

Annuity Divisors for Notional Defined Contribution (NDC) Pension Schemes

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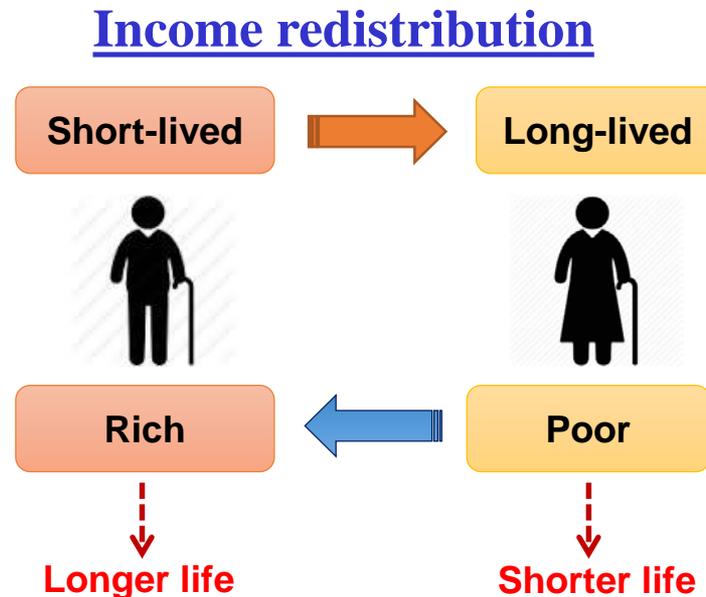
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MOTIVATION

- A pension system aims to provide **adequate** and **equitable** old-age income.
- On the basis of the “**gender equality**” principle:

Use of **unisex (average) life expectancy** to determine pension benefits



**Redistributive effects driven by heterogeneity in life expectancy
under NDC scheme**

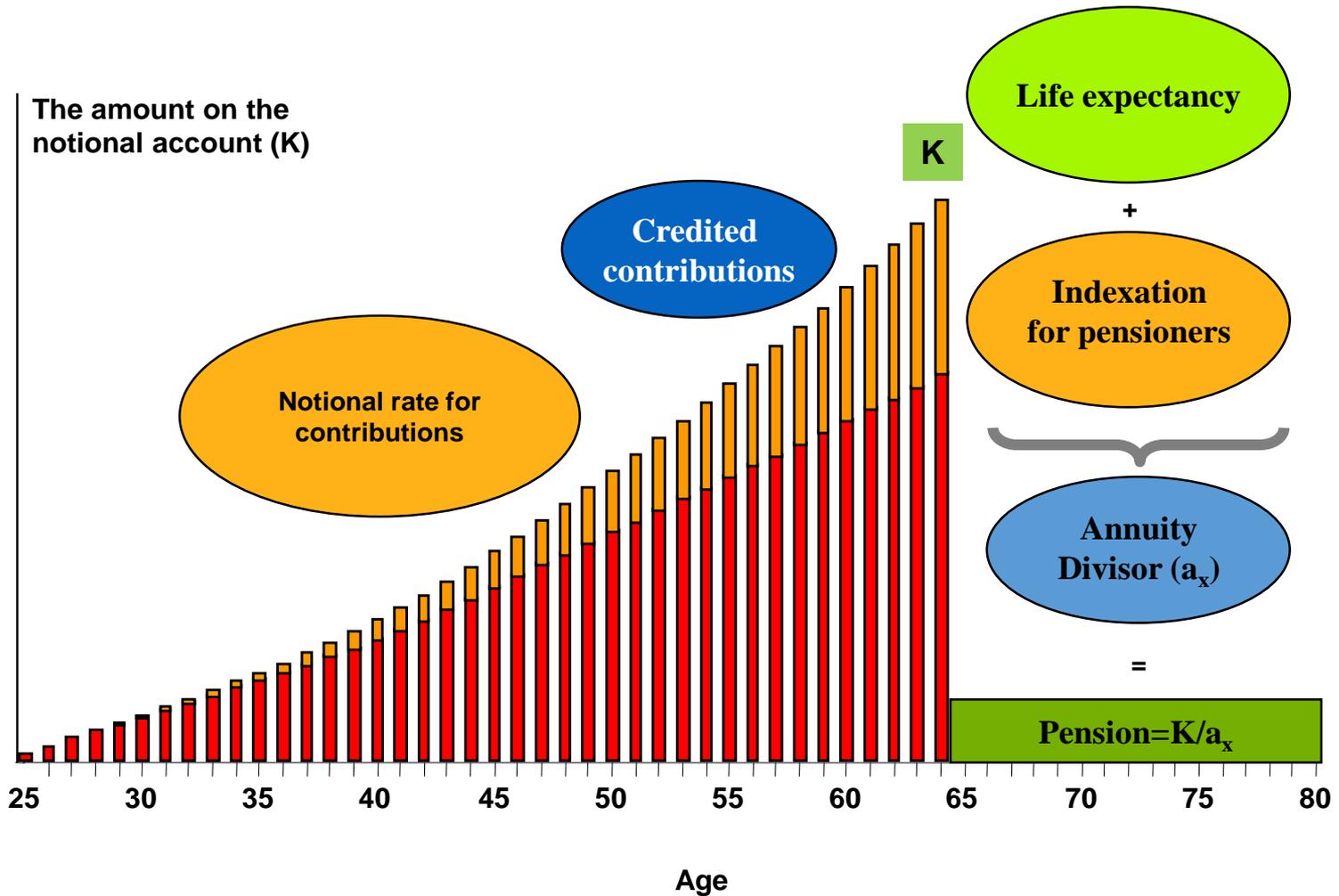
Outline

- NDC pension system
- Measuring income redistribution
- Numerical analysis
- Conclusions

What is an NDC scheme?

- Italy (1995), Latvia (1996), Poland (1999), Sweden (1999)
- a state pension scheme
- **defined contribution + PAYG**
 - a fixed contribution rate on earnings into an individual account
 - pay-as-you-go financing: current contributors pay for current pensioners
- notional/ fictitious interest rate
- use of unisex life expectancy to convert the accumulated capital into an annuity

An NDC scheme



A generic NDC

- Notional capital

We assume that an individual enters the system at age x_e and pays a fixed contribution rate c until the retirement age x_r .

The accumulated capital at retirement age, K_{x_r} , is :

$$K_{x_r} = \frac{\sum_{k=0}^{x_r-x_e-1} c \cdot s_{x_e+k} \cdot l_{x_e+k} \cdot (1+\alpha)^{x_r-x_e-k}}{l_{x_r}}$$

Note: This formula is considering the account balances of the **deceased participants distributed to those survivors** (“*survivor dividend*” or “*inheritance gains*”) (Boado-Penas and Vidal-Meliá, 2014).

where $c \cdot s_{x_e+k}$ is contribution paid at age $x_e + k$, α is notional interest rate, l_{x_e+k} is the number of individuals surviving at age $x_e + k$.

A generic NDC (cont.)

- Initial pension benefits

The initial pension for an individual at retirement age, P_{x_r} , is defined as:

$$P_{x_r} = \frac{K_{x_r}}{\ddot{a}_{x_r}}$$

where

$$\ddot{a}_{x_r} = \sum_{k=0}^{w-x_r} (1+r)^{-k} \cdot {}_k p_{x_r} = \sum_{k=0}^{w-x_r} (1+r)^{-k} \cdot \frac{l_{x_r+k}}{l_{x_r}}$$

is the present value of a whole life annuity-due at retirement age with interest rate r .

This factor is called as “*annuity divisor*” or “*annuitisation divisor*”

w is the maximum attainable age;

${}_k p_{x_r}$ is probability that an individual at retirement will survive at least k year;

l_{x_r+k} is the number of individuals alive at age $x_r + k$.

Variants of a generic NDC

- The accumulated capital of an individual at retirement is denoted $K_{x_r}^*$.

$$K_{x_r}^* = \sum_{k=0}^{x_r - x_e - 1} c \cdot s_{x_e + k} \cdot (1 + \alpha)^{x_r - x_e - k}$$

- The initial pension at retirement age is $P_{x_r}^*$.

$$P_{x_r}^* = \frac{K_{x_r}^*}{\ddot{a}_{x_r}}$$

Variants of a generic NDC (cont.)

- Economic annuity divisor (based on Sweden)
 - It is related to the size of pension disbursements and the pay-out period (the expected remaining number of years that pension will be disbursed.)
 - Economic divisor at retirement age, ED_{x_r} , is defined as:

$$ED_{x_r} = \frac{\sum_{k=0}^{w-x_r} 0.5(l_{x_r+k}^* + l_{x_r+k+1}^*)(1+r)^{-k}}{l_{x_r}^*}$$

where $l_{x_r+k}^* = l_{x_r+k-1}^* \times he_{x_r+k}$ and $l_{w+1}^* = 0$

$l_{x_r+k}^*$ the proportion of remaining pension disbursements at age $x_r + k$;

he_{x_r+k} change in pension disbursement due to deaths of aged $x_r + k$;

r the interest rate

Measuring lifetime redistribution

- **Redistributive considerations:** heterogeneity in mortality risk across population
- **Unused resources** transferring from **shorter-lived** → **longer-lived**
- **Present value ratio (PVR):** the expected money's worth of participation to the pension system

$$PVR = \frac{\sum_{x=x_r}^w x-x_e P_{x_e} (1+r)^{x-w} P_x}{\sum_{x=x_e}^{x_r-1} x-x_e P_{x_e} (1+r)^{x_r-x} c \cdot s_x}$$

where P_x pension benefits at age x ; $c \cdot s_x$ contributions paid in the NDC plan at age x ; $x-x_e P_{x_e}$ the probability that an individual at entry age x_e survives at age x

- $PVR = 1$ **no redistribution** and **actuarial fairness**
- $PVR > 1$ **welfare gain** for the individual from the system
- $PVR < 1$ **welfare loss** for the individual from the system

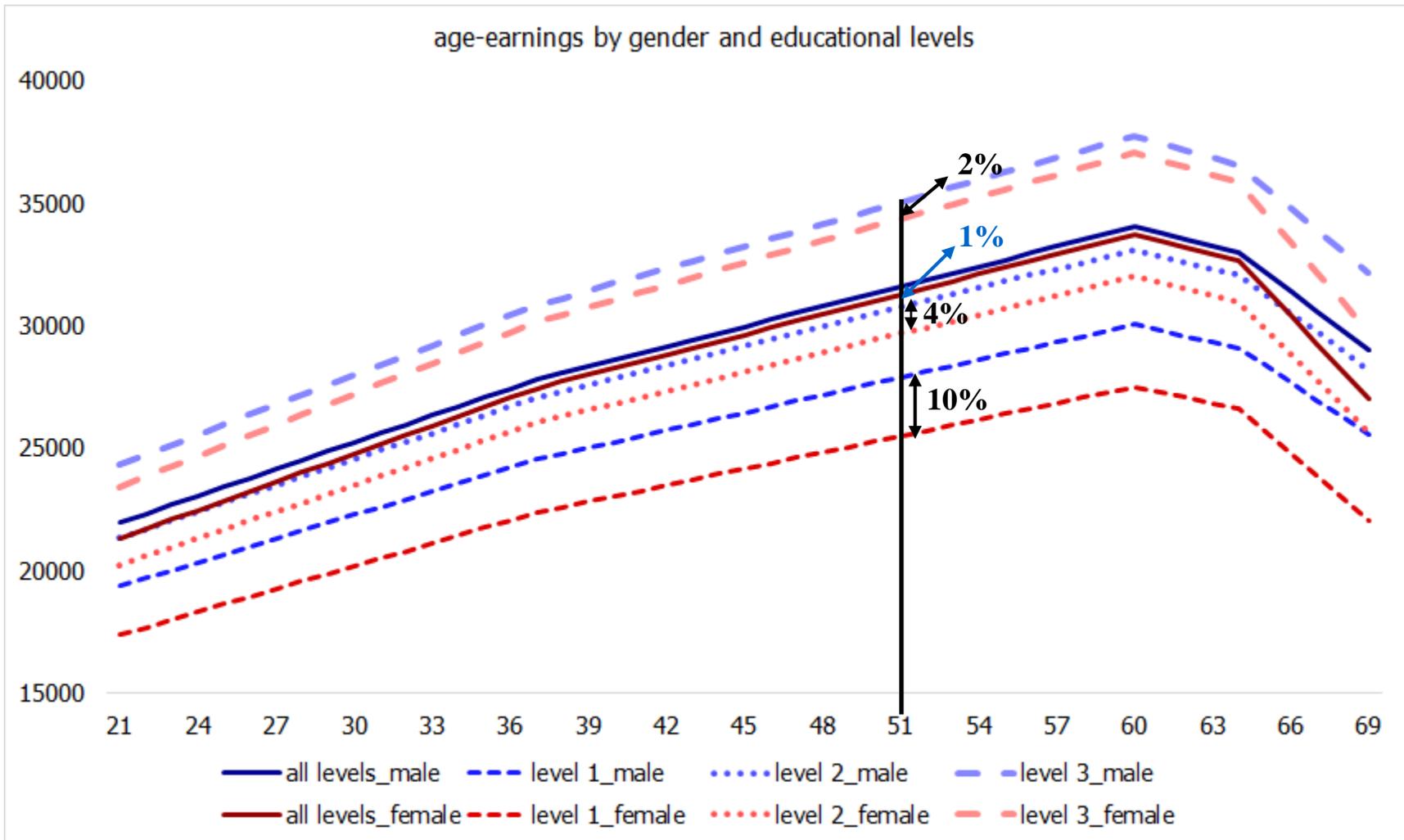
Numerical Analysis

- Main features and assumptions based on Sweden

Country	Sweden
Contribution rate	16%
Notional interest rate	1.6%
Discount rate for divisor	1.6%
Discount rate for PVR	1.6%
Entry age	21
Retirement age	61-70
Maximum attainable age	100
Educational attainment levels	
<ul style="list-style-type: none">• All levels – All ISCED 2011 levels• Level 1 – Below upper-secondary education• Level 2 – Upper secondary education• Level 3 – Tertiary education	
- Contributions and pension benefits are payable yearly in advance	
- Crude death rates by educational levels in 2013 are from the Eurostat	
- Pension remains constant throughout lifetime	

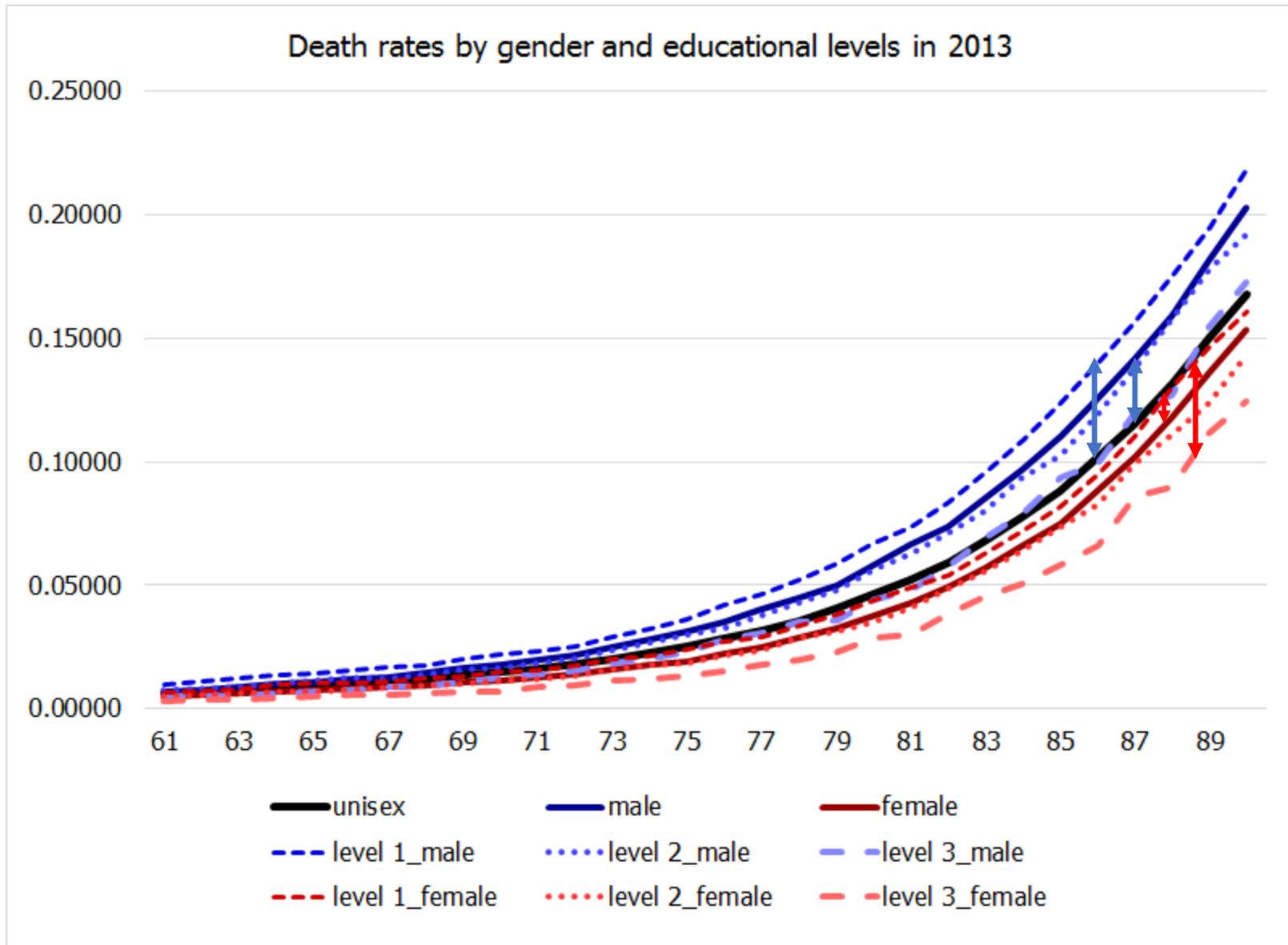
Numerical Analysis (cont.)

- Age-earnings profile, age 21-69



Source: based on Eurostat Database

- Mortality rates across gender and socio-economic status



Source: based on Eurostat Database

- Present value ratio (PVR) with different scenarios
 - Scenario 1: Initial pension with survivor dividend (unisex annuity divisor)

	Retirement age				
	61	63	65	67	69
Unisex AD	19.5746	18.4015	17.2279	16.055	14.8846
Present Value Ratio (PVR), Unisex					
all levels	1.0000	1.0000	1.0000	1.0000	1.0000
Present Value Ratio (PVR), Men					
all levels	0.9358	0.9301	0.9236	0.9163	0.9078
level 1	0.8654	0.8563	0.8464	0.8354	0.8231
level 2	0.9530	0.9489	0.9441	0.9388	0.9326
level 3	1.0334	1.0348	1.0361	1.0372	1.0380
Present Value Ratio (PVR), Women					
all levels	1.0495	1.0534	1.0578	1.0628	1.0685
level 1	0.9961	0.9973	0.9987	1.0006	1.0027
level 2	1.0591	1.0643	1.0702	1.0771	1.0849
level 3	1.1462	1.1586	1.1725	1.1883	1.2067

- Scenario 2: Initial pension without survivor dividend (unisex annuity divisor)

	Retirement age				
	61	63	65	67	69
Unisex AD	19.5746	18.4015	17.2279	16.055	14.8846
Present Value Ratio (PVR), Men					
all levels	0.8936	0.8784	0.8604	0.8391	0.8140
level 1	0.8264	0.8087	0.7884	0.7650	0.7381
level 2	0.9100	0.8961	0.8795	0.8597	0.8363
level 3	0.9868	0.9773	0.9651	0.9498	0.9307
Present Value Ratio (PVR), Women					
all levels	1.0022	0.9950	0.9855	0.9733	0.9581
level 1	0.9512	0.9419	0.9304	0.9164	0.8991
level 2	1.0114	1.0052	0.9970	0.9864	0.9727
level 3	1.0945	1.0943	1.0923	1.0882	1.0820

- Scenario 3: Initial pension with survivor dividend (unisex economic divisor)

- 3.1: Unisex economic divisor, ignoring educational levels

	Retirement age				
	61	63	65	67	69
Unisex ED	18.673797	17.492834	16.307866	15.125852	13.946856
Present Value Ratio (PVR), Men					
all levels	0.9809	0.9784	0.9757	0.9726	0.9689
level 1	0.9072	0.9007	0.8941	0.8867	0.8785
level 2	0.9990	0.9981	0.9974	0.9965	0.9953
level 3	1.0833	1.0885	1.0945	1.1009	1.1078
Present Value Ratio (PVR), Women					
all levels	1.1001	1.1082	1.1175	1.1281	1.1403
level 1	1.0441	1.0491	1.0551	1.0621	1.0701
level 2	1.1102	1.1196	1.1306	1.1432	1.1578
level 3	1.2015	1.2188	1.2387	1.2613	1.2878

- 3.2: Unisex economic divisor, each group of education contributed equally

	Retirement age				
	61	63	65	67	69
Unisex ED	18.949368	17.767287	16.579269	15.390429	14.194152
Present Value Ratio (PVR), Men					
all levels	0.9667	0.9633	0.9598	0.9559	0.9520
level 1	0.8940	0.8868	0.8795	0.8714	0.8632
level 2	0.9845	0.9827	0.9810	0.9793	0.9780
level 3	1.0675	1.0717	1.0766	1.0820	1.0885
Present Value Ratio (PVR), Women					
all levels	1.0841	1.0910	1.0992	1.1087	1.1204
level 1	1.0289	1.0329	1.0378	1.0438	1.0515
level 2	1.0941	1.1023	1.1121	1.1236	1.1376
level 3	1.1840	1.1999	1.2184	1.2396	1.2654

- 3.3: Unisex economic divisor, large group of lower education (70%) in the system

	Retirement age				
	61	63	65	67	69
Unisex ED	18.404978	17.25295	16.094198	14.936014	13.756137
Present Value Ratio (PVR), Men					
all levels	0.9952	0.9920	0.9887	0.9849	0.9823
level 1	0.9204	0.9133	0.9060	0.8980	0.8907
level 2	1.0136	1.0120	1.0106	1.0091	1.0091
level 3	1.0991	1.1037	1.1091	1.1149	1.1231
Present Value Ratio (PVR), Women					
all levels	1.1162	1.1236	1.1323	1.1424	1.1561
level 1	1.0594	1.0637	1.0691	1.0756	1.0850
level 2	1.1264	1.1352	1.1456	1.1578	1.1739
level 3	1.2190	1.2357	1.2551	1.2773	1.3056

- 3.4: Unisex economic divisor, large group of higher education (70%) in the system

	Retirement age				
	61	63	65	67	69
Unisex ED	19.557483	18.344689	17.125314	15.910974	14.68204
Present Value Ratio (PVR), Men					
all levels	0.9366	0.9329	0.9292	0.9246	0.9203
level 1	0.8662	0.8589	0.8514	0.8429	0.8345
level 2	0.9539	0.9518	0.9498	0.9473	0.9455
level 3	1.0343	1.0380	1.0423	1.0466	1.0523
Present Value Ratio (PVR), Women					
all levels	1.0504	1.0567	1.0642	1.0724	1.0832
level 1	0.9969	1.0004	1.0047	1.0097	1.0166
level 2	1.0600	1.0676	1.0766	1.0868	1.0998
level 3	1.1472	1.1622	1.1796	1.1990	1.2233

Conclusions

- The use of average (unisex) annuity divisor for converting notional balances into pension benefits in the NDC scheme entails a transfer of wealth from **high-mortality risk groups towards low-mortality risk; men → women, low education → high education.**
- In general, the pension scheme is worthy for females in all groups and males with degree level because these groups live longer than average population.
- Notional capital taking into account survivor dividend creates an actuarially fair pension system if mortality rates are as expected. When looking at different groups most women and men with high education get some gain from the system, due to the fact that the initial pension with survivor dividend is higher.
- It is important to consider the structure of the population because it will have an important impact on the gains and losses from the system.

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Thank you