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Linking pensions to life expectancy: A solution to guarantee long-term sustainability?

By

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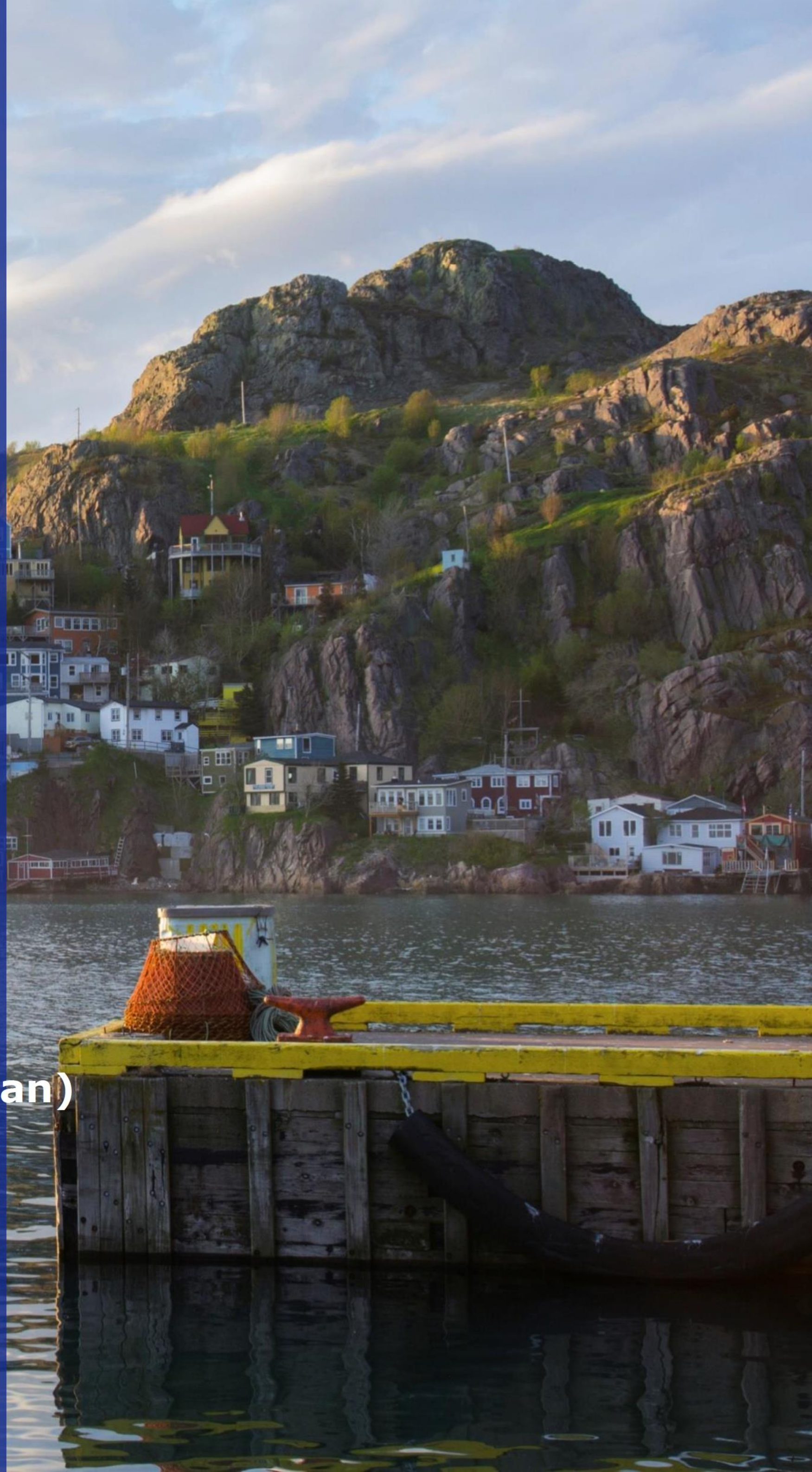
(joint with Humberto Godínez-Olivares & Steven Haberman)



IPEBLA IACA IAAHS PBSS Canadian Institute of Actuaries / Institut canadien des actuaires

Motivation

- With continuous improvements in life expectancy and low fertility rates, pensions are paid over a longer time horizon.
- *The European Commission* (White Paper (2012)), show a clear increase in the life expectancy at birth for males (7.9) and females (6.5) in 2060, comparing with 2010.
- The current forecasts for the ageing of the baby-boom generation will contribute equally to substantial increase of the old-age dependency ratio.
- In 2012, pension expenditure represented more than 10% on average of GDP and the forecast provision is to be risen to 12.5% in 2060 in the EU as a whole.

Contents

Aim of the paper

- To assess, using optimisation, whether the recent reforms on pension policy based on linking benefits to life expectancy (or any other kind of demographic factors) are sufficient to guarantee the financial sustainability in pension systems.
- To design different optimal strategies (Automatic Balancing Mechanisms - ABMs), that involve variables such as the contribution rate, age of retirement and indexation of pensions to restore the sustainability considering different types of demographic factors.

Aim of the paper

- What is an ABM? An Automatic Balance Mechanism (ABM) can be defined as a set of pre-determined measures established by law to be applied immediately as required according to the solvency or sustainability indicator.

Contents

Sustainability

How do we measure sustainability?

Aggregate accounting projection model of spending on pensions and income from contributions (Actuarial Balance). Basically, the method relies on making a variety of assumptions regarding:

- the economy as a whole, taking into account future trends in demography (fertility rates, migration flows, life expectancy);
- economic conditions (participation and employment rates, productivity, wages, interest rates) and
- institutional factors (coverage, pension levels).

Sustainability

- Countries like Canada, Finland, Japan, Sweden, USA publish, on a regular basis, official actuarial balances to contribute to the transparency of the pension system.
- Even though the information provided by the actuarial balance can help to take better and more informed decisions, some countries decide not to use it, i.e. USA, or take some parametric reforms via emergency modifications in legislation.
- ABMs (measures established by law) can be applied immediately as required according to an indicator of the financial health of the system.

Contents

ABM with demographic corrections

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

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

with

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

ABM with demographic corrections

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

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

The initial pension, that includes the demographic correction, is set as a percentage (p%) of a worker's pre-retirement income and can be expressed as:

$$\text{Initial Pension} = \text{Last Salary} * p\% * Correction \tag{4}$$

ABM with demographic corrections

Demographic correction:

- Life expectancy indicator based on Finnish pension system
- Life expectancy indicator based on Portugal pension system
- Age-dependency indicator (based on Germany)

ABM with demographic corrections

Correction based on Finnish Life expectancy indicator (FLE)
We first define the Longevity Indicator (LI^n) as:

$$LI^n = \sum_{x=x^{(r)}}^{N} (1+i)^{-(x+0.5-x^{(r)})} \frac{L_x^n}{l_{x^{(r)}}^n} \quad (5)$$

The life expectancy indicator at time n (FLE^n) is calculated as follows:

$$FLE^n = \frac{LI^{base}}{LI^n} \quad (6)$$

ABM with demographic corrections

Correction based on Portuguese Life Expectancy indicator (PLE)

$$PLE^n = \frac{e_{x(r)}^{base}}{e_{x(r)}^{n}} \quad (7)$$

Correction based on Age-dependency indicator

This indicator links the initial pension to changes in the age-dependency ratio.

$$ADF^n = \frac{AD^{base}}{AD^n} \quad (8)$$

Contents

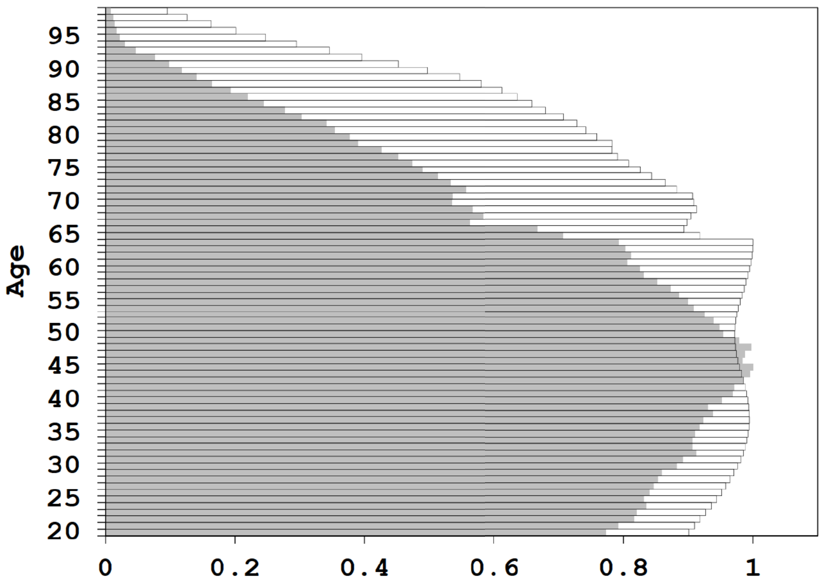
Application

The population structure used for the analysis is the European Population from 2013 to 2087. The data comes from Eurostat that provides statistical information about the European Union (EU). The population structure has been normalised.

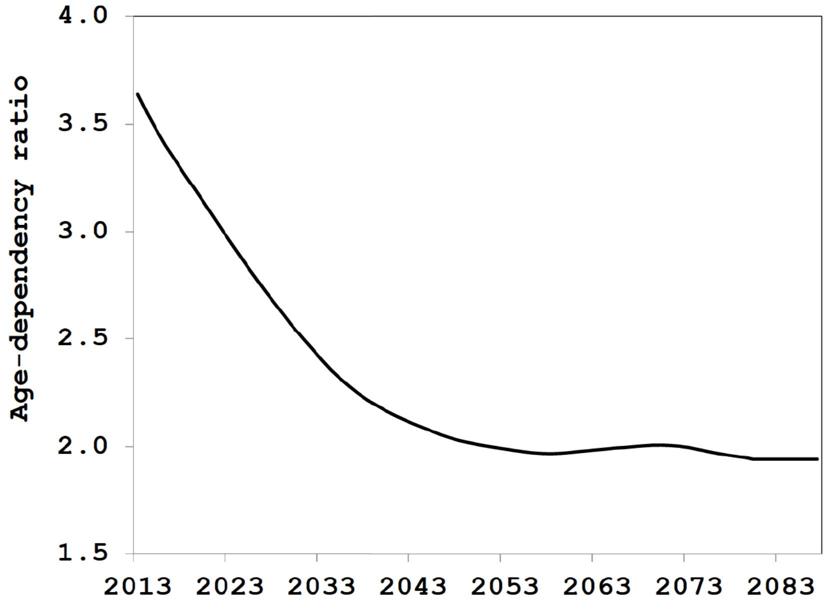
Figure 2 represents the normalised mature population of the European Union in 2013 (grey) and 2087 (transparent) to highlight the differences.

Application II

Figure 1: *Population and age-dependency ratio*

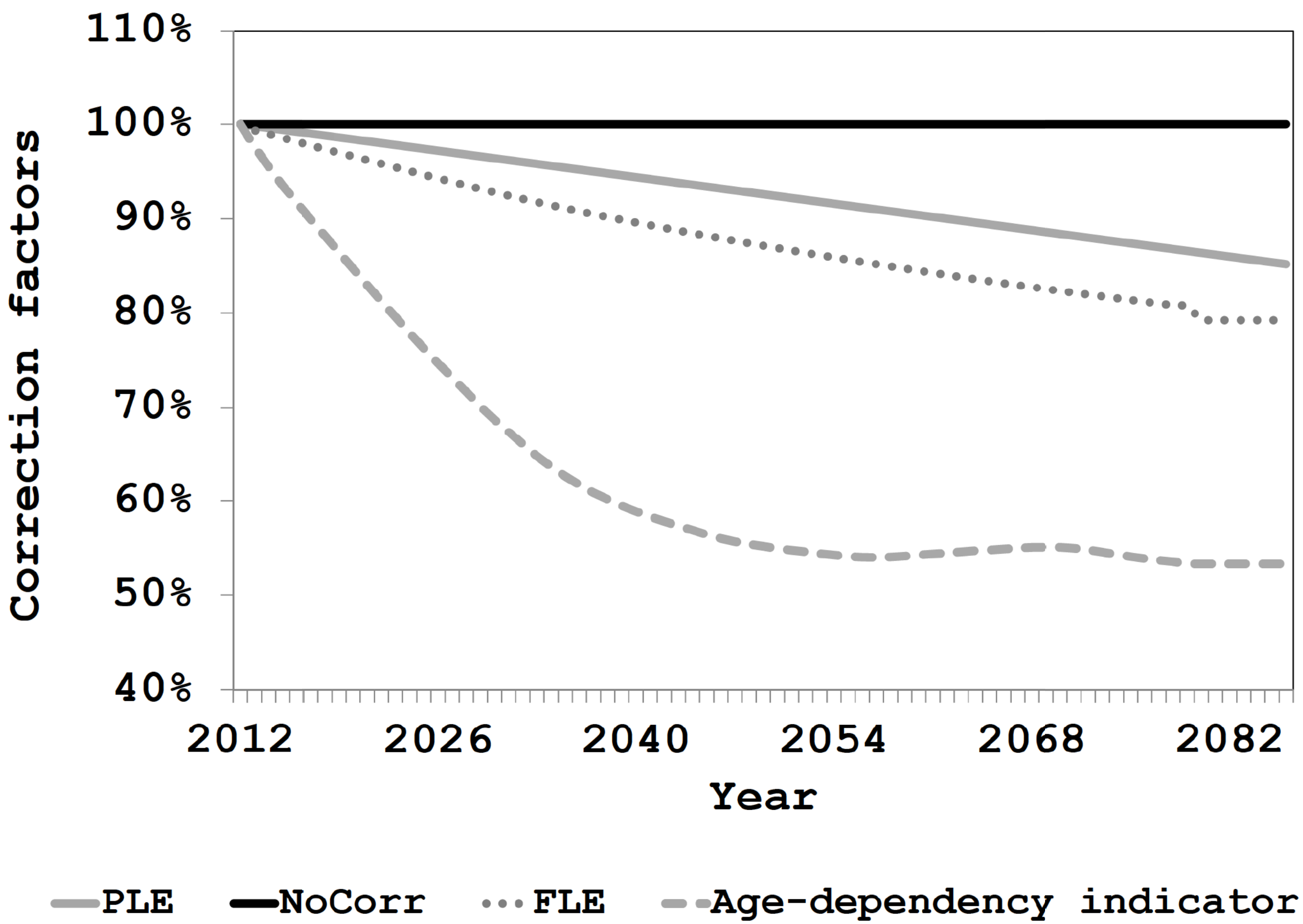


(a) *EU Population 2013 and 2087*



(b) *EU age-dependency ratio*

Figure 3: *Correction factors*

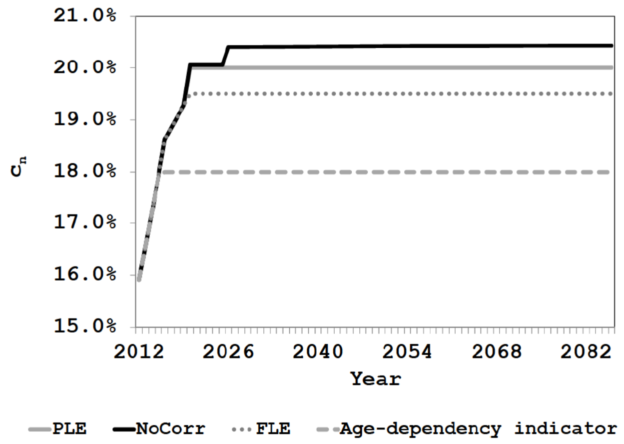


Application III

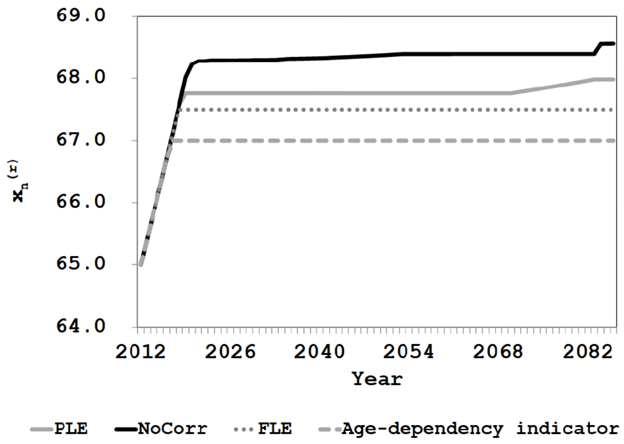
Assumptions:

- Initial values of 16% for the contribution rate, 65 for the retirement age and 2% for indexation of pensions.
- The minimum value for the contribution rate, age of normal retirement and indexation of pensions are respectively 16%, 65 and 0% and the maximum values are 24%, 69 and 2%.
- It is also assumed that the change in the contribution rate varies between 0% and 0.5%, the age of normal retirement between 0 and 3 months and the indexation of pensions between -1% and 0%.
- The accumulated fund increases at an annual rate of 3% while the annual salary growth is equal to 2.5%.

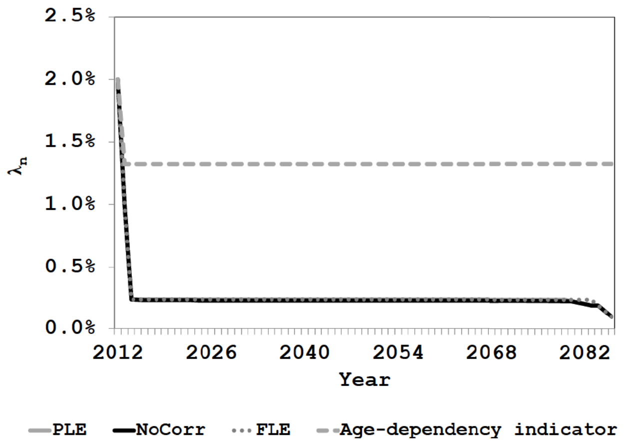
Figure 4: *Results of the four ABM when the three variables are projected.*



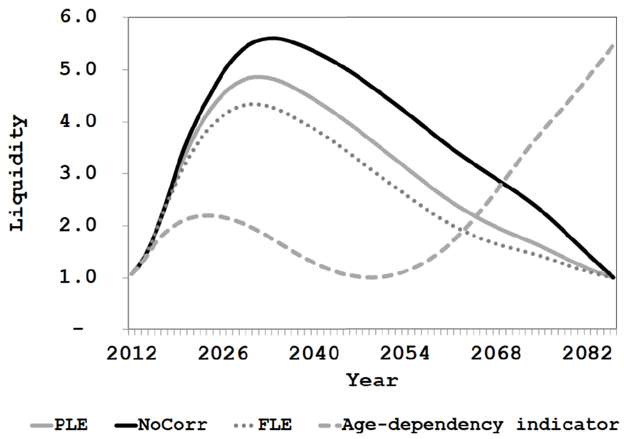
(a) *Contribution rate*



(b) *Age of retirement*



(c) *Indexation of pensions*



(d) *Liquidity indicator*

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Concluding comments

- This research aims to assess whether linking pension benefits to different demographic factors is sufficient to guarantee financial sustainability in the pension system.
- We have shown that none of the demographic factors will restore the sustainability of the system unless other measures are taken from now on.
- The age-dependency indicator provides a higher reduction of the amount of the initial pension. But even in this case, the contribution stabilises at 18% (2 points more), the age of retirement at 67 (2 years more) while the indexation of pensions would reach a value of 1.5% after 75 years.

Further Research

- Application of this optimisation method to real data.
- Develop a dynamic optimisation method.
- Study the share of risk between contributors and pensioners if different types of mechanisms are taken.

Contents

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Thanks

Thanks for your attention

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GRG

- Following general ideas about optimisation techniques in discrete-time, we will use the Generalized Reduced Gradient Method (GRG).
- The GRG is an active set method that works with inequalities constraints. The inequalities are replaced by their linear Taylor approximation and then the reduced gradient algorithm is applied.

Modelling the total contribution

For W_n, the total contribution rate, the dynamic of the population is considered as an input and the total contribution base is modeled as the total active workers at the age of normal retirement, x_n, over the time. We forecast the average wage for the whole population as:

$$W_1 = \left(\sum_{x=20}^{x_n - 1} l_{x,1} * wage(x) \right).$$

For $n > 1$, we have:

$$W_n = \left(\sum_{x=20}^{\lfloor x_n \rfloor - 1} (l_{x,n}) * wage(x) * (1+g)^n \right) + (x_n mod \lfloor x_n \rfloor) l_{\lfloor x_n \rfloor, n} * wage(\lfloor x_n \rfloor)(1+g)^n$$

We assume that $l_{x,n}$ is distributed uniformly over the year.

Modelling the total expenditures

The total expenditure on pensions at year 1 is modelling thus the observing average pension at year 1 and the projected number of individuals through projected mortality tables.

$$B_1 = \sum_{x=x_0(n)}^{X} P_{x,1} l_{x,1}$$

For $n > 1$, the total expenditure on pensions is forecasted as follows:

$$B_n = \left(1 - (x_{0(n)} mod \lfloor x_{0(n)} \rfloor) l_{\lfloor x_{0(n)} \rfloor, n}\right) * P_{\lfloor x_{0(n)} \rfloor, n} + \sum_{x=\lceil x_{0(n)} \rceil}^{X} P_{x,n} l_{x,n}$$