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

- We take health dynamics conditional on education and lifestyle as given
- Calibrate the model to match:

  2) Adulthood — Wealth accumulation by education and lifestyles of 1930's cohort

  1) Early life — The joint distribution of education and lifestyles for different cohorts

→ Education gradient of lifestyles (recall: it explains 40% of the education gradient of LE)

- Income advantage explains 40% (⇒ 1 year of LE gradient)
- Health advantage of protective behavior explains 30% (⇒ 10 months)
- Selection explains 50% (⇒ 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); Margaris, 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 chanels

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

Health Dynamics and Health Behavior

The Data

- HRS and PSID
  - Unbalanced panels of individuals $i = 1, ..., N$ followed $t = 1, ..., T$ 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 $\in Y \equiv \{y_1, y_2, ...\}$
  - 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

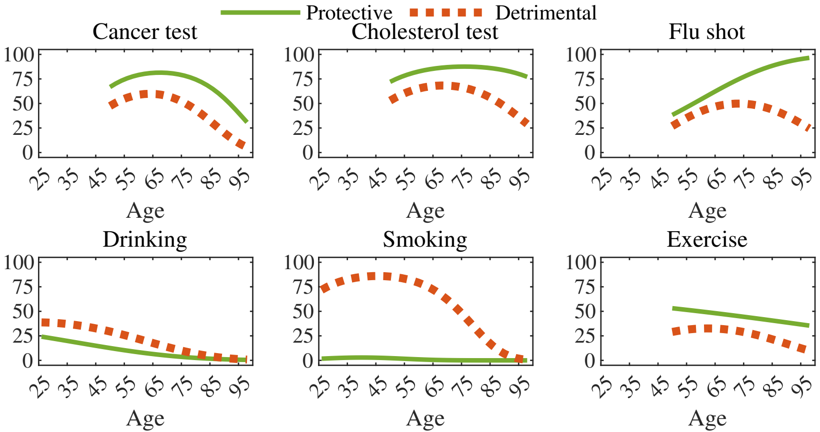
- We *jointly estimate* health dynamics and lifestyles using a mixture model:

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

Results: Lifestyles and health behavior

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

Figure 1: **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

Table 1: **LE at age 50 across education and lifestyles: males born in 1970s**

	All		HSD		HSG		CG		ΔLE (CG-HSD)		
	%	LE	%	LE	%	LE	%	LE	Data	(a)	(b)
All	100	**29.3**	100	24.9	100	28.0	100	32.8	7.9	4.7	3.2
PRO	74.4	**31.5**	44.3	28.5	69.0	30.1	93.6	33.4	4.9		
DET	25.6	**22.9**	55.7	22.0	31.0	23.3	6.4	23.8	1.9		
Δ	48.8	**8.6**	-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, $\Delta_e p(\boldsymbol{h}|e, y)$
(b) Gradient explained by difference in lifestyles across education groups for given health dynamics, $\Delta_e p(y|e)$

Results: Lifestyles, education, and health dynamics

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

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

Results: Lifestyles, education, and health dynamics

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

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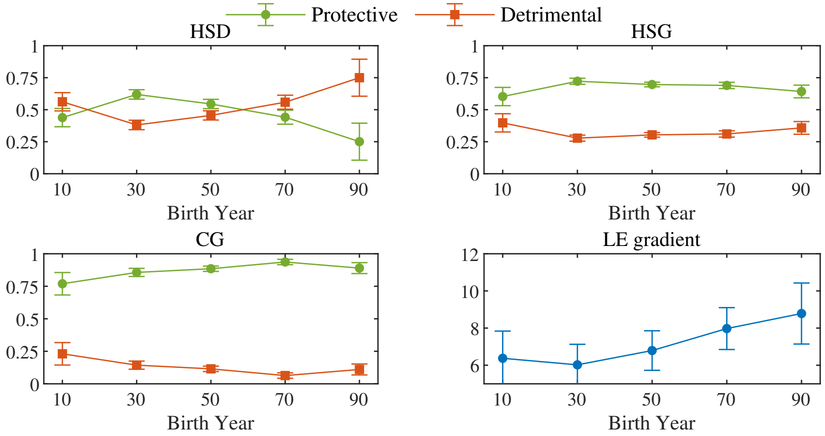
(b) Gradient explained by difference in lifestyles across education groups for given health dynamics, $\Delta_e p(y|\mathrm{e})$

Results: Changes across cohorts

5. Education gradient of lifestyles widens over time

Figure 2: **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 $\max_{e,y} \left\{ V_0^{eyc} - \tau_e - \tau_y \right\}$
  - Value V_0^{eyc} of starting stage 2 with type (e, y, c)
  - Cost τ_e of education e:

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

  - Cost τ_y of lifestyle y:

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

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

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

[See theory]

Stage 2: Life cycle

STATE VARIABLES

- Working agents are heterogeneous with respect to:

1. Types
   - Education e ∈ {HSD, HSG, CG}
   - Lifestyle y ∈ {DET, PRO}
   - Cohort c ∈ {1930, 1970}
2. Exogeneous and deterministic state
   - Age $t \in \{25, 27, 29, ...\}$
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 $T()$ and minimum income floor $\underline{x}$

Worker's problem

- Worker's problem can be written as:

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

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

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

$$\begin{aligned}
\text{s.t. } k' &= x - c \\
\tilde{x}' &= (1+r)\,k' + T\,[l_{t+1}^{\text{ec}}(\varepsilon',h')w_{t+1}^{\text{ec}}(\zeta',\epsilon',h')] - m_{t+1}^{\text{e}}(\xi',h') \\
x' &= \max\{\tilde{x}',\underline{x}\}
\end{aligned}$$

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

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

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 $l_t^{\text{ec}}(\varepsilon, h)$
    - Cohort-independent health dynamics $s_t^{\text{ey}}(h)$ and $\Gamma_t^{\text{ey}}(h'|h)$
    - Cohort-independent 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 marginal distributions of education and lifestyles for two different cohorts: 1930 and 1970.
- Outside loop:
  - Perceptions λ^c to match joint distribution of education and lifestyles: 1930, 1970

Estimation: Life-cycle

Externally estimated parameters

- Labor income (PSID and Census):
  - Extensive margin (probit):

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

  - Intensive margin:

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

- Medical expenses (HRS):

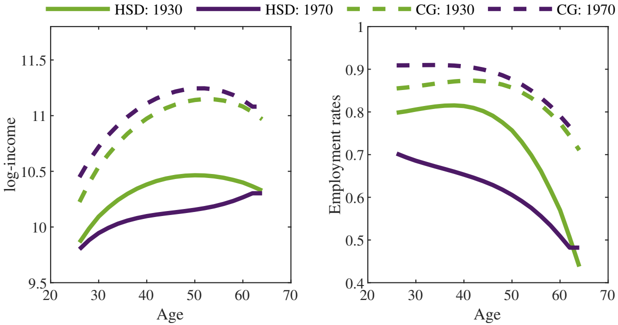
$$\log m_t^{\text{e}}(\xi_t, h_t) = \lambda_t^e(h_t) + \xi_t, \qquad \xi_t \sim N(0, \sigma_\xi^2)$$

Estimation: Life-cycle

Cohort-specific lifetime earnings

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

Figure 3: **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 $

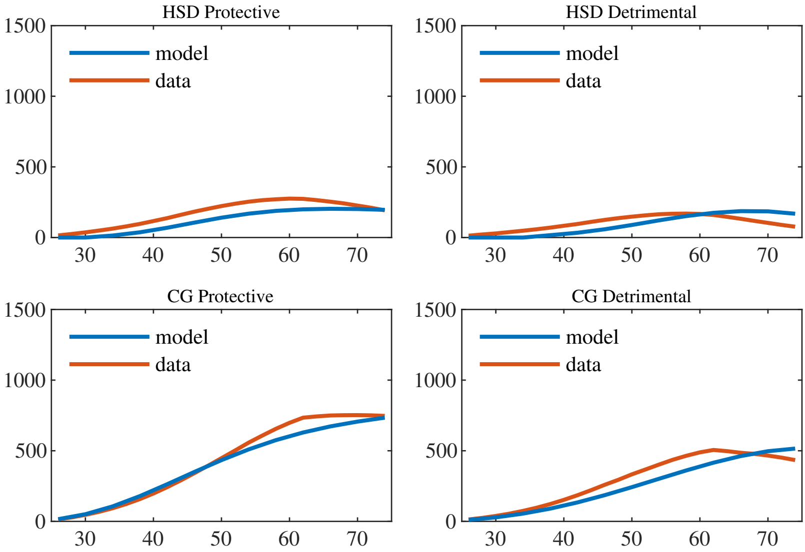
- Parameter values

Parameter	Description	Value
$\underline{x}$	income floor	17.34
θ_1	bequest motive: marginal utility	9.23
θ_2	bequest motive: non-homoteticity	455.35
b	value of life	1.25

Estimation: Life-cycle

Model Fit

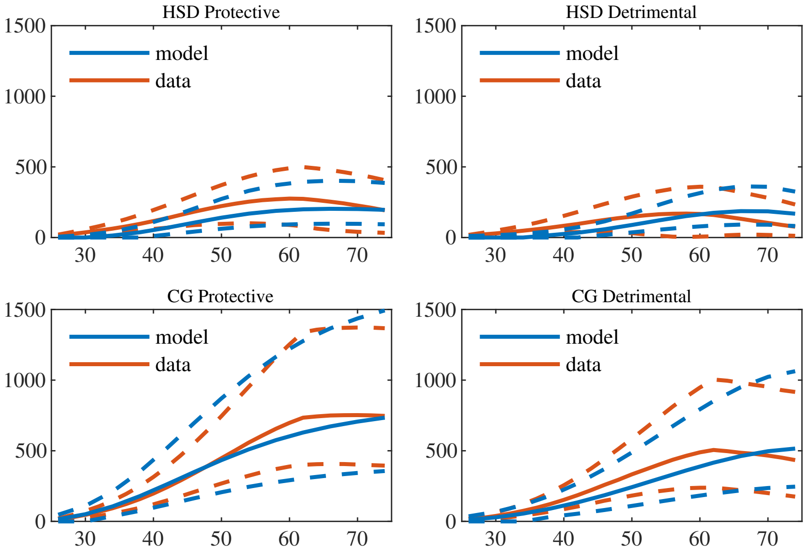
Figure 4: **Wealth profiles: median**



Estimation: Life-cycle

Model Fit

Figure 5: **Wealth profiles: median, 25th, 75th**



Estimation: Early-life

- Match the marginal distribution of e and y in each cohort $c \in \{1930, 1970\}$
  - → A total of 6 parameters and 6 statistics

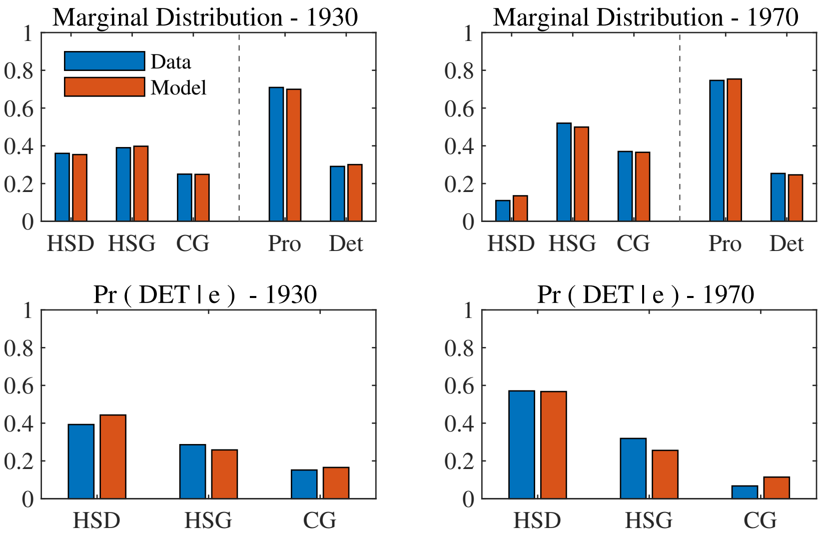
- Identification
  - μ_{hsg}, μ_{CG}, μ_{PRO} drive the average share of e and y for one cohort
  - σ_{hsd}, σ_{cg}, σ_{PRO} drive changes in e and y over cohorts c as V_0^{eyc} changes (due to changes in wages and labor force participation)

- Calibrate $\lambda^{1970} = 1$ and λ^{1930} to match the increase in the life-expectancy gradient between the 1930 and the 1970 cohort.

Parameter	Value	Parameter	Value
μ_{HSD}	6.53	σ_{HSD}	2.02
μ_{CG}	26.55	σ_{CG}	18.92
μ_{PRO}	-1.27	σ_{PRO}	10.38
λ^{1930}	0.85		

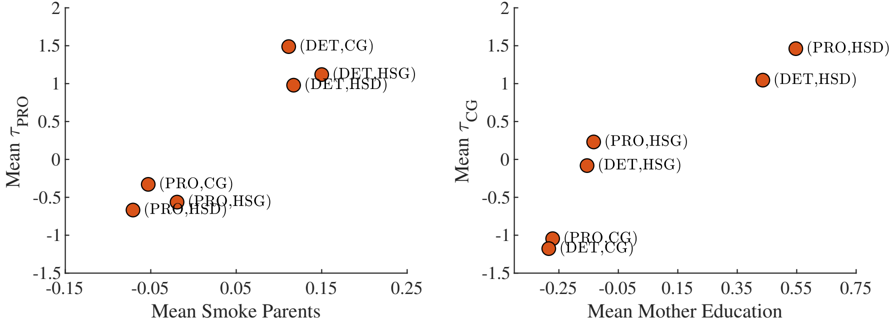
Estimation: Early-life

Figure 6: **Model Fit: Early-life**



Estimation: Early-life

Figure 7: **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: $w_t^{\text{ec}}(\zeta, \epsilon, h)$ and $l_t^{\text{ec}}(\varepsilon, h)$

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

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

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

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

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

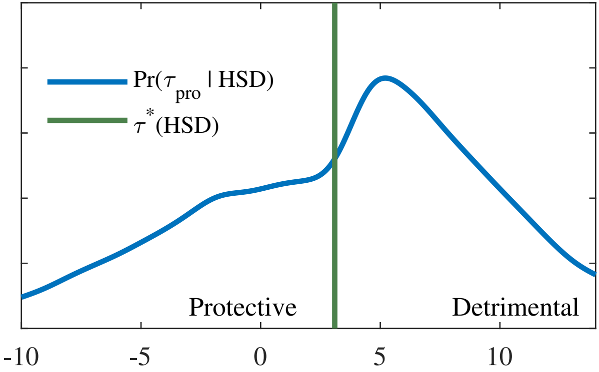
3. Selection:

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

Education gradient of lifestyle

Lifestyle Choice for HSD

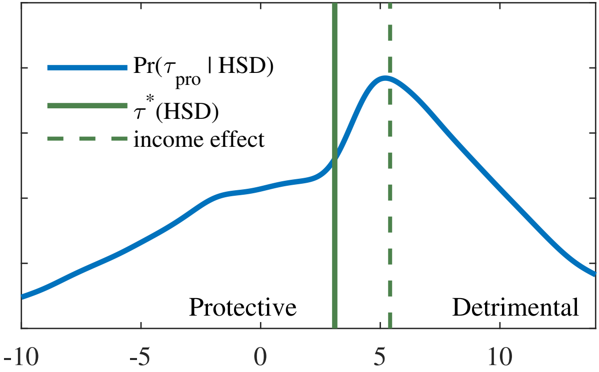
- HSD choose y = PRO iff $\tau_{\text{PRO}} < V_0^{\text{HSD,PRO}} - V_0^{\text{HSD,DET}} \equiv \tau^*(\text{HSD})$



Education gradient of lifestyle

1. Income Effect

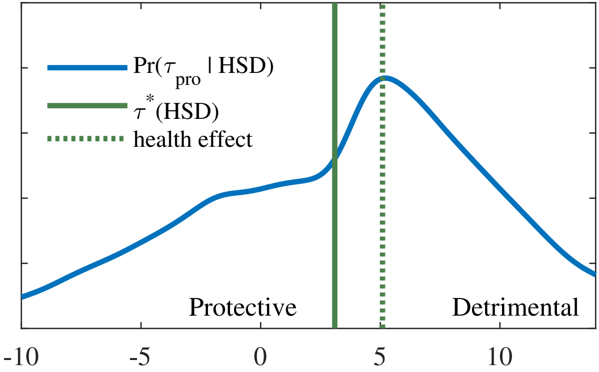
→ If HSD had same income as CG: 16pp more of PRO (out of 43pp gap)



Education gradient of lifestyle

2. Health Effect

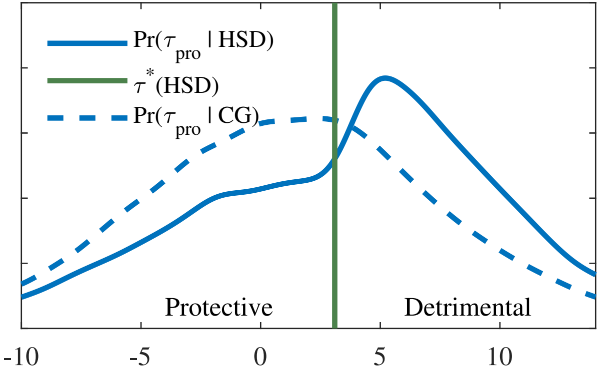
→ If HSD had same health gain of PRO as CG: 13pp more of PRO (out of 43pp gap)



Education gradient of lifestyle

3. Selection

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



Education gradient of lifestyle

Summary

Table 2: **Decomposition: 1970s cohort**

	Pr(PRO|HSD)	Pr(PRO|CG)	ΔPr(PRO)	LE(HSD)	LE(CG)	ΔLE
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,

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

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

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

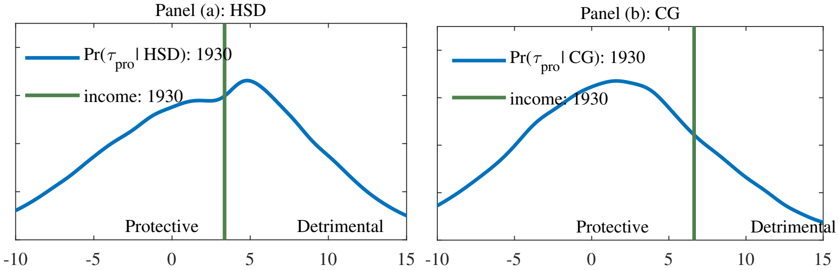
  → Unclear effect on the education gradient

- Selection effect: worse pool of individuals in terms τ_{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

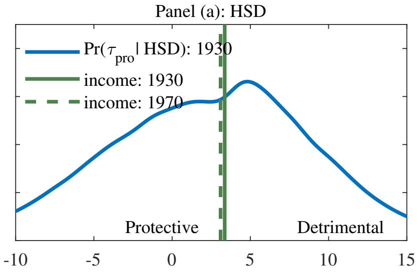
Income effect

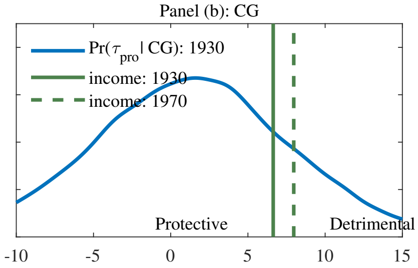
$\Pr(\tau_{\text{PRO}}\,|e)$ as in 1930, education premium widens

→ Pr(PRO|HSD) declines 1pp

→ Pr(PRO|CG) increases 5pp

→ LE gradient widens 7 months





Changes over Time: 1930 vs 1970 cohorts

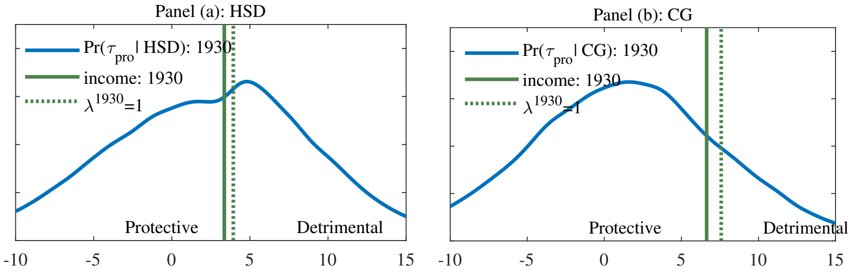
Changes in Perceptions

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

→ Pr(PRO|HSD) increases 3pp

→ Pr(PRO|CG) increases 4pp

→ LE gradient widens 2 months



Changes over Time: 1930 vs 1970 cohorts

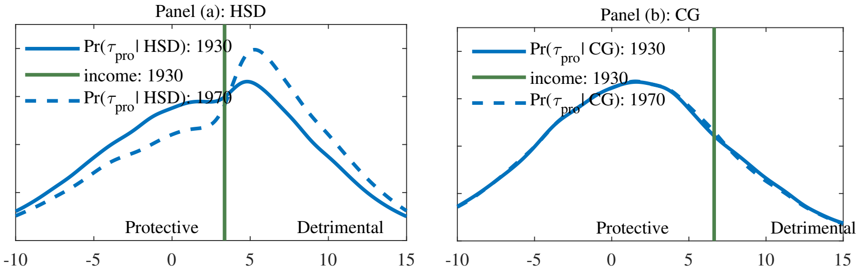
Selection effect

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

→ Pr(PRO|HSD) declines 11pp

→ Pr(PRO|CG) increases 1pp

→ LE gradient widens 9 months



Changes over Time: 1930 vs 1970 cohorts

Summary

Table 3: **Decomposition**

	$\Delta_c \Pr(\text{CG})$	$\Delta_c \Pr(\text{HSD})$	$\Delta_c \Pr(\text{PRO})$	$\Delta_c \Pr(\text{PRO}\mid\text{CG})$	$\Delta_c \Pr(\text{PRO}\mid\text{HSD})$	$\Delta_c \Delta_e \text{LE}$
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 (ϵ_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,

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

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

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

Back to Mixture Model

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 ($\epsilon_{h'}$)

$$h^*_{h,h'} \quad = \quad f(a, s, e, y; \boldsymbol{\beta}_{h,h'}) + \epsilon_{h'}$$

with,

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

Back to Mixture Model

Econometric Model

3. Weights

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

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

- 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

Table 4: **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.

Back to Data

Health Behaviour Data

Table 5: **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.

Back to Data

SET UP: TWO EDUCATION CHOICES

- An individual decides to hold a protective lifestyle if:

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

Go back

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:

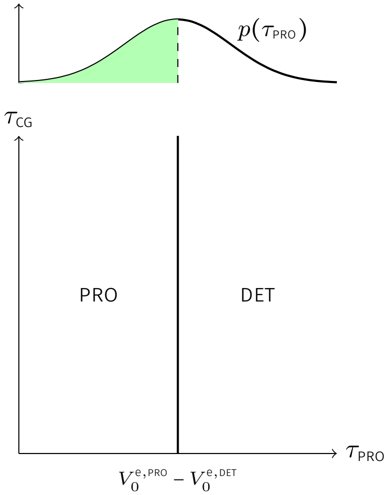
$$\tau_{\text{PRO}} < V^{e,\text{PRO}} - V^{e,\text{DET}}$$

  - The decision of being protective is independent on the value of τ_{CG}

Go back

Choices: two education levels

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



Go back

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:

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

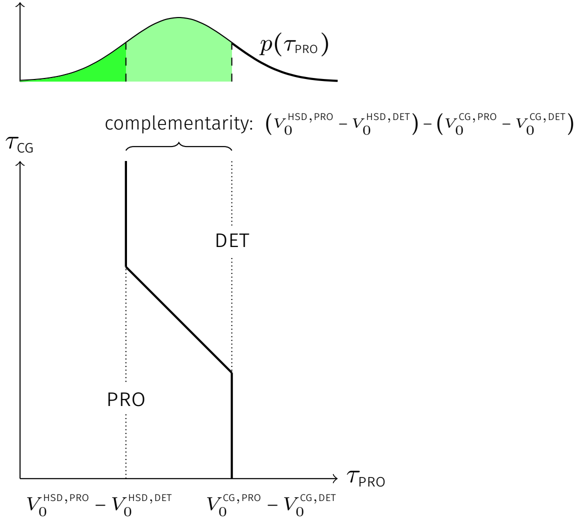
    B. $\tau_{\text{CG}} > V^{\text{CG,PRO}} - V^{\text{HSD,PRO}} : \tau_{\text{PRO}} < V^{\text{HSD,PRO}} - V^{\text{HSD,DET}}$

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

Go back

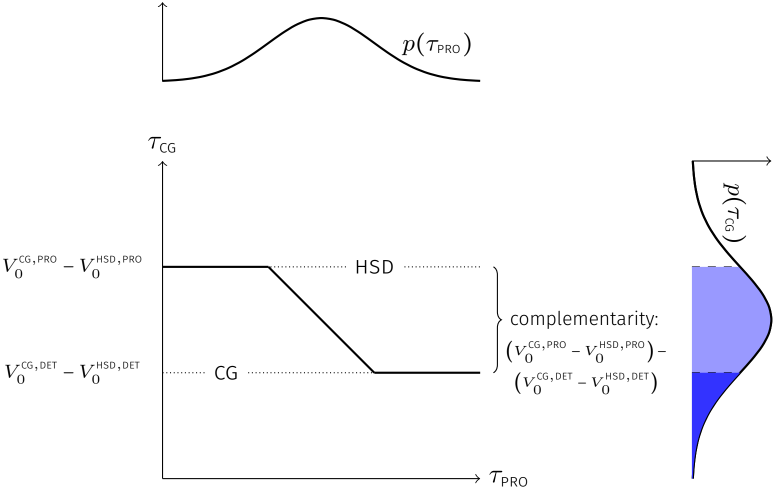
Choices: two education levels

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



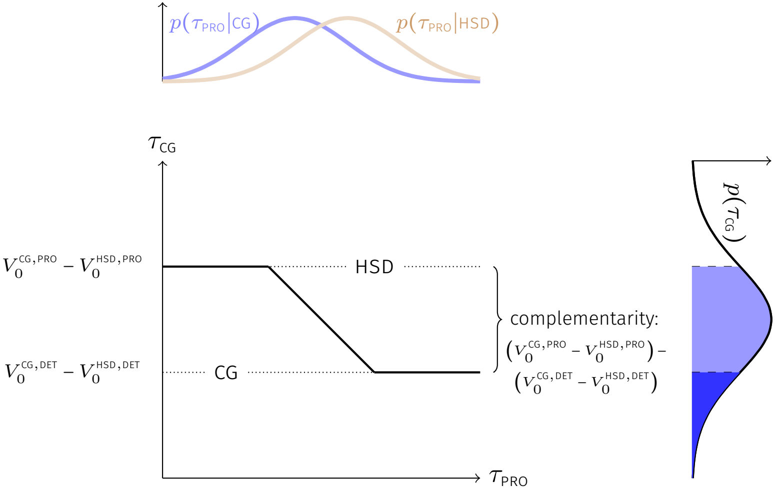
Choices: two education levels

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



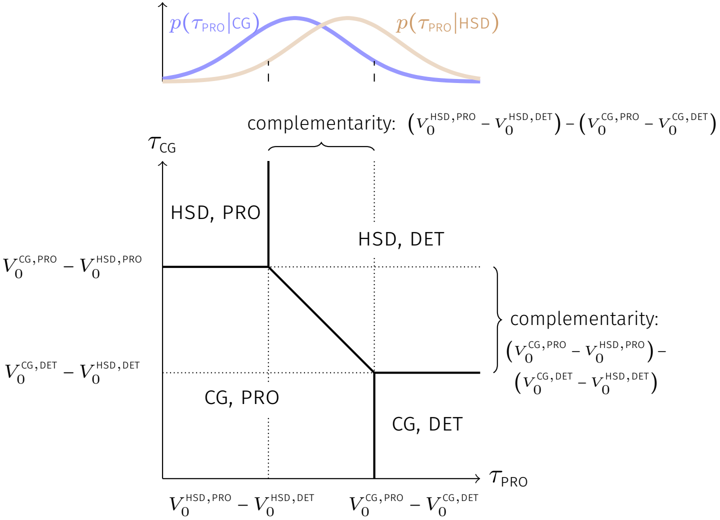
Choices: two education levels

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



Choices: two education levels

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

- 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 τ_{PRO} across education groups is different:

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

$\Rightarrow$ High-school dropouts are negatively selected in terms of τ_{PRO}

Go back