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

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Motivation

Long-term goal:

- An integrated, quantitative theory of the evolution of the U.S. wage distribution.

Why?

- Well known facts:
  rising college premium, changing returns to experience, rising variance of log (residual) wages, ...
- Several candidate explanations:
  SBTC, rising return to "ability," unionization, minimum wage, ...

Open questions:

- Quantitative importance of the various explanations
- Their "indirect" effects. E.g., SBTC $\rightarrow$ variance of log wages
- Policy analyis

Approach

How far can we go in a "standard" human capital model?

Basic ideas:

1. Katz & Murphy ▸ Details
   inverse relationship between supply of college educated labor and college wage premium
   suggests that skills are **imperfect substitutes**
2. Kambourov & Manovskii
   changing **returns to experience**
   need to model experience → Ben-Porath
3. Hendricks & Schoellman
   changing **cohort qualities** as schooling expands
   need to model discrete school choice
4. Heckman, Lochner, Taber (1998); Bowlus & Robinson (2012)
   with human capital, **wages are not skill prices**
   one main objective: measure skill prices by schooling and year

Approach

Develop a model with

- 4 imperfectly substitutable skill types: HSD, HSG, CD, CG
- discrete school choice
- Ben-Porath on-the-job learning
- no shocks - can only talk about conditional means, not variances

Driving forces:

- expansion of schooling $\rightarrow$ cohort quality
- constant SBTC + fluctuations in cohort sizes (Katz & Murphy)

Calibrate to CPS wage data

- age wage profiles of cohorts born since 1920

Result Preview

1. The model fits changing age wage profiles "well."
2. It replicates:
    1. changing returns to experience (Kambourov & Manovskii)
    2. different evolution of college premium by age (Card & Lemieux)
3. Skill prices look like smoothed versions of observed median wages
4. Human capital does not lead to significant revisions of average wage growth rates

Literature

Quantitative models of the evolution of the U.S. wage distribution:

- Heckman, Lochner, Taber (1998); Guvenen & Kuruscu (2010)

Recovering skill prices from wages

- a long-standing issue in labor economics: Juhn et al. (1993, 2005); ...
- Bowlus & Robinson (2012)

Model Outline

- Small open economy (fixed interest rate)
- Overlapping generations
- 4 school groups: HSD, HS, CD, CG
- Exogenous aggregate schooling
- Ben-Porath on-the-job learning
- Constant skill-biased technical change (Katz & Murphy)
- No shocks

Demographics

In period c, N_c households are born.

Each lives for T periods.

Life stages:

1. Draw endowments
2. Choose schooling $s \in \{HSD, HS, CD, CG\}$
3. Study in school for T_s periods
4. Learn and earn on the job until retirement at age T.

Households maximize lifetime earnings.

Endowments

$$\begin{bmatrix} a \\ \ln(h_1) \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho_{a,h1} \\ \rho_{a,h1} & \sigma^2_{h1} \end{bmatrix} \right) \tag{1}$$

a: learning ability in school and on the job

h_1: human capital endowment

Human Capital Technologies

On the job:

$$h_{t+1} = (1-\delta_s)h_t + A(a,s)(h_t l_t)^{\alpha_s} \tag{2}$$

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

In school: the same with $l_t = 1$:

$$h_{T_s+1} = F(h_1, a, s) \tag{3}$$

Goods Production

Output is produced from skilled and unskilled (no college degree) labor:

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

G aggregates "unskilled" labor:

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

L: labor supplies in efficiency units.

Skill prices equal marginal products: $w_{s,\tau} = \partial Q_\tau / \partial L_{s,\tau}$.

Labor Aggregation

Each individual supplies

$$e_{i,s,c,t} = h_{i,s,c,t}(\ell_{s,c,t} - l_{i,s,c,t}) \tag{6}$$

efficiency units of labor.

Aggregate labor inputs:

$$L_{s,\tau} = \sum_{t=T_s+1}^{T} \sum_{i=1}^{N_{c(t,\tau)}} p_{i,s,c} e_{i,s,c,t} \tag{7}$$

where $p_{i,s,c}$ is the (endogenous) probability that agent i chooses schooling level s.

Household: Work Phase

$$V(h_{T_s+1}, a, s, c) = \max_{\{l_t\}} \sum_{t=T_s+1}^{T} R^{-t} y(l_t, h_t, t, s, c) \tag{8}$$

subject to

$y(l, h, t, s, c) = w_{s,\tau(c,t)} h(\ell_{t,s,c} - l)$

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

$0 \leq l_t \leq \ell_{t,s,c}$.

This problem has an analytical solution.

Household: School Phase

The agent chooses schooling to maximize

$$W_s(p_s, h_1, a, s, c) = \underbrace{\ln V(F[h_1, a, s], a, s, c)}_{\text{lifetime earnings}} + \mu_{s,c} + \underbrace{\pi p_s + \pi_a T_s (a - \underline{a})}_{\text{"psychic cost"}} \quad (9)$$

$\mu_{s,c}$: school costs, common to all agents

- allow the model to match each cohort's schooling exactly

$\pi p_s + \pi_a T_s (a - \underline{a})$: "psychic cost"

- generates imperfect school sorting by ability
- π_a governs ability gaps between school groups
- p_s: type I extreme value shocks

This problem has an analytical solution.

Calibration

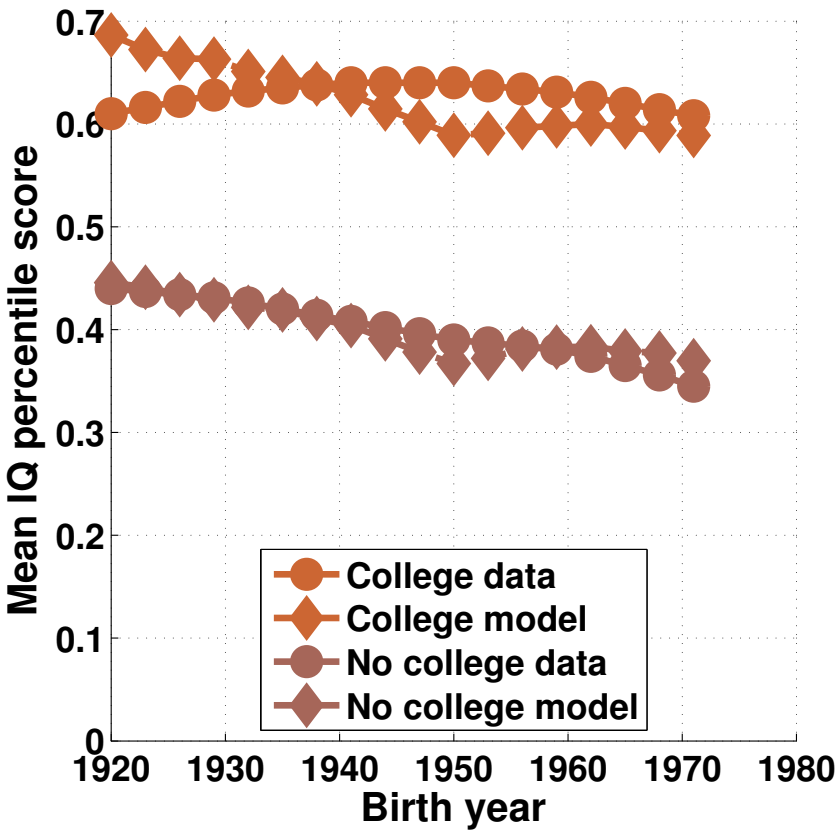
Calibration: Overview

- Simulate $1,000$ individuals in each of 18 birth cohorts born between 1920 and 1971.
- Set school costs $(\mu_{s,c})$ to exactly match each cohort's attainment.
- For aggregation: assume that non-modeled cohorts are identical to the nearest model cohort.
- Restrict relative skill weights to grow at a constant rate (constant SBTC, Katz & Murphy)
- Restrict average skill price growth "out of sample" to equal average "in sample" growth

Calibration Targets

1. Median **age wage profiles** for all model cohorts
   CPS, men, $1964-2010$
2. **Cognitive test scores** moments
   In the model: $IQ = a + noise$

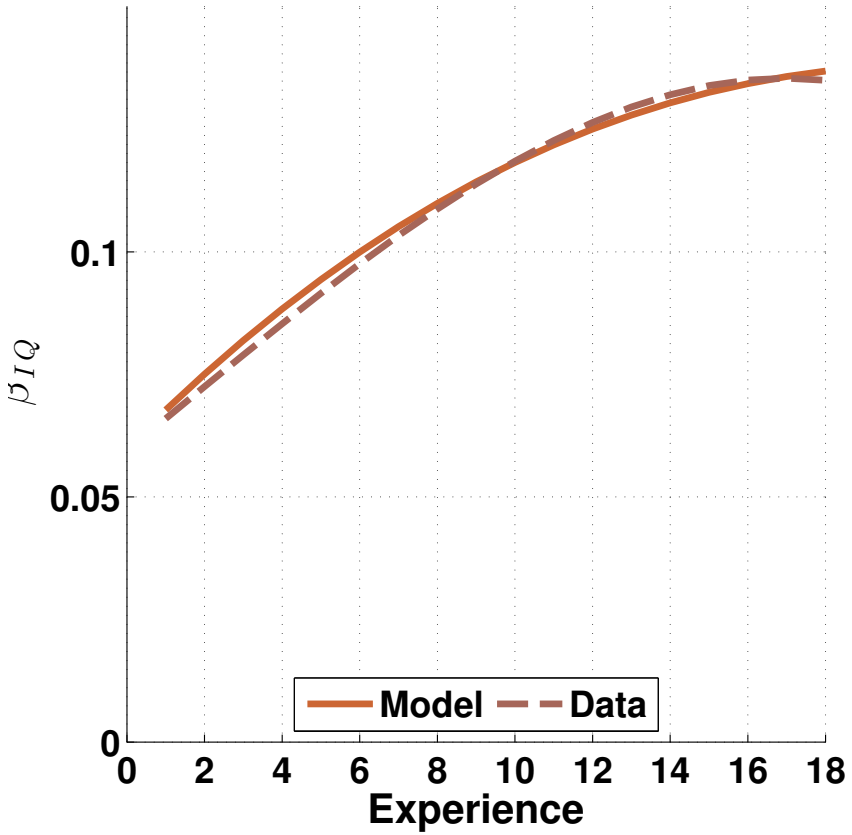
Cognitive Test Scores



Mean cognitive test scores of college educated and high school educated workers.
From Hendricks & Schoellman (2014).
They help identify:

- school sorting by ability (and how it changes over time)
- contribution of ability selection to the level of the college premium

Cognitive Test Scores



Coefficients of regressing log wage on IQ, IQ*experience, school dummies.
NLSY79, men
They help identify:

- ability dispersion θ
- correlation between a and h_1

Fixed Parameters

Parameter	Description	Value
T	Lifespan	65
c	Birth cohorts	1920, 1923, 1926, ..., 1965, 1968, 1971
T_s	School duration	2, 3, 5, 7
$\ell_{t,s,c}$	Market hours	CPS data
n/a	Nodes of skill price spline	1935, 1941, 1947, ..., 2023, 2029, 2035
R	Gross interest rate	1.04

Calibrated Parameters

24 parameters are calibrated. They govern:

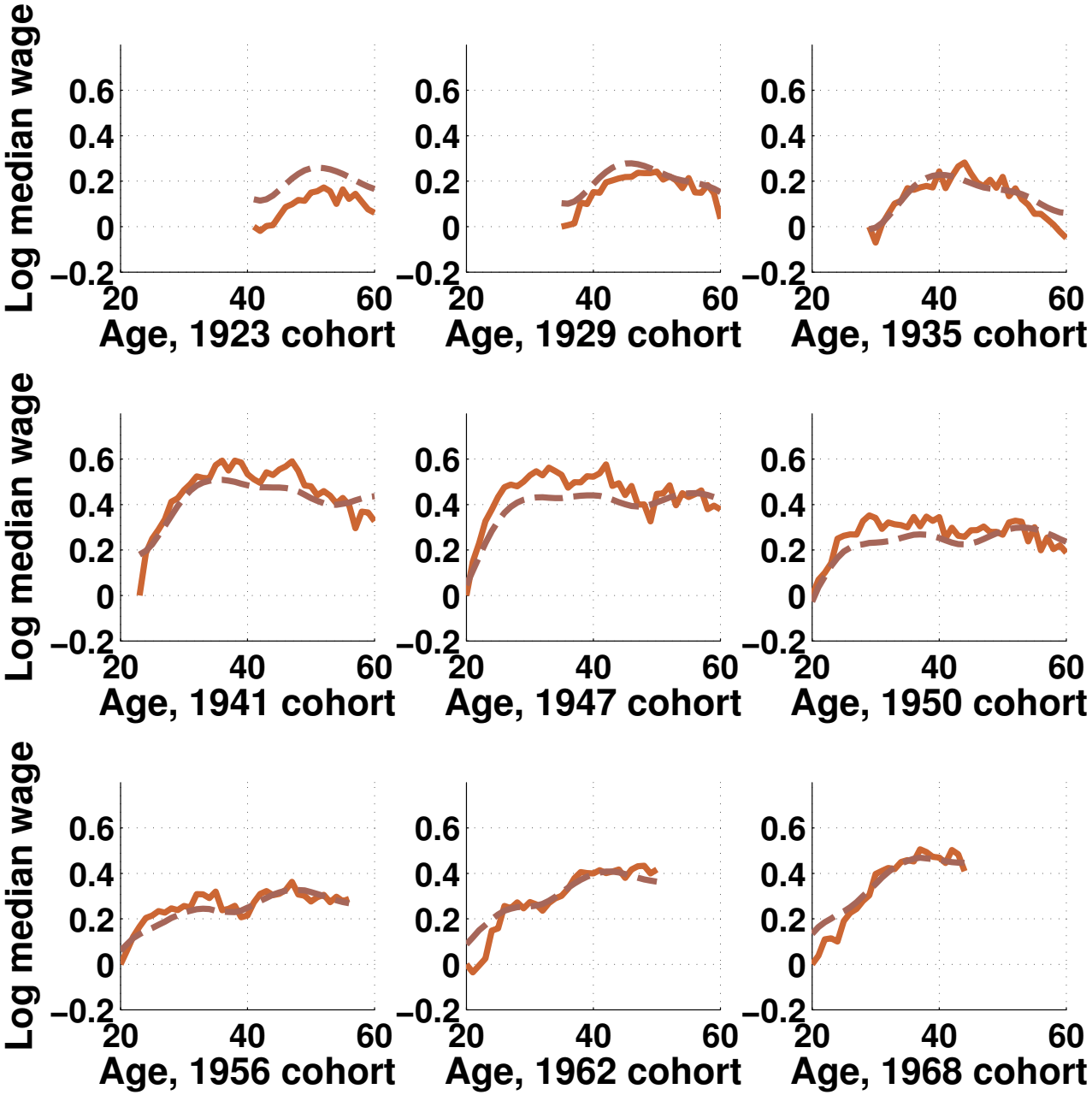
- endowment distributions
- Ben-Porath technologies
- aggregate technology: skill weights, elasticities of substitution

Curvature of the Ben-Porath technology: $\alpha_s \approx 0.3 - 0.5$

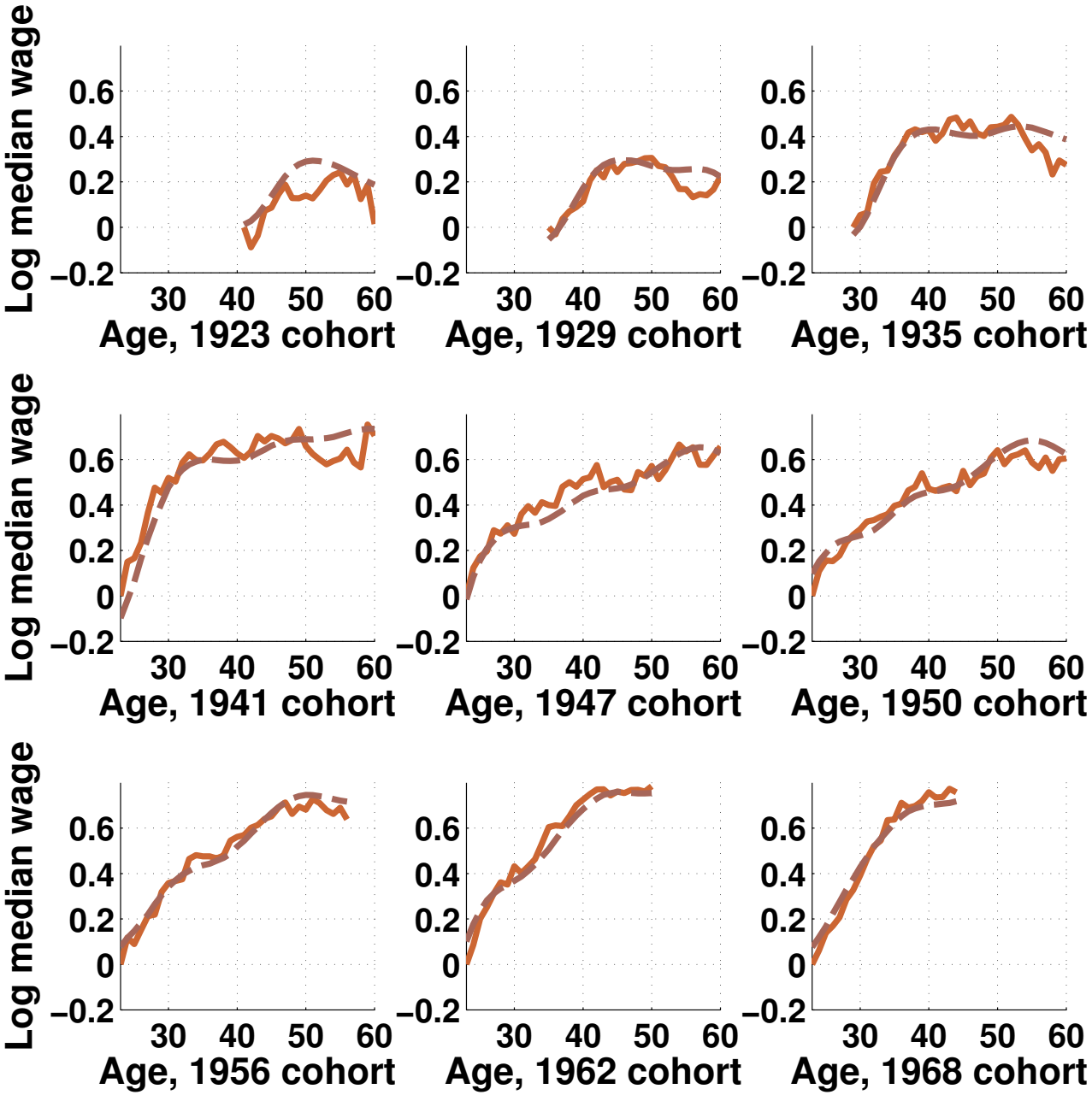
- recent estimates are much higher (Heckman et al. 1998: $\alpha \approx 0.9$)
- intuition: when α is high, h investment is extremely volatile
- this matters for: flat spot method, gains from training, tax effects, ...

▸ Details

Fit: Wage Profiles, HSG



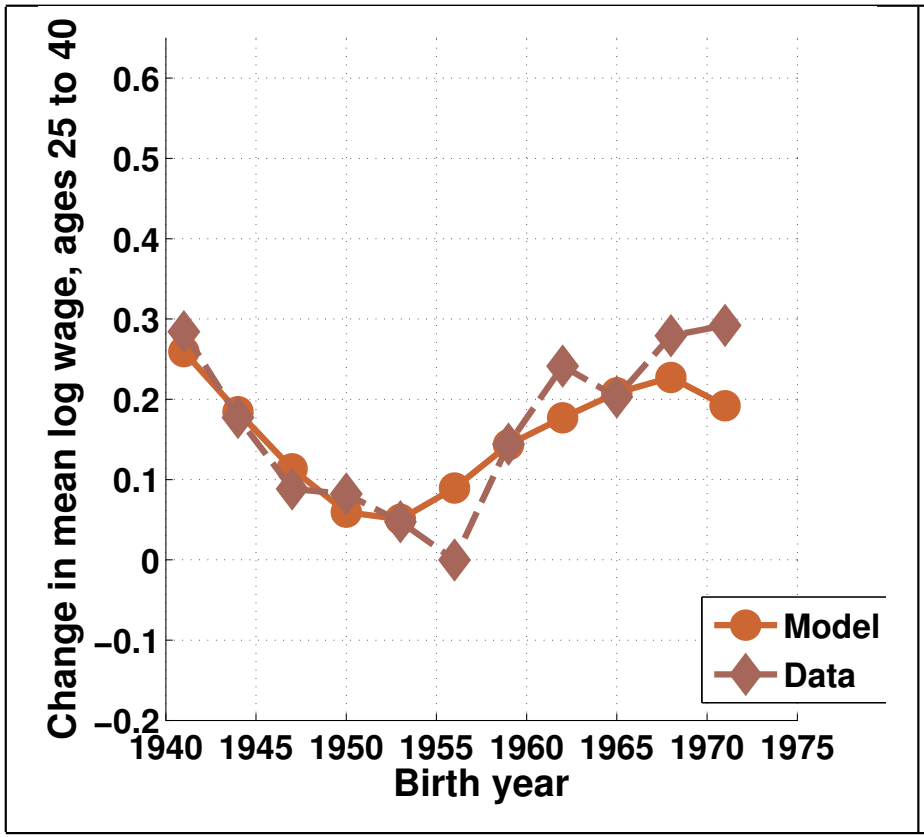
Fit: Wage Profiles, CG



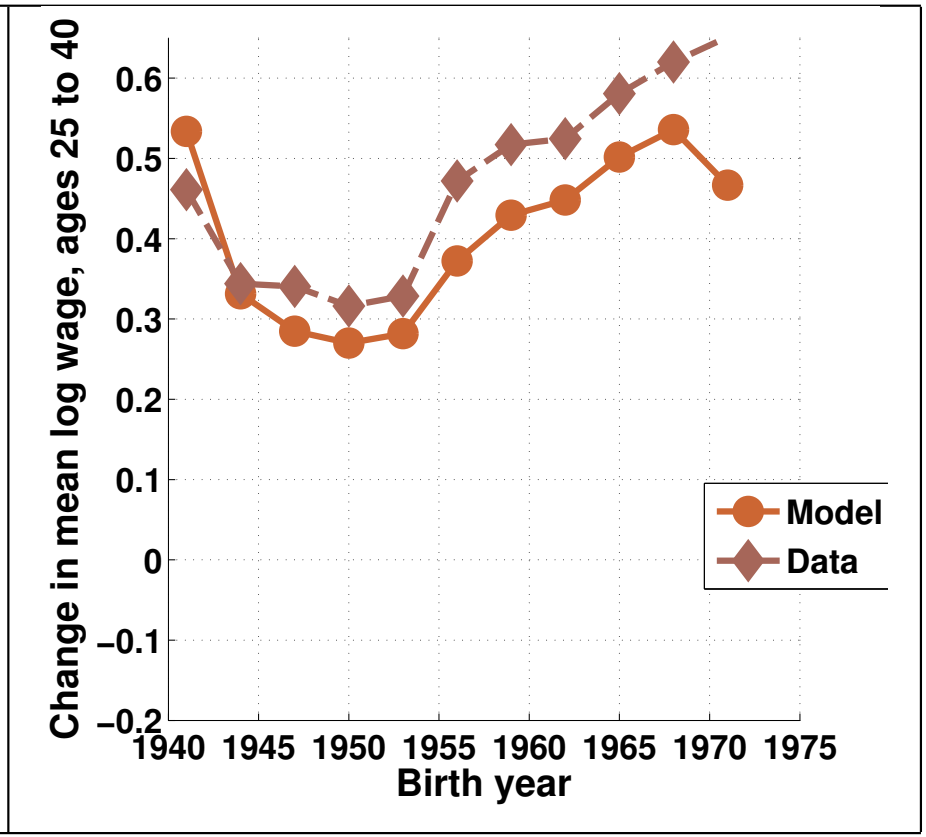
Lesson

- Good fit of age wage profiles supports Ben-Porath as a credible model wage determination.
- Can account for changing returns to experience without occupation specific human capital (Kambourov & Manovskii).
- Can account for different behavior of college premium for young and old (Card & Lemieux)

Fit: Returns to Experience

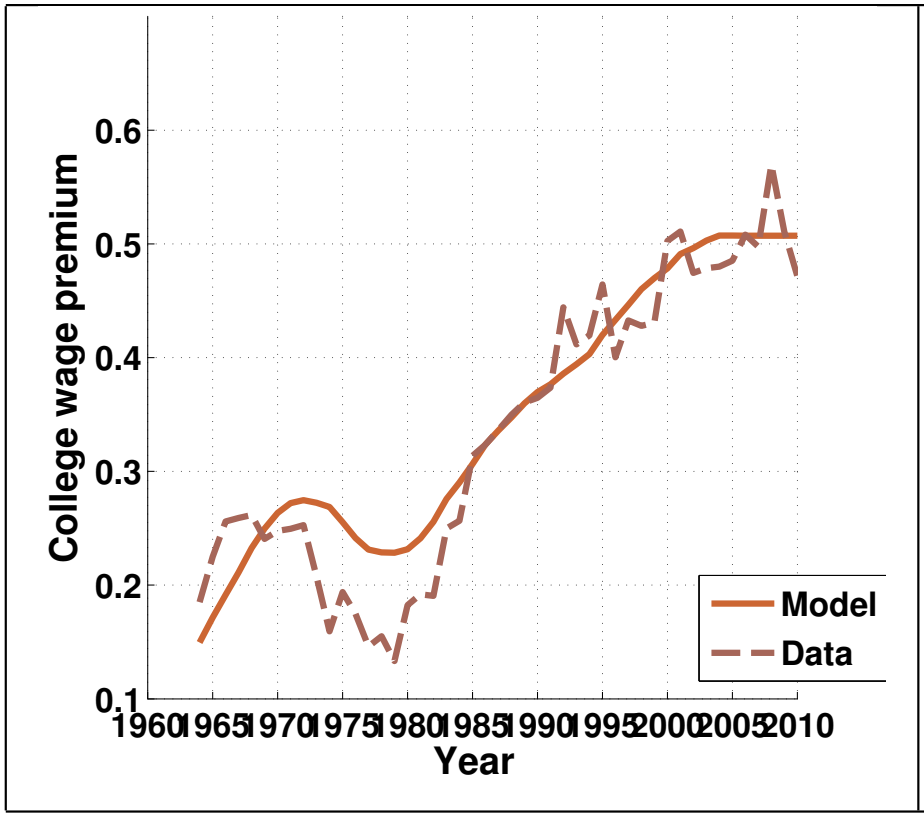


High school graduates

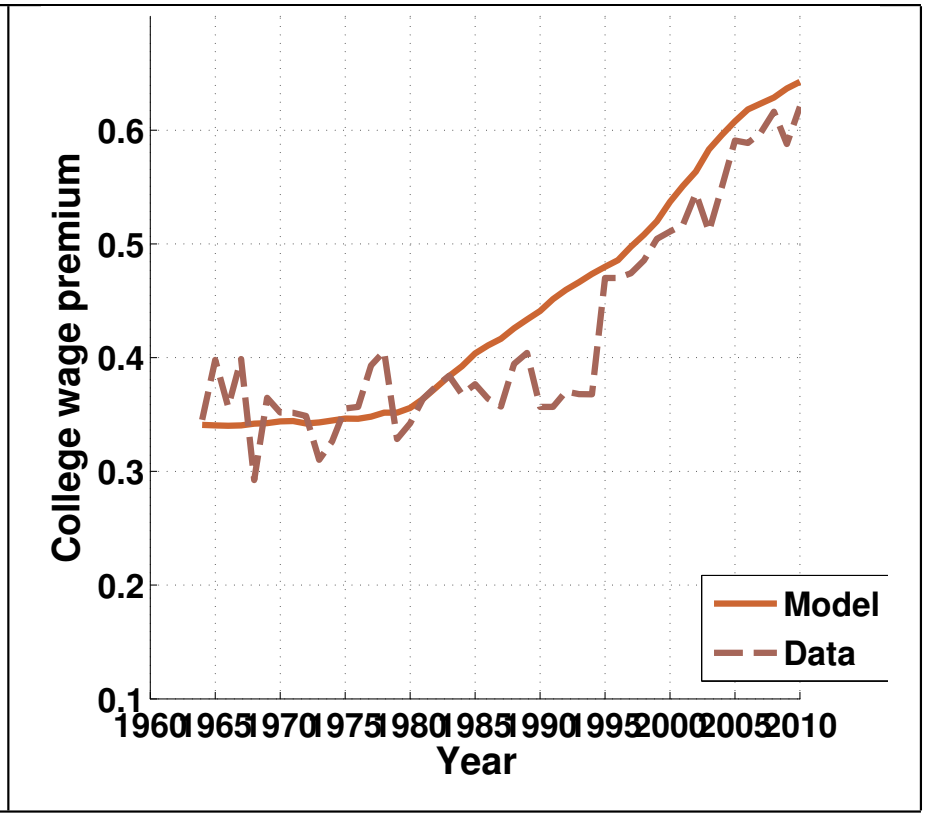


College graduates

Fit: College Premium

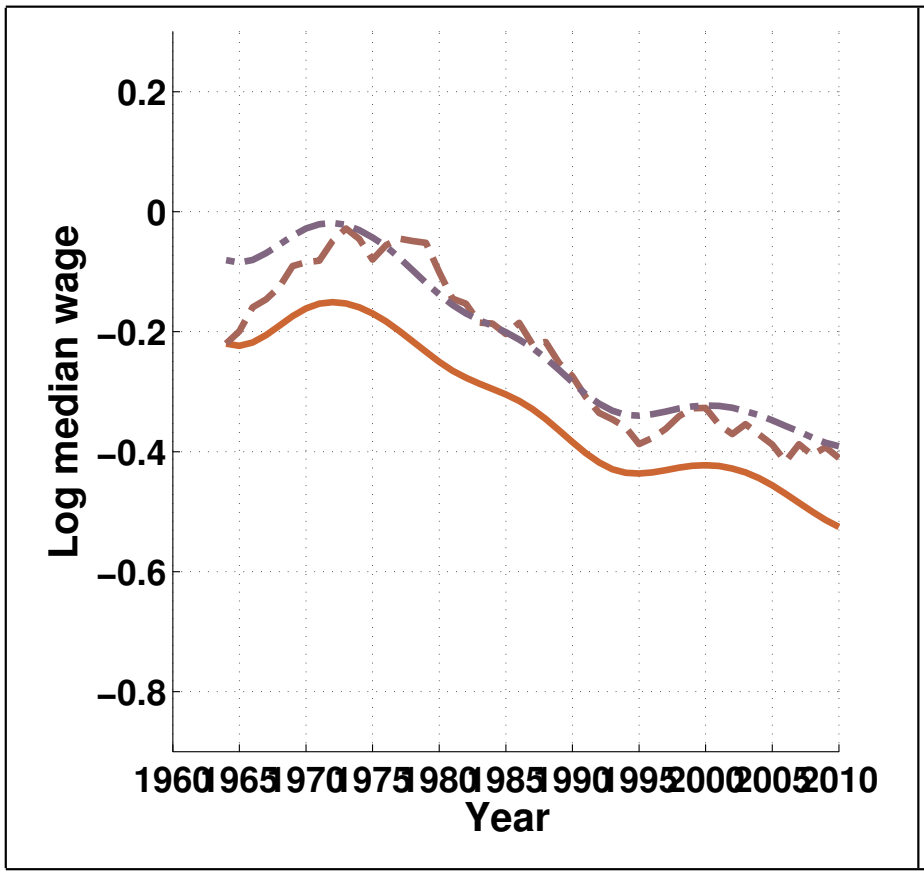


Age group $26-35$



Age group $46-55$

Skill Prices vs Wages



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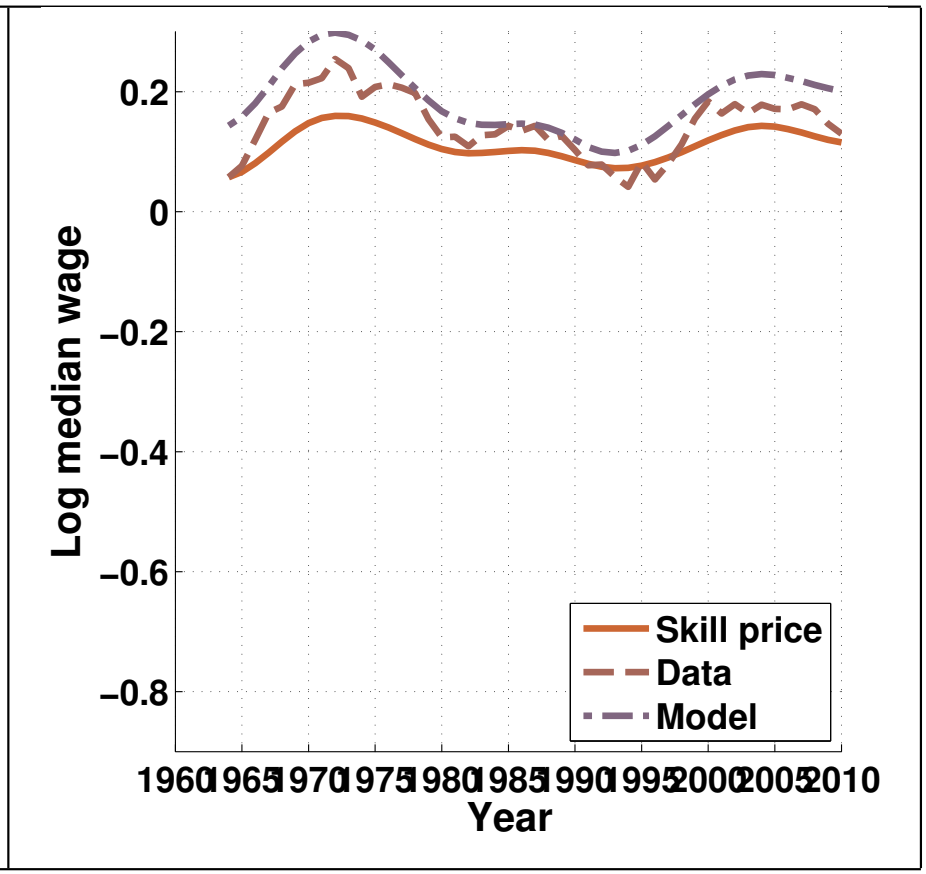


College graduates

Skill Prices vs Wages

Skill prices are essentially **smoothed** (observed) wages

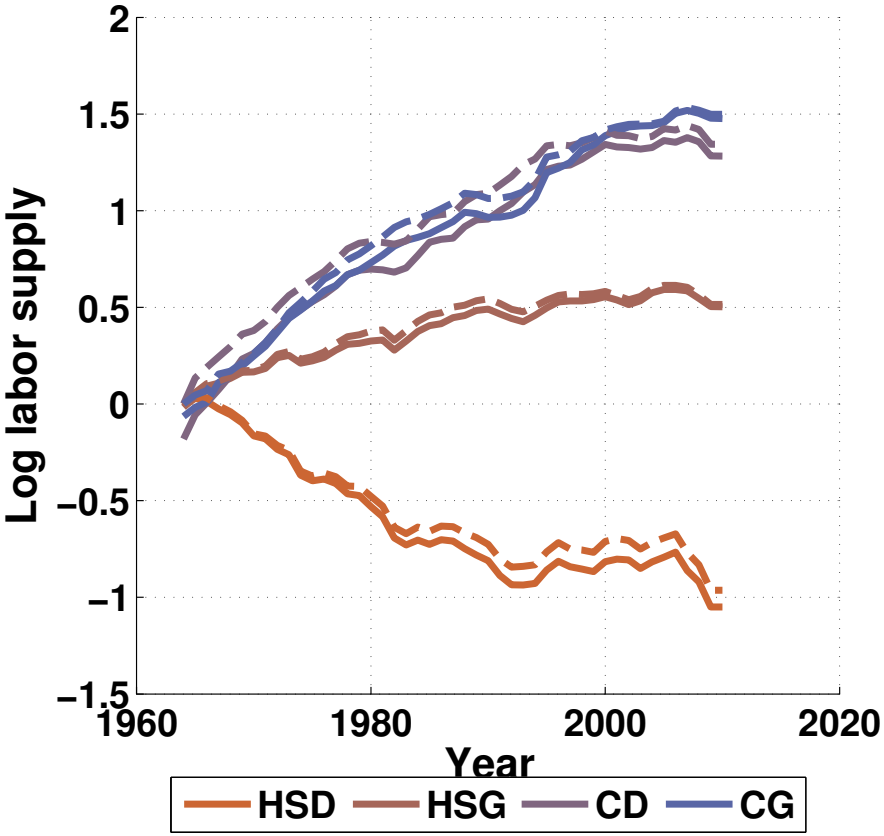
Why so smooth?

- human capital investment **amplifies** variation in skill price growth

Skills must be highly **substitutable**

- Katz/Murphy (1992) ▸ Details
  - labor supply = hours worked
  - elasticity of substitution between college / non-college labor ≈ 1.5
- Ben-Porath: ≈ 6

Skill Prices vs Wages

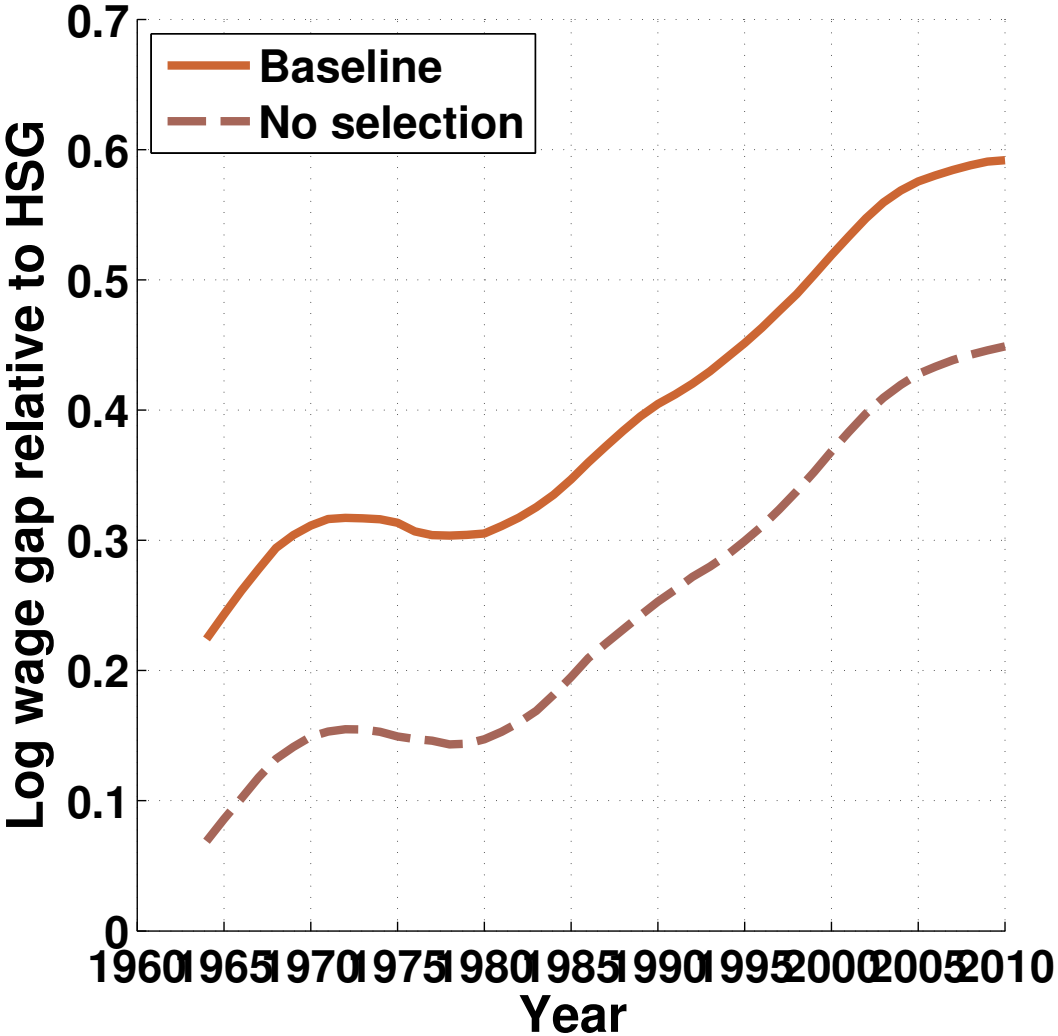


Aggregate labor supplies $\approx$ aggregate hours worked.
Labor efficiency for all school groups is roughly constant.

Reasons:

- Smooth wages $\Longrightarrow$ roughly constant human capital investment.
- Small ability dispersion $(\theta = 0.09)$ $\Longrightarrow$ small changes in cohort qualities as schooling expands.

Selection and the College Premium



Experiment:

- Shut off school sorting
- Recompute aggregate (constant composition) college wage premium

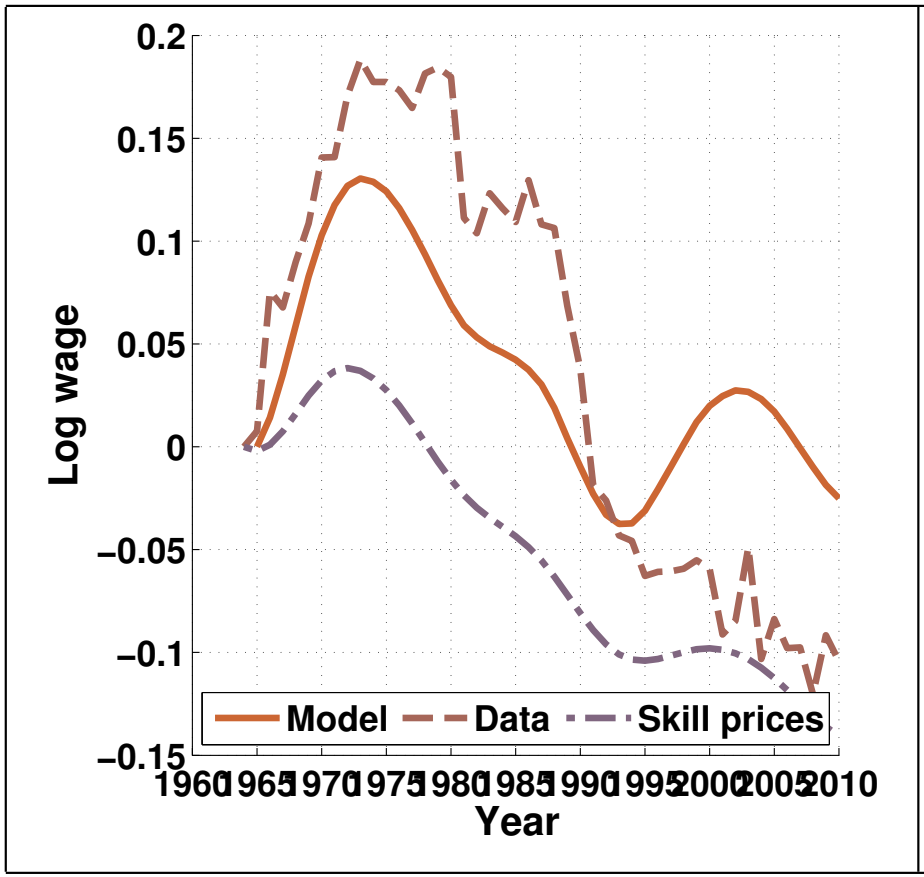
Result:

15 log points of the college premium are due to selection constant over time

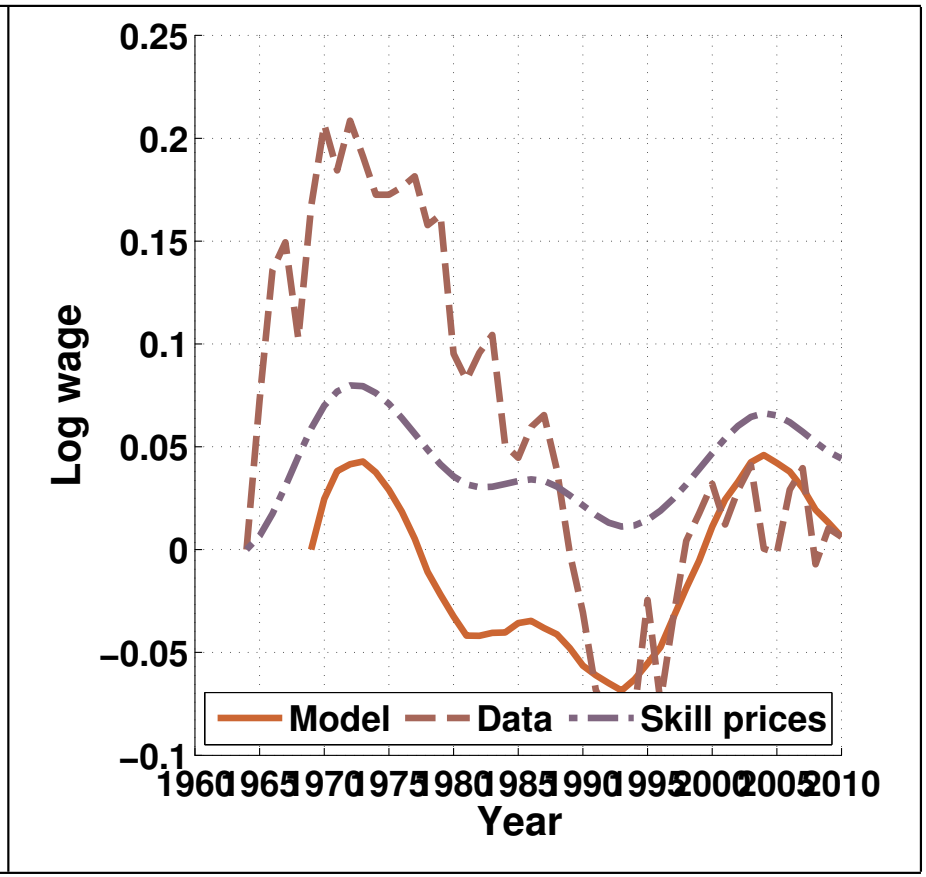
The Flat Spot Method

- Heckman, Lochner, Taber (1998)
  - if α is high enough and $\delta = 0$, then h investment stops some time before retirement.
  - for older workers, wage growth = skill price growth
- Bowlus & Robinson (2012)
  - apply this method to CPS data
  - main result: on average, all skill prices grow at the same rate
- What happens if we apply the flat spot method to the wage data generated by this model?
  - using the Bowlus & Robinson flat spot age ranges
  - $44-52$ for HSD, ..., $50-58$ for CG

The Flat Spot Method



High school graduates



College graduates

The Flat Spot Method

Results:

1. Skill prices are smoother than flat spot wages.
2. For HSG, the flat spot method overstates the skill price growth rate.

Intuition:

- With low α and $\delta > 0$, h investment continues until retirement ▸ Details
- Study time at age 50 is between $0.1 - 0.15$
- Efficiency is not constant during the flat spot period
  It rises by 10-15 log points after age 50 b/c of falling study time
  This is counteracted by depreciation

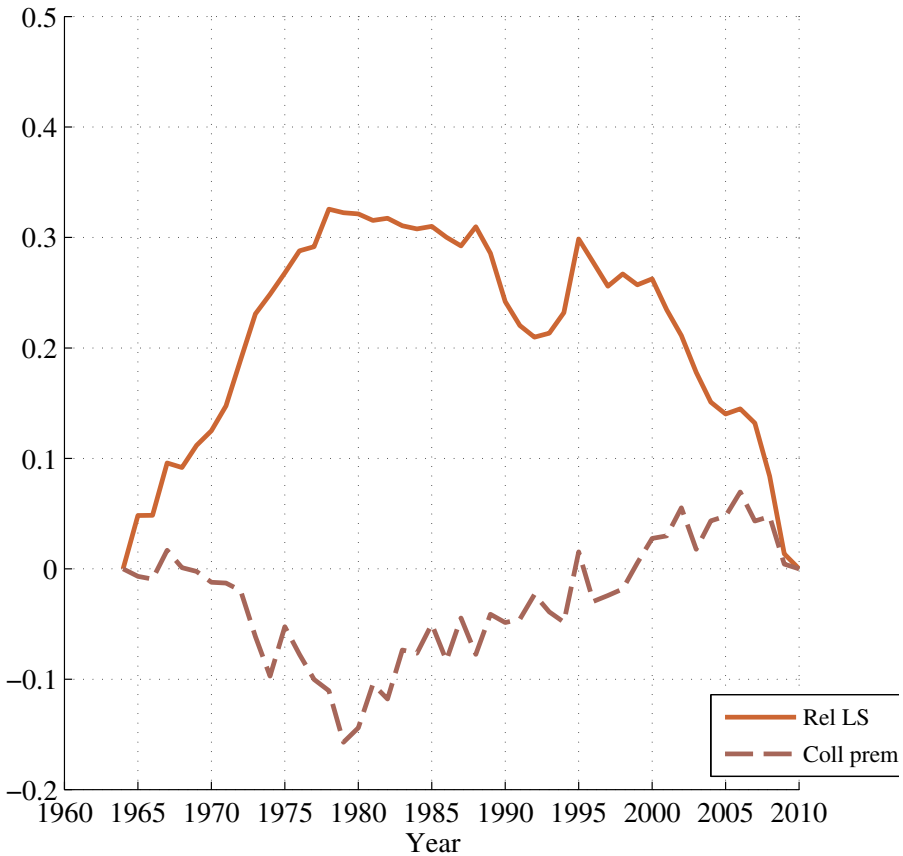
Conclusion

- The Ben-Porath model is a credible model of wages over the life-cycle.
- A simple human capital model replicates
  - age wage profiles for most cohorts in CPS data
  - returns to experience
  - college premium by age
- Average human capital (conditional on schooling) is roughly constant over time
  - caveat: do not have time-varying school sorting yet
- Future work:
  - wage shocks / implications for variances

Calibrated Parameters

Parameter	Description	Value
On-the-job training		
A_s	Productivity	0.13, 0.14, 0.13, 0.12
α_s	Curvature	0.15, 0.15, 0.54, 0.54
δ_s	Depreciation rate	0.048, 0.048, 0.045, 0.045
Endowments		
σ_{h1}	Dispersion of h_1	0.401
θ	Ability scale factor	0.092
π_1	Psychic cost scale factor	0.312
γ_{ap}	Ability weight in psychic cost	0.076
γ_{ah}	Governs correlation of $\ln h_1$ and a	0.302
σ_{IQ}	Noise in IQ	0.283
Other		
Δw_s	Skill price growth rate, 1964-2010 [pct]	-0.92, -0.66, -0.73, 0.13
$(1+\rho_{HS})^{-1}$, $(1+\rho_{CG})^{-1}$	Substitution elasticities	7.43, 3.64

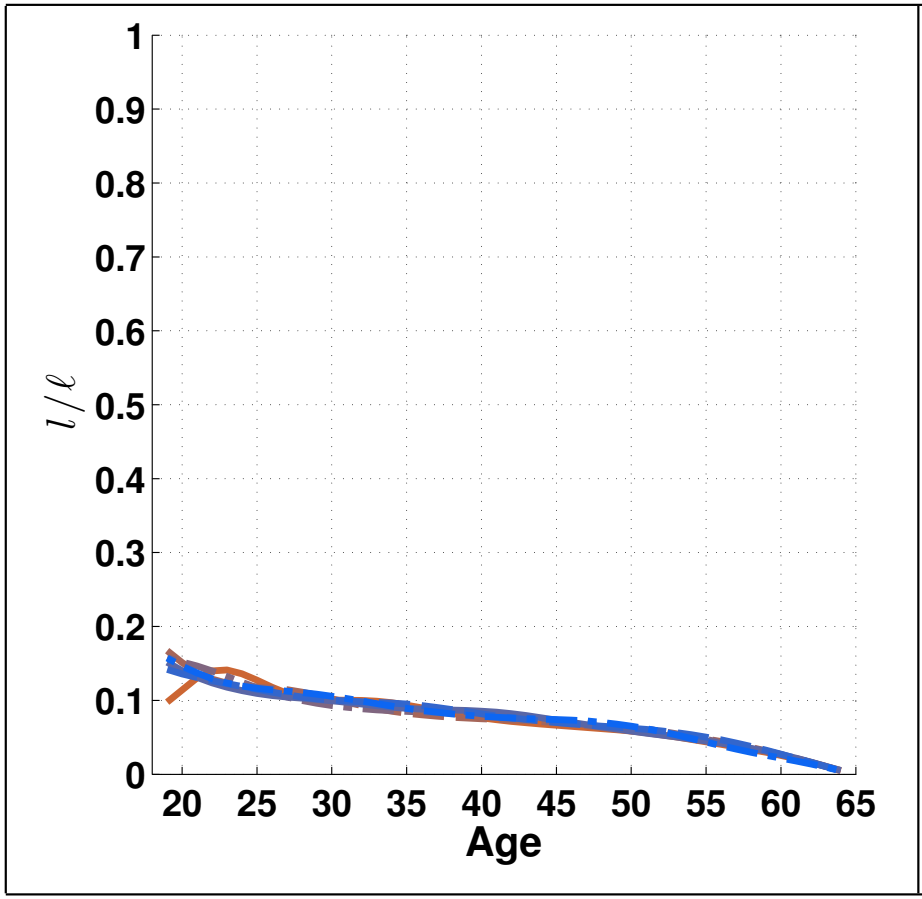
Katz & Murphy (1992)



Inverse relationship between

- detrended hours worked college / high school workers
- detrended college wage premium

Study Time Profiles



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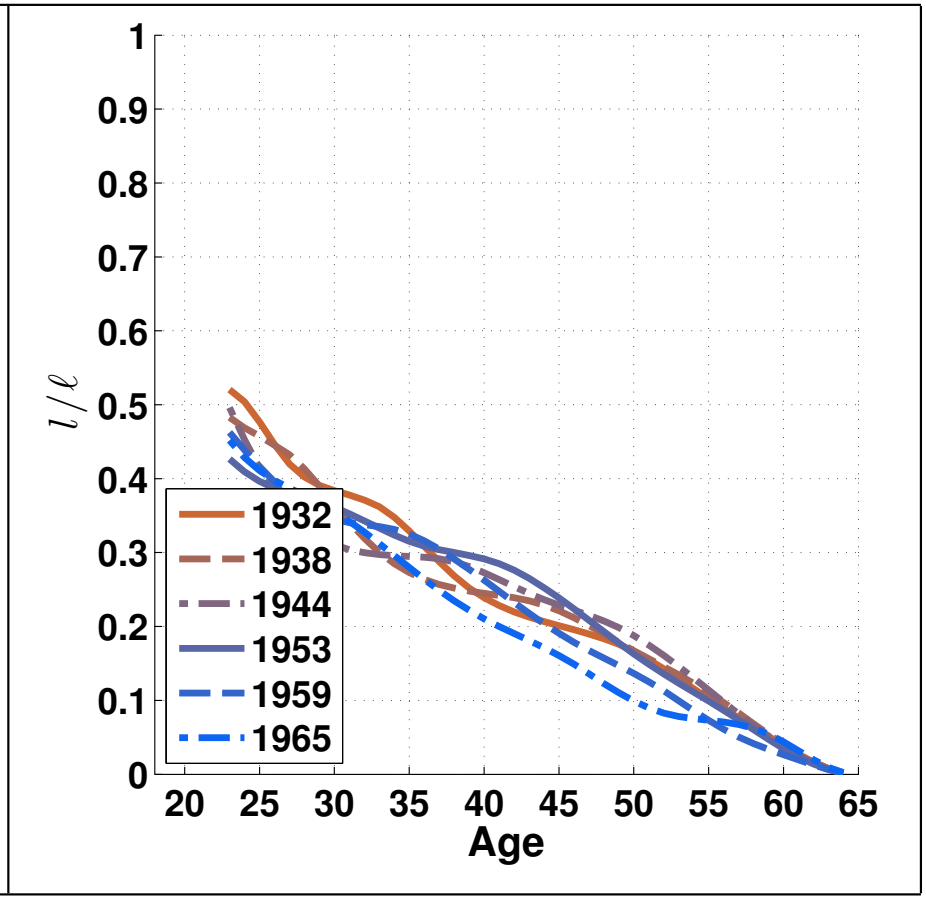

College graduates