The Allocation of Teaching Talent and Human Capital Accumulation

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June 3, 2022

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 other developed countries (e.g. *PISA* assessments)
- Potential explanations include:
  - U.S. education underfunded by international comparison
  - Role of (powerful) teachers' unions

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  - Role of (powerful) teachers' unions
  - Occupational choice
  - Local funding for public education (e.g. property taxes)

Research Questions

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

- To what extent static efficiency gains associated with improved career opportunities in non-teaching occupations are 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

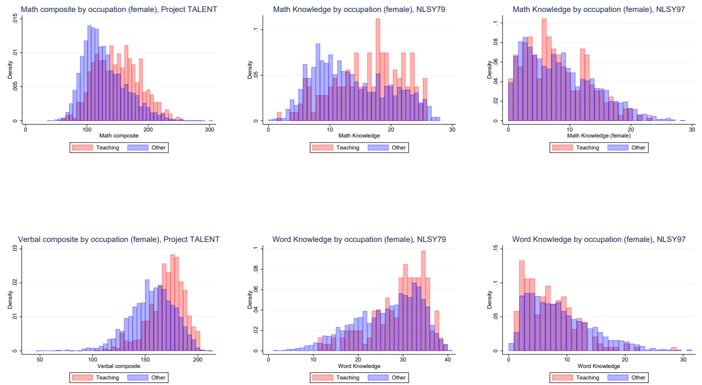
Stylized Fact #2

Educational Barriers / Labor Market Discrimination

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

Stylized Fact #3

Ability Distribution of Females by Occupation



Model

Overview

- 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

Technologies

- "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, time $s_{i,g}$ and goods $e_{i,g}$ investments:

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

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

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

Values

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

where

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

Model

Constraints, Laws of Motion

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

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

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

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

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

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

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:

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

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

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

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

▸ Parameter Restrictions

Teacher's Wage Profile

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

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

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)
- 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 Normalization

Parameter	Definition	Determination	Value
$\tau^w_{i,men}$	Labor market barriers for men	Assumption	0
$\tau^e_{i,men}$	Human capital barriers for men	Assumption	0
$\tau^w_{T,g}$	Labor market barriers for all groups	Assumption	0
$\tau^e_{T,g}$	Human capital barriers for all groups	Assumption	0
$\tau^e_{i,g}$	Human capital barriers for other groups	Normalization	0
A_T	Teachers productivity	Normalization	1
μ_a	Mean ability distribution	Normalization	0
σ_a	St.dev. ability distribution	Normalization	1

Calibration

Baseline Parameters

Param.	Definition	Determination
α	Ability elasticity of human capital	Wage dispersion
η	Goods elasticity of human capital	Aggregate education spending share
ϕ	Time elasticity of human capital	Mincerian return to education for other
A_i	Occupation-specific productivity	Labor market shares for men
$\tau^w_{i,g}$	Labor market barriers for other groups	Group gap in labor market shares by occupation

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
λ_m	Scale for male labor market barriers	Share of teachers among men
λ_f	Scale for other group labor market barriers	Share of teachers among other group

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
- Constructed occupation-specific abilities

Ongoing and Future Work

- Calibrated 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

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

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

Back

Optimal Goods Investment

$$
\begin{aligned}
e_{T,g} &= \frac{\beta}{\sigma} \cdot \eta^{\frac{1}{1-\eta}} \cdot \left(\frac{2\widetilde{H}_T}{M}\right)^{\frac{\sigma}{1-\eta}} \\
&\times \frac{\sum_{g=1}^{G} {A'_O}^{\frac{1}{1-\eta}} \cdot \tau_{O,g}^{\frac{\eta}{1-\eta}} \cdot s_{O,g}^{\frac{\phi}{1-\eta}} \cdot \int_0^\infty a^{\frac{\alpha}{1-\eta}} f_{O,g}(a)da}{\sum_{g=1}^{G} f_{O,g}(a)da} \\
&\times \frac{\tau_{T,g}^{\frac{\sigma}{\sigma-\eta\beta}} \cdot s_{T,g}^{\frac{\phi\beta}{\sigma-\eta\beta}} \cdot a_T^{\frac{\alpha\beta}{\sigma-\eta\beta}}}{\sum_{g=1}^{G} \tau_{T,g}^{\frac{\eta\beta}{\sigma-\eta\beta}} \cdot s_{T,g}^{\frac{\phi\beta}{\sigma-\eta\beta}} \cdot \int_0^\infty a^{\frac{\alpha\beta}{\sigma-\eta\beta}} f_{T,g}(a)da} \\
e_{O,g} &= \left(\tau_{O,g} \cdot \eta \cdot \left(\frac{2\widetilde{H}_T}{M}\right)^{\sigma} \cdot {A'_O}^{\eta} \cdot s_{O,g}^{\phi} \cdot a_O^{\alpha}\right)^{\frac{1}{1-\eta}}
\end{aligned}
$$

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Aggregate Laws of Motion

$$\widetilde{H}'_T = \Bigg[\left(\frac{\beta}{\sigma}\right)^{\eta} \cdot \eta^{\frac{1}{1-\eta}} \cdot \left(\frac{2\widetilde{H}_T}{M}\right)^{\frac{\sigma}{1-\eta}}$$

$$\times \left(\frac{\sum_{i=2}^{I} \sum_{g=1}^{G} A_i'^{\frac{1}{1-\eta}} \cdot \tau_{i,g}^{\frac{\eta}{1-\eta}} \cdot s_{i,g}^{\frac{\phi}{1-\eta}} \cdot \int_0^\infty a^{\frac{\alpha}{1-\eta}} f_{i,g}(a)da}{\sum_{i=2}^{I} \sum_{g=1}^{G} f_{i,g}(a)da} \right)^{\eta}$$

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

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

Back

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 $s^{O*} \in (0, 1)$

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