NEW DESIGN OF SOCIAL SECURITY PENSION SCHEMES

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Netspar, July 2018

Overview

- 1. Hybrid Pension Schemes
- 2. Project of Belgian Points System
- 3. PAYG Risk Sharing Model
- 4 . Optimal Control and Hybridization

1. Hybrid Pension Schemes

Challenges of social security

- Financial viability of classical Pay As You Go (PAYG) social security pension schemes
- Most of them using a Defined Benefit (DB) structure
- Important risk factors :
  - Ageing
  - Fertility
  - Baby boom effect

Some classical solutions

- Parametric reforms (*retirement age, early retirement , indexation,…*)
- Trend of moving from DB schemes to DC schemes (*Notional Accounts* , *NDC*)
- Introduction of Automatic Balance Mechanisms as an answer to risk exposure (DB and DC)

Sustainability and Adequacy

- …But Pension reform is not just a matter of financial sustainability
- The mission of the social security is also social adequacy
- Fairness between generations and between categories of workers is a key point

Search for collective risk sharing solutions to mitigate the participants exposures

Hybrid pension plans

- Development of Hybrid pension plans between DB and DC as well for public as for occupational pension schemes
- ***Sweden*** : NDC with automatic adjustment
- ***Netherlands*** : conditional indexation, collective DC plans
- ***Belgium :*** project of reform of the first pillar (points system with Musgrave rule)

2. Project of Belgian Points System (PAYG)

UN CONTRAT SOCIAL
PERFORMANT ET FIABLE

Commission de réforme des pensions 2020-2040

http://pension2040.belgium.be

General Principle

FIRST PILLAR / Switch from:

Defined Benefit in euros (pension = fixed function of the wages) (*protection only for the retirees*)

To

Point system with a **mix** between ***Defined Benefit*** and ***Defined Contribution*** (*risk sharing between active people and retirees*)

Intergenerational Solidarity of the Ageing cost

Points system

1°) before retirement :

Each year, you collect points which are added in your ***personal point account***.

$$\text{Number point for year t} = \frac{\text{YOUR WAGE OF YEAR t}}{\text{MEAN WAGE OF POPULATION t}}$$

If you work during 42 years and if each year you obtain a wage exactly equal to the mean wage of the population , you will collect 42 points at retirement.

Points system

<u>2°) at retirement :</u>

Your personal point account is ***converted into euro*** taking into account your choice in terms of retirement age :

pension = (point account) x (value of the point) x (conversion coefficient)

- point account: *your total number of points at retirement*
- value of the point: *the value in € of one point*
- conversion coefficient:

$$\frac{\textit{Your Life expectation at expected retirement age}}{\textit{Your Life expectation at real retirement age}}$$

Proposition of a points system BEFORE RETIREMENT

Each year , during the active career, acquisition of points:

$$n_t = \frac{S_t}{S_t^r}$$

$$\text{where: } n_t = \text{number of points for year t}$$

$$S_t = \text{individual salary of year t}$$

$$S_t^r = \text{reference salary of year t}$$

Proposition of a points system AT RETIREMENT AGE

Total number of points at retirement :

$$N_T = \sum_{t=T-M}^{T} n_t$$

Conversion of the points at retirement age :

$$P_T = N_T . V_T . r_T$$

where : N_T = total number of points

V_T = value of the point (in €)

r_T = actuarial coefficient(age / career)

Proposition of a points system
Value of the point

<u>**Assumption**</u> : *representative agent*

- salary equal to the reference salary each year
- working period = reference period N*

  (*no actuarial correction / r = 1*)

Pension benefit :

$$P_T = N^*.V_T = \delta_T.S_T^r$$

with δ_T = replacement rate

$$V_T = \frac{\delta_T.S_T^r}{N^*}$$

?

3. PAYG Risk Sharing Model

Equilibrium Equation

Incomes :

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

$W(t)$ = mean wage

$\pi(t)$ = contribution rate

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

Equilibrium Equation

Outcomes :

$B(t)$ = number of retirees at time t

$P(t)$ = mean pension

$\delta(t)$= replacement rate

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

Equilibrium Equation

Actuarial equilibrium :

$$\mathrm{IN(t) = OUT(t)}$$

$$\mathrm{A(t).\pi(t).W(t) = B(t).P(t)}$$

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

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

$$\delta(\mathrm{t}) = \text{replacement rate}$$

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

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

Risk factor

Automatic Adjustment :

How to maintain automatically this equilibrium in case of change of D(t) (*! Increase* !)

Automatic Adjustment

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

Risk factor

Constant in pure DC

Adjustment of δ

Social risk

Constant in pure DB

Adjustment of π

Financial risk

Risk Sharing

$$\pi(t) = D(t).\frac{P(t)}{W(t)}$$

$$\ln(\pi(t)) = \ln(D(t)) + \ln(P(t)) - \ln(W(t))$$

$$\frac{d\pi(t)}{\pi(t)} = \left(\frac{dP(t)}{P(t)} - \frac{dW(t)}{W(t)}\right) + \frac{dD(t)}{D(t)}$$

Spread of dynamic evolution between pension and wage

Ageing

Risk Sharing

$$\frac{d\pi(t)}{\pi(t)} = \left(\frac{dP(t)}{P(t)} - \frac{dW(t)}{W(t)}\right) + \frac{dD(t)}{D(t)}$$

CASE 1 : DB / Defined Benefit

$$\frac{dP(t)}{P(t)} = \frac{dW(t)}{W(t)}$$

→ Full indexation of pensions on wages

$$\frac{d\pi(t)}{\pi(t)} = \frac{dD(t)}{D(t)}$$

→ Full impact of the Ageing effect on the active generation

Risk Sharing

$$\frac{d\pi(t)}{\pi(t)} = \left(\frac{dP(t)}{P(t)} - \frac{dW(t)}{W(t)}\right) + \frac{dD(t)}{D(t)}$$

CASE 2 : DC / Defined Contribution

$$\frac{d\pi(t)}{\pi(t)} = 0$$

→ Full stability of the cost

$$\frac{dP(t)}{P(t)} = \frac{dW(t)}{W(t)} - \frac{dD(t)}{D(t)}$$

→ Full impact of the Ageing effect on the retirees

Risk Sharing

$$\frac{d\pi(t)}{\pi(t)} - \left(\frac{dP(t)}{P(t)} - \frac{dW(t)}{W(t)}\right) = \frac{dD(t)}{D(t)}$$

Fair risk sharing between generations :

$$\frac{d\pi(t)}{\pi(t)} = (1-\alpha(t)).\frac{dD(t)}{D(t)}$$

→ Ageing impact on the contribution rate

$$\frac{dP(t)}{P(t)} = \frac{dW(t)}{W(t)} - \alpha(t).\frac{dD(t)}{D(t)}$$

→ Ageing impact on the benefits

$0 \leq \alpha(t) \leq 1$: automatic adjuster

Musgrave case

$$\frac{d\pi(t)}{\pi(t)} - \left(\frac{dP(t)}{P(t)} - \frac{dW(t)}{W(t)}\right) = \frac{dD(t)}{D(t)}$$

EXAMPLE : MUSGRAVE rule

Goal:

To keep constant the replacement rate but net of contributions :

$$\delta(t) = \frac{P(t)}{W(t)} \longrightarrow M = \frac{P(t)}{W(t).(1-\pi(t))}$$

Musgrave case

$$M = \frac{P(t)}{W(t).(1-\pi(t))}$$

Musgrave Condition

$$\frac{dP(t)}{P(t)} = \frac{dW(t)}{W(t)} + \frac{d(1-\pi(t))}{1-\pi(t)} = \frac{dW(t)}{W(t)} - \frac{\pi(t)}{1-\pi(t)}.\frac{d\pi(t)}{\pi(t)}$$

Equilibrium Condition

$$\frac{d\pi(t)}{\pi(t)} = (\frac{dP(t)}{P(t)} - \frac{dW(t)}{W(t)}) + \frac{dD(t)}{D(t)}$$

$$\frac{d\pi(t)}{\pi(t)} = (1-\pi(t)).\frac{dD(t)}{D(t)}$$

$$\alpha(t) = \pi(t)$$

Replacement rate

$$\frac{d\pi(t)}{\pi(t)} = \frac{d\delta(t)}{\delta(t)} + \frac{dD(t)}{D(t)}$$

DB

$$d\delta(t) = 0$$

$$\frac{d\pi(t)}{\pi(t)} = \frac{dD(t)}{D(t)}$$

DC

$$\frac{d\delta(t)}{\delta(t)} = -\frac{dD(t)}{D(t)}$$

$$d\pi(t) = 0$$

Risk Sharing

$$\frac{d\delta(t)}{\delta(t)} = -\alpha(t).\frac{dD(t)}{D(t)}$$

$$\frac{d\pi(t)}{\pi(t)} = (1-\alpha(t)).\frac{dD(t)}{D(t)}$$

$$\alpha = 0$$

$$\alpha = 1$$

$$0 \le \alpha(t) \le 1$$

Summary

	DB	Musgrave	Constant proportion	DC
Replacement Rate	$\delta(t) = \delta_0$	$\delta(t) = \dfrac{K}{1 + K.D(t)}$	$\delta(t) = A.D(t)^{-\alpha}$	$\delta(t) = \pi_0.D(t)^{-1}$
Contribution Rate	$\pi(t) = \delta_0.D(t)$	$\pi(t) = \dfrac{K.D(t)}{1 + K.D(t)}$	$\pi(t) = A.D(t)^{1-\alpha}$	$\pi(t) = \pi_0$

4. Optimal Control and Hybridization

Optimal hybridization by stochastic control

- Optimal choice for the risk sharing level between DB and DC

↓

Stochastic optimal control

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- *State variable + equation*
- *Control variable*
- *Optimization criterion*

Stochastic optimal control

Criterion : joined **stability** of

- the replacement rate (*retirees point of view*)
- the contribution rate (*active point of view*)

Stability around a target value :

$$\text{for} \quad \pi(t) \to \overline{\pi}$$

$$\text{for} \quad \delta(t) \to \overline{\delta}$$

Stochastic optimal control

Value function to minimize (*cf. Cairns (2000)*)

$$J = E\left(\int_t^T e^{-r.(s-t)}((1-\rho)(\frac{\delta(s)}{\overline{\delta}} - 1)^2 + \rho.(\frac{\pi(s)}{\overline{\pi}} - 1)^2).ds \right)$$

$$\text{where } \ 0 \le \rho \le 1 : \text{ weight to fix}$$

$$(DC : \rho = 1 / \ \ DB : \rho = 0)$$

Basic model for the dependence ratio (*Black-Karasinski*)

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

Stochastic optimal control

Solution

Optimal replacement rate

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

Optimal contribution rate

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

Stochastic optimal control

Calibration of the target values

2 natural constraints :

- initial conditions : $\delta^*(0) = \delta_0$

- link between the targets:

$$\overline{\pi} = D_\infty . \overline{\delta}$$

Solution :

$$\overline{\delta} = \delta_0 \frac{(1-\rho) + \rho \dfrac{D_0^2}{D_\infty{}^2}}{(1-\rho) + \rho \dfrac{D_0}{D_\infty}}$$

Numerical illustration

Assumptions

The initialisation of our model in $t_0 = 2017$:

- Dependence ratio: $D_0 = 30\%$
- Contribution rate: $\pi_0 = 15\%$
- Replacement rate: $\delta_0 = 50\%$
- Net replacement rate: $M = 59\%$

$$d \ln D(t) = \alpha \left(\ln D_\infty - \ln D(t)\right) dt + \sigma \, dW(t)$$

$$\alpha = 0.059\,, \quad D_\infty = 0.47 \quad \text{and} \quad \sigma = 0.0046$$

Numerical illustration

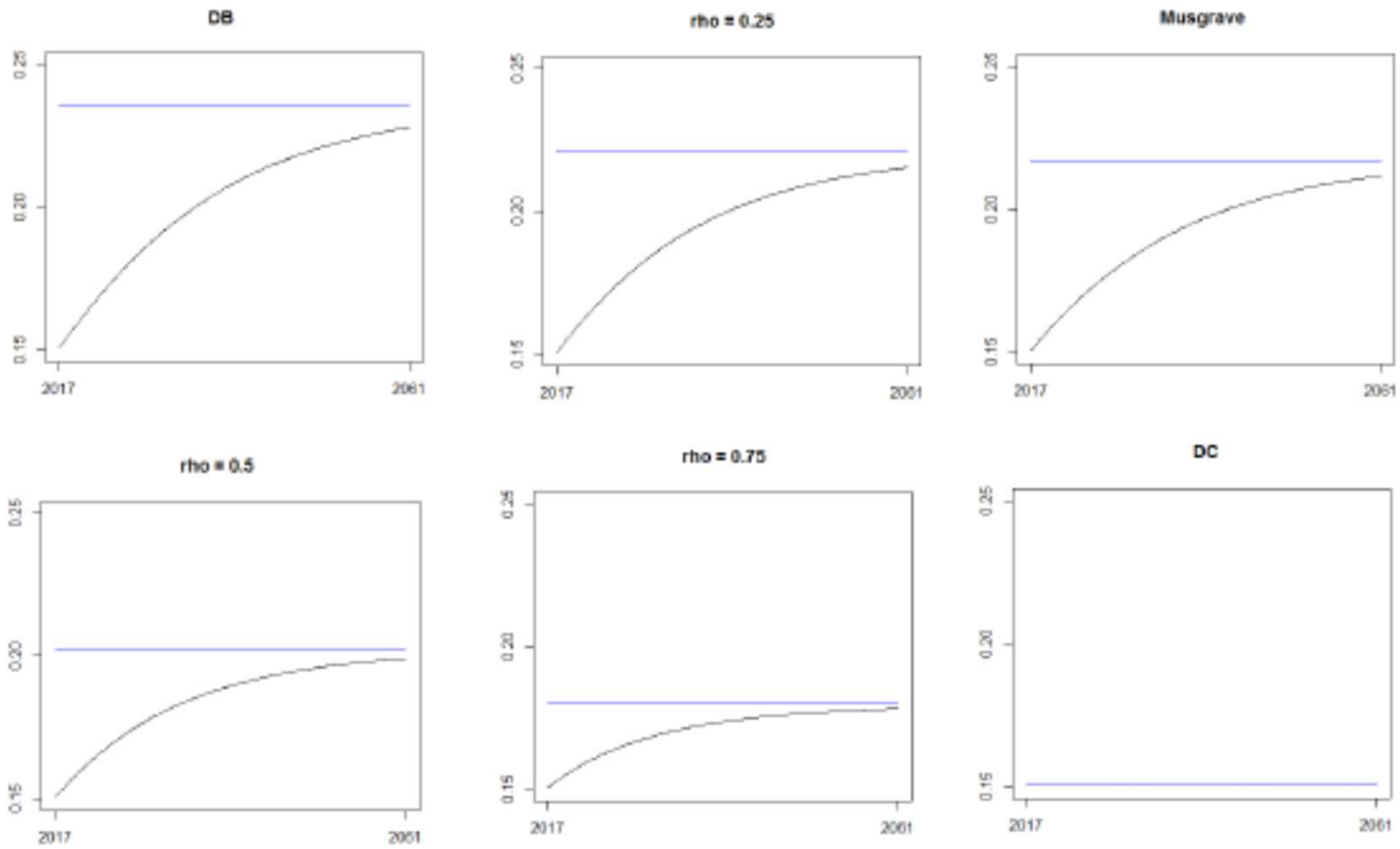
Targets in terms of contribution rate and replacement rate

$$(1-\rho)\left(\frac{\delta_t}{\overline{\delta}}-1\right)^2+\rho\left(\frac{D_t\,\delta_t}{\overline{\pi}}-1\right)^2$$

scheme	ρ	$\overline{\pi}$	$\overline{\delta}$
DB	0	24%	50%
risk sharing	0.25	22%	47%
Musgrave	$\widetilde{\rho}_t$	22%	46%
risk sharing	0.5	20%	43%
risk sharing	0.75	18%	38%
DC	1	15%	32%

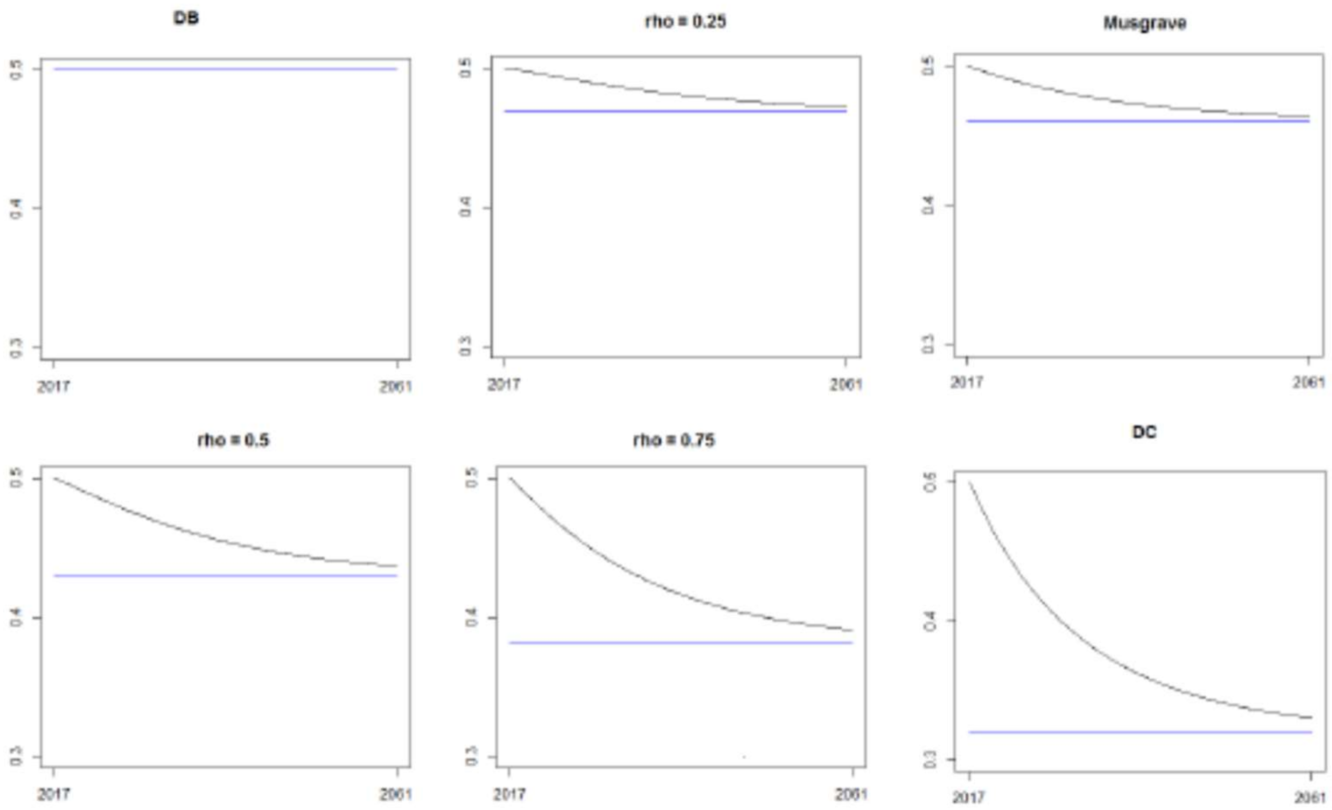
Numerical illustration

Mean evolution of the contribution rate



Numerical illustration

Mean evolution of the replacement rate



Work in progress

- Model with conditional indexation

2 levels of risk sharing

- **level 1**: risk sharing ***between the workers and the retirees*** through the contribution rate and the benefit ratio (*for instance Musgrave*)

- **level 2** : risk sharing ***among the retirees*** through the replacement rate for the new retirees and the indexation process for the old retirees (*eventual limited indexation by sustainability factor*)

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THANK YOU

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