Accounting for the Evolution of U.S. Wage Inequality

Lutz Hendricks

UNC

Preliminary
July 17, 2013

Motivation

- 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 investigated 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
- Causes of changing wage distribution:
  - demographics (cohort sizes)
  - rising schooling (school costs)
  - skill-biased technical change
  - rising shock variances

Result Preview

- 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

Guvenen and Kuruscu

- How does it differ from Guvenen and Kuruscu's "A Quantitative Analysis of the Evolution of the U.S. Wage Distribution, 1970-2000"?
- 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: $a, \ln h_1$ ∼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:

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

$$A(a,s) = e^{A_s + \theta a} \tag{2}$$

Labor Supply

Labor supply in efficiency units

$$e_{i,s,c,t} = \underbrace{q_{i,s,c,t}\zeta_{i,s,c,t}}_{\text{shocks}}\underbrace{h_{i,s,c,t}(\ell_{s,c,t} - l_{i,s,c,t})}_{\text{Ben-Porath}} \tag{3}$$

ζ: transitory shock or measurement error

- Normal distribution

q: persistent shock:

- AR(1) with linear trend in shock variance

Aggregate output and skill prices

$L_{s,\tau}$: aggregate labor supply in efficiency units.

Aggregate production function

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

where

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

Skill prices equal marginal products:

$$w_{s,\tau} = \partial Y_\tau / \partial L_{s,\tau} \tag{6}$$

Constant SBTC: ω_s / ω_{HSG} grows at a constant rate.

Household Problem: Work

Maximizes the expected value of lifetime earnings

$$V(h_{T_s+1}, a, s, c) = \max \mathbb{E} \sum_{t=T_s+1}^{T} R^{-t} \underbrace{w_{s,\tau(c,t)} e_{s,c,t}}_{\text{earnings}} \tag{7}$$

subject to

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

Human capital investment is chosen before the current transitory shock, ζ_t, is realized.

Solution: Work

Backward induction leads to

$$(1-\alpha_s)\ln(h_t l_t) = \theta a + C_1 + \ln\left(\sum_{j=1}^{T-t} X_{s,c,t,j} \frac{\mathbb{E}(q_{i,s,c,t+j}|t)}{q_{i,s,c,t}}\right)$$

$$X_{s,c,t,j} = \left(\frac{1-\delta_s}{R}\right)^j \frac{w_{s,\tau(c,t+j)}}{w_{s,\tau(c,t)}} \ell_{s,c,t+j} \tag{8}$$

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

Investment responses are the **same for high / low ability workers**.

Household Problem: Schooling

Choose schooling to maximize

$$W_s(p_s, h_1, a, s, c) = \underbrace{\ln V(F[h_1, a, s], a, s, c)}_{\text{lifetime earnings}} + \mu_{s,c} + \underbrace{\pi p_s + \pi_a (T_s - T_1) a}_{\text{"psychic cost"}}$$

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 (θ) and school choice

$$IQ = a + \sigma_{IQ}\varepsilon_{IQ} \tag{9}$$

$$\varepsilon_{IQ} \sim N(0,1) \tag{10}$$

Calibration

Data Moments

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

Parameter	Description	Value
T	Lifespan	65
τ	Birth cohorts	1935, 1938, 1941, ..., 1962, 1965, 1968
T_s	School duration	2, 3, 5, 7
$\ell_{t,s,\tau}$	Market hours	CPS data
n/a	Nodes of skill price spline	1950, 1957, 1964, ..., 2010, 2021, 2032
R	Gross interest rate	1.04

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.
- Minimize sum of squared deviations from calibration targets.

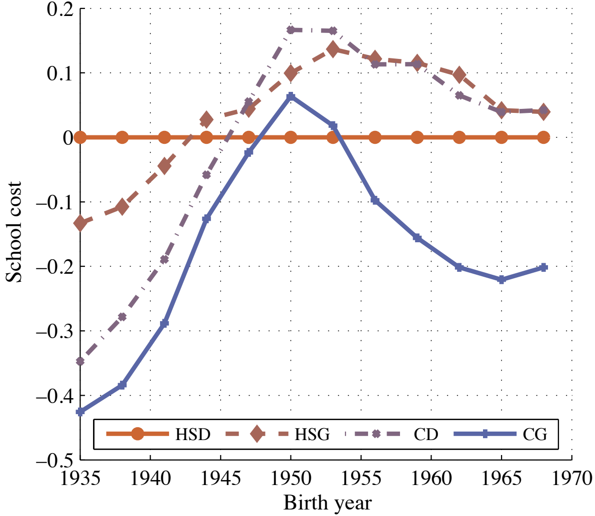
Calibrated Parameters

- 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 α_s near 0.4
  - much lower than most previous estimates (> 0.8)

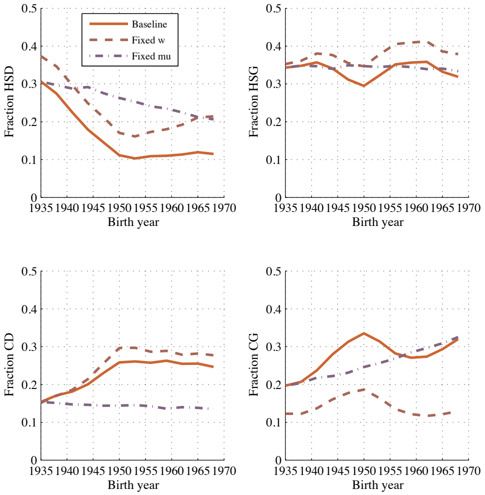
Calibrated Parameters

Parameter	Description	Value
On-the-job training		
A_s	Productivity	0.14, 0.12, 0.15, 0.23
α_s	Curvature	0.43, 0.38, 0.42, 0.48
δ_s	Depreciation rate	0.053, 0.041, 0.051, 0.089
Endowments		
σ_{h1}	Dispersion of h_1	0.297
θ	Ability scale factor	0.115
π_1	Psychic cost scale factor	0.296
γ_{ap}	Ability weight in psychic cost	0.123
γ_{ah}	Governs correlation of $\ln h_1$ and a	0.362
σ_{IQ}	Noise in IQ	0.587
Shocks		
$\sigma(q_1)$	Std dev of first shock	0.00, 0.00, 0.00, 0.00
ρ_s	Shock persistence	0.98, 0.97, 0.97, 0.97
$\sigma(\zeta)$, 1964	Std deviation of shocks	0.12, 0.11, 0.11, 0.11
$\sigma(\zeta)$, 2010	Std deviation of shocks	0.11, 0.16, 0.15, 0.14
Other		
Δw_s	Skill price growth rate, 1964-2010 [pct]	-1.00, -0.76, -0.69, -0.09
$(1+\rho_{HS})^{-1}$, $(1+\rho_{CG})^{-1}$	Substitution elasticities	8.30, 6.05

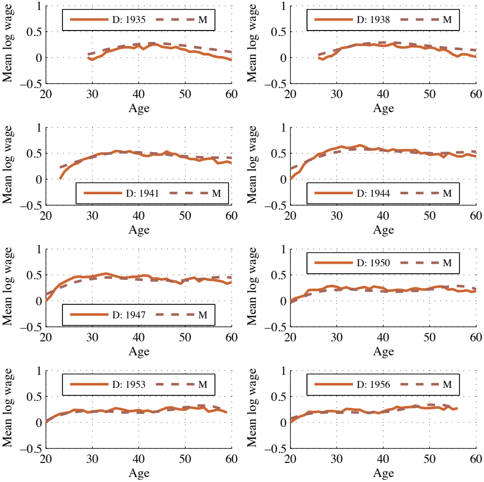
School Costs



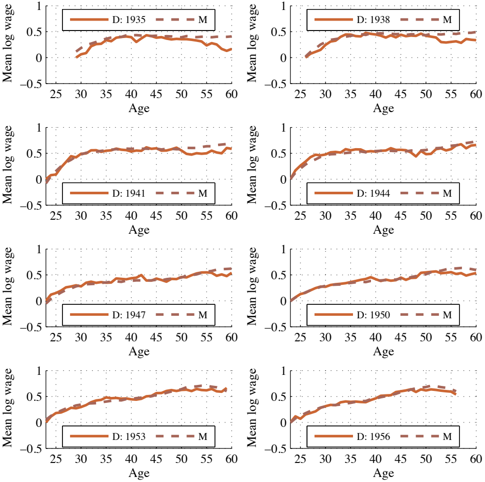
The Role of School Costs



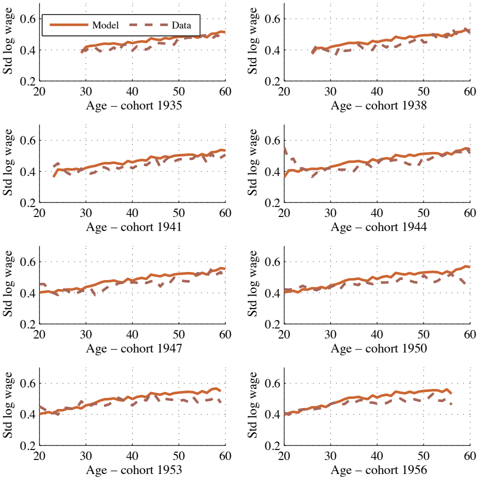
Model Fit: Mean Log Wages (HSG)



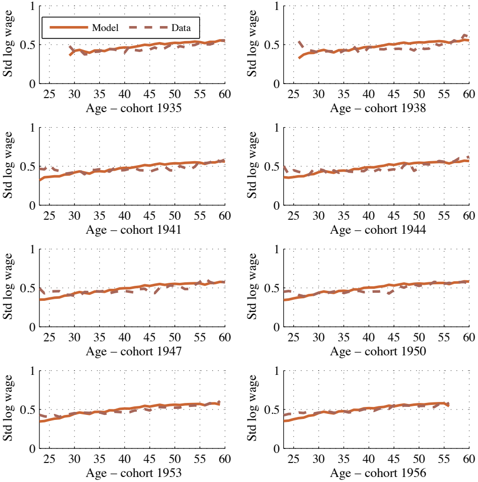
Model Fit: Mean Log Wages (CG)



Model Fit: Standard Deviation (HSG)



Model Fit: Standard Deviation (CG)



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?
4. Predictability of lifetime earnings?

"Shocks" and Inequality

Counterfactual experiments 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

Direct and total effects are (almost) always very similar.

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

Within-group Inequality

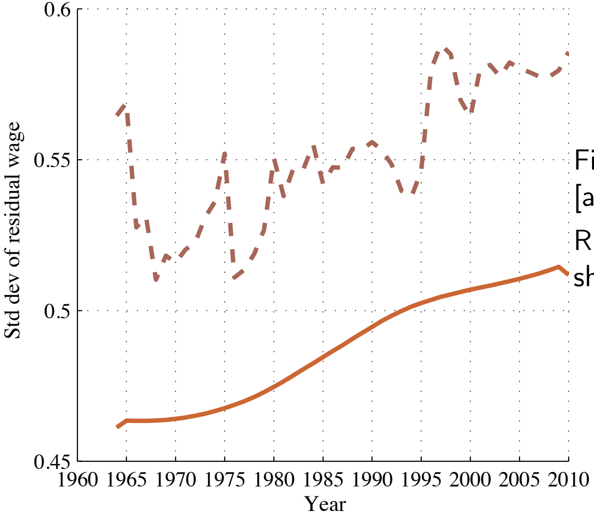


Figure: std dev of log wages in [age, school] cells.

Rises mostly due to rising shock variances.

Unchanging Dispersion of Efficiencies

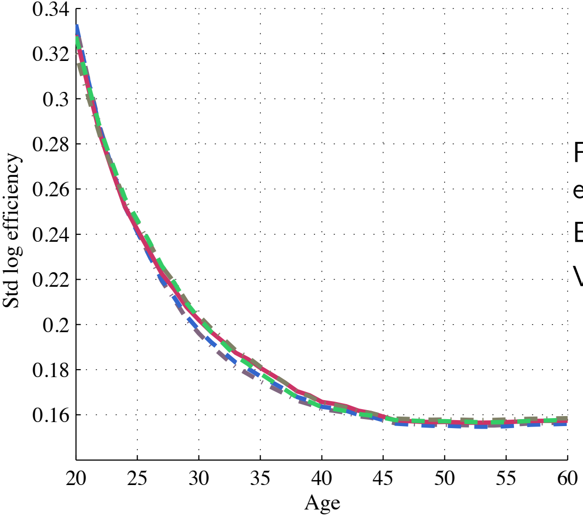


Figure: std dev of log efficiencies for HSG.

Efficiency = $h(1 - l/\ell)$.

Very similar across cohorts

Unchanging Dispersion of Efficiencies

- Why does efficiency dispersion not change over time?
- **Rising schooling** has large effects on mean endowments, but small effects on endowment variances
- **Skill price growth** and **shock variances**
  - affect human capital investment of high and low ability workers by similar amounts
  - $\Longrightarrow$ small effect on efficiency dispersion

Wage Dispersion and Schooling

College Premium

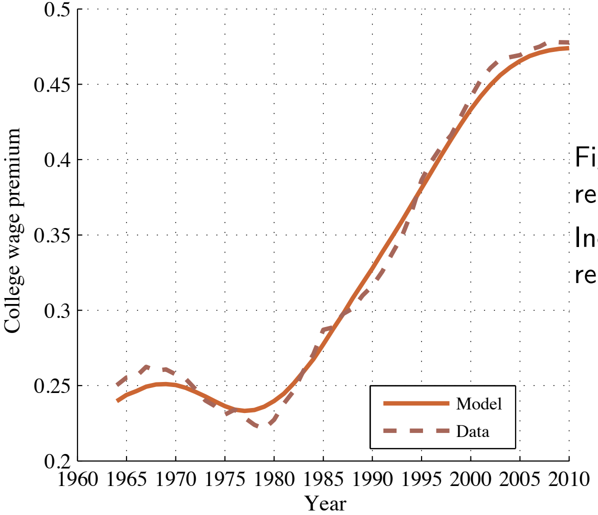


Figure: mean log wage of CG relative to HSG.

Increase mostly due to rising relative price of CG labor.

College Premium

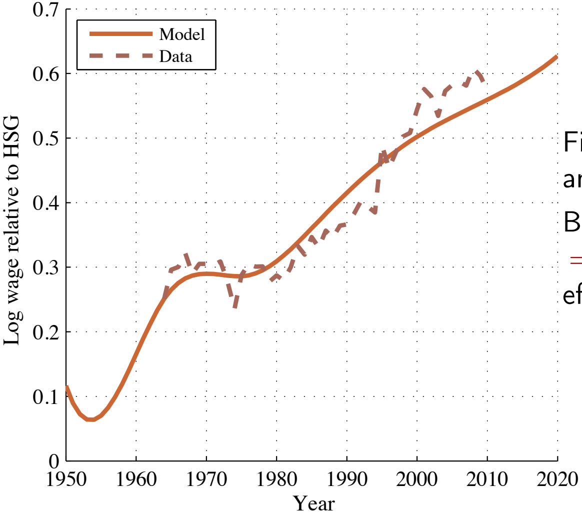


Figure: CPS college premium and model skill price premium.

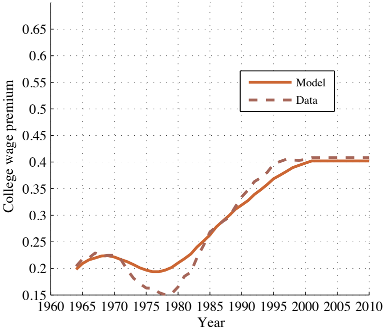
Both rise by the same amount.

$\Longrightarrow$ constant relative efficiencies of CG vs HSG

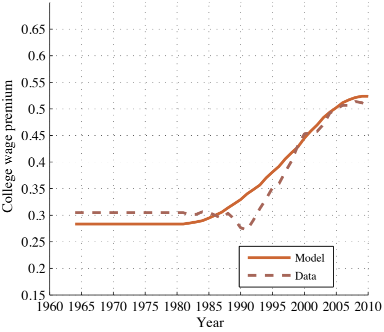
College Premium

- Why are relative efficiencies of CG and HSG workers roughly constant over time?
- Expansion of schooling
  - lowers mean a and h_1 of both groups by similar amounts
- Time varying skill price growth
  - induces variation in h investment
  - magnitude and timing similar for both groups

College Premium: Young and Old



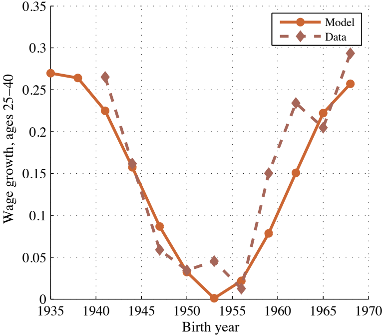
Ages 26-35



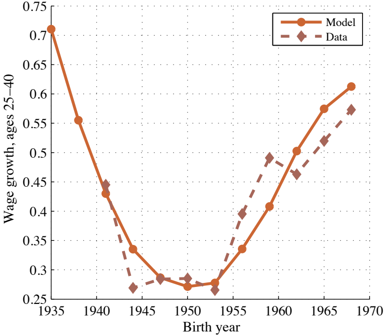
Ages 46-55

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.

Overall Wage Dispersion

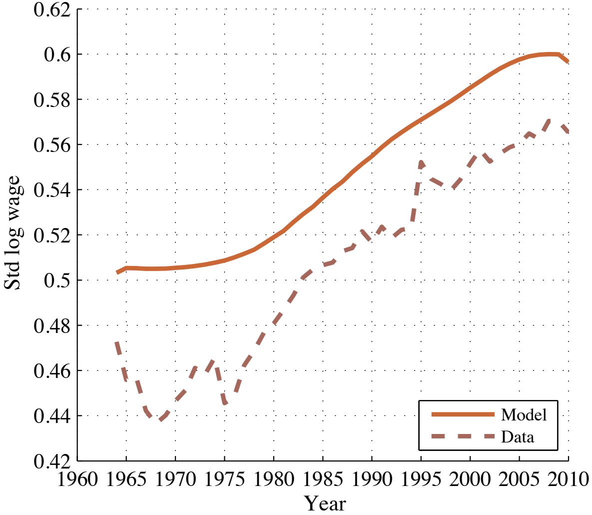
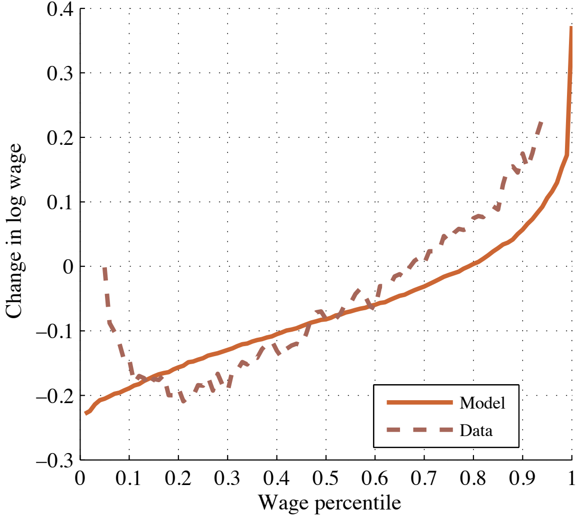


Figure: std dev of log wages

Increase roughly 50% due to diverging skill prices, 50% due to rising shock variances

Fanning Out of the Wage Distribution



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
4. Endogenous human capital and schooling are not important.
5. Rising education matters only for skill prices.

Lifetime Earnings Inequality

Lifetime Earnings Inequality

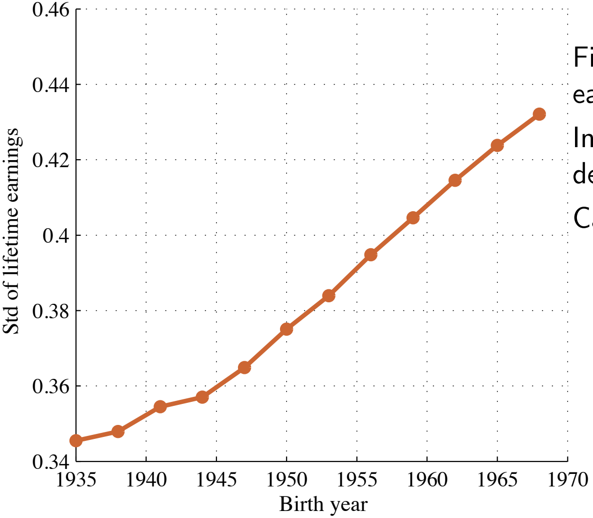


Figure: std dev of log lifetime earnings.

Increase similar to standard deviation of log wages.

Causes:

- rising college skill price: 50% .
- rising shock variances: 50%

Predictability of Lifetime Earnings

- Predictability = Var(E log lifetime earnings) / Var(log lifetime earnings)
- Huggett / Ventura / Yaron (2011 AER): 0.6
- This model:
  - pooling school groups: 0.35
  - within school groups: ≈ 0.2
- **Lifetime earnings are largely unpredictable.**

Why Is Predictability Low?

- One reason: curvature in human capital production
  - $\alpha_s \approx 0.45$
- Intuition: consider a worker who lives forever, no shocks
  - $Var(\ln h_t) \to \left(\frac{\theta}{1-\alpha_s}\right)^2 \approx \left(\frac{0.1}{1-0.45}\right)^2 = 0.03$
  - Variance of log wages among older workers ≈ 0.3
- Implications:
  1. Most of the wage variance among older workers must be due to shocks.
  2. Rising wage variance with age must come from persistent shocks.

Wage Variance and Age

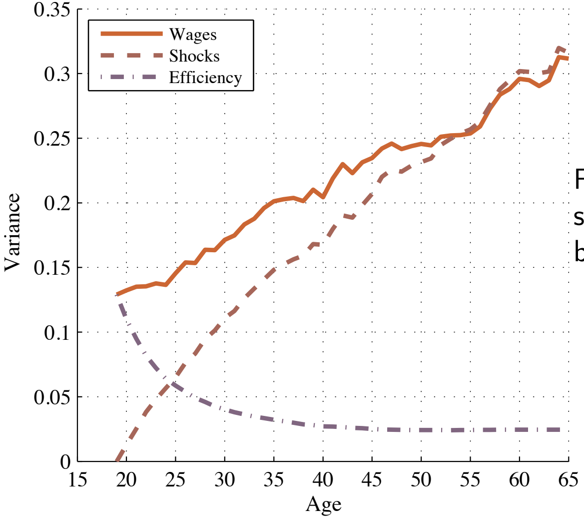


Figure: var of wages, efficiency, shocks
by age; HSG

Comparing with Huggett / Ventura / Yaron

Difference 1: $\alpha = 0.7 \implies Var(\ln h_t) \to 0.13$

Difference 2: shocks hit human capital

Human capital shocks are not very persistent

- workers undo the shocks through investment
- example: half-life of a shock to h_1 is 10 years
- equivalent to $\rho = 0.935$ in an AR(1) process

Low persistence shocks generate less increase in wage dispersion by age.

- model needs larger contribution of human capital to wage dispersion

The End