Student Abilities during the Expansion of US Education

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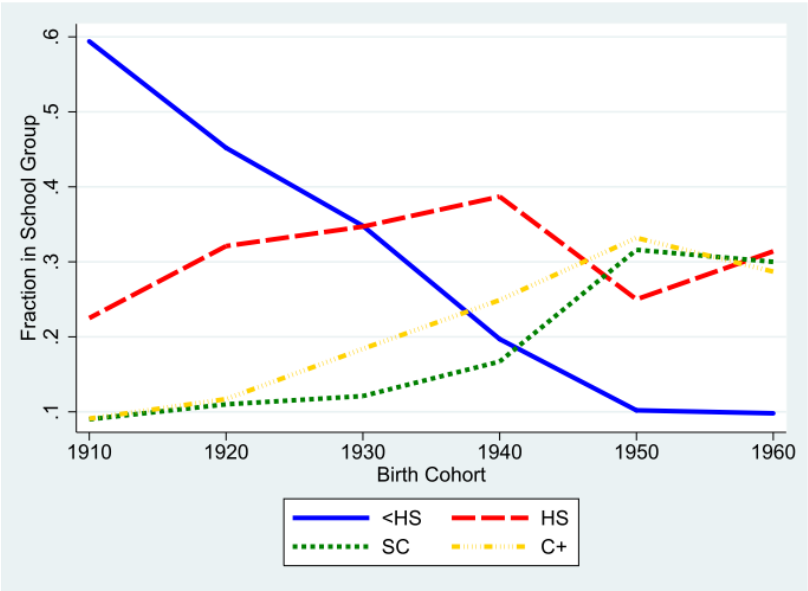
Motivation

Two major changes happened between 1950 and 2000 (1910 to 1960 cohorts):

1. Wide expansion of education: high school graduation has become nearly universal;
2. Gap in IQ tests of college vs. noncollege increased.

(a) The Expansion of Education



(b) Changes in IQ Test Scores

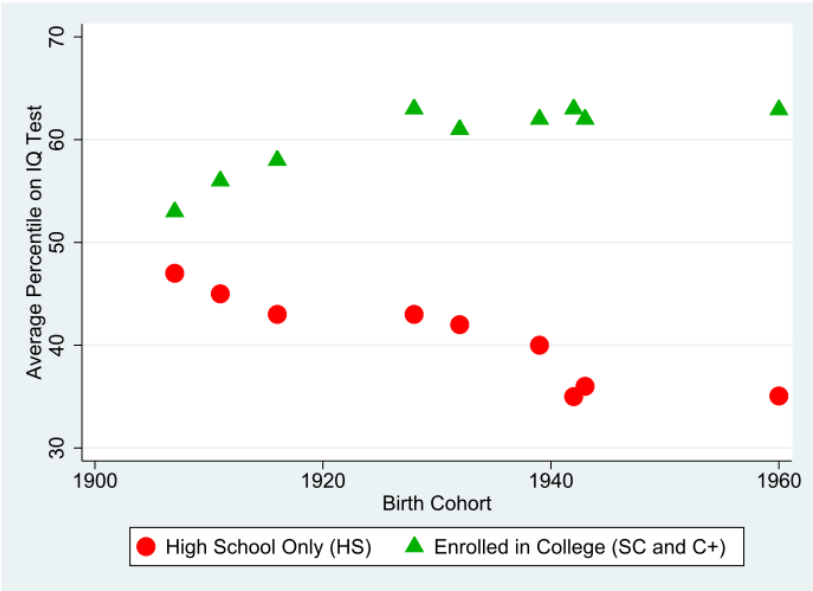


Figura : Changes in US Education in the 20th Century

Research question

How does this translate into the college wage premium?

- These two trends have combined to change the composition of abilities by educational attainment.
- Previous explanations rely on skill-biased technological change (keeping skills fixed);
- Idea: use IQ tests as proxies of ability and disentangle its role.

Economic Mechanism and Results

- Log wages depend on both ability and schooling;
- People choose schooling according to both **ability** and **other costs of attending**.
- Distribution of ability stays constant; other costs of attending have lower dispersion over time.
- Consequence: people sort more **strongly** according to ability!

Results

1. Differences in ability account for **half** of the 2000 college wage premium.
2. Changes in the ability gap explain the **entire** rise in the college wage premium between 1950 and 2000.

Related Literature

- *Finch (1946), Taubman and Wales (1972):*
  use test scores to identify changes in student abilities;
- *Laitner (2000):*
  model of human capital investment qualitatively consistent with post-war data;
- *Card (2001), Card and Lemieux (2001), Acemoglu (2002), Heckman, Juhn, Kim and Vella (2005), Lochner and Todd (2006):*
  estimation of returns to schooling.
- *Bowlus and Robinson (2010):*
  use human capital model to disentangle changes in skill prices/quantities.

Model - Environment and Preferences

- Discrete time OLG model;
- Each year a cohort of measure 1 is born, indexed by τ; it will live T periods.
- At birth, each person is endowed with
  1. Cognitive ability a;
  2. Taste for schooling p;

  independently normally distributed with mean zero and standard deviations $1, \sigma_{p,\tau}$.
- Thus the type of an agent is $q = (a, p, \tau)$.
- Preferences take the form

$$\sum_{v=1}^{T} \beta^v \log[c(q, v)] + (p + a)\chi(s, \tau).$$

Model - Budget Constraint and Wages

- School type s takes $T(s)$ years to complete. Then the choice is subject to

$$\sum_{v=1}^{T} \frac{c(q,v)}{R^v} = \sum_{v=T(s)+1}^{T} \frac{w(s,q,v)}{R^v}.$$

- Wages are given by

$$\log[w(s,q,v)] = \theta a + z(s, \tau + v - 1) + h(s,v).$$

Choices

- Consumption satisfies the Euler equation $c(q, v+1) = \beta R c(q, v)$;
- Then lifetime utility can be written as

$$\underbrace{\theta a \sum_{v=1}^{T} \beta^{v}}_{\textbf{Ability premium}} + \underbrace{\sum_{v=1}^{T} \beta^{v} \log\left[\frac{R(\beta R)^{v-1}}{\sum_{u=1}^{T} \beta^{u-1}} \sum_{u=T(s)+1}^{T} \frac{e^{h(s,u)+z(s,\tau+u-1)}}{R^{u}}\right]}_{\textbf{Future earnings by schooling}} + \underbrace{(p+a)\chi(s,\tau)}_{\textbf{Utility of schooling}}.$$

- Schooling choice depends only on $(p+a)$ and not on p or a independently;
- Ability does not influence schooling through the earnings channel;
- Sorting into schooling is determined by $\sigma_{p,\tau}$!

Implications

Average wage of workers from cohort τ with education s at age v is

$$\mathbb{E}[\log(w)|s,\tau,v] = \underbrace{\theta\mathbb{E}[a|s,\tau]}_{\textbf{Effective Ability}} + \underbrace{z(s,\tau+v-1)}_{\textbf{Skill Prices}} + \underbrace{h(s,v)}_{\textbf{Human Capital}}$$

- Last two are not disentangled in this work.

Calibration on the NLSY

- Data: collection of wages, education levels and IQ test scores for white men born around 1960;
- Reasons: labor supply participation and discrimination in early 20th century);
- IQ measured with the Army Force Qualification Test;
- IQ tests considered as noisy, scaled proxies for ability: $\tilde{IQ} = \eta(a + \epsilon_{IQ})$;
- Assume ϵ_{IQ} is normal, with mean 0 and std. dev. σ_{IQ}. Then, normalization implies

$$IQ = \frac{a}{\sqrt{1 + \sigma_{IQ}^2}} + \epsilon_{IQ}$$

$$\epsilon_{IQ} \simeq \mathcal{N}\left(0, \frac{\sigma_{IQ}}{\sqrt{1 + \sigma_{IQ}^2}}\right)$$

Identification

- Identifying θ: assuming $\sigma_{IQ} = 0$, just run a regression on age-40 wages in the NLSY79:

Dependent variable: log-wages	
β_{IQ}	0.104
	(0.017)
γ_{HS}	0.17
	(0.06)
γ_{SC}	0.35
	(0.06)
γ_{C+}	0.69
	(0.07)
Observations	1942
R^2	0.24

Figura : Returns to IQ in the NLSY79

- $\chi(s, 1960)$ is used to get the observed educational attainment;

Identification

- $\sigma_{p,1960}$ is calibrated so that the model fits the sorting by IQ as close as possible.

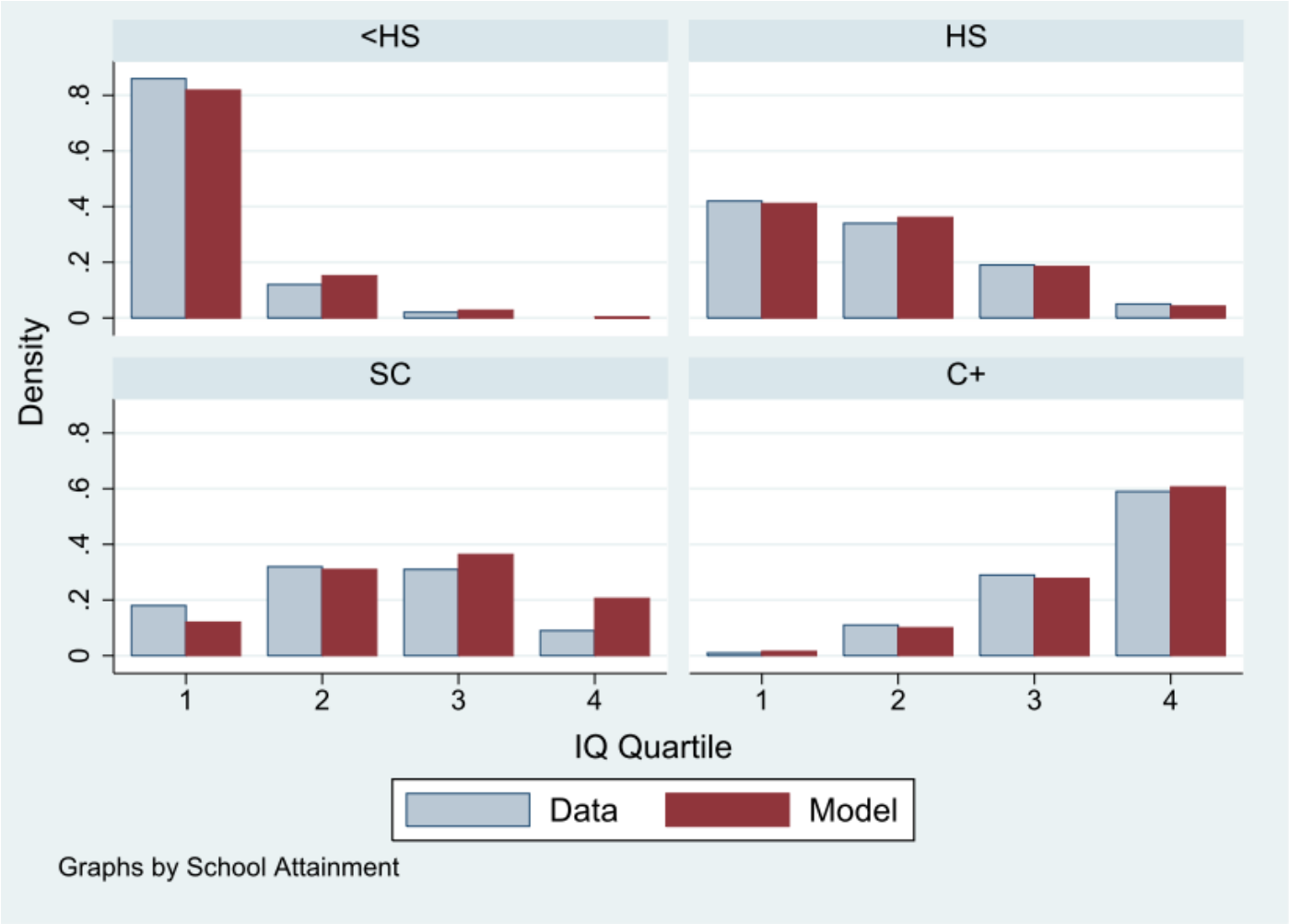


Figura : Model-Predicted and Actual Distribution of IQ given Schooling

Wage gaps

School Comparison	Effective Ability Gap		Wage Gap
	Calculation	Model	Data
<HS–HS	-0.08	-0.08	-0.24
SC–HS	0.06	0.07	0.18
C+–HS	0.14	0.15	0.52

Figura : Results when IQ Tests Measure Ability Exactly

- Differences in ability account from 1/4 to 1/3 of the wage premiums.
- Partial solution for a puzzle in the literature: why people do not enroll into college?

Noisy IQ

- If tests include noise, θ may suffer from attenuation bias!
- Authors provide lower bound and upper bound for σ_{IQ}: 'simulate' estimation when accounting for noise.

	Model: Effective Ability Gap			Wage Gap
	IQ = a	LB	UB	
σ_{IQ}	0.00	0.50	0.68	
θ	0.104	0.155	0.228	
<HS–HS	-0.08	-0.14	-0.22	-0.24
SC–HS	0.07	0.11	0.18	0.18
C+–HS	0.15	0.25	0.39	0.52

Figura : Cross-Sectional Results when IQ Tests Measure Ability with Noise

- 'True' θ is higher than observed and suffers from attenuation bias: IQ accounts for larger amount of the wage premium!

Time Series

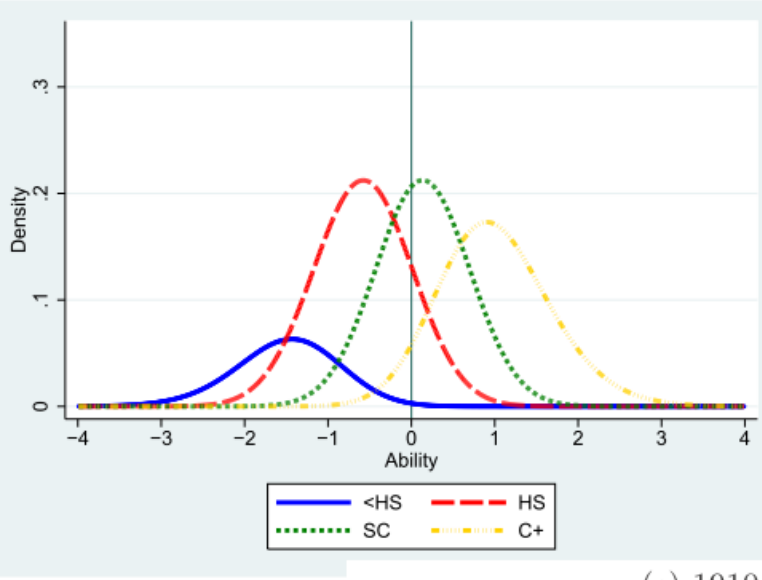
- Assumption: θ constant through time (as in 1960), $\sigma_{IQ} = LB$;
- $\chi(s, \tau)$ is used to match the expansion in schooling;
- $\sigma_{p,\tau}$ is used to fit sorting into educational attainment.

Parameter	Role	Value
σ_{IQ}	Noise in IQ Tests	0.50
θ	Effect of Ability on Wages	0.155
$\sigma_{p,1960}$	Dispersion of Preferences	0.62
$\sigma_{p,1950}$	Dispersion of Preferences	0.81
$\sigma_{p,1940}$	Dispersion of Preferences	1.04
$\sigma_{p,1930}$	Dispersion of Preferences	1.19
$\sigma_{p,1920}$	Dispersion of Preferences	1.39
$\sigma_{p,1910}$	Dispersion of Preferences	2.27

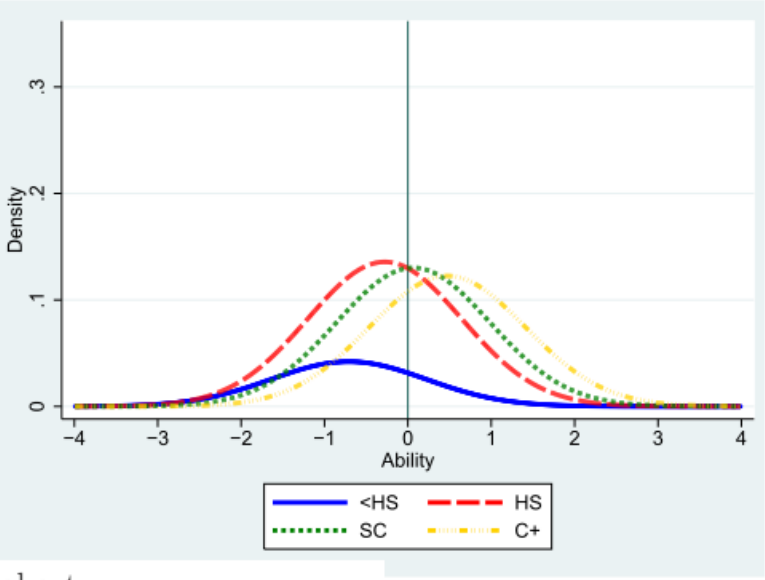
Figura : Calibrated Parameters for the Lower Bound

Sorting

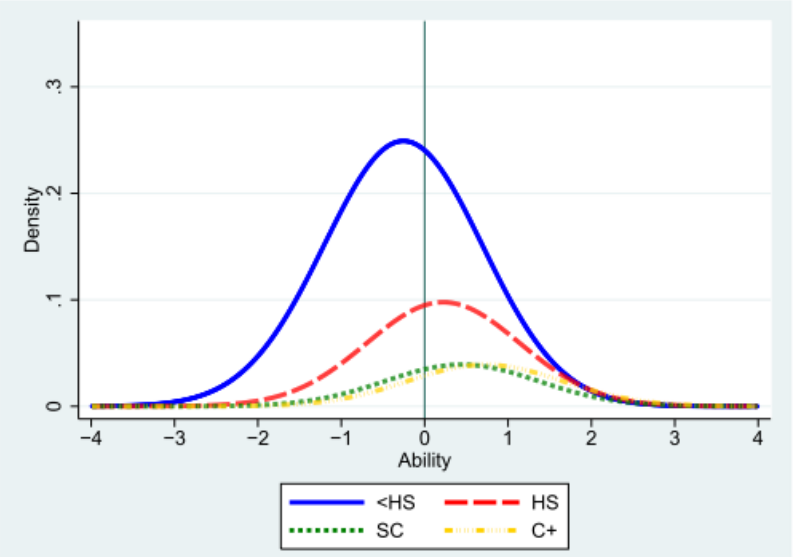
(a) 1960 Cohort



(b) Counterfactual: 1960 Cohort with 1910 Sorting



(c) 1910 Cohort



Sorting: effects

	Model-Predicted Change		Data Change
	Effective Ability Gap	$h + z$ Gap	Wage Premium
<HS–HS	-0.07	0.00	-0.06
SC–HS	0.08	-0.06	0.02
C+–HS	0.17	-0.02	0.15

Figura : Changes in Mean Ability Gaps and Wage Premiums, 1910-1960 Cohorts

Sorting by ability accounts for the **whole** premia!!!!

Conclusions

- Most papers attribute the college wage premium to skill-biased technological change;
- This paper shows that a large fraction of it is due to **sorting** i.e. quantity versus prices;
- **The whole** change in the wage premium for 1910-1960 cohorts can be attributed to quantity changes;
- **Half** of the current wage premium is due to sorting into education;
- Results are still economically significant even if IQ measured ability exactly.