

# Education, Healthy Habits, and Inequality

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# INTRODUCTION

- Health inequalities in the United States are large
- Two important facts:
  - a) Strong connection between **economic and health inequality**  
Kitagawa, Hauser (1973); Pijoan-Mas, Rios-Rull (2014); Chetty et al. (2016)
  - b) **Growing educational gradients** of health inequality  
Preston, Elo (1995); Meara et al. (2009); Montez et al. (2011); Case, Deaton (2015)
- Reasons not well-understood
- We study to which extent **differences in health behaviors** across education groups can account for these facts
  - Health behaviors are an important driver of health outcomes  
McGinnis, Foege (1993); Li et al. (2018); Zaninotto et al. (2020)
  - Individuals with higher levels of education are more likely to adopt health-enhancing behaviors  
Lantz et al. (1998); Cutler, Lleras-Muney (2010); Polvinen et al. (2013)

# OBJECTIVES

- 1 Measure the impact of lifestyles on health dynamics and economic outcomes
- 2 Understand the joint determination of education and lifestyles
  - Why is there an education gradient of lifestyles?
    - a) Do higher educated individuals have a higher incentives to invest in protective lifestyles?
    - b) Do individuals raised in healthier environments self-select into higher education?
- 3 Understand the increase in the education gradient of life expectancy
  - Quantify the role played by the increase in the education wage premium

## WHAT WE DO: DATA

- There are many indicators of health behavior in HRS and PSID  
(*preventive tests, substance abuse, exercise*)
    - Ideally, we would like to incorporate all this info into a structural model
  - Problems:
    - Observed health behaviors are noisy signals of lifestyles  
(they are imperfectly correlated across individuals and over time)
    - Hard to identify their long-run effect on health outcomes
    - Curse of dimensionality
  - We identify patterns in health behavior types that we interpret as lifestyles based on:
    - Cross-sectional and panel variation of health behaviors
    - Health dynamics
- Types are permanent, but health behaviors change with age and health status

# WHAT WE DO: DATA

## Results

- 1 Health behavior well represented by two lifestyles: **protective** and **detrimental**
- 2 Large effects of lifestyle on LE
  - LE at age 50 is 8.5 years larger for **protective** than for **detrimental**
- 3 Complementarity between education and lifestyles
  - Effects of lifestyle on LE larger for the more educated
- 4 Lifestyles are correlated w/ education
  - **Detrimental** type much more frequent among the less educated
  - Lifestyles explain around 40% of the education gradient in LE
- 5 The difference in lifestyles across education groups has increased over time

# WHAT WE DO

## Model

- Heterogeneous agents model featuring two different stages
  - 2) Adulthood — standard life-cycle model with labor income and health risks
    - Given education and lifestyle
    - Choice of consumption and savings
    - Provides *early life* value of each education and lifestyle choice
  - 1) Early life — simple static problem
    - Once and for all choice of education and lifestyle
    - Cost of education and lifestyle that is idiosyncratic across individuals
    - Provides joint distribution of education and lifestyles
- Complementarities between education and lifestyle choices
  - a) An extra year of life is more valuable with higher consumption possibilities
  - b) The benefit in health dynamics of **protective** behavior larger for the more educated

⇒ Selection: individuals from healthier backgrounds tend to pursue higher education.

## WHAT WE DO: MODEL

### Results

- Education gradient of lifestyles (recall: it explains 40% of the education gradient of LE)
  - Income advantage explains 40% ( $\Rightarrow$  1 year of LE gradient)
  - Health advantage of protective behavior explains 30% ( $\Rightarrow$  10 months)
  - Selection explains 50% ( $\Rightarrow$  1 year 2 months)
- Increase in education gradient of LE between 1930s and 1970s cohorts
  - Changes in college wage premium explain 2/3 of the increase in the LE gradient
  - 40% explained by direct effect
  - 60% explained by selection

## LITERATURE ON HEALTH AND ECONOMIC INEQUALITY

- Models with *exogenous health dynamics*

De Nardi et al. (2010); Ameriks et al. (2020); Bueren (2023); Nakajima, Telyukova (2023)  
Capatina (2015); Braun et al (2019); Hosseini et al (2021); De Nardi et al. (2023)

→ We model endogenous health dynamics

- Models with *endogenous monetary health investments*

Fonseca et al. (2023); Ozkan (2023); Hong, Pijoan-Mas, Ríos-Rull (2024)

→ Scarce causal evidence of effects of money on health

→ We focus on health-related behaviour

- Models with *endogenous health behaviour investments*

Cole et al. (2019); Mahler, Yum (2023); Margaritis, Wallenius (2023)

→ Joint decision of education and lifestyle: deal with selection

→ Effect of lifestyle identified by long-run health dynamics

Hai, Heckman (2024)

→ We model different channels

→ We study long-run changes of economic and health inequality



# Health Dynamics and Health Behavior

# THE DATA

- HRS and PSID
  - Unbalanced panels of individuals  $i = 1, \dots, N$  followed  $t = 1, \dots, T$  periods
- Demographic information: birth cohort ( $c$ ), sex ( $s$ ), education ( $e$ ), age ( $a_t$ )
- Wide array of information on health status and health behavior
  - Health state  $h_t$ : self-reported health (good/bad) + death
  - Health behavior  $z_{mt} \in \{0, 1\}$ :
    - 1 Preventive cancer tests (mammography / prostate check)
    - 2 Cholesterol test
    - 3 Flu shot
    - 4 Heavy drinking (2+ drinks on the day they drink)
    - 5 Smoking
    - 6 Exercise

# HEALTH BEHAVIOR AND HEALTH OUTCOMES

- Across demographic groups: **health behaviors** associated w/ health outcomes
- But, at individual level:
  - Different **health behaviors** imperfectly correlated across individuals and over time  
[\[See data\]](#)
  - Hard to identify their long-run effect on health outcomes
  - Curse of dimensionality if you want to put them in a model

## LATENT TYPES

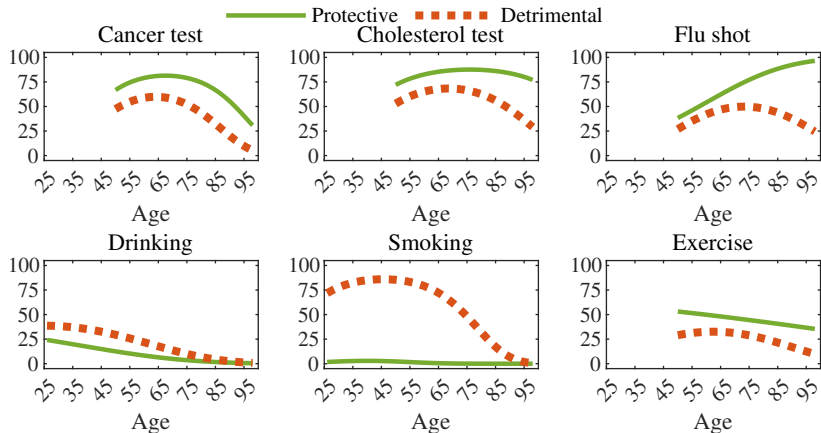
- We assume that observed **health behavior** is the (noisy) result of a **latent time-invariant** factor  $y \in Y \equiv \{y_1, y_2, \dots\}$ 
  - We interpret **y** as the individual lifestyle: propensity to engage in healthy behaviors
- We propose a novel econometric model to
  - Allocate individuals to lifestyles **y**
  - Measure the importance of lifestyles on health dynamics
- We *jointly estimate* health dynamics and lifestyles using a mixture model:

$$\begin{aligned}
 p(\mathbf{z}, \mathbf{h} | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0) &= \sum_{y \in Y} p(\mathbf{z}, \mathbf{h} | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0, y) p(y | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0) \\
 &= \sum_{y \in Y} p(\mathbf{z} | \mathbf{h}, \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0, y) p(\mathbf{h} | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0, y) p(y | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0) \\
 &\simeq \sum_{y \in Y} \underbrace{p(\mathbf{z} | \mathbf{h}, a_0, y)}_{\text{health behavior}} \underbrace{p(\mathbf{h} | \mathbf{s}, \mathbf{e}, a_0, y)}_{\text{health dynamics}} \underbrace{p(y | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0)}_{\text{lifestyle distribution}}
 \end{aligned}$$

## RESULTS: LIFESTYLES AND HEALTH BEHAVIOR

1. Lifestyles “well” approximated by 2 types: protective and detrimental

### Probability of reporting health behaviors by lifestyle



## RESULTS: LIFESTYLES AND HEALTH DYNAMICS

2. LE at age 50 is 8.6 years larger for **protective** than for **detrimental**

## LE at age 50 across education and lifestyles: males born in 1970s

	All		HSD		HSG		CG		$\Delta$ LE (CG-HSD)		
	%	LE	%	LE	%	LE	%	LE	Data	(a)	(b)
All	100	<b>29.3</b>	100	24.9	100	28.0	100	32.8	7.9	4.7	3.2
PRO	74.4	<b>31.5</b>	44.3	28.5	69.0	30.1	93.6	33.4	4.9		
DET	25.6	<b>22.9</b>	55.7	22.0	31.0	23.3	6.4	23.8	1.9		
$\Delta$	48.8	<b>8.6</b>	-11.4	6.6	37.9	6.8	87.2	9.6	3.0		

(a) Gradient explained by difference in health dynamics across education groups for given lifestyle,  $\Delta_e p(\mathbf{h}|\mathbf{e}, \mathbf{y})$

(b) Gradient explained by difference in lifestyles across education groups for given health dynamics,  $\Delta_e p(\mathbf{y}|\mathbf{e})$

## RESULTS: LIFESTYLES, EDUCATION, AND HEALTH DYNAMICS

## 3. Effect of lifestyle on LE larger for the more educated (3 years)

## LE at age 50 across education and lifestyles: males born in 1970s

	All		HSD		HSG		CG		$\Delta$ LE (CG-HSD)		
	%	LE	%	LE	%	LE	%	LE	Data	(a)	(b)
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(a) Gradient explained by difference in health dynamics across education groups for given lifestyle,  $\Delta_e p(\mathbf{h}|\mathbf{e}, y)$ (b) Gradient explained by difference in lifestyles across education groups for given health dynamics,  $\Delta_e p(y|\mathbf{e})$

## RESULTS: LIFESTYLES, EDUCATION, AND HEALTH DYNAMICS

## 4. Lifestyles explain around 40% of the education gradient of LE

## LE at age 50 across education and lifestyles: males born in 1970s

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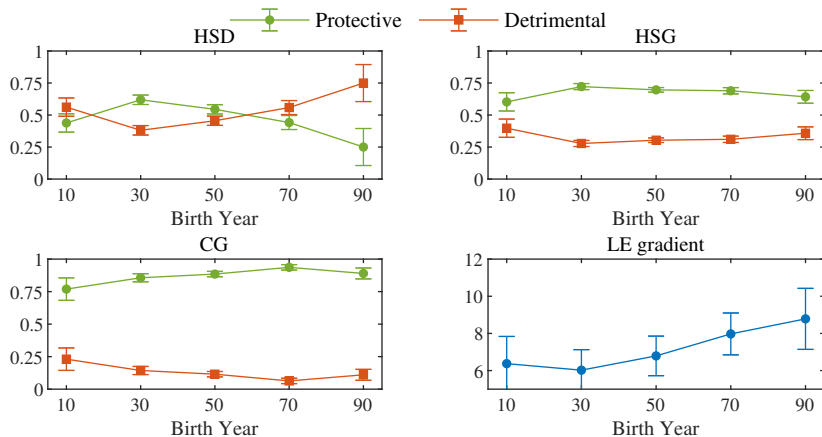
(a) Gradient explained by difference in health dynamics across education groups for given lifestyle,  $\Delta_e p(\mathbf{h}|\mathbf{e}, y)$ (b) Gradient explained by difference in lifestyles across education groups for given health dynamics,  $\Delta_e p(y|\mathbf{e})$



## RESULTS: CHANGES ACROSS COHORTS

### 5. Education gradient of lifestyles widens over time

#### Probability of lifestyle at age 50 across cohorts. Males



## The Model

# THE MODEL

## Two different stages

- 1 Early life
  - Choice of education and lifestyle
- 2 Life cycle
  - a) **Working age**: standard life-cycle incomplete-markets model of consumption with health and labor market risks
  - b) **Retirement**: as before, but without labor market risks

## Stage 1: Early life

## SET UP

- Teenager/parents in cohort  $c$  make once-and-for-all simultaneous choices of
  - education  $e \in \{\text{HSD}, \text{HSG}, \text{CG}\}$
  - lifestyle  $y \in \{\text{DET}, \text{PRO}\}$

- They solve  $\max_{e,y} \left\{ V_0^{\text{eyc}} - \tau_e - \tau_y \right\}$

- Value  $V_0^{\text{eyc}}$  of starting stage 2 with type  $(e, y, c)$
- Cost  $\tau_e$  of education  $e$ :

$$\tau_{\text{HSD}} = 0 \quad | \quad \tau_{\text{HSG}} \sim N(\mu_{\text{HSG}}, \sigma_{\text{HSG}}) \quad | \quad \tau_{\text{CG}} \sim N(\mu_{\text{CG}}, \sigma_{\text{CG}})$$

- Cost  $\tau_y$  of lifestyle  $y$ :

$$\tau_{\text{DET}} = 0 \quad | \quad \tau_{\text{PRO}} \sim N(\mu_{\text{PRO}}, \sigma_{\text{PRO}})$$

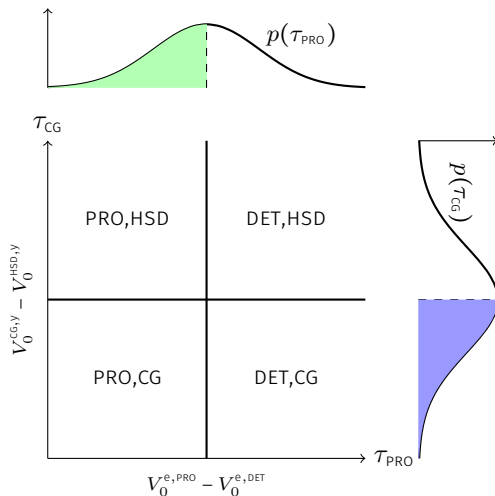
- The choices are independent if  $V_0^{\text{CG,PRO}} - V_0^{\text{CG,DET}} = V_0^{\text{HSD,PRO}} - V_0^{\text{HSD,DET}}$
- There are [complementarities](#) between education and lifestyle if:

$$V_0^{\text{CG,PRO}} - V_0^{\text{CG,DET}} > V_0^{\text{HSD,PRO}} - V_0^{\text{HSD,DET}} \Leftrightarrow V_0^{\text{CG,PRO}} - V_0^{\text{HSD,PRO}} > V_0^{\text{CG,DET}} - V_0^{\text{HSD,DET}}$$

[\[See theory\]](#)

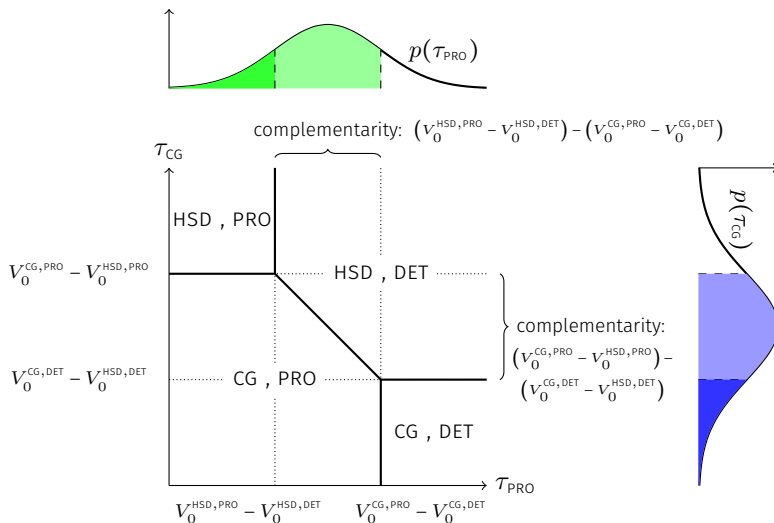
## CHOICES: TWO EDUCATION LEVELS

Independent choices:  $V_0^{CG,PRO} - V_0^{CG,DET} = V_0^{HSD,PRO} - V_0^{HSD,DET}$



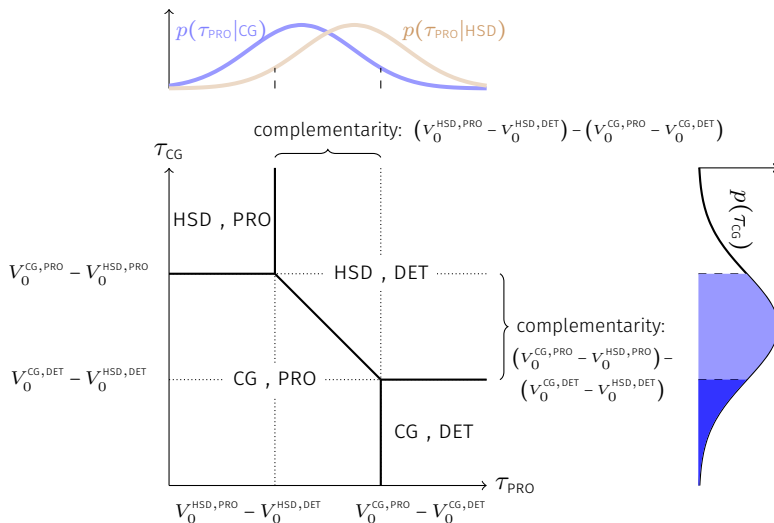
## CHOICES: TWO EDUCATION LEVELS

Complementarities:  $V_0^{\text{CG}, \text{PRO}} - V_0^{\text{CG}, \text{DET}} > V_0^{\text{HSD}, \text{PRO}} - V_0^{\text{HSD}, \text{DET}}$



## CHOICES: TWO EDUCATION LEVELS

Complementarities:  $V_0^{CG,PRO} - V_0^{CG,DET} > V_0^{HSD,PRO} - V_0^{HSD,DET}$





Stage 2: Life cycle

## STATE VARIABLES

- Working agents are heterogeneous with respect to:

### 1 Types

- Education  $e \in \{\text{HSD}, \text{HSG}, \text{CG}\}$
- Lifestyle  $y \in \{\text{DET}, \text{PRO}\}$
- Cohort  $c \in \{1930, 1970\}$

### 2 Exogeneous and deterministic state

- Age  $t \in \{25, 27, 29, \dots\}$

### 3 Exogeneous and stochastic states

- Health status  $h_t \in \{h_g, h_b\}$
- Employment status  $l_t \in \{0, 1\}$
- Shock to earnings  $\zeta_t \in \mathbb{R}$

### 4 Endogenous state

- Cash-on-hand  $x_t \in [\underline{x}, \infty)$

# INGREDIENTS

- Cohort-specific ingredients

- Perceptions about effect of type  $y$  on health dynamics
  - Individuals do not understand well the link between type  $y$  and health dynamics
  - $\lambda^c \in [0, 1]$  indicates how much individuals born in cohort  $c$  know about it
- Employment status  $l_t^{ec}(\varepsilon, h)$
- Labor earnings  $w_t^{ec}(\zeta, \epsilon, h)$

- Cohort-independent ingredients

- Health dynamics  $s_t^{ey}(h)$  and  $\Gamma_t^{ey}(h'|h)$   
*(but cohort effects appear through the joint distribution of  $e$  and  $y$ )*
- Medical expenses  $m_t^e(\xi, h)$
- Progressive tax system  $T(\cdot)$  and minimum income floor  $\underline{x}$

## WORKER'S PROBLEM

- Worker's problem can be written as:

$$V_t^{\text{eyc}}(h, \zeta, x) = \max_{c, k'} \left\{ u(c) + \beta \left[ \lambda^c W_t^{\text{eyc}}(h', \zeta', x') + (1 - \lambda^c) \widehat{W}_t^{\text{eyc}}(h', \zeta', x') \right] \right\}$$

$$W_t^{\text{eyc}}(h', \zeta', x') = s_t^{\text{ey}}(h) \sum_{h'} \Gamma_t^{\text{ey}}(h'|h) \mathbb{E}[V_{t+1}^{\text{eyc}}(h', \zeta', x')] + (1 - s_t^{\text{ey}}(h)) v_{t+1}(k')$$

$$\widehat{W}_t^{\text{eyc}}(h', \zeta', x') = s_t^{\text{e}}(h) \sum_{h'} \Gamma_t^{\text{e}}(h'|h) \mathbb{E}[V_{t+1}^{\text{eyc}}(h', \zeta', x')] + (1 - s_t(h)) v_{t+1}(k')$$

$$\text{s.t. } k' = x - c$$

$$\tilde{x}' = (1 + r) k' + T[l_{t+1}^{\text{ec}}(\varepsilon', h') w_{t+1}^{\text{ec}}(\zeta', \epsilon', h')] - m_{t+1}^{\text{e}}(\xi', h')$$

$$x' = \max\{\tilde{x}', \underline{x}\}$$

$$\text{Flow utility: } u(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma} + b$$

$$\text{Bequest motive: } v_{t+1}(k) = \beta^{T-(t+1)} \theta_1 \frac{(k + \theta_2)^{1-\sigma} - 1}{1 - \sigma}$$

## Calibration

# ESTIMATION

- Life-cycle:
  - External:
    - Parameters related to: demographics, taxes, social security
    - Cohort-specific wages  $w_t^{\text{ec}}(\zeta, \epsilon, h)$  and labor force participation  $l_t^{\text{ec}}(\epsilon, h)$
    - Cohort-independent health dynamics  $s_t^{\text{ey}}(h)$ ,  $\Gamma_t^{\text{ey}}(h'|h)$ , and medical spending  $m_t^{\text{e}}(\xi, h)$
  - Internal: SMM to calibrate remaining 4 parameters  $(\underline{x}, \theta_1, \theta_2, b)$ 
    - Median wealth across age (by education and lifestyles) for the 1930s cohort
    - Value of statistical life
- Early life:
  - Estimate cost parameters by matching the joint distribution of education and lifestyles for two different cohorts: 1930 and 1970.
- Outside loop:
  - Perceptions  $\lambda^c$  best matches the joint distribution of education and lifestyles: 1930, 1970

## ESTIMATION: LIFE-CYCLE

### Externally estimated parameters

- Labor income (PSID and Census):

- Extensive margin (probit):

$$\begin{aligned}\hat{l}_t^{\text{ec}}(\varepsilon_t, h_t) &= f_t^{\text{ec}} + f_t^{\text{e}}(h_t) + \varepsilon_t, & \varepsilon_t &\sim N(0, 1) \\ l_t^{\text{ec}}(\varepsilon_t, h_t) &= 1 \text{ if } \hat{l}_t^{\text{ec}}() > 0\end{aligned}$$

- Intensive margin:

$$\begin{aligned}\log w_t^{\text{ec}}(\zeta_t, \epsilon_t, h_t) &= \omega_t^{\text{ec}} + \omega_t^{\text{e}}(h_t) + \zeta_t + \epsilon_t, & \epsilon_t &\sim N(0, \sigma_\epsilon^2) \\ \zeta_t &= \rho_\zeta \zeta_{t-1} + \nu_t, & \nu_t &\sim N(0, \sigma_\nu^2)\end{aligned}$$

- Medical expenses (HRS):

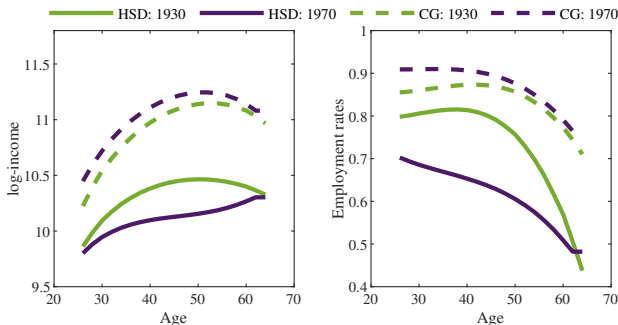
$$\log m_t^{\text{e}}(\xi_t, h_t) = \lambda_t^{\text{e}}(h_t) + \xi_t, \quad \xi_t \sim N(0, \sigma_\xi^2)$$

## ESTIMATION: LIFE-CYCLE

## Cohort-specific lifetime earnings

- Lifetime earnings
  - CG:  $\Delta_{sc} = +12\%$
  - HSD:  $\Delta_{sc} = -18\%$

## College premium and labor force participation across cohorts



Source: US Census (1940-2022)



## ESTIMATION: LIFE-CYCLE

### Internally estimated parameters

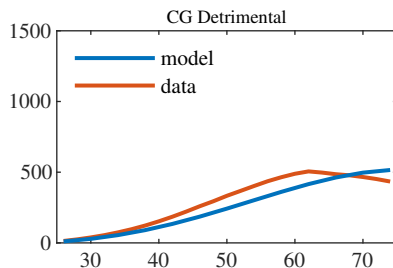
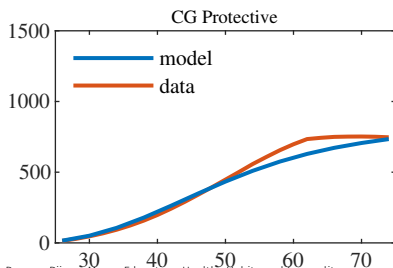
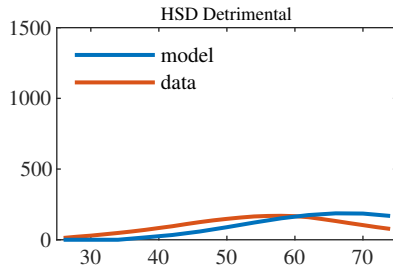
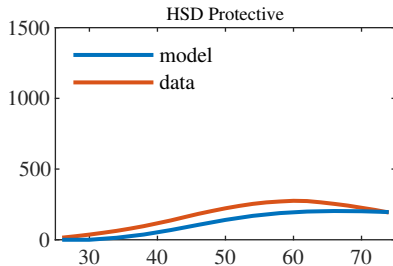
- The model is able to replicate
  - Higher wealth accumulation for the more educated
  - Higher wealth accumulation for the **protective** (conditional on education)
- We choose a VSL of 1 Million \$
- Parameter values

Parameter	Description	Value
$\underline{x}$	income floor	17.34
$\theta_1$	bequest motive: marginal utility	9.23
$\theta_2$	bequest motive: non-homoteticity	455.35
$b$	value of life	1.25

## ESTIMATION: LIFE-CYCLE

## Model Fit

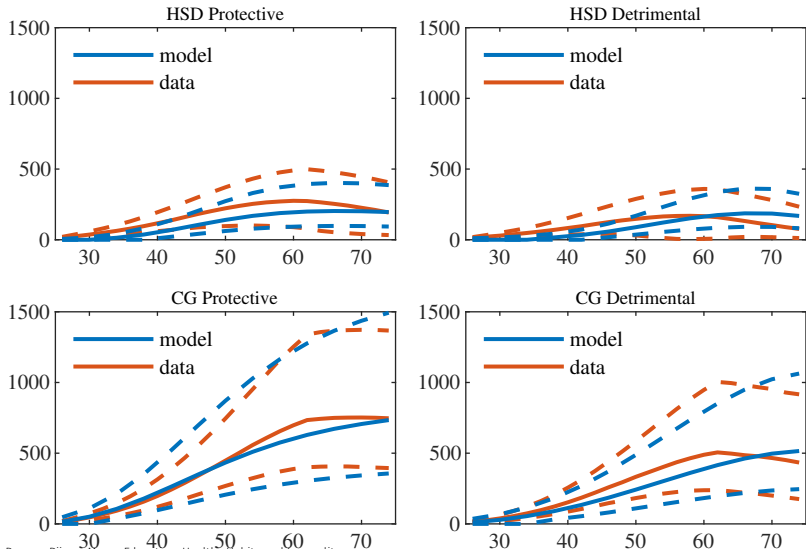
## Wealth profiles: median



## ESTIMATION: LIFE-CYCLE

## Model Fit

## Wealth profiles: median, 25th, 75th



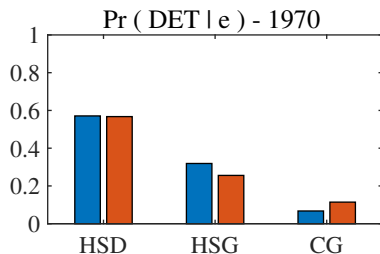
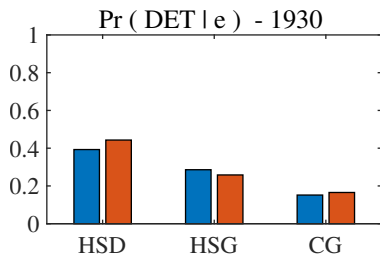
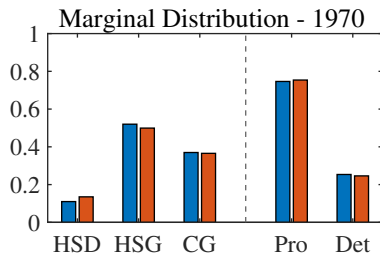
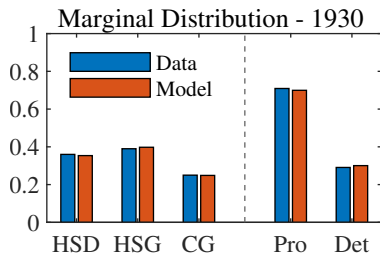
## ESTIMATION: EARLY-LIFE

- Match the joint distribution of  $e$  and  $y$  in each cohort  $c \in \{1930, 1970\}$ 
  - A total of 6 parameters and 10 statistics
- Identification
  - $\mu_{\text{HSD}}, \mu_{\text{CG}}, \mu_{\text{PRO}}$  drive the average share of  $e$  and  $y$  for one cohort
  - $\sigma_{\text{HSD}}, \sigma_{\text{CG}}, \sigma_{\text{PRO}}$  drive changes in  $e$  and  $y$  over cohorts  $c$  as  $V_0^{\text{eyc}}$  changes (due to changes in wages and labor force participation)
- Calibrate  $\lambda^{1970} = 1$  and  $\lambda^{1930}$  to match the increase in the life-expectancy gradient between the 1930 and the 1970 cohort.

Parameter	Value	Parameter	Value
$\mu_{\text{HSD}}$	6.53	$\sigma_{\text{HSD}}$	2.02
$\mu_{\text{CG}}$	26.55	$\sigma_{\text{CG}}$	18.92
$\mu_{\text{PRO}}$	-1.27	$\sigma_{\text{PRO}}$	10.38
$\lambda^{1930}$	0.85		

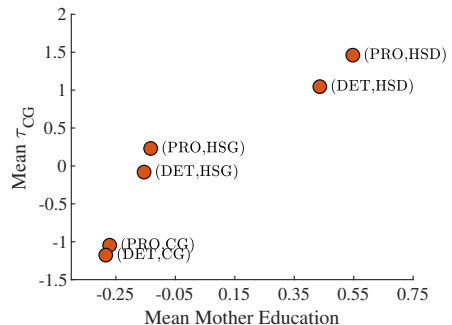
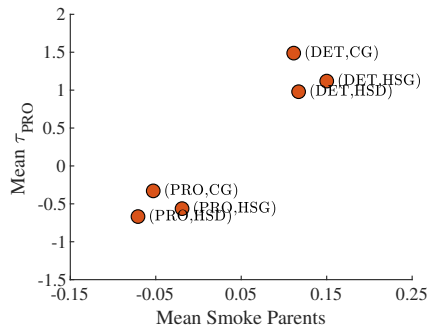
## ESTIMATION: EARLY-LIFE

## Model Fit: Early-life



## ESTIMATION: EARLY-LIFE

## Model Validation: Early-life



# Counterfactuals

## TWO QUESTIONS

- 1 Why is there an education gradient of lifestyles?
- 2 What has been the effect of the rise in the education wage premium on the increase in education gradient of LE?



Question 1: Education gradient of lifestyle

# EDUCATION GRADIENT OF LIFESTYLE

## Mechanisms

- Why higher educated individuals are more likely to be **protective**?

① Income gradient:  $w_t^{ec}(\zeta, \epsilon, h)$  and  $l_t^{ec}(\epsilon, h)$

Higher expected income for the more educated motivates healthier behavior because the value of life increases w/ consumption possibilities

$$V_0^{CG,PRO} - V_0^{CG,DET} > V_0^{HSD,PRO} - V_0^{HSD,DET}$$

② Complementarities in health dynamics:  $s_t^{ey}(h)$  and  $\Gamma_t^{ey}(h|h)$

Gains in life expectancy due to protective health behavior are larger for those with a college education

$$V_0^{CG,PRO} - V_0^{CG,DET} > V_0^{HSD,PRO} - V_0^{HSD,DET}$$

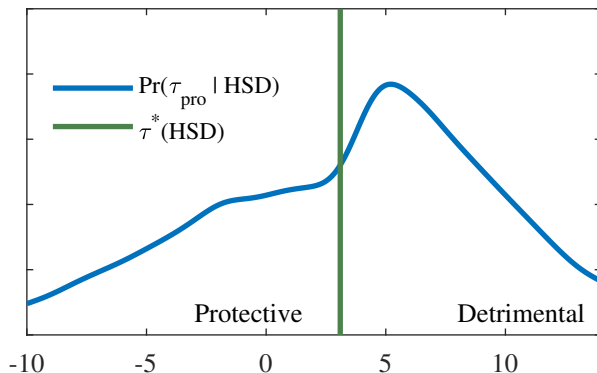
③ Selection:

Given the complementarities between lifestyle and education, individuals facing lower cost of **protective** behavior ( $\tau_{PRO}$ ) are more likely to choose higher education.

## EDUCATION GRADIENT OF LIFESTYLE

### Lifestyle Choice for HSD

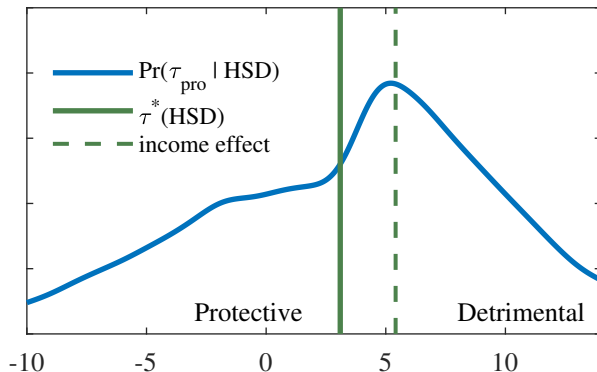
- HSD choose  $y = \text{PRO}$  iff  $\tau_{\text{PRO}} < V_0^{\text{HSD,PRO}} - V_0^{\text{HSD,DET}} \equiv \tau^*(\text{HSD})$



# EDUCATION GRADIENT OF LIFESTYLE

## 1. Income Effect

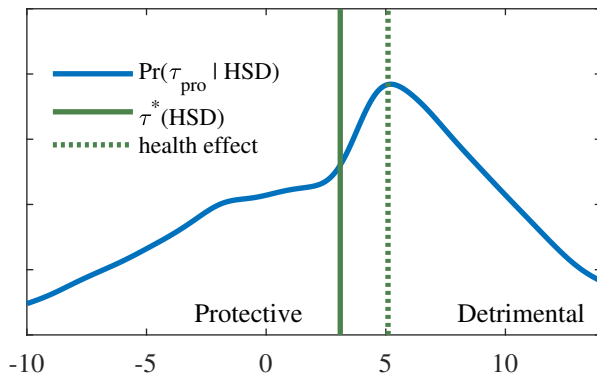
→ If HSD had **same income** as CG: 16pp more of PRO (out of 43pp gap)



# EDUCATION GRADIENT OF LIFESTYLE

## 2. Health Effect

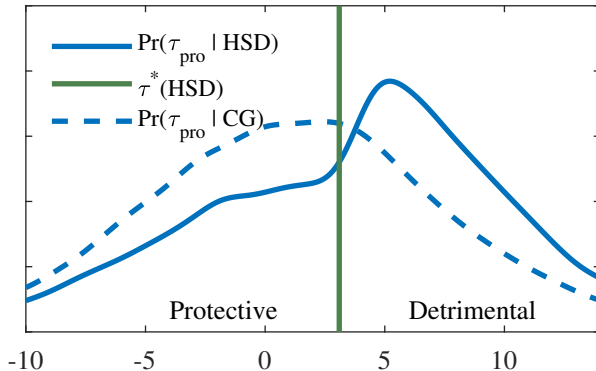
→ If HSD had **same health gain of PRO** as CG: 13pp more of PRO (out of 43pp gap)



## EDUCATION GRADIENT OF LIFESTYLE

### 3. Selection

→ If HSD had same distribution of  $\tau_{\text{PRO}}$  as CG: 19pp more of PRO (out of 43pp gap)



# EDUCATION GRADIENT OF LIFESTYLE

## Summary

### Decomposition: 1970s cohort

	$\Pr(\text{PRO} \text{HSD})$	$\Pr(\text{PRO} \text{CG})$	$\Delta\Pr(\text{PRO})$	LE(HSD)	LE(CG)	$\Delta\text{LE}$
Model	0.42	0.85	0.43	24.7	32.1	7.3
Same lifestyle	0.85	0.85	0.00	27.5	32.1	4.7
Health	0.55	0.85	0.30	25.6	32.1	6.5
Income	0.58	0.85	0.27	25.8	32.1	6.3
Selection	0.61	0.85	0.24	26.0	32.1	6.1

## Question 2: Changes over time



## CHANGES OVER TIME

### Mechanisms

- Income effect: Increases in the education wage premium strengthen the complementarity between education and lifestyles,

$$\Delta_c (V_0^{\text{CG,PRO,C}} - V_0^{\text{CG,DET,C}}) > \Delta_c (V_0^{\text{HSD,PRO,C}} - V_0^{\text{HSD,DET,C}})$$

→ This increases the education gradient in  $\Pr[y = \text{PRO} | e]$

- Perceptions: As individuals become aware of the importance of types on health outcomes, they are more willing to invest in **protective** behavior.

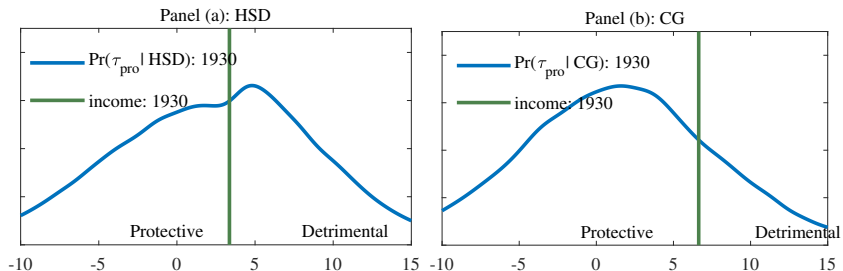
→ Unclear effect on the education gradient

- Selection effect: worse pool of individuals in terms  $\tau_{\text{PRO}}$  for both HSD and CG.

→ Unclear effect on the education gradient

## CHANGES OVER TIME: 1930 VS 1970 COHORTS

1930 cohort

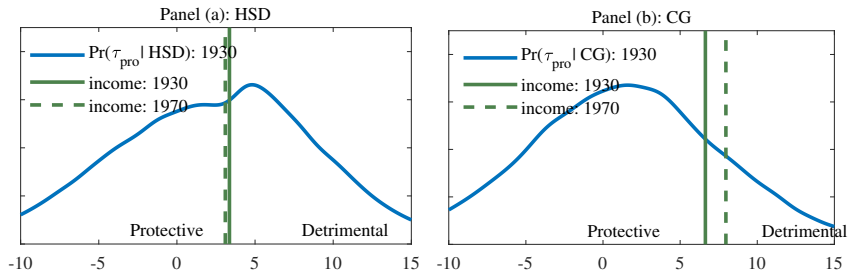


# CHANGES OVER TIME: 1930 VS 1970 COHORTS

## Income effect

$\Pr(\tau_{\text{PRO}} | e)$  as in 1930, education premium widens

- $\Pr(\text{PRO} | \text{HSD})$  declines 1pp
- $\Pr(\text{PRO} | \text{CG})$  increases 5pp
- LE gradient widens 7 months

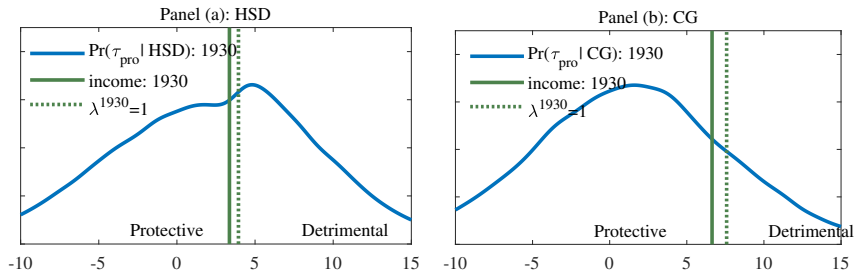


# CHANGES OVER TIME: 1930 VS 1970 COHORTS

## Changes in Perceptions

$\Pr(\tau_{\text{PRO}} | e)$  and income as in 1930, perceptions as in 1970 (fully aware)

- $\Pr(\text{PRO}|\text{HSD})$  increases 3pp
- $\Pr(\text{PRO}|\text{CG})$  increases 4pp
- LE gradient widens 2 months

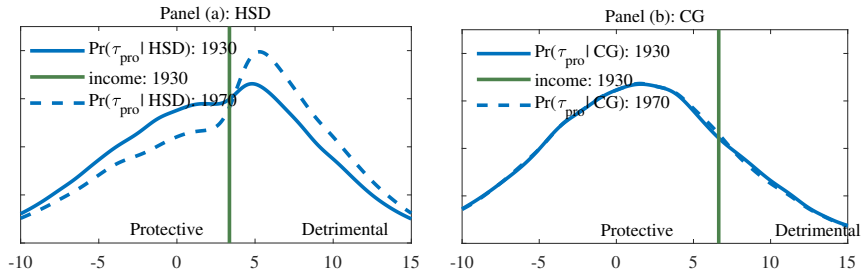


# CHANGES OVER TIME: 1930 VS 1970 COHORTS

## Selection effect

$\Pr(\tau_{\text{PRO}} | e)$  changes, education premium and perceptions as in 1930

- $\Pr(\text{PRO} | \text{HSD})$  declines 11pp
- $\Pr(\text{PRO} | \text{CG})$  increases 1pp
- LE gradient widens 9 months



# CHANGES OVER TIME: 1930 VS 1970 COHORTS

## Summary

### Decomposition

	$\Delta_c \text{Pr}(\text{CG})$	$\Delta_c \text{Pr}(\text{HSD})$	$\Delta_c \text{Pr}(\text{PRO})$	$\Delta_c \text{Pr}(\text{PRO} \text{CG})$	$\Delta_c \text{Pr}(\text{PRO} \text{HSD})$	$\Delta_c \Delta_e \text{LE}$
Data	0.12	-0.25	0.04	0.08	-0.18	1.92
Model	0.12	-0.26	0.05	0.06	-0.11	1.28
Income				0.05	-0.01	0.57
Perception				0.04	0.03	0.15
Selection				0.01	-0.11	0.75

## Conclusions

## CONCLUSIONS

- We develop an econometric model to identify latent types in lifestyles
  - ⇒ Differences in lifestyles across education groups account for 40% of the LE gradient (3.1 out of 7.8 years)
- HA model w/ complementarities in edu and health investments
  - ① Education gradient of lifestyles
    - Income advantage explains 25% (⇒ 8 months of LE gradient)
    - Health advantage of **protective** behavior explains 23% (⇒ 7 months)
    - Selection explains 66% (⇒ 1 year 10 months)
  - ② 1.9 years **increase in education gradient of LE** between 1930s and 1970s cohorts
    - Changes in wages and perceptions explains 2/3 of the increase
    - 44% explained by changes in wages
    - 5% explained by changes in perceptions
    - 60% explained by changes in selection



# ECONOMETRIC MODEL

## 1. Health Behavior

- We model the probability of individual  $i$  of reporting the  $m$ 'th behaviour ( $z_{mt} = 1$ ) at time  $t$  as a [probit model](#).
  - There is a latent variable ( $z_{mt}^*$ ) that depends on type ( $y$ ), age ( $a_t$ ), health ( $h_t$ ), and an idiosyncratic shock ( $\epsilon_t$ )

$$z_{mt}^* = \gamma_{0,m,y} + \gamma_{1,m,y}a_t + \gamma_{2,m,y}a_t^2 + \gamma_{3,m,y}h_t + \epsilon_t, \quad \epsilon_t \sim N(0, 1)$$

- Then,

$$\text{Prob}(z_{mt} = 1) = \text{Prob}(z_{mt}^* > 0) = \underbrace{\alpha_m(y, a_t, h_t)}_{\alpha_{mt}}$$

- Considering independence of health behaviour given type, the probability of observing a sequence of health behaviours  $\mathbf{z}$  for an individual across time, is assumed to be given by:

$$p(\mathbf{z}|\mathbf{h}, y) = \prod_{t=1}^T \prod_{m=1}^M \alpha_{mt}^{z_{mt}} (1 - \alpha_{mt})^{1-z_{mt}}$$

# ECONOMETRIC MODEL

## 2. Health Dynamics

- We model the probability of reporting some health  $h' \in \{Good, Bad, Dead\}$  next period as a [multinomial probit model](#)
  - There are latent variables ( $h_{h,h'}^*$ ) that depend on gender ( $g$ ), education ( $e$ ), type ( $y$ ), health ( $h$ ), age ( $a$ ), and an idiosyncratic shock ( $\epsilon_{h'}$ )

$$h_{h,h'}^* = f(a, s, e, y; \beta_{h,h'}) + \epsilon_{h'}$$

with,

$$f(a, g, e, y; \beta_{h'}) = \beta_{0,y,e,g,h,h'} + \beta_{1,y,e,g,h,h'} a$$

Back to Mixture Model

# ECONOMETRIC MODEL

## 3. Weights

- The mixture weights at the initial age (age 25) are modeled as a multinomial probit model:

$$\begin{aligned} y_1^* &= \lambda_{0,s,e,c}^1 + \lambda_{1,s,e}^1 bh + \epsilon_1 \\ &\vdots \\ y_Y^* &= \lambda_{0,s,e,c}^Y + \lambda_{1,s,e}^Y bh + \epsilon_Y, \end{aligned}$$

- We compute weights for future ages using the health transition model:

$$p(y, h_t | s, e, c) = \sum_{h_{t-1}} p(h_t | h_{t-1}, y, s, e) p(y, h_{t-1} | s, e, c)$$

[Back to Mixture Model](#)

## HEALTH BEHAVIOUR DATA

## Mean health behavior and 4-year auto-correlation

	Mean					AC	
	HSD	HSG	CG	50-60	70-80	50-60	70-80
Drinking	0.09	0.10	0.07	0.13	0.05	0.53	0.48
Smoking	0.23	0.16	0.07	0.21	0.08	0.81	0.78
Cancer test	0.66	0.76	0.85	0.71	0.77	0.42	0.41
Cholesterol	0.77	0.84	0.89	0.79	0.89	0.37	0.30
Flu shot	0.58	0.62	0.69	0.49	0.77	0.55	0.62
Exercise	0.26	0.39	0.55	0.42	0.38	0.40	0.39

Notes: HRS. HSD: high-school dropout; HSG: high-school graduate; CG: college graduate; 50-60: sub-sample of individuals aged 50 to 60; 70-80: sub-sample of individuals aged 70 to 80. The last two columns show the autocorrelation (AC) of each health behavior with a 4-year lag.

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## HEALTH BEHAVIOUR DATA

## Cross correlation health behaviors

	Drinking	Smoking	Cancer	Cholesterol	Flu shot	Exercise
Drinking	1.00	0.08	-0.02	-0.03	-0.03	0.02
Smoking	0.18	1.00	-0.10	-0.07	-0.06	-0.08
Cancer test	-0.04	-0.13	1.00	0.26	0.19	0.11
Cholesterol	-0.04	-0.11	0.39	1.00	0.24	0.07
Flu shot	-0.05	-0.05	0.23	0.24	1.00	0.02
Exercise	-0.01	-0.14	0.08	0.04	0.02	1.00

Notes: HRS. Upper diagonal: individuals aged 70 to 80. Lower diagonal: individuals aged 50 to 60.

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## SET UP: TWO EDUCATION CHOICES

- An individual decides to hold a protective lifestyle if:

$$\tau_{\text{PRO}} < \max\{V^{\text{CG,PRO}} - \tau_{\text{CG}}, V^{\text{HSD,PRO}}\} - \max\{V^{\text{CG,DET}} - \tau_{\text{CG}}, V^{\text{HSD,DET}}\}$$

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## SET UP: TWO EDUCATION CHOICES

- An individual decides to hold a protective lifestyle if:

$$\tau_{\text{PRO}} < \max\{V^{\text{CG,PRO}} - \tau_{\text{CG}}, V^{\text{HSD,PRO}}\} - \max\{V^{\text{CG,DET}} - \tau_{\text{CG}}, V^{\text{HSD,DET}}\}$$

- $V^{\text{CG,PRO}} - V^{\text{CG,DET}} = V^{\text{HSD,PRO}} - V^{\text{HSD,DET}}$ .

- An individual decides to be protective if:

$$\tau_{\text{PRO}} < V^{e,\text{PRO}} - V^{e,\text{DET}}$$

- The decision of being protective is independent on the value of  $\tau_{\text{CG}}$

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## SET UP: TWO EDUCATION CHOICES

- An individual decides to hold a protective lifestyle if:

$$\tau_{\text{PRO}} < \max\{V^{\text{CG,PRO}} - \tau_{\text{CG}}, V^{\text{HSD,PRO}}\} - \max\{V^{\text{CG,DET}} - \tau_{\text{CG}}, V^{\text{HSD,DET}}\}$$

- With  $V^{\text{CG,PRO}} - V^{\text{HSD,PRO}} > V^{\text{CG,DET}} - V^{\text{HSD,DET}}$ :

- An individual decides to be protective if:

$$\text{A. } \tau_{\text{CG}} < V^{\text{CG,DET}} - V^{\text{HSD,DET}} : \tau_{\text{PRO}} < V^{\text{CG,PRO}} - V^{\text{CG,DET}}$$

$$\text{B. } \tau_{\text{CG}} > V^{\text{CG,PRO}} - V^{\text{HSD,PRO}} : \tau_{\text{PRO}} < V^{\text{HSD,PRO}} - V^{\text{HSD,DET}}$$

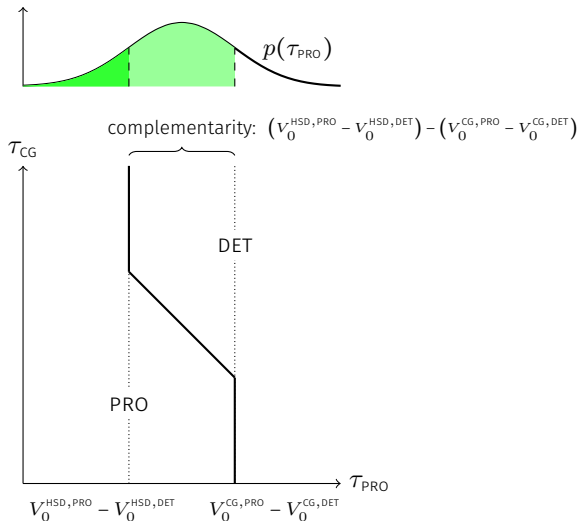
$$\text{C. } V^{\text{CG,DET}} - V^{\text{HSD,DET}} < \tau_{\text{CG}} < V^{\text{CG,PRO}} - V^{\text{HSD,PRO}} : \tau_{\text{PRO}} < V^{\text{CG,PRO}} - \tau_{\text{CG}} - V^{\text{HSD,DET}}$$

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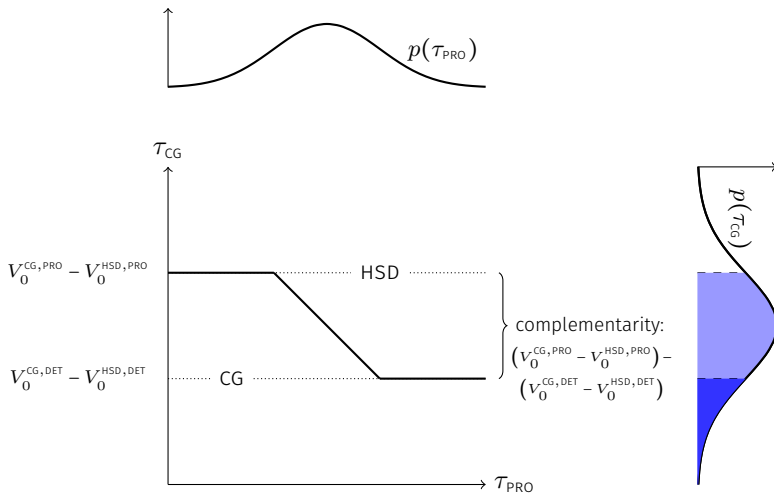
## CHOICES: TWO EDUCATION LEVELS

Complementarities:  $V_0^{\text{CG},\text{PRO}} - V_0^{\text{CG},\text{DET}} > V_0^{\text{HSD},\text{PRO}} - V_0^{\text{HSD},\text{DET}}$



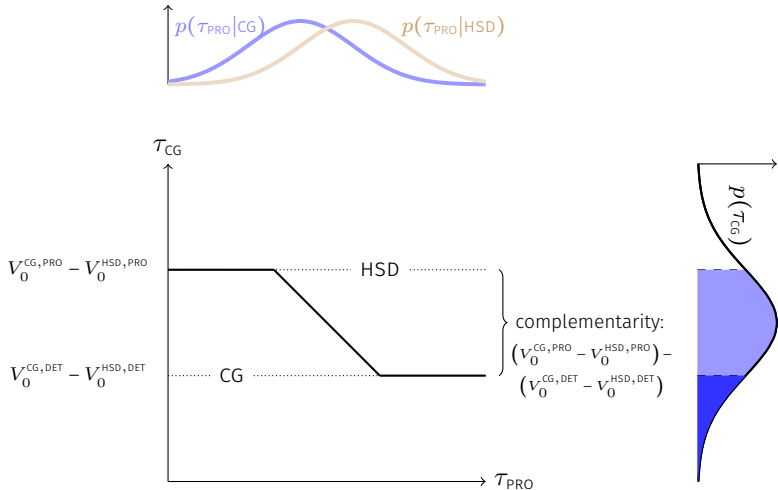
## CHOICES: TWO EDUCATION LEVELS

Complementarities:  $V_0^{\text{CG,PRO}} - V_0^{\text{CG,DET}} > V_0^{\text{HSD,PRO}} - V_0^{\text{HSD,DET}}$



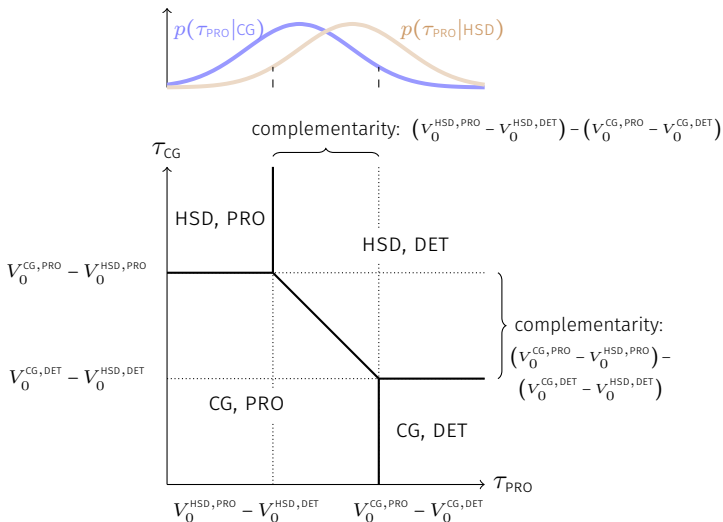
## CHOICES: TWO EDUCATION LEVELS

Complementarities:  $V_0^{\text{CG}, \text{PRO}} - V_0^{\text{CG}, \text{DET}} > V_0^{\text{HSD}, \text{PRO}} - V_0^{\text{HSD}, \text{DET}}$



## CHOICES: TWO EDUCATION LEVELS

Complementarities:  $V_0^{CG, PRO} - V_0^{CG, DET} > V_0^{HSD, PRO} - V_0^{HSD, DET}$



## CHOICES: TWO EDUCATION LEVELS

Complementarities:  $V_0^{\text{CG,PRO}} - V_0^{\text{CG,DET}} > V_0^{\text{HSD,PRO}} - V_0^{\text{HSD,DET}}$

- Complementarities imply:
  - Higher educated individuals are more likely to invest in protective lifestyle as the returns are larger: *direct effect*.
  - Individuals with lower cost cost of adopting health behavior (healthy parents/peers) are more likely to go to college: *selection effect*.
- Selection drives that the distribution of  $\tau_{\text{PRO}}$  across education groups is different:

$$F(\tau_{\text{PRO}}|\text{CG}) \geq F(\tau_{\text{PRO}}|\text{HSD})$$

⇒ High-school dropouts are negatively selected in terms of  $\tau_{\text{PRO}}$

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