

# The Allocation of Teaching Talent and Human Capital Accumulation

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# 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)
- ▶ Moderate to no changes in levels of educational achievement (NAEP)
- ▶ Potential explanations include:
  - U.S. education underfunded
  - Role of (powerful) teachers' unions

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  - U.S. education underfunded
  - Role of (powerful) teachers' unions
  - 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?  
⇒ human capital accumulation channel

# What We Do

- ▶ Highlight stylized facts
- ▶ Develop a novel theory of occupational choice and human capital formation:
  - non-linear wages
  - intergenerational dynamics of human capital accumulation
- ▶ Combine three longitudinal surveys:
  - Project TALENT
  - NLSY79
  - NLSY97

# Outline

Stylized Facts

Model

Data

Calibration

Calibration

Preliminary Results

Counterfactual

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# Stylized Fact #1

Majority of (Public) School Teachers is Female

Time Period		% Female
early 70s	Project TALENT	61.1
	Census 1980	59.8
1986-1993	NLSY79	77.7
	Census 1990	74.8
2009-2013	NLSY97	77.1
	ACS 2009-2013	76.4
2003-2004	NCES (2006)	75

# Stylized Fact #2

## Educational Barriers / Labor Market Discrimination

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

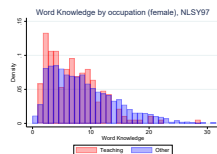
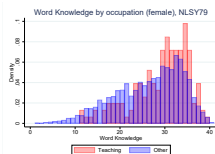
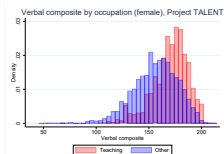
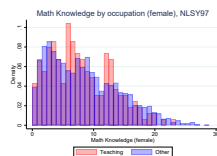
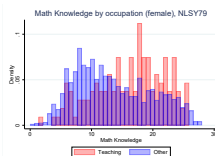
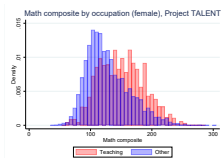
# Stylized Fact #3

## Trends in Occupational Choice

- ▶ Share of women choosing teaching:  
3.4% in 1970 to 6.0% in 2010
- ▶ Share of men choosing teaching:  
2.6% in 1970 to 1.9% in 2010
- ▶ Sharp rise in female labor force participation rate
- ▶ Slight decline in male labor force participation rate

# Stylized Fact #4

## Trends in Ability Distribution of Females by Occupation



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# Model

## Three Major Building Blocks

- ▶ 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
- ▶  $I$  occupations indexed by  $i \in \{1, \dots, I\}$
- ▶ Occupational abilities  $\vec{a}$  drawn from joint distribution  $F(\vec{a})$
- ▶ log preferences over consumption and leisure:

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

# Simple Two-Sector 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  $a_i$ , time  $s_{i,g}$  and goods  $e_{i,g}$  investments:

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

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

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

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



# Simple Two-Sector Model

## Values

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

where

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

# Simple Two-Sector Model

## Constraints

$$\begin{aligned} & t \left[ \sum_{g=1}^G \int_0^{\infty} (1 - \tau_{T,g}^{\omega}) \omega_{T,g}(h_{T,g}(a)) f_{T,g}(a) da \right. \\ & \quad \left. + \sum_{g=1}^G \int_0^{\infty} (1 - \tau_{O,g}^{\omega}) A_O h_{O,g}(a) f_{O,g}(a) da \right] \\ & = \sum_{g=1}^G \int_0^{\infty} (1 - \tau_{T,g}^{\omega}) \omega_{T,g}(h_{T,g}(a)) f_{T,g}(a) da \end{aligned}$$

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

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

# Simple Two-Sector Model

## Laws of Motion

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

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

# Simple Two-Sector Model

## Occupational Threshold

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

such that

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

# 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*

$$N(h_{T,g}) = h_{T,g}^{\frac{\beta}{\sigma}} \cdot \frac{M}{2\tilde{H}_T}$$

- ▶ Teacher's wage  $\omega_{T,g}$  depends on teacher's human capital:

$$\omega_T(h_{T,g}) = \kappa h_{T,g}^{\gamma}$$

# Equilibrium

Given occupational choices of today's "old" and aggregate human capital  $\tilde{H}_T$  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 investment and occupational choice problems ▶ Time Investment ▶ Goods Investment
2. Aggregate human capital follows the laws of motion ▶ Laws of Motion
3. Government budget constraint is satisfied

# Occupational Choice Boundary...

...depends on aggregate state  $\widetilde{H^T}$

$$\begin{aligned} & \frac{\bar{a}_T(a_O)^{\frac{\alpha}{\frac{1}{\gamma}-\eta}}}{a_O^{\frac{\alpha}{\frac{1}{\gamma}-\eta}}} \cdot \frac{s_{T,g}^{\frac{\frac{\phi}{\frac{1}{\gamma}-\eta}}{\frac{1}{\gamma}-\eta}}}{s_{O,g}^{\frac{\frac{\phi}{\frac{1}{\gamma}-\eta}}{\frac{1}{\gamma}-\eta}}} \cdot \frac{\tau_{T,g}^{\frac{1}{\frac{1}{\gamma}-\eta}}}{\tau_{O,g}^{\frac{1}{\frac{1}{\gamma}-\eta}}} \cdot \frac{1 + \tau_{T,g}^e}{1 + \tau_{O,g}^e} \cdot \left( \frac{1 - s_{T,g}}{1 - s_{O,g}} \right)^{\frac{1}{\mu}} \\ & \times \frac{(\kappa \cdot \gamma)^{\frac{1}{\frac{1}{\gamma}-\eta}}}{A_O'^{\frac{1}{\frac{1}{\gamma}-\eta}}} \cdot \frac{\frac{1}{\gamma} - \eta}{1 - \eta} \cdot \eta^{\frac{\eta(\gamma-1)}{(1-\eta)(1-\eta\gamma)}} \cdot \left( \frac{2\tilde{H}_T}{M} \right)^{\frac{\sigma(\gamma-1)}{(1-\eta)(1-\eta\gamma)}} = 1 \end{aligned}$$

where

$$\tau_{i,g} = \frac{(1-t)(1-\tau_{i,g}^\omega)}{1 + \tau_{i,g}^e}$$

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# 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)

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# Calibration

## Assumptions and Normalizations

Parameter	Definition	Determination	Value
$\tau_{o,men}^w$	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
$\alpha$	elasticity of human capital with respect to idiosyncratic ability	normalization	1
$A_{12}$	productivity in "Fire, Police, ..." sector	normalization	1
$\beta$	elasticity of human capital with respect to teacher's human capital	free parameter	0.5
$\sigma$	elasticity of human capital with respect to class size	free parameter	0.5

# Calibration

## Time-Invariant Parameters

Parameter	Definition	Determination	Value
$\theta$	shape parameter of Fréchet-distributed idiosyncratic abilities	wage dispersion in non-teaching occupations (indirect inference)	1.476
$\eta$	goods elasticity of human capital	aggregate education spending share (indirect inference)	0.103
$\phi$	time elasticity of human capital	Mincerian returns to education (non-teaching) (indirect inference)	2.745
$\gamma$	curvature of wage function in teaching	wage dispersion in teaching (indirect inference)	0.83
$\mu$	trade-off between consumption and time spent accumulating human capital	schooling of teachers relative to schooling of others	0.714

# Calibration

## Time-Varying Parameters

Parameter	Definition	Determination
$A_o$	occupational productivities (non-teaching)	labor market shares for men
$\tau_{o,women}^w$	labor market barriers (non-teaching) faced by women	labor market shares for women
$\kappa$	scale parameter of wage function in teaching	fraction of males who are teachers
$\lambda_f$	aggregate labor market barrier for women in non-teaching occupations	fraction of females who are teachers

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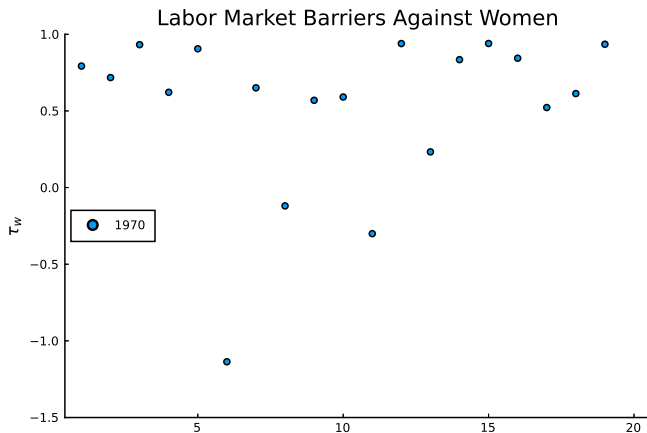
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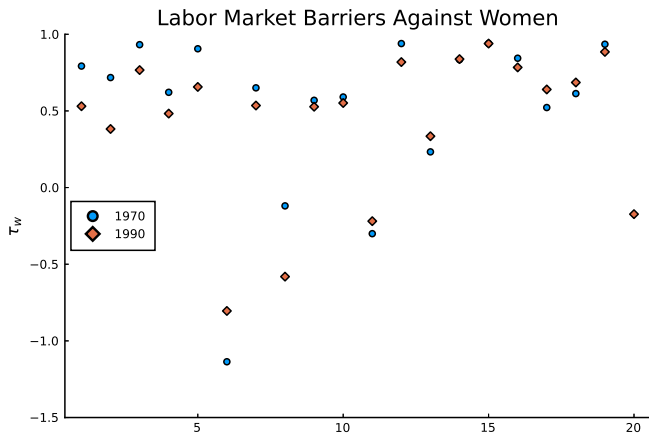
# Labor Market Barriers



► Occupations

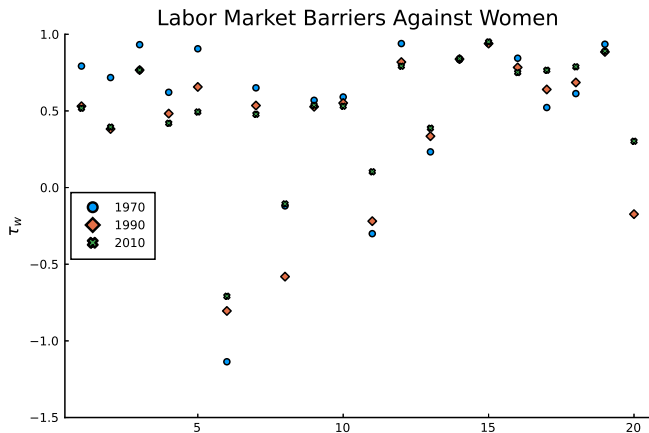


# Labor Market Barriers



► Occupations

# Labor Market Barriers



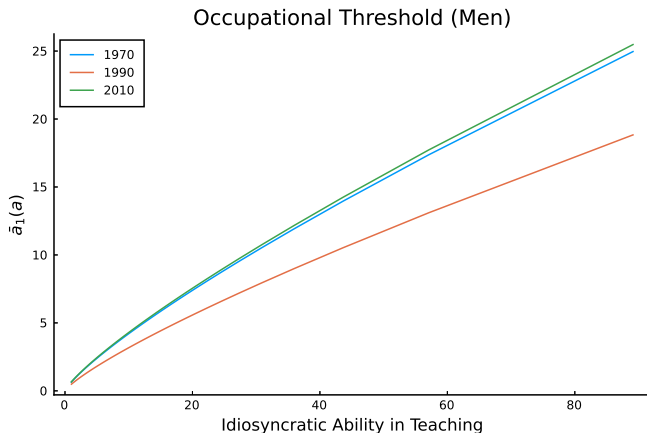
► Occupations

► Occupational Productivity

# Occupational Threshold

For Men, Vis-à-Vis “Executives, . . .”

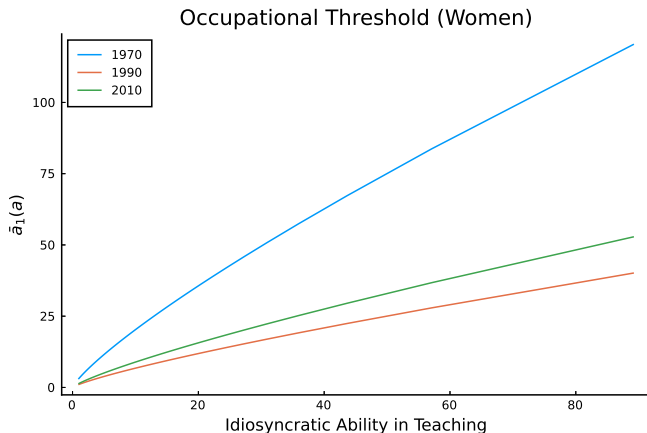
Men below threshold become teachers.



# Occupational Threshold

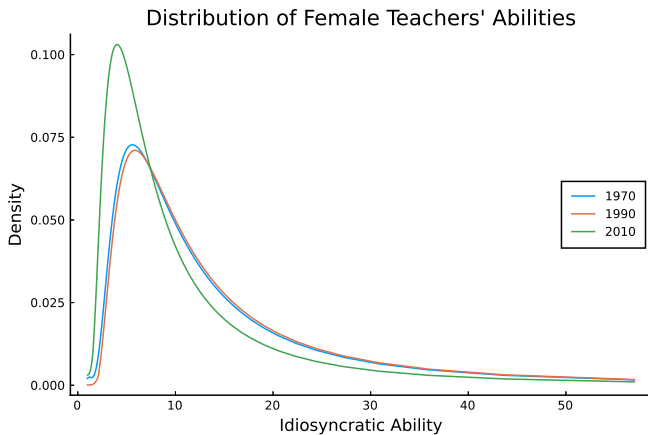
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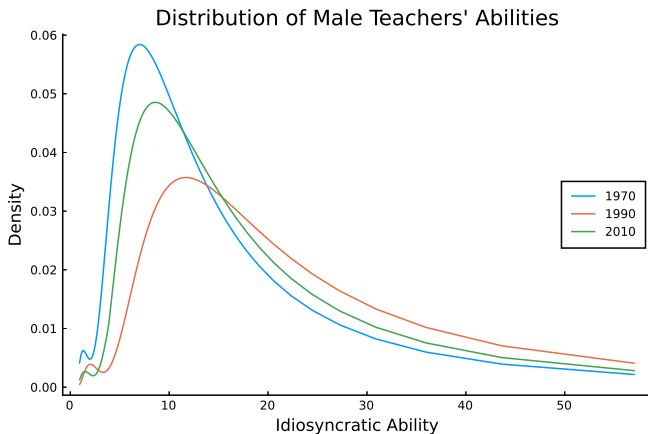
# Distribution of Teaching Abilities

Female workers with lower abilities become teachers



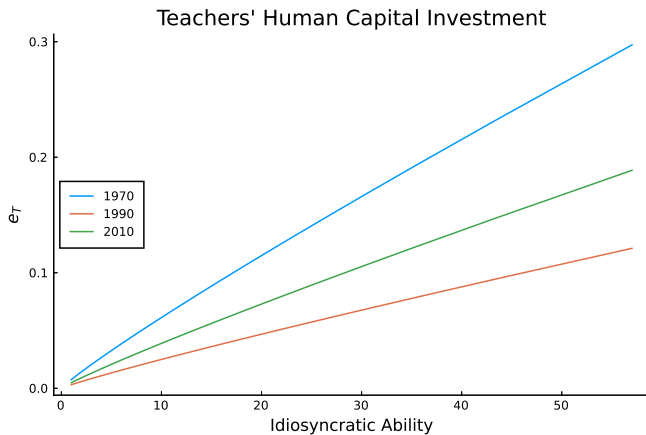
# Distribution of Teaching Abilities

Male workers with higher abilities become teachers



# Human Capital Investment

Human capital investment decline over time, given ability



# Human Capital and Output

	1970	1990	2010
measure of teachers (female)	1	1.000	1.765
measure of teachers (male)	1	0.462	0.731
$\tilde{H}_T^*$ per teacher (female)	1	0.732	0.665
$\tilde{H}_T^*$ per teacher (male)	1	1.069	1.107
$\tilde{H}_T^*$	1	0.620	1.002



# Summing up

- ▶ Ability composition of teachers change over time:
  - Women with lower ability select into teaching career
  - Men with higher ability select into teaching career
- ▶ Human capital investment drop over time, given ability
- ▶ More women become teachers
- ▶ Slightly fewer men become teachers
- ▶  $\Rightarrow$  Same level of aggregate teaching human capital

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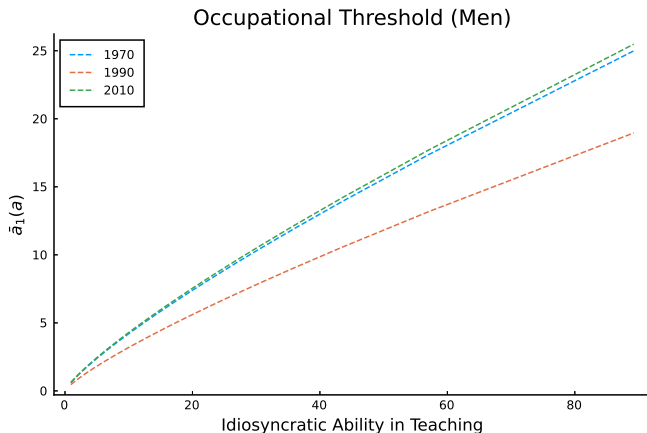
# Counterfactual Experiment

- ▶ "Freeze" women's labor market barriers at 1970 level (i.e.,  $\tau_w$  constant over time)
- ▶ Use occupational productivities from benchmark calibration.
- ▶ Adjust value of  $\kappa$  to match men's occupational choices from benchmark calibration.

# Occupational Threshold

For Men, Vis-à-Vis “Executives, . . .”

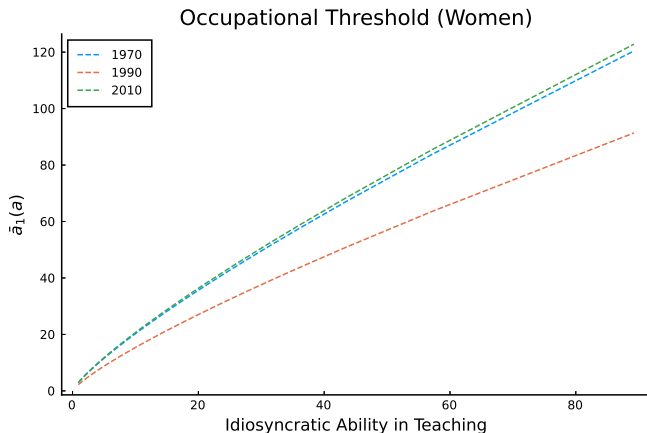
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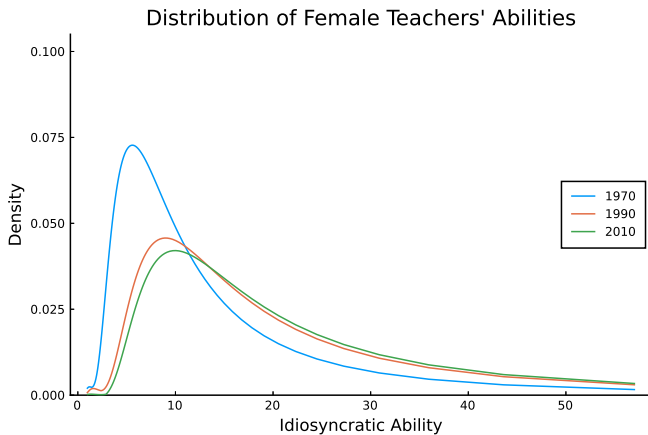
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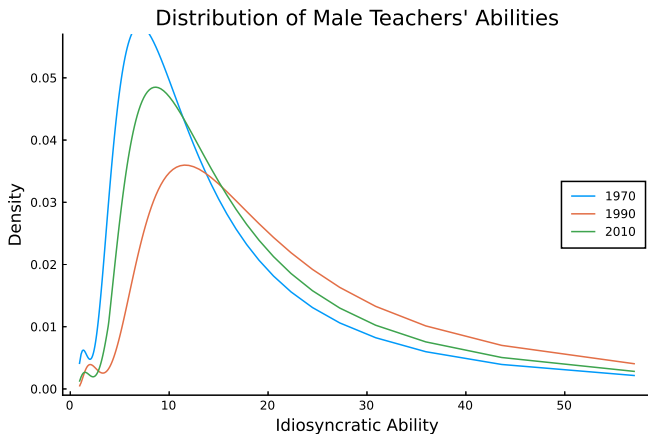
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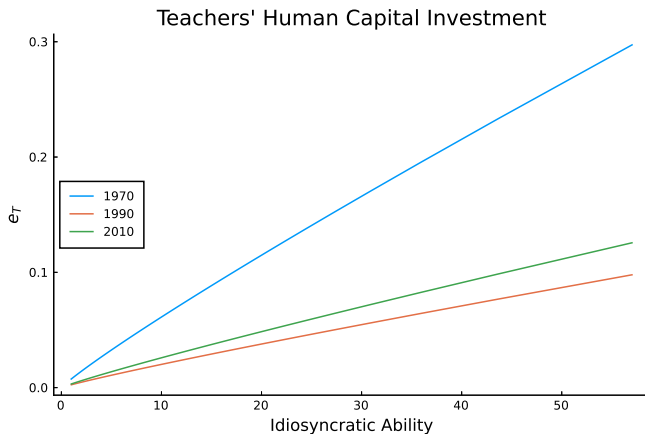
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# Human Capital Investment

Human capital investment decline over time, given ability





# Counterfactual Human Capital and Output

Values Relative to Benchmark Calibration

	1970	1990	2010
$\tilde{H}_T^*$	1	0.681	0.472
measure of teachers	1	1.291	0.855
$\tilde{H}_T^*$ per teacher (men)	1	0.798	0.660
$\tilde{H}_T^*$ per teacher (women)	1	1.132	1.410
$Y_O^*$	1	1.058	0.638

# Counterfactual Results: Summing Up

- ▶ Ability composition of teachers differ:
  - Women with (relatively) higher ability select into teaching career
  - Men with (relatively) lower ability select into teaching career
- ▶ Human capital investment drop over time, given ability
- ▶ Fewer women become teachers
- ▶ Slightly more men become teachers
- ▶  $\Rightarrow$  Lower level of aggregate teaching human capital
- ▶  $\Rightarrow$  Lower non-teaching output

# Conclusion

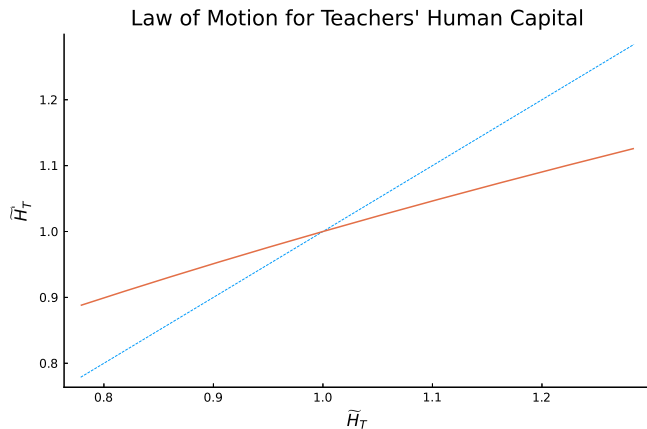
## Results

- ▶ Develop a novel theory of occupational choice and human capital formation:
  - non-linear wages
  - intergenerational dynamics of human capital accumulation
- ▶ Calibrate change in barriers

## Ongoing and Future Work

- ▶ Decomposition:
  - 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)

# Law of Motion



# Optimal Time Investment

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

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

► Back

# Optimal Goods Investment

$$e_{T,g} = \left( (\kappa \cdot \gamma \cdot \eta \cdot \tau_{T,g})^{\frac{1}{\gamma}} \cdot a_T^\alpha \cdot s_{T,g}^\phi \cdot \left( \frac{2\tilde{H}_T}{M} \right)^\sigma \right)^{\frac{1}{\frac{1}{\gamma} - \eta}}$$

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

where

$$\tau_{i,g} = \frac{(1-t)(1-\tau_{i,g}^\omega)}{1+\tau_{i,g}^e}$$

► Back

# Aggregate Laws of Motion

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

where

$$\tau_{i,g} = \frac{(1-t)(1-\tau_{i,g}^\omega)}{1+\tau_{i,g}^e}$$

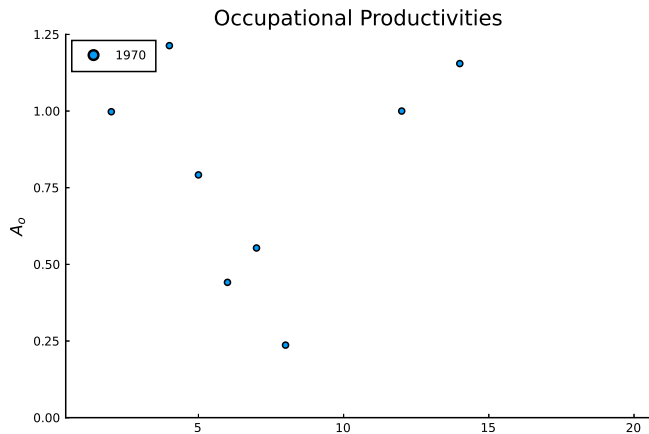
► Back

## Occupations

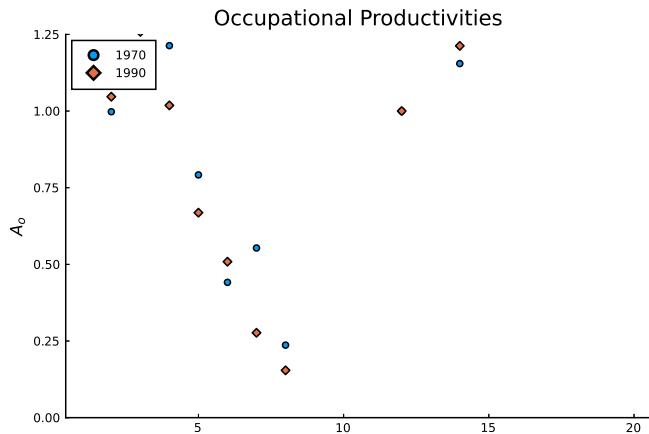
1. Executives, Administrative, and Managerial
2. Management Related
3. Architects, Engineers, Math, and Computer Science
4. Natural and Social Scientists, Recreation, Religious, Arts, Athletes
5. Doctors and Lawyers
6. Nurses, Therapists, and Other Health Service
7. Teachers, Postsecondary
8. Teachers, Non-Postsecondary and Librarians
9. Health and Science Technicians
10. Sales, All
11. Administrative Support, Clerks, Record
12. Fire, Police, and Guards
13. Food, Cleaning, and Personal Services and Private Household
14. Farm, Related Agriculture, Logging, and Extraction
15. Mechanics and Construction
16. Precision Manufacturing
17. Manufacturing Operators
18. Fabricators, Inspectors, and Material Handlers
19. Vehicle Operators
20. Home Production



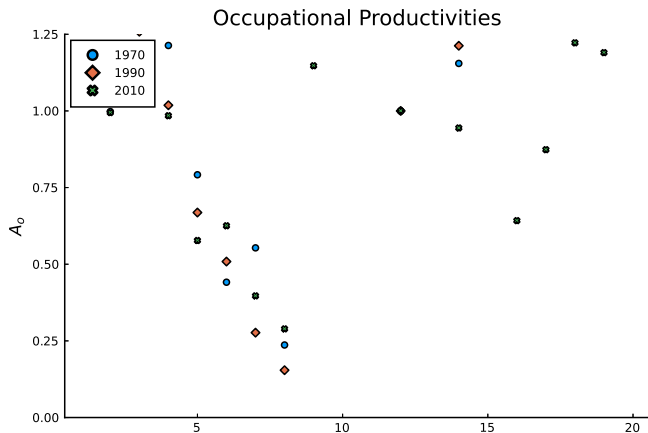
# Occupational Productivity



# Occupational Productivity



# Occupational Productivity



► Occupations

► Back

# Counterfactual #1

Distribution of Teaching Abilities (Women)

plots/counter\_1/fT\_women\_steadystate-eps-converted-to

# Counterfactual #1

Distribution of Teaching Abilities (Men)

plots/counter\_1/fT\_men\_steadystate-eps-converted-to.p

# Counterfactual #1

Human Capital Investment

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# Counterfactual #2

Distribution of Teaching Abilities (Women)

# Counterfactual #2

Distribution of Teaching Abilities (Men)



# Counterfactual #2

Human Capital Investment