Accounting for the Evolution of U.S. Wage Inequality

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Preliminary
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Wage inequality has increased in the U.S. since the 1970s
  - standard deviation of log wages, college wage premium, “residual” wage inequality, ...

A vast, most non-structural literature has investigate explanations.

A structural model allows to investigate shocks and their indirect effects.
The Questions

- How far can a standard human capital model go towards accounting for changing wage inequality?
- What are the (proximate) causes of rising inequality?
- What happened to lifetime inequality?
Approach

- Calibrate a stochastic Roy / Ben-Porath model to match CPS wage moments, 1964 – 2010, men
  - building on Heckman / Lochner / Taber (1998 RED)
- Discrete school choice
- Heterogeneity in “abilities,” human capital endowments, shocks
- Rising inequality is due to
  - diverging skill prices (demographics + SBTC)
  - rising schooling
  - rising shock variances
The model accounts for trends in several inequality statistics

- Rising “overall wage inequality” is 50% skill prices / 50% rising shock variances
- Rising “between group” inequality is almost 100% skill prices
- Rising “within group” inequality is almost 100% shock variances
- Lifetime earnings inequality rises nearly as much as overall wage inequality

GK argue that single shock (acceleration of SBTC) accounts for everything
  - There is no role for labor supply / demographics

I run with the Katz and Murphy view that demographics + SBTC drive the college wage premium

Other differences:
  - stochastic model
  - discrete school choice and skill prices
Model
Model Outline

- General equilibrium
- Overlapping generations
- “Small open economy” - no capital, fixed interest rate
- Individuals
  - draw endowments: ability $a$, human capital $h_1$
  - choose schooling $s$: HSD, HSG, CD, CG (Roy model)
  - work and produce human capital (Ben-Porath)
Demographics, Endowments, Preferences

- $N_c$: size of cohort born in $\tau = c$
- $T$: fixed lifetime
- $t$: age
- $\ell_{s,c,t}$: time endowment, used for work and studying
- Endowments: $a, h_1 \sim \text{joint Normal}$
- Preferences: maximize expected lifetime earnings
Human Capital Production

In school:

- duration $T_s$
- $h_{T_s+1} = F(h_1, a, s)$

On the job:

$$h_{t+1} = (1 - \delta_s)h_t + A(a, s)(h_t l_t)^{\alpha_s}$$  \hspace{1cm} (1)

$$A(a, s) = e^{A_s + \theta a}$$  \hspace{1cm} (2)
Labor Supply

Labor supply in efficiency units

\[ e_{i,s,c,t} = q_{i,s,c,t} \xi_{i,s,c,t} h_{i,s,c,t} (l_{s,c,t} - l_{i,s,c,t}) \]

(3)

\[ \xi: \text{ transitory shock or measurement error} \]

- Normal distribution

\[ q: \text{ persistent shock:} \]

- AR(1) with linear trend in shock variance
Aggregate output and skill prices

Aggregate production function

\[
Y_\tau = \left[ G_\tau^{\rho_{CG}} + (\omega_{CG,\tau}L_{CG,\tau})^{\rho_{CG}} \right]^{1/\rho_{CG}}
\]  
(4)

where

\[
G_\tau = \left[ \sum_{s=HSD}^{CD} (\omega_{s,\tau}L_{s,\tau})^{\rho_{HS}} \right]^{1/\rho_{HS}}
\]  
(5)

Skill prices equal marginal products:

\[
w_{s,\tau} = \frac{\partial Y_\tau}{\partial L_{s,\tau}}
\]  
(6)

\(L_{s,\tau}\): labor supply in efficiency units

Constant SBTC: \(\omega_s / \omega_{HSG}\) grows at a constant rate.
Household Problem: Work

Maximizes the expected value of lifetime earnings

\[ V(h_{T_s+1}, a, s, c) = \max \mathbb{E} \sum_{t=T_s+1}^{T} R^{-t} w_{s, \tau(c,t)} e_{s,c,t} \]

subject to

- law of motion for \( h \)
- time constraint \( 0 \leq l_t \leq \bar{l}_{s,c,t} \).

The model has a closed form solution.
Human capital investment is chosen before the current transitory shock, \( \xi_t \), is realized.

Backward induction leads to

\[
(h_{i,s,c,t} l_{i,s,c,t})^{1-\alpha_s} = \frac{\alpha A(a,s)}{(1 - \delta_s)} \sum_{j=1}^{T-t} X_{s,c,t,j} \frac{\mathbb{E}(q_{i,s,c,t+j} | t)}{q_{i,s,c,t}}
\]

(8)

where

\[
X_{s,c,t,j} = \left( \frac{1 - \delta_s}{R} \right)^j \frac{w_{s,\tau(c,t+j)}}{w_{s,\tau(c,t)}} \ell_{s,c,t+j}
\]

(9)

Recursive solution: Solve for \( l_t(h_t) \), compute \( h_{t+1} \), and iterate forward.
Household Problem: Schooling

Choose schooling to maximize

$$W_s(p_s, h_1, a, s, c) = \ln V(F[h_1, a, s], a, s, c) + \mu_{s,c} + \pi p_s + \pi_a (T_s - T_1) a$$

The household values:

- lifetime earnings $V$
- school “costs” $\mu_{s,c}$: common; allow the model to match cohort schooling
- “psychic costs” generate imperfect ability sorting

With Type I Extreme Value shocks $p_s$: school choice has a closed form solution.
Cognitive Test Scores

- IQ as a proxy for unobserved ability.
- Helps with identification of ability dispersion ($\theta$) and school choice

$$IQ = a + \sigma_{IQ} \varepsilon_{IQ}$$  \hspace{1cm} (10)

$$\varepsilon_{IQ} \sim N(0, 1)$$  \hspace{1cm} (11)
Calibration
Mean and standard deviation of log wage by \((s,c,t)\):

- March CPS, 1964 – 2011
- Men born between 1935 and 1968.

Test scores (IQ):

- mean scores of high school and college students
- selected cohorts
  - Taubman and Wales (1972) and NLSY79

Shocks:

- PSID: covariance matrix of log wages
Assumptions

- schooling technology = job training technology
- for aggregation:
  - cohorts born before 1935 look like 1935 cohort
  - cohorts born after 1968 look like 1968 cohort
## Fixed Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T$</td>
<td>Lifespan</td>
<td>65</td>
</tr>
<tr>
<td>$T_s$</td>
<td>School duration</td>
<td>2, 3, 5, 7</td>
</tr>
<tr>
<td>$\ell_{t,s,\tau}$</td>
<td>Market hours</td>
<td>CPS data</td>
</tr>
<tr>
<td>n/a</td>
<td>Nodes of skill price spline</td>
<td>1950, 1957, 1964, ..., 2010, 2021, 2032</td>
</tr>
<tr>
<td>$R$</td>
<td>Gross interest rate</td>
<td>1.04</td>
</tr>
</tbody>
</table>
Calibration Approach

- Simulate **1,000** individuals in each cohort.
- Choose school costs $\mu_{s,c}$ to match the fraction of persons choosing each school level in each cohort.
- Choose variance of transitory shocks to best fit variance of wages across ages (for each $s, \tau$)
- Minimize sum of squared deviations from calibration targets.
Calibrated Parameters

- 36 calibrated parameters governing endowments, technologies, shocks
- 36 parameters governing skill prices
  - unrestricted skill weight on HSG labor by year
  - for all other school groups: skill weight in 1964 and rate of SBTC
- Of note: Ben-Porath curvature parameters $\alpha_s$ near 0.4
  - much lower than most previous estimates ($>0.8$)
# Calibrated Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On-the-job training</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$A_s$</td>
<td>Productivity</td>
<td>0.14, 0.12, 0.15, 0.23</td>
</tr>
<tr>
<td>$\alpha_s$</td>
<td>Curvature</td>
<td>0.49, 0.40, 0.38, 0.46</td>
</tr>
<tr>
<td>$\delta_s$</td>
<td>Depreciation rate</td>
<td>0.050, 0.040, 0.048, 0.088</td>
</tr>
<tr>
<td><strong>Endowments</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{h1}$</td>
<td>Dispersion of $h_1$</td>
<td>0.290</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Ability scale factor</td>
<td>0.098</td>
</tr>
<tr>
<td>$\pi_1$</td>
<td>Psychic cost scale factor</td>
<td>0.257</td>
</tr>
<tr>
<td>$\gamma_{ap}$</td>
<td>Ability weight in psychic cost</td>
<td>0.111</td>
</tr>
<tr>
<td>$\gamma_{ah}$</td>
<td>Governs correlation of $\ln h_1$ and $a$</td>
<td>0.328</td>
</tr>
<tr>
<td>$\sigma_{IQ}$</td>
<td>Noise in IQ</td>
<td>0.610</td>
</tr>
<tr>
<td><strong>Shocks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma(q_1)$</td>
<td>Std dev of first shock</td>
<td>0.03, 0.01, 0.29, 0.29</td>
</tr>
<tr>
<td>$\rho_s$</td>
<td>Shock persistence</td>
<td>0.98, 0.97, 0.99, 0.98</td>
</tr>
<tr>
<td>$\sigma(\zeta)$, 1964</td>
<td>Std deviation of shocks</td>
<td>0.12, 0.11, 0.08, 0.08</td>
</tr>
<tr>
<td>$\sigma(\zeta)$, 2010</td>
<td>Std deviation of shocks</td>
<td>0.12, 0.16, 0.11, 0.14</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta w_s$</td>
<td>Skill price growth rate, 1964-2010 [pct]</td>
<td>-1.27, -0.69, -0.61, -0.02</td>
</tr>
<tr>
<td>$(1 + \rho_{HS})^{-1}$, $(1 + \rho_{CG})^{-1}$</td>
<td>Substitution elasticities</td>
<td>6.03, 4.09</td>
</tr>
</tbody>
</table>
Model Fit: Mean Log Wages (HSG)

![Graphs showing mean log wages from 1935 to 1956](image-url)

- **D:** 1935 - **M:** 0.24
- **D:** 1938 - **M:** 0.53
- **D:** 1941 - **M:** 0.76
- **D:** 1944 - **M:** 0.79
- **D:** 1947 - **M:** 0.48
- **D:** 1950 - **M:** 0.48
- **D:** 1953 - **M:** 0.15
- **D:** 1956 - **M:** 0.36

![Graphs showing mean log wages from 1935 to 1956](image-url)
Model Fit: Mean Log Wages (CG)

![Graphs showing mean log wages for different years: 1935, 1938, 1941, 1944, 1947, 1950, 1953, 1956. Each graph compares male (M) and female (D) wages.]

- D: 1935 M: 0.34
- D: 1938 M: 0.41
- D: 1941 M: 0.50
- D: 1944 M: 0.68
- D: 1947 M: 0.62
- D: 1950 M: 0.70
- D: 1953 M: 0.79
- D: 1956 M: 0.84
Model Fit: Standard Deviation (HSG)
Model Fit: Standard Deviation (HSG)
Results
Questions

1. How far can a simple human capital model go towards accounting for wage distribution facts?
2. What is the contribution of various “shocks” to changing wage inequality?
3. Limetime earnings inequality?
Use counterfactual experiments to shut down one shock at a time

1. fixed wages: $w_{s,\tau} = w_{s,1964}$
2. fixed schooling at level of 1935 cohort
3. fixed shock variances: $\sigma_{\xi,s,\tau} = \sigma_{\xi,s,1964}$

Two cases:

1. Direct effect: holding human capital investments and school choices constant
2. Total effect: allowing human capital investments to adjust

All inequality statistics hold population composition constant at cross-year average.
Overall Wage Dispersion

Roughly 50% due to diverging skill prices, 50% due to rising shock variances
Fanning Out of the Wage Distribution

![Graph showing the fanning out of the wage distribution with a model line and data points.](image-url)
Residual Wage Inequality

Mostly due to rising shock variances
Almost entirely due to diverging skill prices
## College Premium: Young and Old

<table>
<thead>
<tr>
<th>Year</th>
<th>College Wage Premium</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>0.15</td>
</tr>
<tr>
<td>1965</td>
<td>0.2</td>
</tr>
<tr>
<td>1970</td>
<td>0.25</td>
</tr>
<tr>
<td>1975</td>
<td>0.3</td>
</tr>
<tr>
<td>1980</td>
<td>0.35</td>
</tr>
<tr>
<td>1985</td>
<td>0.4</td>
</tr>
<tr>
<td>1990</td>
<td>0.45</td>
</tr>
<tr>
<td>1995</td>
<td>0.5</td>
</tr>
<tr>
<td>2000</td>
<td>0.55</td>
</tr>
<tr>
<td>2005</td>
<td>0.6</td>
</tr>
</tbody>
</table>

### Ages 26-35

Early decline in the young college premium is due to falling human capital investment of high school graduates in the 1970s.
Returns to Experience

High school graduates

College graduates

Changes are 50% skill prices / 50% human capital investment.
Summary

1. Overall wage inequality: 50% due to diverging skill prices / 50% due to rising shock variances
2. Within group inequality: due to rising shock variances
3. College wage premium: due to diverging skill prices
   Human capital investment plays a role for the divergent behavior of young / old.
4. Returns to experience: 50% skill prices; 50% human capital investment.
5. Rising education matters only for skill prices.
6. Secondary effects are generally small.
Why Are Indirect Effects Small?

- Optimal human capital investment:
  \[
  (h_{i,s,c,t}l_{i,s,c,t})^{1-\alpha_s} = \frac{\alpha A(a,s)}{(1-\delta_s)} \sum_{j=1}^{T-t} X_{s,c,t} E(q_{i,s,c,t+j}|t) \frac{X_{s,c,t}}{q_{i,s,c,t}}
  \]

- Changing skill prices affect \(X_{s,c,t,j}\).
  - Investment response is the same for all individuals in a [school, age] cell (except for interaction with expected shock growth term)
  - Small effect on within group inequality

- Rising shock variances affect \(E(q_{i,s,c,t+j}|t)/q_{i,s,c,t}\)
  - Investment response is the same for all individuals in a [school, age] cell
  - Small amplification of within group inequality
  - Since \(Var(q)\) rises by similar amounts for CG and HSG: small effect on college premium.
Increase similar to standard deviation of log wages.
50% diverging skill prices.
50% rising shock variances (accounts for within school group rise in lifetime earnings inequality).
Predictability of Lifetime Earnings

- Predictability $= \frac{\text{var of lifetime earnings without shocks}}{\text{var of lifetime earnings}}$
- Huggett / Ventura / Yaron (2011 AER): 0.6
- This model: 0.25
  - 0.1 for college educated workers
  - 0.25 for high school educated workers
- Why so much smaller than HVY?
The End