The macroeconomic effects of longevity risk under private and public insurance and asymmetric information

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Annuity puzzle

- Annuity puzzle: despite the theoretical attractiveness of annuities, in practice people tend not to invest much of their wealth in private annuity markets.
- Possible explanations:
  - Bequest motive
  - Psychological factors
  - Crowding out by social annuities
  - Actuarially unfair rates of return
    - Administrative costs and taxes
    - Imperfect competition
    - Adverse selection
- Goal of the paper: analyze the macroeconomic and welfare effects of adverse selection in private annuity markets and the role of social annuities
- General equilibrium framework instead of partial equilibrium
- Individuals are heterogeneous along two dimensions: health and ability

Main findings

- As in Heijdra & Reijnders (2009): Under asymmetric information there will be a pooling equilibrium in the private annuity market. [Contrast to Bester (1985) and Rothschild & Stiglitz (1976) who argue that credit and insurance markets have separating equilibria.]
- Asymmetric information is important quantitatively (crowding out)
- Funded social security systems cause additional crowding out
- As in Abel (1986), Walliser (2000) and Palmon & Spivak (2007): The introduction of social annuities aggravates adverse selection in the private annuity market
- Even though a social security system is immune to adverse selection, it may decrease welfare
- Privatizing (abolishing) social security is not Pareto improving to all cohorts: shock-time healthy lose out

Outline

1. Model
   - Consumers
   - Demography
   - Firms
   - Capital stock dynamics
2. Private annuity markets
   - Separating equilibrium
   - Pooling equilibrium
3. Public annuities
   - Pension system A
   - Pension system B
   - Pension system C
   - Privatizing social security?

Individuals (1)

- Consumers differ in two dimensions:
  - health (survival probability): μ
  - ability (labour productivity): η
  - positive correlation between μ and η
- They live for a maximum of two periods (youth and old age), and work full time during youth and part time during old-age
- Expected lifetime utility of a consumer of type (μ, η):

$$\mathbb{E}\Lambda_t(\mu, \eta) \equiv U\left(C_t^y(\mu, \eta)\right) + \mu\beta U\left(C_{t+1}^o(\mu, \eta)\right)$$

with:

$$U(x) \equiv \begin{cases} \dfrac{x^{1-1/\sigma} - 1}{1 - 1/\sigma}, & \text{for } \sigma \neq 1, \\ \ln x & \text{for } \sigma = 1, \end{cases}$$

  - $C_t^y(\mu, \eta)$ is youth-consumption
  - $C_{t+1}^o(\mu, \eta)$ is old-age consumption
  - β is the discount factor due to time preference

Individuals (2)

- Periodic budget constraints:

$$C_t^y(\mu,\eta) + A_t^p(\mu,\eta) = w_t(\eta)$$

$$C_{t+1}^o(\mu,\eta) = \lambda w_{t+1}(\eta) + (1 + r_{t+1}^p(\mu))A_t^p(\mu,\eta)$$

  - $A_t^p(\mu,\eta)$ is annuity purchases
  - $r_{t+1}^p(\mu)$ is the net rate of return on annuities
  - $w_t(\eta)$ is the wage rate
  - λ is the proportion of time devoted to work in old age (exogenous)

- Interior solutions for $C_t^y(\mu,\eta)$ and $A_t^p(\mu,\eta)$:

$$C_t^y(\mu,\eta) = \Phi\left(\mu, 1 + r_{t+1}^p(\mu)\right)\left[w_t(\eta) + \frac{\lambda w_{t+1}(\eta)}{1 + r_{t+1}^p(\mu)}\right]$$

$$A_t^p(\mu,\eta) = \left[1 - \Phi\left(\mu, 1 + r_{t+1}^p(\mu)\right)\right] w_t(\eta) - \Phi\left(\mu, 1 + r_{t+1}^p(\mu)\right)\frac{\lambda w_{t+1}(\eta)}{1 + r_{t+1}^p(\mu)}$$

with $\Phi(\mu,x) \equiv [1 + (\mu\beta)^\sigma x^{\sigma-1}]^{-1}$

Demography

- The density of consumers with health type μ and working ability η is:

$$L_t(\mu, \eta) \equiv h(\mu, \eta) L_t$$

  - L_t is the size of the population cohort born at time t
  - $h(\mu, \eta)$ is the density function

- The density of (young and old) consumers of type μ alive at time t is:

$$P_t(\mu) \equiv \mu \int_{\eta_L}^{\eta_H} L_{t-1}(\mu, \eta) d\eta + \int_{\eta_L}^{\eta_H} L_t(\mu, \eta) d\eta = \mu h_\mu(\mu) L_{t-1} + h_\mu(\mu) L_t$$

  - $h_\mu(\mu)$ is the marginal distribution of μ

- The newborn cohort sizes evolves according to $L_t = (1+n)L_{t-1}$ so the total population at time t is:

$$P_t \equiv \int_{\mu_L}^{\mu_H} P_t(\mu) d\mu = \frac{1+n+\bar{\mu}}{1+n} L_t$$

  - $\bar{\mu} \equiv \int_{\mu_L}^{\mu_H} \mu h_\mu(\mu) d\mu$ is the average survival rate of a newborn cohort

Production (1)

- Closed economy with perfectly competitive firms
- Production technology is Cobb-Douglas:

$$Y_t = \Omega_0 K_t^{\varepsilon} N_t^{1-\varepsilon}, \qquad 0 < \varepsilon < 1, \quad \Omega_0 > 0$$

  - Y_t is total production
  - K_t is the aggregate capital stock
  - N_t is the *effective* labor force:

$$N_t \equiv \int_{\eta_L}^{\eta_H} \int_{\mu_L}^{\mu_H} \eta \left[L_t(\mu, \eta) + \lambda L_{t-1}(\mu, \eta) \right] d\mu d\eta$$

  - N_t has the dimension of worker efficiency (denoted by η) times number of working hours
  - N_t / L_t can be written as:

$$\frac{N_t}{L_t} = \bar{\eta} + \frac{\lambda}{1+n} \left[\bar{\eta}\bar{\mu} + \mathrm{cov}\left(\eta, \mu\right) \right]$$

  where $\mathrm{cov}\left(\eta, \mu\right)$ is the (positive) covariance between μ and η

Production (2)

- Intensive-form production function:

$$y_t = \Omega_0 k_t^{\varepsilon}$$

with $y_t \equiv Y_t / N_t$ and $k_t \equiv K_t / N_t$

- Factor demand equations:

$$\begin{aligned} r_t + \delta &= \varepsilon \Omega_0 k_t^{\varepsilon - 1} \\ w_t &= (1 - \varepsilon) \Omega_0 k_t^{\varepsilon} \\ w_t(\eta) &= \eta w_t \end{aligned}$$

  - r_t is the net rate of return on physical capital
  - δ is the depreciation rate of capital ($0 < \delta < 1$)
  - w_t is the rental rate on efficiency units of labour

Equilibrium

- Capital market clearing condition:

$$K_{t+1} = L_t \int_{\mu_L}^{\mu_H} \int_{\eta_L}^{\eta_H} A_t^p(\mu,\eta) h(\mu,\eta) d\eta d\mu \qquad \text{(FDE)}$$

- The demand for annuities $A_t^p(\mu,\eta)$ depends on w_t, w_{t+1}, and $r_{t+1}^p(\mu)$
- The rate of return on annuities $r_{t+1}^p(\mu)$ depends on r_{t+1}
- Hence: w_t and (w_{t+1}, r_{t+1}) depend on, respectively, k_t and k_{t+1} so (FDE) is a non-linear implicit function relating k_{t+1} to k_t and the exogenous variables

Perfect information in the private annuity market

- Benchmark assumptions:
  - (A0) Health status is public information.
  - (A1) The annuity market is perfectly competitive. There is a large number of risk neutral firms offering annuities to individuals, and firms can freely enter or exit the market.
  - (A2) Annuity firms do not use up any real resources.
- Separating equilibrium
- Zero-profit condition for each μ:

$$(1+r_{t+1})\int_{\eta_L}^{\eta_H} L_t(\mu,\eta)A_t^p(\mu,\eta)d\eta = (1+r_{t+1}^p(\mu))\int_{\eta_L}^{\eta_H} \mu L_t(\mu,\eta)A_t^p(\mu,\eta)d\eta$$

- Annuity rate of return for μ-type individual:

$$1+r_{t+1}^p(\mu) = \frac{1+r_{t+1}}{\mu}$$

- Full annuitization optimal as $r_{t+1}^p(\mu) > r_{t+1}$ for all μ
- Economic intuition: **Figure 2**

show

Parameterization and visualization

- Model too stylized to calibrate on an actual economy
- Parameterization approach
  - Pick plausible values for σ, δ_a, n_a, and $\hat{r}_a$
  - Set length of life period at 40 years
  - Set mandatory retirement age at 65 years (by choice of λ)
  - Postulate a joint distribution for μ and η: bivariate uniform with a positive correlation between the two ($\text{cor}(\mu, \eta) = 0.3$). See **Figure 1** show
- Summary of the structural parameters: **Table 1** show
- Steady-state equilibrium under **Full Information**: **Table 2(a)** show
- Steady-state average profiles by health (solid lines): **Figure 3** show

Asymmetric information in the private annuity market (1)

- Replace Assumption (A0) by:

  (A3) Health status and productivity are private information of the annuitant. The distribution of health and productivity types in the population, $H(\mu, \eta)$, is common knowledge.

  (A4) Annuitants can buy multiple annuities for different amounts and from different annuity firms. Individual annuity firms cannot monitor their clients' wage income or annuity holdings with other firms.

- Pooling equilibrium
  - Healthy agents ($\mu_t^{bc} \leq \mu \leq \mu_H$) buy annuities and face a common rate, $r_{t+1}^p(\mu) = \bar{r}_{t+1}^p$
  - Unhealthy agents ($\mu_L \leq \mu < \mu_t^{bc}$) drop out of the annuity market and face borrowing constraints
- The zero-profit condition for the private annuity market is given by:

$$(1+r_{t+1}) \int_{\eta_L}^{\eta_H} \int_{\mu_t^{bc}}^{\mu_H} L_t(\mu, \eta) A_t^p(\mu, \eta) d\mu d\eta = (1+\bar{r}_{t+1}^p) \int_{\eta_L}^{\eta_H} \int_{\mu_t^{bc}}^{\mu_H} \mu L_t(\mu, \eta) A_t^p(\mu, \eta) d\mu d\eta$$

Asymmetric information in the private annuity market (2)

- The pooling rate is:

$$1+\bar{r}^{p}_{t+1}=\frac{1+r_{t+1}}{\bar{\mu}^{p}_{t}}$$

- Here $\bar{\mu}^{p}_{t}$ is the asset-weighted average survival rate of annuity purchasers:

$$\bar{\mu}^{p}_{t}\equiv\int_{\mu^{bc}_{t}}^{\mu_H}\mu\omega_t(\mu)d\mu,\quad \omega_t(\mu)\equiv\frac{\int_{\eta_L}^{\eta_H}A^{p}_{t}(\mu,\eta)h(\mu,\eta)d\eta}{\int_{\eta_L}^{\eta_H}\int_{\mu^{bc}_{t}}^{\mu_H}A^{p}_{t}(\mu,\eta)h(\mu,\eta)d\mu d\eta}$$

- Since $\mu^{bc}_{t}<\bar{\mu}^{p}_{t}<\mu_H<1$ it follows that $\bar{r}^{p}_{t+1}$ exceeds r_{t+1}: all net savers will completely annuitize their wealth
- Economic intuition: **Figure 4**

show

Asymmetric information in the private annuity market (3)

- The pooling rate is demographically unfair because it is based on the *asset-weighted* survival rate $\bar{\mu}_t^p$ rather than on the *average* survival rate in the population $\bar{\mu}$
- The demographically fair pooling rate is given by:

$$1 + \bar{r}_{t+1}^{df} = \frac{1 + r_{t+1}}{\bar{\mu}}$$

  and, since $\bar{\mu} < \bar{\mu}_t^p$ it follows readily that $\bar{r}_{t+1}^p < \bar{r}_{t+1}^{df}$
- Steady-state equilibrium under **Asymmetric Information**: **Table 2(b)** show
- Steady-state average profiles by health (dashed lines): **Figure 3** show

Fully funded pensions (1)

- Features of the Asymmetric Information equilibrium:
  - Relatively unhealthy annuitants face a disadvantageous pooling rate of interest on their annuities. In essence such individuals are subsidizing their healthy cohort members through the annuity market.
  - Very unhealthy individuals drop out of the annuity market and face binding borrowing constraints
- A government-run and fully-funded mandatory social security system is immune to adverse selection because all individuals are forced to participate in it
- Pension contributions during youth
  - An individual's contributions during youth are proportional to wage income, $A_t^s(\eta) = \theta w_t(\eta)$, where θ is the social security tax (such that $0 < \theta < 1$)
  - Total pension contributions, $A_t^s = \theta \bar{\eta} w_t L_t$, are invested in the capital market earning a gross rate of return equal to $1 + r_{t+1}$
  - In the next period the returns $R_{t+1} = (1 + r_{t+1}) A_t^s$ are paid out to surviving agents

Fully funded pensions (2)

- Pension receipts during old-age
  - System A: pension receipts during old-age are proportional to contributions made during youth
  - System B: pension contributions of η types are distributed during old-age to surviving η types
  - System C: pension receipts are the same in absolute value for all surviving agents
- What are the allocational and welfare effects of public annuities?

Pension system A (SA_A)

- Pension received by an η individual:

$$R^s_{t+1}(\eta) = \zeta\theta w_t(\eta)$$

- The clearing condition for the public annuity system:

$$(1 + r_{t+1})A^s_t = \int_{\eta_L}^{\eta_H} \int_{\mu_L}^{\mu_H} \mu R^s_{t+1}(\eta) L_t(\mu, \eta) d\mu d\eta$$

- Since $w_t(\eta) = \eta w_t$ the balanced-budget solution for ζ is:

$$\zeta = \zeta_A \, \frac{1 + r_{t+1}}{\bar{\mu}}, \qquad \zeta_A \equiv \frac{\bar{\eta}\bar{\mu}}{\mathrm{cov}\,(\eta, \mu) + \bar{\eta}\bar{\mu}}$$

- Since $0 < \zeta_A < 1$, the rate of return on social annuities falls short of the demographically fair social annuity yield, $(1 + r_{t+1})/\bar{\mu}$, because health and productivity are positively correlated (high contributors tend to live longer than average)

Pension system A (2)

- Effective pension contribution rate is:

$$\theta_t^n \equiv \theta \left(1 - \zeta_A \frac{\bar{\mu}_t^p}{\bar{\mu}}\right)$$

where the plausible case is that $\theta_t^n < 0$ (see **Figure 9(c)**) ▸ show

- Economic intuition: **Figure 5** ▸ show
- Steady-state equilibrium under SA_A: **Table 2(c)-(d)** ▸ show
- Comparison SA_A (solid lines) and AI (dashed lines) in **Figure 6** ▸ show

Pension system B (SA_B)

- The pension authority uses its knowledge of η by setting pension receipts according to the following rule:

$$R^s_{t+1}(\eta) = \zeta(\eta)\theta w_t(\eta)$$

- The clearing condition for the public annuity system:

$$(1 + r_{t+1})\theta w_t(\eta) \int_{\mu_L}^{\mu_H} L_t(\mu, \eta) d\mu = \int_{\mu_L}^{\mu_H} \mu R^s_{t+1}(\eta) L_t(\mu, \eta) d\mu$$

- Since $w_t(\eta) = \eta w_t$ the balanced-budget solution for $\zeta(\eta)$ is:

$$\zeta(\eta) = \zeta_B(\eta)\,\frac{1 + r_{t+1}}{\bar{\mu}}, \quad \zeta_B(\eta) \equiv \frac{\bar{\mu}}{\bar{\mu} + \xi\sigma^2_\mu(\eta - \bar{\eta})} \begin{matrix} > \\ = \\ < \end{matrix} 1 \;\Leftrightarrow\; \eta \begin{matrix} < \\ = \\ > \end{matrix} \bar{\eta}$$

- *Explicit* redistribution from high-ability to low-ability individuals
- *Implicit* redistribution from healthy to unhealthy individuals (due to positive correlation between ability and health)

Pension system B (2)

- Effective pension contribution rate is:

$$\theta_t^n(\eta) \equiv \theta \left(1 - \zeta_B(\eta)\frac{\bar{\mu}_t^p}{\bar{\mu}}\right)$$

  where the plausible case is that $\theta_t^n(\eta) < 0$ for all η (see **Figure 9(c)**) show
- Economic intuition: **Figure 7** show
- Steady-state equilibrium under SA_B: **Table 2(e)** show
- Comparison SA_B (solid lines) and AI (dashed lines) in **Figure 10** show

Pension system C (SA_C)

- The pension authority provides everybody with the same pension:

$$R^s_{t+1}(\eta) = \bar{R}^s_{t+1}$$

- The clearing condition for the public annuity system:

$$(1 + r_{t+1})\theta\bar{\eta}w_t L_t = L_t \int_{\mu_L}^{\mu_H} \int_{\eta_L}^{\eta_H} \mu \bar{R}^s_{t+1} h(\mu, \eta) d\eta d\mu \qquad \Leftrightarrow$$

$$\bar{R}^s_{t+1} = \theta\bar{\eta}w_t \frac{1 + r_{t+1}}{\bar{\mu}}$$

- In summary:

$$R^s_{t+1}(\eta) = \zeta(\eta)\theta w_t(\eta)$$

$$\zeta(\eta) = \zeta_C(\eta)\,\frac{1 + r_{t+1}}{\bar{\mu}}, \qquad \zeta_C(\eta) \equiv \frac{\bar{\eta}}{\eta} \begin{matrix} > \\ = \\ < \end{matrix} 1 \Leftrightarrow \eta \begin{matrix} < \\ = \\ > \end{matrix} \bar{\eta}$$

- Redistribution is similar to that under pension system B

Pension system C (2)

- Effective pension contribution rate is:

$$\theta_t^n(\eta) \equiv \theta \left(1 - \zeta_C(\eta)\frac{\bar{\mu}_t^p}{\bar{\mu}}\right)$$

where the plausible case is that $\theta_t^n(\eta) > 0$ for very high valus of η (see **Figure 9(c)**) show

- Steady-state equilibrium under SA_C: **Table 2(g)** show
- Comparison SA_C (solid lines) and AI (dashed lines) in **Figure 11** show

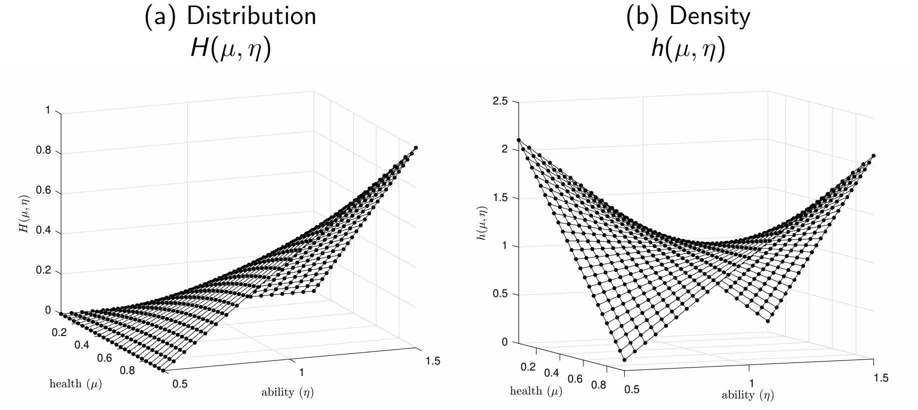
Summary on public annuities

- All pension systems that we have studied are immune to adverse selection by design but they:
  - exacerbate the adverse selection problem in the market for private annuities
  - increase the fraction of borrowing-constrained ('over-annuitized') individuals in the population. See **Figure 8** show
  - lead to long-run crowding out of capital and substantial output losses. See **Table 2** show
- Is it better to privatize social security altogether and to allow individuals to insure against longevity risk in the private annuity market even though this market is not perfect?
- Privatising social security: Abolishing pension system A
  - Large steady-state output and welfare gains
  - There is some transitional dynamics in macro variables. See **Figure 12** show
  - Privatization is not a 'win-win' scenario. Shock-time healthy individuals are worse off as a result of the privatization. See **Figure 13** show

Conclusions

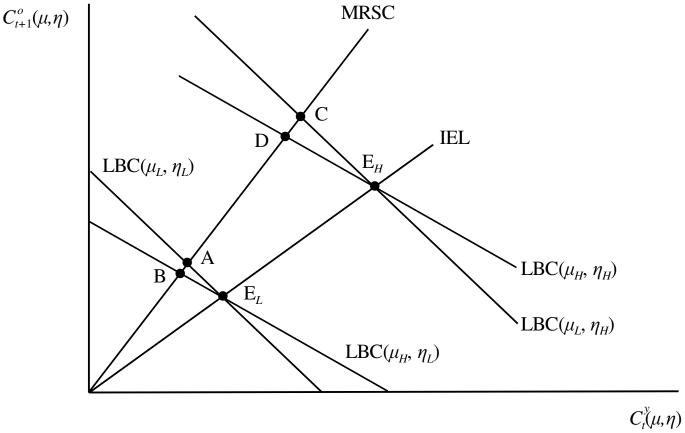
- When an individual's health and ability are private information there will be a pooling equilibrium in the private annuity market
- Asymmetric information matters quantitatively
- Funded social security causes further crowding out under asymmetric information
- When people differ along two dimensions (health and ability) private and public longevity insurance cause explicit and implicit redistribution effects
- Pension systems that redistribute from high- to low-ability types exacerbate the incidence of borrowing constraints
- Abolishing social security does not benefit all cohorts

Figure 1: Features of the distribution for μ and η



return

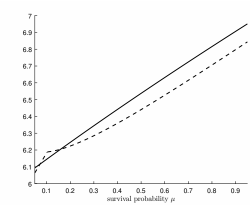
Figure 2: Consumption-saving choices under full information



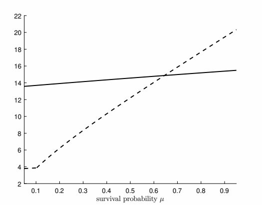
return

Figure 3: Steady-state profiles

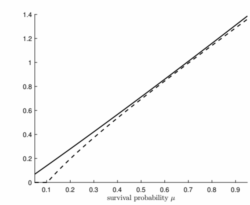
(a) Youth consumption
$\hat{C}^y(\mu)$



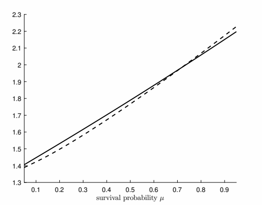
(b) Old-age consumption
$\hat{C}^o(\mu)$



(c) Annuity demand
$\hat{A}^p(\mu)$



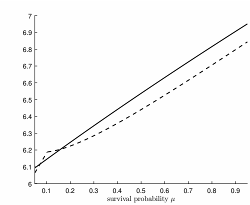
(d) Expected utility
$\mathbb{E}\hat{\Lambda}(\mu)$



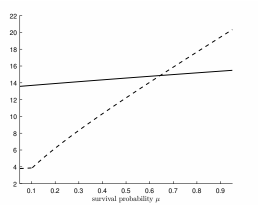
return

Figure 3: Steady-state profiles

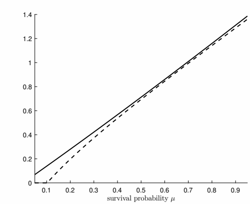
(a) Youth consumption
$\hat{C}^y(\mu)$



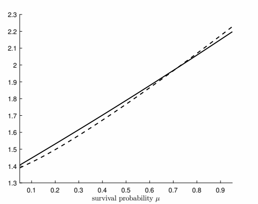
(b) Old-age consumption
$\hat{C}^o(\mu)$



(c) Annuity demand
$\hat{A}^p(\mu)$

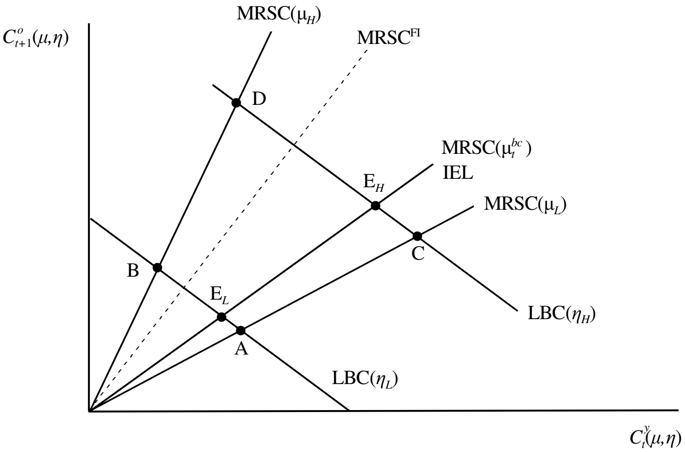


(d) Expected utility
$\mathbb{E}\hat{\Lambda}(\mu)$



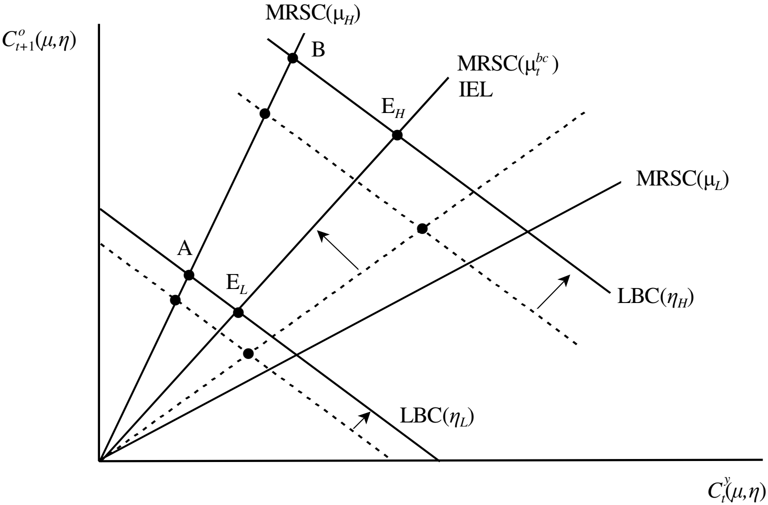
▸ return

Figure 4: Consumption-saving choices under asymmetric information



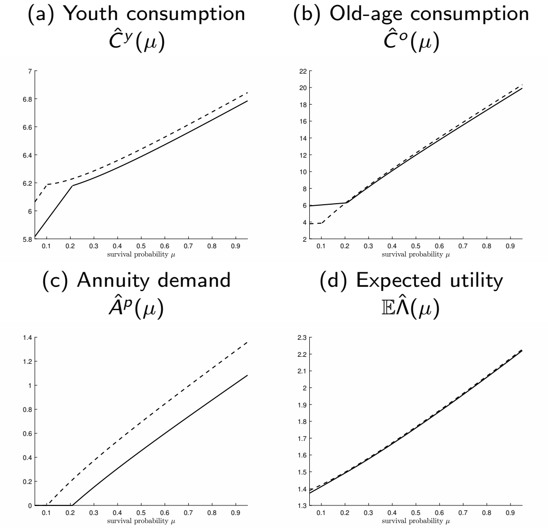
return

Figure 5: Consumption-saving choices under pension system A



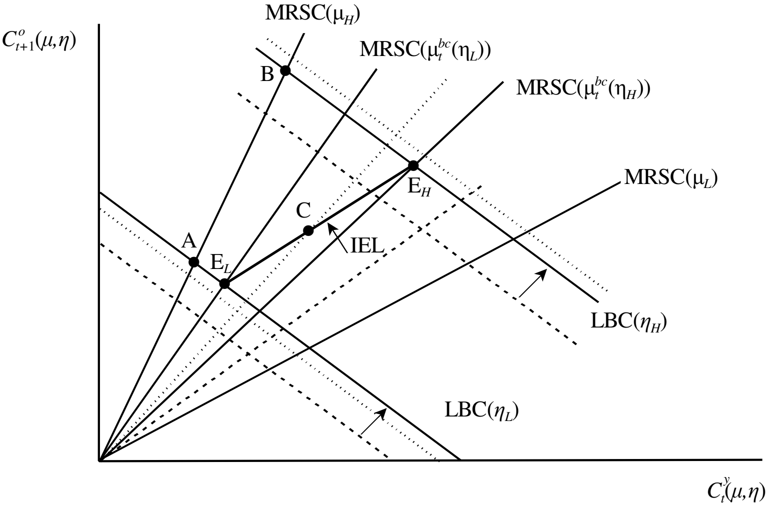
return

Figure 6: Steady-state profiles under pension system A



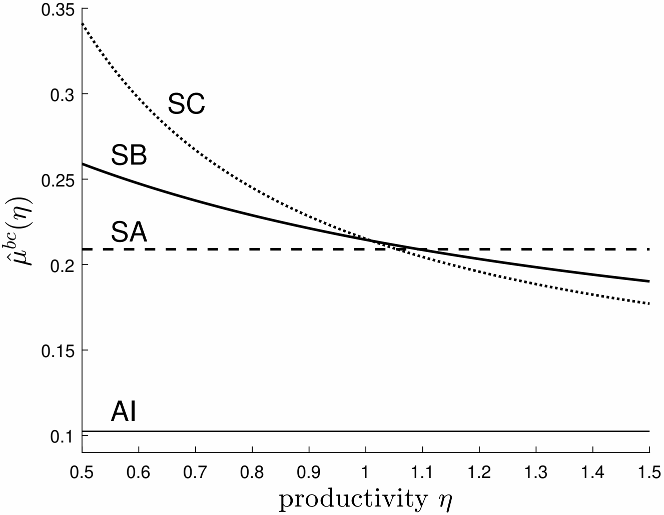
return

Figure 7: Consumption-saving choices under pension system B



return

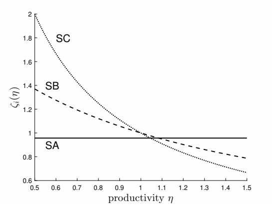
Figure 8: Ability and borrowing constraints



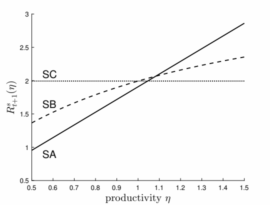
return

Figure 9: Comparing pension systems

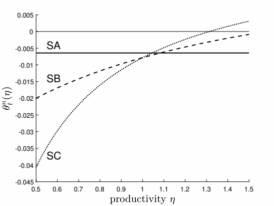
(a) Fair-rate share
$\zeta_i(\eta)$



(b) Pension receipt
$R^s_{t+1}(\eta)$

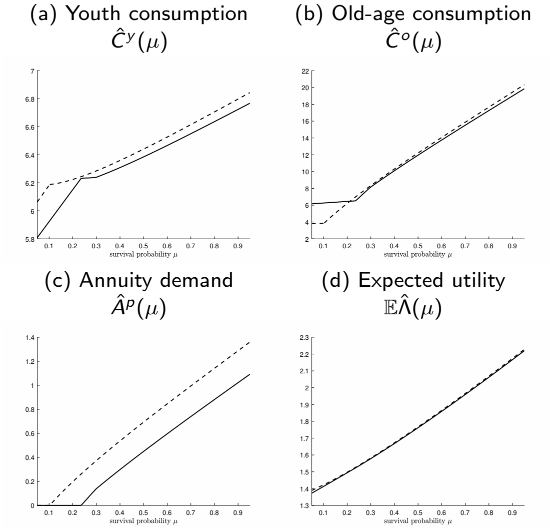


(c) Effective pension contribution rate
$\theta^n_t(\eta)$



return to SA_A return to SA_B return to SA_C

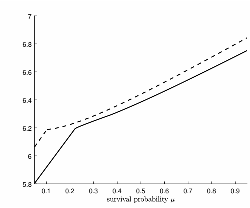
Figure 10: Steady-state profiles under pension system B



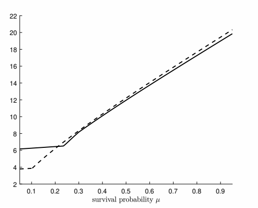
return

Figure 11: Steady-state profiles under pension system C

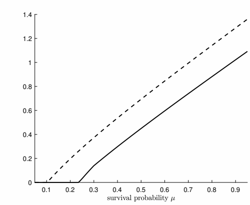
(a) Youth consumption
$\hat{C}^y(\mu)$



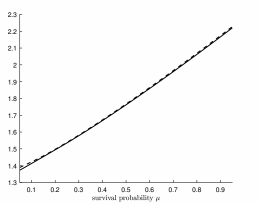
(b) Old-age consumption
$\hat{C}^o(\mu)$



(c) Annuity demand
$\hat{A}^p(\mu)$



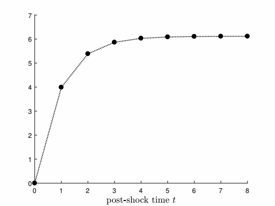
(d) Expected utility
$\mathbb{E}\hat{\Lambda}(\mu)$



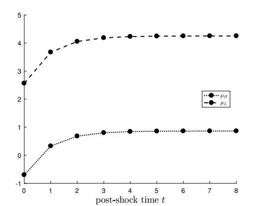
return

Figure 12: Abolishing pension system A

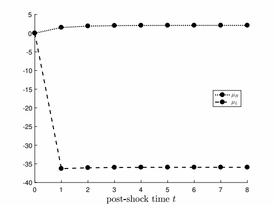
(a) Capital intensity $\frac{\Delta k_t}{\hat{k}} \cdot 100\%$



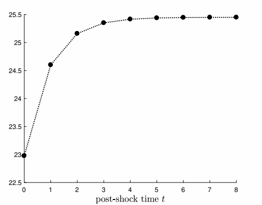
(b) Youth consumption $\frac{\Delta C_t^o(\mu_i,\eta_L)}{\hat{C}^o(\mu_i,\eta_L)} \cdot 100\%$



(c) Old-age consumption $\frac{\Delta C_t^y(\mu_i,\eta_L)}{\hat{C}^y(\mu_i,\eta_L)} \cdot 100\%$



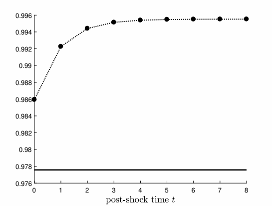
(d) Annuity demand $\frac{\Delta A_t^p(\mu_i,\eta_L)}{\hat{A}^p(\mu_i,\eta_L)} \cdot 100\%$



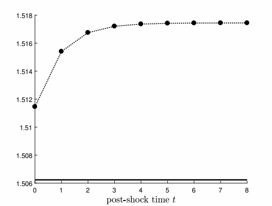
return

Figure 13: Lifetime utility of corner types

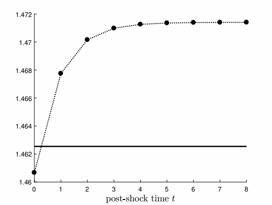
(a) Unhealthy and low productivity $\mathbb{E}\Lambda_t(\mu_L, \eta_L)$



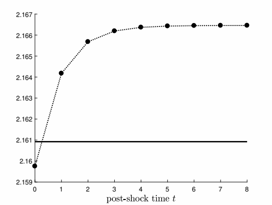
(b) Unhealthy and high productivity $\mathbb{E}\Lambda_t(\mu_L, \eta_H)$



(c) Healthy and low productivity $\mathbb{E}\Lambda_t(\mu_H, \eta_L)$



(d) Healthy and high productivity $\mathbb{E}\Lambda_t(\mu_H, \eta_H)$



return

Table 1: Structural parameters

σ	intertemporal substitution elasticity		0.7000
ε	capital efficiency parameter		0.2750
δ_a	annual capital depreciation rate		0.0600
δ	capital depreciation factor		0.9158
n_a	population growth rate		0.0100
n	population growth factor		0.4889
β	time preference parameter	c	0.4462
λ	mandatory retirement parameter		0.6250
Ω_0	scale factor production function	c	12.9071
μ_L	survival rate of the unhealthiest		0.0500
μ_H	survival rate of the healthiest		0.9500
η_L	lowest working ability		0.5000
η_H	highest working ability		1.5000
ξ	covariance parameter of the distribution function		4.0000

return

Table 2: Allocation and welfare

	(a) FI	(b) AI	(c) SA_A $\theta = 0.010$	(d) SA_A $\theta = 0.025$	(e) SA_B $\theta = 0.010$	(f) SA_B $\theta = 0.025$	(g) SA_C $\theta = 0.010$	(h) SA_C $\theta = 0.025$
$\hat{y}$	10.000	9.840	9.776	9.680	9.768	9.668	9.762	9.660
$\hat{k}$	0.395	0.373	0.364	0.351	0.363	0.350	0.362	0.349
%Q1	12.34	11.78	10.15	7.73	9.69	6.69	9.15	5.50
%Q2	19.81	19.46	17.14	13.59	16.90	12.98	16.75	12.60
%Q3	28.73	28.84	25.81	21.05	25.92	21.26	26.12	21.66
%Q4	39.12	39.93	36.18	30.11	36.74	31.46	37.22	32.58
%SAS			10.72	27.51	10.74	27.60	10.76	27.67
$\hat{r}$	6.04	6.34	6.47	6.66	6.48	6.69	6.50	6.70
$\hat{r}^a$	5.00%	5.11%	5.16%	5.22%	5.16%	5.23%	5.17%	5.24%
$\hat{w}$	7.250	7.134	7.087	7.018	7.082	7.010	7.077	7.003
$\widehat{BC}$	0.00%	5.83%	10.03%	17.66%	10.63%	19.33%	10.63%	19.33%
$\hat{\bar{r}}^p$		10.18	10.12	9.99	10.12	9.98	10.12	9.96
$\hat{\bar{\mu}}^p$		0.66	0.67	0.70	0.67	0.70	0.67	0.70
$\widehat{AS}$		1.31	1.34	1.39	1.35	1.40	1.35	1.41
$\hat{c}^y$	5.357	5.296	5.270	5.233	5.268	5.228	5.265	5.225
%Q1	15.99	16.03	16.02	15.98	16.06	16.09	16.12	16.20
%Q2	22.10	22.13	22.12	22.10	22.14	22.16	22.16	22.20
%Q3	28.06	28.05	28.05	28.06	28.04	28.04	28.02	27.99
%Q4	33.85	33.79	33.81	33.86	33.75	33.72	33.70	33.61
$\hat{c}^o$	4.087	4.021	3.994	3.954	3.991	3.949	3.988	3.946
%Q1	12.23	10.70	10.72	10.77	10.77	10.93	10.83	11.14
%Q2	19.74	18.78	18.79	18.82	18.82	18.90	18.83	18.95
%Q3	28.75	29.04	29.03	29.02	29.02	28.98	29.00	28.91
%Q4	39.28	41.48	41.46	41.39	41.39	41.18	41.33	41.00
$\mathbb{E}\hat{\Lambda}(\mu_L, \eta_L)$	1.014	0.996	0.989	0.978	1.022	1.020	1.026	1.029
$\mathbb{E}\hat{\Lambda}(\mu_H, \eta_L)$	1.433	1.471	1.468	1.463	1.260	1.261	1.266	1.276
$\mathbb{E}\hat{\Lambda}(\mu_L, \eta_H)$	1.529	1.517	1.513	1.506	1.532	1.527	1.531	1.525
$\mathbb{E}\hat{\Lambda}(\mu_H, \eta_H)$	2.143	2.167	2.164	2.161	2.031	2.026	2.030	2.024

return

Table 2: Allocation and welfare

	(a) FI	(b) AI	(c) SA_A $\theta = 0.010$	(d) SA_A $\theta = 0.025$	(e) SA_B $\theta = 0.010$	(f) SA_B $\theta = 0.025$	(g) SA_C $\theta = 0.010$	(h) SA_C $\theta = 0.025$
$\hat{y}$	10.000	9.840	9.776	9.680	9.768	9.668	9.762	9.660
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$\mathbb{E}\hat{\Lambda}(\mu_H, \eta_H)$	2.143	2.167	2.164	2.161	2.031	2.026	2.030	2.024

return

Table 2: Allocation and welfare

	(a) FI	(b) AI	(c) SA_A $\theta = 0.010$	(d) SA_A $\theta = 0.025$	(e) SA_B $\theta = 0.010$	(f) SA_B $\theta = 0.025$	(g) SA_C $\theta = 0.010$	(h) SA_C $\theta = 0.025$
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return

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$\hat{k}$	0.395	0.373	0.364	0.351	0.363	0.350	0.362	0.349
%Q1	12.34	11.78	10.15	7.73	9.69	6.69	9.15	5.50
%Q2	19.81	19.46	17.14	13.59	16.90	12.98	16.75	12.60
%Q3	28.73	28.84	25.81	21.05	25.92	21.26	26.12	21.66
%Q4	39.12	39.93	36.18	30.11	36.74	31.46	37.22	32.58
%SAS			10.72	27.51	10.74	27.60	10.76	27.67
$\hat{r}$	6.04	6.34	6.47	6.66	6.48	6.69	6.50	6.70
$\hat{r}^a$	5.00%	5.11%	5.16%	5.22%	5.16%	5.23%	5.17%	5.24%
$\hat{w}$	7.250	7.134	7.087	7.018	7.082	7.010	7.077	7.003
$\widehat{BC}$	0.00%	5.83%	10.03%	17.66%	10.63%	19.33%	10.63%	19.33%
$\hat{r}^p$		10.18	10.12	9.99	10.12	9.98	10.12	9.96
$\hat{\mu}^p$		0.66	0.67	0.70	0.67	0.70	0.67	0.70
$\widehat{AS}$		1.31	1.34	1.39	1.35	1.40	1.35	1.41
$\hat{c}^y$	5.357	5.296	5.270	5.233	5.268	5.228	5.265	5.225
%Q1	15.99	16.03	16.02	15.98	16.06	16.09	16.12	16.20
%Q2	22.10	22.13	22.12	22.10	22.14	22.16	22.16	22.20
%Q3	28.06	28.05	28.05	28.06	28.04	28.04	28.02	27.99
%Q4	33.85	33.79	33.81	33.86	33.75	33.72	33.70	33.61
$\hat{c}^o$	4.087	4.021	3.994	3.954	3.991	3.949	3.988	3.946
%Q1	12.23	10.70	10.72	10.77	10.77	10.93	10.83	11.14
%Q2	19.74	18.78	18.79	18.82	18.82	18.90	18.83	18.95
%Q3	28.75	29.04	29.03	29.02	29.02	28.98	29.00	28.91
%Q4	39.28	41.48	41.46	41.39	41.39	41.18	41.33	41.00
$\mathbb{E}\hat{\Lambda}(\mu_L, \eta_L)$	1.014	0.996	0.989	0.978	1.022	1.020	1.026	1.029
$\mathbb{E}\hat{\Lambda}(\mu_H, \eta_L)$	1.433	1.471	1.468	1.463	1.260	1.261	1.266	1.276
$\mathbb{E}\hat{\Lambda}(\mu_L, \eta_H)$	1.529	1.517	1.513	1.506	1.532	1.527	1.531	1.525
$\mathbb{E}\hat{\Lambda}(\mu_H, \eta_H)$	2.143	2.167	2.164	2.161	2.031	2.026	2.030	2.024

Table 2: Allocation and welfare

	(a) FI	(b) AI	(c) SA_A $\theta = 0.010$	(d) SA_A $\theta = 0.025$	(e) SA_B $\theta = 0.010$	(f) SA_B $\theta = 0.025$	(g) SA_C $\theta = 0.010$	(h) SA_C $\theta = 0.025$
$\hat{y}$	10.000	9.840	9.776	9.680	9.768	9.668	9.762	9.660
$\hat{k}$	0.395	0.373	0.364	0.351	0.363	0.350	0.362	0.349
%Q1	12.34	11.78	10.15	7.73	9.69	6.69	9.15	5.50
%Q2	19.81	19.46	17.14	13.59	16.90	12.98	16.75	12.60
%Q3	28.73	28.84	25.81	21.05	25.92	21.26	26.12	21.66
%Q4	39.12	39.93	36.18	30.11	36.74	31.46	37.22	32.58
%SAS			10.72	27.51	10.74	27.60	10.76	27.67
$\hat{r}$	6.04	6.34	6.47	6.66	6.48	6.69	6.50	6.70
$\hat{r}^a$	5.00%	5.11%	5.16%	5.22%	5.16%	5.23%	5.17%	5.24%
$\hat{w}$	7.250	7.134	7.087	7.018	7.082	7.010	7.077	7.003
$\widehat{BC}$	0.00%	5.83%	10.03%	17.66%	10.63%	19.33%	10.63%	19.33%
$\hat{\bar{r}}^p$		10.18	10.12	9.99	10.12	9.98	10.12	9.96
$\hat{\bar{\mu}}^p$		0.66	0.67	0.70	0.67	0.70	0.67	0.70
$\widehat{AS}$		1.31	1.34	1.39	1.35	1.40	1.35	1.41
$\hat{c}^y$	5.357	5.296	5.270	5.233	5.268	5.228	5.265	5.225
%Q1	15.99	16.03	16.02	15.98	16.06	16.09	16.12	16.20
%Q2	22.10	22.13	22.12	22.10	22.14	22.16	22.16	22.20
%Q3	28.06	28.05	28.05	28.06	28.04	28.04	28.02	27.99
%Q4	33.85	33.79	33.81	33.86	33.75	33.72	33.70	33.61
$\hat{c}^o$	4.087	4.021	3.994	3.954	3.991	3.949	3.988	3.946
%Q1	12.23	10.70	10.72	10.77	10.77	10.93	10.83	11.14
%Q2	19.74	18.78	18.79	18.82	18.82	18.90	18.83	18.95
%Q3	28.75	29.04	29.03	29.02	29.02	28.98	29.00	28.91
%Q4	39.28	41.48	41.46	41.39	41.39	41.18	41.33	41.00
$\mathbb{E}\hat{\Lambda}(\mu_L, \eta_L)$	1.014	0.996	0.989	0.978	1.022	1.020	1.026	1.029
$\mathbb{E}\hat{\Lambda}(\mu_H, \eta_L)$	1.433	1.471	1.468	1.463	1.260	1.261	1.266	1.276
$\mathbb{E}\hat{\Lambda}(\mu_L, \eta_H)$	1.529	1.517	1.513	1.506	1.532	1.527	1.531	1.525
$\mathbb{E}\hat{\Lambda}(\mu_H, \eta_H)$	2.143	2.167	2.164	2.161	2.031	2.026	2.030	2.024

return