Pension Economics: Basic Concepts and Identities

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Outline

- Pension system finances: key factors and relationships
- PAYG DB schemes
- Funded DC schemes
- Notional defined contribution plans
- Pension systems: individuals’ perspective
Pension system: main flows

Demography

Contributors → Beneficiaries

Economy

PS revenues ← PS design → PS expenditures

PF balance

Accumulated reserves/debt
Demography:
key demographic factors

- Population, age/gender composition → working age and old age population
- Fertility rates
- Mortality rates → life expectancy, life expectancy at retirement
- Migration flows, age and gender composition
Economy: key economic factors

- Macroeconomy
  - GDP
  - Inflation
  - Interest rates

- Labor market
  - Labor force participation rates
  - Unemployment
  - Wages, earning profile, income distribution
Pension system design: key parameters

- Revenue side
  - coverage
  - exempted
  - contribution rate
  - covered wage (ceilings/floors)

- Expenditure side
  - coverage
  - eligibility criteria (vesting period, retirement age, disability, survivorship)
  - benefit formula
  - indexation rules for post-retirement pensions
PAYG Defined Benefit systems

- Pension contributions are not saved. Instead, workers contributions today is used to pay pensioners today, according to a prescribed (defined benefit) formula. In return, workers gets a promise that they will receive a pension tomorrow, paid for by workers tomorrow.
PAYG DB finances

- Total expenditures \(\text{EXP} = B \times P\)
- Total revenues \(\text{REV} = C \times E\)
- Books are balanced when \(B \times P = C \times E\)

\[\begin{align*}
C & = \text{average contribution} \\
B & = \text{average benefit (pension)} \\
P & = \text{number of pensioners} \\
E & = \text{number of contributors}
\end{align*}\]
PAYG DB finances (cont.)

- Given that:
  \[ B = RR \times W; \quad C = W \times CR; \quad \text{and} \quad DR = \frac{P}{E} \]

- The pension fund balance equation can be presented as:
  \[ CR = RR \times DR \]

where:

- \( CR \) = contribution rate
- \( RR \) = average replacement rate (relative pension level)
- \( W \) = average wage
- \( DR \) = system dependency rate (the inverse – support ratio)
How to keep the system in balance?

- Adjust contribution rate
- Adjust replacement rate
- Adjust parameters affecting the dependency rate
- Combination of the above
- More direct control of CR and RR; less control over DR
Equilibrium contribution rate

- If replacement rate is fixed (target RR)
- Contribution rate required to finance a given average replacement rate is:
  \[ CR = RR \times DR \]
- So if the dependency rate grows the contribution rate has to be increased in order to bring the pension fund into balance
Example: Equilibrium contribution rate

Suppose:
– promised benefit (RR) = 60% wage
– system is new and populations young, DR = 1/8
– so each point of CR yields 8 points RR

Then: required CR = 60/8 = 7.5%

But:
– as population and system age, DR = 1/2
– so each point of CR yields 2 points RR

Then: required CR = 60/2 = 30%
Equilibrium replacement rate

- If contribution rate is fixed
- Another way to balance the system is through the replacement rate → affordable replacement rate is:
  \[ RR = \frac{CR}{DR} \]
- So, if the dependency rate grows and the contribution rate remains unchanged the replacement rate has to be reduced in order to keep the system in balance
Average replacement rate depends on:

- Policy choices about target individual replacement rate → Benefit formula
- Policy choices about pension indexation method
- Wages, wage growth rate
Benefit formula: benefit at retirement

- Accrual rate per year of service
- Min/Max replacement rates, min/max pensions
- Measure of income (reference wage, pensionable earning measure)
  - ceiling on pensionable wages
  - averaging period
  - valorization rules
- Penalties for early retirement, increments for late retirement
Post-retirement pensions: indexation methods

- Price indexation: pensions move with the price level; their real value remains unchanged
- Wage indexation: pensions move with wages; their relative value remains unchanged
- Combination of price and wage indexation (e.g. Swiss formula)
- Other indexation rules (ad hoc, fixed %, COLA, etc.)
How to affect finances through dependency rate?

- If contribution rate and replacement rate are fixed:
  \[ \text{DR} = \frac{\text{CR}}{\text{RR}} \]

- Dependency rate is not a policy variable, but some policy choices can change it.
System dependency rate depends on:

- Number of pensioners (P) ←
  - Demographic factors (population size and age structure, mortality rate after retirement → life expectancy after retirement)
  - Policy choices in social security system (coverage in the past, retirement age, vesting period, eligibility criteria for receiving disability pensions, survivors benefits)
System dependency rate depends on (cont.):

✓ Number of contributors (E) ←
  - Demographic factors (working age population, fertility in the past, mortality, migration)
  - Economic factors (school-leaving age, labor force participation, unemployment, the size of informal sector)
  - Policy choices (retirement age, coverage, contribution rate (if high→evasion), other)
Key policy choices to adjust system dependency rate:

- Coverage
- Retirement age
- Other (eligibility criteria, min/max, etc.)
Coverage: link between contributors and beneficiaries

- Contributors today $\rightarrow$ beneficiaries tomorrow $\rightarrow$ long-term changes in dependency rate
- Increase/decrease in coverage rates for contributors today result in increase/decrease in coverage rates for pensioners tomorrow

*Example: low dependency rates when system is young $\rightarrow$ dependency rate increases as system matures*
Coverage: link between contributors and beneficiaries (cont.)

- Average contribution density to the pension system affects the link between today’s contributors and tomorrow’s pensioners.

- Average years of service at retirement – proxy for “contribution density”. Pension system design (e.g. vesting period, max RR, other) \(\rightarrow\) built-in incentives + economy \(\rightarrow\) behavior

- Same coverage rates for contributors today result in higher/lower coverage rates for pensioners tomorrow with lower/higher contribution density
Retirement age

- Quantitative analysis of various pension systems: retirement age is the most effective policy variable to adjust long run DR
- Changes in retirement age affect both the nominator and denominator in DR=P/E
- If life expectancy increases, retirement age has to be adjusted to keep the system balanced
From the basic relationship (CR=RR*DR) → To make a PAYG DB financially sustainable, policy makers can change only two of the three key parameters:

- contribution rate
- replacement rate
- retirement age

Once two parameters are set, the third is determined endogenously.

Limits for setting exogenous parameters (e.g. replacement rate – social, contribution rate – economic, retirement age – physical)
Implicit pension debt in PAYG

- PAYG hides the true long-run cost of pension system
- As workers contribute, they are promised future pension, so the system accumulates liabilities, but no funds accumulate to pay debt: system has implicit (hidden) liabilities
- Three main approaches to measure IPD (unfunded liabilities): termination, closed-system, open-system measures
IPD: termination measure

- Liabilities accrued-to-date – if the system were stopped today; no new contributions, no new pension rights (variants – current vs. projected wages, indexation)

- Present value of future benefits owed to pensioners and workers for past contributions:

\[ \frac{B_1}{1+d} + \frac{B_2}{(1+d)^2} + \ldots + \frac{B_T}{(1+d)^T} \]

Where \( B_t \) = pension payments in year \( t \), \( t=1,\ldots,T \)
\( d \) = discount rate

- Important estimate of transition costs in case of shift to a funded DC system
IPD: closed-system measure

- Closed system liabilities – if the system continues only for existing participants; no new entrants

- Net present value of future contributions and benefit payments

\[
(C_1 - B_1)/(1+d) + (C_2 - B_2)/(1+d)^2 + \ldots + (C_N - B_N)/(1+d)^N
\]

where

- \(B_t\) = pension payments in year \(t\), \(t=1,\ldots,N\)
- \(C\) = contributions in year \(t\), \(t=1,\ldots,N\)
- \(d\) = discount rate
IPD: open-system measure

- Open system liabilities – if the system continues indefinitely; open to new entrants

- Net present value of future contributions and benefit payments

\[
\frac{(C_1 - B_1)}{(1+d)} + \frac{(C_2 - B_2)}{(1+d)^2} + \ldots + \frac{(C_M - B_M)}{(1+d)^M}
\]

Where

- \( B_t \) = pension payments in year \( t, t=1,\ldots,M \)
- \( C \) = contributions in year \( t, t=1,\ldots,M \)
- \( d \) = discount rate
Fully Funded Defined Contribution systems

- Contribution is put into individual’s account → Assets are accumulated and earn interest, accumulated capital used to pay for pensions. So, no implicit debt or unaffordable promises;

- Pension depends on:
  - Contribution rate
  - Individual’s wages
  - Rate of return, rate of return-wage growth gap
  - Passivity ratio (retirement years/working years → years of service, retirement age, life expectancy)
  - Other (e.g. administrative costs)
Capital accumulated by the year of retirement

\[ AC = C_1*(1+r)^N + C_2*(1+r)^{N-1} + \ldots + C_N*(1+r) \]

where

\[ C_t = CR_t * W_t \]

\[ N = \text{number of working years} \]

\[ r = \text{rate of return (here assumed to be constant)} \]

\[ C_t = \text{contribution in year } t, \text{ for } t = 1, 2, \ldots, N \]

\[ CR_t = \text{contribution rate in year } t, \text{ for } t = 1, 2, \ldots, N \]

\[ W_t = \text{worker’s wage in year } t, \text{ for } t = 1, 2, \ldots, N \]
Benefit payout: annuity

- When worker retires, AC is turned into pension which is set so that:

\[ B_0 + \frac{B_1}{(1+r)} + \ldots + \frac{B_M}{(1+r)^M} = AC \]

- Initial benefit calculation: \( B_0 = \frac{AC}{AF} \)

where

\[ B_t = B_{t-1} \times \text{indexation coefficient, } t>0 \]

\( M = \text{number of retirement years} \)

\( AF = \text{annuity factor} \)

- No bequest to survivors
Annuity factor:

- If a person of certain age and gender is promised a benefit=$1, with specified indexation rules, how much is such a promise worth in today’s dollars?

\[ 1 + \text{ind}_1 \cdot \frac{\text{surv}_1}{1+r} + (\text{ind}_1 \cdot \text{ind}_2) \cdot \frac{\text{surv}_1 \cdot \text{surv}_2}{(1+r)^2} + \ldots \]

where

- \( \text{ind}_t \) = indexation coefficient in year \( t \) of retirement
- \( \text{surv}_t \) = probability of surviving from year \( t-1 \) to \( t \)
Benefit payout: programmed withdrawals

- The account continues to earn interest while pensioner withdraws funds
- Benefit is recalculated each year:
  \[ B_t = \frac{RC_t}{LE_{t,a}} \]
  where
  \( RC_t = \) remaining capital in year \( t \)
  \( LE_{t,a} = \) life expectancy at age \( a \) in year \( t \)
- If dies early, the remaining balance is turned over to survivors. If lives very long, \( B_t \) may become very low
- Other payout forms (lumpsums, required minimum annuity, etc.)
Notional Defined Contribution schemes

- Contributions based on a fixed percent of individual earnings create account values
- Account balances earn a rate of return (notional) set by the government
- PAYG financed: current contributions pay for current benefits
- “Notional accounts”: just a series of individual claims on the future public budget
- DC formula for pension calculation
Notional capital accumulated by the year of retirement

\[ \text{NAC} = C_1 \times (1+n)^N + C_2 \times (1+n)^{N-1} + \ldots + C_N \times (1+n) \]

where

\[ C_t = CR_t \times W_t \]
\[ N = \text{number of working years} \]
\[ n = \text{notional interest rate (here assumed to be constant)} \]
\[ C_t = \text{contribution in year } t, \text{ for } t = 1, 2, \ldots, N \]
\[ CR_t = \text{contribution rate in year } t, \text{ for } t = 1, 2, \ldots, N \]
\[ W_t = \text{worker’s wage in year } t, \text{ for } t = 1, 2, \ldots, N \]
Notional defined contribution schemes: payouts

- Accumulated account values are annuitized at the time of retirement
- Annuities are calculated on the basis of accumulated notional capital and life expectancy at the age of retirement:
  \[ B_0 = \frac{NAC}{AF} \]
  where
  - \( B_0 \) = initial annuity (pension)
  - NAC = account value (notional capital)
  - AF = annuity factor
- Further indexed according to system rules
Pension systems: individual’s perspective

- How do particular types of individuals fare under different types of pension system?
- Compare what a person contributes to the system and what he/she receives from the system
- Indicators: contribution rate, covered wage, individual replacement rate, pension wealth (present value of expected pension payments), internal rate of return
Internal rate of return

- Participation in a pension system can be viewed as investment (implicit in PAYG, more explicit in FF)
- Comprehensive measure of effectiveness of participating in the pension system from individual’s standpoint: interest paid by the system
- Calculated as discount rate equalizing the present of contributions paid to the system and the present value of benefits received from the system
How IRR can be used?

- Do individuals lose or benefit? Comparison with alternative investment options (e.g. IRR vs market interest rate)
- Important in the analysis of intra- and intergenerational distribution effects
  
  Example: men and women with same wages pay same contributions, retire at the same age, get same replacement rate but IRR for women is higher $\Leftarrow$ life expectancy (hidden redistribution from men to women in DB; also in DC if unisex mortality table)
- An important indicator in the financial sustainability analysis of pension system as a whole
Thank You!