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.

Figure: 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 \textit{ability} and \textit{other costs of attending}.
- Distribution of ability stays constant; other costs of attending have lower dispersion over time.
- Consequence: people sort more \textit{strongly} according to ability!

\begin{itemize}
\item Differences in ability account for \textit{half} of the 2000 college wage premium.
\item Changes in the ability gap explain the \textit{entire} rise in the college wage premium between 1950 and 2000.
\end{itemize}
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;


- **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 $\tau$; 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

$$\log[w(s, q, v)] = \theta a + z(s, \tau + v - 1) + h(s, v).$$
Consumption satisfies the Euler equation $c(q, \nu + 1) = \beta Rc(q, \nu)$;

Then lifetime utility can be written as

\[
\theta a \sum_{\nu=1}^{T} \beta^\nu + \sum_{\nu=1}^{T} \beta^\nu \log \left[ \frac{R(\beta R)^{\nu-1}}{\sum_{u=1}^{T} \beta^{u-1}} \sum_{u=T(s)+1}^{T} \frac{e^{h(s,u)+z(s,\tau+u-1)}}{R^u} \right] + (p + a)\chi(s, \tau).
\]

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 $\tau$ with education $s$ at age $v$ is

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

- 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 \( \epsilon_{IQ} \) is normal, with mean 0 and std. dev. \( \sigma_{IQ} \). Then, normalization implies

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

\[
\epsilon_{IQ} \sim N\left(0, \frac{\sigma_{IQ}^2}{\sqrt{1 + \sigma_{IQ}^2}}\right)
\]
Identification

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

<table>
<thead>
<tr>
<th>Dependent variable: log-wages</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_{IQ}$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$\gamma_{HS}$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$\gamma_{SC}$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$\gamma_{C+}$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Observations</td>
</tr>
<tr>
<td>$R^2$</td>
</tr>
</tbody>
</table>

Figure: 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

**Figura**: Results when IQ Tests Measure Ability Exactly

<table>
<thead>
<tr>
<th>School Comparison</th>
<th>Effective Ability Gap Calculation</th>
<th>Effective Ability Gap Model</th>
<th>Wage Gap Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;HS–HS</td>
<td>-0.08</td>
<td>-0.08</td>
<td>-0.24</td>
</tr>
<tr>
<td>SC–HS</td>
<td>0.06</td>
<td>0.07</td>
<td>0.18</td>
</tr>
<tr>
<td>C+–HS</td>
<td>0.14</td>
<td>0.15</td>
<td>0.52</td>
</tr>
</tbody>
</table>

- 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, $\theta$ may suffer from attenuation bias!
- Authors provide lower bound and upper bound for $\sigma_{IQ}$: ‘simulate’ estimation when accounting for noise.

<table>
<thead>
<tr>
<th>Model: Effective Ability Gap</th>
<th>Wage Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ = a</td>
<td>LB</td>
</tr>
<tr>
<td>$\sigma_{IQ}$</td>
<td>0.00</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.104</td>
</tr>
<tr>
<td>&lt;HS–HS</td>
<td>-0.08</td>
</tr>
<tr>
<td>SC–HS</td>
<td>0.07</td>
</tr>
<tr>
<td>C+-HS</td>
<td>0.15</td>
</tr>
</tbody>
</table>

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

- ‘True’ $\theta$ is higher than observed and suffers from attenuation bias: IQ accounts for larger amount of the wage premium!
Time Series

- Assumption: $\theta$ 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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Role</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_{IQ}$</td>
<td>Noise in IQ Tests</td>
<td>0.50</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Effect of Ability on Wages</td>
<td>0.155</td>
</tr>
<tr>
<td>$\sigma_{p,1960}$</td>
<td>Dispersion of Preferences</td>
<td>0.62</td>
</tr>
<tr>
<td>$\sigma_{p,1950}$</td>
<td>Dispersion of Preferences</td>
<td>0.81</td>
</tr>
<tr>
<td>$\sigma_{p,1940}$</td>
<td>Dispersion of Preferences</td>
<td>1.04</td>
</tr>
<tr>
<td>$\sigma_{p,1930}$</td>
<td>Dispersion of Preferences</td>
<td>1.19</td>
</tr>
<tr>
<td>$\sigma_{p,1920}$</td>
<td>Dispersion of Preferences</td>
<td>1.39</td>
</tr>
<tr>
<td>$\sigma_{p,1910}$</td>
<td>Dispersion of Preferences</td>
<td>2.27</td>
</tr>
</tbody>
</table>

Figura: Calibrated Parameters for the Lower Bound
Sorting

(a) 1960 Cohort

(b) Counterfactual: 1960 Cohort with 1910 Sorting

(c) 1910 Cohort
Sorting: effects

<table>
<thead>
<tr>
<th>Model-Predicted Change</th>
<th>Data Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective Ability Gap</td>
<td>Wage Premium</td>
</tr>
<tr>
<td>h + z Gap</td>
<td></td>
</tr>
</tbody>
</table>

| <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.