Closing Down the Shop: Optimal Health and Wealth Dynamics near the End of Life

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1- Health falls, 2- death risk exposure increases, esp. poor

Age	40 to 70	70 to 80
Share in poor/ bad health	$\times 2$	$\times 2$
Drop survivors	-19.3%	-29.7%

Notes: Health: [Banks et al., 2015, Smith, 2007, Heiss, 2011, Van Kippersluis et al., 2009], survivors [Arias, 2014].

Income decile	Longevity 1940 cohort
1^{st}	73.3
3^{rd}	77.9
6^{th}	81.8
10^{th}	84.6

Notes: [Bosworth et al., 2016]

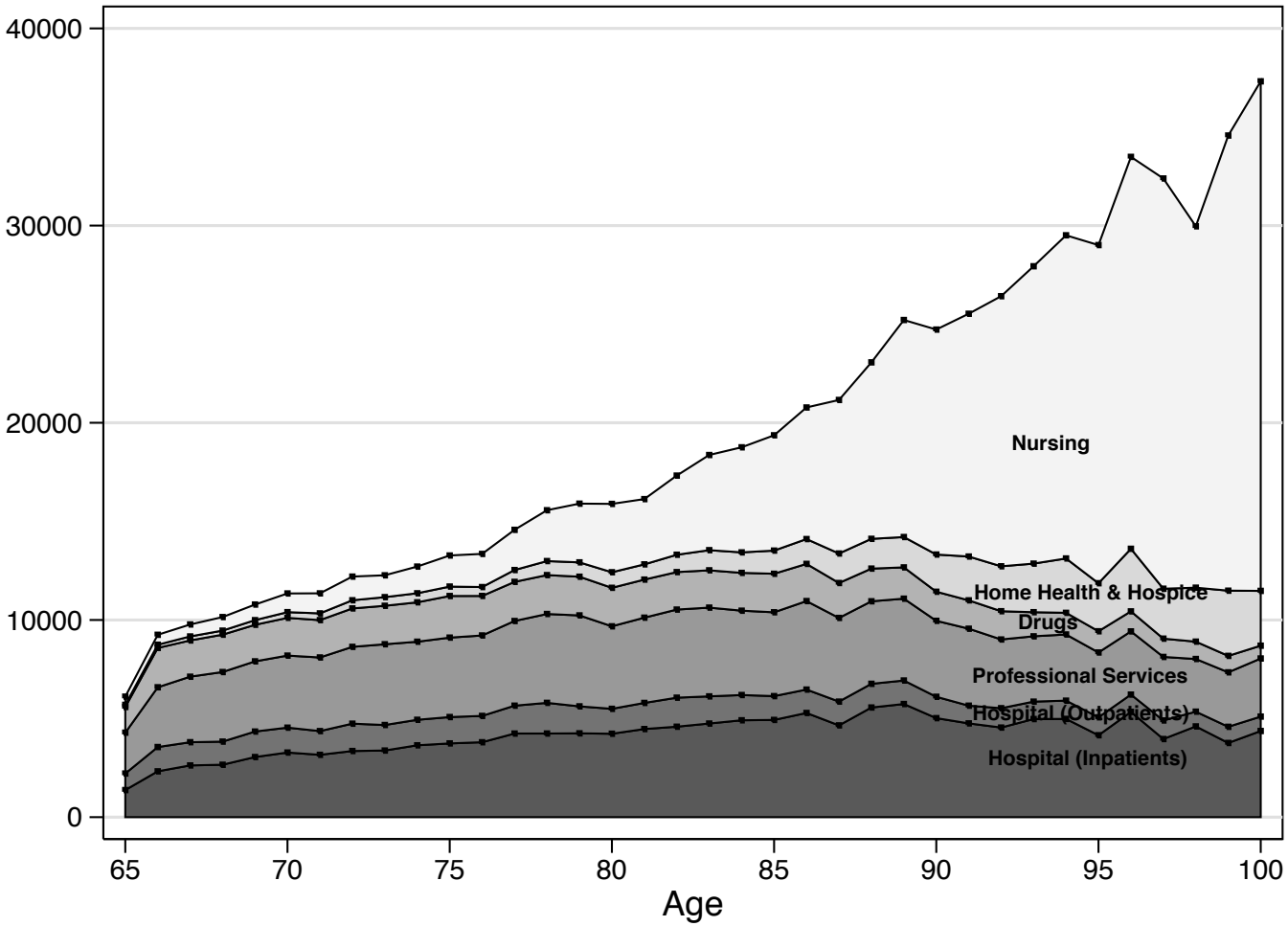
3.a- Health expenses increase

Age	Average total expend.
70–90	\$25'000
last year	\$43'000

Notes: [De Nardi et al., 2015b]

- Concentrated in long-term care (LTC), less curative care.
- LTC very income/wealth elastic $\approx$ normal consumption good.

3.b- Health expenses change in composition



Notes: Source: [De Nardi et al., 2015b, Fig. 3, p. 22].

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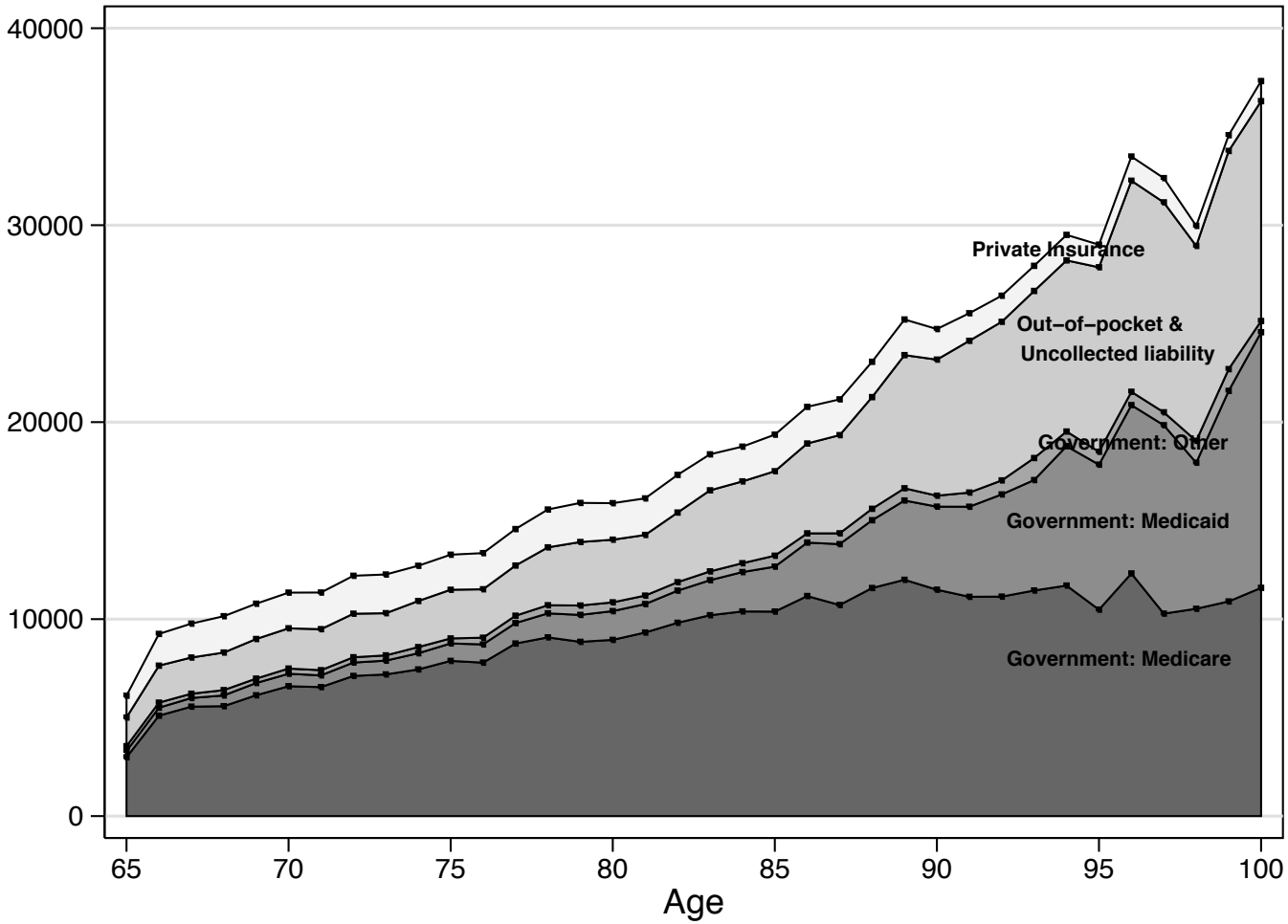

Notes: Source: [De Nardi et al., 2015b, Fig. 3, p. 22].

4- Wealth falls

- Fall by 50% last 3 years, 30% last year alone, vs 2% for survivors [De Nardi et al., 2015a, French et al., 2006].
- LTC not covered by Medicare, means-testing for Medicaid.
- Correlated with changes in health, family composition [Poterba et al., 2015, Lee and Kim, 2008].

Standard explanation

Ineluctable aging process:

- Biological decline in health status.

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- Medicaid once depleted wealth.

Main research question

Joint decline in (H_t, W_t) $\Longleftarrow$ aging (inevitable), (and/) or optimal?

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  4. Convergence towards state where *indifferent* between life and death.

Model [Hugonnier et al., 2013, *RESTUD*]

- Health dynamics [Grossman, 1972, augmented]:

$$\mathrm{d}H_t = \left((I_t/H_t)^{\alpha} - \delta\right) H_t \mathrm{d}t - \phi H_t \mathrm{d}Q_{st}, \quad H_0 > 0,$$

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$$\lambda_k(H_t) = \begin{cases} \lambda_{s0} & k = s \quad \text{(sickness)} \\ \lambda_{m0} + \lambda_{m1} H_t^{-\xi_m}, & k = m \quad \text{(death)} \end{cases}$$

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- Wealth dynamics:

$$\mathrm{d}W_t = \left(rW_{t-} + Y_t - C_t - I_t\right)\mathrm{d}t + \Pi_t \sigma_S \left(\mathrm{d}Z_t + \theta \mathrm{d}t\right) + X_{t-}\mathrm{d}M_{st}.$$

Model [Hugonnier et al., 2013, *RESTUD*]

- Objectives: $V(W_t, H_t) = \sup_{(C,\Pi,X,I)} U_t(C)$, where

$$U_t(C) = 1_{\{T_m > t\}} E_t \int_t^{T_m} \left(f(C_\tau, U_{\tau-}) - \frac{\gamma \sigma_\tau^2}{2U_\tau} - \sum_{k=m}^{s} F_k(U_{\tau-}, H_{\tau-}, \Delta_k U_\tau) \right) \mathrm{d}\tau,$$

where,

$$f(C, U) = \frac{\rho U}{1 - 1/\varepsilon} \left(((C - a)/U)^{1 - \frac{1}{\varepsilon}} - 1 \right)$$

$$F_k(U, H, \Delta_k U) = U \lambda_k(H) \left[\frac{\Delta_k U}{U} + u(1; \gamma_k) - u\left(1 + \frac{\Delta_k U}{U}; \gamma_k\right) \right],$$

$$u(c; \gamma_k) = \frac{c^{1-\gamma_k}}{1 - \gamma_k}, \quad k = m, s.$$

subject to health, wealth dynamics.

Health investment: Two components

$$I^*(W,H) = \underbrace{KBH}_{\text{Order-0 demand}} + \underbrace{\mathcal{I}_1 H^{-\xi_m} N_0(W,H)}_{\text{Death risk hedging demand}}$$

where $N_0(W,H)$ is net total wealth. Other solutions for X^*, Π^*.

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- If death risk can be hedged $\Longrightarrow$ larger demand for health.
- Non-monotone in H:
  - Low H: Net wealth effect dominant, investment increases if better health.
  - High H: Mortality risk effect dominant, investment decreases if better health.

Admissibility and preference for life

- Consumption:

$$C^*(W,H) = a + \left[A + \mathcal{C}_1 H^{-\xi_m}\right] N_0(W,H)$$
$$N_0(W,H) = W + BH + (y_0 - a)/r$$

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  - As approach non-admissible region, become indifferent between life and death.

Expected local dynamics and depletion: Health

1. Local expected changes:

$$\mathrm{E}_{t-}[\mathrm{d}H] = [\underbrace{I^{*h}(W,H)^{\alpha}}_{I^*/H} - \underbrace{\tilde{\delta}}_{\delta+\lambda_{s0}\phi}]H\mathrm{d}t,$$

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2. Health depletion/accelerating regions:

$$\mathcal{D}_H = \{(W,H) \in \mathcal{A} : \mathrm{E}_{t-}[\mathrm{d}H] < 0\},$$
$$\mathcal{AC} = \left\{(W,H) \in \mathcal{D}_H : I_H^h(W,H) > 0\right\}.$$

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Sufficient conditions for Closing down: Realistic for EOL

Health depletion/accelerating:

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$$\beta < \tilde{\delta}^{1/\alpha},$$

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- High consumption $\Longleftarrow$ $(\gamma, \rho, \lambda_{m0}, \gamma_m)$ high

$$(1+\varepsilon)\frac{\theta^2}{2\gamma} < \varepsilon(\rho - r) + (\varepsilon - 1)\frac{\lambda_{m0}}{1-\gamma_m}.$$

Phase diagram

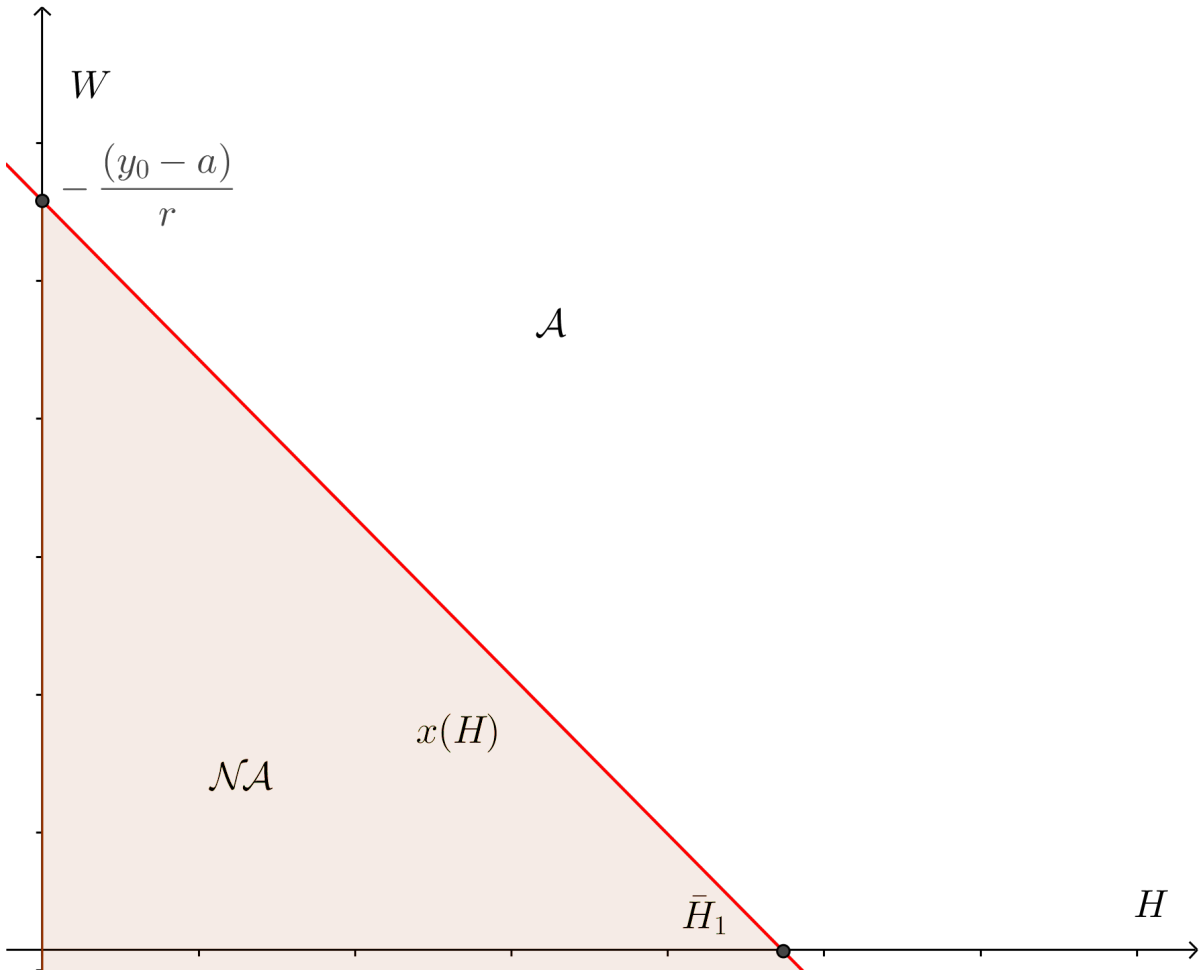

Figure: Health and wealth dynamics

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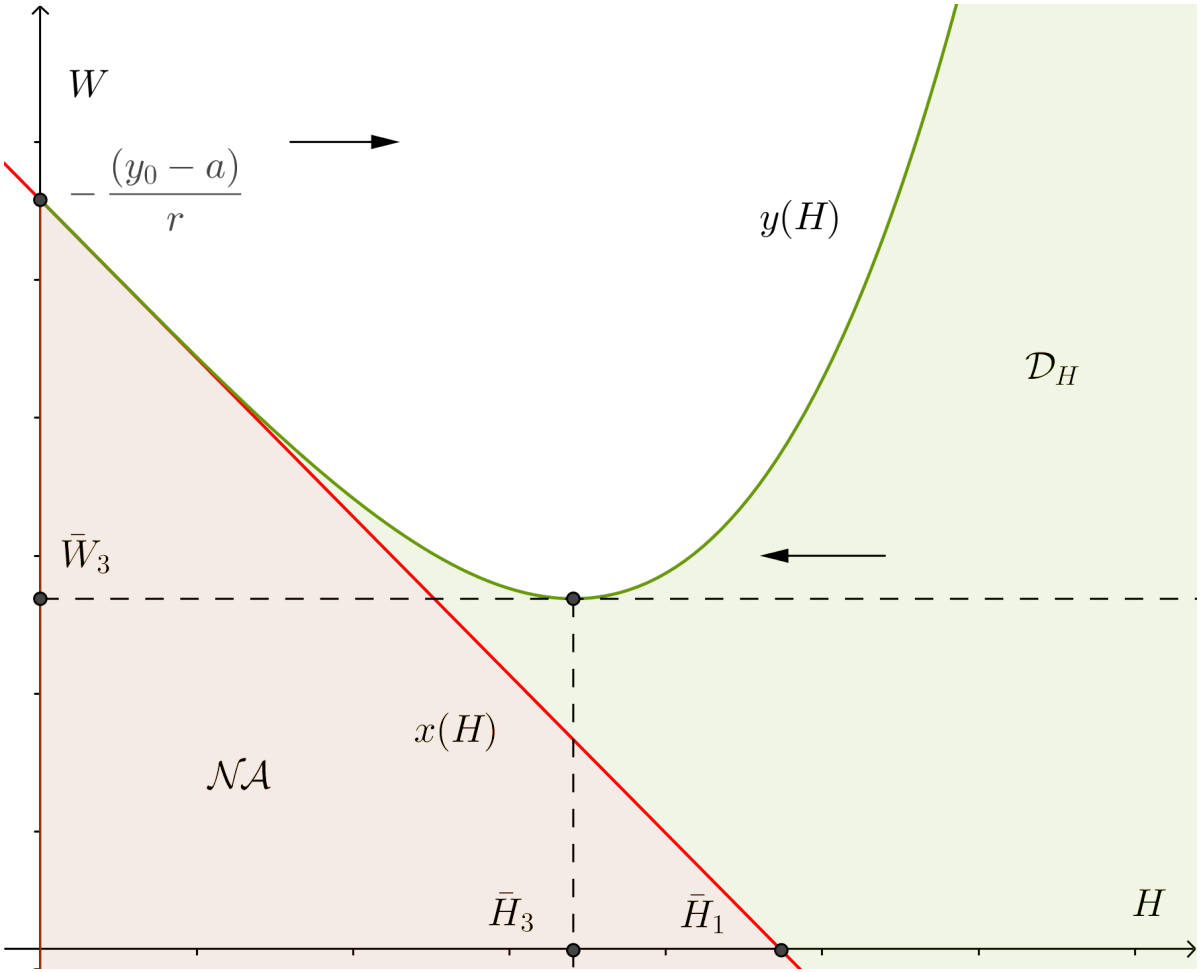

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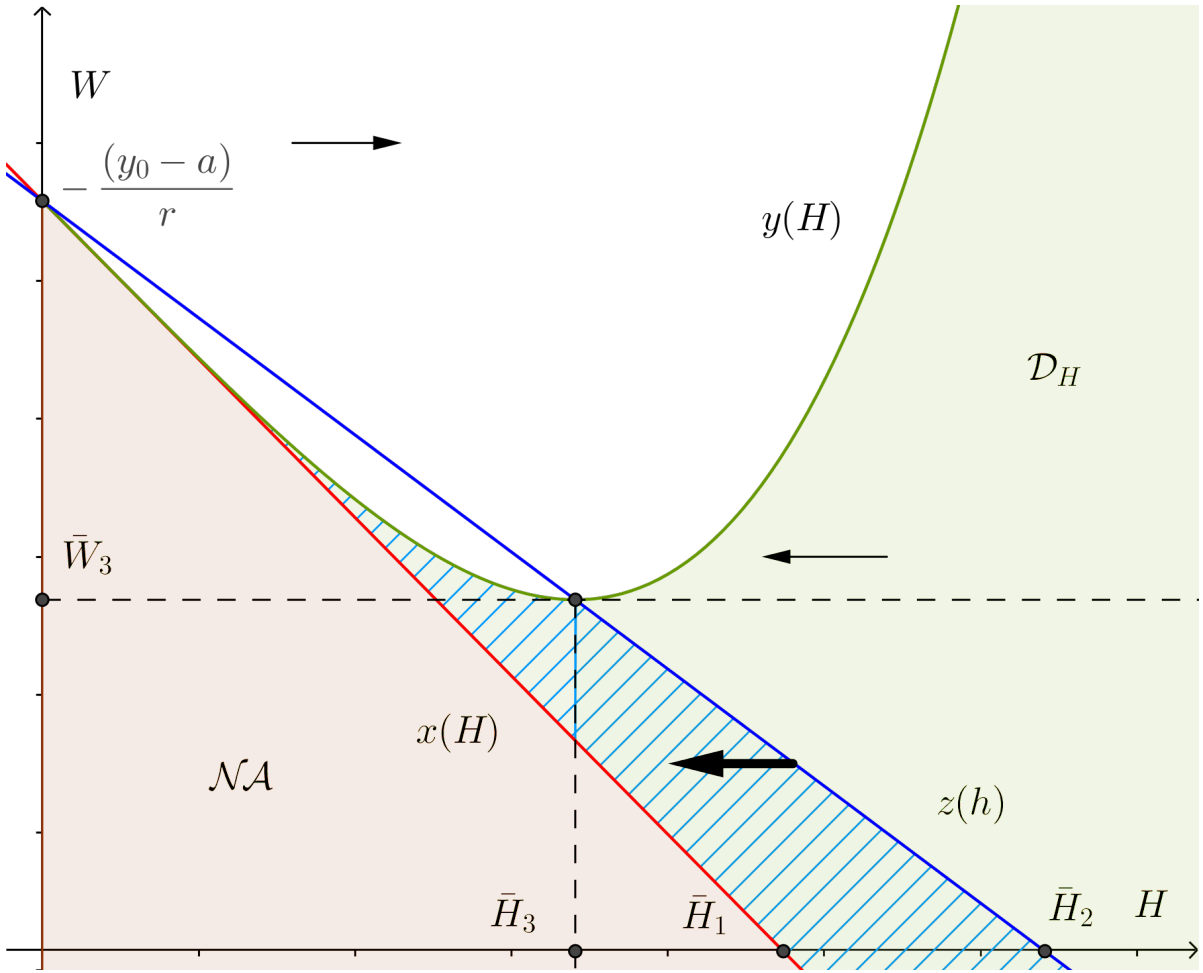

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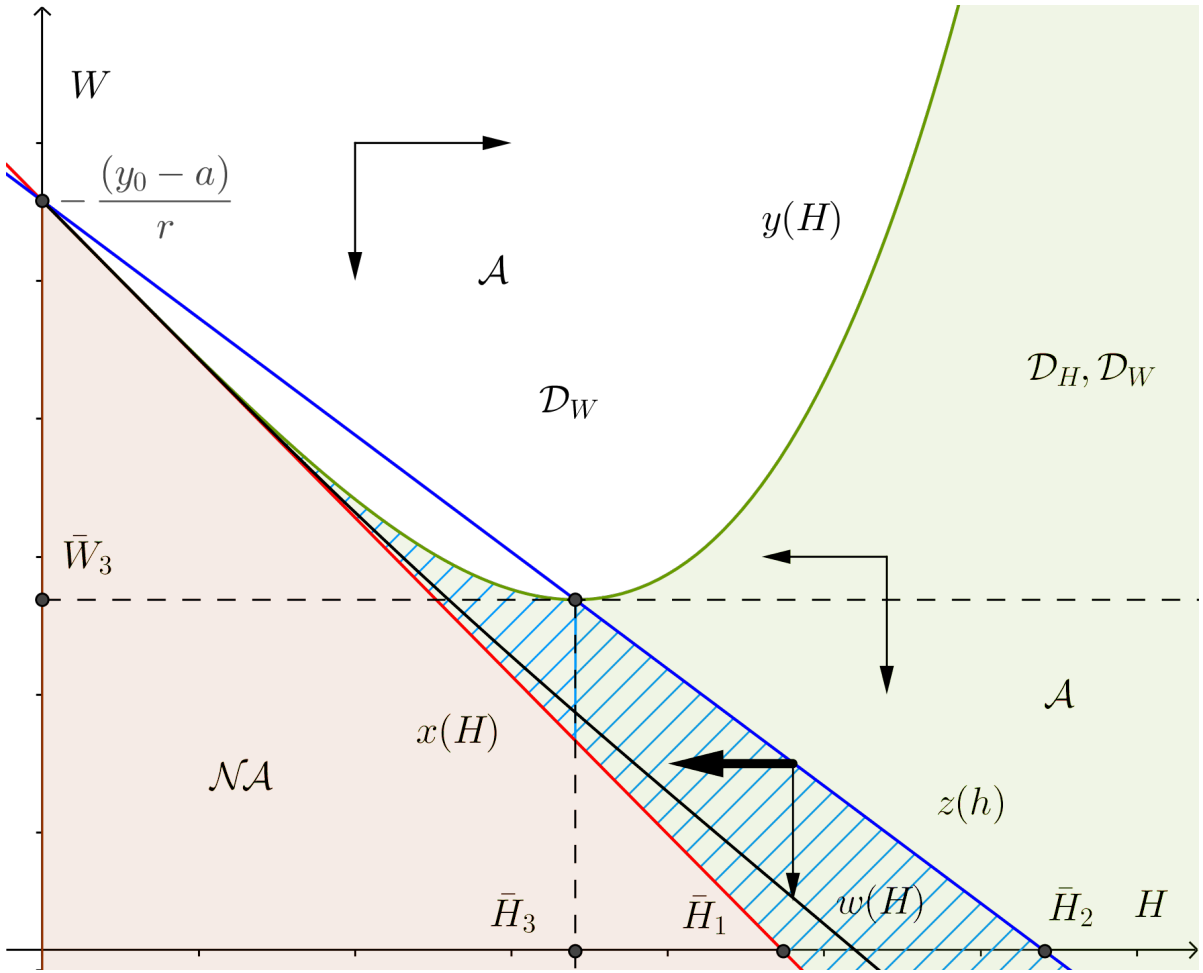

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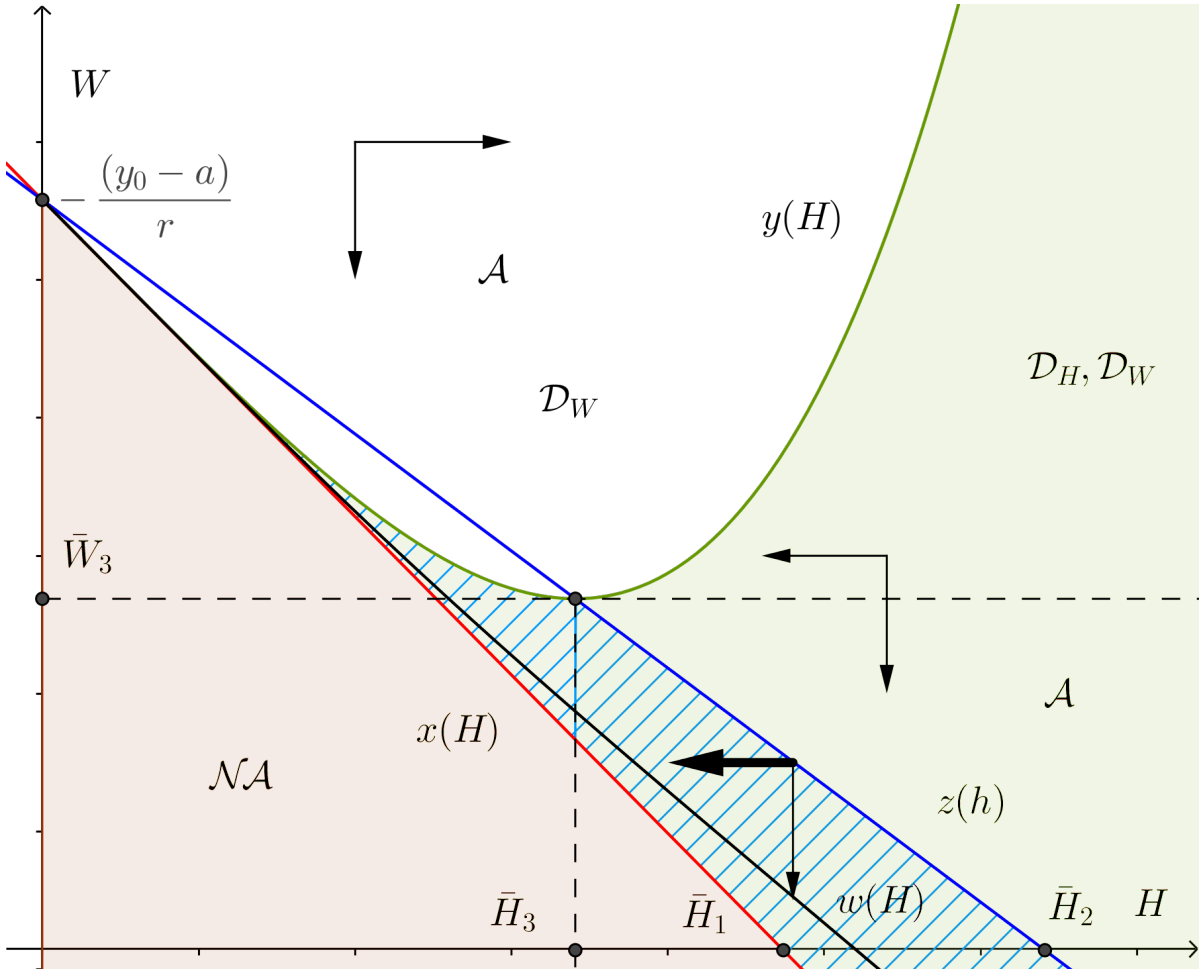
Terminal illness: $\lambda_m(H) = \lambda_{m0}, \forall H$, and $\lambda_{m0}, \tilde{\delta} \uparrow$

Main result: $\mathcal{D}_H = \mathcal{A}; \mathcal{AC} = \emptyset$



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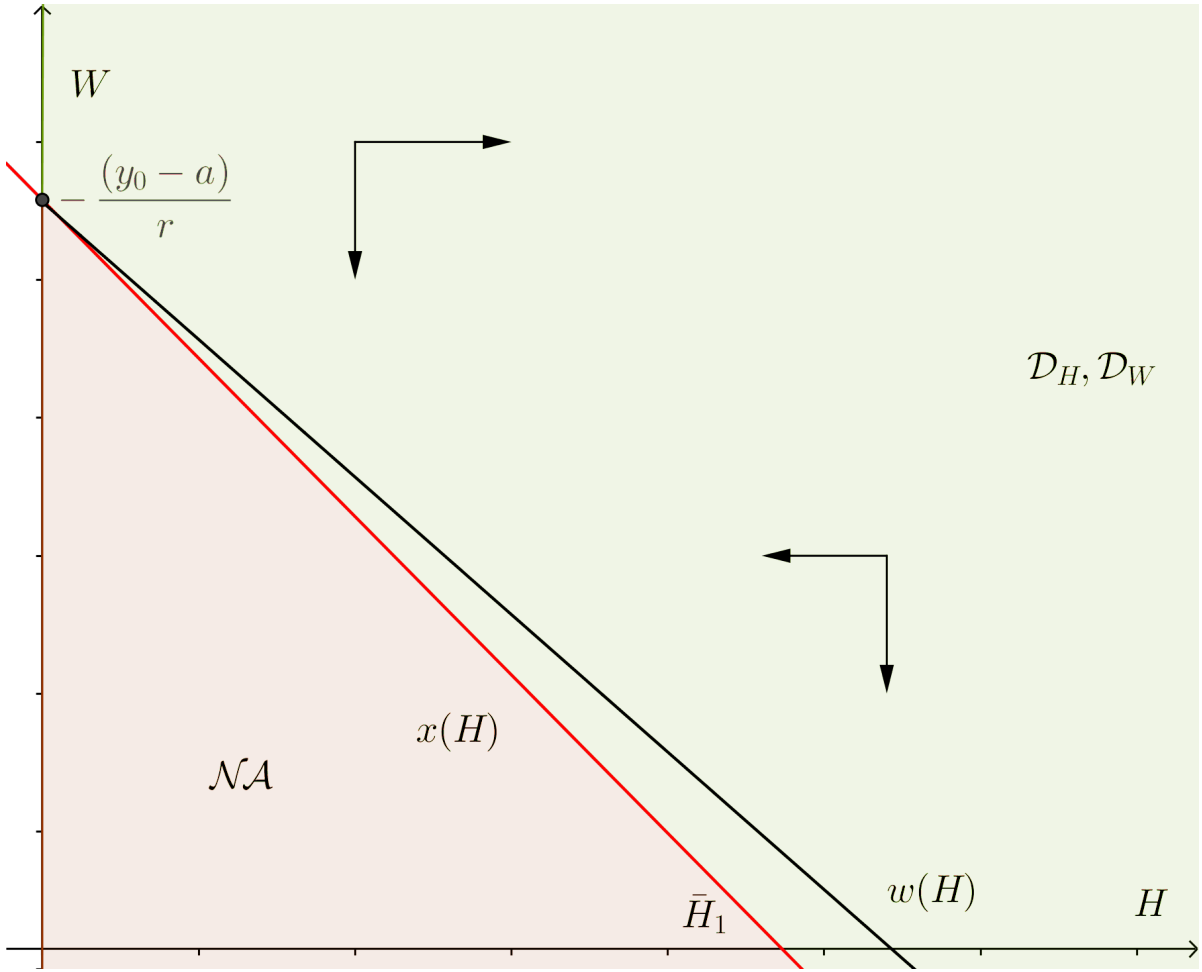

Reducing incidence of Closing Down strategies

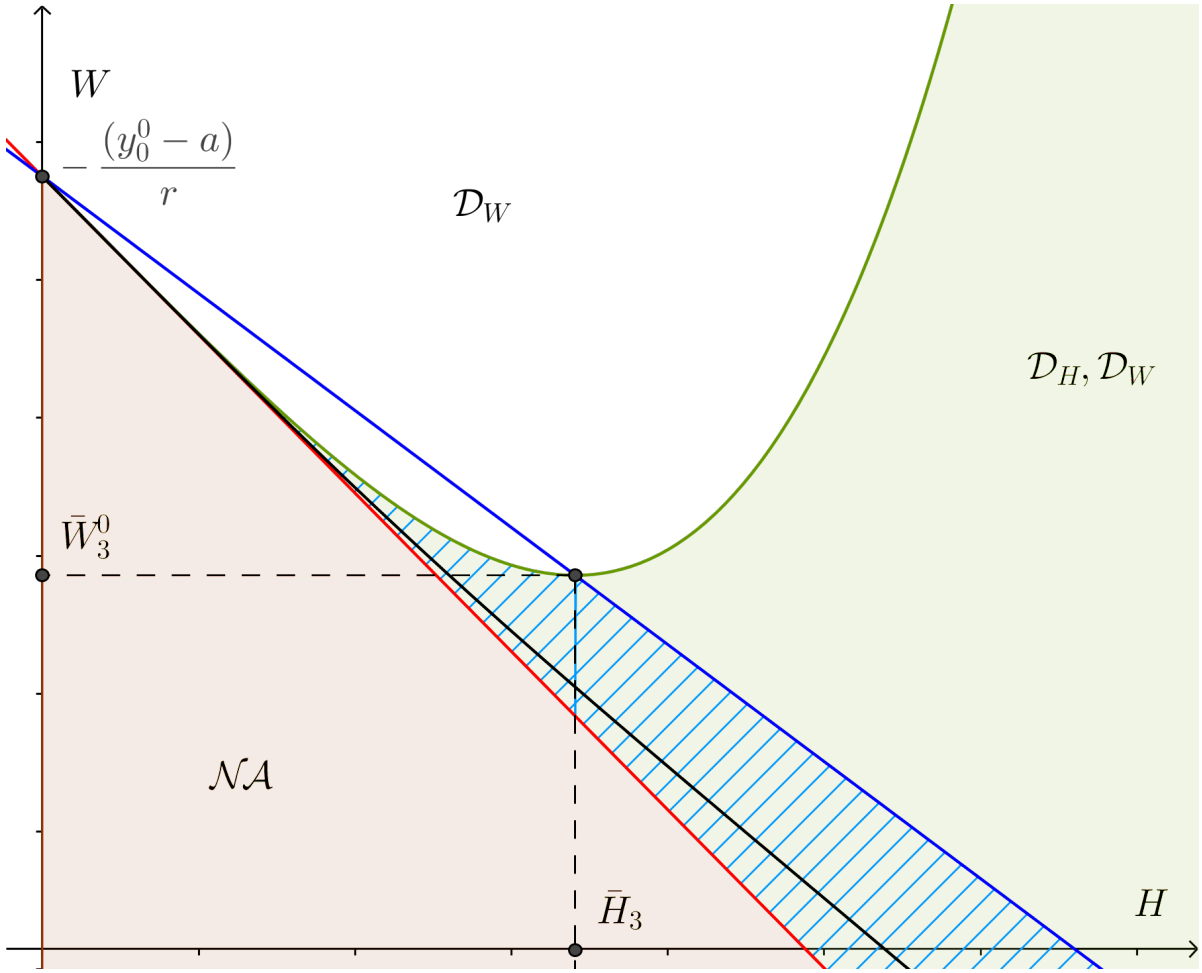

Figure: Increase in y_0 (e.g. Social Security)

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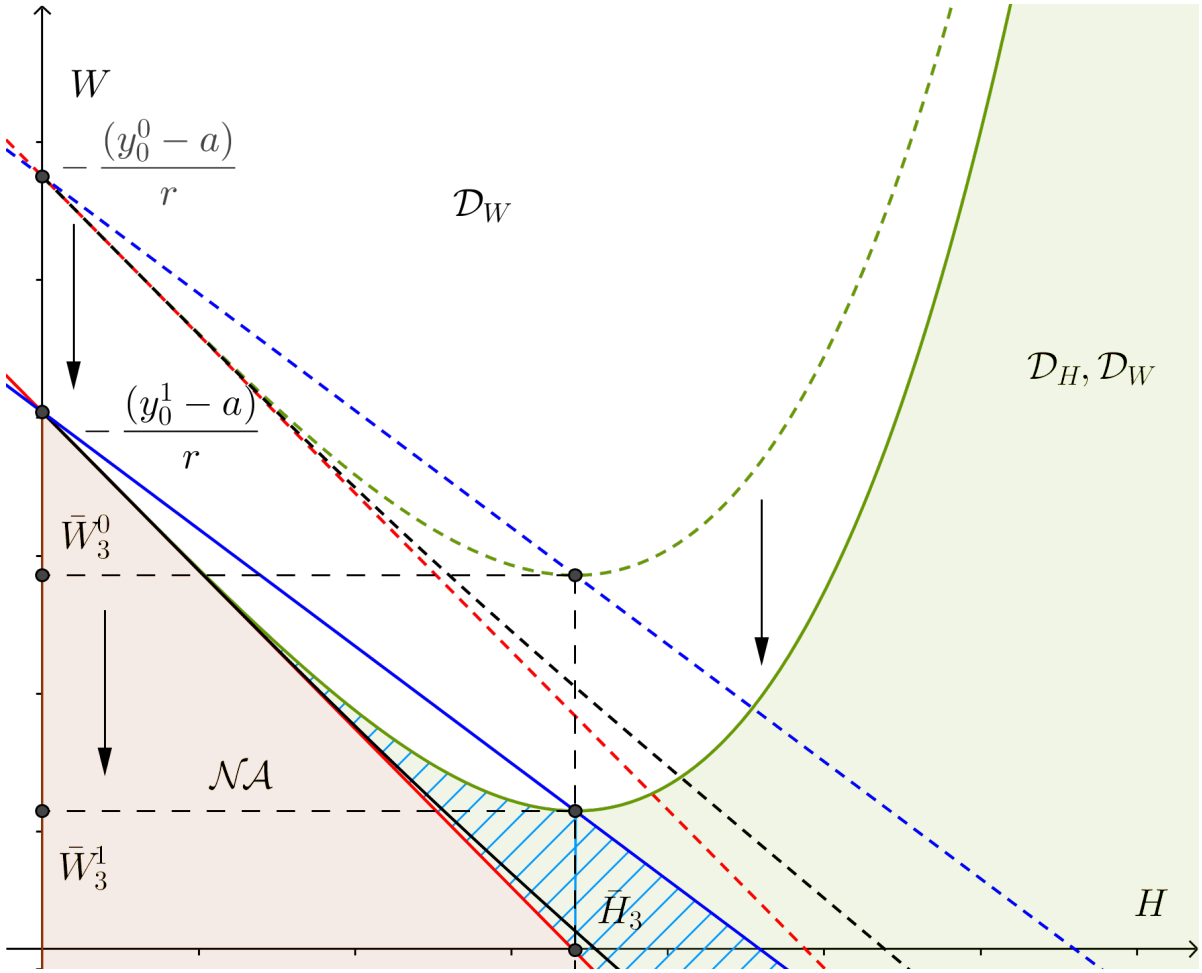

Figure: Increase in y_0 (e.g. Social Security)

Model and data

- Structural trivariate econometric model:

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\begin{aligned}
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  - Additional transversality conditions.
  - By iterative 2-step ML.
- Data: HRS, 2002
  - Detailed info on total health spending.
  - Focus on elders 65+, with positive wealth (9,817 obs., mean age 75.3).
  - No consumption data.
  - Medicare $\Longrightarrow$ drop optimal insurance.

Estimated and calibrated parameters

Realistic for relatively old population (75.3 years):

Param.	Value	Param.	Value	Param.	Value
α	0.6940^{*}	δ	0.0723^{*}	ϕ	0.011^{c}
λ_{s0}	0.2876^{*}	λ_{m0}	0.2356^{*}		
λ_{m1}	0.0280^{*}	ξ_m	2.8338^{*}		
y_0	$0.0082^{*\$}$	β	0.0141^{*}		
μ	0.108^{c}	r	0.048^{c}	σ_S	0.20^{c}
a	$0.0127^{*\$}$	ε	1.6738^{*}	γ	2.7832^{*}
ρ	0.025^{c}	γ_m	0.75^{c}	γ_s	N.I.

Notes: *: Estimated structural and induced parameters (standard errors in parentheses), significant at 5% level; c: calibrated parameters; \$: In \$M; N.I.: non-identifiable/irrelevant under the exogenous morbidity restriction.

Conditions for depletion: All verified

Parameter	Value	Parameter	Value
$\beta - \tilde{\delta}^{1/\alpha}$	-0.0086^{*}	$\theta^2/\gamma + r - A$	-0.5533^{*}

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Estimated and calibrated parameters

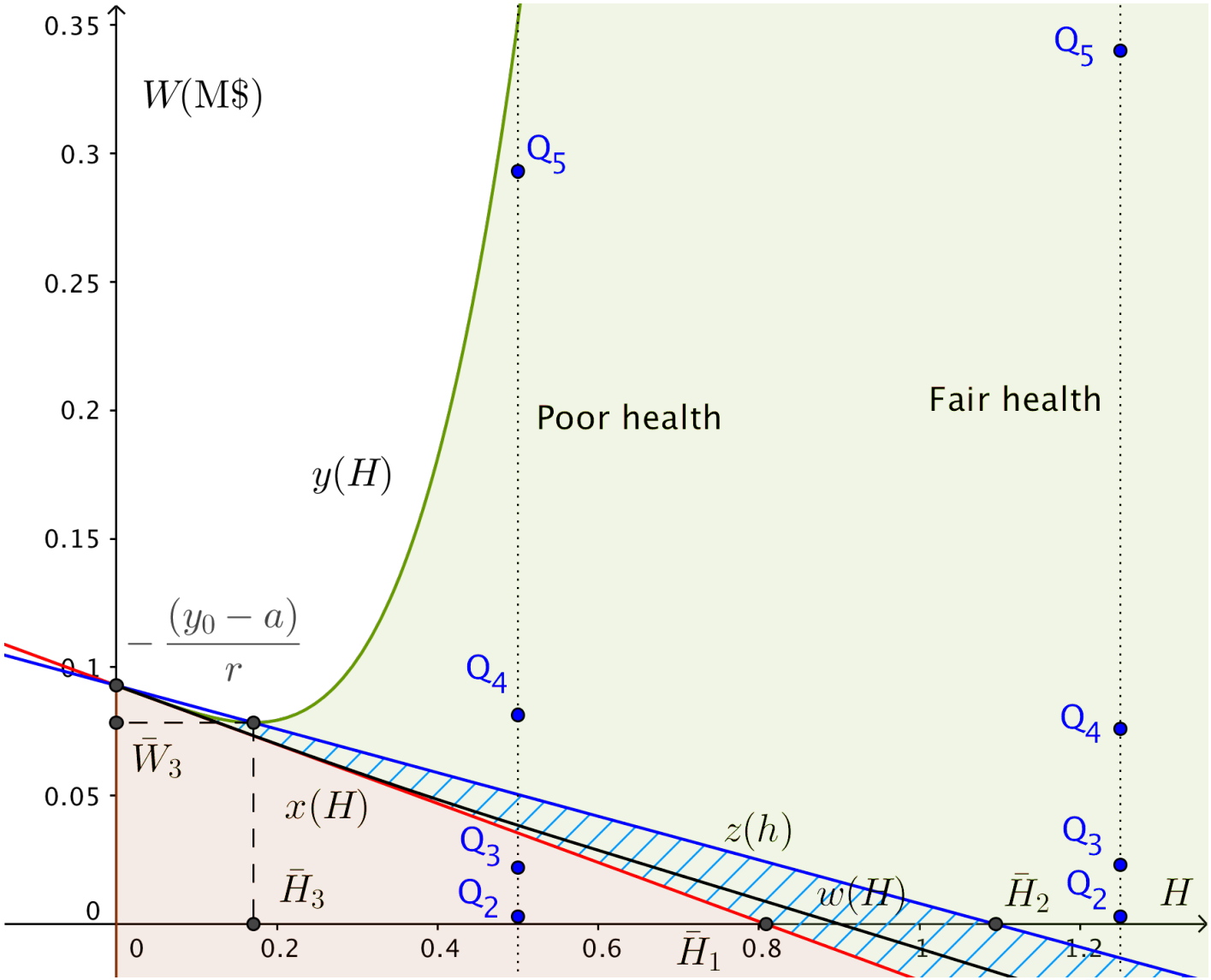
Out-of-sample checks: Expected longevity

$$\ell(W_t, H_t) = (1/\lambda_{m0})(1 - \lambda_{m1}\kappa_0 H_t^{-\xi_m})$$

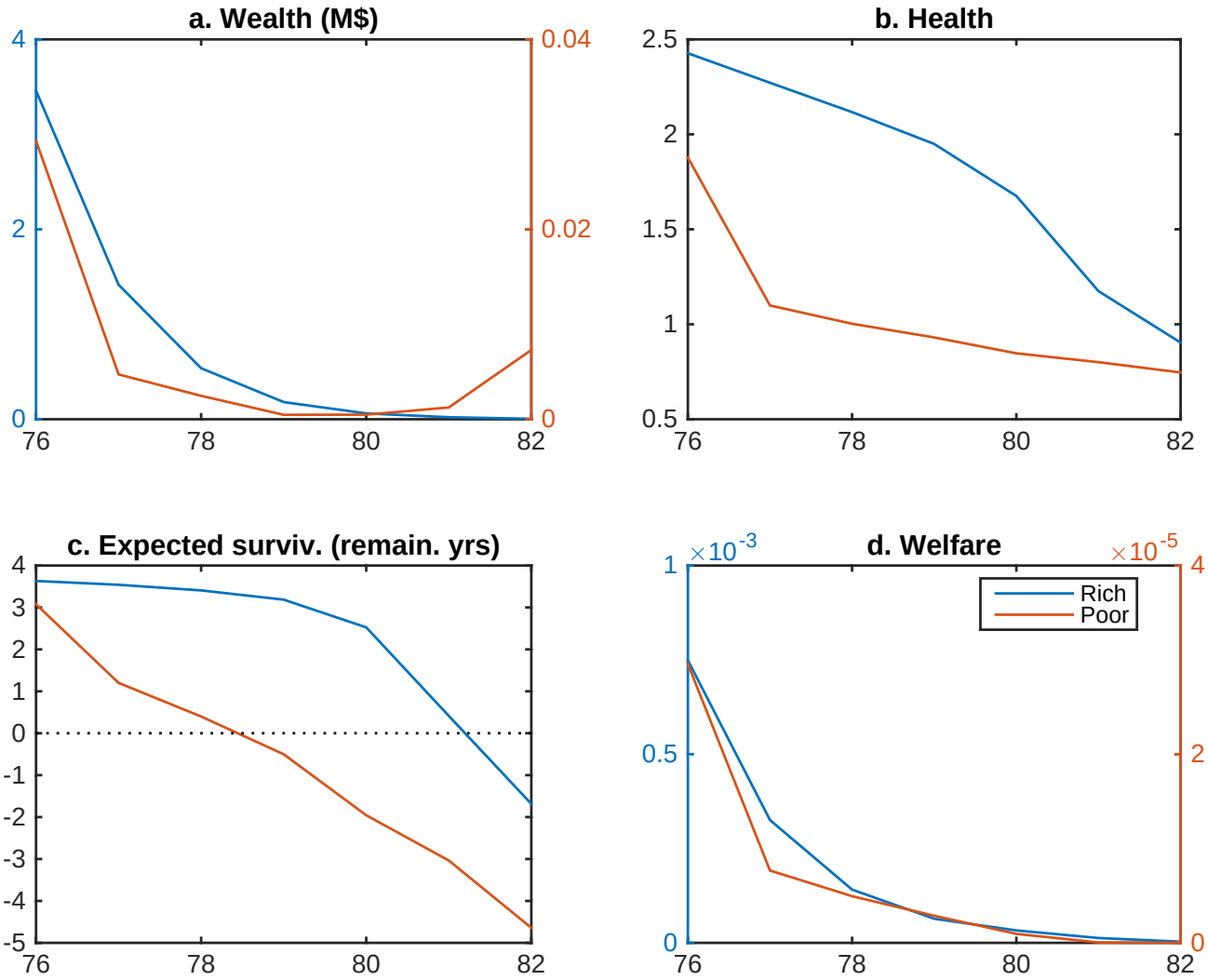
Level	H	% Pop.	Exp. longev.
Poor	0.50	10.7	51.94
Fair	1.25	21.1	77.49
Good	2.00	31.5	79.00
Very good	2.75	26.9	79.32
Excellent	3.50	9.9	79.43

Data (2002): 74.5 (M); 79.9 (F); 77.3 (A)

Estimated partitions: All in $(\mathcal{D}_H, \mathcal{D}_W)$ for $H \geq$ Fair



Simulated life paths: Closing Down the Shop



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- Accelerating depletion subsets.
- Paths converging to states where indifference life/death.
- Realistic sufficient theoretical conditions, verified empirically:
  - High consumption.
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Concluding remarks

Closing down the shop strategy:

- Optimal depletion of health/wealth capitals.
- Accelerating depletion subsets.
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  2. Death risk increasing.
  3. Change in composition: Less curative care.
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- Applicable to incurable terminal diseases.

Normative issues

Reducing incidence of closing down:

1. Feasible? Yes.
   - Base income $y_0 \uparrow$ (e.g. Soc. Sec., min. revenues, Medicaid).
   - Subsidized medical research $\delta, \lambda_{s0}, \phi \downarrow$.
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2. Optimal? No clear normative arguments.
   - Myopia? No, fully endogenize effects of choices $\iff$ horizon.
   - Market failure? No, optimal strategy by agents in *complete* markets setting.
   - Redistribution? No, poverty endogenously determined.
   - Against excessive/aggressive EOL therapy.
   - In favor of rights to refuse treatment.


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