The Allocation of Teaching Talent and Human Capital Accumulation

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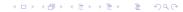[1]University of Wisconsin–Madison

July 25, 2023

Introduction

- ▶ Public education in U.S. has gone through major (positive) changes since end of WW II:

  - ○ Annual real expenditures per student: $2,100 (1950s) to $12,000 (2010s)

  - ○ Student-teacher ratio: 27 (1955) to 16 (2010s)

- ▶ Evolution of educational outcomes doesn't compare favorably with countries at similar income level (e.g. *PISA* assessments)

- ▶ Potential explanations include:

  - ○ U.S. education underfunded by international comparison

  - ○ Role of (powerful) teachers' unions

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    - ○ Occupational choice

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  - ○ Occupational choice

  - ○ Local funding for public education (e.g. property taxes)

Research Questions

▶ To what extent do changes in career opportunities in other occupations affect selection of workers into teaching careers?

▶ To what extent are static efficiency gains associated with improved career opportunities in non-teaching occupations muted or amplified by dynamic effects?
$\Rightarrow$ human capital accumulation channel

What We Do

- ▶ Highlight stylized facts

- ▶ Develop a novel theory of occupational choice and human capital formation:
    - ○ non-linear wages $\Rightarrow$ comparative and absolute advantage
    - ○ intergenerational dynamics of human capital accumulation

- ▶ Combine three longitudinal surveys:
    - ○ Project TALENT, NLSY79, NLSY97

Stylized Fact #1

Majority of (Public) School Teachers is Female

	% Female	Time Period
Project TALENT	61.1	early 70s
NLSY79	77.7	1986-1993
NLSY97	77.1	2009-2013
NCES (2006)	75	2003-4

Stylized Fact #2
Educational Barriers / Labor Market Discrimination

- ▶ Females face low barriers / discrimination in teaching
- ▶ Barriers / discrimination in non-teaching occupations falling over time

Stylized Fact #3
Occupational Choice

- Share of women in teaching: 4.6% in 1970 to 6.7% in 2010

- Share of men in teaching: 2.9% in 1970 to 2.1% in 2010

- Sharp rise in female labor force participation rate

- Slight decline in male labor force participation rate

Stylized Fact #4

Ability Distribution of Females by Occupation

Model

- ▶ OLG

- ▶ Non-linear version of occupational choice model

- ▶ Educational barriers / labor market discrimination
  (as in Hsieh et al., 2019)

Model

Endowments, Preferences

- Each period, a measure M of agents is born and lives for two periods: "young" and "old"

- G groups of individuals

- With occupation-specific abilities from $F_a(\vec{a})$

- $\log$ preferences over consumption and leisure:

$$\mu \ln C_g' + \ln(1 - s_{i,g})$$

Model

- ▶ "Young" make occupation-specific time and goods investments

- ▶ "Old" work as teachers or production workers

  Human capital production (teaching) depends on
  teacher's $h_{T,\hat{g}}$, class size $N(h_{T,\hat{g}})$, own ability
  a_i, time $s_{i,g}$ and goods $e_{i,g}$ investments:

  $$h'_{i,g}(a_i) = (h_{T,\hat{g}})^\beta \, a_i^\alpha (s_{i,g})^\phi (e_{i,g})^\eta \big(N(h_{T,\hat{g}})\big)^{-\sigma}$$

  $$\text{where } \widetilde{H}_T = \sum_{\hat{g}=1}^{G} \int_0^\infty (h_{T,\hat{g}}(a))^{\frac{\beta}{\sigma}} \, f_{T,\hat{g}}(a)da$$

  Final output production depends on adult worker's human
  capital $h_{O,g}$ and exogenous productivity A_O:

  $$y_g = A_O h_{O,g}$$

Model

$$V_g(a_T, a_O, \widetilde{H}_T) = \max_{\{s_{O,g}, s_{T,g}, e_{O,g}, e_{T,g}\}} \left\{ V_{O,g}(a_O, \widetilde{H}_T), V_{T,g}(a_T, \widetilde{H}_T) \right\}$$

where

$$
\begin{aligned}
V_{O,g}(a_O, \widetilde{H}_T) &= \ln \left(1 - s_{O,g} \left(a_O, \widetilde{H}_T \right) \right) \\
&\quad + \mu \ln \left[h'_{O,g} A'_O (1 - t')(1 - \tau_{O,g}^{\omega'}) \right. \\
&\quad \left. - e_{O,g}(a_O, \widetilde{H}_T)(1 + \tau_{O,g}^e) \right], \\
V_{T,g}(a_T, \widetilde{H}_T) &= \ln \left(1 - s_{T,g} \left(a_T, \widetilde{H}_T \right) \right) \\
&\quad + \mu \ln \left[\omega'(h'_{T,g}, \widetilde{H}'_T)(1 - t')(1 - \tau_{T,g}^{\omega'}) \right. \\
&\quad \left. - e_{T,g}(a_T, \widetilde{H}_T)(1 + \tau_{T,g}^{e'}) \right]
\end{aligned}
$$

Model

Constraints, Laws of Motion

$$t \left[\sum_{g=1}^{G} \int_0^\infty \omega_T \left(h_{T,g}(a) \right) f_{T,g}(a) da + \sum_{g=1}^{G} \int_0^\infty \omega_O \left(h_{O,g}(a) \right) f_{O,g}(a) da \right]$$

$$= \sum_{g=1}^{G} \int_0^\infty \omega_T \left(h_{T,g}(a) \right) f_{T,g}(a) da$$

$$f_{T,g}(a) = \int_0^{\bar{a}_g^{-1}(a)} f(a,b) db$$

$$f_{O,g}(b) = \int_0^{\bar{a}_g(b)} f(a,b) da$$

$$H_O' = \sum_{g=1}^{G} \int_0^\infty \left(\frac{2\widetilde{H}_T}{M} \right)^\sigma a^\alpha s_{O,g} \left(a, \widetilde{H}_T \right)^\phi e_{O,g}(a, \widetilde{H}_T)^\eta f_{O,g}(a) da$$

$$\widetilde{H}_T' = \sum_{g=1}^{G} \int_0^\infty \left(\left(\frac{2\widetilde{H}_T}{M} \right)^\sigma a^\alpha s_{T,g} \left(a, \widetilde{H}_T \right)^\phi e_{T,g}(a, \widetilde{H}_T)^\eta \right)^{\frac{\beta}{\sigma}} f_{T,g}(a) da$$

Model
Occupational Threshold

$$a_{T,g}^*(a_O) = \bar{a}_g\big(a_O, \widetilde{H}_T\big)$$

such that

$$V_{O,g}(a_O, \widetilde{H}_T) = V_{T,g}\left(a_{T,g}^*(a_O), \widetilde{H}_T\right), \text{ for all } a_O \in (0, \infty)$$

Model

- Assignment of students to teachers is random
  $\Rightarrow$ distribution of students' skill identical across classrooms

- Teachers with different $h_{T,g}$ vary with respect to class *size*

- $\omega(\cdot,\cdot)$ is proportional to the *number of students* in a teacher's class:

$$\omega(h_{T,g}, \widetilde{H}_T) = \lambda N(h^T, \widetilde{H}^T)$$

$$= \underbrace{\frac{H'^O A'^O}{\frac{M}{2} \sum_{g=1}^{G} \int_0^\infty f_{O,g}(a)da}}_{\text{total output (next period)}} \cdot \underbrace{\overbrace{N(1, \widetilde{H}^T)}^{=\frac{M}{2}\frac{1}{\widetilde{H}^T}} \left(h^T\right)^{\frac{\beta}{\sigma}}}_{=N(h^T, \widetilde{H}^T)}$$

$$= \frac{\overbrace{H'_O A'_O}}{\underbrace{\sum_{g=1}^{G} \int_0^\infty f_{O,g}(a)da}_{\substack{\text{fraction of prospective} \\ \text{production workers in class}}}} \cdot \underbrace{\frac{(h_{T,g})^{\frac{\beta}{\sigma}}}{\widetilde{H}_T}}_{\text{fraction of students taught}}$$

Equilibrium

Given occupational choices of today's "old" and aggregate human capital $\widetilde{H}_T$ and H_O, the equilibrium consists of individual choices of "young" $\{e_{T,g}, s_{T,g}, e_{O,g}, s_{O,g}\}$, the occupational choice boundary $a^*_{T,g}(a_O)$, the corresponding densities $f_{T,g}$ and $f_{O,g}$, and occupation- and group-specific wage profiles $\{\omega_{T,g}, \omega_{O,g}\}$ such that:

1. Individuals solve their problem ▸ Time Investment ▸ Goods Investment

2. Aggregate human capital follows the laws of motion ▸ Laws of Motion

3. Government budget constraint is satisfied

▸ Wage Profile ▸ Parameter Restrictions

Occupational Choice Boundary. . .

. . . does not depend on aggregate state $\widetilde{H^T}$

$$\frac{a_O^{\frac{\alpha}{1-\eta}}}{\bar{a}_T(a_O)^{\frac{\alpha\beta}{\sigma-\eta\beta}}} \cdot \frac{\tau_{O,g}^{\frac{1}{1-\eta}}}{\tau_{T,g}^{\frac{\sigma}{\sigma-\eta\beta}}} \cdot \frac{1-\eta}{1-\frac{\beta\eta}{\sigma}} \cdot \frac{1+\tau_{O,g}^e}{1+\tau_{T,g}^e} \cdot \left(\frac{1-s_{O,g}}{1-s_{T,g}}\right)^{\frac{1}{\mu}} \cdot \frac{s_{O,g}^{\frac{\phi}{1-\eta}}}{s_{T,g}^{\frac{\phi\beta}{\sigma-\eta\beta}}}$$

$$= \frac{\sum_{g=1}^{G} \tau_{O,g}^{\frac{\eta}{1-\eta}} \cdot s_{O,g}^{\frac{\phi}{1-\eta}} \cdot \int_0^\infty a^{\frac{\alpha}{1-\eta}} f_{O,g}(a) da}{\sum_{g=1}^{G} \tau_{T,g}^{\frac{\eta\beta}{\sigma-\eta\beta}} \cdot s_{T,g}^{\frac{\phi\beta}{\sigma-\eta\beta}} \cdot \int_0^\infty a^{\frac{\alpha\beta}{\sigma-\eta\beta}} f_{T,g}(a) da \cdot \sum_{g=1}^{G} \int_0^\infty f_{O,g}(a) da}$$

Data

- ▶ Micro-data on abilities and occupational choice:
    1. Project TALENT (1960-1975):
        - ▶ representative 5% sample of high school population in 1960
        - ▶ follow-up surveys at 1, 5, and 11-year post graduation
    2. NLSY 79
    3. NLSY 97
- ▶ *Math*, *Verbal*, and *Social* abilities
- ▶ Occupational choice 11 years after (likely) high school graduation in all surveys ($\sim$ age 29)

Occupation-specific Abilities

- Ability rank from NLSY 79 and NLSY 97:
  Math, *Verbal*, and *Social* (Guvenen et al, 2020)

- "Crosswalk" from composite math and verbal scores in
  Project TALENT to AFQT equivalents (Air Force, 1990)

- Social composite in Project TALENT (Deming, 2017)

- Skill requirements by occupation from O*NET:
  Math, *Verbal*, and *Social* (Guvenen et al, 2020)

- Occupation-specific ability:

$$\bar{a} = \frac{a_m + a_v + a_s}{b_m + b_v + b_s} + \sum_{i=\{m,v,s\}} \frac{a_i}{b_i} \left| \frac{a_i}{a_v + a_m + a_s} - \frac{b_i}{b_v + b_m + b_s} \right|$$

Calibration

Assumptions and Normalizations

Parameter	Definition	Determination	Value
$\tau_{o,\mathrm{men}}^{w}$	Labor market barriers for men	Assumption	0
$\tau_{o,g}^{e}$	Human capital barriers for all groups	Assumption	0
$\tau_{T,g}^{w}$	Labor market barriers in teaching (all groups)	Assumption	0
$\tau_{T,g}^{e}$	Human capital barriers in teaching (all groups)	Assumption	0
α	elasticity of human capital with respect to idiosyncratic ability	Normalization	1

Calibration

Baseline Parameters

Param.	Definition	Determination
θ	shape parameter of Fréchet-distributed idiosyncratic abilities	wage dispersion in non-teaching occupations (indirect inference)
η	goods elasticity of human capital	aggregate education spending share (indirect inference)
ϕ	time elasticity of human capital	Mincer returns to education (non-teaching) (indirect inference)
γ	curvature of wage function in teaching	wage dispersion in teaching (indirect inference)
A_o	occupational productivities (non-teaching)	labor market shares for men
$\tau_{o,\text{women}}^w$	labor market barriers (non-teaching) faced by women	labor market shares for women
κ	scale parameter of wage function in teaching	fraction of males who are teachers
λ_f	aggregate labor market barrier for women in non-teaching occupations	fraction of females who are teachers

Calibration

Benchmark Calibration

Parameter	Definition	Empirical Targets
β	Teacher elasticity of human capital	Skill composition by occupation and group
σ	Class size elasticity of human capital	Normalization to 1
μ	Trade-off between consumption and time spent accumulating human capital	Schooling of teachers relative to schooling of others

Summing up

Results

- ▶ Develop a novel theory of occupational choice and human capital formation:

    - ○ non-linear wages $\Rightarrow$ comparative and absolute advantage

    - ○ intergenerational dynamics of human capital accumulation

Ongoing and Future Work

- ▶ Calibrate reduction in discrimination & barriers:

    - ○ static gains (as in Hsieh et al., 2019) vs.

    - ○ dynamic effects (human capital accumulation)

- ▶ Multiple locations differentiated by amenities and/or local tax rates (implicit school segregation by income)

Optimal Time Investment

$$s_{T,g} = \frac{\mu\phi}{\mu\phi + \frac{\beta}{\sigma} - \eta}$$

$$s_{O,g} = \frac{\mu\phi}{\mu\phi + 1 - \eta}$$

Optimal Goods Investment

$$e_{T,g} = \frac{\beta}{\sigma} \cdot \eta^{\frac{1}{1-\eta}} \cdot \left(\frac{2\widetilde{H}_T}{M}\right)^{\frac{\sigma}{1-\eta}}$$

$$\times \frac{\sum_{g=1}^{G} A_O'^{\frac{1}{1-\eta}} \cdot \tau_{O,g}^{\frac{\eta}{1-\eta}} \cdot s_{O,g}^{\frac{\phi}{1-\eta}} \cdot \int_0^\infty a^{\frac{\alpha}{1-\eta}} f_{O,g}(a)da}{\sum_{g=1}^{G} f_{O,g}(a)da}$$

$$\times \frac{\tau_{T,g}^{\frac{\sigma}{\sigma-\eta\beta}} \cdot s_{T,g}^{\frac{\phi\beta}{\sigma-\eta\beta}} \cdot a_T^{\frac{\alpha\beta}{\sigma-\eta\beta}}}{\sum_{g=1}^{G} \tau_{T,g}^{\frac{\eta\beta}{\sigma-\eta\beta}} \cdot s_{T,g}^{\frac{\phi\beta}{\sigma-\eta\beta}} \cdot \int_0^\infty a^{\frac{\alpha\beta}{\sigma-\eta\beta}} f_{T,g}(a)da}$$

$$e_{O,g} = \left(\tau_{O,g} \cdot \eta \cdot \left(\frac{2\widetilde{H}_T}{M}\right)^\sigma \cdot A_O'^\eta \cdot s_{O,g}^\phi \cdot a_O^\alpha\right)^{\frac{1}{1-\eta}}$$

Aggregate Laws of Motion

$$
\begin{aligned}
\widetilde{H}_T' = &\Bigg[\left(\tfrac{\beta}{\sigma}\right)^{\eta} \cdot \eta^{\frac{1}{1-\eta}} \cdot \left(\tfrac{2\widetilde{H}_T}{M}\right)^{\frac{\sigma}{1-\eta}} \\
&\times \left(\frac{\sum_{i=2}^{I} \sum_{g=1}^{G} A_i'^{\frac{1}{1-\eta}} \cdot \tau_{i,g}^{\frac{\eta}{1-\eta}} \cdot s_{i,g}^{\frac{\phi}{1-\eta}} \cdot \int_0^\infty a^{\frac{\alpha}{1-\eta}} f_{i,g}(a)da}{\sum_{i=2}^{I} \sum_{g=1}^{G} f_{i,g}(a)da} \right)^{\eta} \\
&\times \left(\sum_{g=1}^{G} \tau_{T,g}^{\frac{\eta\beta}{\sigma-\eta\beta}} \cdot s_{T,g}^{\frac{\phi\beta}{\sigma-\eta\beta}} \cdot \int_0^\infty a^{\frac{\alpha\beta}{\sigma-\eta\beta}} f^{g,T}(a)da \right)^{\frac{\sigma-\eta\beta}{\beta}} \Bigg]^{\frac{\beta}{\sigma}} \\
H_O' = &\sum_{g=1}^{G} \left(\tau_{O,g}^{\eta} \cdot \eta^{\eta} \cdot \left(\tfrac{2\widetilde{H}_T}{M}\right)^{\frac{\sigma}{1-\eta}} \cdot A_O'^{\eta} \cdot s_{T,g}^{\phi} \right)^{\frac{1}{1-\eta}} \cdot \int_0^\infty a^{\frac{\alpha}{1-\eta}} f_{O,g}(a)da
\end{aligned}
$$

Teacher's Wage Profile

$$\omega = \eta^{\frac{\eta}{1-\eta}} \cdot \left(\frac{2\widetilde{H}_T}{M}\right)^{\frac{\sigma}{1-\eta}} \cdot \frac{\sum_{g=1}^{G} A'_O{}^{\frac{1}{1-\eta}} \cdot \tau_{O,g}^{\frac{\eta}{1-\eta}} \cdot s_{O,g}^{\frac{\phi}{1-\eta}} \cdot \int_0^\infty a^{\frac{\alpha}{1-\eta}} f_{O,g}(a)da}{\sum_{g=1}^{G} f_{O,g}(a)da}$$

$$\times \frac{\tau_{T,g}^{\frac{\eta\beta}{\sigma-\eta\beta}} \cdot s_{T,g}^{\frac{\phi\beta}{\sigma-\eta\beta}} \cdot a_T^{\frac{\alpha\beta}{\sigma-\eta\beta}}}{\sum_{g=1}^{G} \tau_{T,g}^{\frac{\eta\beta}{\sigma-\eta\beta}} \cdot s_{T,g}^{\frac{\phi\beta}{\sigma-\eta\beta}} \cdot \int_0^\infty a^{\frac{\alpha\beta}{\sigma-\eta\beta}} f^{g,T}(a)da}$$

Some Parameter Restrictions

- $\beta < 1 - \eta$ to guarantee existence of stable $\widetilde{H^T} = \widetilde{H^T}' > 0$
- $\frac{\sigma}{\beta} > \eta$ and $\mu\phi > 0$ for $s^{T*} \in (0,1)$
- $1 > \eta$ and $\mu\phi > 0$ for $s^{O*} \in (0,1)$