

# 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)
- ▶ 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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  - 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  $\Rightarrow$  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

## 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  $a_i$ , 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  $A_O$ :

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

# 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

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

# Model

## Constraints, Laws of Motion

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

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

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

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

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

# 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  
⇒ distribution of students' skill identical across classrooms
- ▶ Teachers with different  $h_{T,g}$  vary with respect to class *size*

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

- ▶ 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 problem ► 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  $\widetilde{H^T}$

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

where

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

# 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:

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

# Calibration

## Assumptions and Normalizations

Parameter	Definition	Determination	Value
$\tau_{o,men}^w$	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

# Calibration

## Baseline 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	Mincer returns to education (non-teaching) (indirect inference)	0.999
$\gamma$	curvature of wage function in teaching	wage dispersion in teaching (indirect inference)	0.83
$A_o$	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	

# Calibration

## Benchmark Calibration

Parameter	Definition	Empirical Targets
$\beta$	Teacher elasticity of human capital	Skill composition by occupation and group
$\sigma$	Class size elasticity of human capital	Normalization to 1
$\mu$	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
  - intergenerational dynamics of human capital accumulation
- ▶ Calibrate reduction in discrimination & barriers:
  - static gains (as in Hsieh et al., 2019) vs.
  - dynamic effects (human capital accumulation)

## Ongoing and Future Work

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

# Optimal Time Investment

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

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

► 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

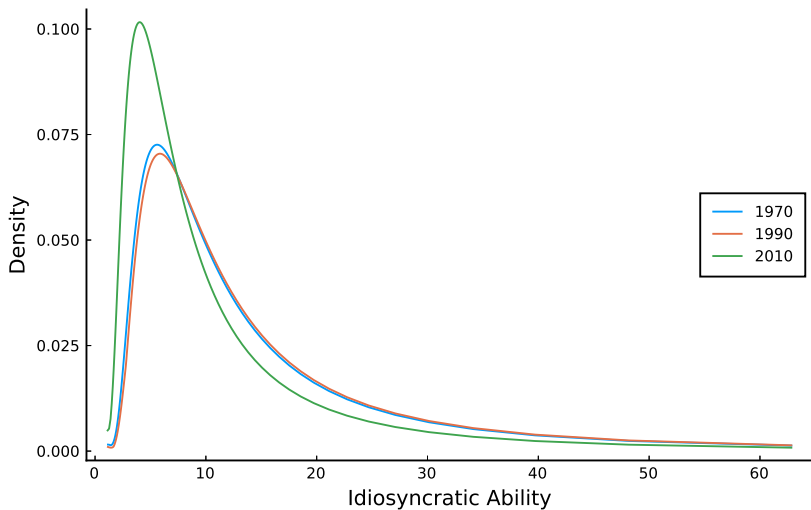
# Aggregate Laws of Motion

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

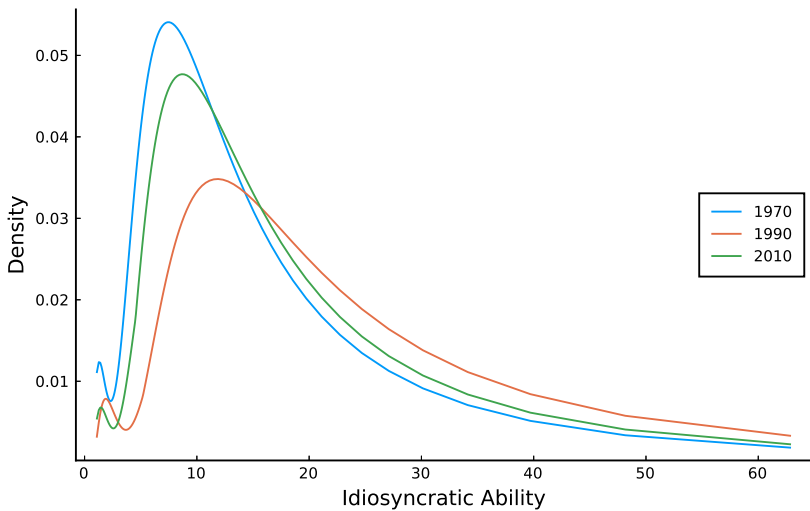
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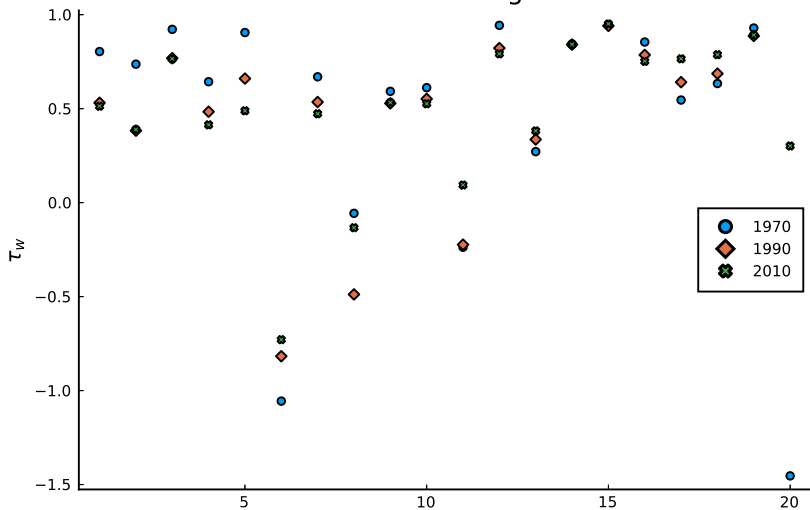
## Distribution of Female Teachers' Abilities



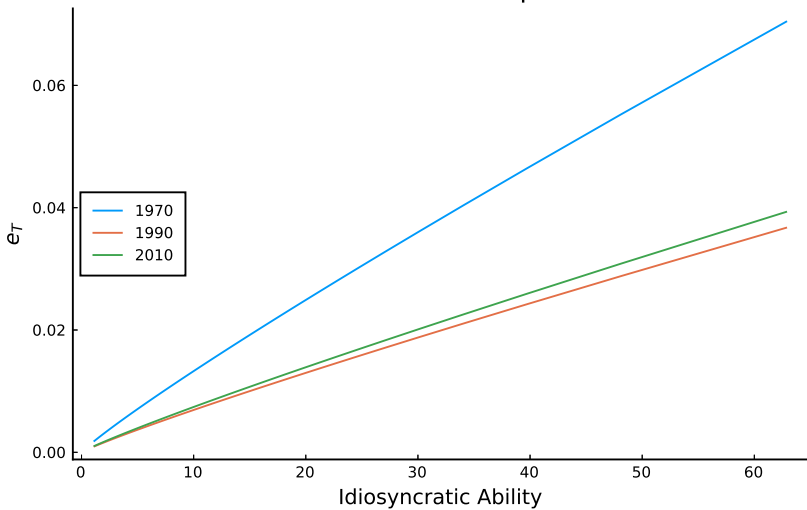
## Distribution of Male Teachers' Abilities



## Labor Market Barriers Against Women

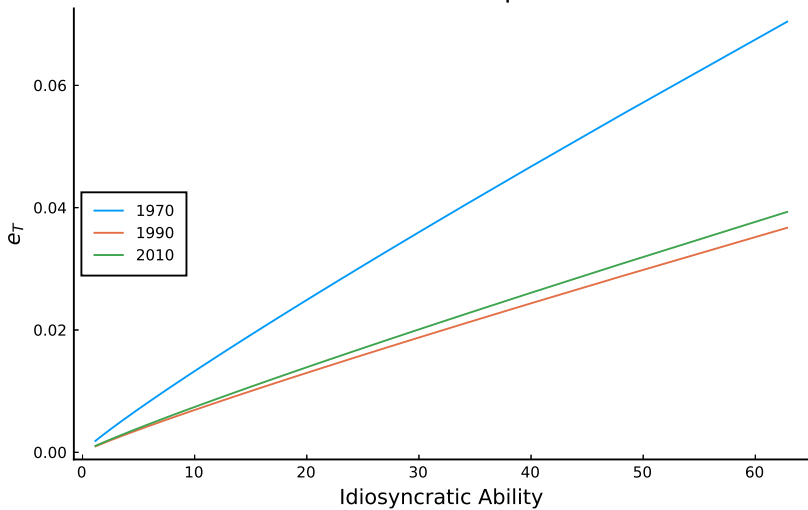


## Female Teachers' Human Capital Investment

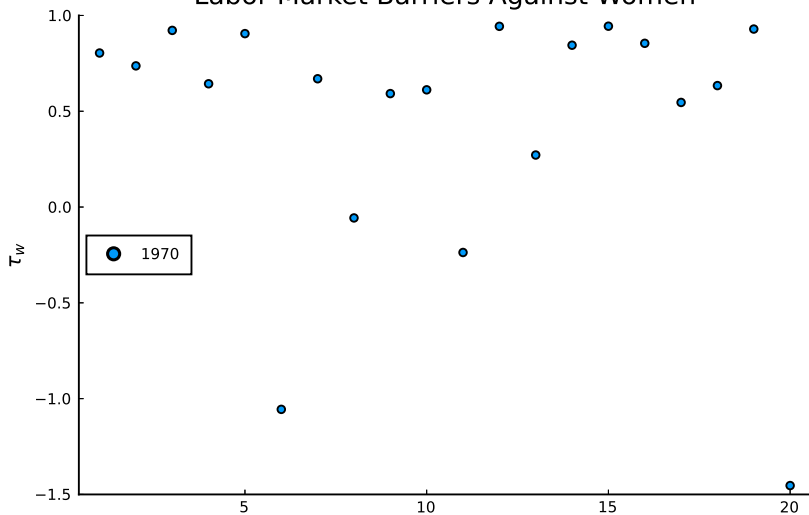




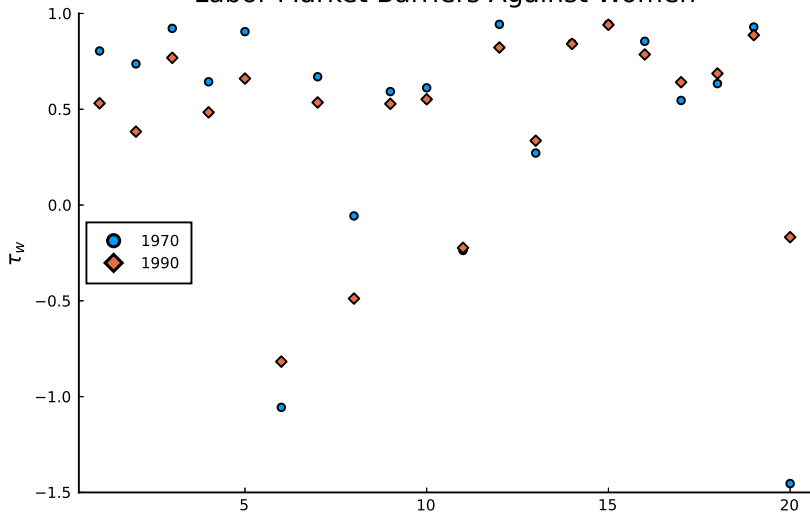
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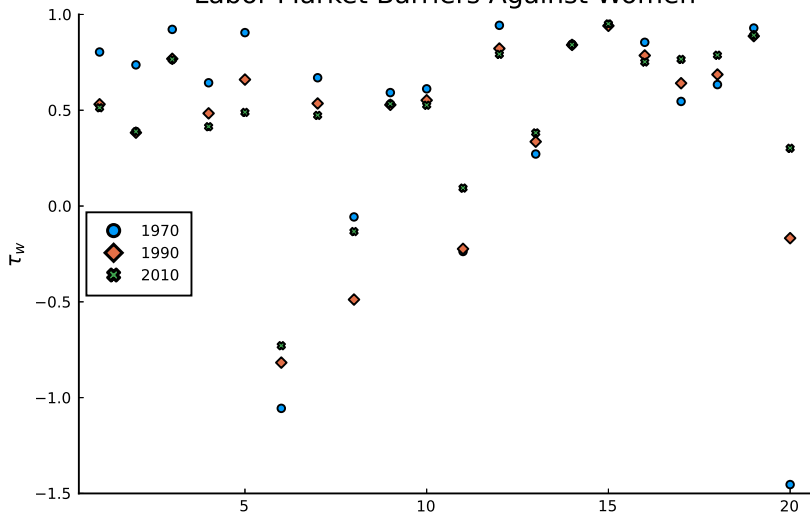
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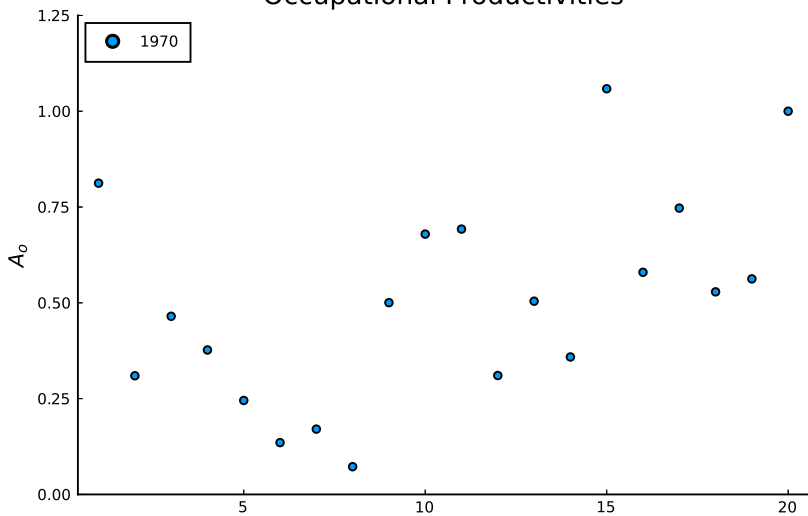
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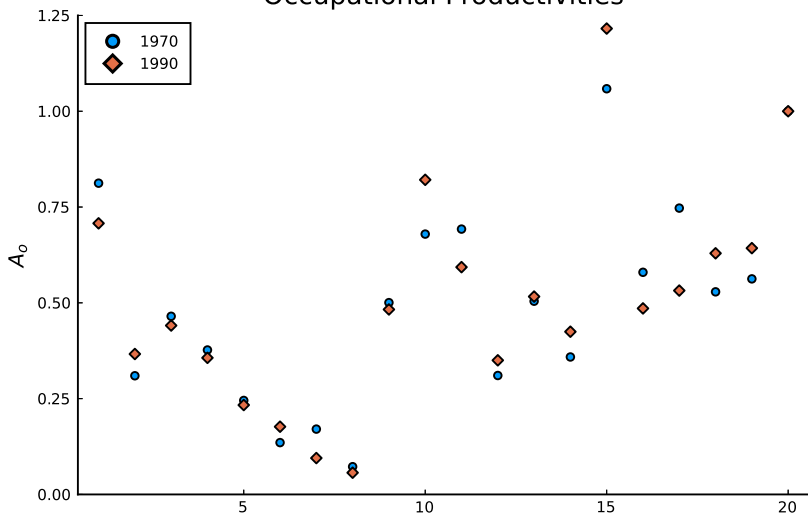
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# Occupational Productivities



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