Teachers and the Evolution of Aggregate Inequality

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Motivation

- Teachers account for less than 5% of the labor force but play a disproportionate role in the production of human capital
- Reward structure of teachers affects:
  - → Teacher labor market equilibrium
  - → Achievements of students (e.g., test scores, earnings)
- This paper studies the dynamic spillover effects of teacher labor market reforms on income inequalities in the aggregate labor market
- Putting the teachers in a dynamic GE context

This paper

- An OLG model of occupation choice & child investments
- Two-way relationship b/w teacher quality & human capital distribution
  1. human capital dispersion affects teacher quality through selection
  2. teacher quality affects dispersion through human capital formation
- Analytical solutions $\Longrightarrow$ closed-form identification using data moments
- Counterfactual + model-based decompositions

Preview of Findings

- Wage compression in the teacher labor market:
  - → Reduce inequality among teachers
  - → Increases inequalities elsewhere
  - → Dampens intergenerational mobility
- One-generation estimates understate long-run effects on teacher quality, child outcomes, and inequalities

Literature

- Education and inequality: Benabou (2002), Durlauf & Seshadri (2018), Caucutt & Lochner (2020), Fogli & Guerrieri (2019)
  Contribution: role of the teacher labor market (supply side)
- Teacher market: Hoxby (1996), Bacolod (2007), Lovenheim & Willèn (2019), Lavy (2020), Tincani (2021), Biasi & Sarsons (2022)
  Contribution: dynamic spillover effects in GE
- Aggregate impacts of occupational reward structure: Murphy, Shleifer, & Vishny (1991), King and Levine (1993), Acemoglu (1995)
  Contribution: new quantification strategy applied to teachers

Roadmap

Model

Solution, Dynamics, and Mechanism

Identification and Calibration

Counterfactual Results

Model Overview

- Two-period OLG: children and adults
- Two occupations: teachers and non-teachers (workers)
- Human capital production w/ parental investments & teacher quality
- In each period: occupation selection, then make child investments

Labor Market

- In period t, heterogeneous human capital $h \sim F_t(h)$
- Labor supply by individuals making occupation choice into teachers $(j = 1)$ and non-teachers $(j = 2)$ and work for 1 unit of time:

$$\max_{j=1,2} \quad \underbrace{\underbrace{\alpha_j}_{\text{base wage}} + \underbrace{\psi_j \log(h)}_{\text{returns to h.c.}}}_{\text{pecuniary benefits}} + \underbrace{\mathbb{1}_{j=1}\kappa}_{\text{non-pecuniary benefits}} + \underbrace{\nu_j}_{\text{Gumbel shocks}}$$

- Labor demand across occupations:
  1. Teachers: $\{\alpha_1, \psi_1\}$ posted by the government, fixed labor demand at $\overline{\pi}$, salaries financed by taxes
  2. Non-teachers: $\{\alpha_2, \psi_2\}$ governed by exogenous technologies
- Non-pecuniary benefits κ adjusts to clear the labor market

Aggregate Teaching Resources

- Following Tamura (2001), assume that an individual's h.c. is transformed to teaching quality by technology:

$$\tilde{h} = \frac{h}{\overline{h}} \tag{1}$$

  where $\overline{h}$ is average h.c. in the population

- Aggregate teaching resources from the teaching population:

$$\mathcal{Q} = \int \underbrace{p(h)}_{\text{labor supply}} \cdot \underbrace{\tilde{h}}_{\text{teaching quality}} \, dF(h). \tag{2}$$

Household-Level Teaching Resources

- Assume that $\mathcal{Q}$ is uniformly distributed to households:

$$q(h) = q = \frac{1}{\overline{\pi}} \cdot \mathcal{Q} \tag{3}$$

- Two parts to this assumption:
  1. Heterogeneous teacher-to-student ratio
     - Hoxby (2000), Cho et al. (2012), Angrist, et al. (2019): Little evidence of class size effects on student achievements
  2. Heterogeneous teacher quality
     - Chetty et al. (2014): Extremely weak sorting between parents' socioeconomic status and teacher VA because 85% of variation in teacher VA is within schools
     - Sorting occurs through school choice – we explicitly model endogenous parental efforts in children's human capital formation

Child Investments

- Parents with occupation j solve the optimization problem

$$\max_{e \in (0,1)} \quad \log(c) + \beta \mathbb{E}_\epsilon \log(h') \tag{4}$$

subject to budget constraint

$$c = w_j(h)(1-\tau)(1-e) \quad \text{where} \quad \log(w_j(h)) = \alpha_j + \psi_j \log(h) \tag{5}$$

and child human capital production function

$$\begin{aligned} \log(h') = A + \underbrace{\log(\epsilon)}_{\text{shock}} + \underbrace{\lambda_1 \log(e\tilde{h})}_{\text{parental effort}} + \underbrace{\lambda_2 \log(q)}_{\text{teachers}} \\ + \underbrace{\lambda_3 \log(e\tilde{h}) \log(q)}_{\text{interaction term}} + \underbrace{\rho \log(\tilde{h})}_{\text{residual persistence}} \end{aligned} \tag{6}$$

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Labor Market Equilibrium

- Define relative base wage and α and relative skill bias ψ:

$$\alpha = \alpha_1 - \alpha_2, \qquad \psi = \psi_1 - \psi_2$$

- Assume $\log(h) \sim \mathcal{N}(\mu, \sigma^2)$, equilibrium conditions can be summarized by:
  - → Labor market clearing condition

$$\overline{\pi} = \exp(\theta(\alpha + \kappa)) \cdot \exp(\theta\psi\mu + (\theta\psi\sigma)^2/2). \tag{7}$$

  - → Wage inequality across occupations

$$\frac{\mathbb{E}(w|j=1)}{\mathbb{E}(w|j=2)} = \exp(\alpha) \cdot \exp(\psi\mu + (\sigma\psi)^2(1+2\theta)/2) \tag{8}$$

  - → Wage inequality within occupations

$$\mathbb{CV}(w|j=1) = \sigma\psi_1 \qquad \text{and} \qquad \mathbb{CV}(w|j=2) = \sigma\psi_2 \tag{9}$$

Teaching Resources

- Teaching resource given by the "teacher selection" (TS) equation:

$$q = \exp(\theta\psi\sigma^2) \tag{TS}$$

- When σ^2 goes up, teaching resource q falls if relative skill bias $\psi < 0$
- In comparative statics, changes in teacher quality can be decomposed as

$$\underbrace{d\log(q)}_{\text{change in teacher quality}} = \underbrace{d\psi}_{\text{change in selection}} + \underbrace{d\sigma^2}_{\text{change in h.c. dispersion}}$$

Thus, the endogenous formation of σ is the key to dynamic effects

Endogenous Human Capital Distribution

- Optimal parental investment

$$e(h) = \beta(\lambda_1 + \lambda_3 \log(q)) \qquad \text{for all } h. \tag{10}$$

- Substitute back to the human capital production function

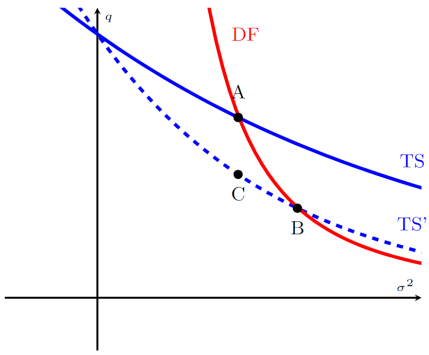
$$\log(h') = A + \log(\epsilon) + \underbrace{(\rho + \lambda_1 + \lambda_3 \log(q))}_{\text{IGE}} \log(\tilde{h}) + \lambda_1 \log(e) + \lambda_2 \log(q) + \lambda_3 \log(e) \log(q) \tag{11}$$

- H.c. dist. follows an AR(1) process that preserves lognormality
- In stationary equilibrium, the "dispersion formation" (DF) equation

$$\sigma^2 = \frac{\sigma_\epsilon^2}{1 - (\rho + \lambda_1 + \lambda_3 \log(q))^2} \tag{DF}$$

Mechanism

- Suppose $\psi < 0$, a further reduction in ψ generates a chain reaction:
  - → Reduces teacher resources q_t
  - → If $\lambda_3 < 0$, hurts low-income children more, raises $\text{IGE}_t = \rho + \lambda_1 + \lambda_3 \log($
  - → Raises σ_{t+1} because $\sigma^2_{t+1} = \text{IGE}^2_t \cdot \sigma^2_t + \sigma^2_\epsilon$
  - → Reduces teacher quality q_{t+1} even further as $q_{t+1} = \exp(\theta \psi_{t+1} \sigma^2_{t+1})$
  - → ...
- Spillover to non-teacher markets as $F_{t+1}(h)$ changes



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Parameters

- 14 Parameters to be calibrated

$$\underbrace{\alpha_1, \alpha_2, \psi_1, \psi_2, \kappa}_{\text{labor market}}, \quad \underbrace{\theta, \beta}_{\text{preference}} \quad , \underbrace{\lambda_1, \lambda_2, \lambda_3, A, \rho, \sigma_\epsilon}_{\text{human capital production}}, \underbrace{\tau}_{\text{taxes}}$$

- Normalize: $A = 1$, $\alpha_2 = 0$, $\psi_2 = 1$ (i.e., only α and ψ matters)
- Exogenously set: $\theta = 2$ (Hsieh et al. 2019), $\rho = 0.24$ (Lefgren et al. 2012)
- **Proposition:** The remaining 9 parameters can be identified in closed form using equilibrium conditions and data moments

Data Moments and Calibration Results

Object	Interpretation	Value	Source
$\overline{\pi}$	Share of teachers in the labor force	0.045	CPS-ASEC
$\mathbb{CV}(w\|j=1)$	Coefficient of variation of income among teachers	0.52	CPS-ASEC
$\mathbb{CV}(w\|j=2)$	Coefficient of variation of income among non-teachers	0.75	CPS-ASEC
$\mathbb{E}(w\|j=1)/\mathbb{E}(w\|j=2)$	Income ratio between teachers and non-teachers	1.03	CPS-ASEC
e	Child investments as a share of total resources	0.07	Daruich (2018)
$d\log(h')/d\log(h)$	Intergenerational elasticity of income	0.344	Chetty et al. (2014b)
$\mathbb{E}(\partial\log(h')\partial\log(q))$	Average effect of teacher quality	0.013	Chetty et al. (2014a)
$\partial^2\log(h'))/(\partial\log(q)\partial\log(h))$	Differential effect of teacher quality	misc.	Lovenheim and Willen (2019)

Parameter	Interpretation	Value
$\{\alpha_1,\psi_1\}$	base wage and return to human capital among teachers	$\{0.35, 0.69\}$
$\{\alpha_2,\psi_2\}$	base wage and return to human capital among non-teachers	$\{0, 1\}$
κ	relative non-pecuniary benefits	-1.5
θ	taste shock dispersion	2
β	preference weight on child's human capital	0.71
$\{\lambda_1,\lambda_2,\lambda_3\}$	human capital production parameter	$\{-0.34, -2.91, -1.31\}$
A	human capital scale	1
ρ	exogenous human capital persistence	0.23
σ_ϵ	ability shock dispersion	0.71
τ	budget-clearing tax rate	0.05

additional evidence on ψ

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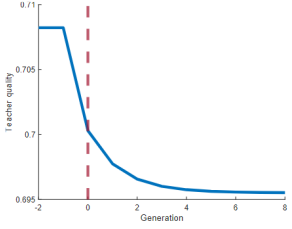
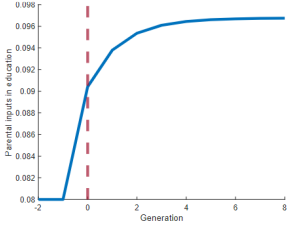
Increasing Teacher Pay Rigidity

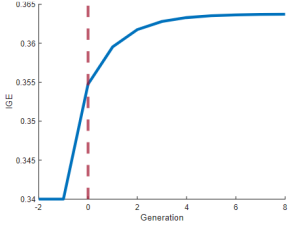
- Reduce the returns to h.c. among teachers (ψ_1) by 0.01



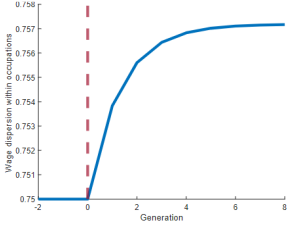
(A) Teacher quality transition



(B) Parental input transition



(C) IGE transition



(D) Wage dispersion transition

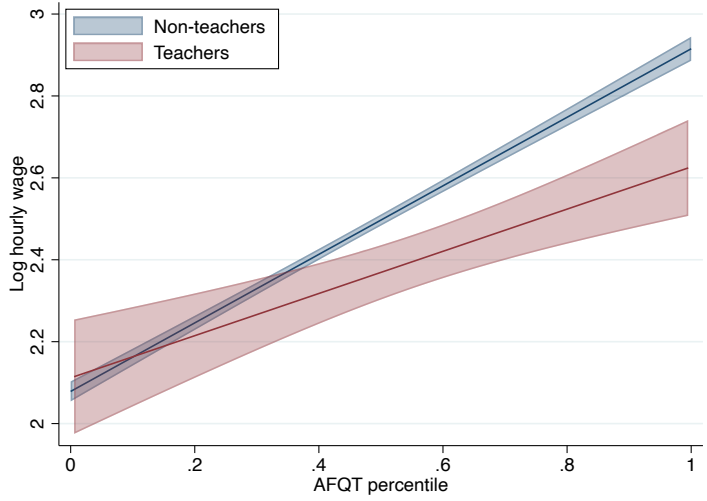
Key Takeaways

1. Wage compression in the teacher labor market spills over to non-teacher markets and affects aggregate inequality and intergenerational mobility
2. The rising σ will gradually dampen the direct effects of wage compression in the teacher labor market
3. One-generation estimates miss these dynamics

Conclusion

- Dynamic effects of teacher labor market reforms on aggregate inequality
- Tractable framework with closed-form identification
- Teacher labor market reforms need to consider its dynamic impacts through human capital formation

Additional Evidence on ψ



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