Directory

The Value of Life and the Rise in Health Spending

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Introduction

- Rising health share in U.S. Why? Future?

- Framework

  - Utility depends on quantity (years) and quality (consumption)

  - $c + h = y$

  - How much to spend on health?

- Standard utility function delivers:

  - MUC falls quickly, while value of life rises.

  - A health share that optimally rises with income...

    - as long as diminishing returns in production are not extremely sharp.

Related Work

- Recent health literature emphasizes technical change as key to a rising health share (e.g. Newhouse 1992)

    - Existing explanation is incomplete.

    - Why use? Why invent?

- c versus h: Grossman (1972), Erlich and Chuma (1990)

- VSL, WTP: Schelling (1968), Usher (1972), Arthur (1981), Shepard and Zeckhauser (1984), Rosen (1988), Murphy and Topel (2003), Nordhaus (2003), Ehrlich and Yin (2004), Becker, Philipson, and Soares (2005).

Outline

1. Introduction

2. Facts

3. Basic Model

4. Full Dynamic Model

5. Results

Figure 1. The Health Share

Health Share

Year
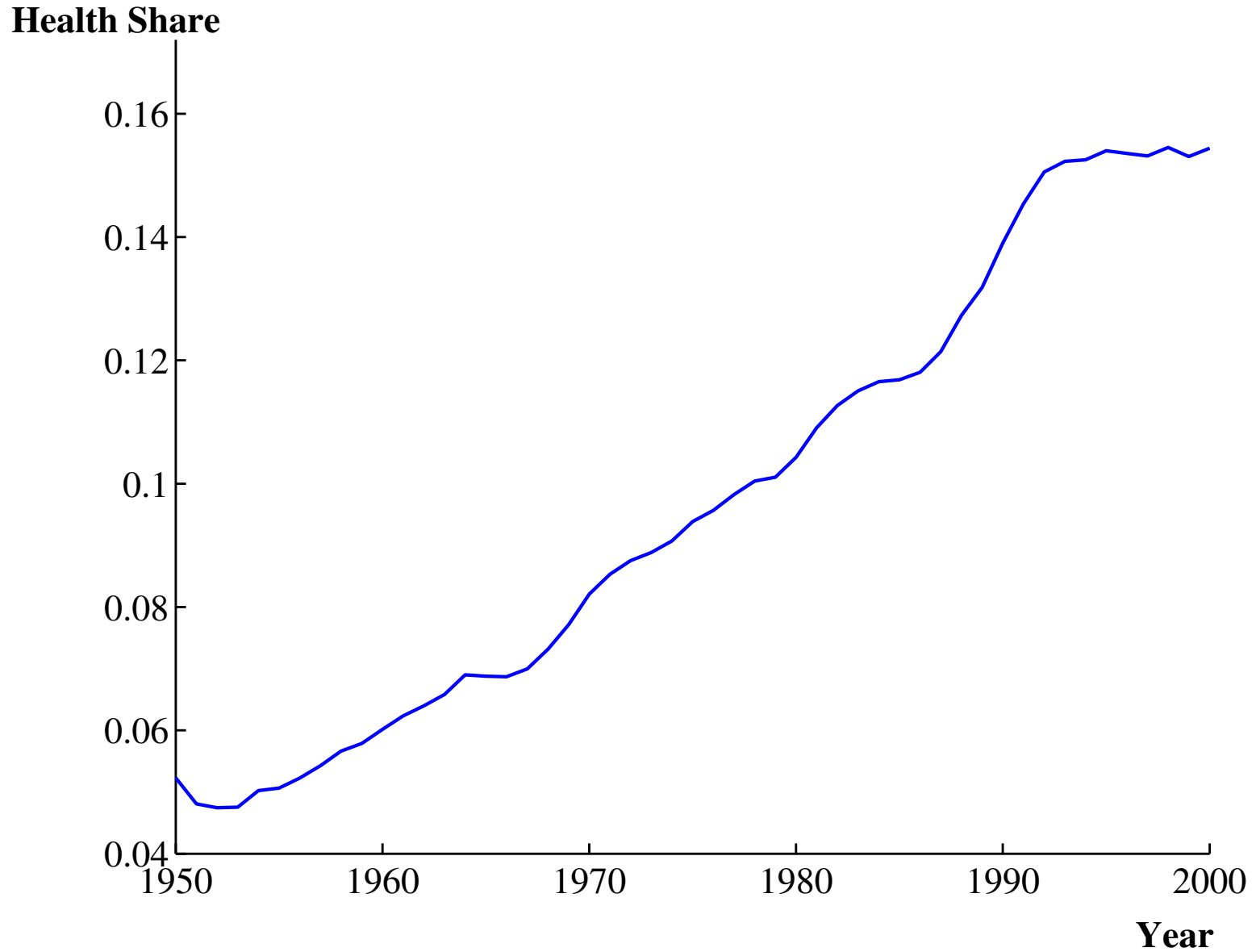
Figure 2. Life Expectancy
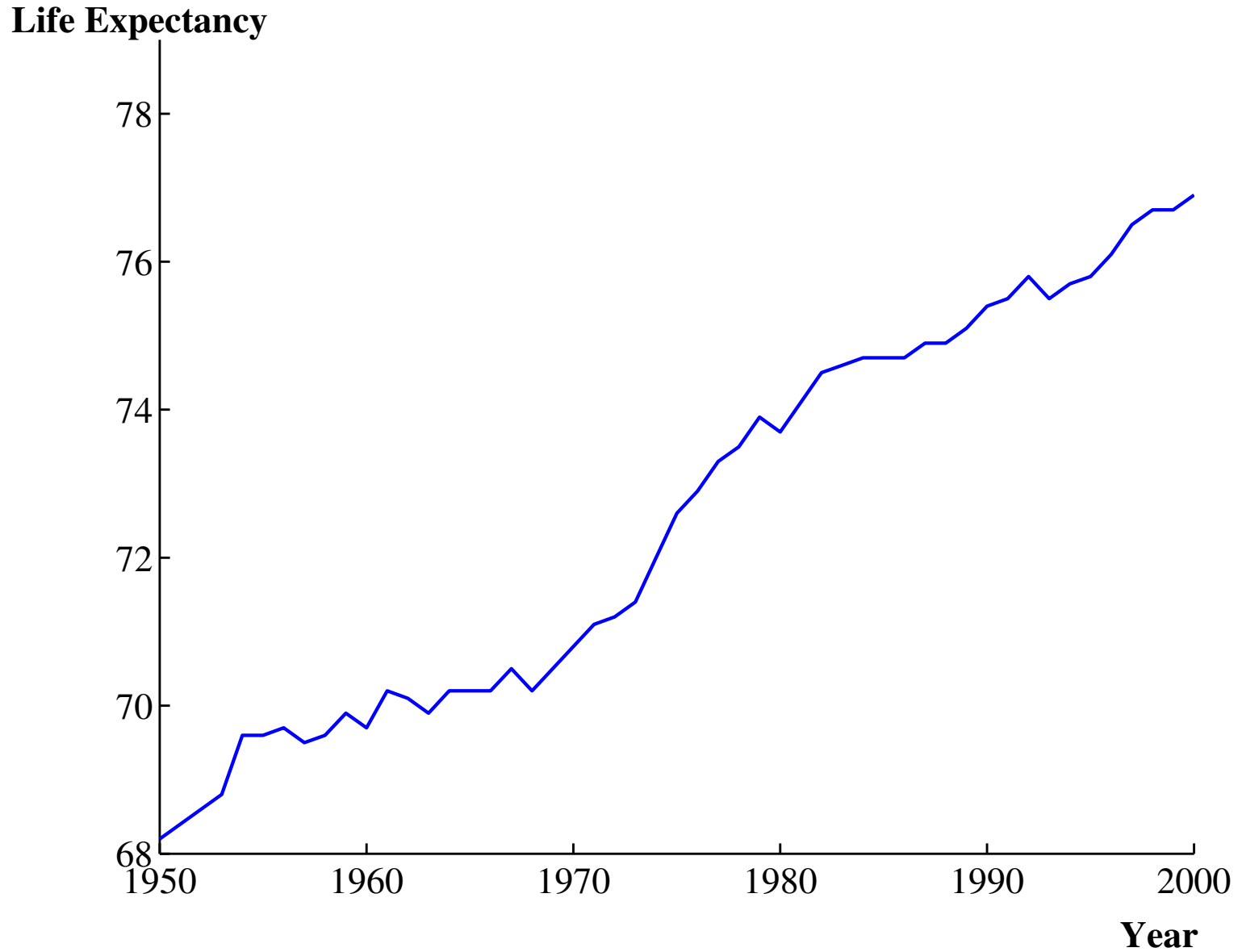
Basic Model

- Our approach: Social Welfare

    - What allocation maximizes social welfare?

    - Alternative would be to study equilibrium with institutions...

- Strong assumptions, relax in full model

    - Representative agent (no age-specific mortality)

    - Constant income and productivity: stationary model.

- $x \equiv$ health status.

    - Mortality rate is $1/x$.

    - So x is also life expectancy.

Environment

- Expected lifetime utility

$$U(c, x) = \int_0^\infty e^{-(1/x)t} u(c) dt = x u(c).$$

- Resource constraint

$$c + h = y$$

- Production function for health

$$x = f(h)$$

Optimal Allocation of Resources

$$\max_{c,h} f(h)u(c) \quad s.t. \quad c + h = y$$

- Solution: Allocations proportional to elasticities

$$\frac{h}{c} = \frac{s}{1-s} = \frac{\eta_h}{\eta_c} = \frac{\text{Elasticity of f(h)}}{\text{Elasticity of u(c)}}$$

- Our story: Declining η_c. Why?

$$u(c) = b + \frac{c^{1-\gamma}}{1-\gamma}, \quad b > 0, \quad \gamma > 1$$

– More generally: u(c) bounded, u(c)=log c

(continued)

$$\frac{s}{1-s} = \frac{\eta_h}{\eta_c}$$

- Requires $\eta_h \equiv f'(h)x/h$ not to fall too quickly.
  i.e. diminishing returns cannot be extremely sharp.
  - True for empirically estimated $f(h)$ (below).
  - Examples: $x = f(h) = (zh)^\theta \Rightarrow \eta_h = \theta$
  - Or $x = f(h) = \phi \log(zh) \Rightarrow \eta_h = \phi/x$.

Alternative characterization

- Value of life: $L(c, x) \equiv U(c, x)/u'(c)$

- Then,

$$s = \eta_h \cdot \frac{L(c, x)/x}{y}$$

- With CRRA utility, value of a life year is

$$\frac{L(c, x)}{x} = bc^\gamma - \frac{c}{\gamma - 1}.$$

Will grow faster than income for $\gamma > 1$.

Generalizing Utility: $U(c, x)$

- Solution:
$$\frac{s}{1-s} = \frac{\eta_x \eta_h}{\eta_c}$$
  where $\eta_x \equiv U_x x / U$.

- Health share rises when consumption elasticity falls faster than the product of the production and life expectancy elasticities.

- Example: $U(c, x) = x^\alpha u(c)$ delivers a constant η_x even with α close to zero.

- Summary: health share rises with income if the joy of living an extra year does not diminish as fast as the MU of consumption.

Discussion

- Simple model inadequate for three reasons:
  1. Constant income and productivity (we cheated!).
  2. No age-specific mortality.
  3. No quality-of-life effect of health spending.
     $\Rightarrow$ Turn to our full, dynamic model.

- Does production elasticity fall faster than consumption elasticity?
  $\Rightarrow$ Empirical work that follows model.

The Full Dynamic Model

- Individual health status: $x_{a,t}$

  - Mortality rate: $1/x_{a,t}$

  - Survival probability: $1 - 1/x_{a,t}$

- Production function for health:

$$x_{a,t} = f_a(h_{a,t}; a, t)$$

- Flow utility: Incorporate quality of life considerations

$$u_{a,t}(c_{a,t}, x_{a,t}) = b + u(c_{a,t}, x_{a,t})$$

where

$$u(c_{a,t}, x_{a,t}) = \frac{c_{a,t}^{1-\gamma}}{1-\gamma} + \alpha \frac{x_{a,t}^{1-\sigma}}{1-\sigma},$$

Social Welfare

- Social welfare function

$$\sum_{t=0}^{\infty}\sum_{a=0}^{\infty} N_{a,t}\beta^t \left(b_{a,t} + u(c_{a,t}, x_{a,t})\right).$$

- Let $N_t \equiv (N_{1,t}, N_{2,t}, ..., N_{a,t}, ...)$ denote the vector of populations by age.

- Let $V(N_t; y_t, z_t)$ denote maximized social welfare.

- Bellman's principle of optimality.

Bellman Equation

$$V_t(N_t) = \max_{\{h_{a,t}, c_{a,t}\}} \sum_{a=0}^{\infty} N_{a,t}\, u_{a,t}(c_{a,t}, x_{a,t}) + \beta V_{t+1}(N_{t+1})$$

subject to

$$\sum_{a=0}^{\infty} N_{a,t}(y_t - c_{a,t} - h_{a,t}) = 0,$$

$$x_{a,t} = f_a(h_{a,t}; a, t)$$

$$N_{a+1,t+1} = (1 - 1/x_{a,t})\, N_{a,t}$$

and $N_{0t} = N_0$, $y_{t+1} = e^{g_y} y_t$.

Optimality Conditions

- $\lambda_t \equiv$ Lagrange multiplier on the resource constraint

- FONC:

$$u_c(c_{a,t}, x_{a,t}) = \lambda_t,$$

$$\frac{\partial V_{t+1}}{\partial N_{a+1,t+1}} \cdot \frac{f'(h_{a,t})}{x_{a,t}^2} + u_x(c_{a,t}, x_{a,t})f'(h_{a,t}) = \lambda_t.$$

- Social value of life: $v_{a,t} \equiv \frac{\partial V_t}{\partial N_{a,t}}$

- Then combining the FONC yields (LINK)

$$\underbrace{\frac{\beta v_{a+1,t+1}}{u_c}}_{\text{Quantity effect}} + \underbrace{\frac{u_x x_{a,t}^2}{u_c}}_{\text{Quality effect}} = \underbrace{\frac{x_{a,t}^2}{f'(h_{a,t})}}_{\text{Marginal cost}}$$

Evolution of Value of Life

- Recall $v_{a,t} \equiv \frac{\partial V_t}{\partial N_{a,t}}$

- Taking the derivative of the value function

$$v_{a,t} = \underbrace{u_{a,t}(c_t, x_{a,t})}_{\text{flow utility}} + \beta \underbrace{(1 - \frac{1}{x_{a,t}})v_{a+1,t+1}}_{\text{expected future VofL}} + \underbrace{\lambda_t(y_t - c_t - h_{a,t})}_{\text{net resource effect}}$$

Relation to the Basic Model

- Assume y constant, $\beta = 1$, $f(h)$ invariant to a and t, and no health status in flow utility.

- Then the Bellman equation is

$$V(y) = \max_{c,h} u(c) + (1 - 1/f(h))\beta V(y) \quad \text{s.t.} \quad c + h = y$$

- Rewriting

$$V(y) = \max_{c,h} x(h)u(c) \quad \text{s.t.} \quad c + h = y$$

Data

- Period = 5 years.
  Ages: 0-4, 5-9, ..., 95-99.
  Years: 1950, 1955,...,2000.

- Age-specific mortality rates: *United States Life Tables, 2000*.

- Age-specific health spending: Meara, White, and Cutler (2004).

- Aggregate data: National Income and Product Accounts (BEA).

Estimating the Health PF

- Separate out accidents/homicides as exogenous.
- Non-accident mortality rate — $\tilde{x}_{a,t} \equiv 1/m_{a,t}^{non}$:

$$\tilde{x}_{a,t} = A_a \left(z_t h_{a,t} w_{a,t} \right)^{\theta_a}$$

- Exponential technical change

$$z_t = z_0 e^{g_z t}$$

- $w_{a,t}$ is other unobserved determinants (education, pollution, etc.)
- Production function for overall health:

$$x_{a,t} = f_{a,t}(h_{a,t}) = \frac{1}{m_{a,t}^{acc} + 1/\tilde{x}_{a,t}}$$

Identification of A_a and θ_a

- Rewrite production function using $s_{a,t} \equiv h_{a,t}/y_t$:

$$\tilde{x}_{a,t} = A_a(z_t y_t \cdot s_{a,t} \cdot w_{a,t})^{\theta_a}.$$

  - Technical change: $z_t y_t$
  - Resource reallocation: $s_{a,t}$
  - Other unobserved: $w_{a,t}$

- Key Identifying assumption: observed trends in $z_t y_t$ and $s_{a,t}$ account for a known fraction μ of general trend in age-specific mortality.

  - Benchmark: $\mu = 2/3 \rightarrow$ Decomposition: (35,32,33)
  - Robustness: $\mu = 1/2 \rightarrow$ Decomposition: (26,24,50)

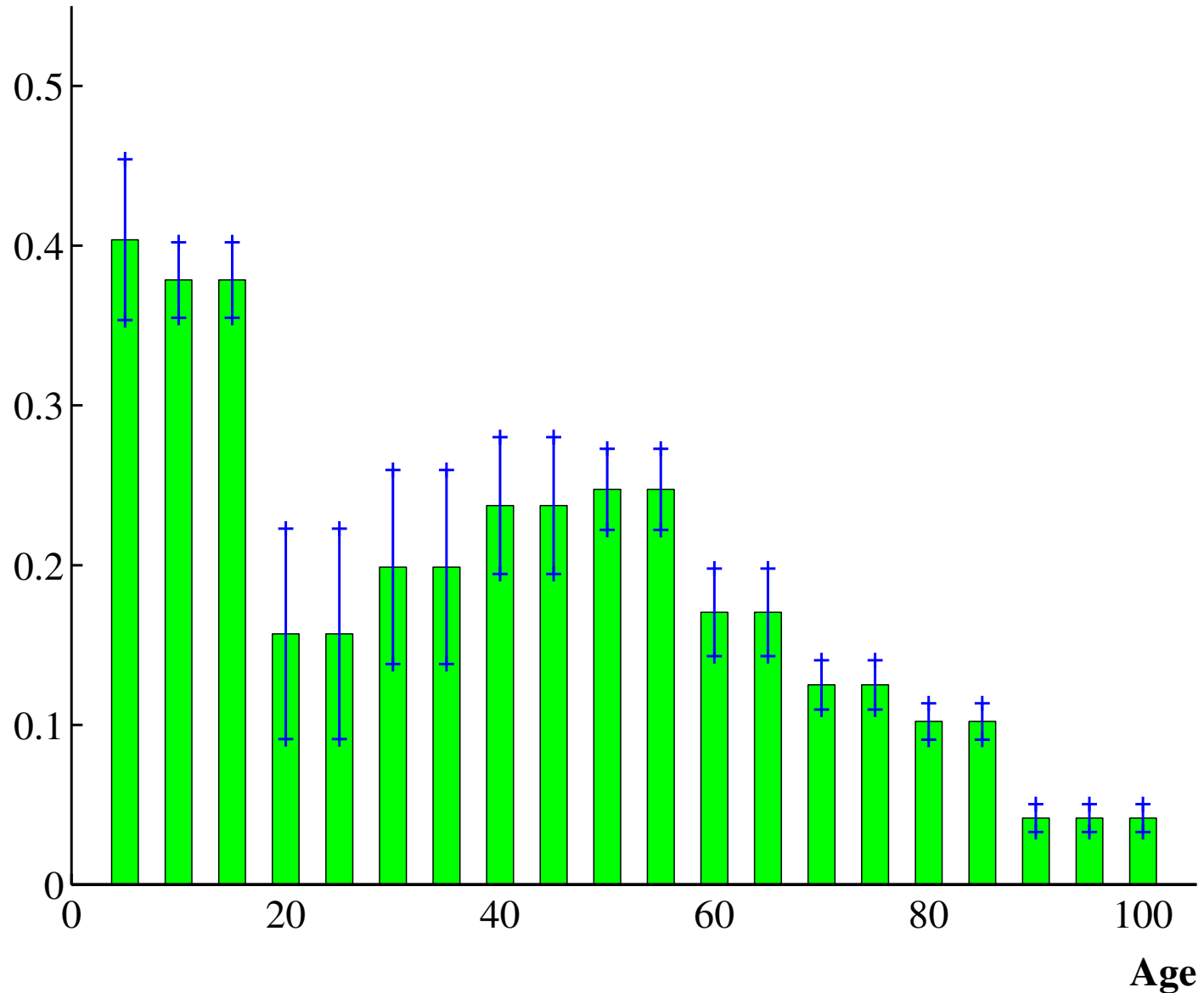- Generally consistent with health literature.
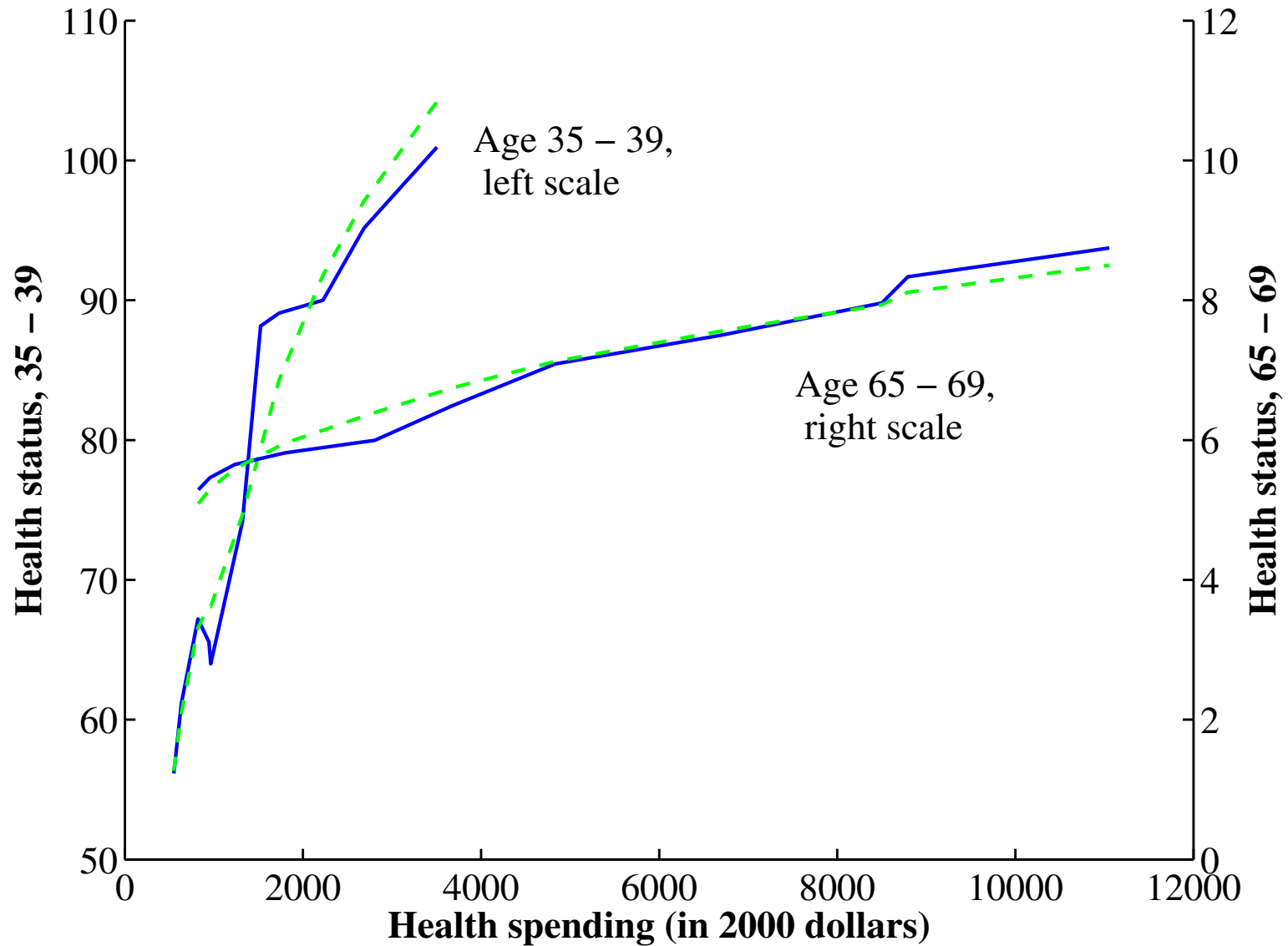
Figure 3. Estimates of θ_a

Figure 4. The Fit of the Health PF

The Marginal Cost of Saving a Life

$x^2/f'(h) = h\tilde{x}/\theta$. Thousands of 2000 dollars.

Age	1950	1980	2000	Robust Maximum 2000	Per Year of Life Saved 2000	Growth Rate 1950–2000
0-4	10	160	590	(790)	8	7.8
10-14	270	2,320	9,830	(13,110)	150	7.2
20-24	1,170	3,840	8,520	(11,360)	153	4.0
30-34	500	2,120	4,910	(6,540)	107	4.6
40-44	160	740	1,890	(2,520)	52	4.9
60-64	50	280	880	(1,180)	47	5.9
70-74	40	280	790	(1,050)	66	6.2
80-84	40	340	750	(1,000)	123	6.1
90-94	50	420	820	(1,090)	373	5.6

Preference Parameters

- See Table 2

- $\gamma = 2$, VSL=$3 million (to get b)

- Robustness checks.

The Quality of Life Parameters

- QALYs: Fryback etal (1993), Cutler-Richardson (1997).
  - QALY weights by age: 20=.94, 65=.73, 85=.62
- Solve these two equations for α and σ:

$$\frac{u(c_t, x_{20,t})}{.94} = \frac{u(c_t, x_{65,t})}{.73} = \frac{u(c_t, x_{85,t})}{.62},$$

- Results: $\alpha = 1.92$, $\sigma = 1.05$, $b = 54.2$, and $\gamma = 1.59$
- To have the health status of a 20 year old, what fraction of consumption would you give up?
  - 65 year-old: 88 percent. 85 year-old: 93 percent

  Why? Because of sharp diminishing returns to consumption.
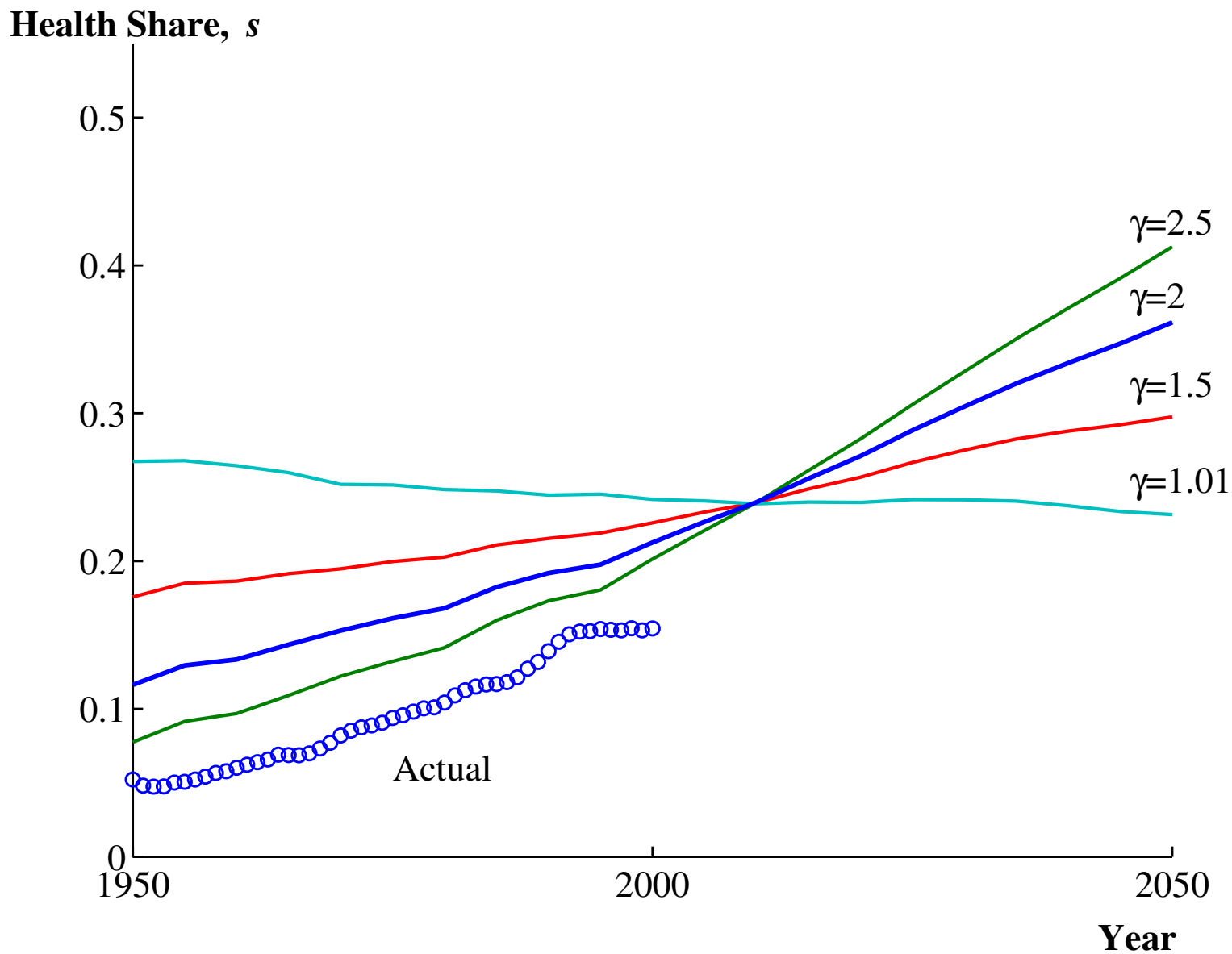
Figure 5. Simulation: Health Share

Health Share, *s*
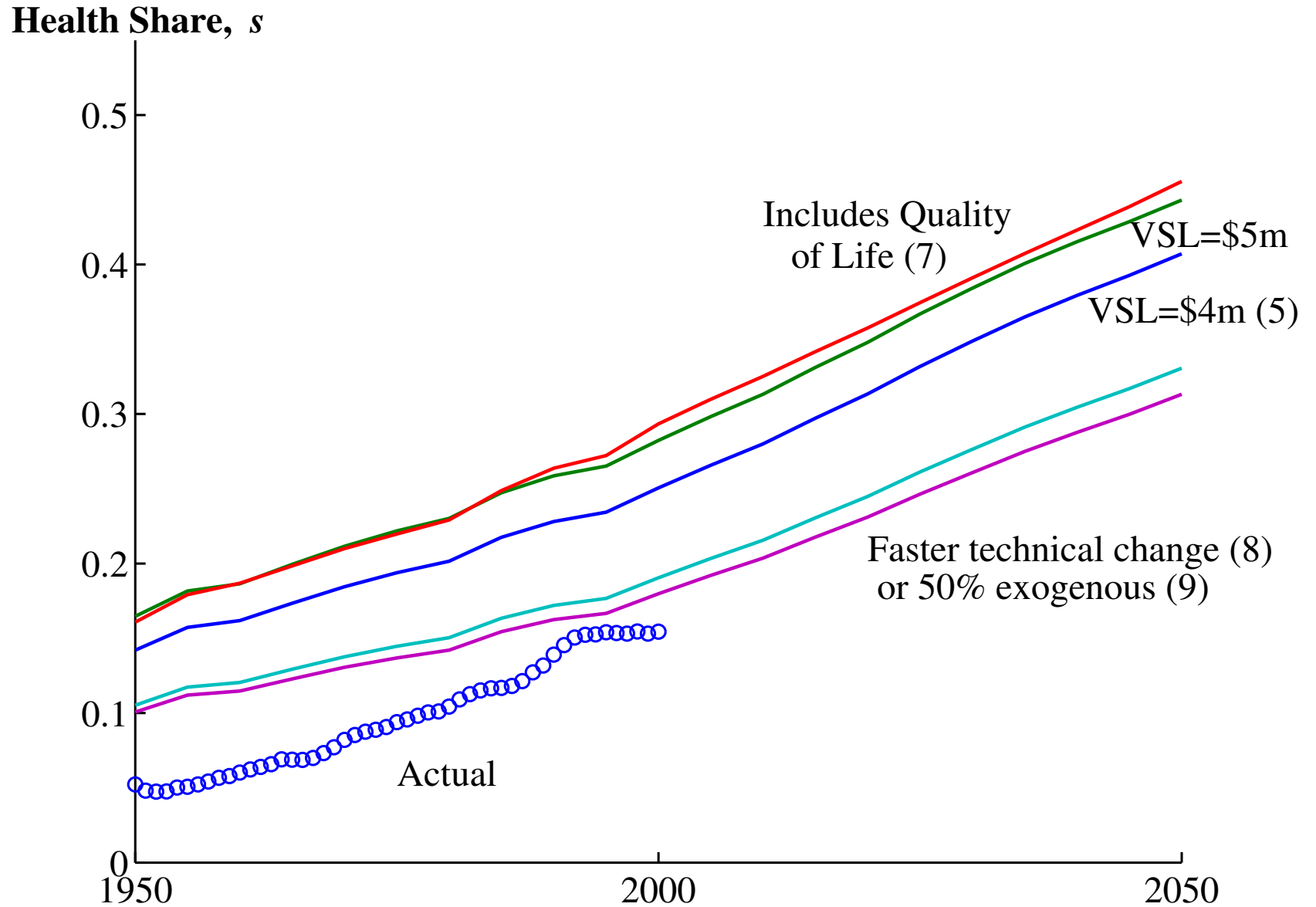
γ=2.5

γ=2

γ=1.5

γ=1.01

Actual

0.5

0.4

0.3

0.2

0.1

0

1950   2000   2050

Year

Figure 6. Robustness

Health Share, *s*

Includes Quality of Life (7)

VSL=$5m

VSL=$4m (5)

Faster technical change (8) or 50% exogenous (9)

Actual

0.5

0.4

0.3

0.2

0.1

0

1950

2000

2050

Year

Figure 7. Health Spending by Age

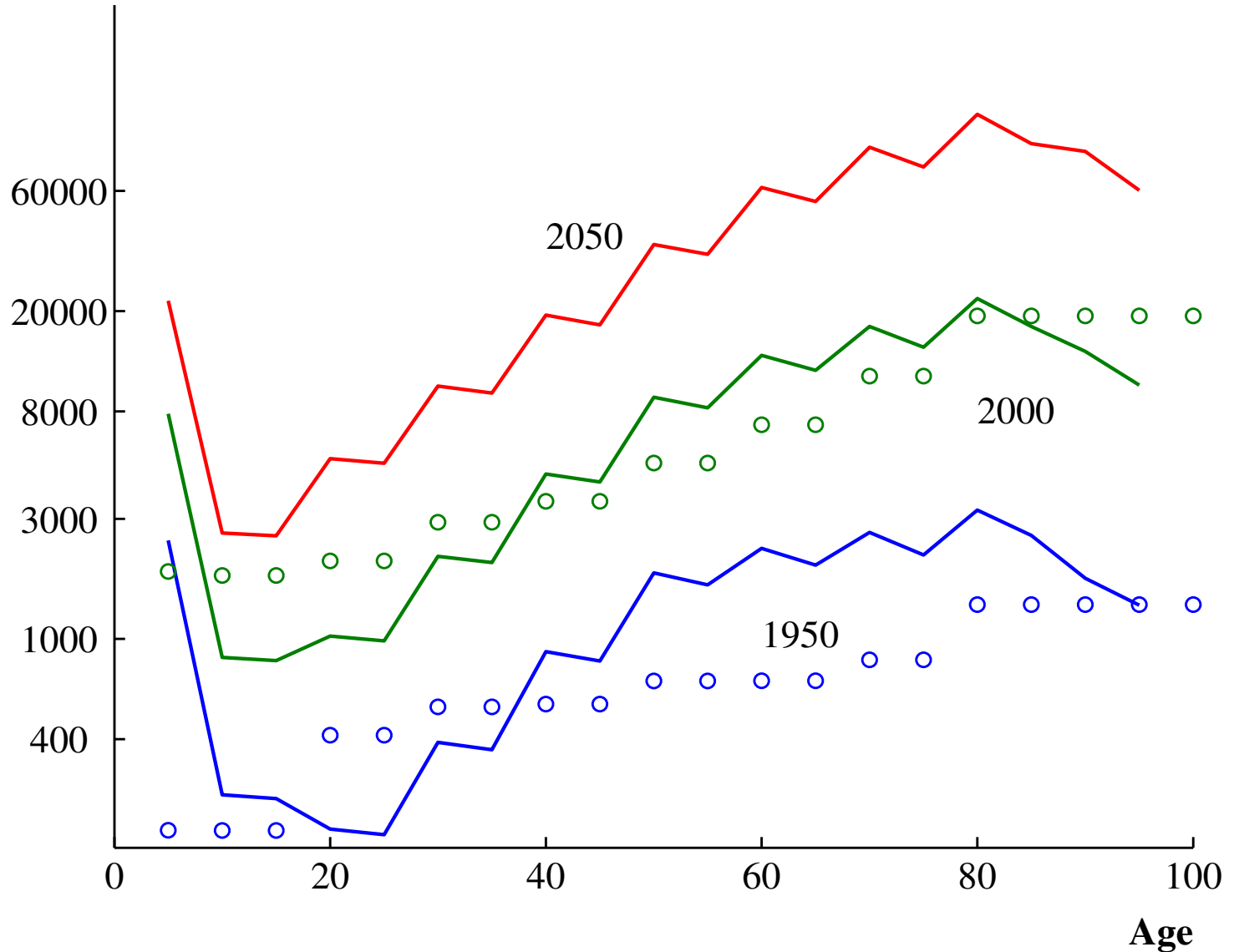**Constant 2000 dollars**
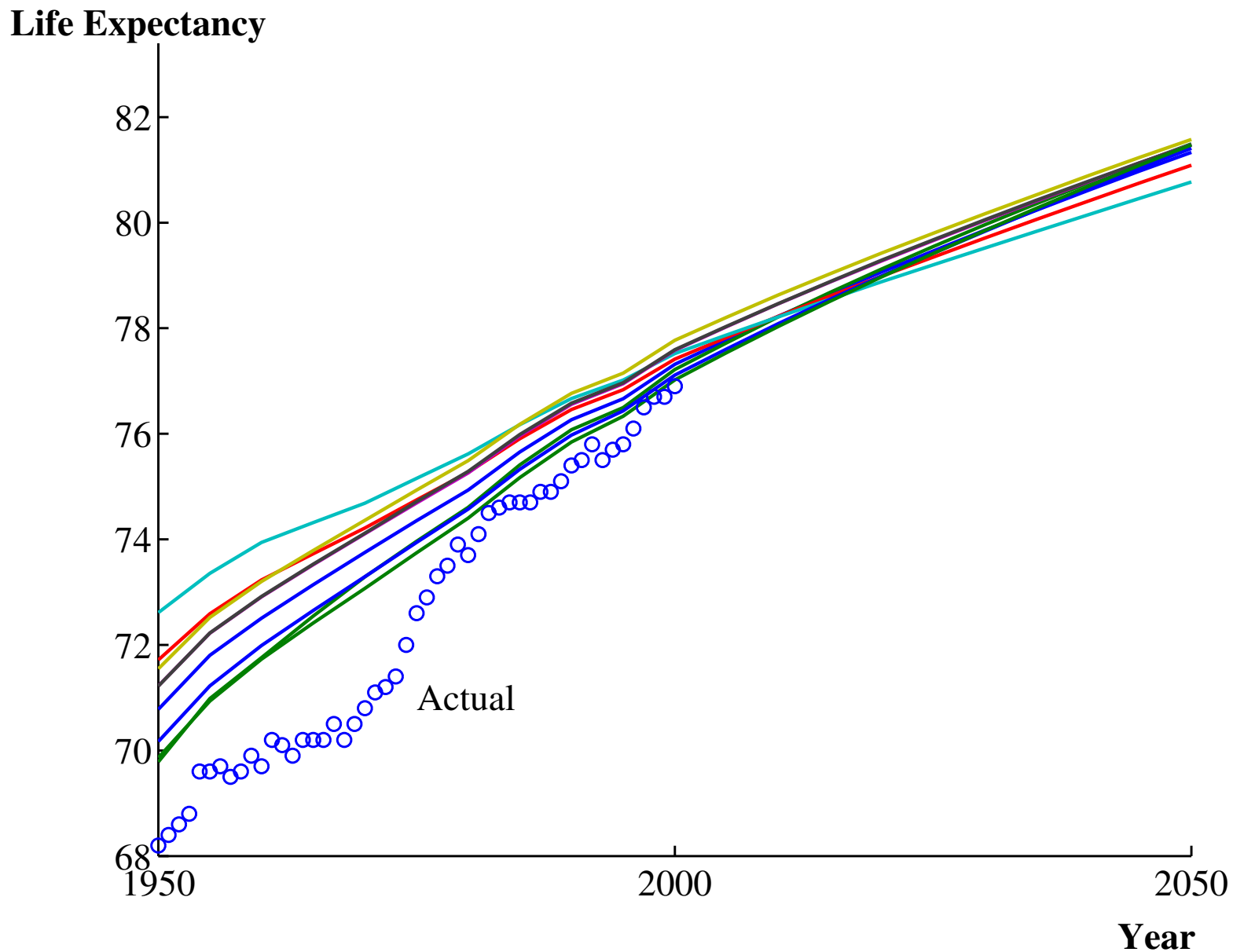
2050

2000

1950

Age

Figure 8. Simulation: Life Expectancy

Conclusions

- IF MUC falls sufficiently quicky

    AND

  health production function does not run into very sharp diminishing returns

    (both of which hold up empirically)...

  THEN the optimal health share rises as income grows.

- Supported by
  - Estimates of low IEOS
  - Rising value of life (Costa and Kahn; Hammit, Liu, and Liu)
  - International macro evidence.

- Counter evidence? Micro income elasticities...

Evidence on VSL

- Our estimation of Health PF allows us to infer VSL. First, we discuss the existing literature.

1. Level of VSL
   - Viscusi & Aldy (2003): 4 million to 9 million
   - Ashenfelter & Greenstone (2004): 1.5 million or less

2. Change in VSL over time
   - Costa & Kahn (2003): U.S. Income elasticity = 1.6
   - Hammitt, Liu & Liu (2000): Taiwan elasticity = 2.5
   - Viscusi & Aldy (2003): Meta-analysis elasticity = 0.5
   - Basic model: Elasticity is roughly γ