Preventive vs. Curative Medicine

A Macroeconomic Analysis of Health Care over the Life Cycle

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Heterogenous Agent Models
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Introduction

Motivation

- Low- and high-income households differ greatly in their health outcomes over the life cycle?

Motivation

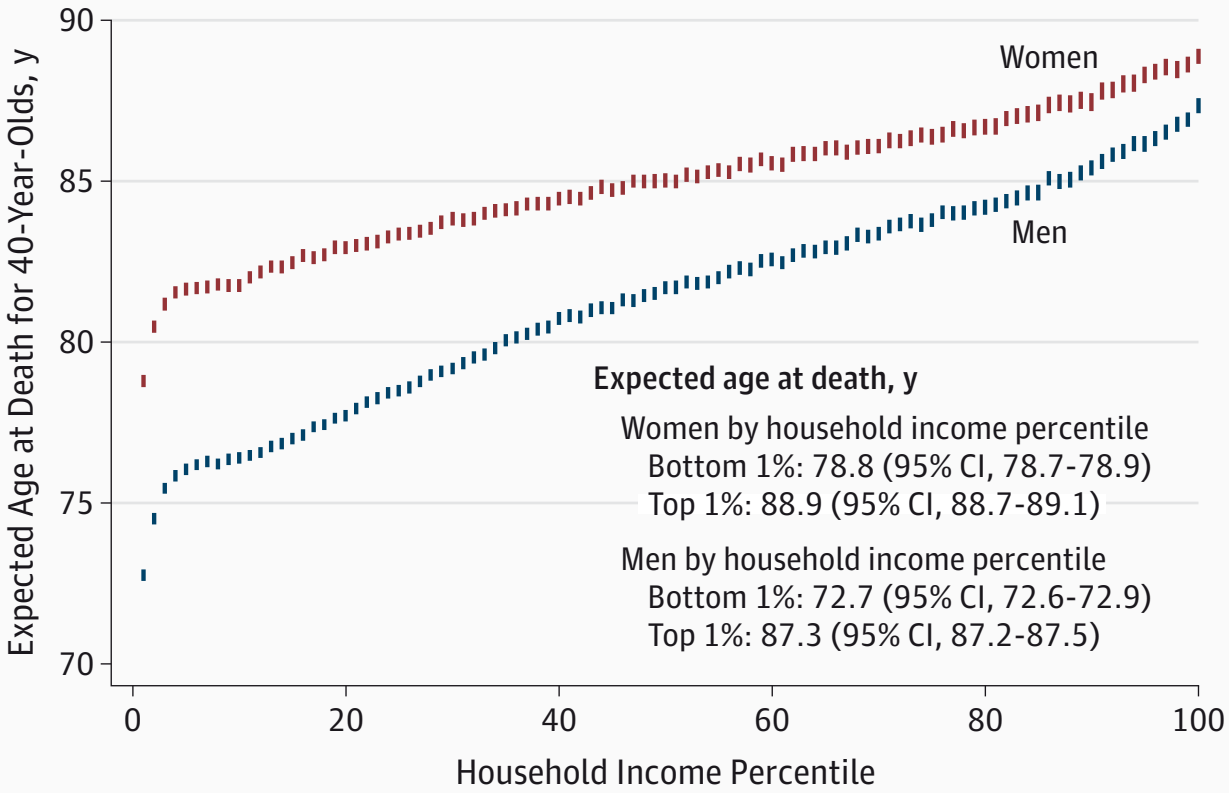

Figure 1: Race- and Ethnicity-Adjusted Life Expectancy for 40-Year-Olds by Household Income Percentile, 2001-2014, Source: Chetty et al 2016 JAMA

Motivation

- Low- and high-income households differ greatly in their health outcomes over the life cycle?
- Why do they differ?

Motivation

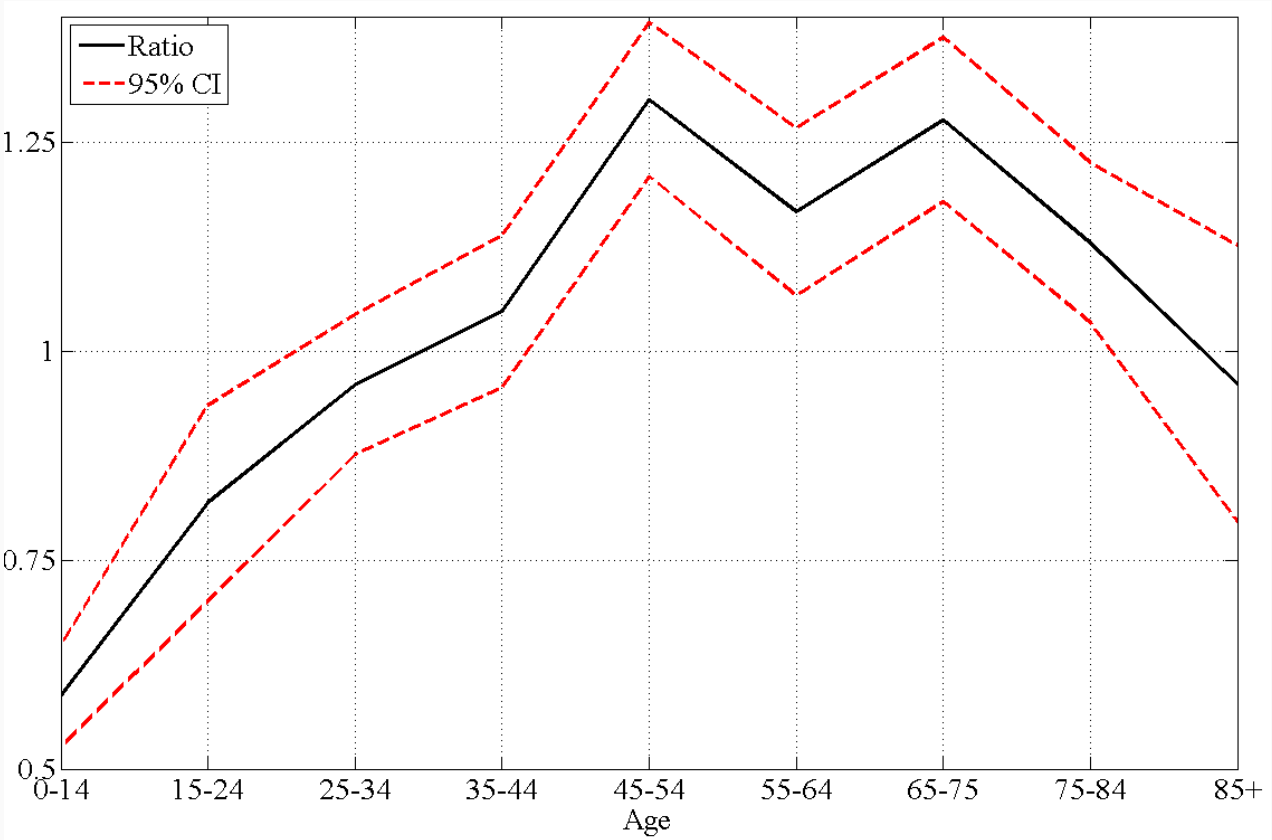

Figure 2: Average Medical Spending of Bottom Income Quntile Relative to Top Income Quintile

Motivation

- Low- and high-income households differ greatly in their health outcomes over the life cycle?
- Why do they differ?
- Why is it important?
  - Reducing disparities in health outcomes is at the center of health care policy design (e.g., ObamaCare).
  - DeNardi, Pashchenko, and Porapakkarm (2018) and Hosseini, Kopecky, and Zhao (2020) find very large welfare costs of bad health.

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- Why is it important?
  - Reducing disparities in health outcomes is at the center of health care policy design (e.g., ObamaCare).
  - DeNardi, Pashchenko, and Porapakkarm (2018) and Hosseini, Kopecky, and Zhao (2020) find very large welfare costs of bad health.
- Goal of this paper: To develop and estimate a model of endogenous health shocks/outcomes.

What do I do?
I. Empirical Facts on Differences in Health Care Usage

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  - The poor less likely to incur any medical expenditures in a year (24% vs 10%).
  - Their health spending is more extreme.

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3. The poor use less preventive care.

What do I do?
II. A Life-Cycle Model of Health Capital

1. **Two distinct types of health capital**

- Physical health capital determines the survival probability
- Preventive health capital governs the distribution of health shocks
- Endogenous distribution of health shocks, thereby endogenous life expectancy.

What do I do?
II. A Life-Cycle Model of Health Capital

1. **Two distinct types of health capital**

2. **Important features of the US health care system**

- Non-elderly are offered private health insurance with copayment and deductible.
  - Endogenous insurance premia.
- Children of the poor are covered by Medicaid
- All elderly are covered by Medicare.
- In case of severe health shocks, default is allowed.

What do I do?
II. A Life-Cycle Model of Health Capital

1. **Two distinct types of health capital**
2. **Important features of the US health care system**
3. **Government budget balances**

- Progressive US tax scheme on income
- Finances social security, Medicaid, Medicare
- Budget surplus or deficit is distributed in a lump sum fashion

What do I do?
III. Estimate Model Using Micro and Macro Data

1. **Set some of the parameter values outside of the model**

- income process
- deductible - co-payment coverage schemes, etc.

What do I do?
III. Estimate Model Using Micro and Macro Data

1. **Set some of the parameter values outside of the model**

2. **Match model moments to data moments**

- From the MEPS
  - Distribution of medical expenditures
  - Differences in the lifetime profile of health care spending
- From aggregate data
  - Age profile of conditional survival probability
  - Differences in life expectancy between the rich and the poor
  - Wealth to income ratio, etc.

What do I do?
IV. Counter-Factual Policy Analysis

1. **Universal Health Insurance Coverage**
   - Increase in life expectancy of the poor by 1.25 years.
   - Increase aggregate medical spending by only 0.8%
   - Welfare gains equivalent to 1.5% of lifetime consumption

What do I do?
IV. Counter-Factual Policy Analysis

1. **Universal Health Insurance Coverage**

2. **75% of preventive medicine expenditures covered by the private insurance.**

- Increase in life expectany in the population except for the richest.
- Aggregate medical spending does not increase
- Welfare improves

Related Literature

Health Spending as Expenditure Shocks

Palumbo (1999), Jeske and Kitao (2009), Attanasio, Kitao and Violante (2008)

"Endogenous" Health Expenditures by Income

De Nardi, French and Jones (2010), Yogo (2009), Jung and Tran (2009), DeNardi, Pashchenko, and Porapakkarm (2018), Hosseini, Kopecky, and Zhao (2020)

Health Capital and Dynamic Inefficiencies in Health Care System

Grossman (1972), Grossman and Rand (1974), Cropper (1977), Fang and Gavazza (2010), Finkelstein, McGarry, Sufi (2005)

Preventive Care

Kenkel (2000), Russell (2007), Russell (1986)

Outline

- **Empirical Facts**
- **Intuition in a Stylized Framework**
- **Full Model**
- **Calibration/Estimation**
- **Model's Performance**
- **Policy Analysis**

Empirical Facts

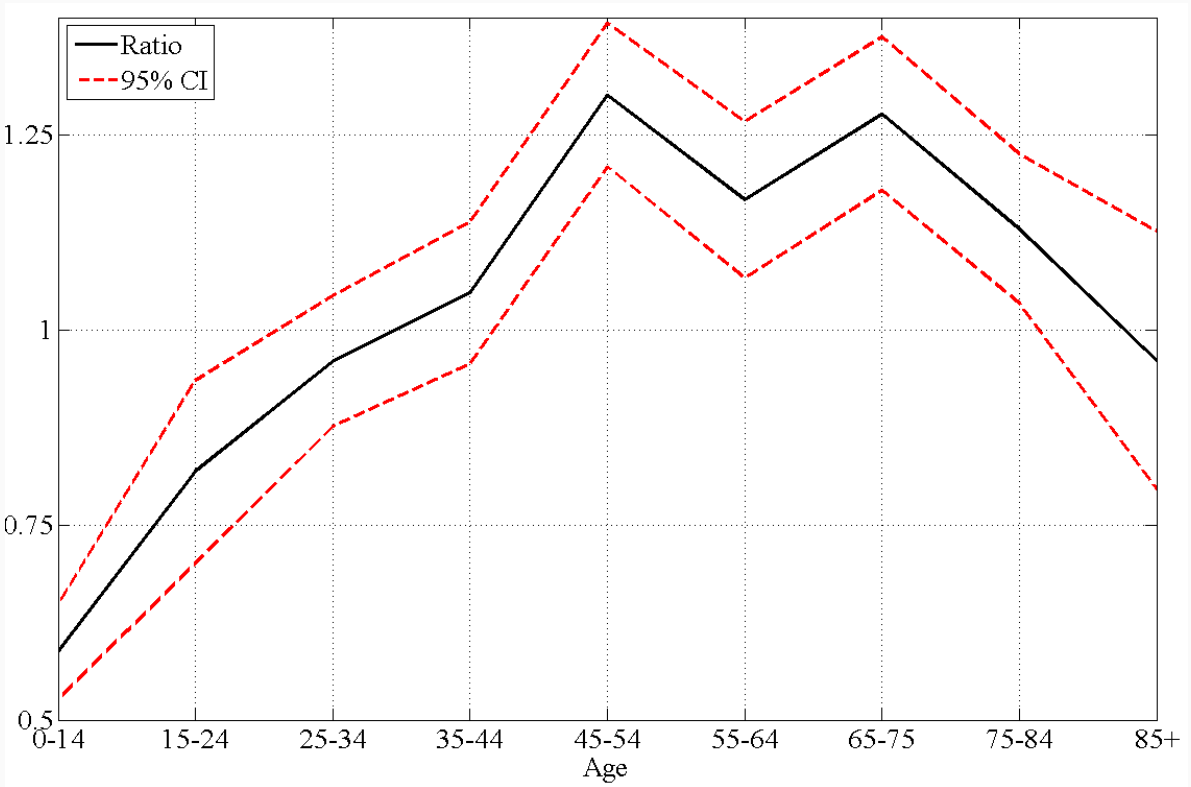
Medical Expenditure Panel Survey (MEPS)

- Yearly survey of both families and individuals between 1996-2007.
- 359,826 observations between ages 0-90.
- Definition of medical expenditure (consumption) includes:
  - office- and hospital-based care,
  - home health care,
  - dental services, vision aids, and
  - prescribed medicines, etc.
- Medical consumption can be paid by:
  - out of pocket expenditures
  - Private insurance firms
  - Government (Medicaid, Medicare, etc.), and others.
- Total income: wage, business, unemployment, dividend, interest, pension, social security, etc.

Methodology

- Group individuals into age intervals: 0-14,15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85 and older
- Normalize total family income by family-type-specific federal poverty threshold.
- Consruct income quintiles with respect to only those families within a particular age bin.
- Study differences in health outcomes between income quintiles.

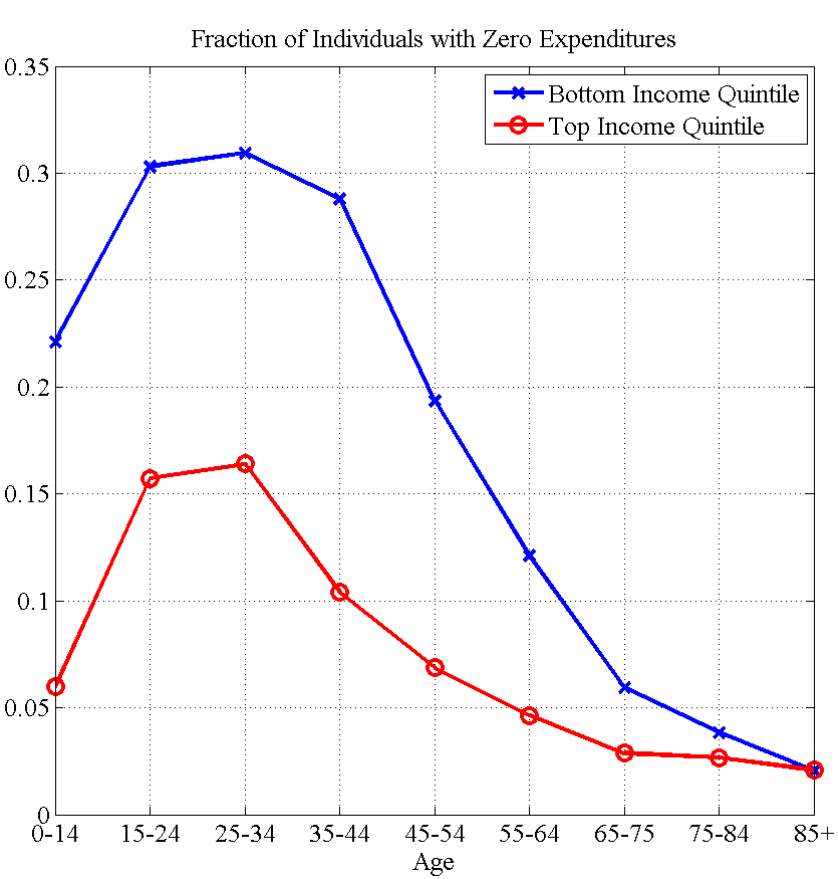
Lifetime Profile of Medical Expenditures by Income

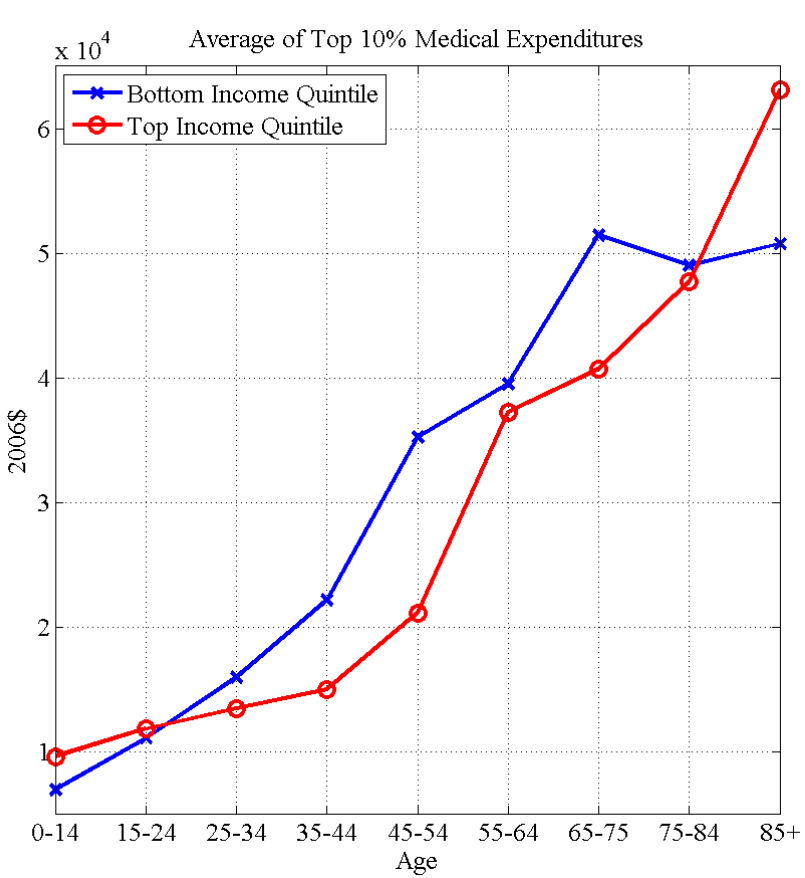


- Humped-shaped average medical spending of low income group relative to high income group.

▸ Expenditure Profile

Distribution of Medical Expenditures





- The distribution of medical expenditures of the poor is more widely spread to the tails.

Preventive Care Consumption by Income

- Survey question: How long since last ...?
- Answer: The duration since last...

Quantiles	Dentist	Cholesterol	Flu Shot	Prostate Test	Mammogram
Low Income	2.608	2.863	4.230	4.057	3.293
	(0.00984)	(0.0235)	(0.0215)	(0.0223)	(0.0149)
High Income	1.689	2.207	3.733	2.814	2.433
	(0.00966)	(0.0180)	(0.0253)	(0.0223)	(0.0184)
Observations	254445	169552	176935	43337	72777

- High income consume preventive care more than low income do.

▶ More examples

Life Expectancy by Income

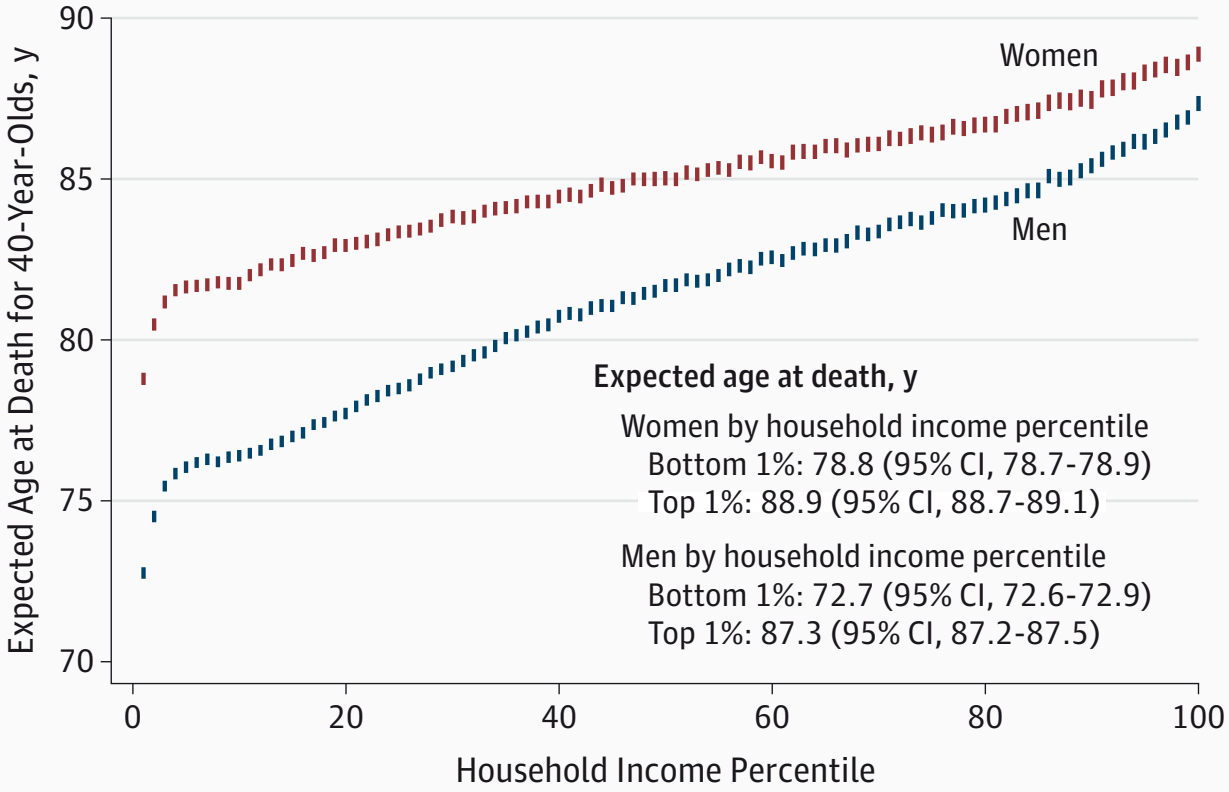


Figure 3: Race- and Ethnicity-Adjusted Life Expectancy for 40-Year-Olds by Household Income Percentile, 2001-2014, Source: Chetty et al 2016 JAMA

- Shorter life expectancy for lower income households.

Basic Model

Intuition in a Stylized Framework

- Two distinct types of health capital.

1. **Physical health capital** determines survival probability.

2. **Preventive health capital** governs the distribution of health shocks to **physical health capital**.

A Model of Health Capital: Environment

- Discrete time $t = 1, 2, ...T$.
- Cohort size of newborns is normalized to 1.
- Ex-ante two types of households: Rich and poor
- Households are subject to health shocks which affect their endogenous survival probability.

Preferences

$$u(c_t) = \frac{c_t^{1-\sigma}}{1-\sigma}$$

- c_t : Consumption
- Value of death is zero.
- $\sigma < 1$: Value of being alive is positive.

Preferences will feature an explicit value of being alive in the full model!

Health Capital

Physical Health Capital

$$
\begin{aligned}
h_0 &= 1 \\
h_{t+1} &= \begin{cases} h_t & \text{if} \quad A_t^c m_{C,t}^{\theta_t^c} \geq \omega_t \\ h_t - \omega_t + A_t^c m_{C,t}^{\theta_t^c} & \text{otherwise} \end{cases}
\end{aligned}
$$

h_t : physical health capital stock

$m_{C,t}$: curative medicine

ω_t : health shock

A_t^c, θ_t^c : curative health production function parameters

Preventive Health Capital

$$
\begin{aligned}
x_0 &= 1 \\
x_{t+1} &= \begin{cases} x_t & \text{if} \quad A^p m_P^{\theta_t^p} \geq \delta_x x_t \\ x_t(1-\delta_x) + A^p m_{P,t}^{\theta^p} & \text{otherwise} \end{cases}
\end{aligned}
$$

x_t : preventive health capital stock

$m_{P,t}$: preventive medicine

A^p, θ^p : preventive health production function parameters

Health Capital

Distribution of Health Shocks

$$log(\omega_t) \quad \sim \quad \begin{cases} \mathbb{N}(\mu_t^G, \sigma_t^2) & w/p \quad \pi(x_t) \\ \mathbb{N}(\mu_t^B, \sigma_t^2) & w/p \quad 1 - \pi(x_t) \end{cases}$$

$\mu^B > \mu^G$

$\pi(x_t)$: x_t probability of health shocks being drawn from the "**good**" distribution with mean μ^G

Health Capital

Survival Probability Function

$$s(h_t - \omega_t) \quad = \quad h_t - \omega_t$$

h_t : physical health capital stock

ω_t : health shock

Budget Constraint

No Default

$$\begin{aligned} w^i + (1+r)a_t &= c_t + m_{C,t} + m_{P,t} + a_{t+1} \\ a_{t+1} &\geq 0 \end{aligned}$$

w^i: constant income per period, $i \in \{rich, poor\}$
a_t: wealth at age t
$m_{C,t}$: curative care expenditure
$m_{P,t}$: preventive care expenditure

Budget Constraint

Option to Default $\left(\text{if } \left(\frac{\omega_t}{A_t^c}\right)^{(1/\theta_t^c)} > w^i + (1+r)a_t - c_{min}\right)$

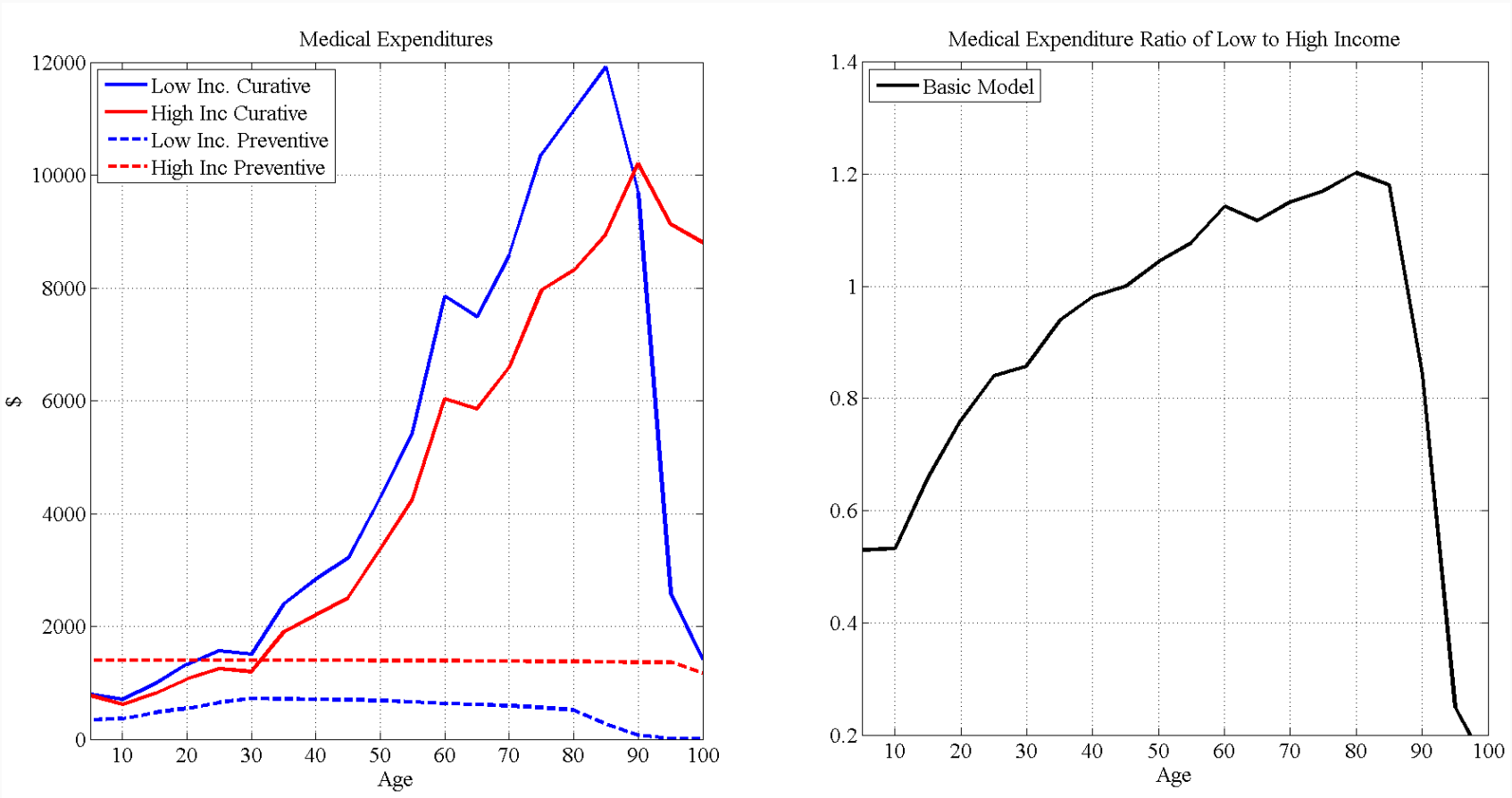
$$
\begin{aligned}
c_t &= c_{min} \\
a_{t+1} &= 0 \\
m_{C,t} &= (\omega_t / A_t^c)^{(1/\theta_t^c)} \\
m_{P,t} &= 0
\end{aligned}
$$

w^i: constant income per period, $i \in \{rich, poor\}$
a_t: wealth at age t
$m_{C,t}$: curative care expenditure
$m_{P,t}$: preventive care expenditure

Understanding the Mechanism

- What's the basic mechanism in the model?
- Simulate the model with the calibrated "full model" parameter values.
- Compare the age profile of medical expenditures of the basic model with:
  - No preventive health capital: $\mu_t^G = \mu_t^B$
  - No default option.

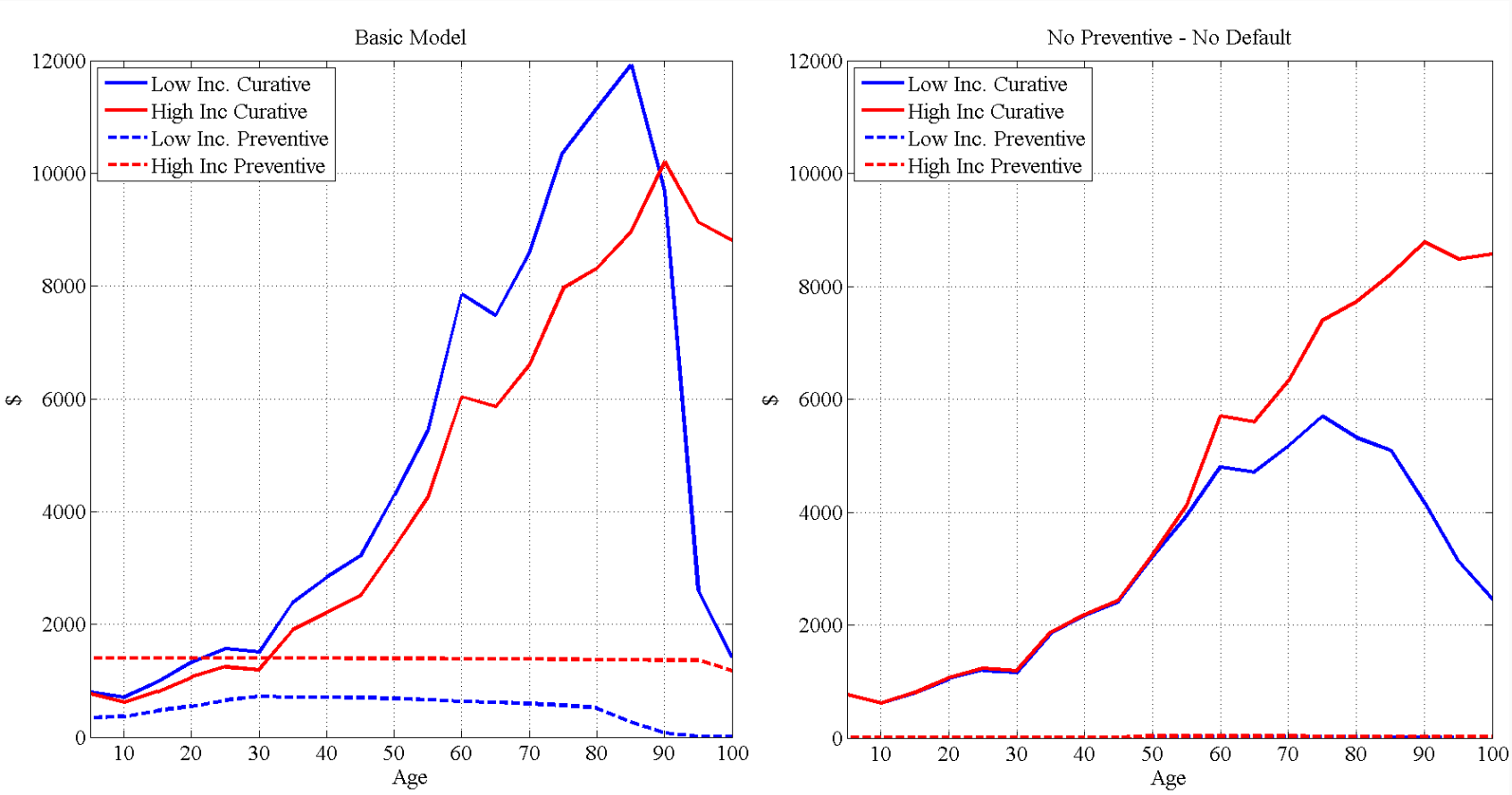
Age Profile of Medical Expenditures



- Capable of generating the humped-shaped profile of relative expenditures.

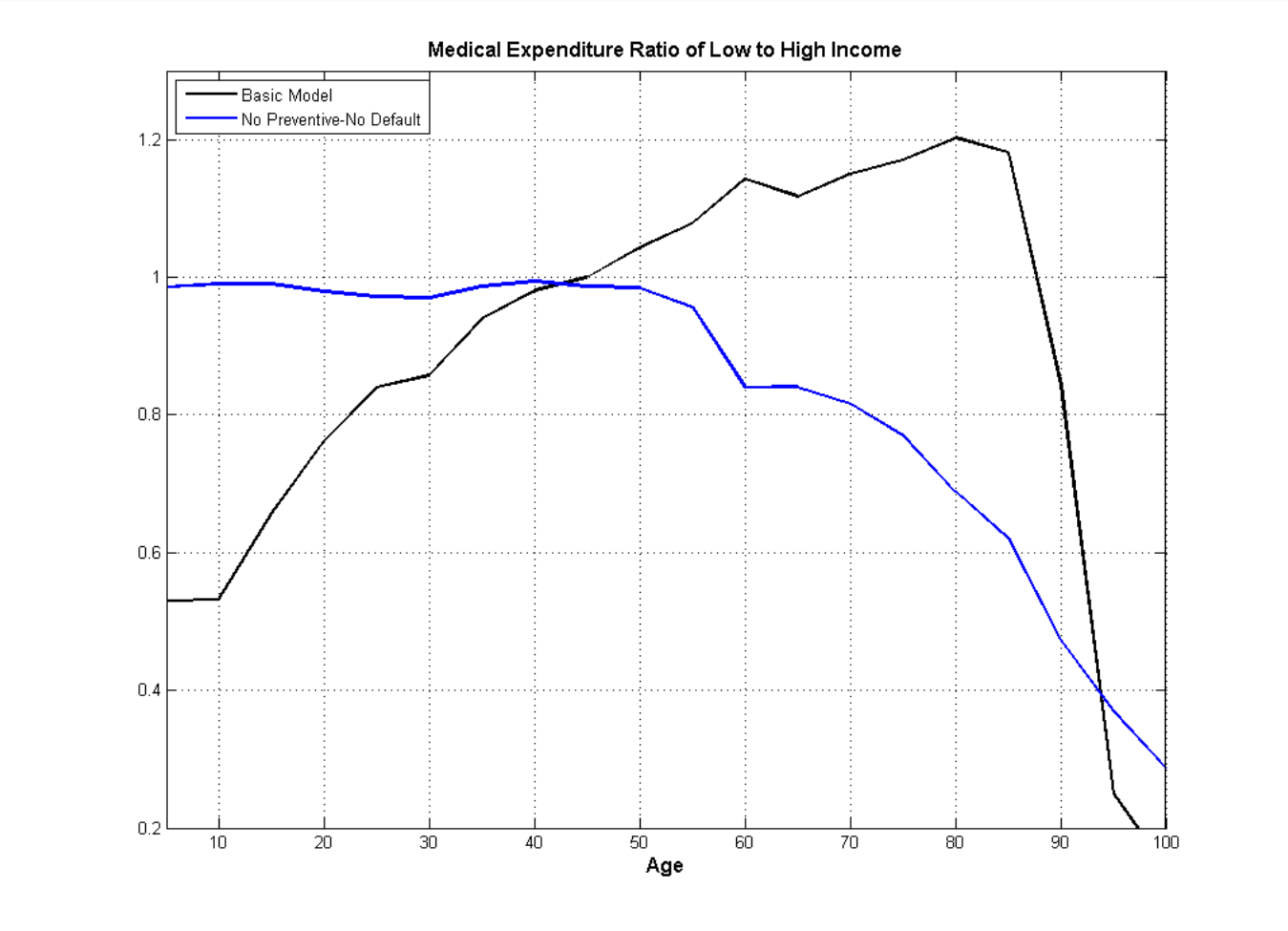
▸ Basic Model with Initial Asset

Age Profile of Medical Expenditures



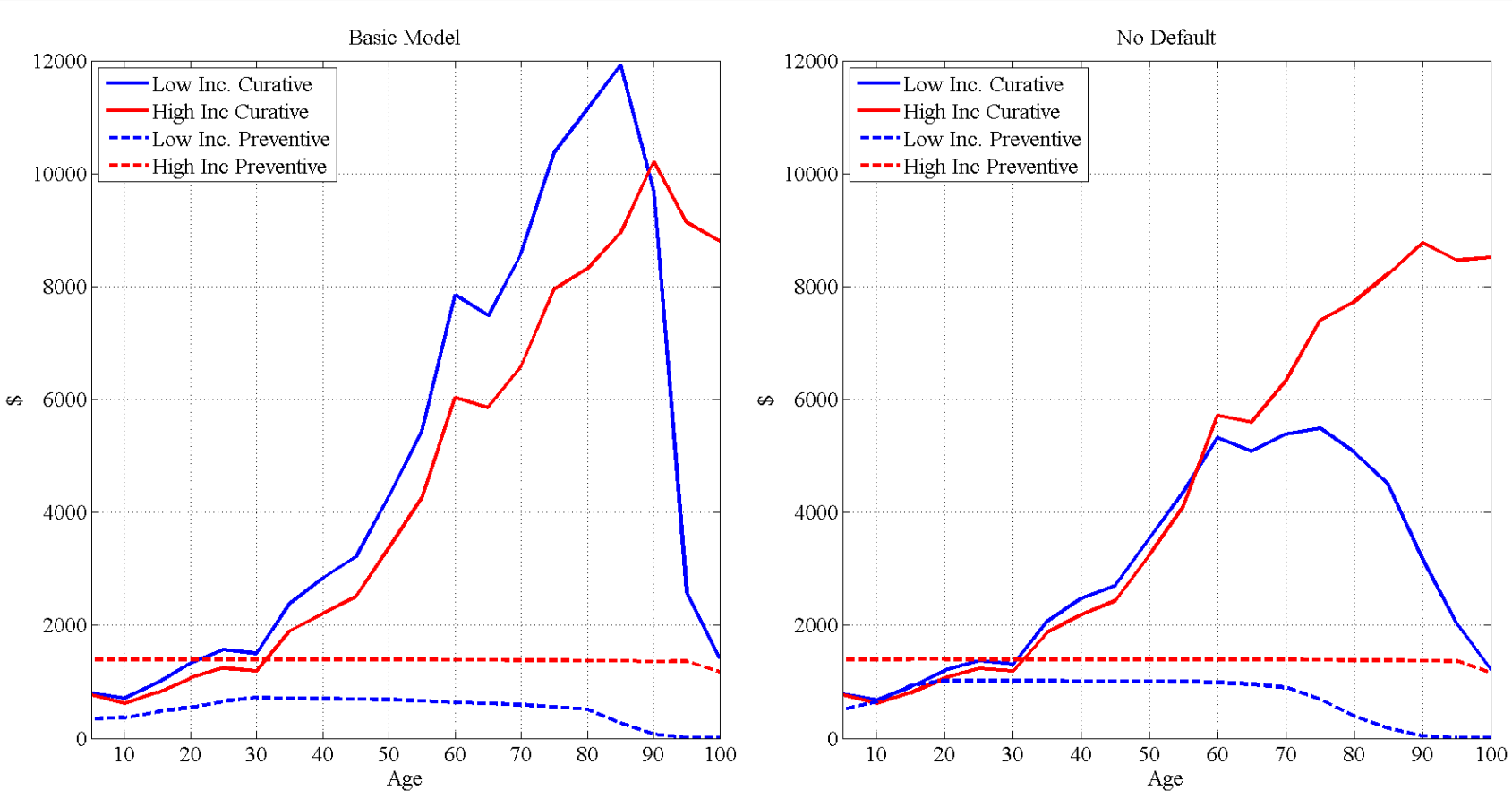
- Preventive health capital endogenizes the distribution of health shocks.

Age Profile of Medical Expenditures



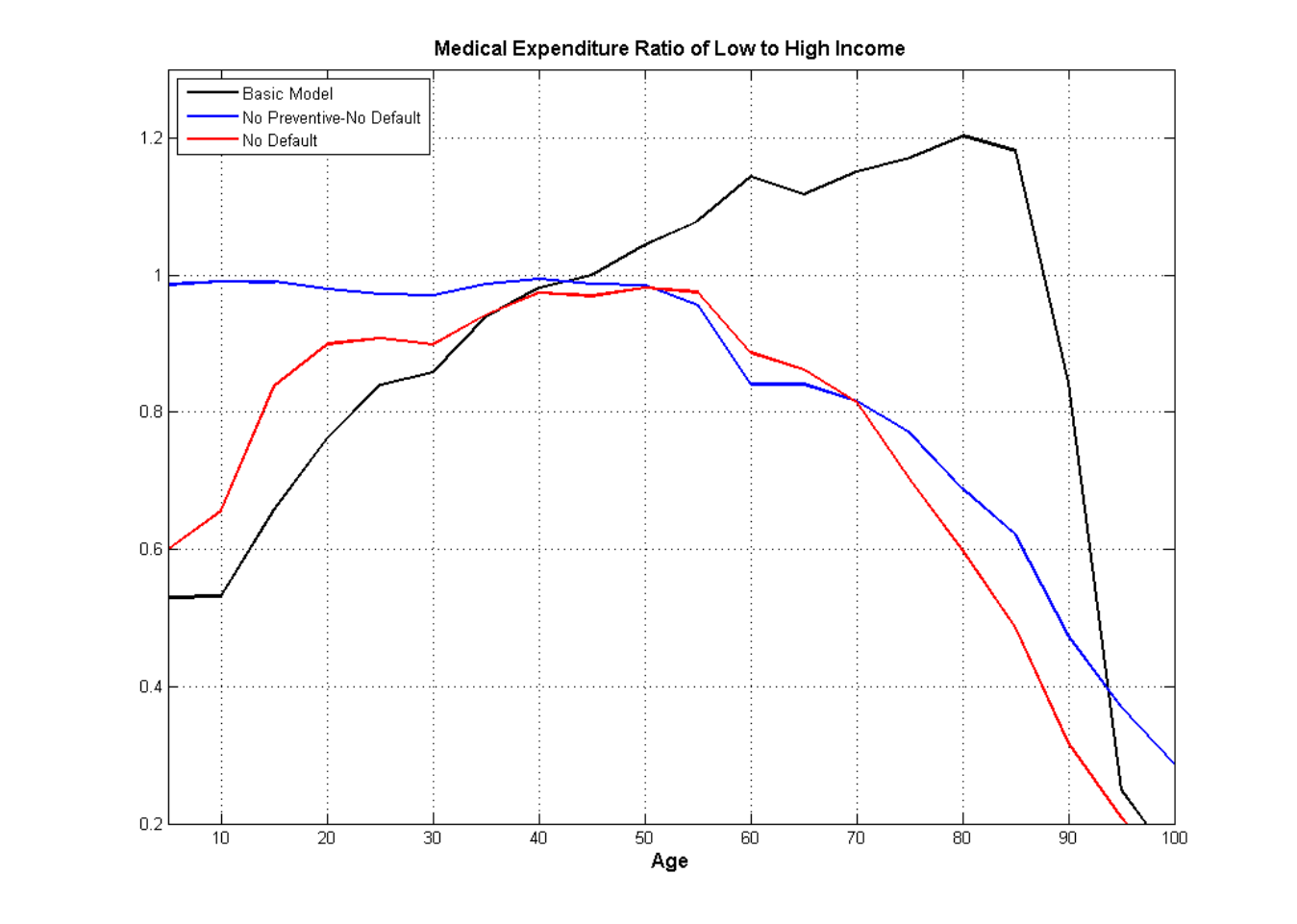
- Without preventive health capital medical spending of the poor relative to the rich decreases over the lifetime.

Age Profile of Medical Expenditures



- Default option hampers incentives of the poor to invest in preventive health.

Age Profile of Medical Expenditures



- Option to default amplifies the mechanism.

Full Model

Three phases of lifecycle

1. Childhood: $t = 1, 2, ... T_{CHILD}$

- Constant stream of income.
- No asset accumulation.
- Private insurance is offered.
- Also households with income lower than poverty threshold are eligible for Medicaid.

Three phases of lifecycle

1. **Childhood:** $t = 1, 2, ...T_{CHILD}$

2. **Working years:** $t = T_{CHILD} + 1, ...T_{RET}$

- Inelastic labor supply in return for idiosyncratic earnings, $w_t^i \sim AR(1)$ process.
- Labor earnings are also affected by physical health status.
- Accumulate risk-free asset at an interest rate, r
- Income is subject to the progressive US tax schedule.
- Tax deductible private insurance is offered.

Three phases of lifecycle

1. **Childhood:** $t = 1, 2, ... T_{CHILD}$
2. **Working years:** $t = T_{CHILD} + 1, ... T_{RET}$
3. **Retirement:** $t = T_{RET} + 1, ... T$

- Government provides retirement pension proportional to last year's earnings.
- All elderly are covered by Medicare.

Hall and Jones (2007) Preferences

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

- Non-homothetic preferences
  - Value of life is explicitly incorporated, b
  - $\sigma > 1$
- Household also enjoys the quality of life.

Insurance Plans

- Exogenous Insurance Plans involve both deductible ι, and co-payment, ς:

$$\chi^j(m) = \begin{cases} 0 & m \leq \iota^j \\ \varsigma^j(m - \iota^j) & m \geq \iota^j \end{cases}$$

  where $j \in \{Private, Medicaid, Medicare\}$

- All plans cover sum of preventive and curative medicine expenditures.

- Private plans are offered before health shocks are realized.

- Private insurance plans satisfy zero profit condition in each period t:

$$\int_{h,p,a,w} I_t^{PRV}(h,x,a,w)[p_t^{PRV} - (1+\Delta)\int_{\omega_t} m(h,x,a,w,\omega)d\omega_t(x)]d\Lambda(h,x,a,w) = 0$$

where $I_t^{PRV}(.)$ is an indicator for signing up for the private insurance plan.

Government Budget

- US progressive taxation on household income
- Tax revenue is used to finance
  - Social security benefits,
  - Medicaid and Medicare expenditures
  - Medical expenditures due to default
  - Exogenous other government expenditures, G
- Budget surplus or deficit is distributed in a lump-sum fashion, Tr

Calibration/Estimation

Methodology

1. Fix some of the parameter values outside the model.

- Ex: Insurance plans, retirement pension scheme etc.

2. Choose parameter values using the model to match the moments in the data.

- Ex: Distribution of health shocks, preventive and curative health production function etc.

Environment

- Model period is 1 year.
- $T_{CHILD} = 20$, $T_{RET} = 65$, $T = 110$.

Fixed Parameters

- Income process estimates from Storesletten et al. (2000)
- $w(h)$: Estimate the decrease in earnings due to health shock from the MEPS
- Insurance plans, $\chi(x)$, estimated from the MEPS.
- SS mimics the US system (Guvenen, Kuruscu, Ozkan (2010))

Preference Parameters

Param.	Explanation	Identifying Moment
β	Discounting factor	Wealth/Income ratio
b	Value of being alive	Life expectancy (particularly, of the poor)
α, γ	Quality of life coefficients	Quality adjusted life years
		▸ Survey Question

Distribution of Health Shocks

$$log(\omega_t) \quad \sim \quad \begin{cases} \mathbb{N}(\mu_t^G, \sigma_t^2) & w/p \quad \pi(x_t) \\ \mathbb{N}(\mu_t^B, \sigma_t^2) & w/p \quad 1 - \pi(x_t) \end{cases}$$

- $\mu_t^B = \mu_t^G + \bar{\mu}$
- Identifying moment: Differences in the lifetime profile of medical expenditures between the poor and the rich.

▸ Figure

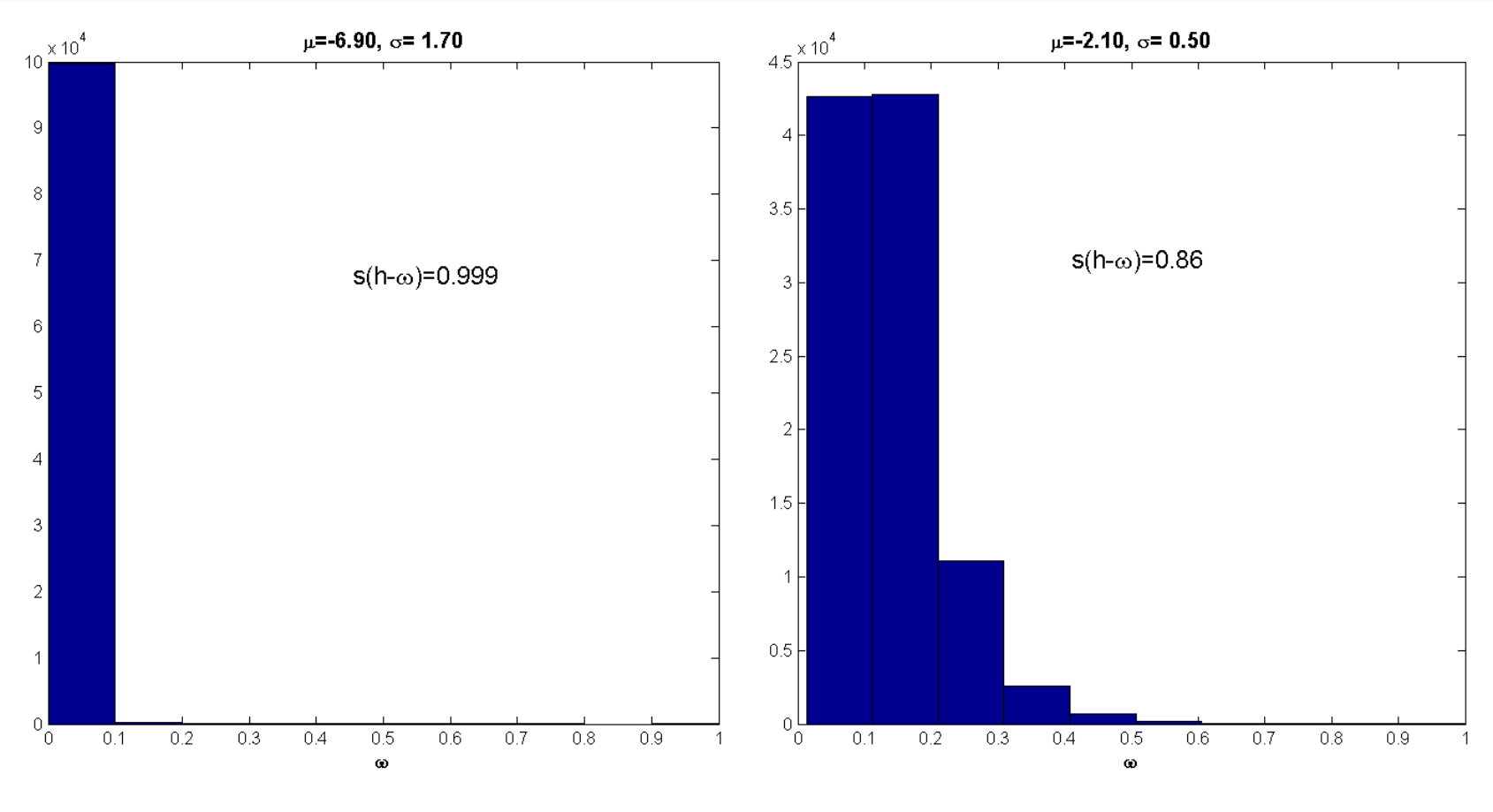
Distribution of Health Shocks

$$log(\omega_t) \quad \sim \quad \begin{cases} \mathbb{N}(\mu_t^G, \sigma_t^2) & w/p \quad \pi(x_t) \\ \mathbb{N}(\mu_t^B, \sigma_t^2) & w/p \quad 1 - \pi(x_t) \end{cases}$$

- Normalize the distribution s.t. $\omega_{99.9\%} = 1$
- $s(h_t - \omega_t) = h_t - \omega_t$
- Conditional survival probability from t to $t + 1$.

Distribution of Health Shocks

Figure 4: Histogram of Health Shocks



Physical Health Technology

- Let's suppose that
  - we can observe $m_{C,t}$ (even though we only observe $m_{C,t} + m_{P,t}$ in the data)
  - households choose to fully recover the shocks

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  - households choose to fully recover the shocks

$$\begin{aligned} \omega_t &= A_t^c m_{C,t}^{\theta_t^c} \\ \log \omega_t &= \log A_t^c + \theta_t^c \log m_{C,t} \\ \log m_{C,t} &= \frac{\log \omega_t - \log A_t^c}{\theta_t^c} \end{aligned}$$

Physical Health Technology

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  - we can observe $m_{C,t}$ (even though we only observe $m_{C,t} + m_{P,t}$ in the data)
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- Mean and variance of medical expenditures can identify θ_t^c, A_t^c

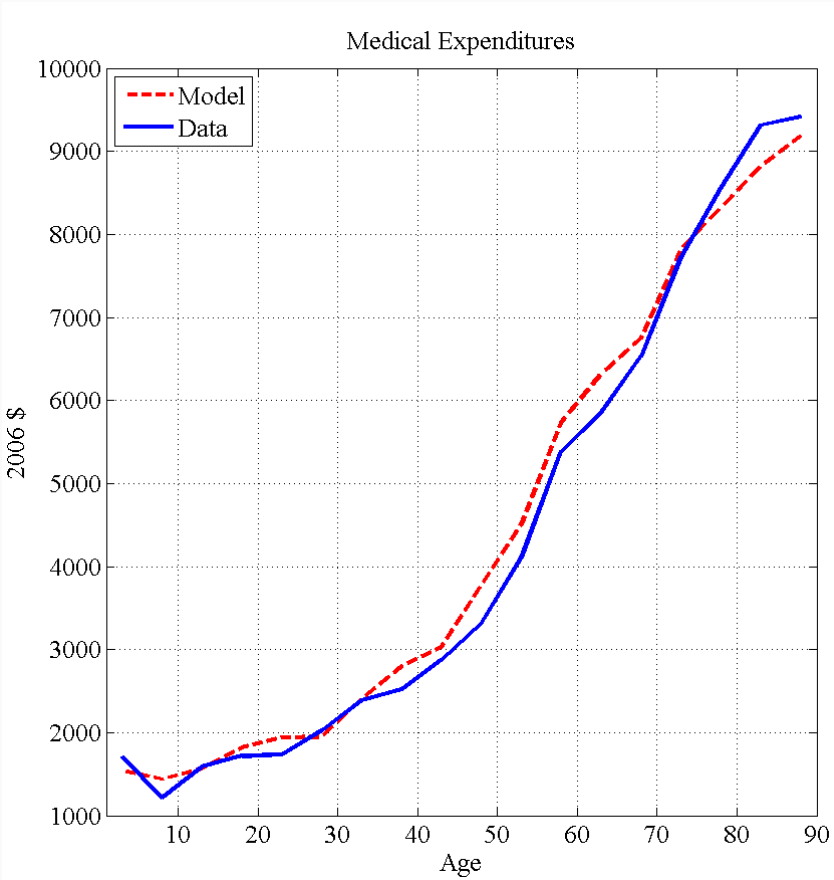
Preventive Health Technology

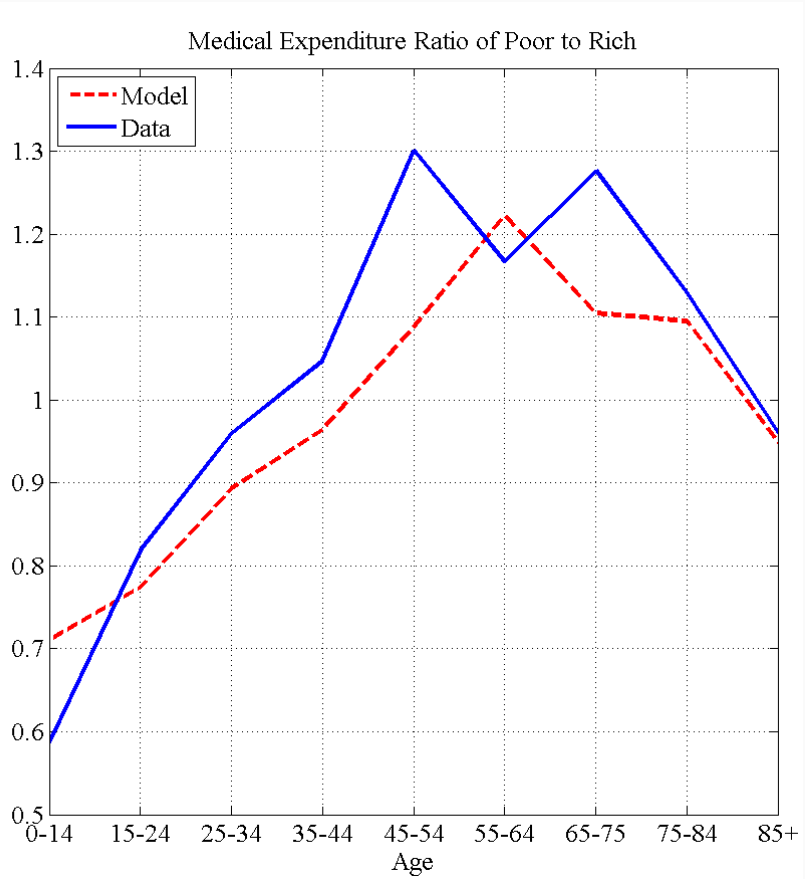
Table 1: Preventive Health Capital Parameters

Param.	Explanation	Identifying Moment
δ_x	Prev. health depreciation rate	5% per year
A^p, θ^p	Prev. health func. params	Increase in relative medical exp. of poor to rich ▸ Figure

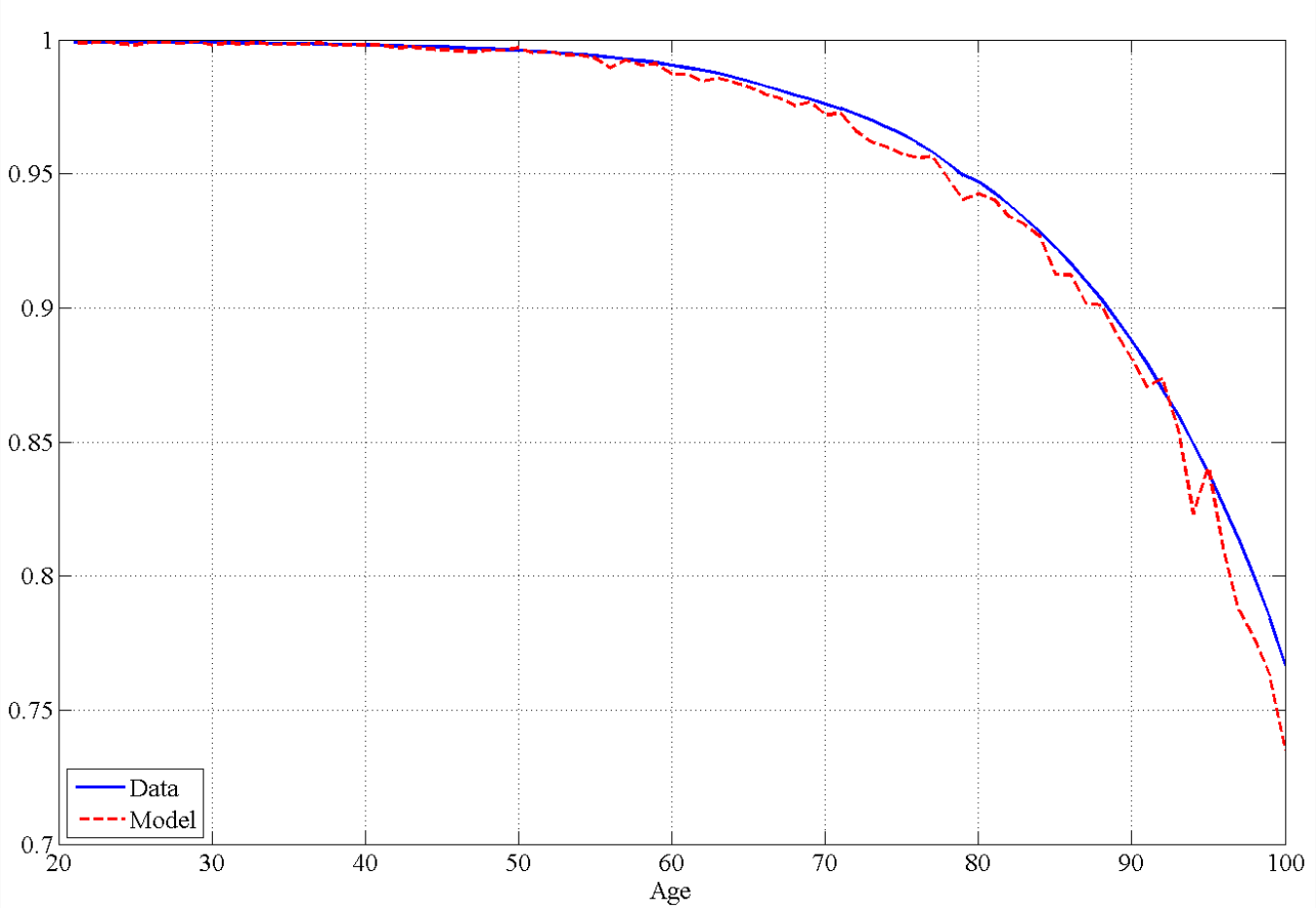
Model Fit

Model's Fit


Medical Expenditures
Model
Data
2006 $
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
10
20
30
40
50
60
70
80
90
Age


Medical Expenditure Ratio of Poor to Rich
Model
Data
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0-14
15-24
25-34
35-44
45-54
55-64
65-75
75-84
85+
Age

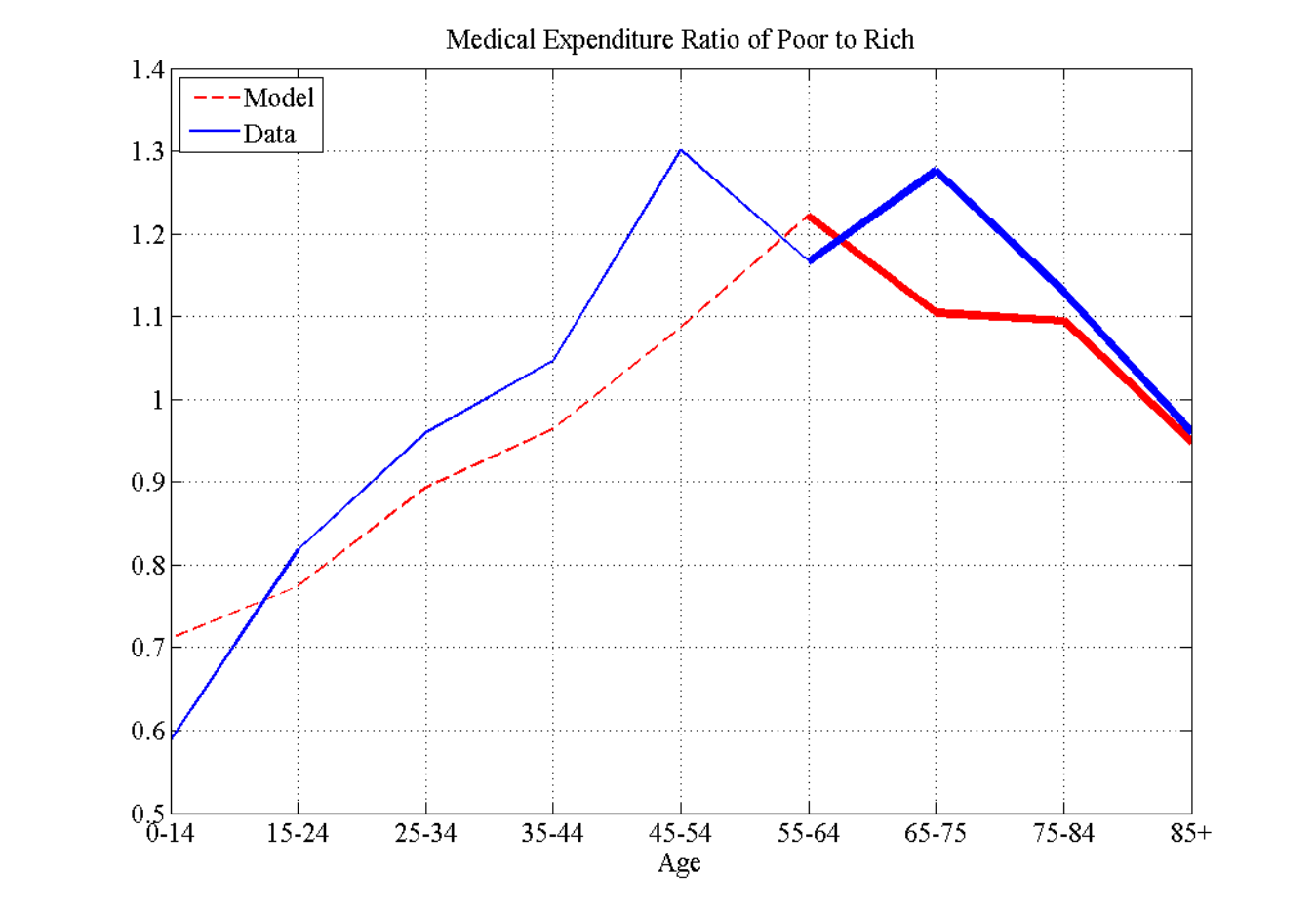
Model's Fit



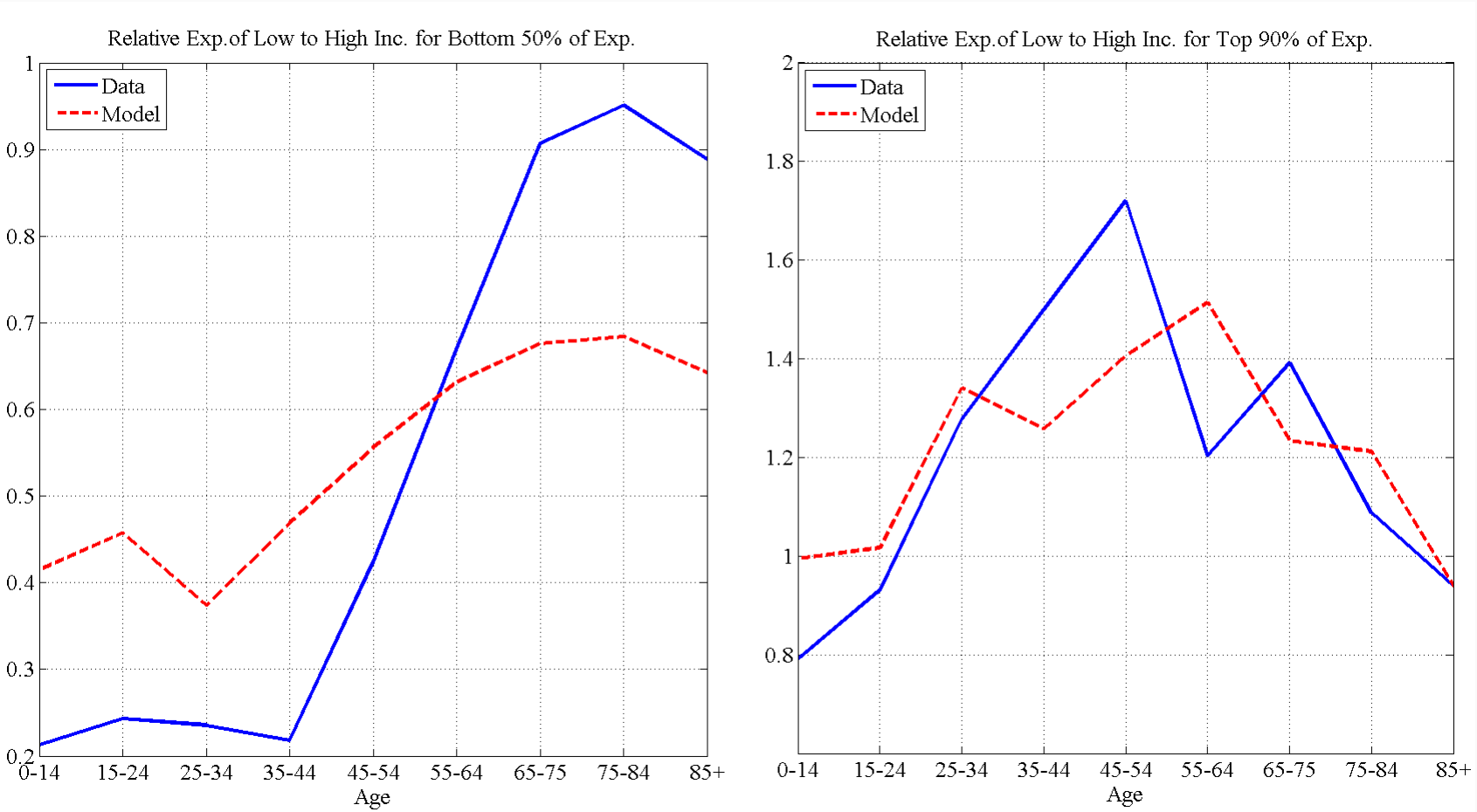
Model's Fit

	Low Income		High Income	
Life Expectancy	Data	Model	Data	Model
Age 25	45.0	48.5	52.9	53.8
Age 45	27.0	30.4	33.9	35.1
Age 65	13.8	15.1	17.1	18.1

An Informal Over-Identification Discussion



An Informal Over-Identification Discussion



▸ Empirical Fact II

An Informal Over-Identification Discussion

	Data	Model
Private Insurance Coverage under age 65	73%	85%
Medicaid Coverage under age 20	22%	23%
Share of Medicaid and Medicare	29%	26%

Policy Analysis

Counter-Factual Policy Analysis I

- Government provides all non-elderly private health insurance.
- To finance this policy an additional flat income tax is imposed on household income.
- All elderly are still covered by Medicare.

Counter-Factual Policy Analysis I

Table 2: Life Expectancy

	Q1	Q2	Q3	Q4	Q5
Benchmark	71.95	75.2	76.3	76.5	76.8
Policy I	**73.2**	75.3	76.3	76.5	76.8

- Aggregate medical spending increases by only 0.8%
- Per capita medical expenditures increase from \$4750 to \$4755

Counter-Factual Policy Analysis I

- Health insurance premia decrease 2.5% for 30-year old and younger.
- Increase 1.5% for older than 30.

Counter-Factual Policy Analysis I

Welfare Analysis

$$\mathbb{E}\sum_{t=1}^{T}\beta^{t-1}s(h_t^B-\omega_t)u(c_t^B,h_t^B-\omega_t)=\mathbb{E}\sum_{t=1}^{T}\beta^{t-1}s(h_t^P-\omega_t)u(\phi c_t^P,h_t^P-\omega_t)$$

Counter-Factual Policy Analysis I

Welfare Analysis

$$\mathbb{E}\sum_{t=1}^{T}\beta^{t-1}s(h_t^B-\omega_t)u(c_t^B,h_t^B-\omega_t)=\mathbb{E}\sum_{t=1}^{T}\beta^{t-1}s(h_t^P-\omega_t)u(\phi c_t^P,h_t^P-\omega_t)$$

- $1-\phi=1.5\%$

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Table 3: Welfare Gains, $1-\phi$

	Bottom 2%	Median	Top 2%
Policy I w.r.t Benchmark	0.6%	2.1%	-0.88%

Counter-Factual Policy Analysis II

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Counter-Factual Policy Analysis II

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Table 4: Life Expectancy

	Q1	Q2	Q3	Q4	Q5
Benchmark	71.95	75.2	76.3	76.5	76.8
Policy I	73.2	75.3	76.3	76.5	76.8
Policy II	**74.65**	**75.9**	**76.5**	**76.6**	**76.8**

Counter-Factual Policy Analysis II

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- Aggregate medical spending **DOES NOT** increase!
- Per capita medical expenditures decrease from \$4755 to \$4738.

Counter-Factual Policy Analysis II

Welfare Analysis

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- $1-\phi=2.5\%$

Table 5: Welfare Gains, $1-\phi$

	Bottom 2%	Median	Top 2%
Policy I w.r.t Benchmark	0.6%	2.1%	-0.88%
Policy II w.r.t Benchmark	0.35%	3.13%	-1.2%
Policy II w.r.t Policy I	-0.24%	1.105%	-0.29%

Conclusion

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  - The young rich spend more on health care whereas medical spending of the old poor is larger in absolute terms.

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  - enables the poor to incur medical spending higher than their income.
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- Public insurance in old ages (Medicaid, Medicare, default option) can be important in explaining these differences:
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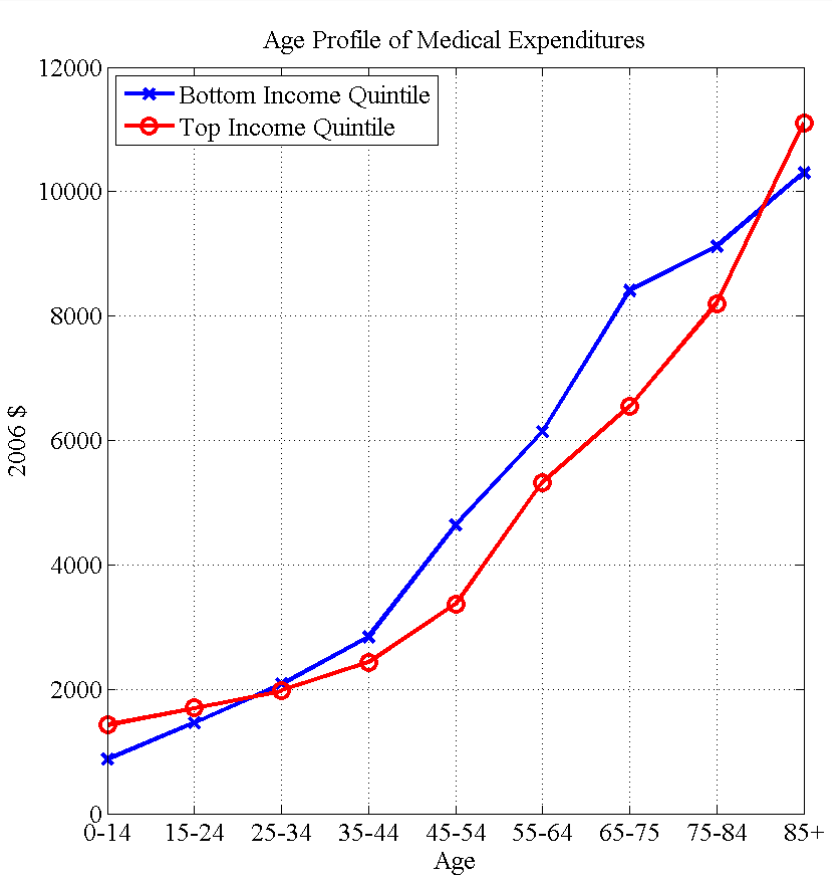
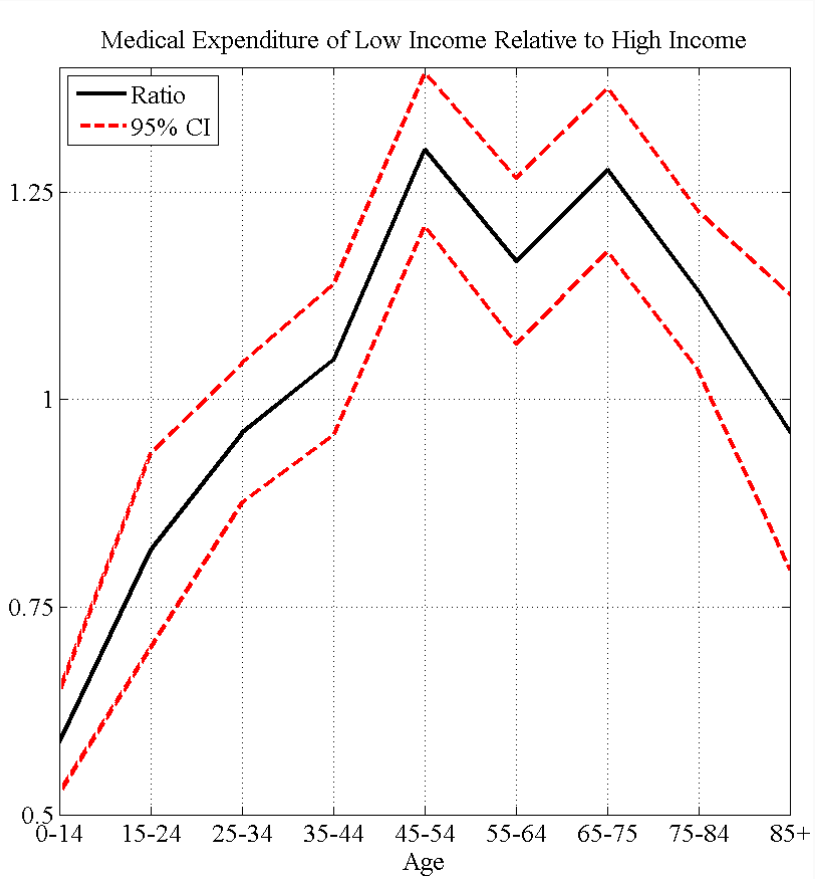
  - hampers incentives of the poor to use preventive care.
- Policies encouraging the use of health care by the poor early in life have significant welfare gains.

Misc

Empirical Fact I





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Preventive Medicine

Table 6: Preventive Medicine

Inc. Quant	Dentist	Blood Pressure	Cholesterol	Flu Shot	Prostate Test	Brest Exam	Mamogram
1	2.608***	1.573***	2.863***	4.230***	4.057***	2.205***	3.293***
	(0.00984)	(0.0106)	(0.0235)	(0.0215)	(0.0223)	(0.0177)	(0.0149)
2	2.356***	1.497***	2.716***	4.151***	7.781***	2.009***	3.011***
	(0.0102)	(0.00905)	(0.0206)	(0.0200)	(0.0215)	(0.0165)	(0.0173)
3	2.102***	1.397***	2.538***	4.004***	3.414***	1.850***	2.722***
	(0.00967)	(0.00827)	(0.0208)	(0.0223)	(0.0200)	(0.0158)	(0.0182)
4	1.883***	1.332***	2.377***	3.927***	3.140***	1.727***	2.552***
	(0.00953)	(0.00784)	(0.0191)	(0.0216)	(0.0253)	(0.0155)	(0.0183)
5	1.689***	1.286***	2.207***	3.733***	2.814***	1.611***	2.433***
	(0.00966)	(0.00615)	(0.0180)	(0.0253)	(0.0223)	(0.0130)	(0.0184)
Obs	254445	175515	169552	176935	43337	93046	72777

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Calibration/Estimation

$$u(c_t, h_t) = b + \frac{c_t^{1-\sigma}}{1-\sigma} + \alpha \frac{h_t^{1-\gamma}}{1-\gamma}$$

- α, γ: Match quality-adjusted life years (QALYs) from surveys (Cutler and Richardson (1997))

$$\frac{u(c_{20}, \bar{h}_{20})}{0.94} = \frac{u(c_{65}, \bar{h}_{65})}{0.73} = \frac{u(c_{85}, \bar{h}_{85})}{0.62}$$

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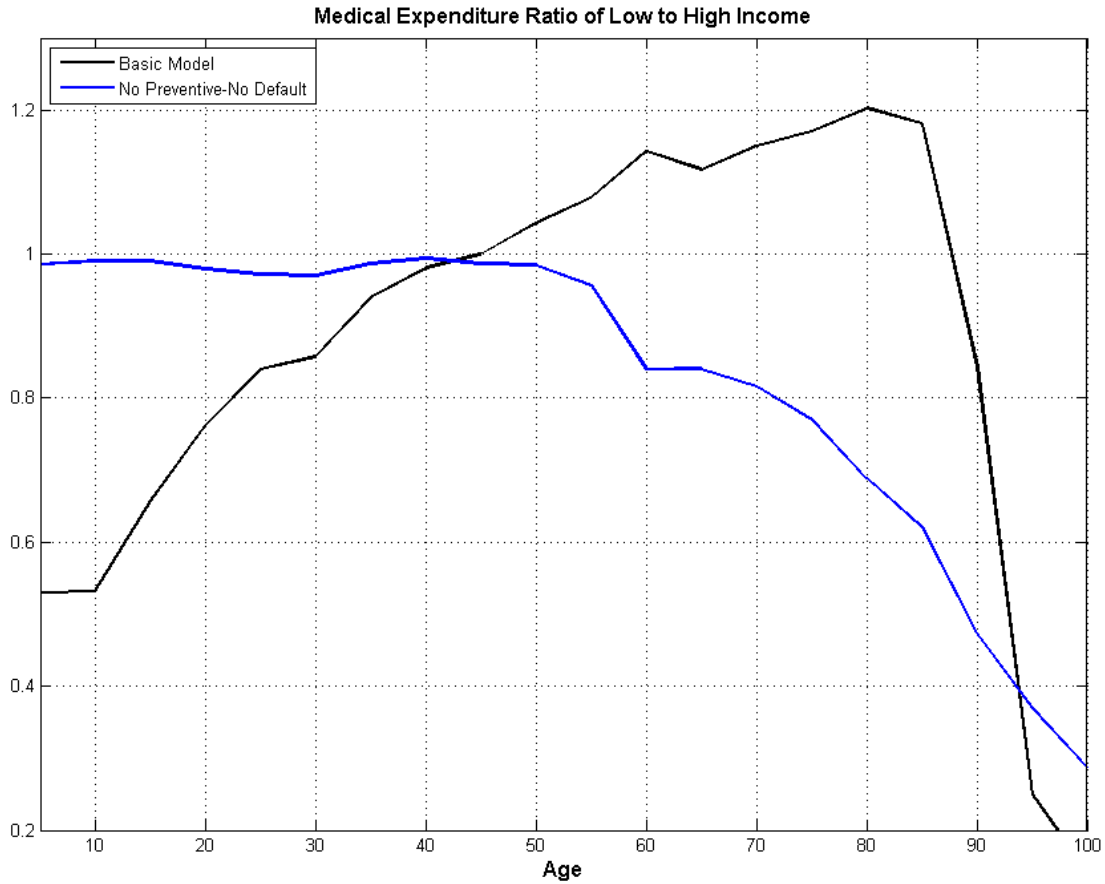
Age Profile of Medical Expenditures



- Without preventive health capital medical spending of the poor relative to the rich decreases over the lifetime.

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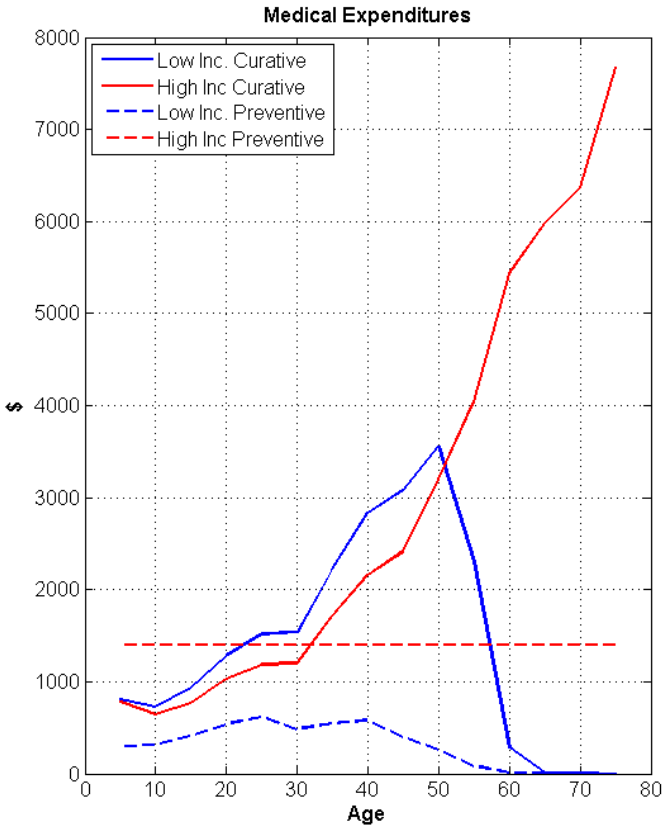
Basic Model with Initial Wealth



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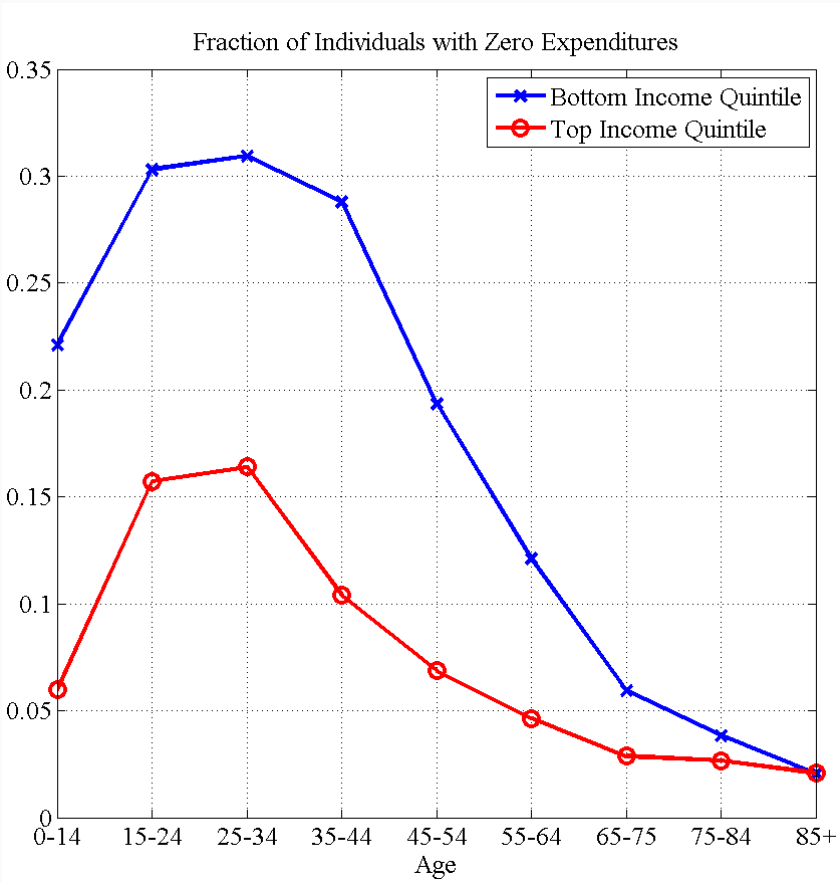
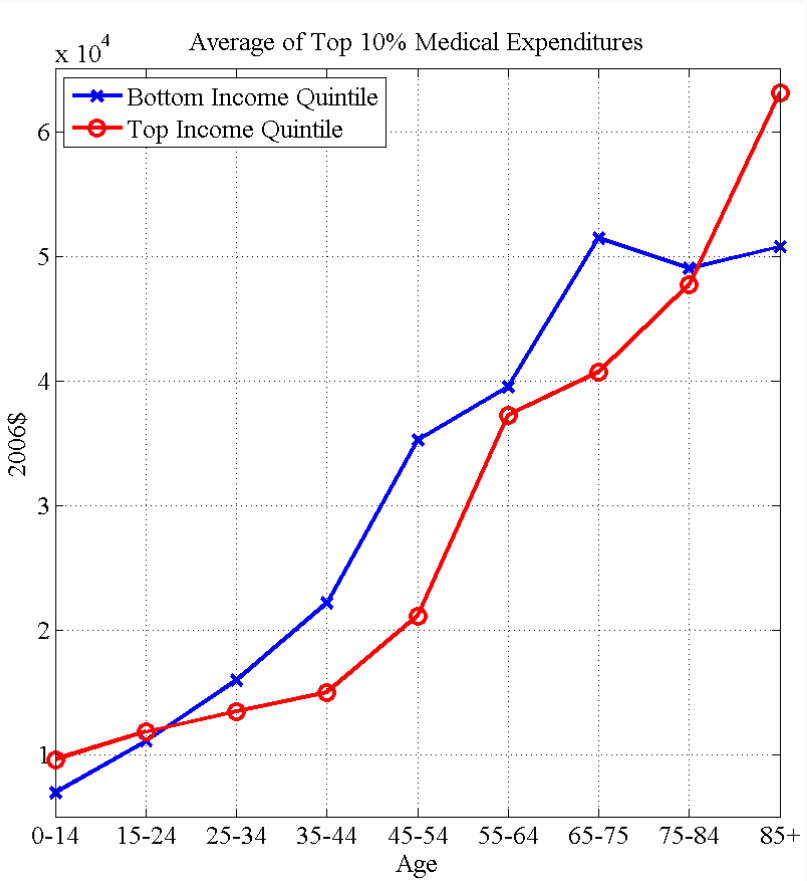
Empirical Fact II





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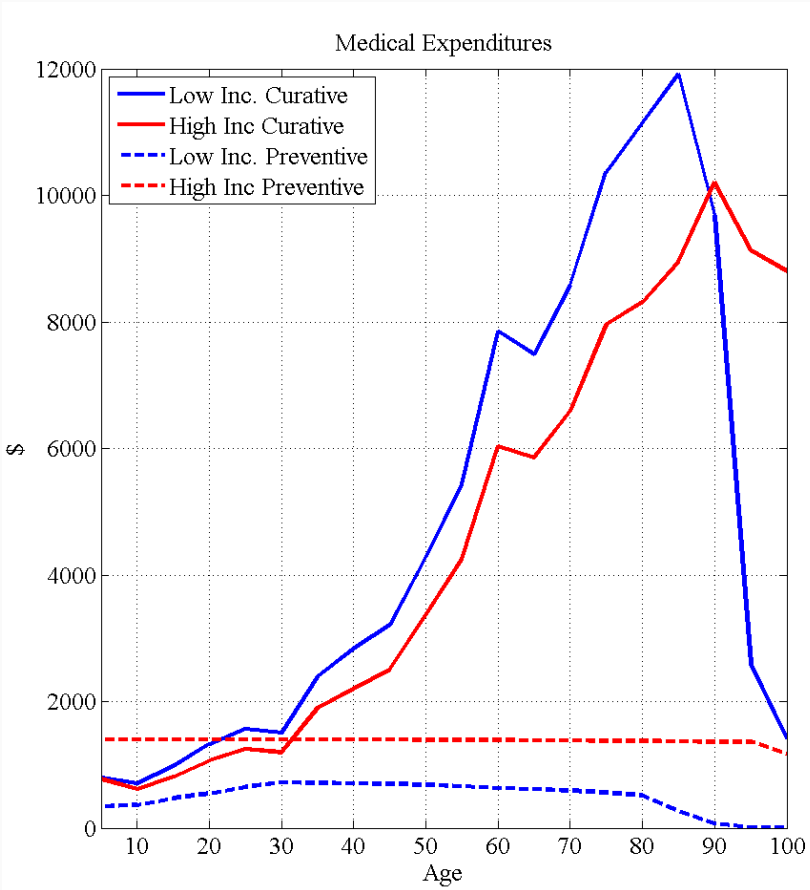
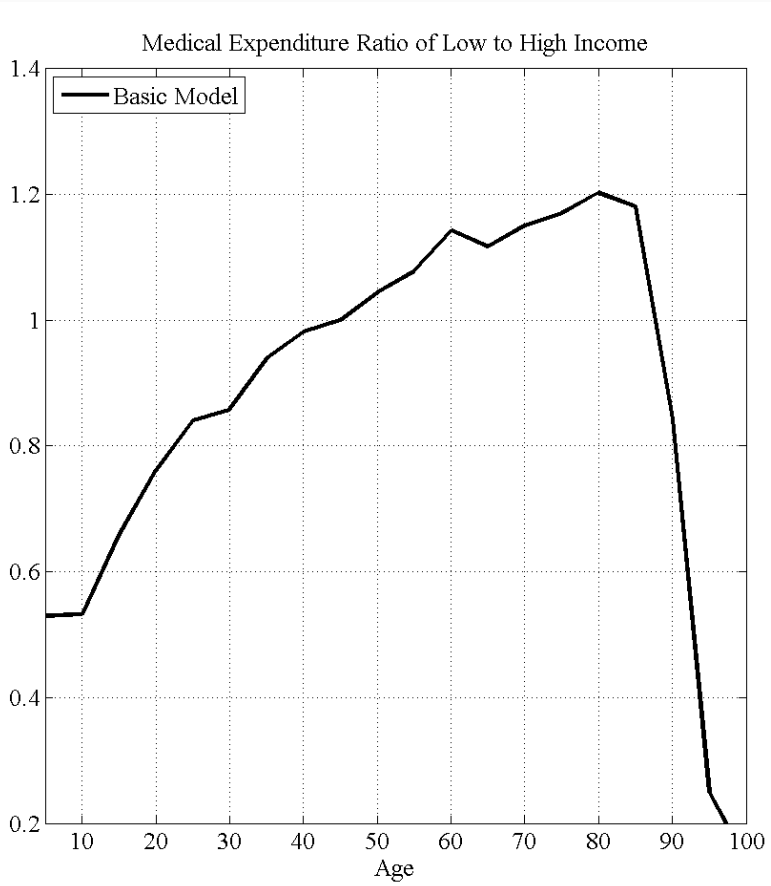
Basic Model





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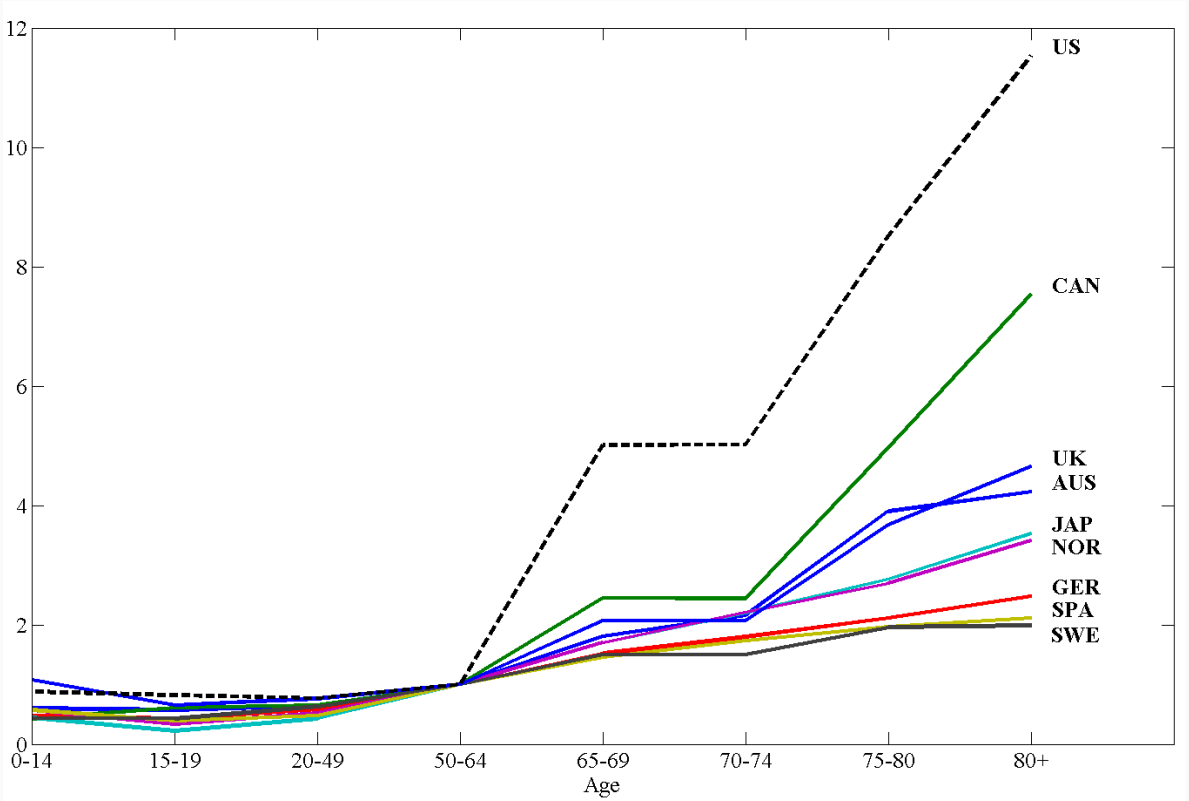
Comparison with the Literature

Outline

- **Empirical Facts** $\surd$
- **Intuition in a Stylized Framework** $\surd$
- **Full Model** $\surd$
- **Calibration/Estimation** $\surd$
- **Model's Performance** $\surd$
- **Policy Analysis** $\surd$
- **Comparison with the Literature**

Comparison with Literature



- In the U.S. the increase in health care spending is dramatically more rapid. (Hagist and Kotlikoff (2005))

Comparison with Literature

- The US ranked last in preventable deaths with timely and effective care among 19 peer countries (Nolte and McKee (2007)).
- Avoidable health condition is a particularly pervasive issue for the poor (National Healthcare Disparities Report (2003)).
  - Low-income patients have higher rates of avoidable hospital admissions
- The difference in probability of surviving to age 75 between the top and the bottom wealth tercile
  - 14% in the US
  - 8% in European countries. (Delavande and Rohwedder (2008))

Comparison with Literature

- Similar to the US healthcare reform
  - individual mandate to obtain health insurance

- Kolstad and Kowalski (2010) find that
  - hospitalizations for preventable conditions are reduced
  - growth in health care spending did not increase relative to other states

▸ Conclusion