The Evolution of U.S. Wages: Skill Prices versus Human Capital

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Preliminary and incomplete
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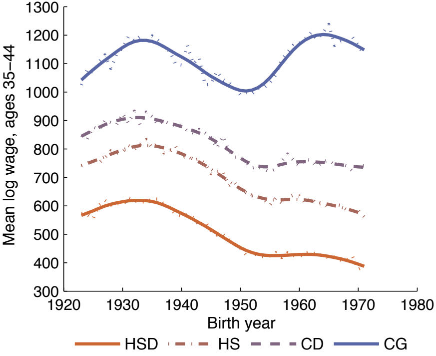
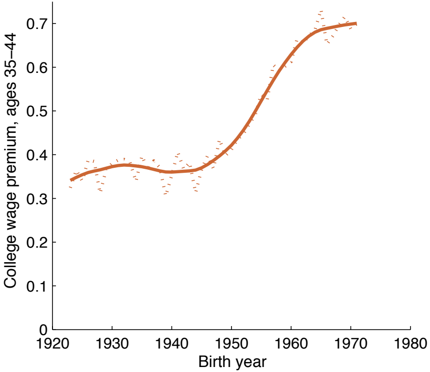
Motivation





Mean log weekly wage, ages 35-44

College wage premium, ages 35-44

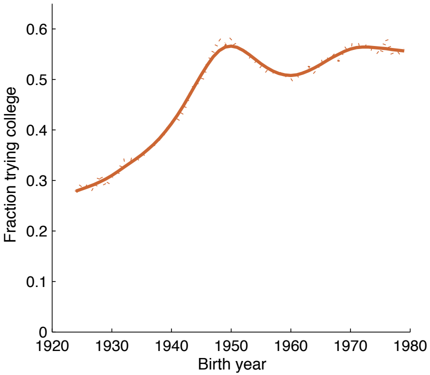
Motivation

Possible interpretations for the rise in the college wage premium:

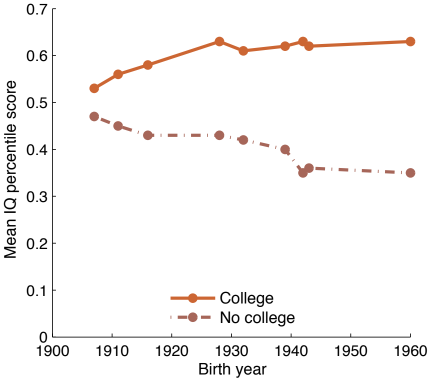
1. The relative **price** of college labor has increased
   skill-biased technical change
2. The relative **quality** of college labor has increased
   selection / human capital investment

The question: How important are price and quality movements?

Why Is Labor Quality Interesting?



Expansion of schooling



Rising IQs of college students

The Questions

1. What part of the rise in the college wage premium reflects
    1. rising skill price of college educated labor?
    2. rising quality of college educated labor?
2. More generally: How can we extract skill prices from measured wages?

Identification Problem

- Measured wages confound skill prices and labor qualities.
- How can the two be disentangled?

The Idea

View the age wage profiles of various cohorts through the lens of human capital theory.

Theory implies:

1. Concave age efficiency profiles.
2. When skill prices grow, wages of all cohorts move together.
3. As schooling expands, the relative abilities of college / high school educated workers change.

The Approach

- Develop a model of school choice and on-the-job training.
- Heterogeneous worker abilities.
- Construct age wage profiles of synthetic cohorts.
- Calibrate the model to fit those profiles.
- The model measures:
    - unobserved skill prices and labor qualities
    - the abilities of workers by [schooling, cohort]

Result Preview

1. One-third of the growth in the college wage premium is growth in the relative human capital of college educated workers.
2. Half of the college wage premium in 2000 reflects the relative human capital of college graduates.
3. Unskilled wages did not fall nearly as much as the data suggest.

Selected Literature

- The expansion of education changes the relative abilities of college / high school students:
  - Hendricks / Schoellman (2011)
- Disentangling skill prices / labor qualities:
  - Heckman et al. (1998); Bowlus / Robinson (2011) - flat spot method
- Age wage profiles contain information about endowments:
  - Huggett et al. (2006) - focus on inequality
- The college premium through the lens of human capital theory
  - Guvenen / Kuruscu (2010) - focus on inequality
  - Heckman et al. (1998)

A Roy/Ben-Porath Model

Demographics

- Size of cohort τ: N_τ (exogenous).
- Individuals live from model ages $t = 1$ (physical age 16) through T (physical age 65).
- $v = \tau + t - 1$ is the time period.

Preferences

- Individuals maximize the discounted present value of lifetime earnings.
- Equivalent: maximize utility with perfect credit markets.

Endowments

Drawn at birth:

- learning ability a.
- human capital h_1.
- preference for schooling p.
- correlated

Time endowment (market hours): $\ell_{t,s,\tau}$.

Schooling

- Discrete school levels:
  - high school dropout (HSD) and graduate (HSG)
  - college dropout (CD) and graduate (CG)
- School durations: T_s, fixed
- Human capital at start of work

$$h_{T_s+1} = F(h_1, a, s; \tau) \tag{1}$$

On-the-job Training

$$h_{t+1,\tau} = (1-\delta)h_{t,\tau} + G(h_{t,\tau}, l_{t,\tau}, a, \tau + t - 1) \tag{2}$$

$l_{t,\tau}$: study time

Technology

$$Y_v = J(L_{1v}, ..., L_{Sv}; \omega_v) \tag{3}$$

where

- ω_v: vector of parameters
- $L_{s,v}$: effective labor supply of type s

Skill prices equal marginal products:

$$w_{s,v} = \partial J / \partial L_{s,v} \tag{4}$$

1. Draw endowments: a, h_1, p
2. Choose schooling s
3. Study for T_s periods and produce h_{T_s+1}
4. Work for $T - T_s$ periods
   In each period, divide time endowment ℓ into training time l and work time $\ell - l$

Household Problem

Work phase

$$V(h_{t,\tau},t,a,s,\boldsymbol{\tau}) = \max_{l_{t,\tau}} y(l_{t,\tau},h_{t,\tau},t,s,\boldsymbol{\tau}) + R^{-1}V(h_{t+1,\tau},t+1,a,s,\boldsymbol{\tau})$$

subject to

- law of motion for h
- definition of period earnings

$$y(l_{t,\tau},h_{t,\tau},t,s,\boldsymbol{\tau}) = w_{s,t+\tau-1}h_{t,\tau}(\ell_{t,s,\tau} - l_{t,\tau}) \tag{5}$$

time constraint $0 \le l \le \bar{l}\ell_{t,s,\tau}$

School phase

$$W_s(h_1, a, p, \tau) = \ln\left(R^{-T_s+1} V(h_{T_s+1}, T_s+1, a, s, \tau)\right)$$
$$+\pi_\tau p T_s + \mu_{s,\tau}$$

$$h_{T_s+1} = F[h_1, a, s; \tau]$$

$\pi_\tau p T_s$: a stand-in friction to ability sorting

$\mu_{s,\tau}$: chosen so that the model matches observed schooling for each cohort

School choice:

$$W(h_1, a, p, \tau) = \max_s W_s(h_1, a, p, \tau)$$

Equilibrium

- For now: partial equilibrium.
- Skill prices $w_{s,v}$ are exogenous.

Calibration

Calibration Strategy

Choose parameters to match:

1. Age wage profiles
   mean log wages for 5 synthetic cohorts (CPS data)
2. IQ scores of college / high school students.
3. β_{IQ}: coefficient from regressing log wage (age 40) on IQ (and school dummies)

- In the data: cognitive test scores (AFQT)
  - measured around age 18
  - NLSY79
- In the model: a noisy measure of a and/or h_1

$$IQ = \frac{\gamma_{IQ,a} a + (1-\gamma_{IQ,a})(\ln h_1 - \mathbb{E} \ln h_1)/\sigma_{h1}}{(\gamma_{IQ,a}^2 + (1-\gamma_{IQ,a})^2)^{1/2}} + \sigma_{IQ} \varepsilon_{IQ}$$

Fixed parameters

Parameter	Description	Value
T	Lifespan	50
Birth cohorts	Cohort 1	1930 - 1936
	Cohort 2	1937 - 1943
	Cohort 3	1944 - 1950
	Cohort 4	1951 - 1957
	Cohort 5	1958 - 1964
T_s	School duration	$(1, 3, 5, 7)$
$\ell_{t,s,\tau}$	Market hours	CPS data
R	Gross interest rate	1.04

Calibrated Parameters

- Job training: $h_{t+1} = (1-\delta)h_t + e^{\theta a} A(s,0) e^{g_A t} (h_t l_t)^{\alpha}$
  - calibrated: $\delta, \theta, A(s,0), g_A, \alpha$
- Schooling: $F(h_1, a, s, \tau)$
  - same as job-training technology with $l_t = 1$.
- Preferences: $\pi_\tau = \pi_1 (1 + g_\pi)^\tau$
  - calibrated: π_1, g_π
- IQ:
  - calibrated: $\gamma_{IQ,a}, \sigma_{IQ}$

Calibrated Parameters

- Endowments: $(a, \ln h_1, p) \sim N$
  - normalized: $\mathbb{E}(a) = \mathbb{E}(p) = 0$, $Var(a) = Var(p) = 1$
  - $\mathbb{E}(\ln h_1 | \boldsymbol{\tau}) = g_{h1} \boldsymbol{\tau}$
  - calibrated: correlations, g_{h1}, σ_{h1}.
- Skill prices: $w_{s,v}$
  - calibrate at 5 dates; cubic spline in between.

Calibrated Parameters

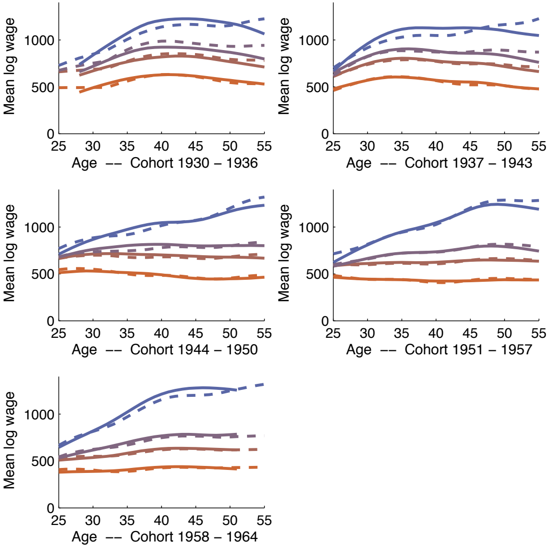
Highlights:

1. $\alpha = 0.27$
   estimates in the literature: 0.5 to 1
2. $g_{h1} = -0.010$
   mean log wages are falling over time in the data

Calibrated Parameters

Parameter	Description	Value
On-the-job training		
$A(s)$	Productivity	0.662 0.768 0.951 0.913
$g(A(s))$	Productivity growth rate	0.0006
α	Curvature	0.267
δ_h	Depreciation rate	0.043
Endowments		
σ_{h1}	Dispersion of h_1	0.032
$g(h_1)$	Growth rate of h_1	-0.0098
θ	Ability scale factor	0.152
π	Psychic cost scale factor	0.186
$g(\pi)$	Growth rate of π	-0.0451
γ_{pa}	Governs correlation of π and a	0.501
γ_{ha}	Governs correlation of $\ln h_1$ and a	0.445
γ_{hp}	Governs correlation of $\ln h_1$ and π	0.204
σ_{IQ}	Noise in IQ	0.876
$\gamma_{IQ,a}$	Governs correlation of a and IQ	0.790

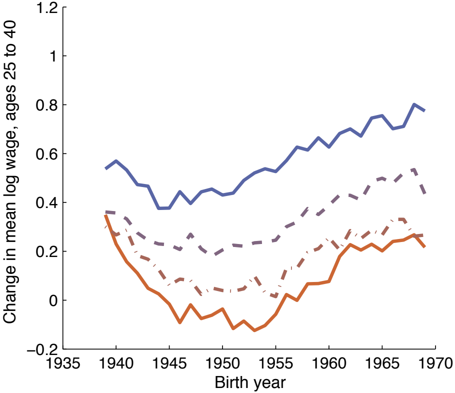
Model Fit



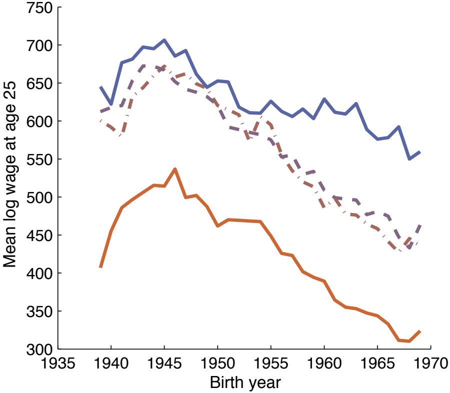
Mean log wage
0
500
1000
25
30
35
40
45
50
55
Age –– Cohort 1930 – 1936
Age –– Cohort 1937 – 1943
Age –– Cohort 1944 – 1950
Age –– Cohort 1951 – 1957
Age –– Cohort 1958 – 1964

Age Wage Profiles

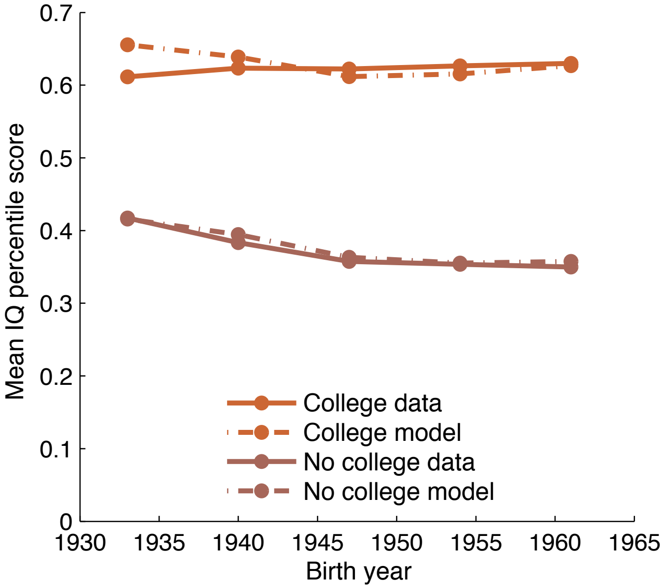
Slopes of age wage profiles



Intercepts of age wage profiles



Model Fit



0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Mean IQ percentile score
1930
1935
1940
1945
1950
1955
1960
1965
Birth year
College data
College model
No college data
No college model

Results

Revisions to Wage Growth

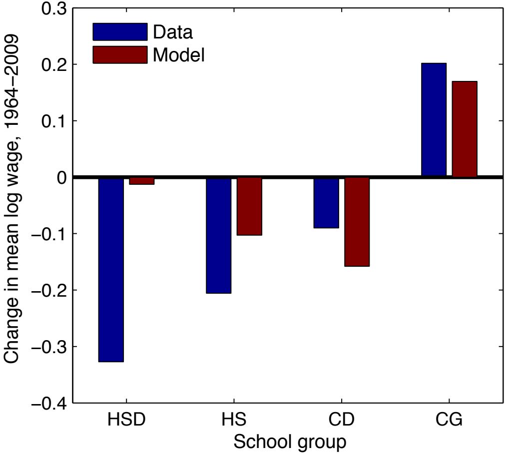
The question:

How much do the growth rates of wages differ from the growth rates of skill prices?

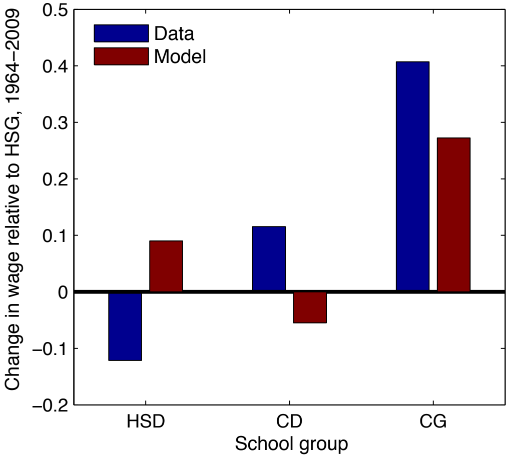
The experiment:

Compare the paths of data wages $z_{s,v}$ with model skill prices $w_{s,v}$.

Revisions to Wage Growth



Revisions to Changes in Skill Premiums



One-third of the rise in the college wage premium is due to human capital, not skill prices.

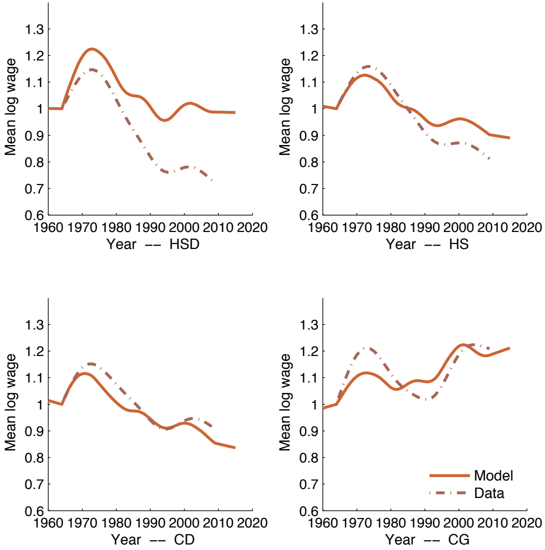
Revisions to Wage Growth

School group	Skill price growth		Skill premium growth	
	Data	Model	Data	Model
HSD	-32.7	-1.3	-12.1	9.0
HS	-20.6	-10.3	0.0	0.0
CD	-9.0	-15.8	11.6	-5.5
CG	20.2	17.0	40.7	27.2

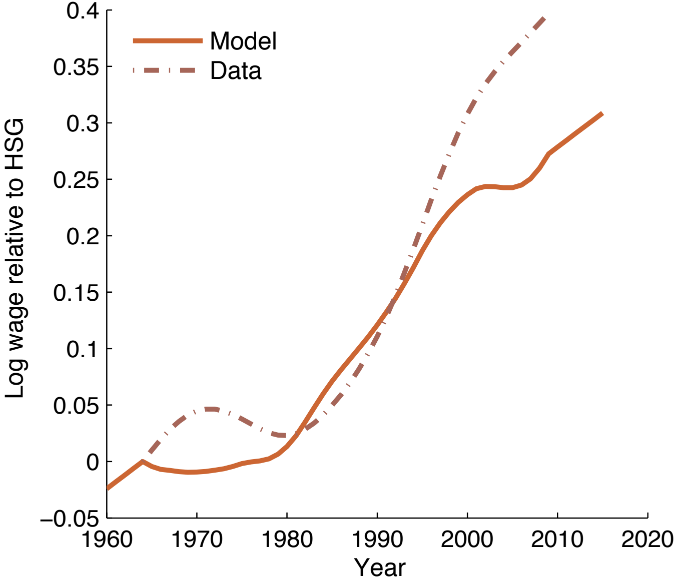
Result:

One-third of the rise in the college wage premium is due to human capital, not skill prices.

Revisions to Wage Growth



College Premium



Revisions to Wage Levels

The question:

*How much would a person with **given** h earn as a HSG / CG?*

The question makes sense, if HSG h and CG h have the same units:

- Just compare $w_{s,v}$ with $z_{s,v}$.

The question is nonsense, if HSG h and CG h have different units.

Need a different approach...

Decomposing Wage Revisions

- Why does the model imply large revisions to measured wages?
- What are the contributions of
  - **selection**: changes in the distribution of (a, h_1) over time?
  - **investment**: changes in l over time?

Measured Wages vs Skill Prices

- Measured mean wage in year v:

$$z_{s,v} = w_{s,v} \bar{h}_{s,v} \tag{6}$$

- Average human capital

$$\bar{h}_{s,v} = \sum_{\tau} \frac{N_{\tau} f_{s,\tau}}{\sum N_{\hat{\tau}} f_{s,\hat{\tau}}} \mathbb{E} \left\{ \frac{h_{t,s,\tau}(\ell_{t,s,\tau} - l_{t,s,\tau})}{\ell_{t,s,\tau}} | s, \tau \right\} \tag{7}$$

  is affected by

  - cohort composition
  - human capital profiles of all working cohorts

  and therefore: past and future skill prices.

- Complicated...

Revisions to Wage Levels

- Consider the wages earned at a fixed age: $t = 40$
- Measured mean wage at age t in year v:

$$z_{t,s,v} = w_{s,v}\bar{h}_{t,s,v} \tag{8}$$

- Average human capital

$$\bar{h}_{t,s,v} = \mathbb{E}\left\{ \frac{h_{t,s,\tau}(\ell_{t,s,\tau} - l_{t,s,\tau})}{\ell_{t,s,\tau}} | t, s, \tau \right\} \tag{9}$$

depends on

  - the human capital of a single cohort
  - its endowments and past investments

Decomposing Wage Revisions

The question:

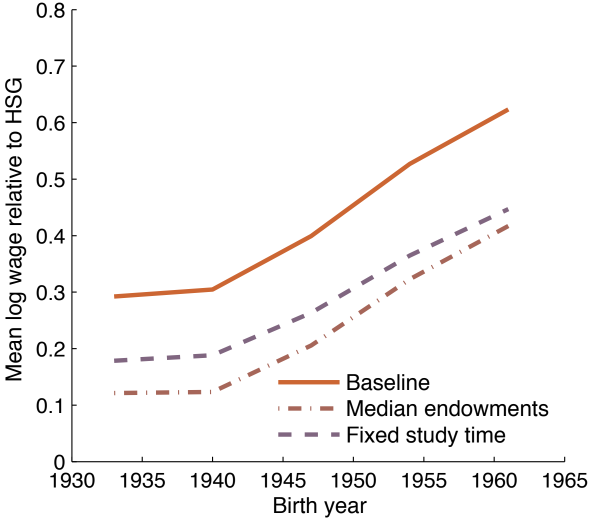
> *How much do selection / investment contribute to skill premiums at a point in time?*

Experiment: solve the model for 3 scenarios:

1. Baseline
2. No selection: workers in all school groups have mean endowments $a = 0$ and $\ln h_1 = g_{h1}\tau$
3. Common investment: workers in all school groups share $l_{t,s}$ set to median age profile of high school graduates

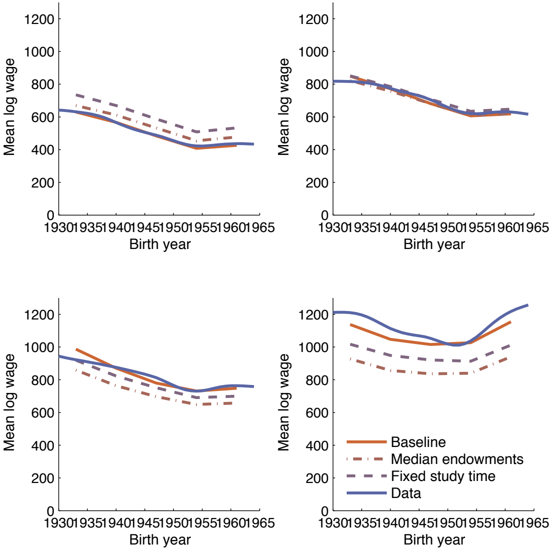
Compute mean log wages at age 40 for each cohort / school group.

Selection and the College Wage Premium



Selection accounts for 30 log points of the college wage premium.

Selection and Wages



Decomposing Wage Growth

The question

> *How much do changing selection / investment contribute to the growth rates of wages?*

Experiment: Solve the model for 3 scenarios

1. Baseline
2. Fix endowments in each school group: a, h_1
3. Fix investment in each school group: $l_{t,s}$
   at levels of the 1st cohort

Decomposing Wage Growth

School group	Wage growth			Skill premium growth		
	Baseline	Fixed a, h_1	Fixed l	Baseline	Fixed a, h_1	Fixed l
HSD	-39.0	-30.6	-19.6	-7.4	-8.0	-3.4
HS	-31.6	-22.5	-16.2	0.0	0.0	0.0
CD	-27.6	-21.3	-17.7	3.9	1.3	-1.5
CG	1.5	7.1	8.9	33.0	29.6	25.1

Changes in mean log wages at age 40, 1964-2009

Changing endowments and investment are equally important for skill premium revisions.

Selection and Lifetime Earnings

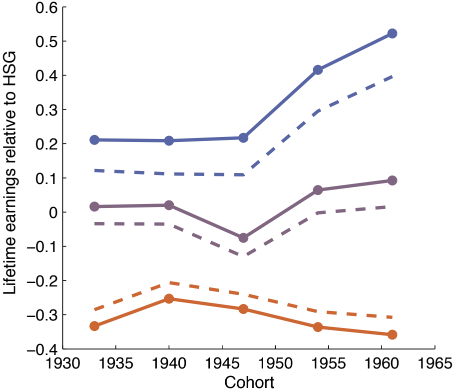
The question:

> *How much of the lifetime earnings gap CG / HSG is due to selection?*

The experiment:

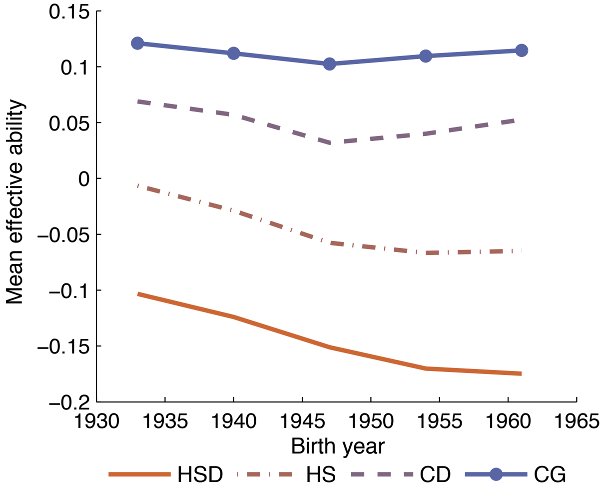
- Solve the model with random school assignment.
- Compare lifetime earnings by (s, τ) with baseline.

Selection and Lifetime Earnings



Result: 15 log points of the college lifetime earnings premium are due to selection

Changing Student Abilities



Conclusion

- A simple human capital model accounts well for the age wage profiles of cohorts observed since 1930.
- Labor quality accounts for
  - **half** of the college wage premium (1960 cohort)
  - **1/3** of the rise in the college wage premium
  - **1/4** of the lifetime college earnings premium (1960 cohort)