Intergenerational Actuarial Fairness when Longevity Increases: Amending the Retirement Age

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Introduction & Motivation

- Linking pensions to life expectancy developments observed at retirement ages has been one of the most common policy responses of national public pension schemes to the long-term affordability and fiscal sustainability challenges posed by population ageing
  - Introducing sustainability factors in the pension formula (e.g., PRT, ESP, FIN)
  - Indexing standard and/or early retirement ages to life expectancy (e.g., NLD, DNK, PRT, SVK, GRC,...)
  - Indexing the eligibility requirements to survival prospects (e.g., FRA, ITA)
  - Introducing longevity-linked pensions & annuities (NLD, USA)
  - Conditioning pension indexation (e.g., NLD)
  - Replacing PAYG DB schemes (NDB) with NDC schemes
- Most OECD countries have increased their normal and early retirement ages in a discretionary, scheduled or automatic way and restricted or closed routes into premature retirement, with some reform reversals too (e.g., POL)

Introduction & Motivation

- To this end, countries have been pursuing different retirement age strategies (Ayuso et al., 2021b):
  - implementing fixed schedules (e.g., GER, ESP, USA, AUS)
  - automatically indexing to life expectancy developments
  - targeting a constant period in retirement (e.g., NLD, DNK)
  - targeting a constant balance (ratio) between time spent in work (contributing) and in retirement (e.g., UK)
  - targeting a constant ratio of adult life (or total lifespan) spent in retirement
  - targeting a stable old-age dependency ratio
  - adopting ad-hoc rules

... often poorly designed and misaligned with the pension scheme's ultimate goals, in which we include intergenerational fairness and neutrality

Linking the retirement age to life expectancy

Illustrative examples

Country	Indexation formula
The Netherlands	$x_r^{NLD}(t) = 65 + \left[\dot{e}_{65}^{P}(t) - 18.26\right]$
Denmark	$x_r^{DNK}(t) = 60 + \left[\dot{e}_{60}^{P}(t-15) - 14.5\right]$
Portugal	$x_r^{PRT}(t) = 66 + \frac{2}{3}\left[\dot{e}_{65}^{P}(t-2) - \dot{e}_{65}^{P}(2012)\right]$
Slovakia	$x_r^{SVK}(t) = x_r^{SVK}(t-1) + \left[\bar{e}_{x}^{P}(t-3) - \bar{e}_{x}^{P}(t-4)\right]$

where $x_r(t)$ is the normal retirement age in year t, $\dot{e}_x^P(t)$ is the period life expectancy at age x in the same year and $\bar{e}_x^P(t)$ is 5-year moving average in the interval $[t; t-4]$

Introduction & Motivation

- The way in which retirement age policies have been legislated and operationalized suffers from several flaws:
  - period and not cohort life expectancy measures have been used to link pensions to life expectancy → **life expectancy gap** (Bravo et al., 2021a)
  - uniform rules across the population were adopted → **longevity heterogeneit**y (Ayuso et al., 2017a,b) and high **lifespan inequality** at retirement
  - Adjustments are inconsistent with **intergenerational fairness** and **neutrality**
  - the corrections are insufficient to restore financial equilibrium
  - there are provisions capping the maximum increase per period, indexation lags and other design features
  - healthy life expectancy (HLE) differs from life expectancy
- Reforms that are either inter-generationally and intra-generationally unfair are less likely to succeed and will tend to be rejected by voters, especially if they involve retrenchments

This paper...

- Discusses how to automatically index the retirement age to longevity developments while respecting principles of intergenerational actuarial fairness and neutrality among generations
- Empirically investigates two alternative retirement age policies
  - A constant accrual-rate-per-year (CAR) policy design
  - A constant replacement rate (CRR) policy design
- Compares the dynamics of actual, legislated and/or forecasted retirement ages of 23 different countries with that required to cope with survival developments in an intergenerationally actuarially fair scheme from 2000 to 2050
- Considers a stylized earnings-related DB pension scheme in which the entry pension is strictly linked to the entire contribution history
- Forecasts life expectancy developments using a BME approach

Outline

Actuarially fair and neutral retirement age policies

- Consider a stylized Bismarckian earnings-related DB pension scheme with entry pension strictly linked to the entire contribution history
- The actuarial balance constraint for a representative individual retiring at age $x_{r(t)}$ in year t is

$$c_t \cdot V\left(x_r, x_e, w_t, y_t\right) = P_{x_r(t)} \cdot a^{\pi,y}_{x_r(t)}, \tag{1}$$

where

  - c_t is the contribution rate
  - $V\left(x_r, x_e, w_t, y_t\right)$ is the cumulative value at retirement age of lifetime pensionable earnings w_t earned since labour market entry age x_e and valued at an (actuarial equilibrium, notional) rate of return y_t,
  - $P_{x_r(t)}$ is the annual pension benefit
  - $a^{\pi,y}_{x_r(t)}$ is the annuity factor computed using a cohort approach,

$$a^{\pi,y}_{x_r(t)} := \sum_{\tau=1}^{\omega-x_r} \left(\frac{1+\pi_\tau}{1+y_\tau}\right)^t \; {}_\tau p_{x_r(t)} \tag{2}$$

  - π is the uprating rate for pensions; ${}_\tau p_x$ is the τ-year survival rate

Actuarially fair and neutral retirement age policies

- The annual pension benefit $P_{x_r(t)}$ is computed as follows

$$P_{x_r(t)} = \theta_t (x_{r(t)} - x_e) \cdot \overline{RE}_{x_r(t)} \cdot RF_{x_r(t)} \cdot b_{x_r(t)}, \tag{3}$$

where

  - θ_t is a linear (usually flat) accrual rate for each year of service
  - $(x_{r(t)} - x_e)$ is the contribution period
  - $RF_{x_r(t)}$ is a sustainability (reduction) factor
  - $b_{x_r(t)}$ are pension decrements (increments) for early $(b_{x_r(t)} < 1)$ or postponed $(b_{x_r(t)} > 1)$ retirement
  - $\overline{RE}_{x_r(t)} \equiv \overline{RE}(x_{r(t)}, x_e, w_t, \upsilon_t) = \frac{RE_{x_r(t)}}{x_r(t) - x_e}$ is the lifetime average revalued earnings at retirement age with

$$RE_{x_r(t)} = \left(w_t^{x_r(t)} + \sum_{x=x_0}^{x_r(t)-1} w_{t-x_r(t)+x}^{x_r(t)} \prod_{j=t-x_r(t)+x+1}^{t} (1+\upsilon_j) \right), \tag{4}$$

where υ_t is the rate of indexation of contributions

Actuarially fair and neutral retirement age policies

- If longevity changes, the pension parameters must be updated to guarantee the scheme remains actuarially neutral across generations
- Without loss of generality, assume that the economy/demography is in a steady-state and that x_e and w_t are kept constant
- Marginal actuarial neutrality between individuals of different generations requires

$$\frac{c_t}{c_0} \cdot \frac{V(x_{r(t)}, \cdot)}{V(x_{r(0)}, \cdot)} = \frac{\theta_t(x_{r(t)} - x_e)}{\theta_0(x_{r(0)} - x_e)} \cdot \frac{\overline{RE}_{x_r(t)}}{\overline{RE}_{x_r(0)}} \cdot \frac{RF_{x_r(t)}}{RF_{x_r(0)}} \cdot \frac{b_{x_r(t)}}{b_{x_r(0)}} \cdot \frac{a^{\pi,y}_{x_r(t)}}{a^{\pi,y}_{x_r(0)}} \tag{5}$$

with $V(x_{r(t)}, \cdot) \equiv V(x_{r(t)}, x_e, w_t, y_t)$

- This condition can be easily extended to account for the ageing of the population (increase in the old-age dependency ratio) and/or the existence of external sources of funding in the pension scheme

Actuarially fair and neutral retirement age policies

- Assume, without loss of generality, that
  - individuals of both cohorts retire at the full old-age pension age (i.e., pension decrements/increments are $b_{x_r(t)} = b_{x_r(0)} = 1$) and
  - the demographic reduction factor is kept constant over time, i.e., $RF_{x_r(t)} / RF_{x_r(0)} = 1$
- The neutrality condition (5) simplifies to

$$\frac{c_t}{c_0} \cdot \frac{V(x_{r(t)}, x_e, w, y_t)}{V(x_{r(0)}, x_e, w, y_0)} = \frac{\theta_t(x_{r(t)} - x_e)}{\theta_0(x_{r(0)} - x_e)} \cdot \frac{\overline{RE}_{x_r(t)}}{\overline{RE}_{x_r(0)}} \cdot \frac{a^{\pi,y}_{x_r(t)}}{a^{\pi,y}_{x_r(0)}}. \tag{6}$$

- Equation (6) offers a full menu of (automatic) pension policy rules
- In a pure NDB scheme, the natural adjustment would come through an update in the contribution rate

$$c_t = c_0 \times \left(\frac{a^{\pi,y}_{x_r(t)}}{a^{\pi,y}_{x_r(0)}} \right) \tag{7}$$

Constant accrual-rate-per-year (CAR) policy

- Under CAR policy $\theta_t = \theta_0$, the required retirement age and the contribution period adjustments are accompanied by an increase in the replacement rate $\rightarrow$ higher pensions, an enlarged pension scheme
- From equation (6), the new equilibrium retirement age is the result of

$$a^{\pi,y}_{x_r(t)} = \frac{V\left(x_{r(t)}, x_e, w_t, y_t\right) / V\left(x_{r(0)}, x_e, w_t, y_0\right)}{RE_{x_r(t)} / RE_{x_r(0)}} \cdot a^{\pi,y}_{x_r(0)} \qquad (8)$$

  - If lifetime earnings are revalued at the scheme's internal rate of return (i.e., if $v_t = y_t \; \forall t$), the fairness condition reduces to

$$a^{\pi,y}_{x_r(t)} = a^{\pi,y}_{x_r(0)} \qquad (9)$$

  - By further assuming the uprating rate for pensions matches the internal rate of return (i.e., $\pi_t = y_t \; \forall t$), we get

$$\dot{e}^{C}_{x_r(t)} = \dot{e}^{C}_{x_r(0)} \qquad (10)$$

  - If lifetime earnings are revalued below (above) y_t, smaller (bigger) retirement age adjustments are required

Constant replacement rate (CRR) policy

- Under a CRR policy, the required adjustments in the retirement age and contribution period are accompanied by a reduction in the accrual rate per year such that the replacement rate (global accrued rate) remains constant, i.e., $\theta_t(x_{r(t)} - x_e) = \theta_0(x_{r(0)} - x_e)$ or, equivalently,

$$\theta_t = \theta_0 \cdot \frac{(x_{r(0)} - x_e)}{(x_{r(t)} - x_e)} \tag{11}$$

- From (6), intergenerational actuarial neutrality demands

$$a^{\pi,y}_{x_r(t)} = \frac{(x_{r(t)} - x_e)}{(x_{r(0)} - x_e)} \cdot \frac{V(x_{r(t)}, x_e, w, y_t)/(Vx_{r(0)}, x_e, w, y_0)}{RE_{x_r(t)}/RE_{x_r(0)}} \cdot a^{\pi,y}_{x_r(0)}$$

which, in the case $v_t = y_t$ and $\pi_t = y_t \; \forall t$, reduces to

$$\frac{\dot{e}^C_{x_r(t)}}{(x_{r(t)} - x_e)} = \frac{\dot{e}^C_{x_r(0)}}{(x_{r(0)} - x_e)} \tag{12}$$

Constant replacement rate (CRR) policy

- In an actuarially fair and neutral pension scheme promising a CRR policy, the retirement age must be adjusted such that the expected years in retirement relative to the contribution period remains constant across generations
- The society may off-course decide to depart from the intergenerational fairness condition and adopt alternative longevity risk sharing mechanisms between current and future pensioners combining actuarial fairness, financial sustainability and social adequacy, e.g., by adopting the rule

$$x_{r(t)} = x_e + \left(x_{r(0)} - x_e\right) \times \left(\frac{\dot{e}^C_{x_r(t)}}{\dot{e}^C_{x_r(0)}} \right)^{\phi}, \tag{13}$$

  where ϕ is a risk-sharing coefficient ($\phi = 1$ defines the CRR policy)
  - For values of ϕ in the range $]0, 1[$ the retirement age updates would only partially reflect life expectancy developments
  - For $\phi = 0$ the policy option would be to keep the contribution period constant over time

Bayesian Model Ensemble (BME) to mortality forecasting

- To forecast mortality, we adopt the BME approach developed in Bravo et al. (2021)
- Instead of pursuing a "winner-take-all" approach, Bayesian model combination aims at finding a composite model that better approximates the actual data generation process and its multiple sources of uncertainty, conditioning the statistical inference on the model confidence set
- Let M_k $(k = 1, ..., K)$ be each candidate model and Δ a quantity of interest present in all models (e.g., future value of y)

$$p(\Delta|y) = \sum_{k=1}^{K} p\left(\Delta|y, M_k\right) p\left(M_k|\, y\right), \tag{14}$$

  where $p\left(\Delta|y, M_k\right)$ denotes the forecast PDF based on model M_k alone, and $p\left(M_k|\, y\right)$ is the posterior probability of model M_k given data, with $\sum_{k=1}^{K} p\left(M_k|\, y\right) = 1$
- The BME PDF is a weighted average of the PDFs given the individual models, weighted by their posterior model probabilities

Bayesian Model Ensemble

- The BME Model weights $p\left(M_k \mid y\right)$ are estimated based on each model out-of-sample predictive accuracy
- We carry out a backtesting exercise considering a 5-year forecasting horizon for all models and populations
- Use the symmetric mean absolute percentage error (SMAPE) to assess the forecasting accuracy
- We compute $p\left(M_k \mid y\right)$ using the normalized exponential function

$$p\left(M_k \mid y\right) = \frac{\exp\left(-\left|\xi_k\right|\right)}{\sum_{l=1}^{K} \exp\left(-\left|\xi_l\right|\right)}, \quad k = 1, \ldots, K, \tag{15}$$

with $\xi_k = S_k / \max\left\{S_l\right\}_{l=1,\ldots,K}$ and $S_k = SMAPE_k$

- The normalized exponential function assigns larger weights to models with smaller forecasting error, with the weights decaying exponentially

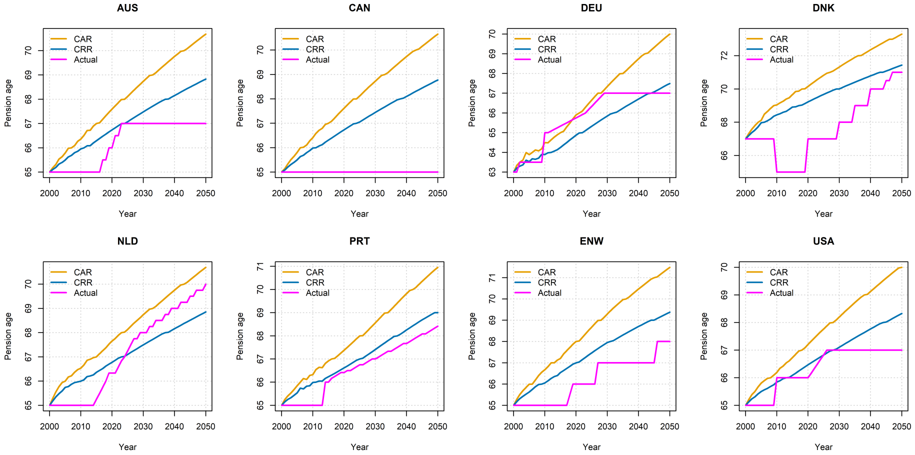
Candidate stochastic mortality models

Model	Model structure
LC	$\eta_{x,t} = \alpha_x + \beta_x^{(1)}\kappa_t^{(1)}$
APC	$\eta_{x,t} = \alpha_x + \kappa_t^{(1)} + \gamma_{t-x}$
RH	$\eta_{x,t} = \alpha_x + \beta_x^{(1)}\kappa_t^{(1)} + \beta_x^{(0)}\gamma_{t-x}$
CBD	$\eta_{x,t} = \kappa_t^{(1)} + (x-\bar{x})\,\kappa_t^{(2)}$
M7	$\eta_{x,t} = \kappa_t^{(1)} + (x-\bar{x})\,\kappa_t^{(2)} + \left((x-\bar{x})^2 - \sigma\right)\kappa_t^{(3)} + \gamma_{t-x}$
Plat	$\eta_{x,t} = \alpha_x + \kappa_t^{(1)} + (x-\bar{x})\,\kappa_t^{(2)} + (\bar{x}-x)^{+}\,\kappa_t^{(3)} + \gamma_{t-x}$
HUw	$y_t(x_i) = f_t(x_i) + \sigma_t(x_i)\,\epsilon_{t,i}$
CPspl	$\eta = B\alpha$
RSVD	$m(x,t) = \sum_{j=1}^{q} d_j U_j(t)\, V_j(x) + \epsilon(x,t)$

Data and BME calibration procedure

- We implement an adaptative BME procedure using a fixed-rule trimming scheme in which three out of six GAPC models are selected based on the model's out-of-sample forecasting performance
- We first calibrate the models using each country population data from 1960 to the most recent year available and for ages in the range 60-95
- We derive prediction intervals accounting for both stochastic process and parameter risk using a bootstrap approach
- The datasets used in this study consist of observed death counts and exposure-to-risk, classified by age, year and sex
- Data is from the Human Mortality Database and national pension agencies

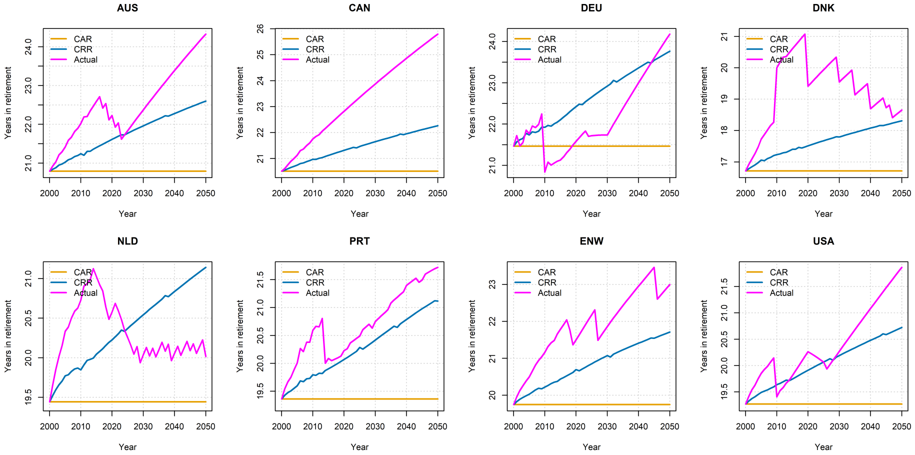
Forecasts of the retirement age under a CAR/CRR policy



Difference between actual and CAR/CRR retirement ages

	2010		2020		2030		2040		2050	
Country	CAR	CRR	CAR	CRR	CAR	CRR	CAR	CRR	CAR	CRR
AUS	1.36	0.95	1.59	0.74	1.74	0.48	2.76	1.15	3.68	1.83
AUT	0.95	0.60	2.00	1.27	3.33	2.22	4.68	3.09	5.73	3.84
BEL	1.00	0.64	-2.65	-3.55	-3.35	-4.79	-2.15	-4.00	-1.05	-3.34
CAN	1.41	0.99	2.62	1.73	3.73	2.45	4.74	3.10	5.66	3.77
CHL	1.45	1.00	2.77	1.88	3.96	2.66	5.00	3.39	5.99	4.06
CHE	1.21	0.79	2.32	1.56	3.49	2.32	4.58	3.02	5.57	3.74
DEU	-0.50	-1.11	0.15	-0.88	0.34	-1.15	1.75	-0.29	3.00	0.50
DNK	4.05	3.44	3.16	2.22	3.33	2.01	2.36	0.79	2.30	0.44
ESP	1.38	0.95	1.42	0.67	1.26	0.14	2.17	0.79	3.00	1.32
FIN	3.10	2.77	3.55	2.80	3.71	2.49	5.00	3.36	6.03	4.08
FRA	1.16	0.70	0.69	-0.39	2.00	0.37	3.06	1.06	4.14	1.77
IRL	0.76	0.13	2.09	1.09	3.35	2.00	4.45	2.73	5.45	3.39
ISL	1.00	0.69	1.72	1.16	2.40	1.67	3.02	2.09	3.69	2.55
ISR	-0.55	-1.00	0.98	0.00	2.21	0.89	3.38	1.67	4.45	2.38
JPN	1.40	0.93	2.63	1.74	4.00	2.74	5.49	3.66	6.63	4.38
NLD	1.53	1.00	1.32	0.44	0.74	-0.50	0.75	-0.84	0.69	-1.15
NOR	1.15	0.77	2.04	1.44	3.02	2.10	3.99	2.77	4.80	3.32
POL	1.40	0.97	2.23	1.48	3.29	2.19	4.49	3.00	5.48	3.69
PRT	1.33	0.99	0.96	0.20	1.56	0.41	2.16	0.59	2.54	0.59
SVK	-0.71	-1.18	-0.29	-1.17	-0.70	-1.94	0.11	-1.39	0.91	-0.94
SWE	1.15	0.82	2.17	1.47	3.17	2.13	4.10	2.80	5.00	3.38
ENW	1.67	1.05	2.00	1.00	2.29	0.95	3.47	1.71	3.49	1.38
USA	0.19	-0.16	1.21	0.47	1.20	0.11	2.13	0.77	3.00	1.33
Max	4.05	3.44	3.55	2.80	4.00	2.74	5.49	3.66	6.63	4.38
Min	-0.71	-1.18	-2.65	-3.55	-3.35	-4.79	-2.15	-4.00	-1.05	-3.34
Average	1.17	0.73	1.59	0.76	2.18	0.95	3.11	1.52	3.92	2.01

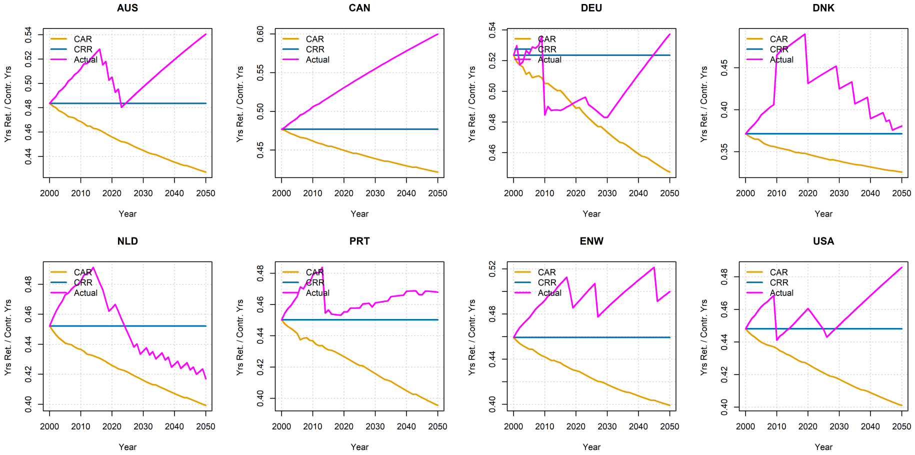
Expected years in retirement



Expected years in retirement

	2000	2020		2030		2040		2050	
Country	Legis	Legis	CRR	Legis	CRR	Legis	CRR	Legis	CRR
AUS	20.79	22.23	21.61	22.37	21.96	23.39	22.28	24.33	22.60
AUT	19.84	21.53	20.42	22.88	20.84	24.06	21.23	25.00	21.57
BEL	24.18	21.75	25.08	21.07	25.53	22.14	25.99	23.15	26.39
CAN	20.51	22.82	21.32	23.88	21.65	24.87	21.95	25.80	22.27
CHL	18.50	20.85	19.28	21.96	19.61	23.02	19.92	24.01	20.20
CHE	20.89	23.02	21.62	24.17	21.98	25.25	22.32	26.27	22.66
DEU	21.47	21.58	22.42	21.73	22.92	23.00	23.36	24.18	23.77
DNK	16.71	19.41	17.51	19.55	17.80	18.70	18.08	18.65	18.31
ESP	20.83	22.19	21.54	21.96	21.84	22.82	22.15	23.61	22.40
FIN	19.78	23.47	20.48	23.16	20.89	24.42	21.29	25.44	21.61
FRA	25.82	26.34	26.79	27.57	27.27	28.72	27.71	29.80	28.16
IRL	19.19	21.10	20.10	22.27	20.50	23.33	20.81	24.31	21.10
ISL	18.18	19.64	18.63	20.28	18.83	20.89	19.00	21.47	19.18
ISR	20.16	20.95	21.07	22.23	21.48	23.40	21.84	24.48	22.16
JPN	21.70	24.13	22.55	25.69	23.05	27.07	23.50	28.14	23.85
NLD	19.44	20.57	20.23	20.04	20.54	20.06	20.84	20.02	21.14
NOR	18.05	19.84	18.61	20.74	18.87	21.58	19.13	22.37	19.35
POL	17.50	19.18	18.09	20.12	18.37	21.12	18.66	21.91	18.96
PRT	19.36	20.23	20.07	20.75	20.42	21.40	20.79	21.72	21.12
SVK	20.21	20.06	21.01	20.82	21.29	21.51	21.55	22.14	21.77
SWE	19.77	21.74	20.43	22.69	20.73	23.61	21.03	24.48	21.29
ENW	19.75	21.50	20.70	21.98	21.07	23.06	21.41	23.09	21.71
USA	19.27	20.26	19.91	20.27	20.19	21.08	20.48	21.86	20.72
Max	25.82	26.34	26.79	27.57	27.27	28.72	27.71	29.80	28.16
Min	16.71	19.18	17.51	19.55	17.80	18.70	18.08	18.65	18.31
Average	20.08	21.50	20.85	22.10	21.20	22.98	21.54	23.75	21.84

Expected years in retirement relative to contribution years



Discussion & conclusions

- The goal of indexing retirement ages and other pension parameters to life expectancy developments observed at retirement ages is primarily to mitigate the impact of demographic, economic and financial shocks on the affordability and fiscal sustainability of pension schemes
- The introduction of automatic stabilizers is also viewed as a mean to address inter- and intra-generational fairness concerns in a more transparent way, by adding some actuarial and/or economic rationality to justify the prescribed adjustments
- This reinforces the credibility and the consistency of the pension promises made to younger generations, on which the fulfillment and stability of the intergenerational social contract ultimately resides
- Nonetheless, the way pensions have been linked to longevity markers is not exempt from several conceptual and policy design flaws, including the use of inappropriate life expectancy measures and the lack of consistency with intergenerational fairness

Discussion & conclusions

- This paper shows how to index the pension age to life expectancy developments while respecting principles of intergenerational actuarial fairness and neutrality among generations
- We concluded that under a CAR policy design in which extended working lives translate into additional pension entitlements, the pension age must be automatically updated to keep the period in retirement constant
- This roughly corresponds to the strategy adopted in The Netherlands and in Denmark to link the pension age to life expectancy, although both countries picked the «wrong» (period) longevity measure
- Alternatively, if policymakers wish to pursue a CRR objective, in which a longer contribution period barely changes pension entitlements, we show that retirement ages must be updated to ensure the time spent in work (or in adult life) and in retirement remains constant over time
- The results also show that the pension age increases prescribed by a CRR policy design are smaller than that dictated by a CAR option

Discussion & conclusions

- The empirical results for both the CAR and CRR policy designs show that the actual and/or legislated retirement age adjustments are not sufficient to ensure intergenerational fairness and neutrality among generations and to cope with increasing longevity
- Consequently, the expected duration of retirement (in absolute terms and as a fraction of the contribution period) is forecasted to growth in the future
- The difference between actual retirement ages and the ones consistent with intergenerational fairness and neutrality are higher under a CAR policy option than under a CRR design, with gaps steadily accumulating over time
- The adoption of a CAR (CRR) policy would contribute to reduce the average cross-country expected period in retirement by 3.92 (2.01) years in 2050 when compared with legislated reforms
- The results obtained for The Netherlands and Denmark deserve a special mention since in both countries they highlight the importance of policy design features (Ayuso et al., 2021b)

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