The Allocation of Teaching Talent and Human Capital Accumulation

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SED Annual Meeting
July 2, 2021

Introduction

- Public education in U.S. has gone through major (positive) changes since end of WW II, e.g.
  - Real expenditures per student per year: $2,100 (1950s) to $12,000 (2010s)
  - Student-teacher ratio: 27 (1955) to 16 (2010s)
- However, evolution of educational outcomes doesn't compare favorably with other developed countries (e.g. *PISA* assessments)
- Potential explanations include:
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  - Occupational choice
  - Local funding for public education (e.g. property taxes)

Introduction

3 Stylized Facts

Model

- OLG
- Non-linear version of canonical occupational choice model
- Educational barriers / labor market discrimination as in Hsieh et al. (2019)

Data

- 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

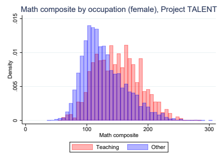
Stylized Fact #2

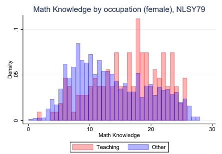
Educational Barriers / Labor Market Discrimination

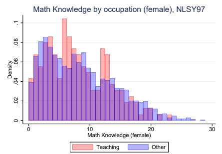
- Females face low barriers / discrimination in teaching
- Barriers / discrimination in non-teaching occupations falling over time

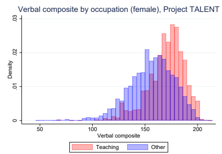
Stylized Fact #3

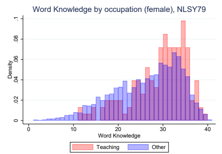
Ability Distribution of Females by Occupation

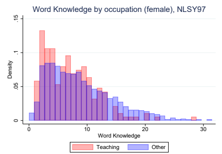












Model

Endowments, Preferences

- Each period, a measure M of agents is born and lives for two periods ("young" and "old")
- Individuals born with occupation-specific abilities drawn from a joint bivariate distribution with c.d.f. $F(a^T, a^O)$
- Individuals have $\log$ preferences over leisure and consumption (no discounting):

$$\ln c_{t+1} + \ln(1 - s_t)$$

Model

Technologies

- Children ("young") make occupation-specific educational investments (in units of time and output)
- Adults work as teachers or production workers.

Human capital production (teaching) depends on teacher's h^T, child's ability a, and child's educational investments (time s and goods e) according to:

$$h'(a) = \left(h^T\right)^{\beta} a^{\alpha} s\,(a)^{\phi}\, e(a)^{\eta} N(h^T, \widetilde{H}^T)^{-\sigma}$$

$$\text{where } \widetilde{H}^T = \int_0^{\infty} \left(h^T\,(a)\right)^{\frac{\beta}{\sigma}} f^T(a)da$$

Final output production depends on adult worker's human capital h^O and exogenous productivity A^O:

$$y = A^O h^O$$

Model

Values

$$V^{g}(a^{T}, a^{O}, \widetilde{H}^{T}) = \max_{\{s^{O}, s^{T}, e^{O}, e^{T}\}} \left\{ V^{O,g}(a^{O}, \widetilde{H}^{T}), V^{T,g}(a^{T}, \widetilde{H}^{T}) \right\}$$

where

$$\begin{aligned}
V^{O,g}(a^{O}, \widetilde{H}^{T}) &= \ln\left(1 - s^{O}\left(a^{O}, \widetilde{H}^{T}\right)\right) \\
&+ \mu \ln\Big[h'^{O} A'^{O} (1 - \tau'^{O,g,w}) \color{red}{(1-t)} \\
&- e^{O}(a^{O}, \widetilde{H}^{T})(1 + \tau^{O,g,e})\Big], \\
V^{T,g}(a^{T}, \widetilde{H}^{T}) &= \ln\left(1 - s^{T}\left(a^{T}, \widetilde{H}^{T}\right)\right) \\
&+ \mu \ln\Big[\omega'(h'^{T}, \widetilde{H'}^{T})(1 - \tau'^{T,g,w}) \color{red}{(1-t)} \\
&- e^{T}(a^{T}, \widetilde{H}^{T})(1 + \tau^{T,g,e})\Big]
\end{aligned}$$

Model (cont'd)

Constraints, Laws of Motion

$$t\int_0^\infty \left(\omega\left(h^T(a)\right)f^T(a) + A^O h^O(a) f^O(a)\right)da = \int_0^\infty \omega\left(h^T(a)\right)f^T(a)da$$

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

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

Aggregate laws of motion for $\widetilde{H}^T$ and H^O:

$$\widetilde{H'}^T = \int_0^\infty \left(\left(\frac{2\widetilde{H}^T}{M}\right)^\sigma a^\alpha s^T\left(a,\widetilde{H}^T\right)^\phi e^T(a,\widetilde{H}^T)^\eta\right)^{\frac{\beta}{\sigma}} f^T(a)da$$

$$H'^O = \int_0^\infty \left(\frac{2\widetilde{H}^T}{M}\right)^\sigma a^\alpha s^O\left(a,\widetilde{H}^T\right)^\phi e^O(a,\widetilde{H}^T)^\eta f^O(a)da$$

Model (cont'd)

Occupational Threshold

$$a^{T*}(a^O) = \bar{a}\big(a^O, \widetilde{H}^T\big)$$

such that

$$V^O(a^O, \widetilde{H}^T) = V^T\left(a^{T*}(a^O), \widetilde{H}^T\right), \text{ for all } a^O \in (0, \infty)$$

Model (cont'd)

- Assignment of students to teachers is random
  $\Rightarrow$ distribution of students' skill identical across classrooms
- Teachers with different h^T vary with respect to class *size*
- $\omega(\cdot,\cdot)$ is proportional to the *number of students* in a teacher's class and to :

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

$$= \frac{H'^O A'^O}{\frac{M}{2}\int_o^\infty f^O(a)da} \underbrace{\overbrace{N(1, \widetilde{H}^T)}^{=\frac{M}{2}\frac{1}{\widetilde{H}^T}} \left(h^T\right)^{\frac{\beta}{\sigma}}}_{=N(h^T, \widetilde{H}^T)}$$

$$= \frac{H'^O A'^O}{\int_o^\infty f^O(a)da} \frac{\left(h^T\right)^{\frac{\beta}{\sigma}}}{\widetilde{H}^T}$$

Optimal Investments for Prospective Teachers (I)

$$s^T = \frac{\mu\phi}{\mu\phi + \frac{\beta}{\sigma} - \eta}$$

$$e^T = \left(\frac{(1-t)(1-\tau'^{T,w}) \left(\frac{2}{M}\right)^{\beta} A'^{O} (s^T)^{\frac{\phi\beta}{\sigma}} \left(\frac{\eta\beta}{\sigma}\right) \left(\widetilde{H}^T\right)^{\beta} (a^T)^{\frac{\alpha\beta}{\sigma}}}{1+\tau^{T,e}} \right)^{\frac{1}{1-\frac{\eta\beta}{\sigma}}}$$

$$\times \left(\frac{H'^{O}}{\int_o^{\infty} f^O(a)da} \left(\widetilde{H'}^T\right)^{-1} \right)^{\frac{1}{1-\frac{\eta\beta}{\sigma}}}$$

Aggregate Laws of Motion

$$\widetilde{H'}^T = \left[\left(\frac{(1-\tau'^{T,w}) \left(\frac{\eta\beta}{\sigma}\right)}{1+\tau^{T,e}} \right)^{\eta} \left(\frac{(1-\tau'^{O,w})\eta}{1+\tau^{O,e}} \right)^{\frac{\eta}{1-\eta}\eta} \left((1-t)A'^O\right)^{\frac{\eta}{1-\eta}} \right.$$

$$\times \left(\frac{2}{M}\right)^{\frac{\sigma}{1-\eta}} (s^T)^{\phi}(s^O)^{\frac{\eta}{1-\eta}\phi} \left(\frac{\int_0^\infty a^{\frac{\alpha}{1-\eta}} f^O(a)da}{\int_0^\infty f^O(a)da} \right)^{\eta}$$

$$\left. \times \left(\int_0^\infty a^{\frac{\alpha\beta}{\sigma-\eta\beta}} f^T(a)da \right)^{\frac{\sigma-\eta\beta}{\beta}} \left(\widetilde{H}^T\right)^{\frac{\sigma}{1-\eta}} \right]^{\frac{\beta}{\sigma}}$$

$$H'^O = \left(\frac{(1-t)(1-\tau'^{O,w})A'^O\eta}{1+\tau^{O,e}} \right)^{\frac{\eta}{1-\eta}} \left(\frac{2}{M}\right)^{\frac{\sigma}{1-\eta}} (s^O)^{\frac{\phi}{1-\eta}}$$

$$\times \left(\int_0^\infty a^{\frac{\alpha}{1-\eta}} f^O(a)da \right) \left(\widetilde{H}^T\right)^{\frac{\sigma}{1-\eta}}$$

Optimal Investments for Prospective Teachers (II)

$$s^T = \frac{\mu\phi}{\mu\phi + \frac{\beta}{\sigma} - \eta}$$

$$e^T = \left((1-t)\left(\tfrac{2}{M}\right)^{\sigma} A'^{O} \eta (s^O)^{\phi} \left(\widetilde{H}^T\right)^{\sigma} \left(a^T\right)^{\alpha} \right)^{\frac{1}{1-\eta}}$$
$$\times \frac{(1-\tau'^{T,w})(1-\tau'^{O,w})^{\frac{\eta}{1-\eta}}}{(1+\tau^{T,e})(1+\tau^{O,e})^{\frac{\eta}{1-\eta}}} \cdot \frac{\beta}{\sigma}$$
$$\times \left(\frac{\int_0^\infty a^{\frac{\alpha}{1-\eta}} f^O(a)da}{\int_0^\infty f^O(a)da} \right) \left(\int_0^\infty a^{\frac{\alpha}{\frac{\sigma}{\beta}-\eta}} f^T(a)da \right)^{-1}$$

Optimal Investments for Prospective “Other” Workers

$$s^O = \frac{\mu\phi}{\mu\phi + 1 - \eta}$$

$$e^O = \left(\frac{(1-t)(1-\tau'^{O,w})\left(\frac{2}{M}\right)^{\sigma} A'^{O}(s^O)^{\phi}\eta\left(\widetilde{H}^T\right)^{\sigma}\left(a^O\right)^{\alpha}}{1+\tau^{O,e}} \right)^{\frac{1}{1-\eta}}$$

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

Occupational Choice Boundary...

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

$$\left(\frac{1-\tau'^{O,w}}{1-\tau'^{T,w}}\right)\left(\frac{1-\eta}{1-\frac{\eta\beta}{\sigma}}\right)\left(\frac{1-s^O}{1-s^T}\right)^{\frac{1}{\mu}}\left(\frac{(a^O)^{\frac{\alpha}{1-\eta}}}{\left(\bar{a}^T(a^O)\right)^{\frac{\alpha}{\frac{\sigma}{\beta}-\eta}}}\right)$$
$$=\left(\frac{\int_0^\infty a^{\frac{\alpha}{1-\eta}} f^O(a)da}{\int_0^\infty f^O(a)da}\right)\left(\int_0^\infty a^{\frac{\alpha}{\frac{\sigma}{\beta}-\eta}} f^T(a)da\right)^{-1}$$

Equilibrium

The equilibrium is characterized by:

1. the optimal investment for prospective teachers
2. the optimal investment for prospective "other" workers
3. the aggregate laws of motion
4. the occupational choice boundary and the corresponding densities f^T and f^O

Data for Quantitative Exercise

- 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
- Cognitive abilities in math, verbal,... based on standardized assessments (e.g. ASVAB in NLSY)
- Occupational choice 11 years after (likely) high school graduation in all surveys

Occupational Skills from Cognitive Scores

- Harmonized cognitive scores from NLSY79 and NLSY97 for:
  1. Mathematics knowledge
  2. Arithmetic reasoning
  3. Word knowledge
  4. Paragraph comprehension
- "Crosswalk" from composite math and verbal scores in Project TALENT to AFQT equivalents (Air Force)
- Skill requirements by occupation from O*NET
- Occupation-specific skills based on "translation" of cognitive scores (work in progress)
- In contrast to standard Roy model, occupational choice depends on *comparative* and *absolute* advantage here!

Ongoing and Future Work

- Decentralized equilibrium vs. planner's solution (human capital externality in teaching)
- 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)