Health Inequality:
Role of Insurance and Technological Progress

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Disclaimer

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Summary

Motivation

- Huge inequality in health outcomes
  - Gap in life-expectancy between top and bottom of income distribution $\approx$ 12 years (Chetty et al., 2016)
- Getting worse over time
  - From 2000 to 2014, rich gained 2.3 years vs poor gained 0.3 years (Chetty et al., 2016)
- Rich and poor have comparable health investments
  - Total health investments (including OOP, insurance and govt. programs) similar across income groups (Ales et al., 2012)
- **This paper**: Timing of investments and its interaction with technological innovation determines the outcomes ▷

Summary

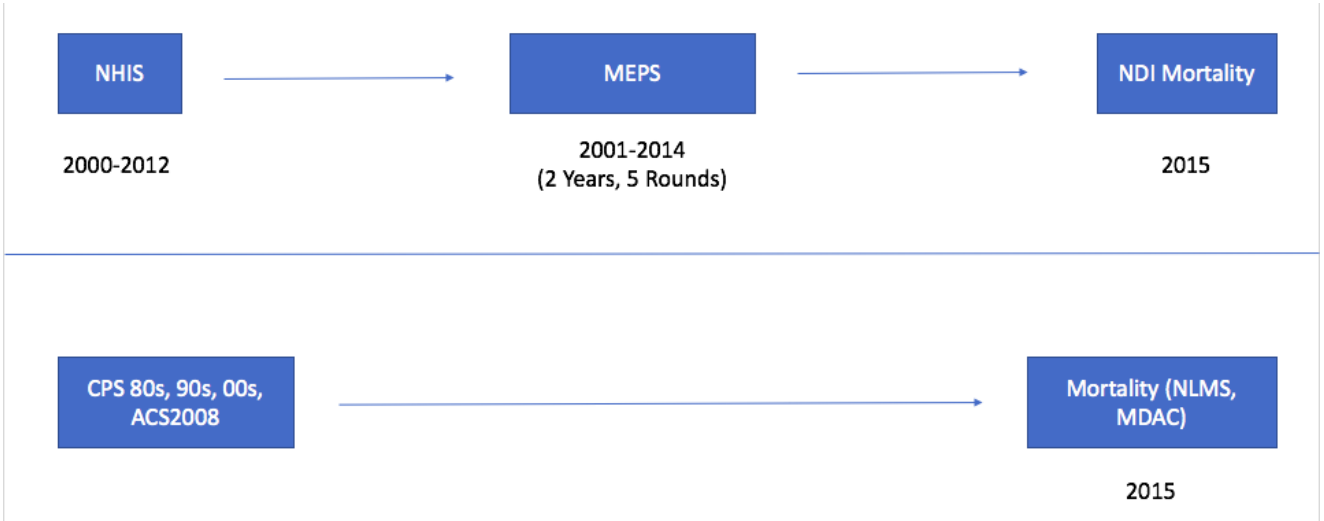
- A life-cycle model with stopping-time where individuals choose how to invest in their health capital, examples include:
  - Purchases of private insurance
  - Timing of doctor visits
  - Medical investments
- Partial equilibrium model, estimated on insured individuals; feed in insurance prices from data

Contribution

1. Theoretical
   - Endogenous health-capital accumulation incorporating the *timing* of investment in a life-cycle model
     - ⋆ Grossman (1972), DeNardi et al (2017), Gilleskie (1998), Ozkan (2016), Hong, Pijoan-Mas and Ríos-Rull (2018),..
   - Use continuous-time tools in health
     - ⋆ Agarwal et al (2018)

Contribution

2. Empirical
   - Put together nationally representative datasets of health, wealth, investments and mortality to estimate the model



   - Document the changes in life-expectancy over time using the mortality follow-up of about 9 Million individuals

Roadmap

1. Facts
2. Model: Individual's Problem
3. Results
4. External Validation: Regression Discontinuity and PSM

Facts

Facts (New facts in blue)

1. Mean medical investment looks "almost" flat across income groups
2. Higher fraction of poor have zero medical investment but they also have very high investment
3. Visit decision of poor is more elastic to their health status compared to rich
4. Cancer related innovation is a major contributor in increased health disparities

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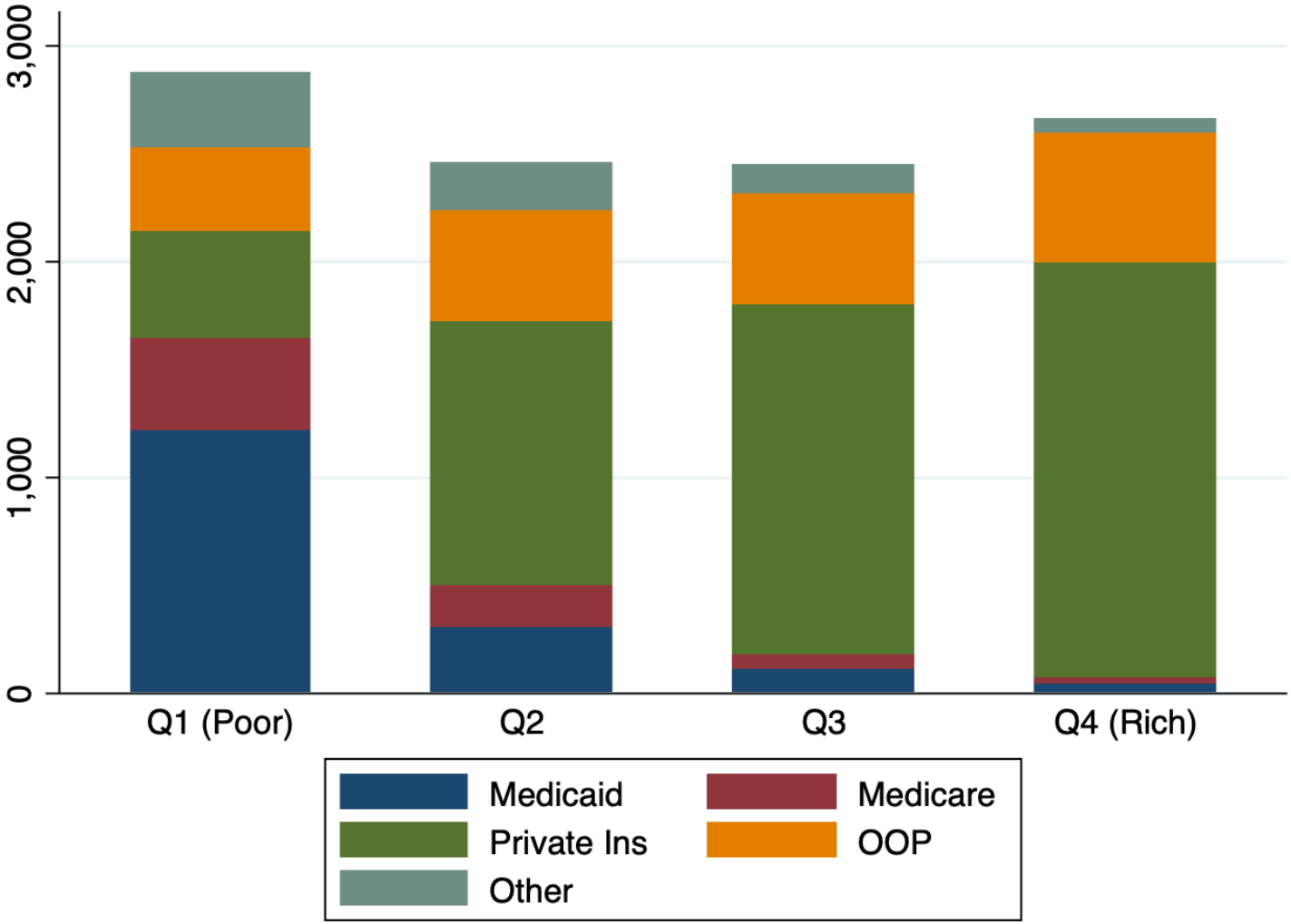
Mean Medical Investment: Age 35-45

Other Age Groups



Source: NHIS-MEPS

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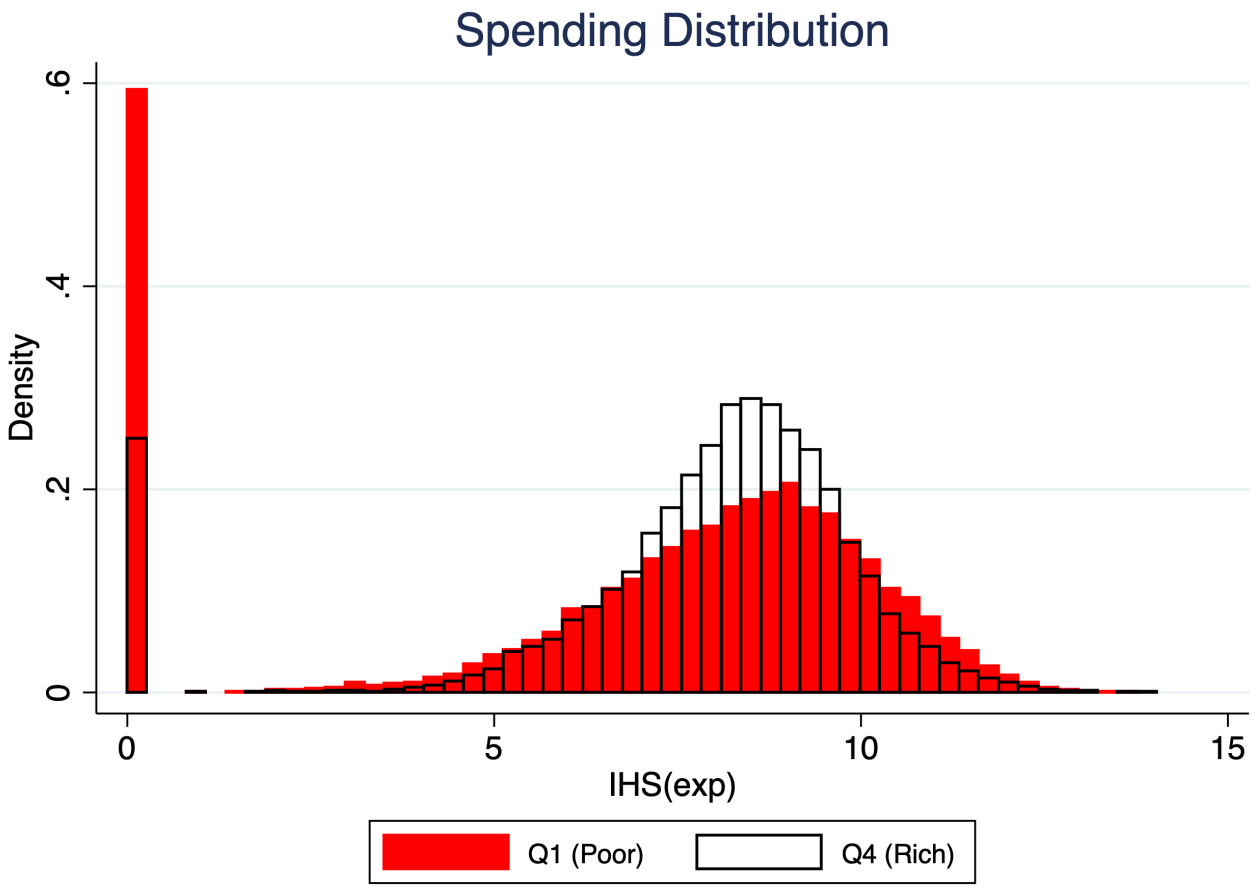
Medical Investment Distribution, Age 45-55



Notes: Inverse Hyperbolic Sine (IHS) Transformation

All Quartiles Other Age Groups

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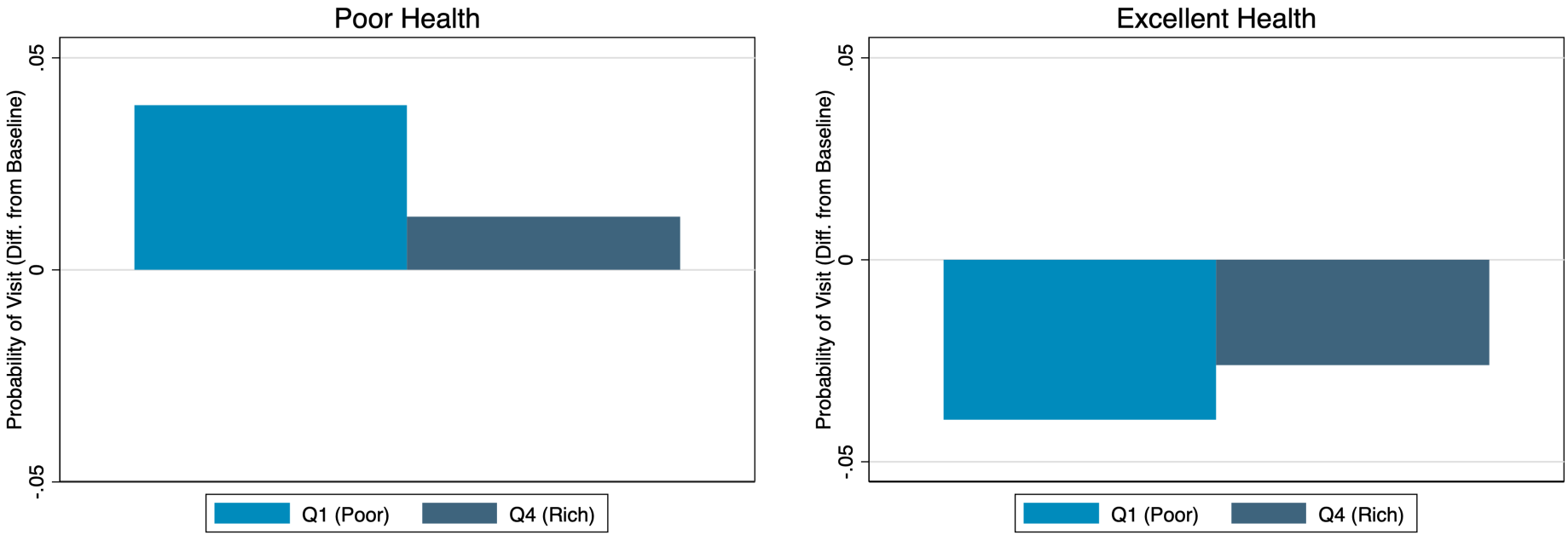
Timing of Visit by Income



Notes: Includes individual fixed effect; base set to average health in each family income group regression

Rich individuals go to the doctor in a much healthier state

By Insurance | All Quartiles

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Gains in Life-expectancy: 1980s to 2000s

	Q1 (Poor)	Q2	Q3	Q4 (Rich)
Life-expectancy 1983	70.7	74.2	77.4	79.2
Total Change (1983 - 2003)	2.4	2.7	3.1	4.7
Cause of death:				
Malignant neoplasms	0.3	0.3	0.7	1.2
Heart	2.8	2.6	2.8	2.9
Diabetes	-0.2	-0.1	-0.0	-0.1

Note: Life-expectancy conditional on surviving until age 20. Family income group.

Full Decomposition

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Model

Model Overview

State variables (endogenous, exogenous):

h: Health, w: Wealth, ν: Transition Intensity to Better Health, I: Insurance Status, a: Age, e: Education, p: Insurance Premium

Setup:

- Continuous Time
- Utility Function ▷
- Wealth Evolution ▷
- Health Evolution ▷

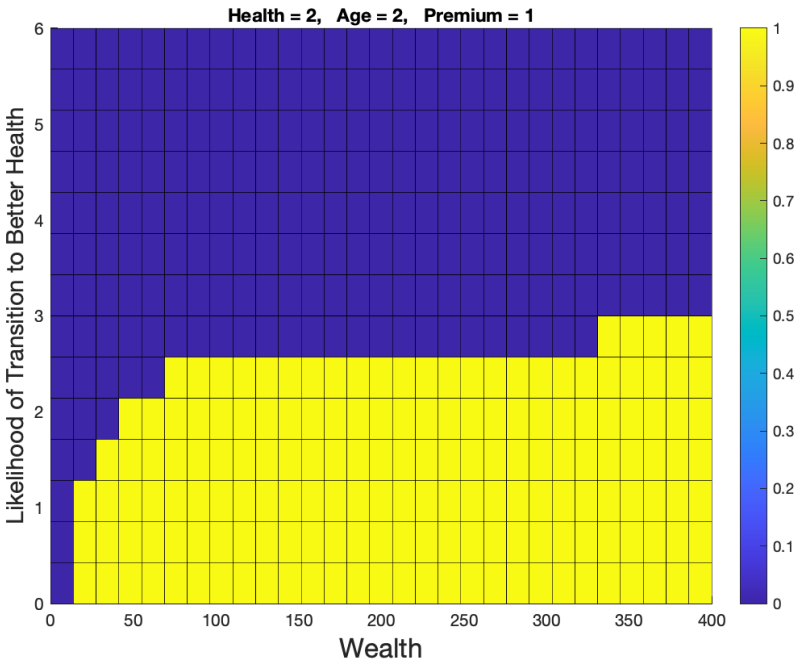
Choices:

1. Consumption-saving
2. Private Insurance Take-up ▷
3. Health Capital Investment ▷

Medicaid | Medicare/ Disability | Insurance Firm Problem

Visit Decision, Age 35-45

Figure: Uninsured, Bad Health



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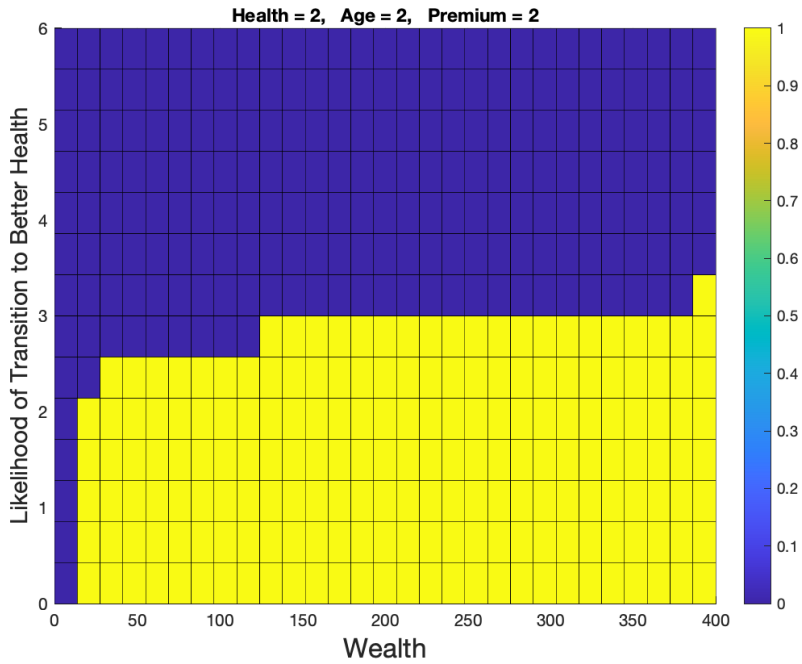

Continuation (don't go to the doctor)

Stopping (go to the doctor)

Visit Decision, Age 35-45

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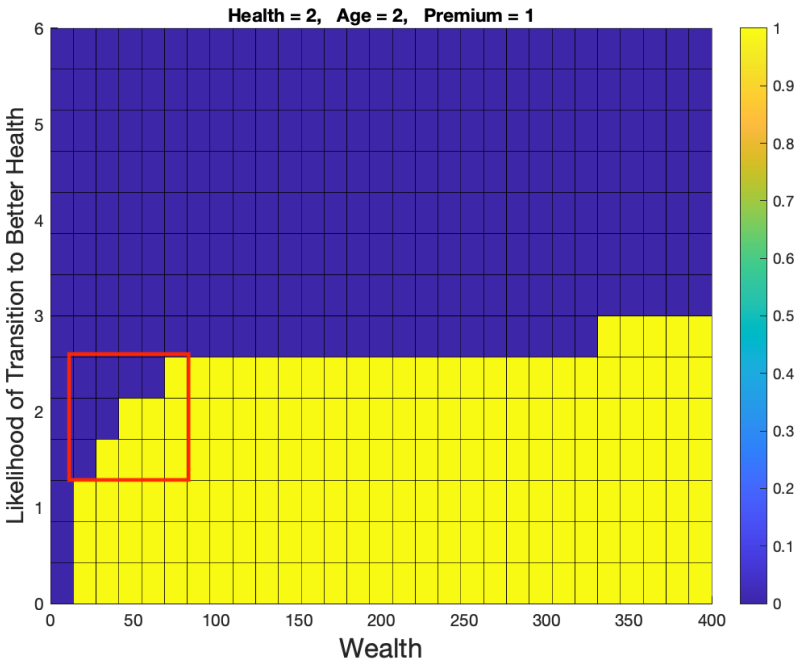

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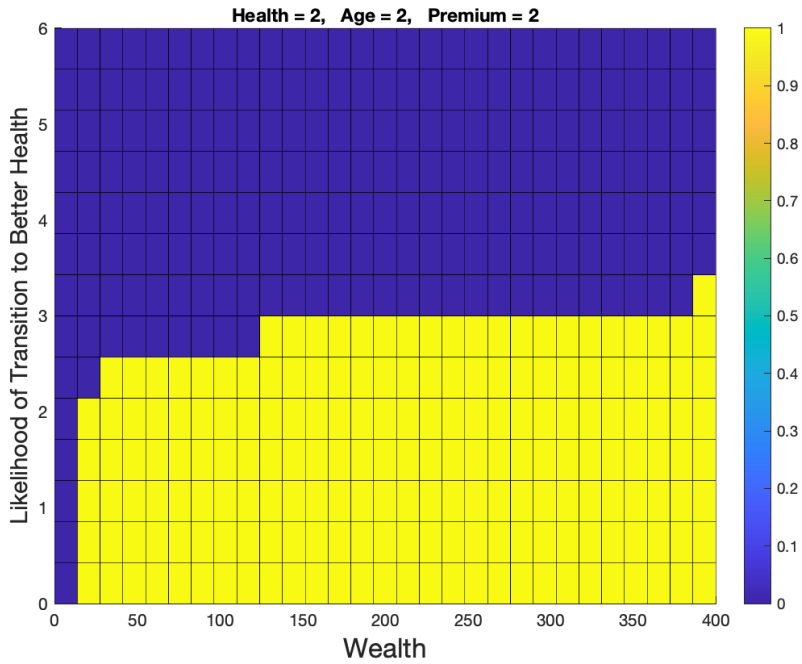

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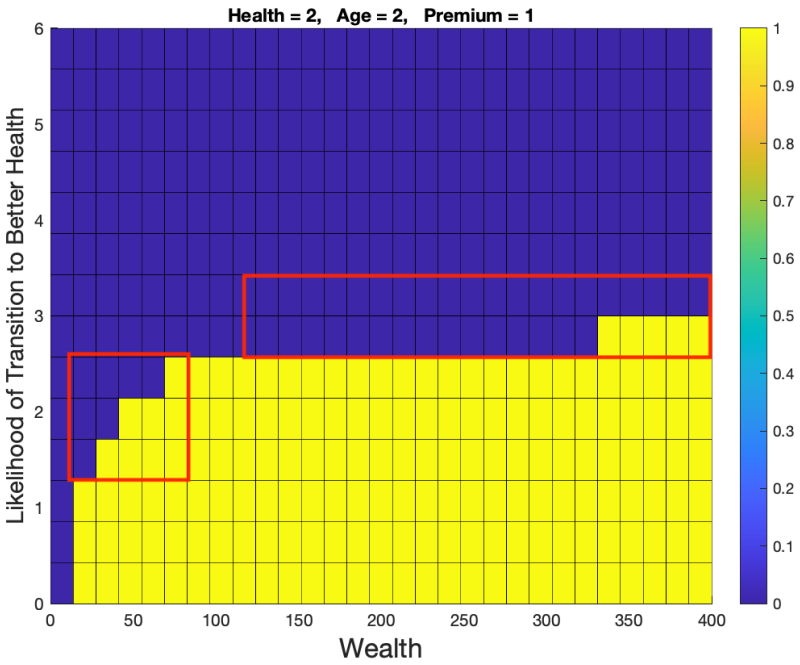

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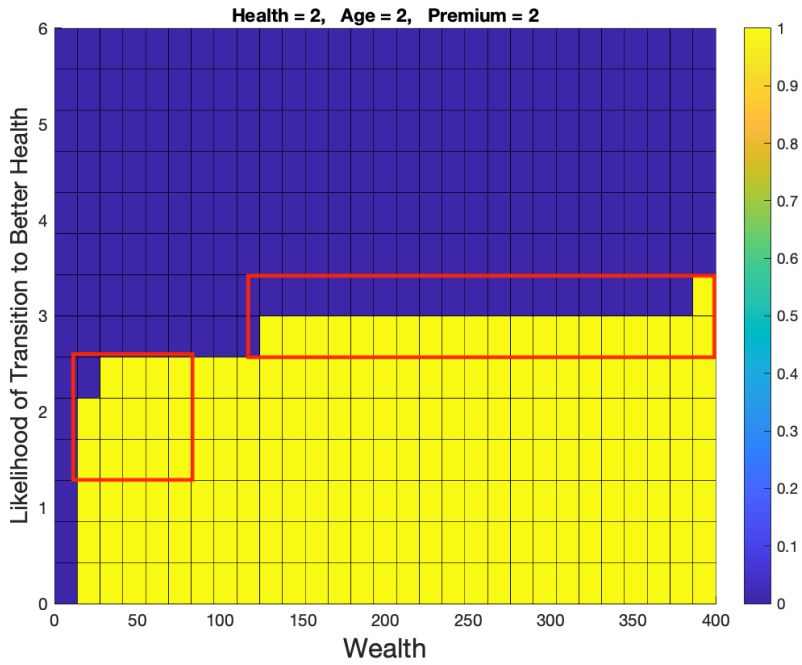

Continuation (don't go to the doctor)

Stopping (go to the doctor)

Estimation Summary

- Parameterize the functional forms to reduce the number of parameters
- Estimating some orthogonal parameters outside of the model
- Using SMM to target choices (visits, investment) and transitions (improvements and changes in health) by age and health
- Leave moments by wealth untargeted

Estimation Identification Table

Summary of Estimates

- Fixed cost per visit: \$213
- Ages 25-35, the expected duration before going to a worse health state: 1 year and 3 months
- Ages 65-75, the expected duration before going to a worse health state: 9 months
- Ages 25-35, the expected duration before going to a better health state without investments: 2 years
- Ages 65-75, the expected duration before going to a better health state without investments: ∞ months
- Marginal utility of consumption at same level of consumption for average health is about 2.52 times that in poor health

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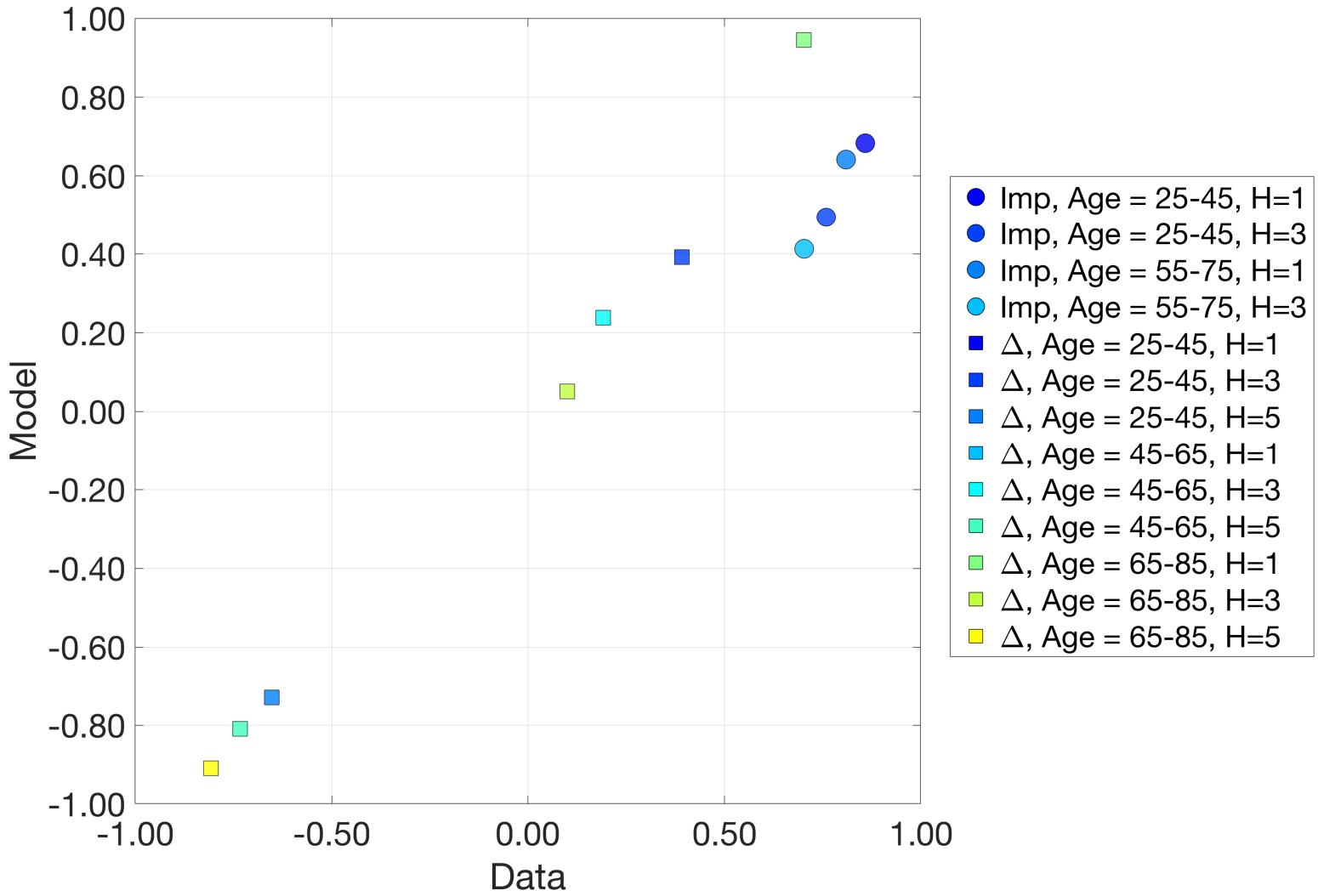
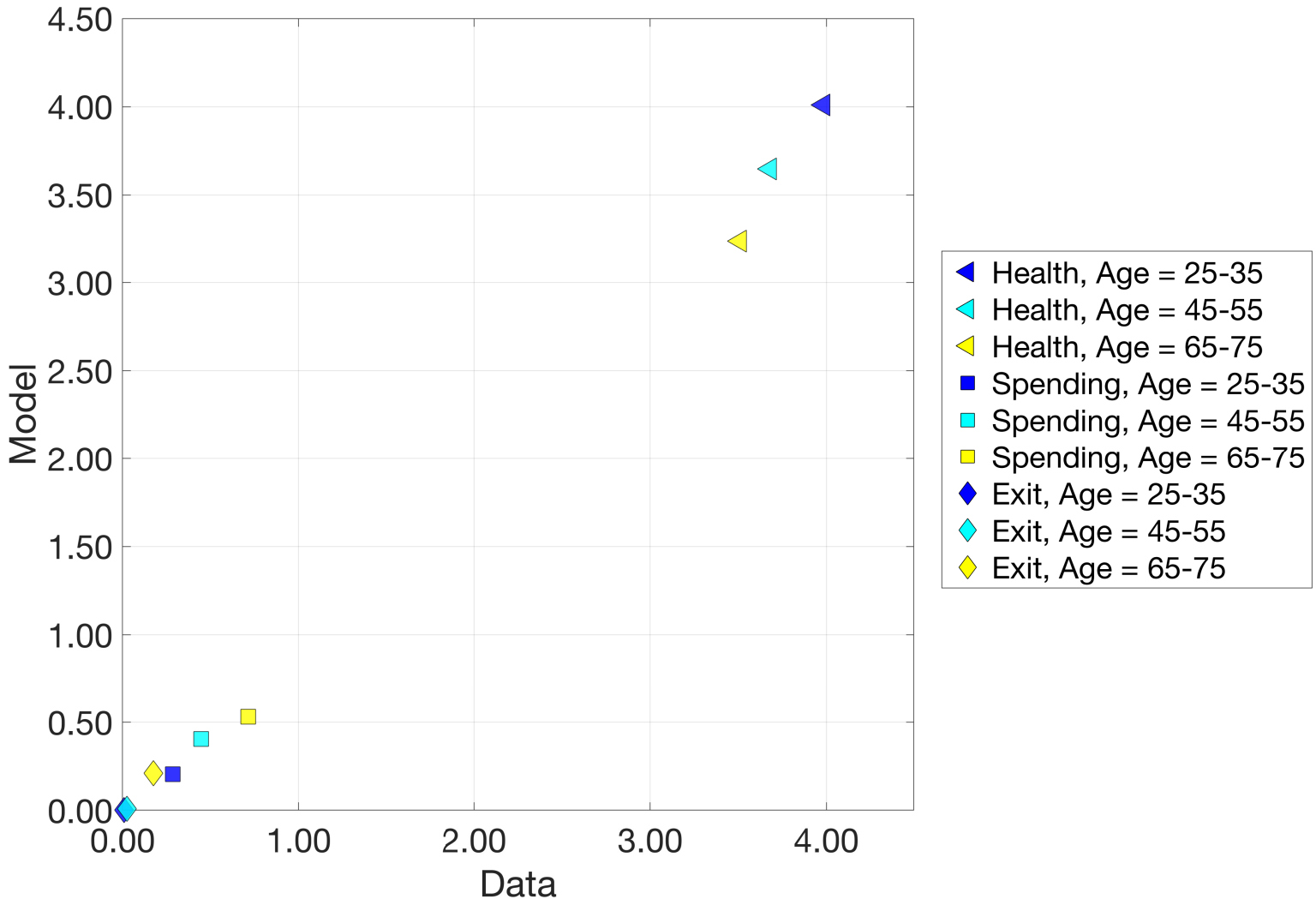
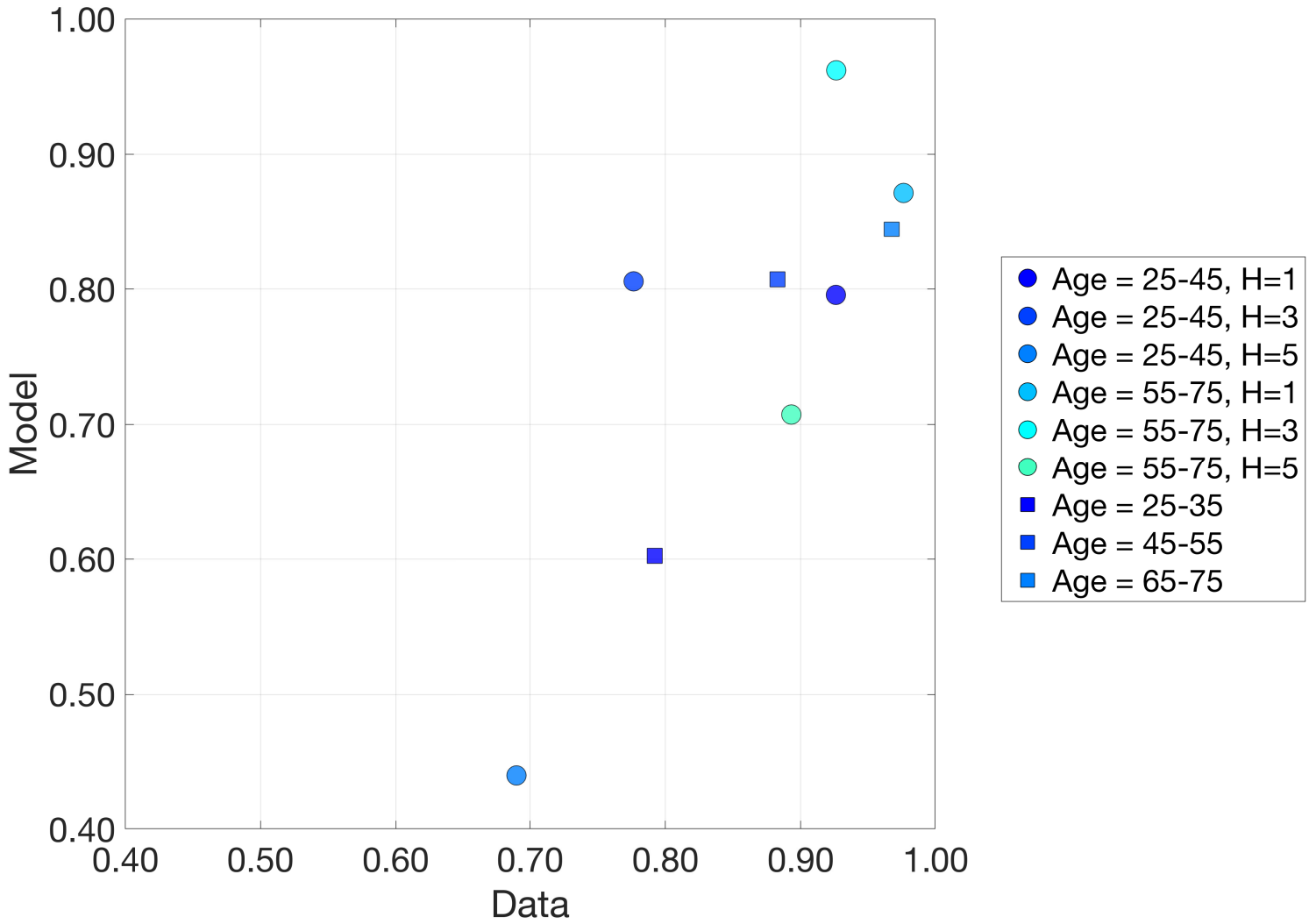
Model Fit: Health Transitions



Model Fit: Health, investment and Mortality over Age



Model Fit: Visit Decisions



Untargeted Moments and Mechanisms

1. Health Inequality over the Life-Cycle ▷
2. Timing of Visit by Wealth ▷
3. Exit by Health and Wealth ▷
4. Health$_{t+1}$| Visit ▷
5. Health-care Investment by Health and Wealth ▷

Result

Result (Untargeted)

Table: Model

	Wealth Quartiles			
	Q1	Q2	Q3	Q4
Life-Expectancy	1.00	1.03	1.08	1.09
Mean Spending 35-45	1.00	1.27	0.75	0.75
Mean Spending 45-55	1.00	0.83	0.60	0.89
Mean Spending 55-65	1.00	1.55	0.94	1.67
100 x Mortality 35-45	1.00	0.98	0.50	0.40
100 x Mortality 45-55	1.00	0.54	0.42	0.33
100 x Mortality 55-65	1.00	0.82	0.34	0.38

Table: Data

Wealth Quartiles			
Q1	Q2	Q3	Q4
1.00	1.05	1.10	1.14
1.00	1.01	1.03	1.12
1.00	0.92	0.94	0.96
1.00	1.11	1.05	1.14
1.00	0.86	0.91	0.58
1.00	0.88	0.75	0.56
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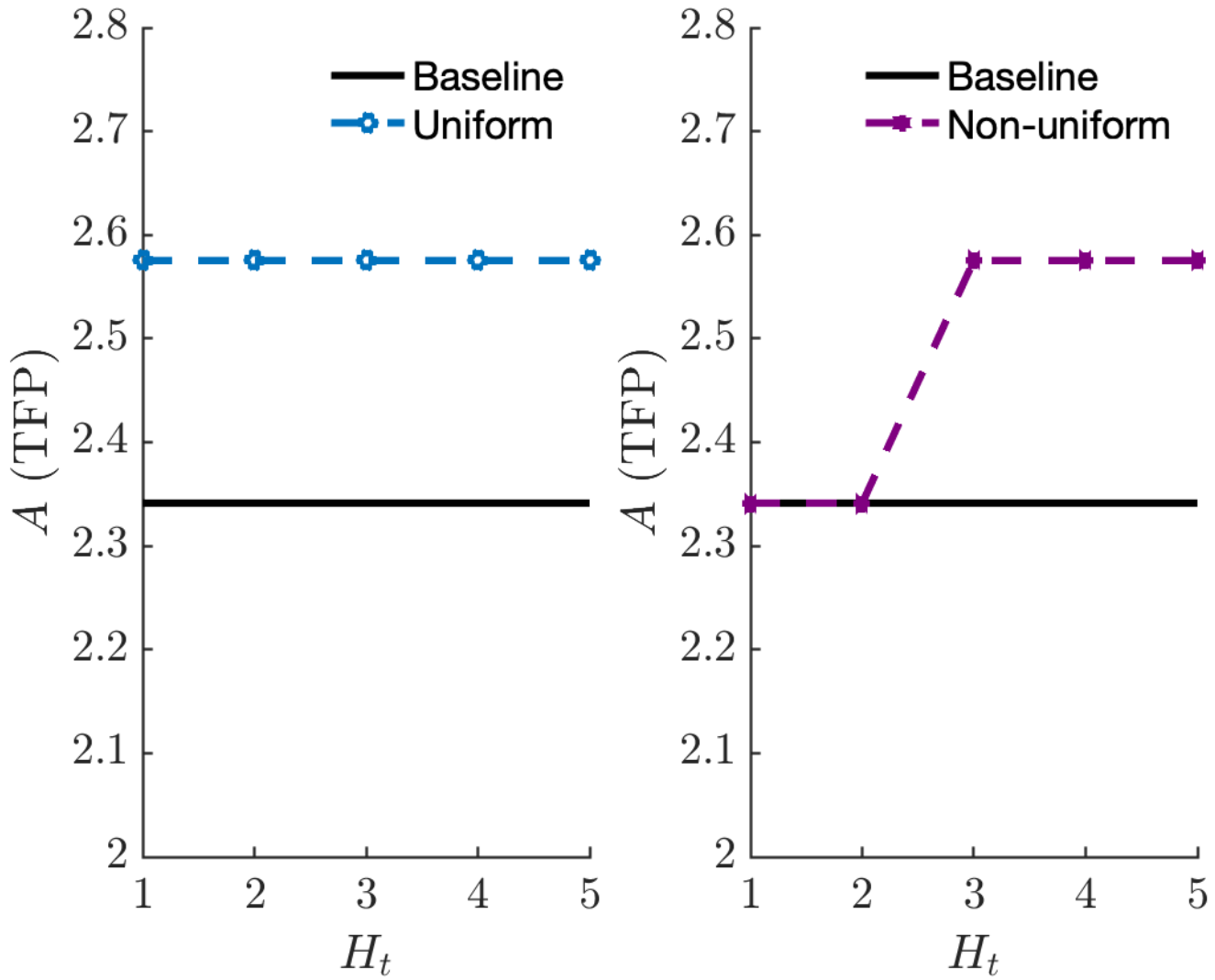
Experiments

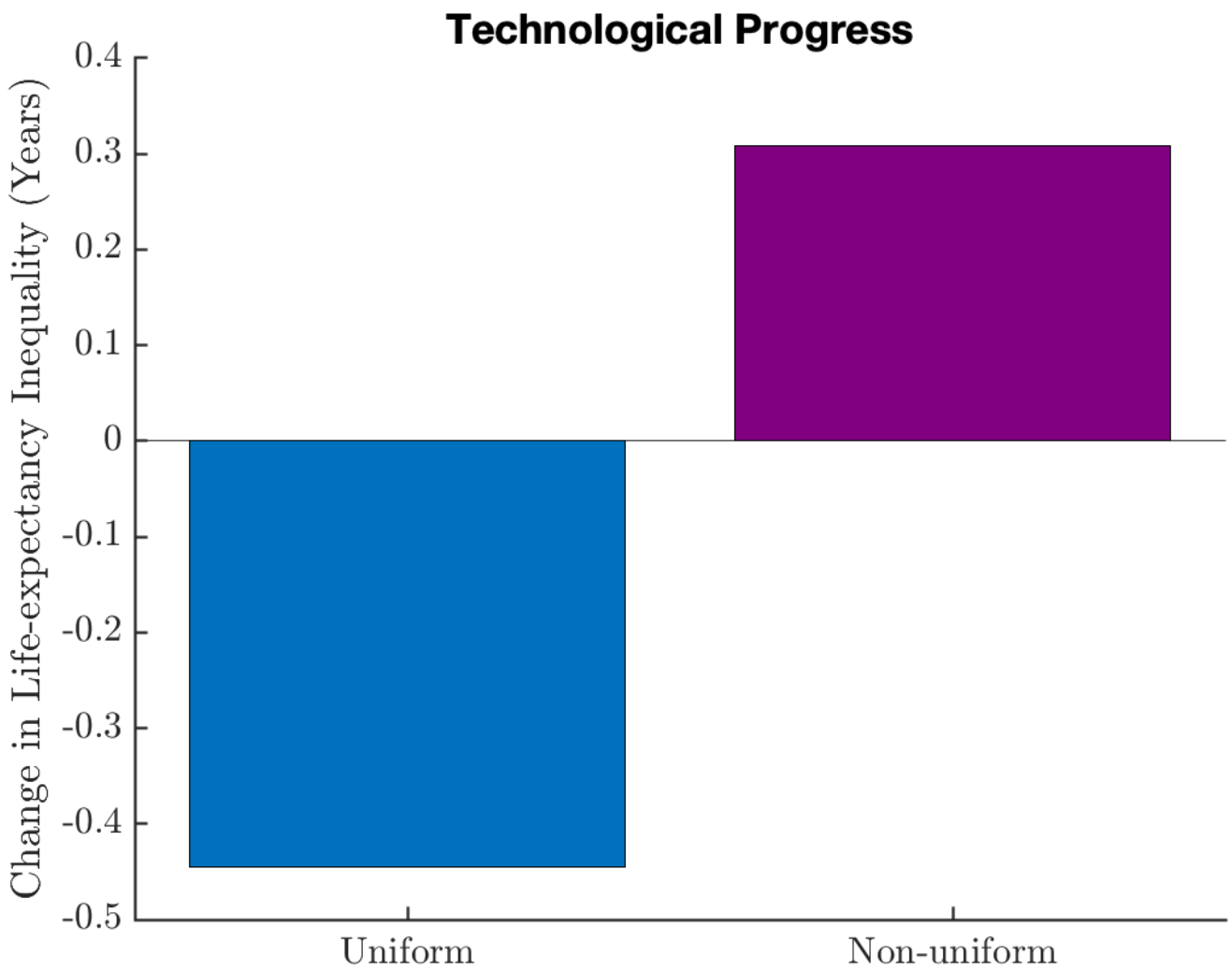
Role of Technological Progress

Recap ▷

1. Uniform (across health states) increase in TFP (10%)
2. Non-uniform (across health states) increase in TFP (10%)



Role of Technological Progress

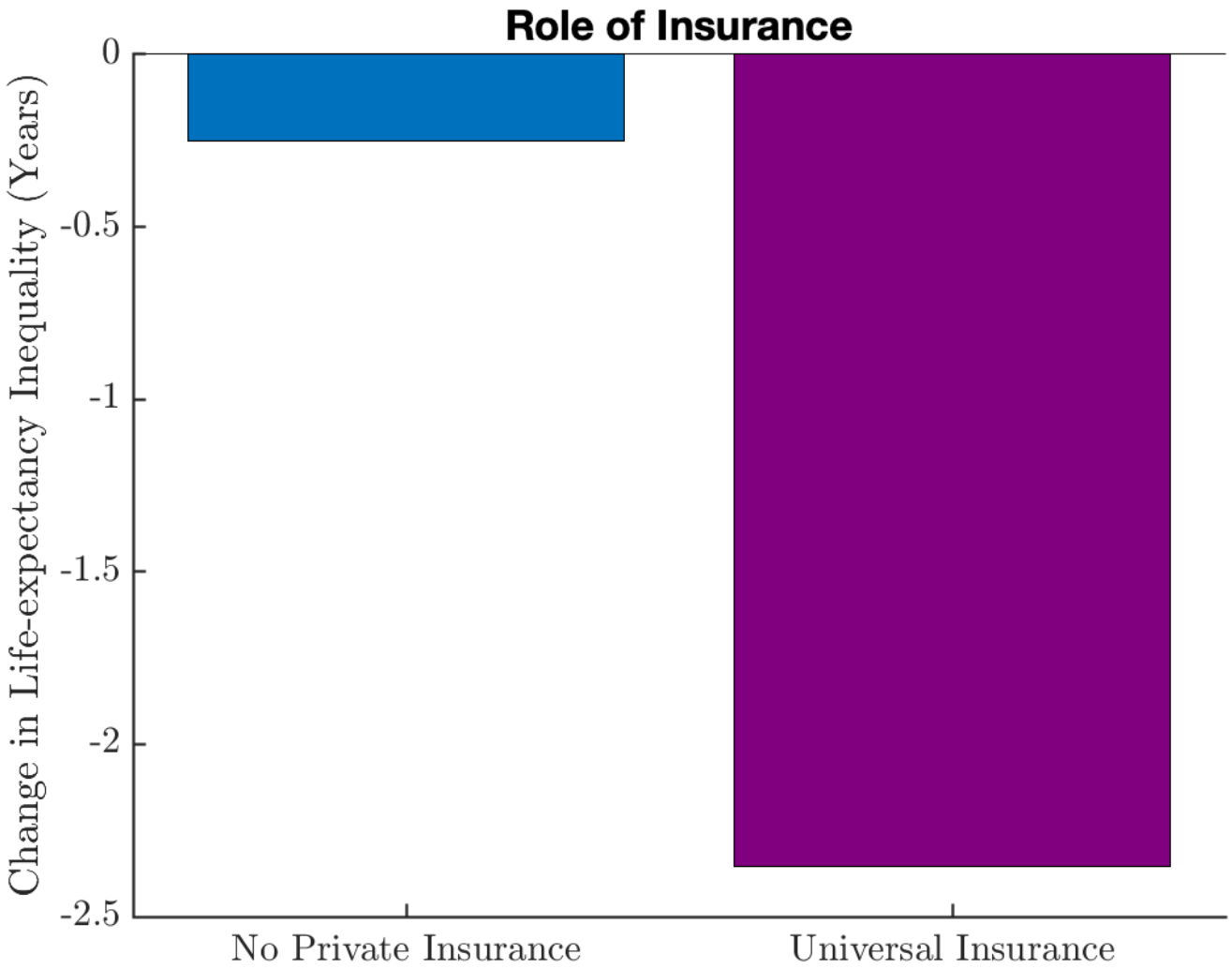


Role of Insurance

Two experiments:

1. We take away the insurance choice Take-up Policy Function
2. Give everyone a public health insurance financed by a flat 15% income tax along with 30% cost sharing

Role of Insurance



External Validation

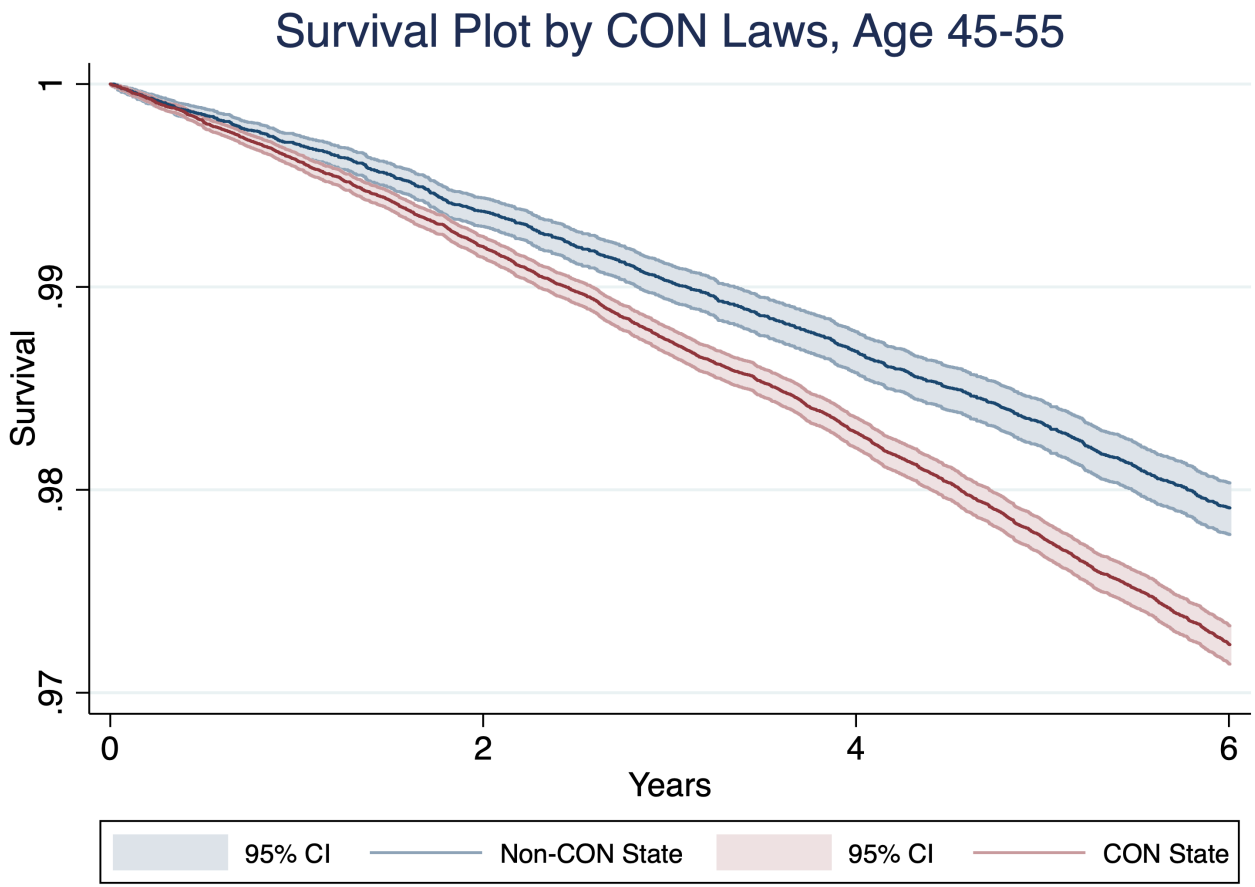
Reduced-form Estimates PSM RD

Table: Effect of Insurance on Mortality

	Logit6a	PSM_6a	Logit6b	PSM_6b	Logit6c	PSM_6c	RD6c
1 if Medicaid	0.0141***		0.0135***		0.0139***		-0.0952***
	[0.0013]		[0.0011]		[0.0008]		[0.0253]
1 if Private Insurance	-0.0052***	-0.0054***	-0.0026***	-0.0035***	-0.0016***	-0.0018***	
	[0.0008]	[0.0012]	[0.0007]	[0.0010]	[0.0006]	[0.0007]	
Adjusted Income	-0.0005***		-0.0008***		-0.0007***		
	[0.0002]		[0.0001]		[0.0001]		
Age	0.0040***		0.0033***		0.0020***		
	[0.0002]		[0.0002]		[0.0002]		
Female	-0.0132***		-0.0107***		-0.0062***		
	[0.0005]		[0.0005]		[0.0004]		
1 if Medicare	0.0121***		0.0133***		0.0145***		
	[0.0010]		[0.0009]		[0.0007]		
Observations	301327	282423	365109	335939	443521	407441	39642
Baseline		0.0231***		0.0157***		0.0121***	
		[0.0007]		[0.0002]		[0.0002]	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Standard Errors are in brackets.

Survival Plot: CON vs Non-CON States, Age 45-55



Summary

1. Timing of the investments explain a substantial part of the health inequality
2. Role of Technological Progress:
   - Rich have gained a year in life-expectancy due to cancer-related medical innovations while poor have gained only 3.5 months
   - Non-uniform increase in TFP can lead to increase in inequality in Life-expectancy
3. Role of Insurance:
   - Public health insurance, funded by flat-income tax, goes a long way in decreasing the inequality by half

Ongoing Steps

1. Estimating the version with disability/ Medicare and Medicaid
2. Simulated Medicaid eligibility across states and over time on visit and outcomes

Extensions

1. Effect of a pandemic: transition dynamics
2. Insurance design: welfare and optimal policy
3. Role of risky behavior, such as smoking
4. Cross country differences
5. Health and human capital

Thanks!

Insurance Firm's Value

Insurance Firm's Value

$$\rho F(w,h,\nu,a,I,p) = p + \underbrace{\eta[F(w,h,\nu,a+1,I,p) - F(.)]}_{\text{aging to } a+1} +$$

$$\underbrace{\nu[F(w,h+1,\nu_0,a,I,p) - F(.)]}_{\text{transition to } h+1} + \underbrace{d(h,a)[F(w,h-1,\nu_0,a,I,p) - F(.)]}_{\text{transition to } h-1} +$$

$$\underbrace{\lambda^T(h,a)[0 - F(.)]}_{\text{death}} + \underbrace{\phi[\bar{F}(w,h,\nu,a,I',p') - F(.)]}_{\text{insurance choice from individual's problem}}$$

$$\bar{F}(w,h,\nu,a,I',p') = \begin{cases} 0, \text{ if } I^* = 0 \\ F(w,h,\nu,a,I,p(h,a)) \text{ if } I^* = 1 \end{cases}$$

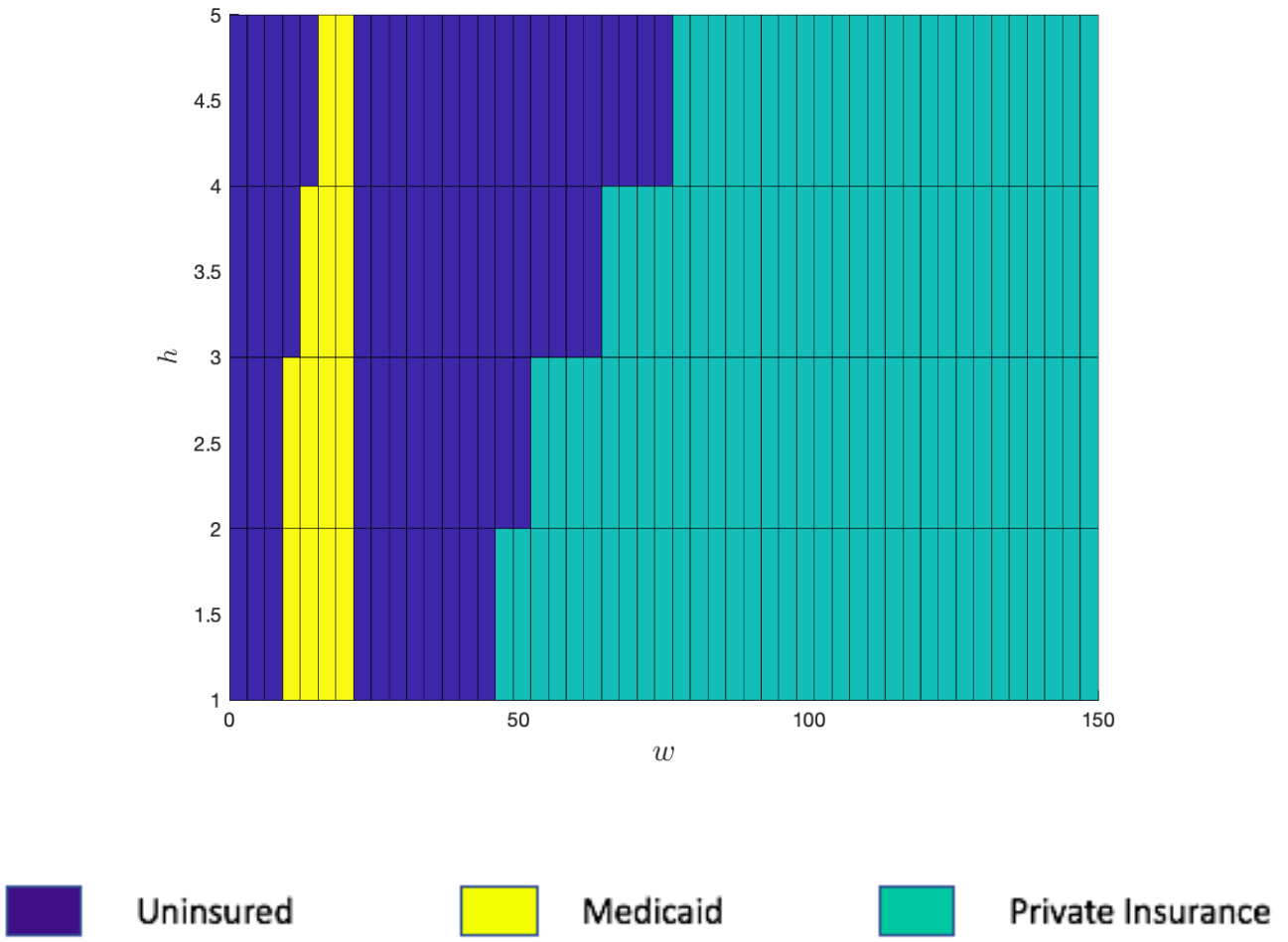
$$\lim_{\tau \to 1} F(.) = -mq(I) + F(w',h',\nu',a,I,p)$$

Back

Medicaid + Private Insurance Take-up

Model Summary ◁ Experiments ◁

Figure: Medicaid + Private Insurance Take-up



Functional Forms

Assumptions (1)

- Equal depreciation across health states:
  $d(5,a) = d(4,a) = d(3,a) = d(2,a) = d(a)$
- Depreciation over age: Power function

$$d(a) = d_0 + d_1 age + d_2 age^2$$

- Natural improvement by age: Power function

$$\nu_0(a) = n_0 + n_1 age + n_2 age^2$$

Assumptions (2)

- Utility cost of health: Power function

$$\phi(h) \quad = \quad \phi_0 + \phi_1 h + \phi_2 h^2$$

Assumptions (3)

- Proportional mortality across health states over age:

$$\lambda(h,a) = \begin{cases} \lambda(h,6)/F_{25-35} \text{ if age } \in \{25-35\} \\ \lambda(h,6)/F_{35-45} \text{ if age } \in \{35-45\} \\ \lambda(h,6)/F_{45-55} \text{ if age } \in \{45-55\} \\ \lambda(h,6)/F_{55-65} \text{ if age } \in \{55-65\} \\ \lambda(h,6)/F_{65-75} \text{ if age } \in \{65-75\} \end{cases} \quad (1)$$

Back

Estimation

Set Outside of the Model

Table: Set Outside of the Model

Parameter	Meaning	Value
ρ	Discount rate	0.06
r	Interest Rate	0.05
γ	Risk Aversion	1.5
T	Exit Age	85
s	Initial Age	25

Back

Estimated Outside of the Model

Table: Estimated Outside of the Model

Meaning	Parameter	Value
Mortality Poisson, Age 75-85, h = 1	$\lambda(1,6)$	0.116
Mortality Poisson, Age 75-85, h = 2	$\lambda(2,6)$	0.024
Mortality Poisson, Age 75-85, h = 3	$\lambda(3,6)$	0.0127
Mortality Poisson, Age 75-85, h = 4	$\lambda(4,6)$	0.0057
Mortality Poisson, Age 75-85, h = 5	$\lambda(5,6)$	0.00325
Survival Factor, Age 65-75	F_{65-75}	1.56
Survival Factor, Age 55-65	F_{55-65}	4.16
Survival Factor, Age 45-55	F_{45-55}	20.6
Survival Factor, Age 35-45	F_{35-45}	22.6
Survival Factor, Age 25-35	F_{25-35}	22.6
Productivity by Health	$\theta(h)$	(1, 1.03, 1.03, 1.04, 1.04)
Income by Education and Age ($10,000)	$y(a)$	(taken from data)
Insurance Premium	p	0.4
OOP Fraction	$q(I_0)$	0.3
Aging Poisson, all ages	η	$\frac{1}{10}$
Joint distribution health and wealth, age 25	$f(h_0, a_5)$	(taken from data)

Back

Estimated Outside of the Model

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Meaning	Parameter	Value
Mortality Poisson, Age 75-85, h = 1	$\lambda(1, 6)$	0.116
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Survival Factor, Age 25-35	F_{25-35}	22.6
Productivity by Health	$\theta(h)$	(1, 1.03, 1.03, 1.04, 1.04)
Income by Education and Age ($10,000)	[illegible]	(taken from data)
Insurance Premium	[illegible]	[illegible]
DOP Fraction	[illegible]	[illegible]
Aging Poisson, all ages	[illegible]	[illegible]
Joint distribution health and wealth, age 25	[illegible]	(taken from data)

Back

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Back

Targeted Moments

Moment	Data	Model
Fraction Visit, Poor Health Age 55-75	0.97	0.80
Fraction Visit, Average Health Age 55-75	0.92	0.80
Fraction Visit, Excellent Health Age 55-75	0.89	0.43
Fraction Visit, Poor Health Age 25-45	0.92	0.87
Fraction Visit, Average Health Age 25-45	0.77	0.96
Fraction Visit, Excellent Health Age 25-45	0.69	0.70
Improvement Poor Health, Age 55-75	0.79	0.68
Improvement Average Health, Age 55-75	0.70	0.50
Improvement Poor Health, Age 25-45	0.86	0.64
Improvement Average Health, Age 25-45	0.75	0.41
Change in Health, Poor Health, Age 25-45	1.07	1.16
Change in Health, Average Health, Age 25-45	0.39	0.39
Change in Health, Excellent Health, Age 25-45	-0.65	-0.72
Change in Health, Poor Health, Age 45-65	0.80	1.09
Change in Health, Average Health, Age 45-65	0.20	0.23
Change in Health, Excellent Health, Age 45-65	-0.72	-0.80
Change in Health, Poor Health, Age 65-85	0.72	0.94
Change in Health, Average Health, Age 65-85	0.10	0.05
Change in Health, Excellent Health, Age 65-85	-0.80	-0.90
Average investment, Age 25-35	0.28	0.20
Average investment, Age 45-55	0.44	0.40
Average investment, Age 65-75	0.71	0.53
Average Health, Age 45-55	3.68	3.64
Average Health Age 25-35/Average Health, Age 45-55	1.08	1.09
Average Health Age 65-75/Average Health, Age 45-55	0.95	0.88
Fraction Visit, Age 25-35	0.79	0.60
Fraction Visit, Age 45-55	0.88	0.80
Fraction Visit, Age 65-75	0.96	0.84

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Back

HJBVI

$$\min\Big\{\rho V(w,h,\nu,a) - \max_{c}\{u(c,h) - V_w[\theta(h)y(a) + rw - c - p]\} -$$
$$\eta[V(w,h,\nu,a+1) - V(w,h,\nu,a)] - \nu[V(w,h+1,\nu_0,a) - V(w,h,\nu,a)] -$$
$$d(h,a)[V(w,h-1,\nu_0,a) - V(w,h,\nu,a)] - \lambda^T(h,a)[V^T - V(w,h,\nu,a)],$$
$$V(w,h,\nu,a) - V^*(w',h,\nu',a)\Big\} = 0$$

Back

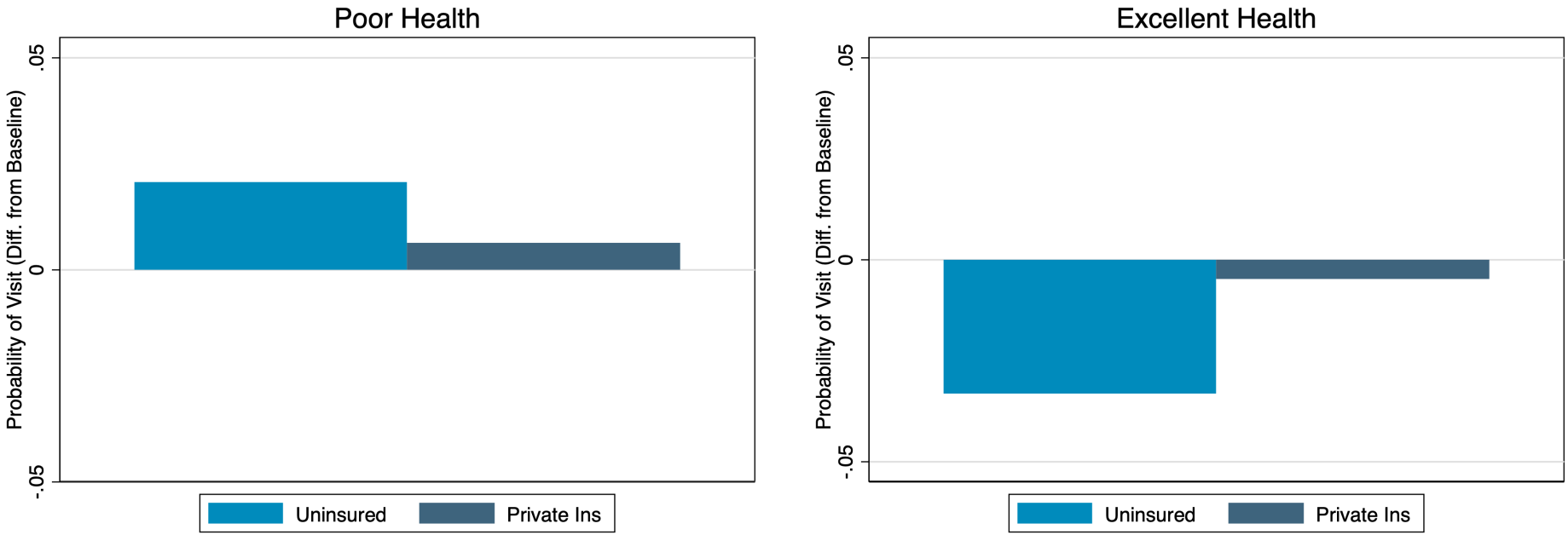
Gains in Life-expectancy: 1980s to 2000s

	Q1 (Poor)	Q2	Q3	Q4 (Rich)
Life-expectancy 1983	70.7	74.2	77.4	79.2
Total Change (1983 - 2003)	2.4	2.7	3.1	4.7
By cause of death:				
Accident	0.1	0.1	0.2	0.2
Other	-1.1	-0.6	-0.6	-0.2
Malignant neoplasms	0.3	0.3	0.7	1.2
Cerebrovascular	0.4	0.2	0.2	0.4
Diabetes	-0.2	-0.1	-0.0	-0.1
Heart	2.8	2.6	2.8	2.9
Respiratory	-0.0	0.1	-0.1	0.2
Unknown	-0.0	-0.0	-0.0	0.0
By age group:				
20-50	-0.1	0.3	0.0	0.5
50-80	2.2	1.7	2.4	3.3
80+	0.2	0.7	0.7	0.9

Note: Life-expectancy conditional on surviving until age 20. Family income group.

Back

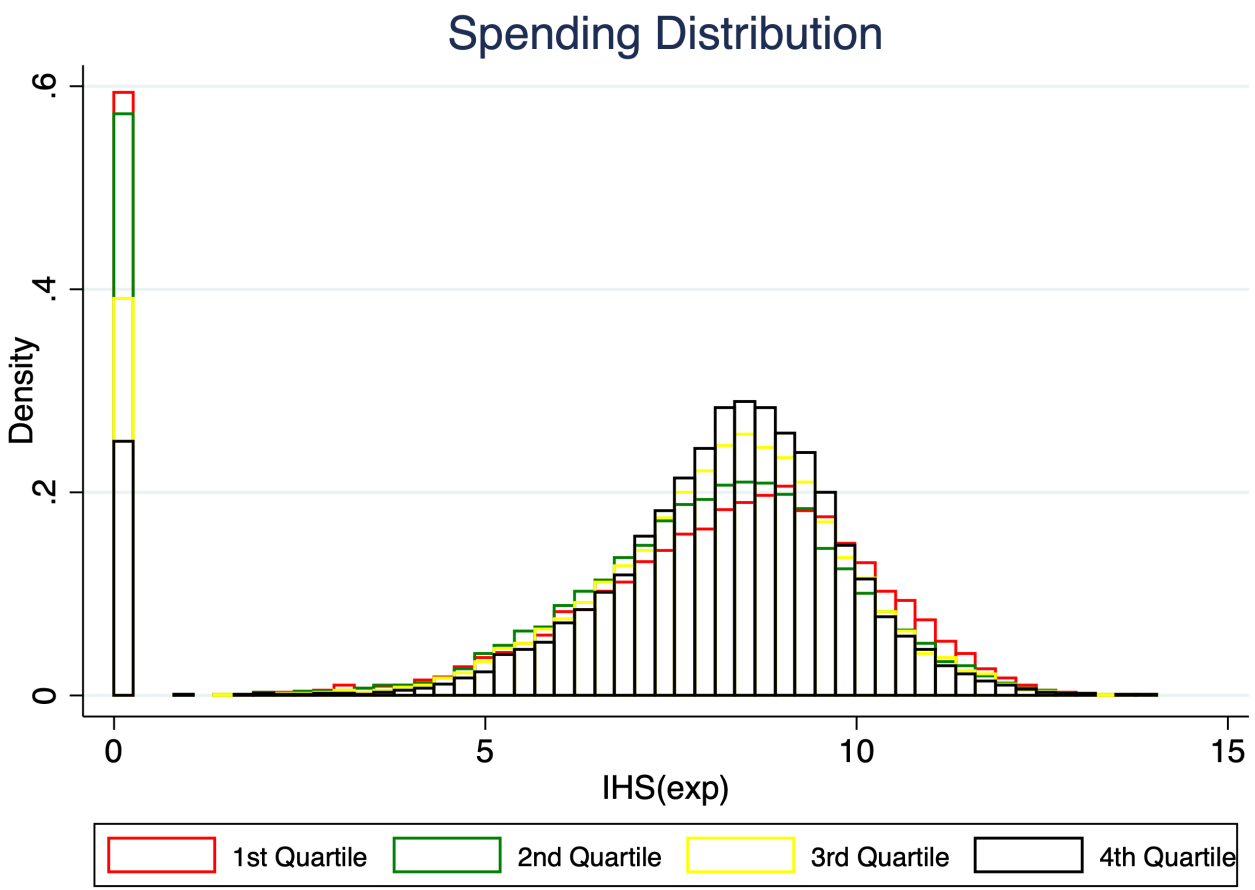
Timing of Visit by Insurance



Notes: Includes individual fixed effect; base set to average health in each income group regression

Back Other Age Groups

Medical Investment Distribution, Age 45-55



Notes: Inverse Hyperbolic Sine (IHS) Transformation

Back Other Age Groups

Estimates: Identification

Table: Estimates: Identification

Moment	Meaning	Parameter	Value	Std. Errors^{+}
Change in health, average health 25-35	TFP	A	2.34	(0.007)
investment by bad health, age 55-65	Elasticity w.r.to. m	α_m	0.10	(0.002)
Fraction Visit Average Health 45-55	Fixed Cost	k	0.0213	(0.000012)
Change in health 35-45	Depreciation Poisson	d_0	0.86	(0.0007)
Change in health 45-55	Depreciation Poisson Age	d_1	0.23	(0.0004)
Change in health 55-65	Depreciation Poisson Age^2	d_2	-0.026	(0.0007)
Improvement bad health 25-35	Natural Improvement	n_0	0.48	(0.001)
Improvement bad health 45-55	Natural Improvement-2	n_1	-0.022	(0.0004)
Improvement bad health 55-65	Natural Improvement-3	n_2	-0.028	(0.0009)
Investment age 35-45	Utility parameter-1	ϕ_0	1.26	(0.0019)
Investment by bad health, age 45-55	Utility parameter-2	ϕ_1	1.016	(0.00029)
Investment by average health, age 45-55	Utility parameter-3	ϕ_2	0.036	(0.0054)

Back

Individual's Problem.

- Long-term Disability: Poisson parameter $\eta(h)$, absorbing state value V^D; Medicare pays $\bar{m}$ continually

$$\eta(h) = \begin{cases} \eta_L \text{ if } h \geq h^D_{high} \\ \eta_H \text{ if } h_{exit} < h < h^D_{high} \\ \eta_{exit} \text{ if } h = h_{exit} \end{cases} \tag{2}$$

$$\eta_L < \eta_H < \eta_{exit}$$

Disability Stage

For without exit and utility from health

$$\rho V^D(w) = \max_c \{u(c) + V_w^D[y^D + rw - c]\} \tag{3}$$

Standard Guess and Verify argument gives,

$$V^D(w) = \frac{(y^D + rw)^{1-\gamma}}{r(1-\gamma)} \left(\frac{\rho - r(1-\gamma)}{r\gamma} \right)^{-\gamma} \tag{4}$$

Disability Stage.

For the version with exit and utility from health,

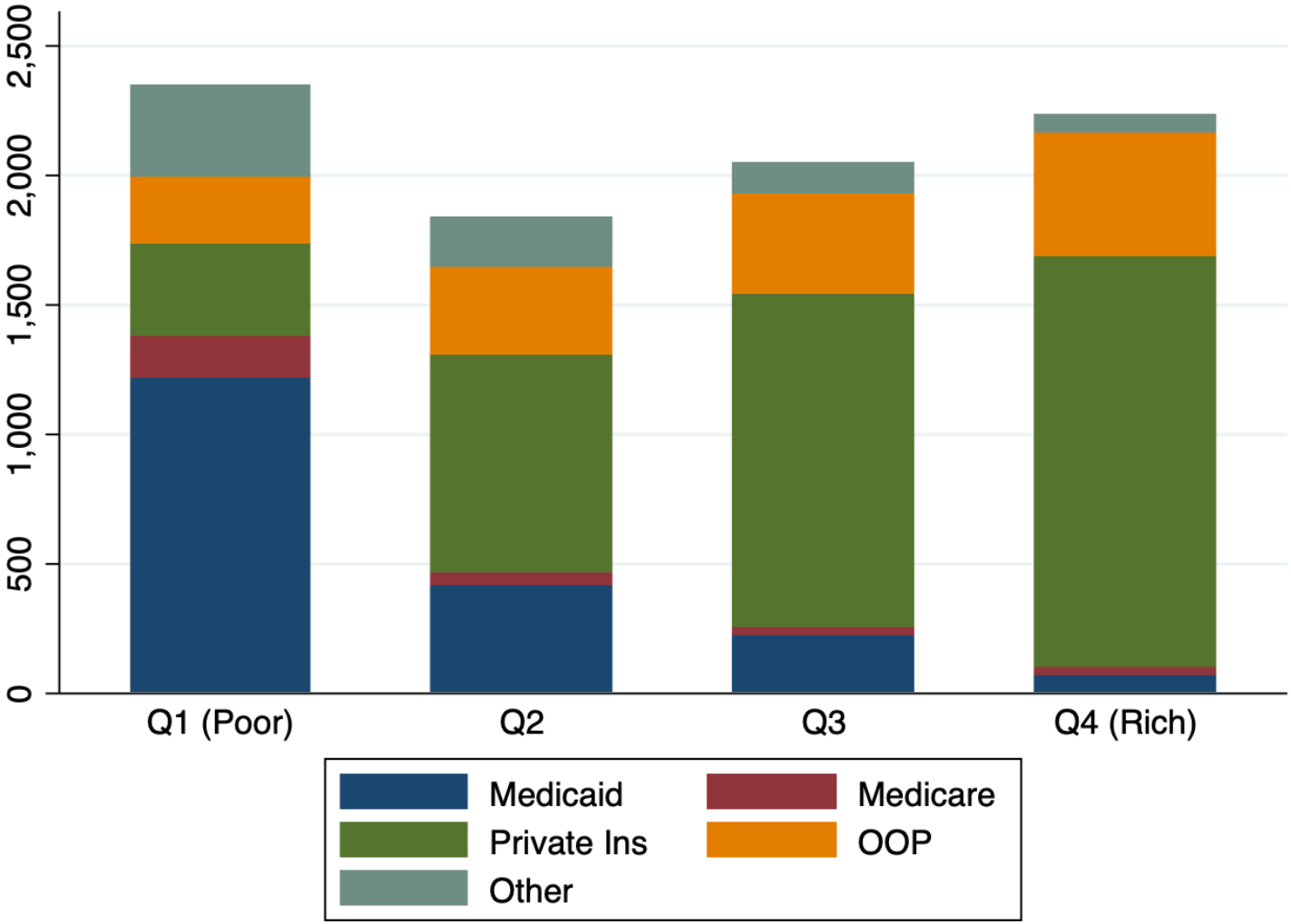
$$\rho V^D(w, h^D) = \max_c \{u(c, h^D) + V_w^D[y^D + rw - c]\} + \lambda^D(V^T - V^D) \quad (5)$$

$$V^D(w, h^D) = \frac{(y^D + rw)^{1-\gamma}}{r(1-\gamma)} \left(\frac{(\rho + \lambda^D) - r(1-\gamma)}{r\gamma} \right)^{-\gamma} + \left(\frac{1}{\rho + \lambda^D} \right) \left(\omega \frac{h^{D\,1-\sigma}}{1-\sigma} + \lambda^D V^T \right) \quad (6)$$

Back

Mean Medical Investment: Age 25-35

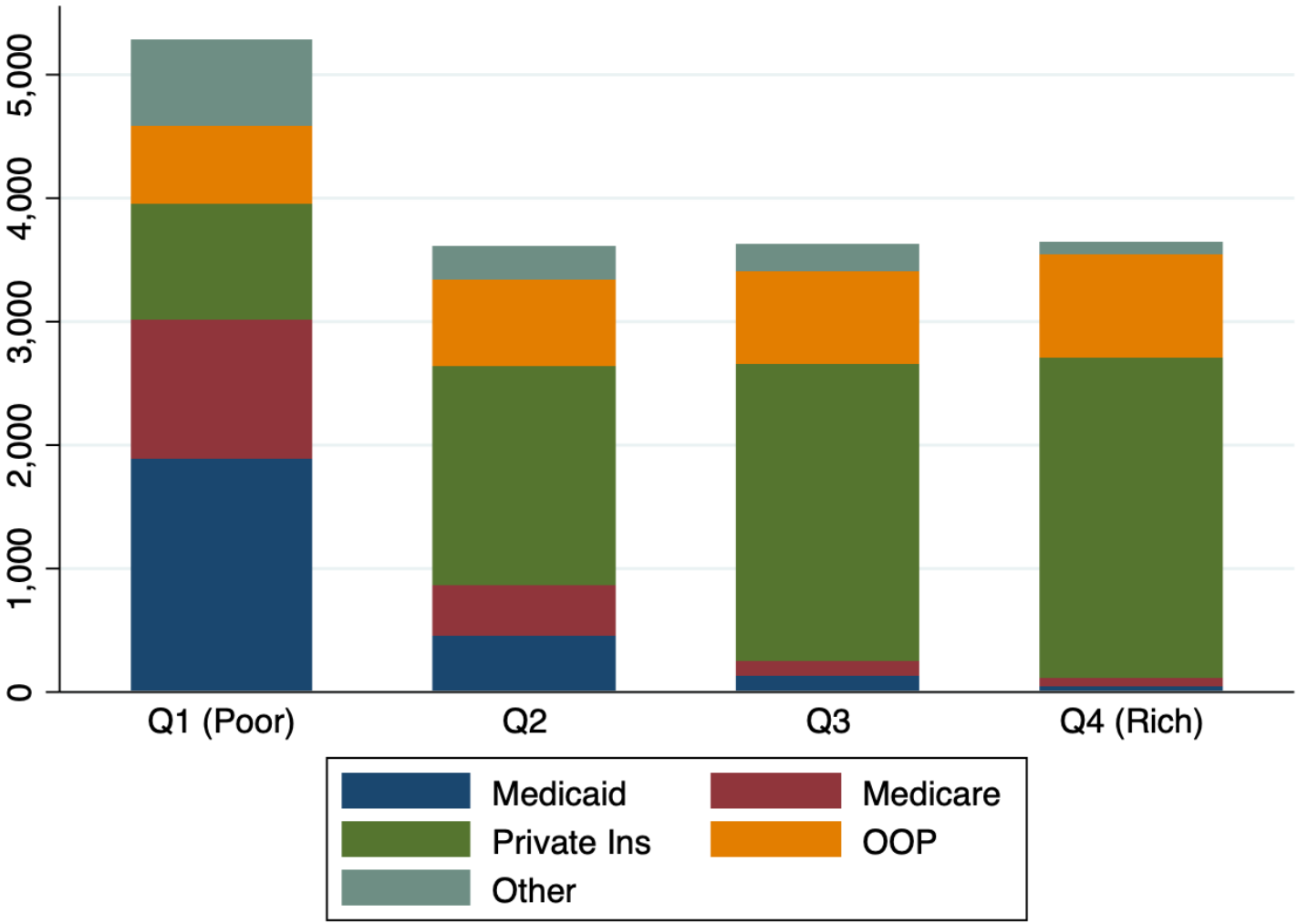
Back



Source: NHIS-MEPS

Mean Medical Investment: Age 45-55

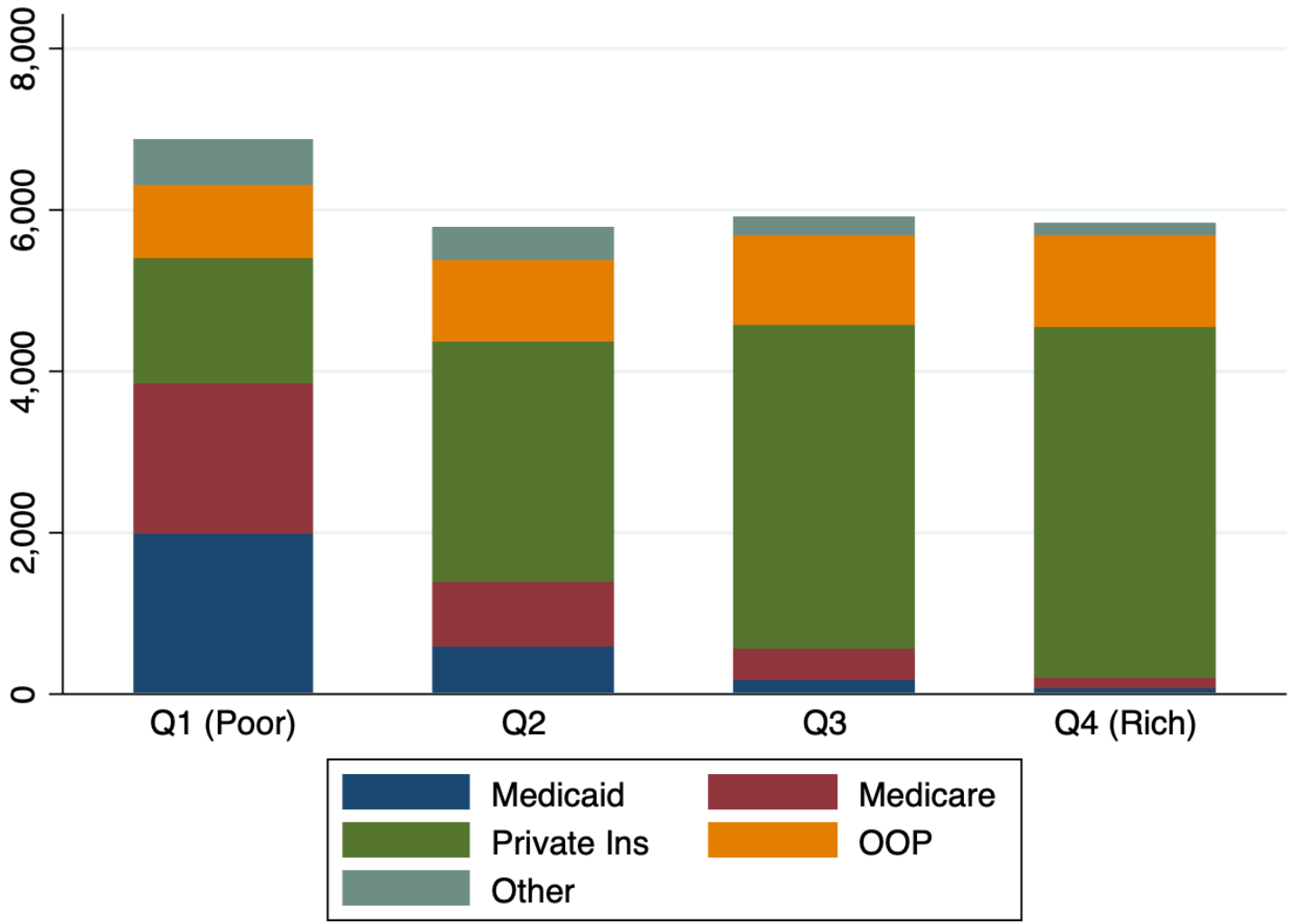
Back



Source: NHIS-MEPS

Mean Medical Investment: Age 55-65

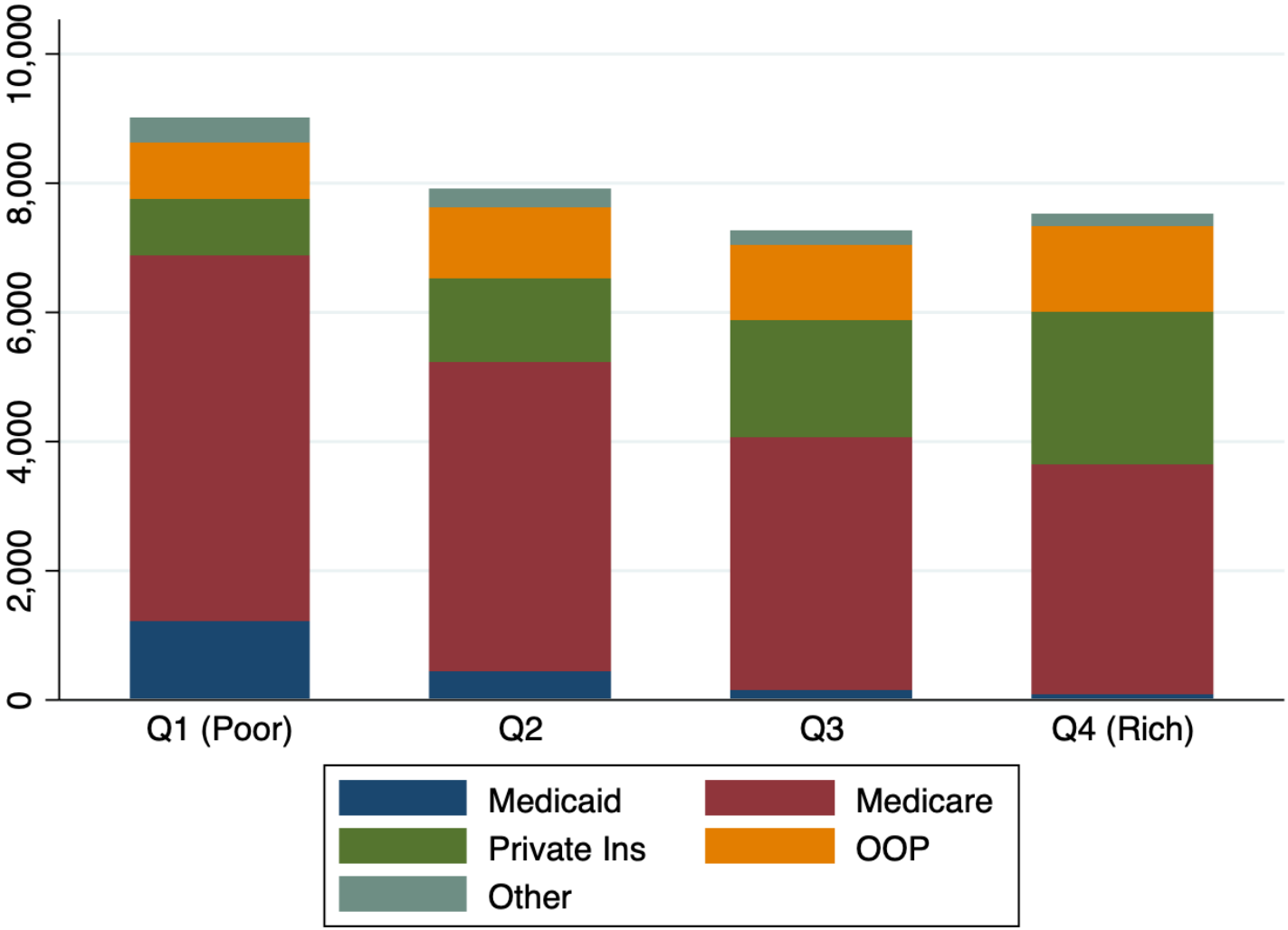
Back



Source: NHIS-MEPS

Mean Medical Investment: Age 65-75

Back



Source: NHIS-MEPS

Individual's Problem

Health can take 5 states: 1,2,3,4,5
How healthy you are affects:

- Flow utility from consumption
- Probability of dying
- Income
- Utility Function

$$u(c,h) = (1+\phi(h))\frac{c^{1-\gamma}-1}{1-\gamma}$$

- Mortality: Poisson intensity $\lambda^T(h)$, terminal value V^T

Back to Model Summary

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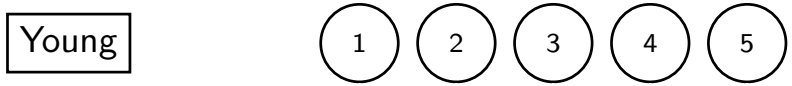
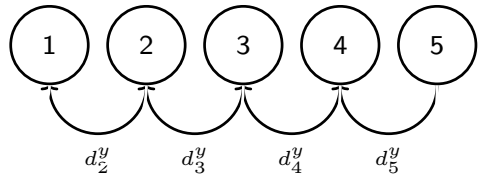
Back to Model Summary ◁

Health Evolution



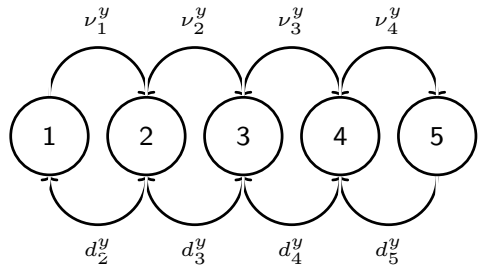
Health Evolution

Young



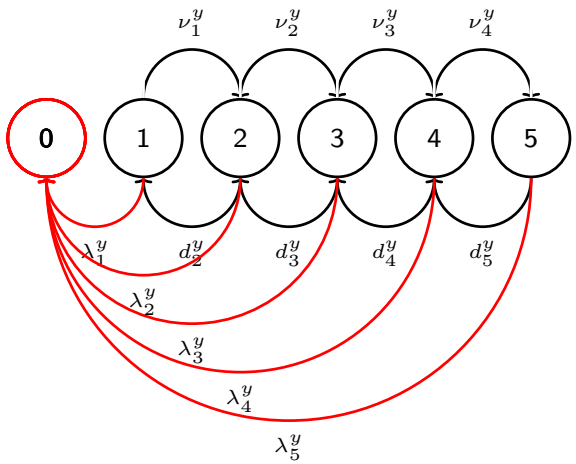
Health Evolution

Young



Health Evolution

Young



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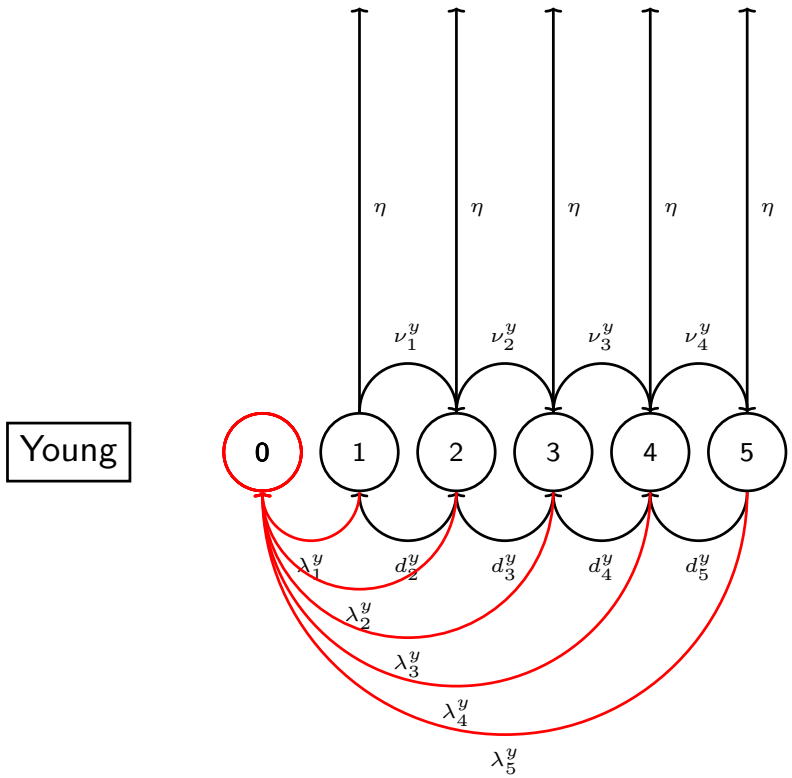

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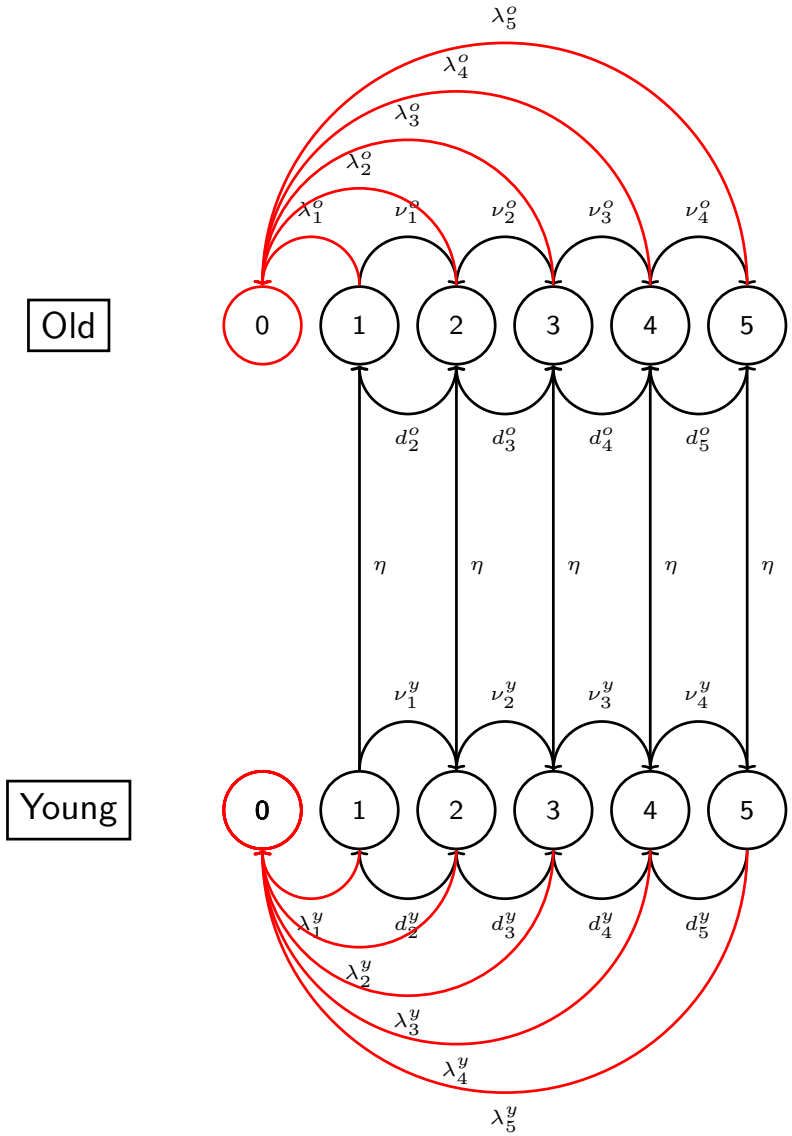
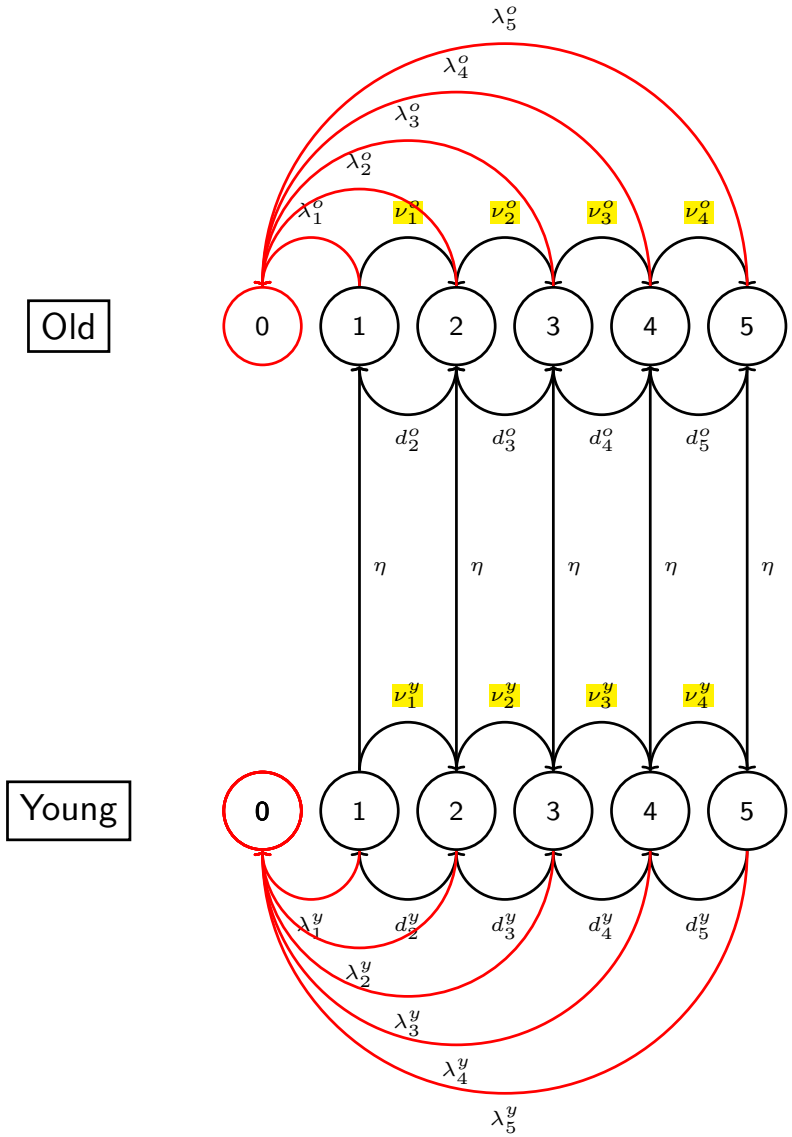


Health Evolution



Back to Model Summary ◁

Individual's Problem

$$\begin{aligned} dw_t &= (rw_t + \theta(h)y(a,e) - c_t - p)\,dt \\ h_t &= \text{Poisson process with intensities } d(h,a), \nu \end{aligned}$$

w: Wealth
$\theta(h)$: Productivity
$y(a,e)$: Income
r: Risk free rate
p: Insurance premium
a: Age
e: Education
$d(h,a)$: Health depreciation intensity
ν: Health improvement intensity

Back to Model Summary ◁

Insurance Take-up Problem

- Individuals can decide on insurance take-up problem at random intervals (Poisson process)
- Offered a price of the premium based on their health and age
- The premium stays the same until another (random) realization of the Poisson

Back to Model Summary ◁

Value Function ▷

Insurance Take-up

Without Medical Investments

$$\rho V(w,h,\nu,a,I,p) = \max_c \{u(c,h) + V_w[\theta(h)y(a) + rw - c - p]\}$$

$$\underbrace{\eta[V(w,h,\nu,a+1,I,p) - V(.)]}_{\text{aging to } a+1} + \underbrace{\nu[V(w,h+1,\nu_0,a,I,p) - V(.)]}_{\text{transition to } h+1} +$$

$$\underbrace{d(h,a)[V(w,h-1,\nu_0,a,I,p) - V(.)]}_{\text{transition to } h-1} + \underbrace{\lambda^T(h,a)[V^T - V(.)]}_{\text{death}} +$$

$$\underbrace{\phi[\bar{V}(w,h,\nu,a,I',p') - V(.)]}_{\text{insurance choice}}$$

$$\bar{V}(w,h,\nu,a,I',p') = max\left\{ \overbrace{V(w,h,\nu,a,1,p(h,a))}^{\text{insurance}}, \overbrace{V(w,h,\nu,a,0,0)}^{\text{no insurance}} \right\}$$

Back to Model Summary ◁

Insurance Take-up

Without Medical Investments

$$\rho V(w,h,\nu,a,I,p) = \max_{c}\{u(c,h) + V_w[\theta(h)y(a) + rw - c - p]\}$$

$$\underbrace{\eta[V(w,h,\nu,a+1,I,p) - V(.)]}_{\text{aging to } a+1} + \underbrace{\nu[V(w,h+1,\nu_0,a,I,p) - V(.)]}_{\text{transition to } h+1} +$$

$$\underbrace{d(h,a)[V(w,h-1,\nu_0,a,I,p) - V(.)]}_{\text{transition to } h-1} + \underbrace{\lambda^T(h,a)[V^T - V(.)]}_{\text{death}} +$$

$$\underbrace{\phi[\bar{V}(w,h,\nu,a,I',p') - V(.)]}_{\text{insurance choice}}$$

$$\bar{V}(w,h,\nu,a,I',p') = max\left\{ \overbrace{V(w,h,\nu,a,1,p(h,a))}^{\text{insurance}}, \overbrace{V(w,h,\nu,a,0,0)}^{\text{no insurance}} \right\}$$

Back to Model Summary ◁

Health Capital Investment

- Individuals can invest in the likelihood of transitioning to a better health
- Face a fixed cost of going to the doctor and a proportional out-of-pocket cost
- Optimally choose when to visit the doctor and how much to spend on medical care

Details ▷

Health Capital Investment

Wealth evolution on Visit

$$\overbrace{w'}^{\text{Wealth after visit}} = \overbrace{w}^{\text{Wealth before visit}} - \overbrace{k(I_0)}^{\text{Fixed Cost}} - \overbrace{m(1-q(I_0))}^{\text{Out-of-pocket Cost}}$$

Health evolution on Visit

$$\nu' = \nu_0(a) + Am^{\alpha_m}$$

HJB Variational Inequality

Health Capital Investment

Wealth evolution on Visit

$$\overbrace{w'}^{\text{Wealth after visit}} = \overbrace{w}^{\text{Wealth before visit}} - \overbrace{k(I_0)}^{\text{Fixed Cost}} - \overbrace{m(1-q(I_0))}^{\text{Out-of-pocket Cost}}$$

Health evolution on Visit

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HJB Variational Inequality

Health Capital Investment

Wealth evolution on Visit

$$\overbrace{w'}^{\text{Wealth after visit}} = \overbrace{w}^{\text{Wealth before visit}} - \overbrace{k(I_0)}^{\text{Fixed Cost}} - \overbrace{m(1-q(I_0))}^{\text{Out-of-pocket Cost}}$$

Health evolution on Visit

$$\nu' = \nu_0(a) + Am^{\alpha_m}$$

m: Medical investment

Health Capital Investment

Wealth evolution on Visit

$$\overbrace{w'}^{\text{Wealth after visit}} = \overbrace{w}^{\text{Wealth before visit}} - \overbrace{k(I_0)}^{\text{Fixed Cost}} - \overbrace{m(1-q(I_0))}^{\text{Out-of-pocket Cost}}$$

Health evolution on Visit

$$\nu' = \nu_0(a) + Am^{\alpha_m}$$

A: TFP

Back to Model Summary ◁

Back to Technological Progress ◁

Insurance Take-up

Without Medical Investments

$$\rho V(w,h,\nu,a,I,p) = \max_{c}\{u(c,h) + V_w[\theta(h)y(a) + rw - c - p]\}$$

$$\underbrace{\eta[V(w,h,\nu,a+1,I,p) - V(.)]}_{\text{aging to } a+1} + \underbrace{\nu[V(w,h+1,\nu_0,a,I,p) - V(.)]}_{\text{transition to } h+1} +$$

$$\underbrace{d(h,a)[V(w,h-1,\nu_0,a,I,p) - V(.)]}_{\text{transition to } h-1} + \underbrace{\lambda^T(h,a)[V^T - V(.)]}_{\text{death}} +$$

$$\underbrace{\phi[\bar{V}(w,h,\nu,a,I',p') - V(.)]}_{\text{insurance choice}}$$

$$\bar{V}(w,h,\nu,a,I',p') = max\left\{ \overbrace{V(w,h,\nu,a,1,p(h,a))}^{\text{insurance}}, \overbrace{V(w,h,\nu,a,0,0)}^{\text{no insurance}} \right\}$$

ν: Transition intensity to a better health

Back to Model Summary ◁

Estimates

Table: Parameter Estimates

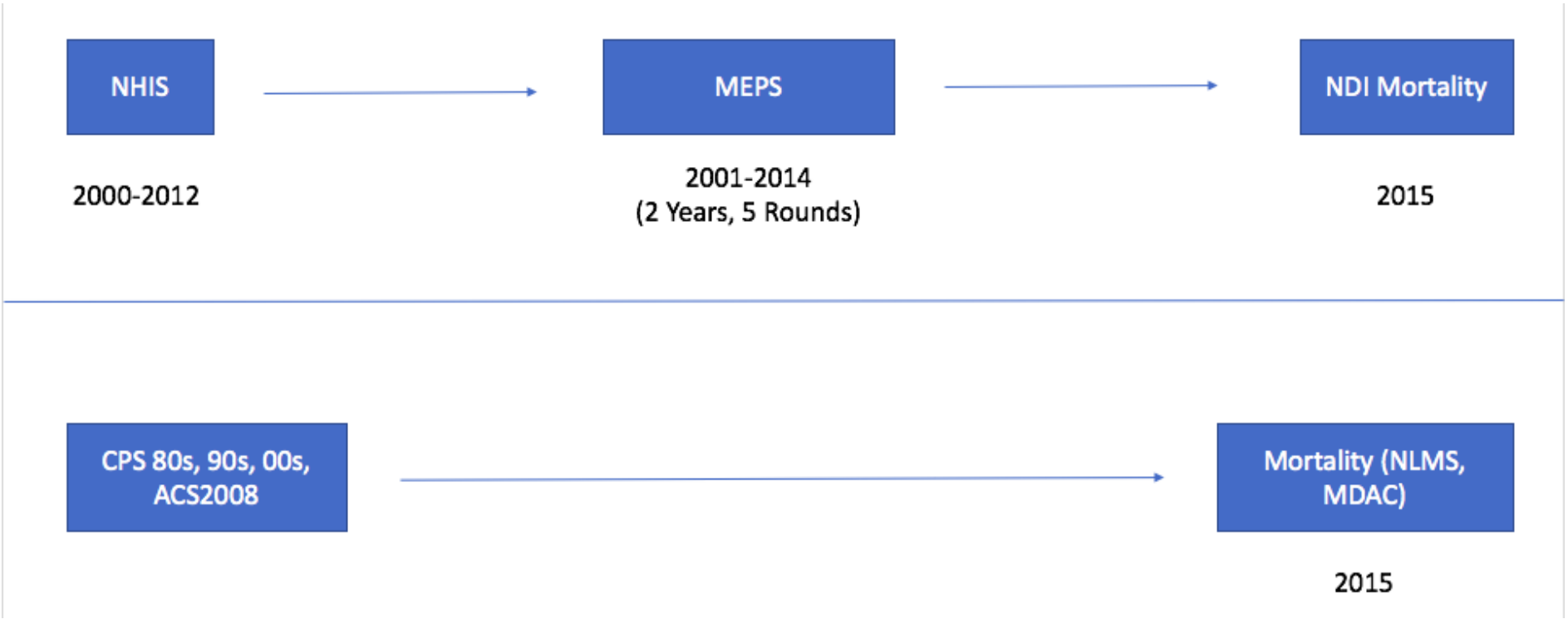
Meaning	Parameter	Value	Std. Errors*
TFP	A	2.34	(0.007)
Elasticity w.r.to. m	α_m	0.10	(0.002)
Fixed Cost	k	0.0213	(0.00011)
Depreciation Poisson-1	d_0	0.86	(0.0007)
Depreciation Poisson-2	d_1	0.23	(0.0005)
Depreciation Poisson-2	d_2	-0.026	(0.0007)
Natural Improvement-1	n_0	0.48	(0.005)
Natural Improvement-2	n_1	-0.022	(0.0004)
Natural Improvement-3	n_2	-0.028	(0.0009)
Utility parameter-1	ϕ_0	1.26	(0.0019)
Utility parameter-2	ϕ_1	1.016	(0.00029)
Utility parameter-3	ϕ_2	0.036	(0.0054)

Back to Estimates Summary ◁

Data Sources

Data Sources

Data Sources



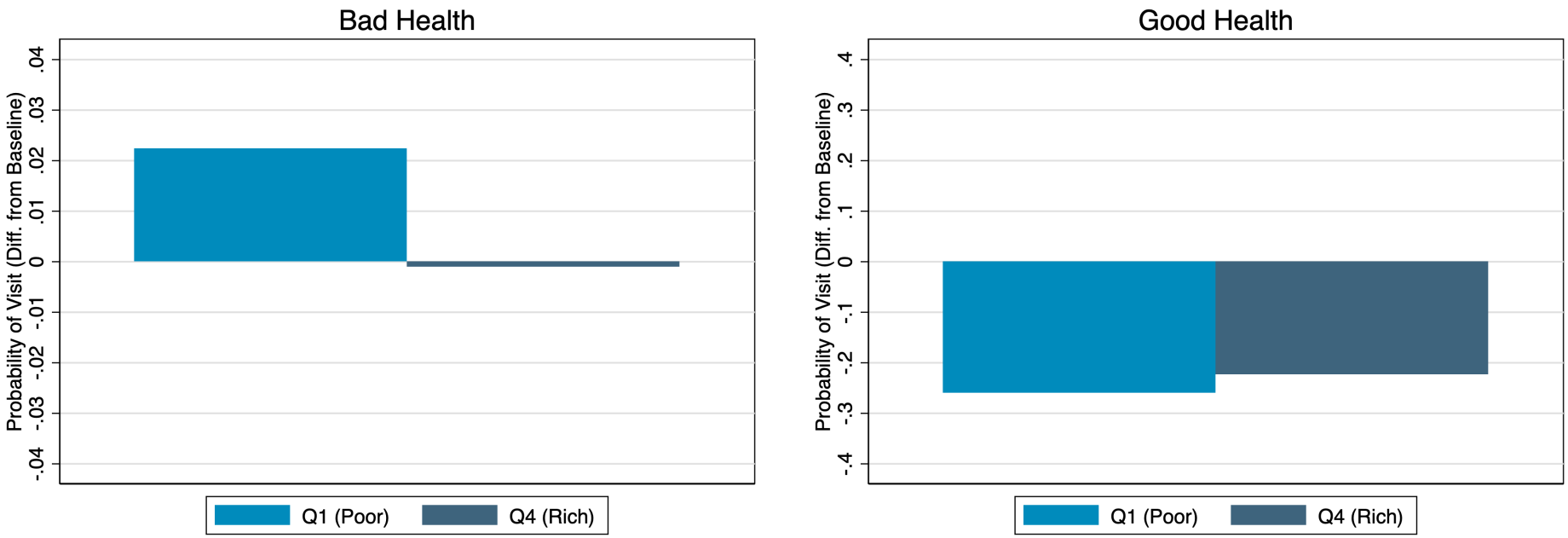
Back

Research Questions

- What explains the increasing health inequality across income groups in the US?
- How does health insurance and medical technology affect individual's decisions on health capital investments, and outcomes such as mortality?
- What is the potential impact of policies on economic output and welfare?

Back

Untargeted: Timing of Visit by Wealth



Lower wealth individuals have a highly elastic visit decision

◁

Untargeted: Health-care Investment by Health and Wealth

Table: Model: Age 35-45

	Health				
	1	2	3	4	5
Q1 (Poor)	0.58	0.62	0.56	0.41	0.19
Q2	0.80	0.79	0.78	0.72	0.37
Q3	0.55	0.59	0.57	0.45	0.27
Q4 (Rich)	0.76	0.78	0.57	0.31	0.21

Table: Data: Age 35-45

	Health				
	1	2	3	4	5
Q1 (Poor)	0.60	0.33	0.21	0.17	0.12
Q2	0.73	0.41	0.25	0.18	0.13
Q3	0.77	0.47	0.29	0.21	0.15
Q4 (Rich)	0.74	0.46	0.32	0.24	0.18

Fixing health, wealthy spend more on their health over the next year thus transitioning to a better health with a higher probability

Untargeted: Exit by Health and Wealth

Table: Model: Age 35-45

	Health				
	1	2	3	4	5
Q1 (Poor)	3.1	1.6	0.8	0.4	0.2
Q2	3.2	1.8	0.7	0.4	0.2
Q3	3.1	1.1	0.7	0.2	0.2
Q4 (Rich)	2.7	1.5	0.7	0.3	0.2

Table: Data: Age 35-45

	Health				
	1	2	3	4	5
Q1 (Poor)	4.8	1.5	0.7	0.3	0.2
Q2	5.4	1.3	0.5	0.2	0.1
Q3	4.0	1.0	0.5	0.4	0.3
Q4 (Rich)	3.1	1.4	0.3	0.3	0.2

Untargeted: $\text{Health}_{t+1}|$ Visit

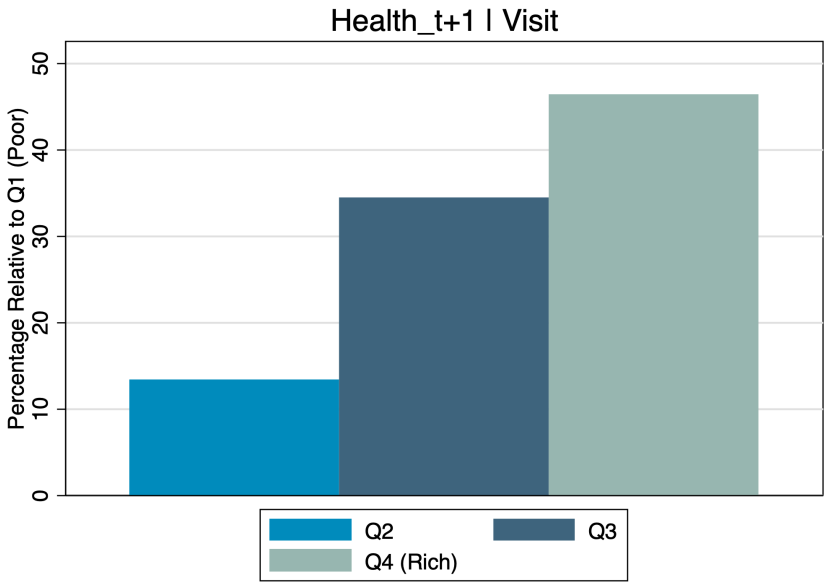


Figure: Model (by Wealth)

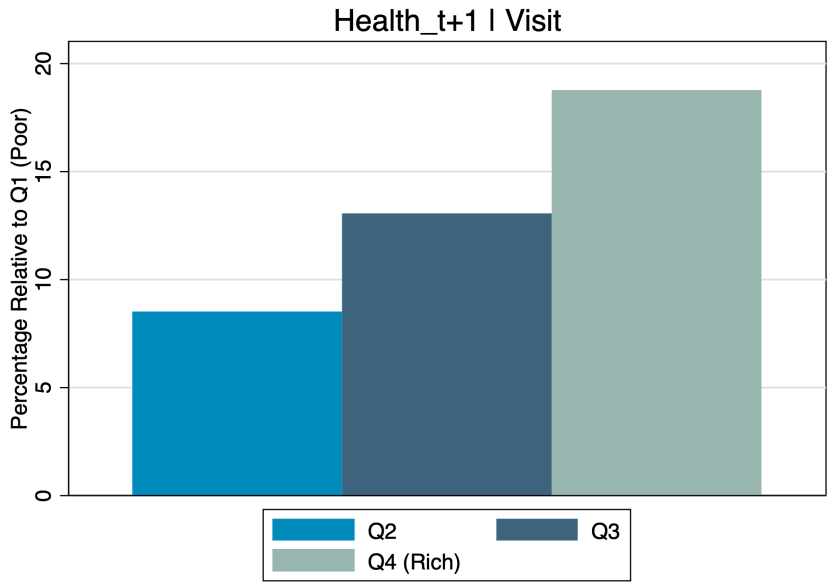


Figure: Data (by Family Income)

Source: NHIS-MEPS
Notes: Regress: Health_{t+1} on Health_t, Age, Age^2; base set to family income (Data) or wealth (Model) poor

Untargeted: Health over the Life-Cycle

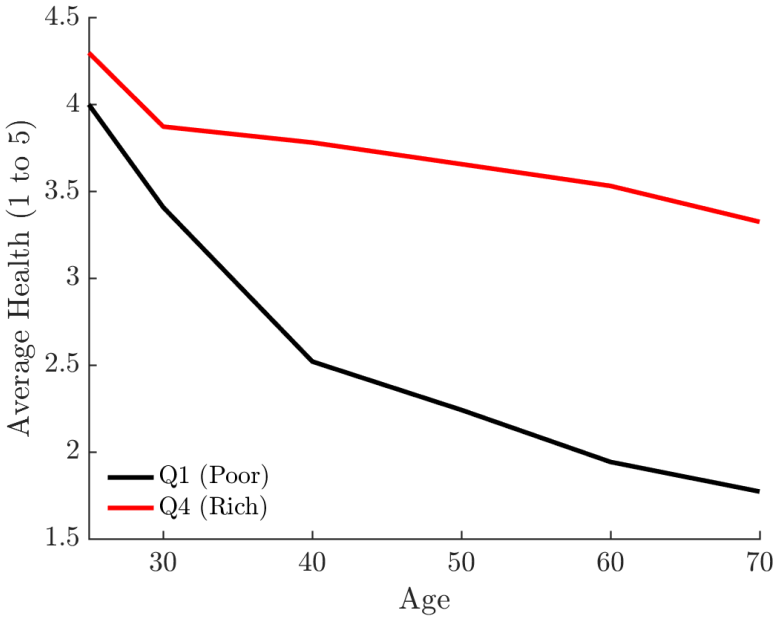


Figure: Model

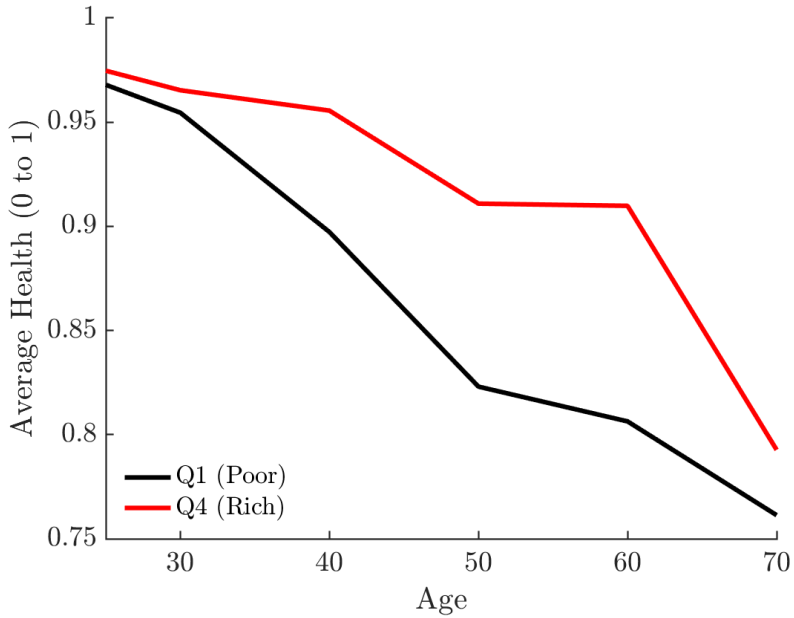


Figure: Data Analogue in PSID

Private Insurance Take-up Decision, Age 25-35

Figure: Good Health

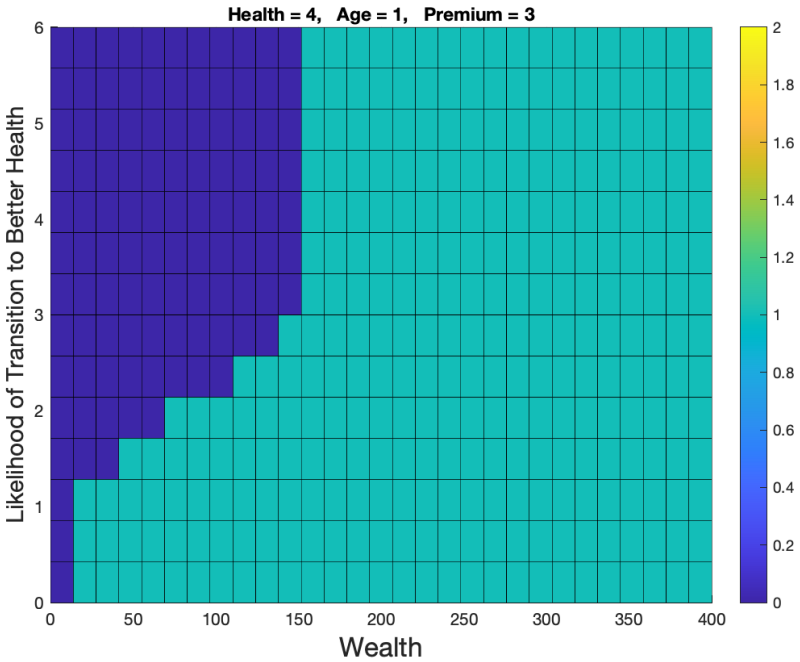
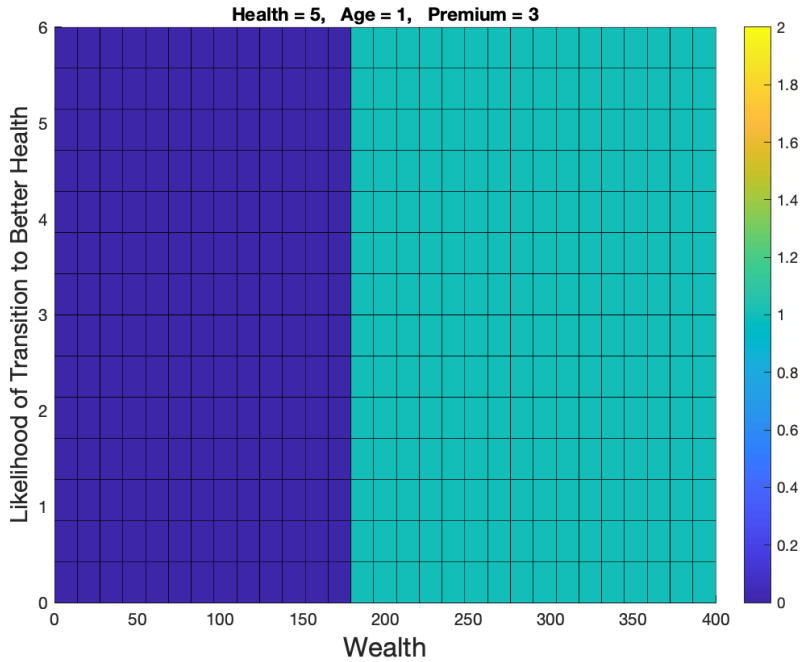


Figure: Excellent Health



Medicaid Back to Policy