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Automatic Balancing Mechanisms for Mixed Pension Systems

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Agenda

Motivation

Methodology - Sustainability

Design of an ABM

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References

Motivation

- The decline in fertility rates, the increase in longevity and the current forecasts for the ageing of baby-boom generation all point to a substantial increase in the age dependency ratio. This leads to serious concerns for the sustainability of the PAYG pension systems.
- In Europe, the common trend of the crisis response is a wave of parametric pension adjustments that mainly affect retirement age or indexation of pensions.
- Most of the countries in Latin America made structural reforms replacing totally or partially their PAYG system with programs systems containing funded components.

Motivation

- The PAYG rate of return can be lower than the return of funding schemes -especially in countries where the working population is not growing.
- However, the high-variability of the funding rate of return makes the choice between PAYG and funding less obvious.
- Countries, such as Australia, Canada, Norway, Sweden, Latvia and Poland, combine funded and PAYG elements within a compulsory basic pension system.

Agenda

Methodology - Sustainability

Sustainability

How do we measure sustainability?

- Following Godínez-Olivares et al. (2016), the optimisation problem uses the actuarial balance (aggregate accounting model) as the different between the net present value of the future income from contributions and the expenditure on pensions (of DB PAYG).
- We consider the accumulated value of the buffer fund that emerges from the difference between the income from contributions and expenditure on pensions in each year.

Agenda

Design of an ABM

Design of an ABM

$$min_{c_n x_n, \lambda_n} \sum_{n=0}^{N} \frac{F_n(n, g, x_n^{(r)}, \lambda_n, J_n)}{(1+\delta)^n}$$

$$s.t. = \begin{cases} c_{min} \le c_n \le c_{max}; x_{min}^{(r)} \le x_n^{(r)} \le x_{max}^{(r)}; \\ \lambda_{min} \le \lambda_n \le \lambda_{max}; \\ c_{1\Delta} \le \dfrac{c_{n+1}}{c_n} \le c_{2\Delta}; x_{1\Delta}^{(r)} \le \dfrac{x_{n+1}^{(r)}}{x_n^{(r)}} \le x_{2\Delta}^{(r)}; \\ \lambda_{1\Delta} \le \dfrac{\lambda_{n+1}}{\lambda_n} \le \lambda_{2\Delta}; \\ F_n \ge 0 \end{cases} \quad (1)$$

$$F_n = (1 + J_n) F_{n-1} + c_n W_n(n, g, x_n^{(r)}) - B_n(n, g, x_n^{(r)}, \lambda_n) \quad (2)$$

Design of an ABM

A liquidity restriction is also set as $F_n \geq 0$ to ensure liquidity in the system.

The liquidity indicator that takes into account the accumulated value of the buffer fund is expressed as follows:

$$Lf_n = \frac{(1 + J_n)F_{n-1} + c_n W_n(g_n, x_n^{(r)})}{B_n(g_n, x_n^{(r)}, \lambda_n)} \tag{3}$$

The gradient method is used to solve this non-linear discrete optimisation problem.

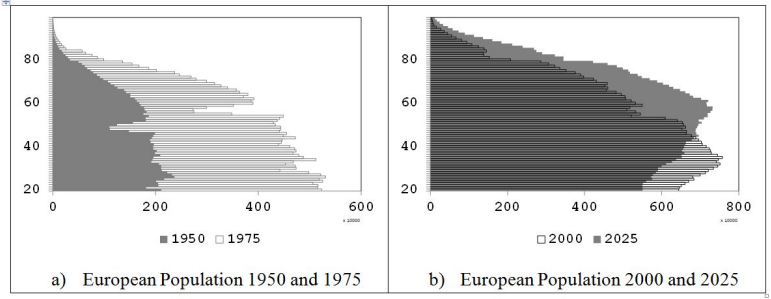
Agenda

Application

Application

We use the demographic structure of the European population from 1950 to 2087.

Figure 1. European Population in 1950, 1975, 2000 and 2025.

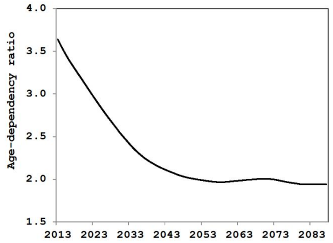


Own source based on Eurostat and United Nations

Application II

Age dependency ratio decreases over time with the number of contributors financing one pensioner falling from 3.6 in 2013 to 1.94 in 2087, as shown in Figure 2.

Figure 2. Age-dependency ratio European population 2013 - 2087



Own source

The average European salary is used. Projected salaries are assumed to increase at an annual constant rate of 2.5%

Application III

- The initial total contribution rate is equal to balanced contribution rate at the beginning of the period of analysis, i.e. 15.92%.
- Contribution rate for the DB part is 13.92% while 2% goes to the DC element.
- Initial pension for the DB pension part is set at 52% of final salary.
- Lower bounds for the contribution rate, retirement age and indexation of pensions are given by 13.92%, 65 and 0% respectively.
- For smooth changes, change in the contribution rate varies between 0.3% and 0.5%, age of retirement between 0 and 3 months and indexation of pensions between -1% and 0%.

Application IV

- The first cohort of the DC part retires at the same age as the DB scheme, i.e. 65.
- Mortality tables for the European Populations are used to forecast the total contributions to the DC part.
- The buffer fund and contributions of the DC part are assumed to increase at an annual rate according to a Cox-Ingersoll-Ross model fitted according to the average value of the Euribor rates during the last 15 years.

Application V

Five scenarios are studied:

- A pure DB pension system where the replacement rate is set at 60% is analysed. Buffer fund follows the mean of the CIR model.
- A mixed system where the RR of the DB part is 52% and the DC part (and buffer fund) follows the first quartile of the CIR model.
- A mixed system where the RR of the DB part is 52% and the DC part (and buffer fund) follows the mean of the CIR model.
- A mixed system where the RR of the DB part is 52% and the DC part (and buffer fund) follows the third quartile of the CIR model.
- A mixed system where the RR of the DB part is 52% and the DC part (and buffer fund) is set at 8%.

Figure 3: ABMs when the three variables are projected simultaneously

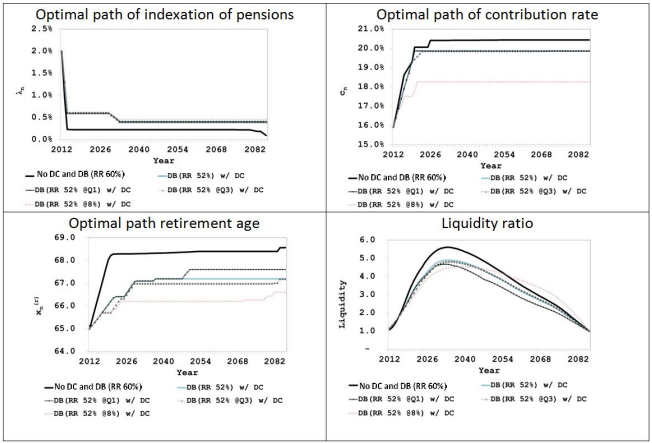
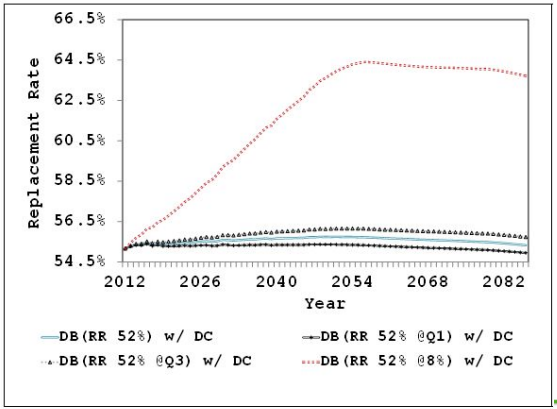


Figure 4: Replacement rate under different investment strategies



Agenda

Concluding comments

Concluding comments I

- This research aims to assess the impact of a compulsory funded pension scheme that complements the traditional PAYG on the pension levels of a generic mixed pension system.
- We analyse the case of a pure PAYG system versus a mixed pension system considering four different investment strategies for the accumulated capital of the DC part and the buffer fund.
- In all of the scenarios analysed, mechanisms need to be put in place in order to guarantee the financial sustainability of the system in the long run.

Concluding comments II

- Although the reforms needed are less severe in the case of a mixed pension system, the pure PAYG gives a higher replacement rate than the mixed pension plan under the assumption of a CIR model.
- However, if the return was set at 8%, the mixed pension plan would outperform the pure DB scheme with a replacement rate higher than 60% after the first 15 years.
- We show that there might be some room to benefit from a mixed pension system with respect to the classical PAYG financing although financial sustainability is still not secure even with an annual return of 8%.

Further Research

- Explore different stochastic approaches to forecast future scenarios regarding the investment returns and study their consequences on sustainability.
- Study the optimal mix between PAYG and DC funding scheme to provide a higher replacement rate.

References

- Bertsekas, D.P. (1999) Nonlinear Programming. *Athena Scientific.* Second Edition.
- Boado-Penas, M.C., Valdés-Prieto , S., and Vidal-Meliá, C. (2008) An Actuarial Balance Sheet for Pay-as-you-go Finance: Solvency Indicator for Spain and Sweden. *Fiscal Studies.* 69, 117-126.
- Godínez-Olivares, H., Boado-Penas, C. and Haberman, S. (2016) Optimal Strategies for Pay-as-you-go Pension Finance: A Sustainability Framework. *Insurance: Mathematics and Economics.* 35(1), 13-33.
- Haberman, S. and Zimbidis, A. (2002) An investigation of the pay-as-you-go Financing method using a contingency Fund and optimal control techniques. *North American Actuarial Journal.* 6, 60-75.
- Vidal-Meliá, M.C., Boado-Penas, M.C., and Settergren, O. (2009) Automatic Balance Mechanisms in Pay-As-You-Go Pension Systems. *The Geneva Papers.* 34, 287-317.

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Thank you very much for your attention!

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