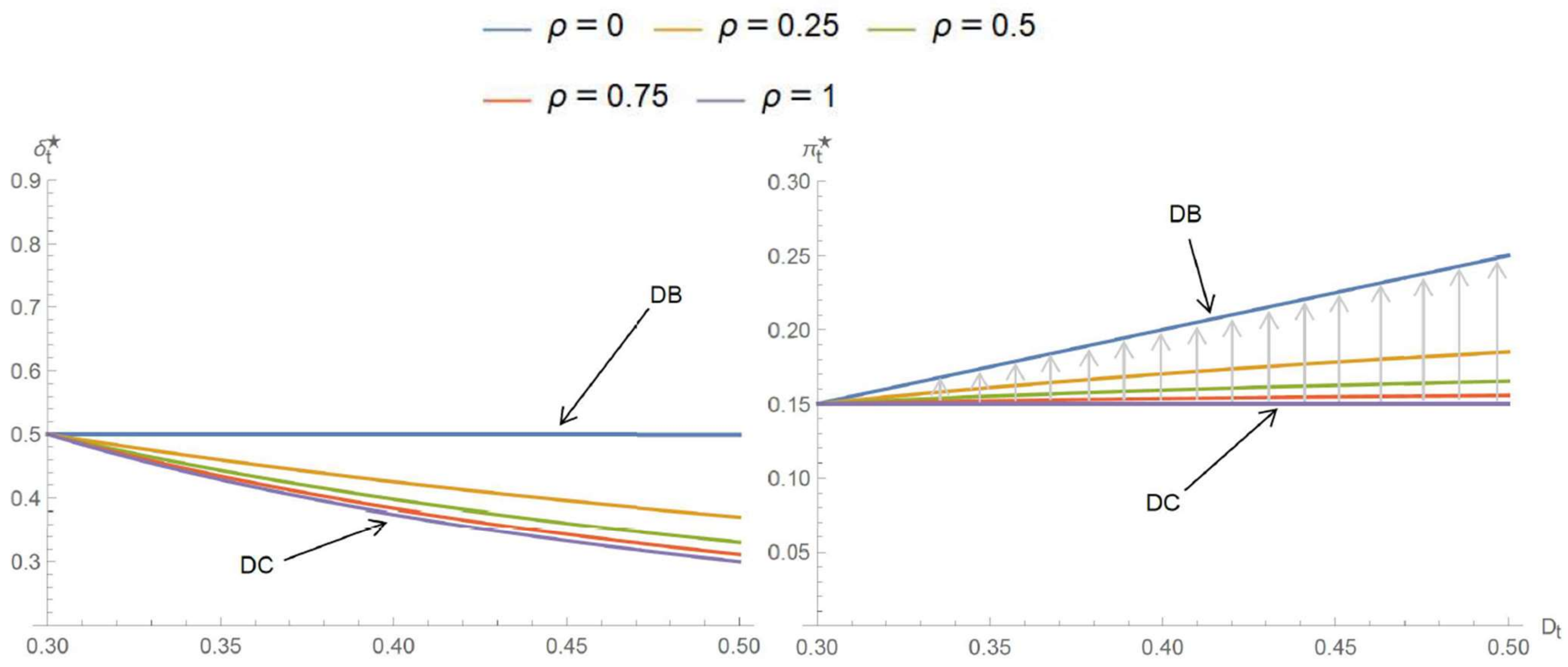
Black- Karasinsky model

$$d\ln(D(t)) = \alpha.(\ln(D_\infty) - \ln(D(t)))\,dt + \sigma\,dw(t)$$



Numerical illustration

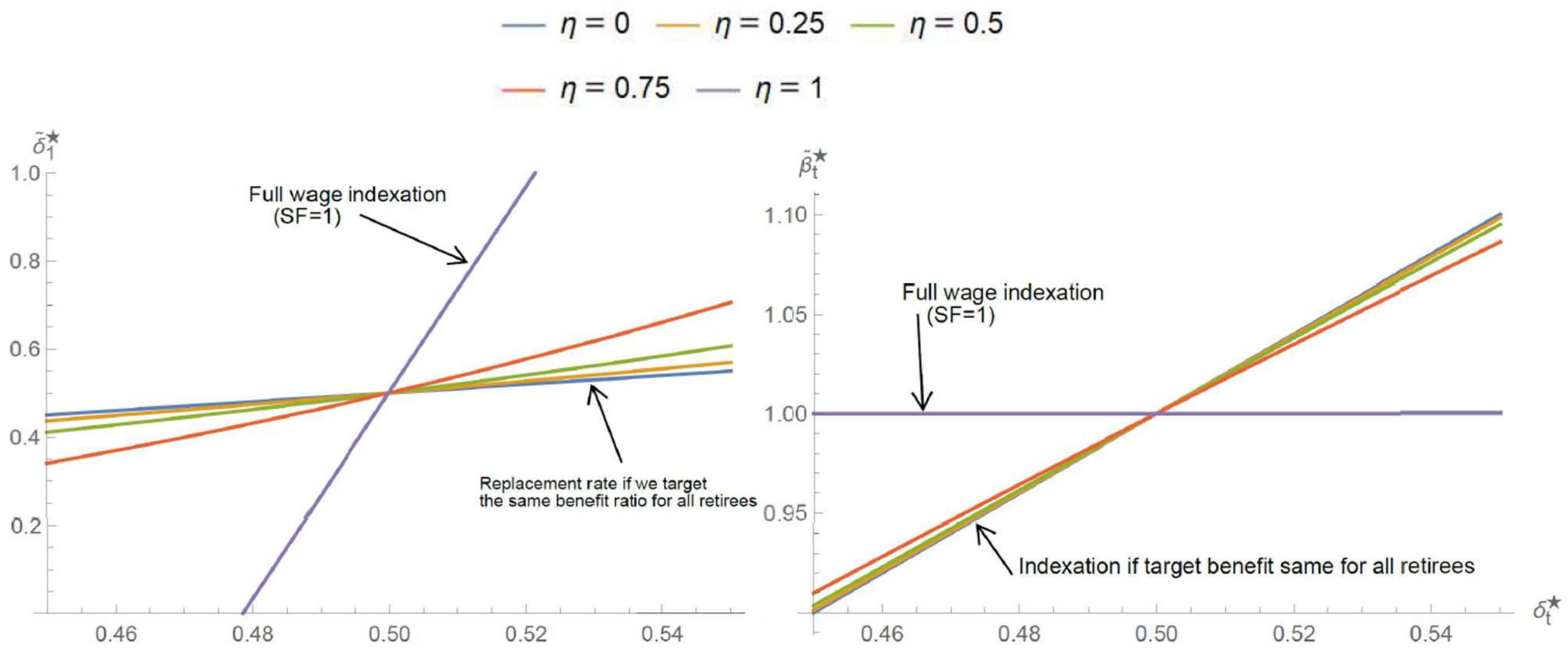
First level : between DB and DC



(a) $\delta_t^\star$ for varying ρ (b) $\pi_t^\star$ for varying ρ

Numerical illustration

Second level : indexation vs replacement rate



(a) $\tilde{\delta}_t^\star$ for $\eta \in [0, 1]$

(b) $\breve{\beta}_t^\star$ for $\eta \in [0, 1]$

Conclusion

- As soon as the planner takes simultaneously into account the interest of the workers and of the retirees, **neither DB nor DC is optimal**

Hybrid pension plans must be preferred (intergenerational risk sharing of the aging cost)

- In an aging phase, **Fully indexing pensions to salaries is unsustainable** and could yield either to unreasonable contribution rates or to low and even negative replacement rates for new retirees !

A sustainability factor on indexation (partial indexation) must be preferred

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THANK YOU !!!!

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