Dissertation Proposal:
Three Essays on the Economics of Social Welfare

Willy Chen

Dissertation Proposal Defense
October 31, 2025

1. The Credentials Arms Race: Examining Immigrant Over-Education using A Signaling Model with Costly Hiring

2. Descriptive Units of Heterogeneity: An Axiomatic Approach to Measuring Heterogeneity

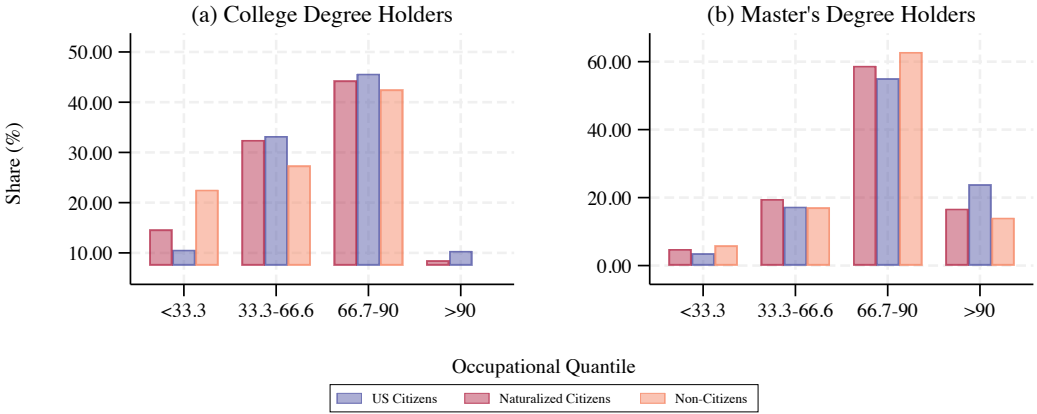
3. Law Law Land: The Effects of Sanctuary City Policies

Chapter 1

The Credentials Arms Race:
Examining Immigrant Over-Education using A Signaling Model with Costly Hiring

Motivation

Figure 1.1: Educational Mismatch of Male Immigrants, 2010-2019 Quartiles



Notes: Data from American Community Survey-5% from 2010 to 2019. Occupational quantile represents the lexicographic order of jobs over the shares of U.S. citizen workers' education attainment of Doctorate/Professional, Master's, College, Associate's, and High School.

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Figure 1.2: Educational Mismatch of Male Immigrants at High Degree Levels, 2010-2019

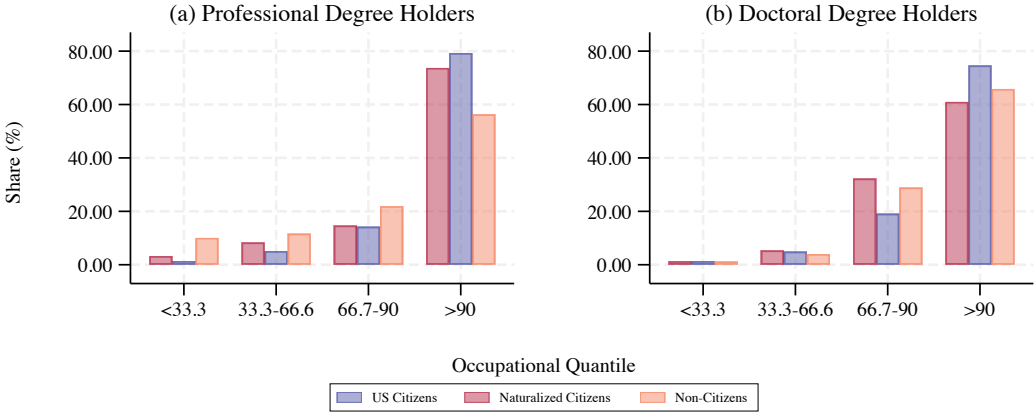

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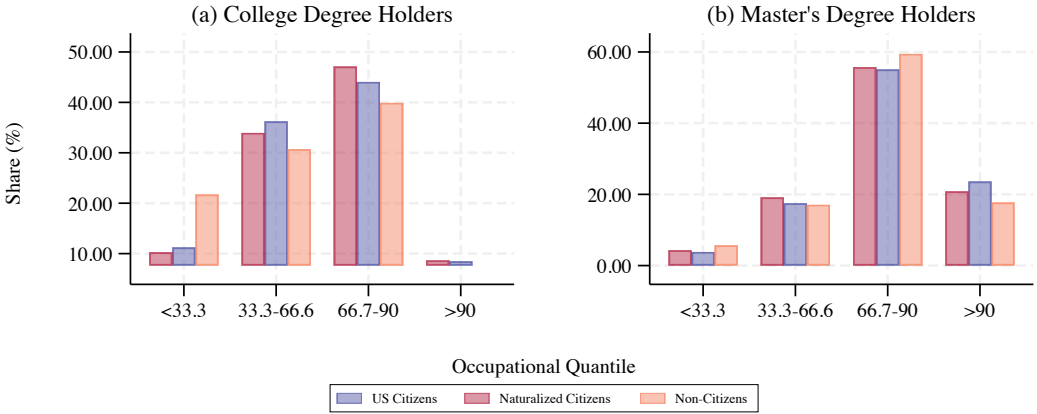
Figure 1.3: Educational Mismatch of Single Immigrants, 2010-2019



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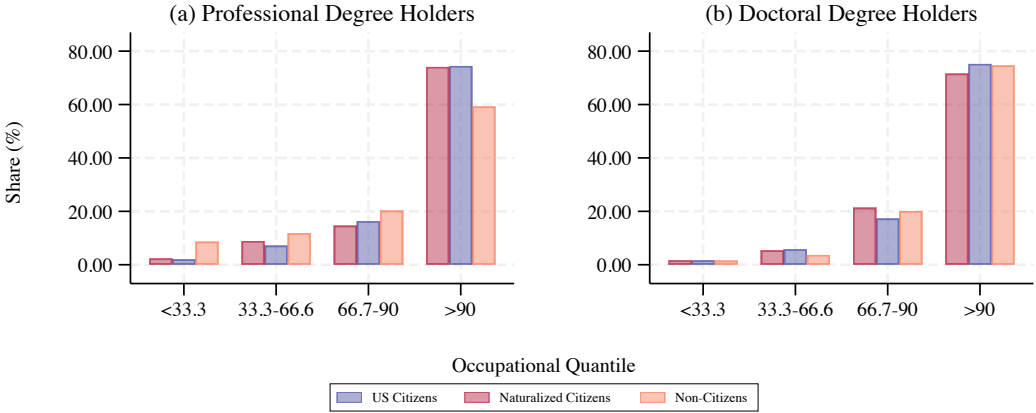

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Population Moments

Table 1.1: Summary Statistics of Workers Age 25-64 in the US with at least High School Education, 2010-2019 By Degree Level

	US Citizens	Naturalized citizens	Non-citizens
% of Workforce	85	8.4	6.6
Median Value			
Age	44	46	39
Years in US		24	12
Occ. Quantile	53.5	53.7	40.5
Birthplace Official Language			
% Not English		73.5	74.6
% English		24.7	23.8
% Mixed		1.8	1.6
Highest Degree Obtained			
% High School	50.6	43.1	54.4
% Associate's	10.4	9.5	6
% College	24.9	27.4	21
% Master's	10.1	12.9	12.5
% Professional	2.6	3.9	2.3
% Doctorate	1.4	3.2	3.8
% Single	23.9	15.1	24.4
% Married	59.2	69.9	63.5
Spouse's Citizenship			
US Citizen	95.0	28.0	22.6
Naturalized Citizen	3.1	56.4	16.1
Non-citizen	1.9	15.6	61.3

Related Literature

This paper concerns four strands of literature:

1. Wage Penalty and Over-education (Cassidy and Gaulke, 2024; Chiswick et al., 2009, 2013; Hartog, 2000; Kiker et al., 1997; Li et al., 2023; Lu et al., 2021; Verdugo et al., 1989; Warman et al., 2015).

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4. Separating equilibria in games with productive signals (Chatterjee et al., 2021; Cho et al., 1987; Kaymak, 2025; Mailath, 1987; Spence, 1978; Tyler et al., 2000).

Model Environment (Modified Spence (1978))

Consider an economy where there are two otherwise identical firms that compete for workers. There is a measure 1 of workers that can be hired.

- Each worker has a private productivity type $\theta \in \Theta \subset \mathbb{R}_+$.

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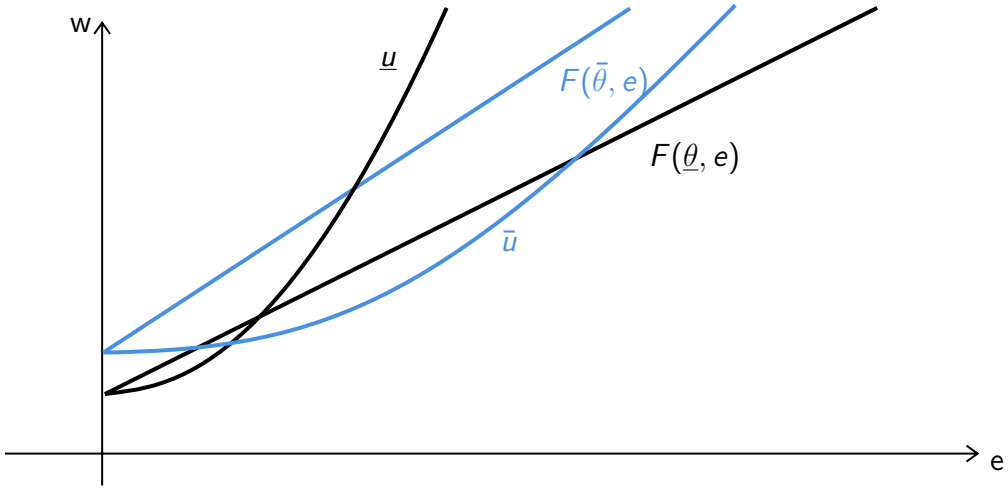
- The firm's profit is $\pi(\theta, e, w) = F(\theta, e) - w$.

For building intuition, we will consider an $F(\theta, e)$ that is linear and strictly increasing in e, a slight modification of the Spence (1978) case.

First, let's consider if there are only two productivity types, i.e., $\Theta = \left\{\underline{\theta}, \bar{\theta}\right\}$.

Two Types: $\Theta = \left\{\underline{\theta}, \bar{\theta}\right\}$



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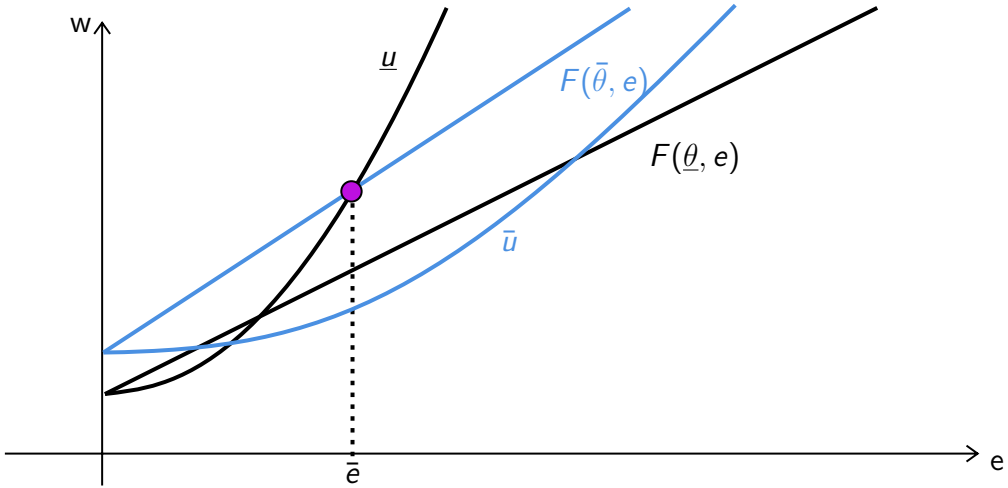

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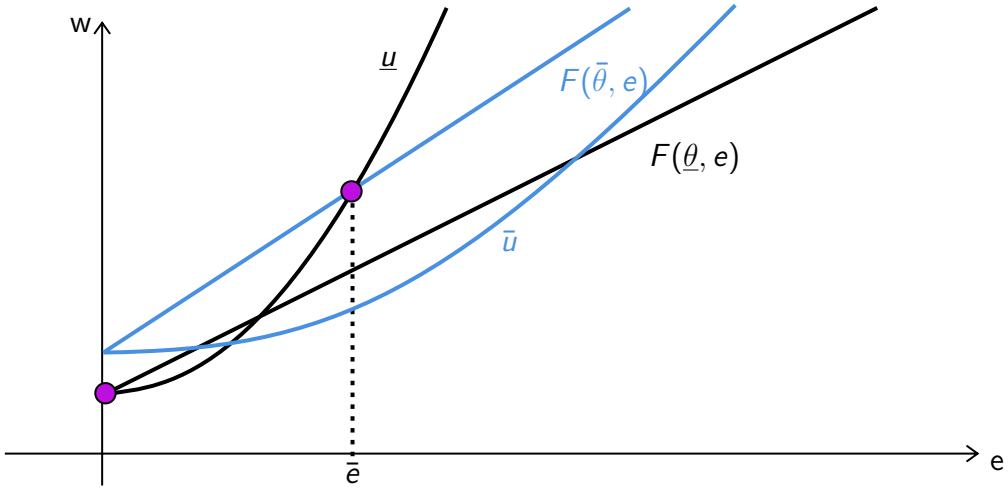

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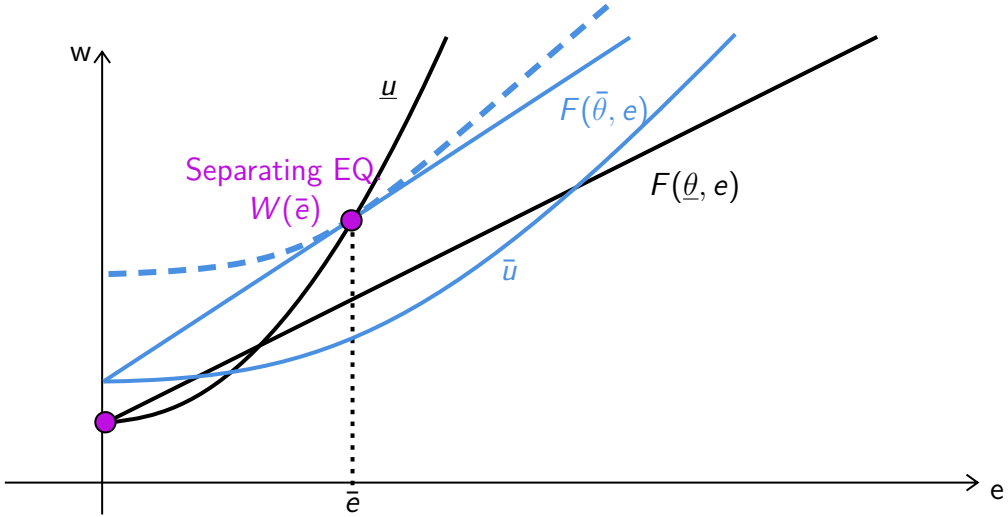

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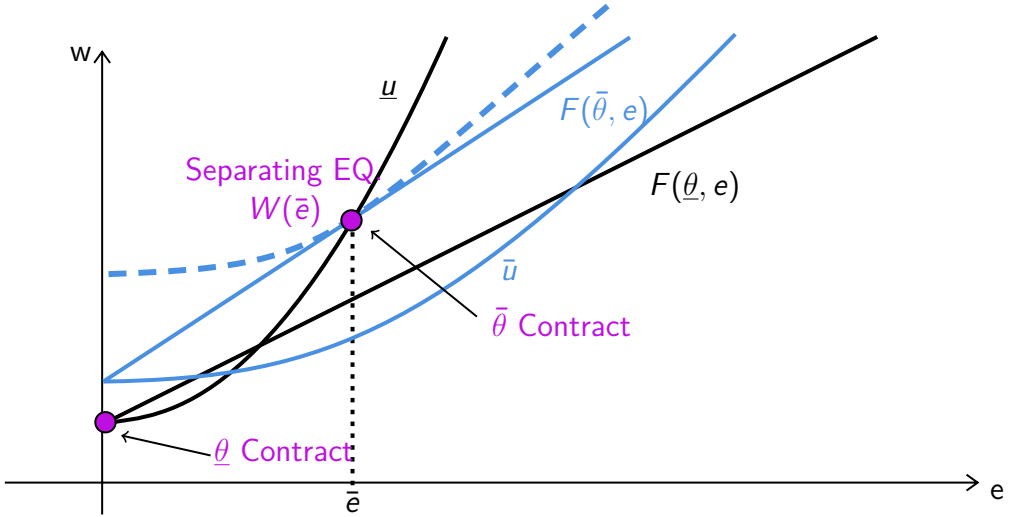

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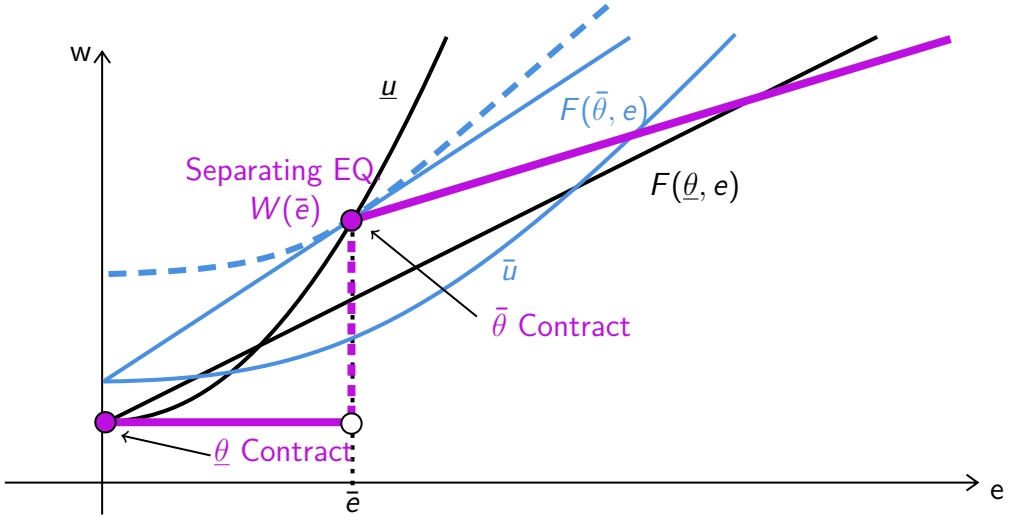

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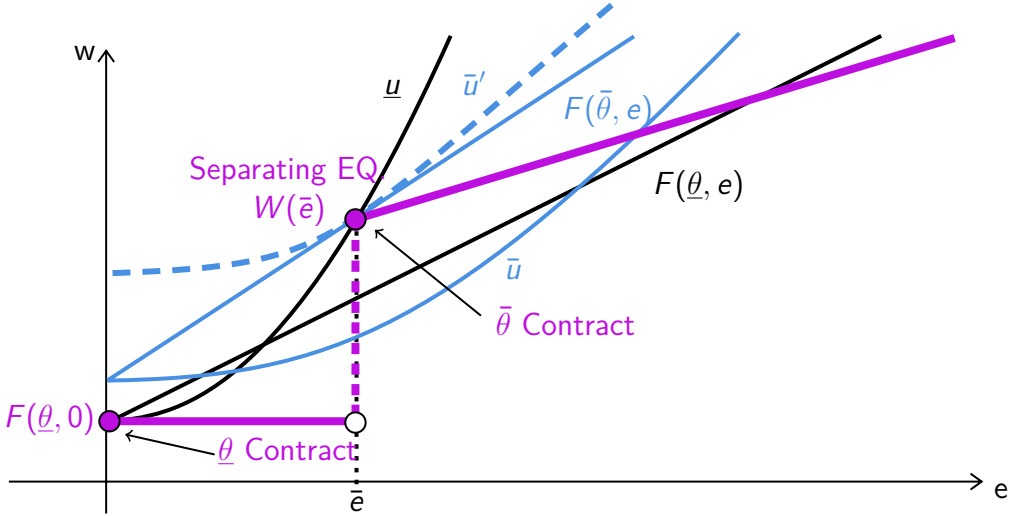

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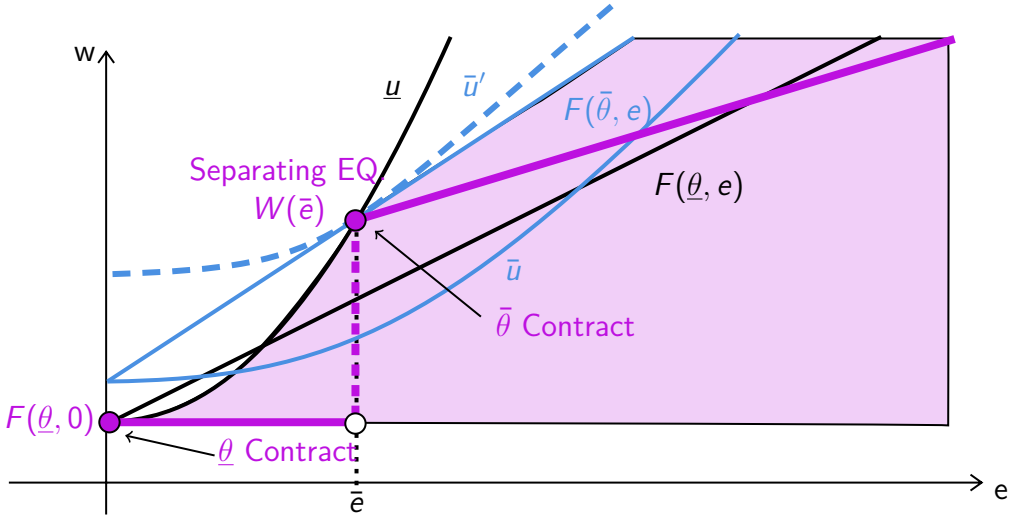
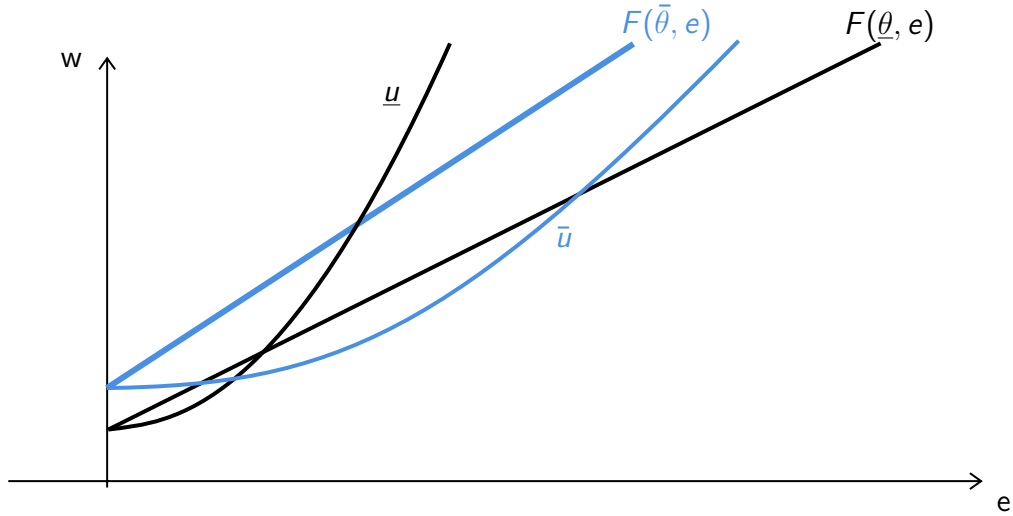


Now, let's consider if there is an additional intermediate type, i.e.,

$$\Theta = \left\{\underline{\theta}, \theta_M, \bar{\theta}\right\}.$$

Three Types $\Theta = \left\{\underline{\theta}, \theta_M, \bar{\theta}\right\}$



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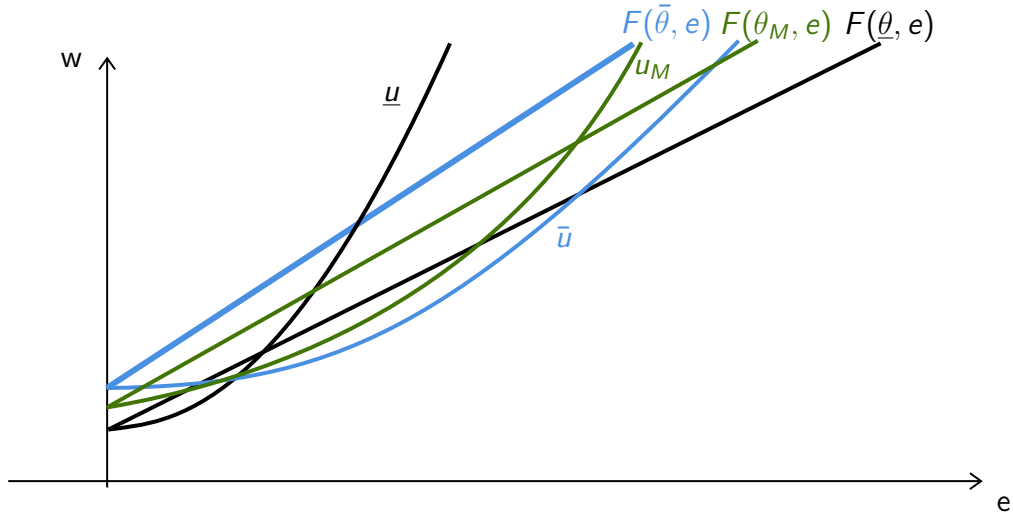

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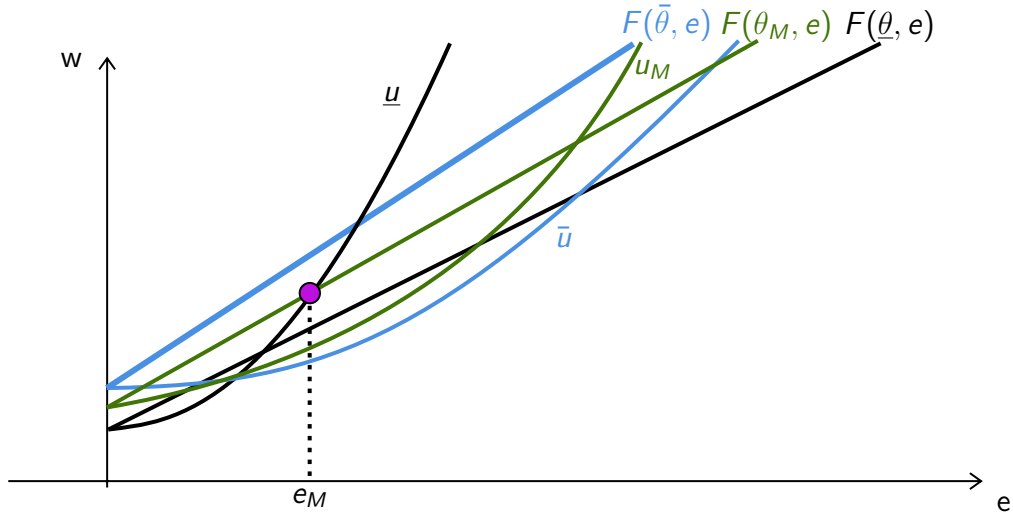

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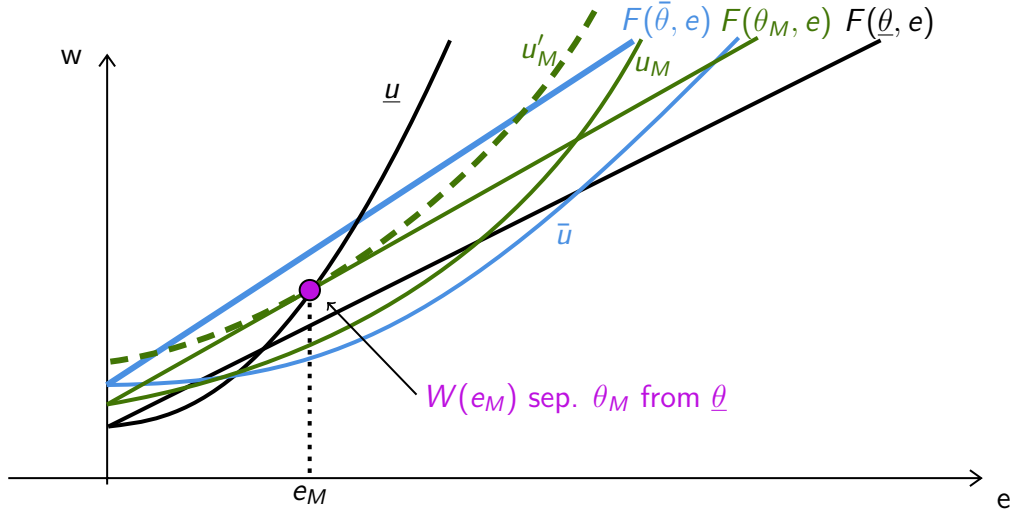

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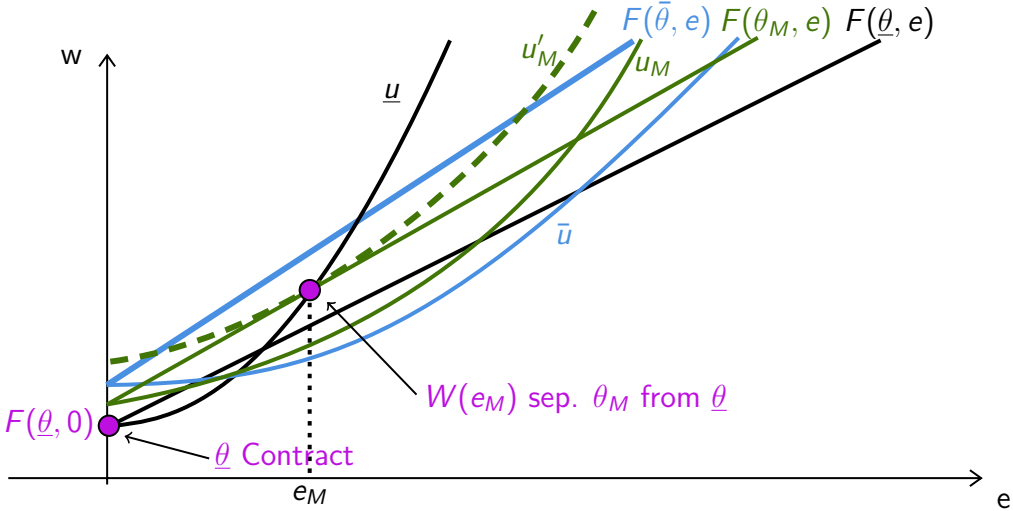

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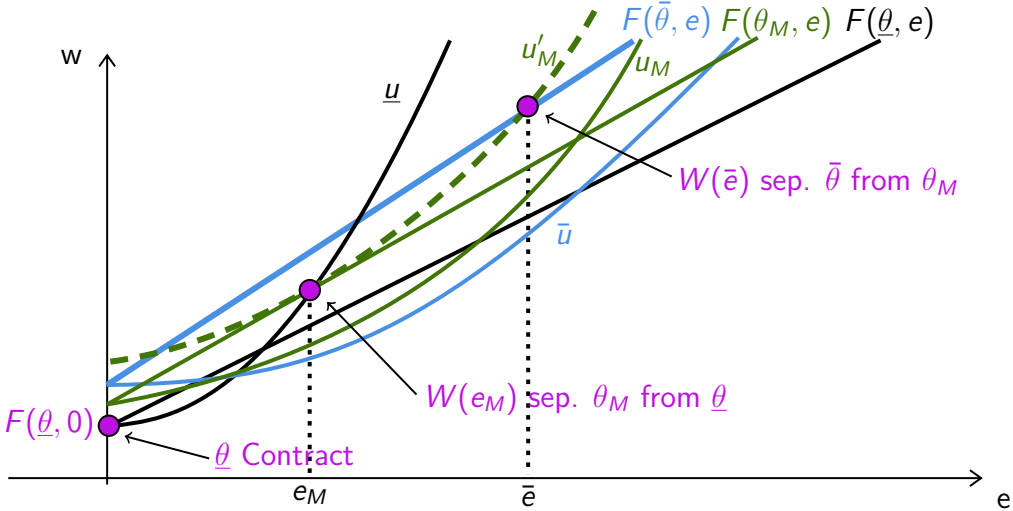

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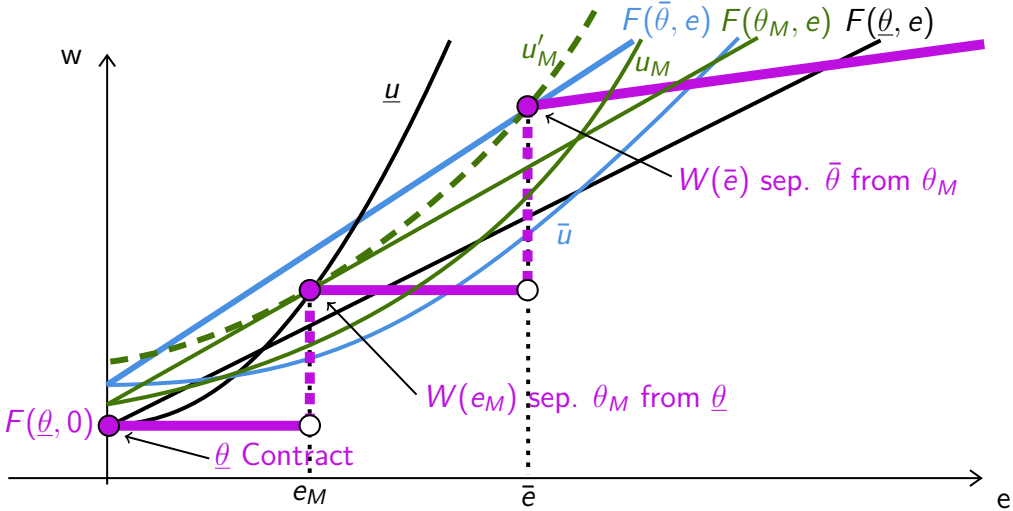

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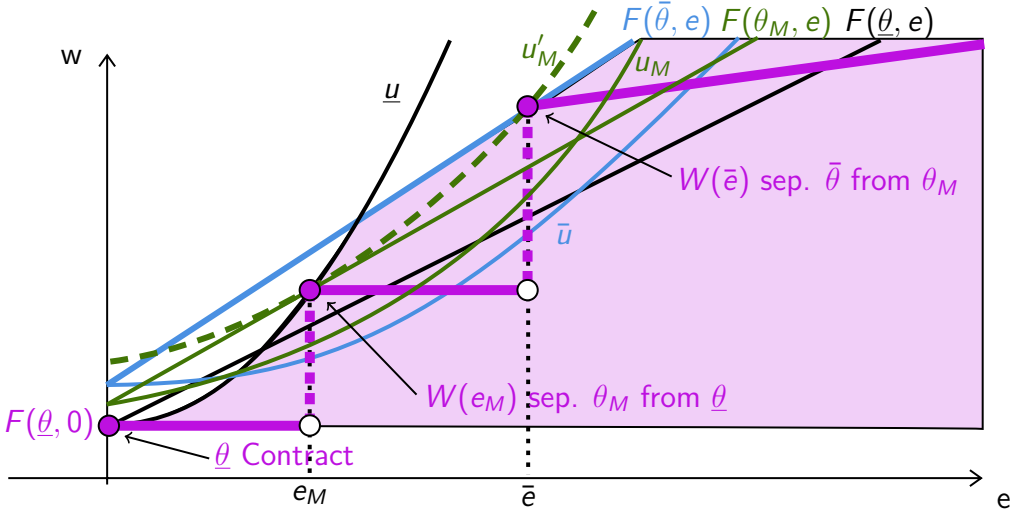

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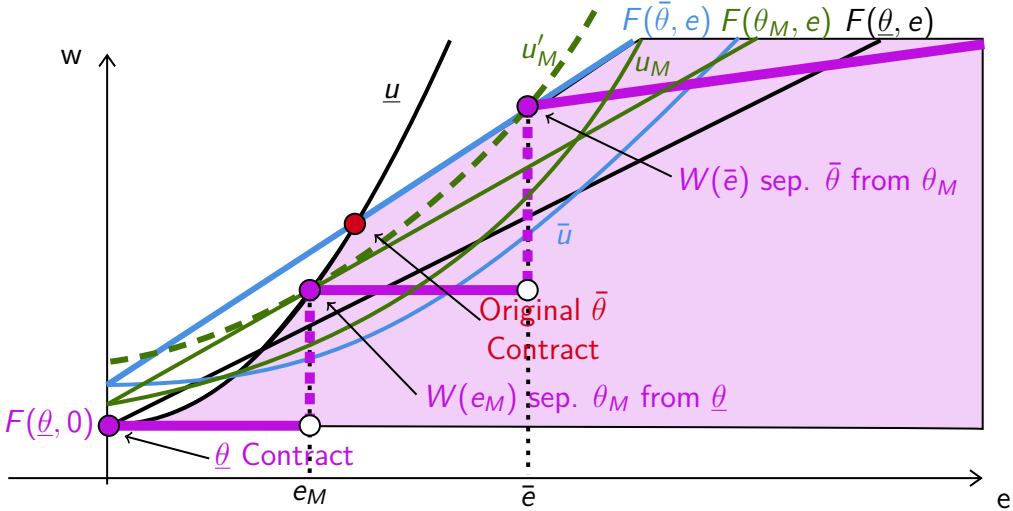

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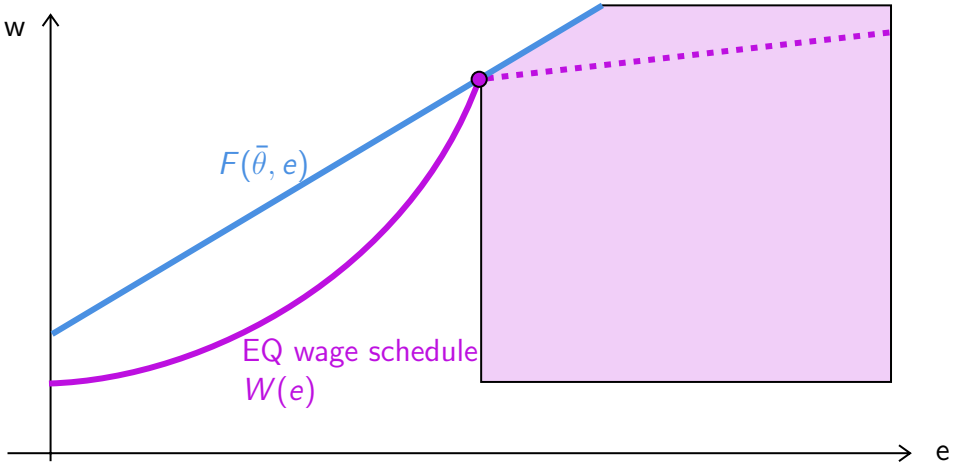

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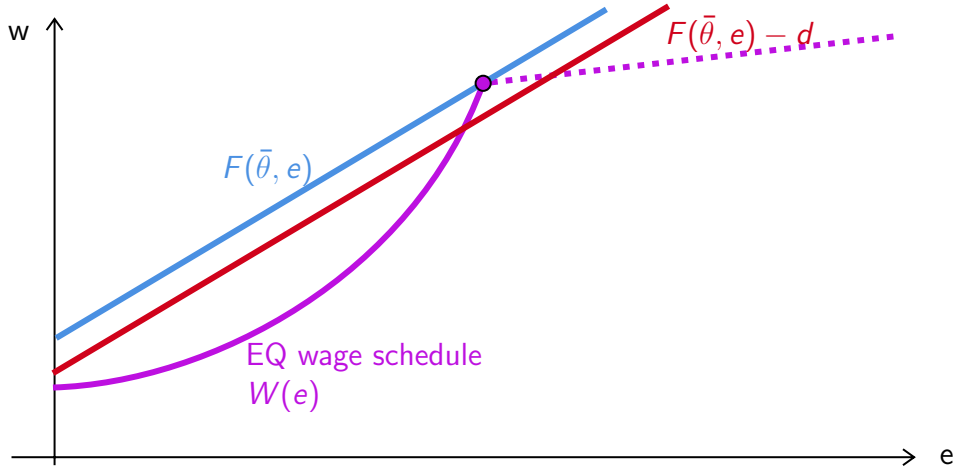

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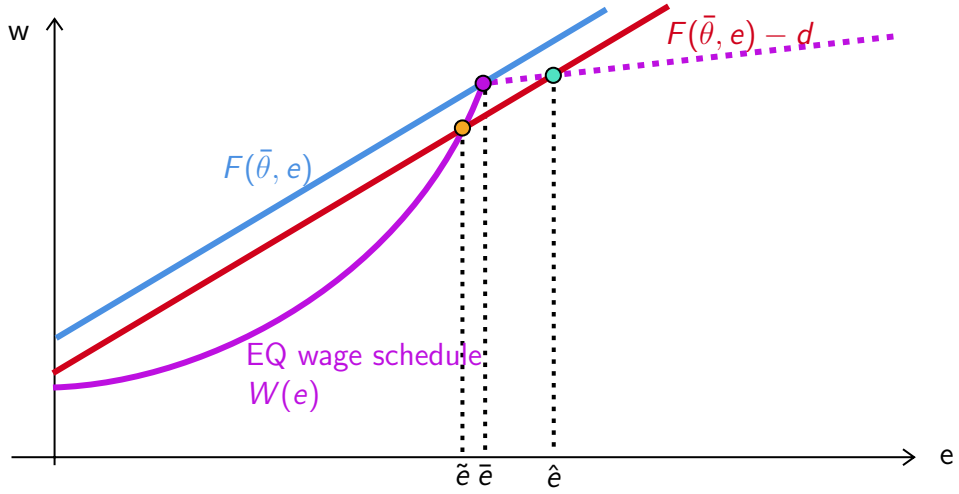

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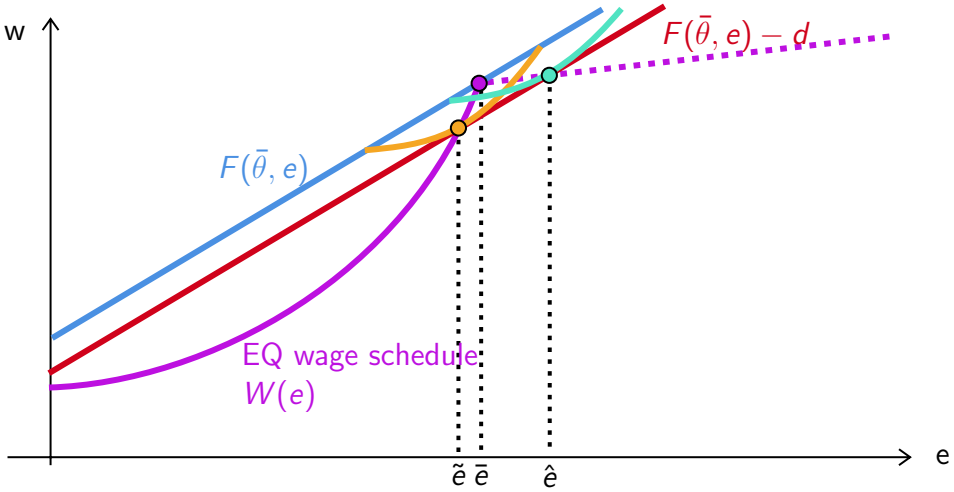

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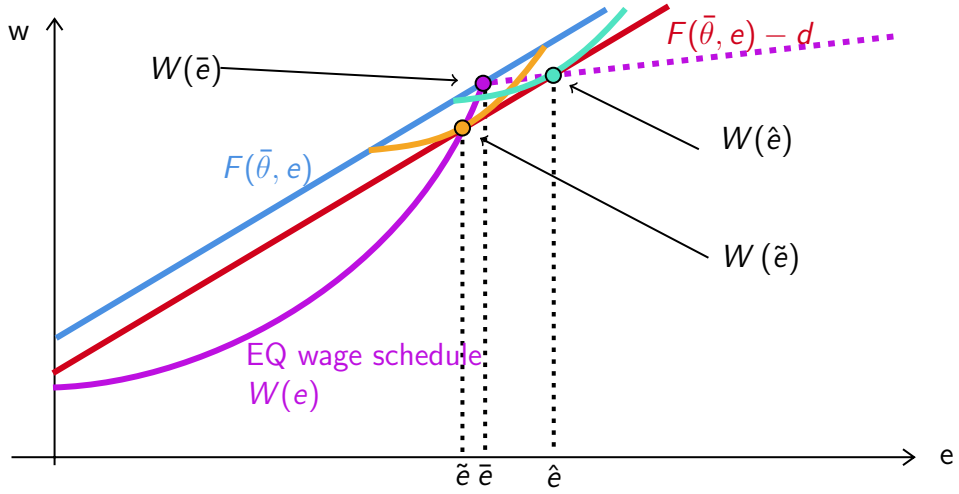

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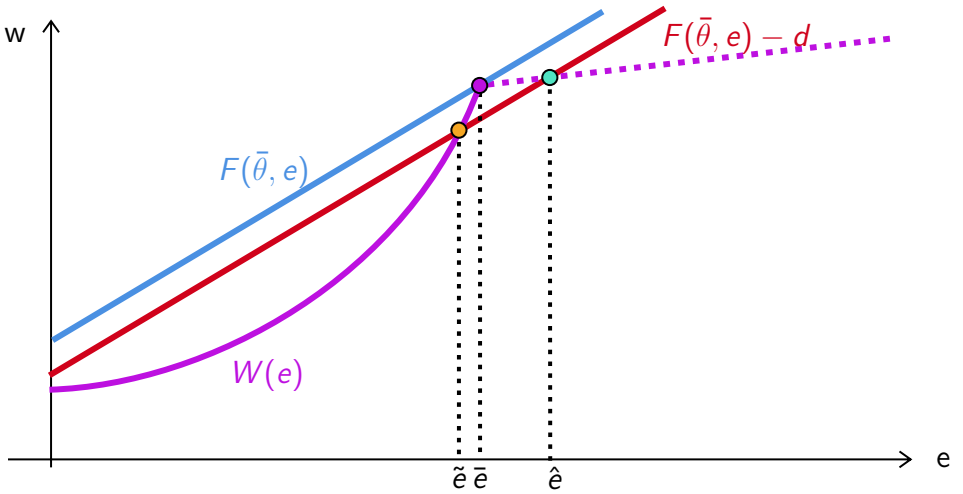

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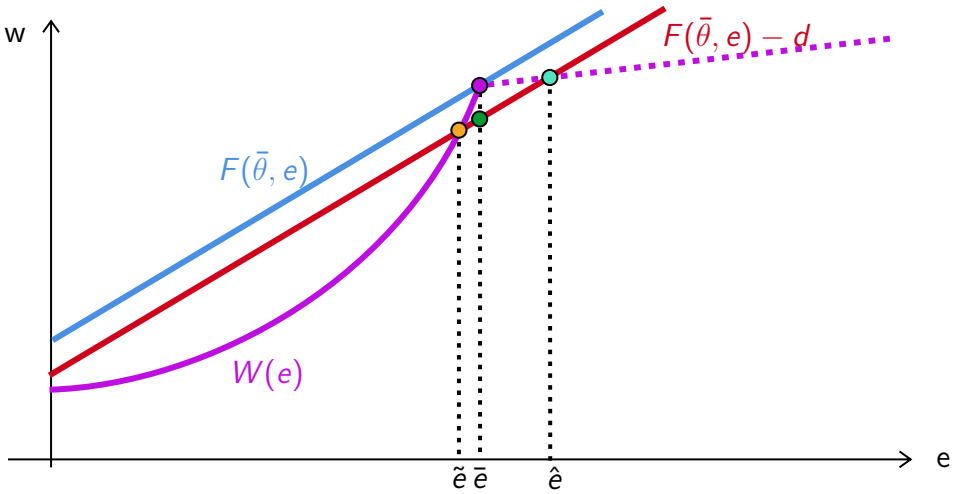

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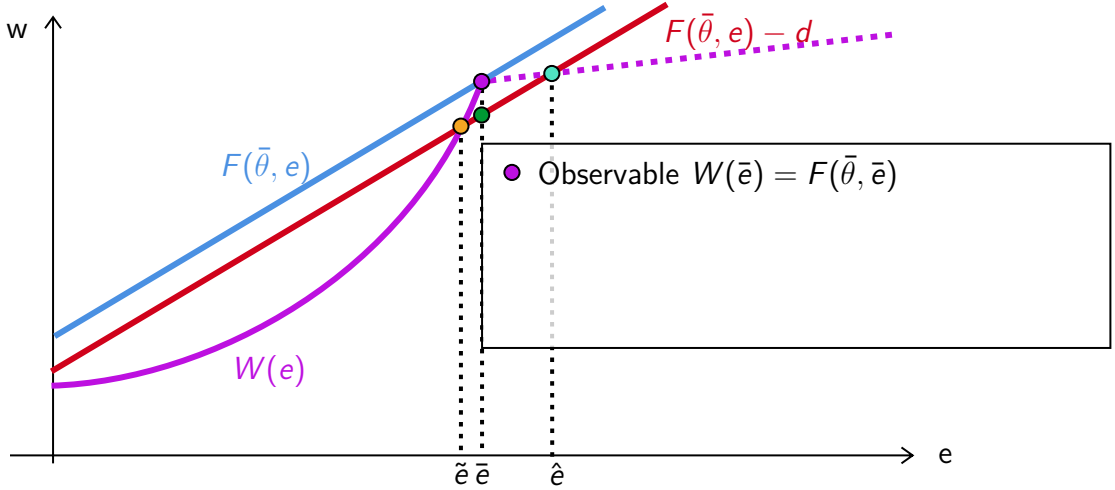

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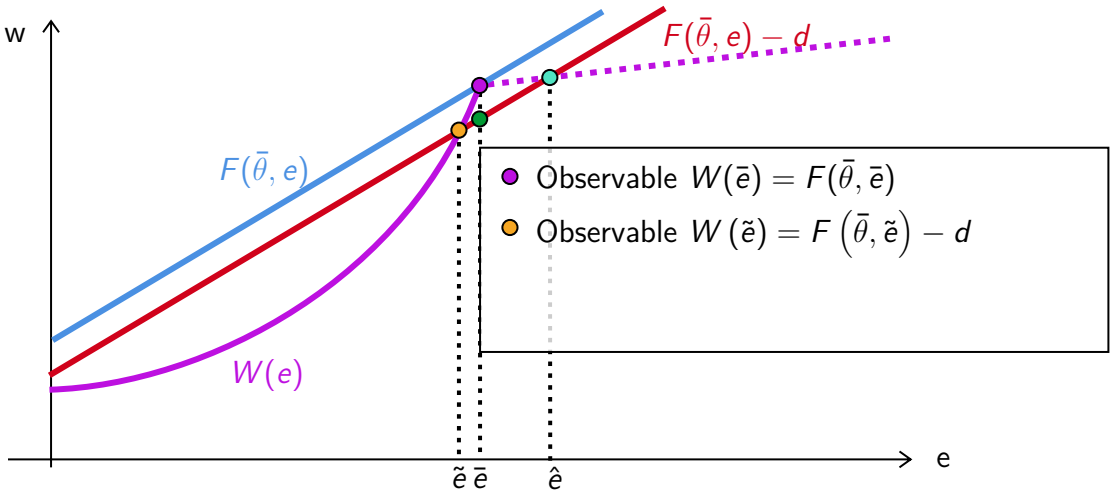

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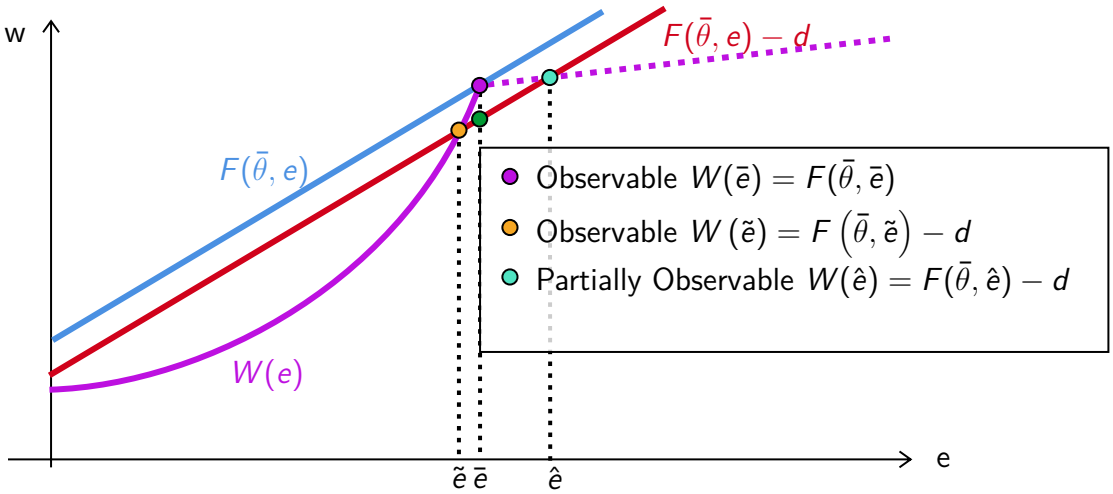

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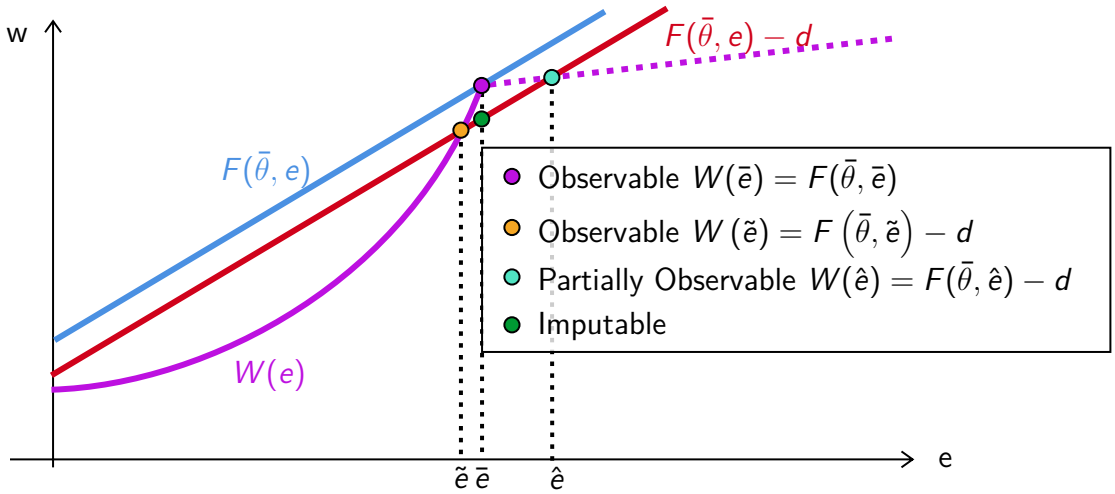

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In a full **separating** equilibrium, σ is a one-to-one function, i.e.,

$$\widehat{\Theta}(e) = \{\sigma^{-1}(e)\}, \forall e \in \mathcal{E} \tag{1}$$

and $\sigma(\theta)$ must satisfy *strict incentive compatibility*:

$$\{\sigma(\theta)\} = \underset{e}{\textit{argmax}}\ U(\theta, \sigma^{-1}(e), e), \forall \theta \in \Theta \tag{2}$$

Regularity Conditions

1. (Smoothness) $U(\theta, \hat{\theta}, e)$ is twice differentiable on $\Theta^2 \times \mathcal{E}$.
2. (Belief Monotonicity) $\frac{\partial}{\partial \hat{\theta}} U\left(\theta, \hat{\theta}, e\right) > 0$.
3. (Type monotonicity) $\frac{\partial^2}{\partial \theta \partial e} U\left(\theta, \hat{\theta}, e\right) > 0$
4. ("Strict" Quasi-Concavity) $\frac{\partial}{\partial e} U\left(\theta, \hat{\theta}, e\right) = 0$ has a unique solution in e, denoted $\phi(\theta)$ such that $\phi(\theta) \in \underset{e}{argmax}\ U\left(\theta, \hat{\theta}, e\right)$, and $\frac{\partial^2}{\partial e^2} U\left(\theta, \hat{\theta}, e\right)\Big|_{e=\phi(\theta)} < 0$.
5. (Boundedness) $\exists k > 0$ such that

$$\forall (\theta, e) \in \Theta \times \mathcal{E}, \frac{\partial^2}{\partial e^2} U(\theta, \hat{\theta}, e) \geq 0 \ \Rightarrow\ \left|\frac{\partial}{\partial e} U(\theta, \hat{\theta}, e)\right| > k.$$

Regularity Conditions

1. (Smoothness) $U(\theta, \hat{\theta}, e)$ is twice differentiable on $\Theta^2 \times \mathcal{E}$.
2. (Belief Monotonicity) $\frac{\partial}{\partial \hat{\theta}} U\left(\theta, \hat{\theta}, e\right) > 0$.
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Additionally, there are two niceness conditions: Initial Value (IV) and Single Crossing (SC).

Characterization of the Solution

Mailath (1987) shows that
If conditions 1-5 are satisfied, then a strictly increasing function σ, continuous at $\underline{\theta}$, satisfies strict incentive compatibility if and only if:

1. σ solves $\dfrac{d\sigma}{d\theta} = -\dfrac{\frac{\partial}{\partial\hat{\theta}}U\left(\theta,\hat{\theta},e\right)}{\frac{\partial}{\partial e}U\left(\theta,\hat{\theta},e\right)}$
2. when $\frac{\partial}{\partial\hat{\theta}}U\left(\theta,\hat{\theta},e\right) > 0$, $\dfrac{\frac{\partial}{\partial e}U\left(\theta,\hat{\theta},e\right)}{\frac{\partial}{\partial\hat{\theta}}U\left(\theta,\hat{\theta},e\right)}$ is a strictly increasing function of θ.

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Moreover, the strictly increasing σ that satisfies strict incentive compatibility is unique.

In other words, there is an unique full separating equilibrium in the natives' labor market given the assumptions in the basic model environment.

Interpreting θ as Transferrable Human Capital

The assumption of two otherwise identical firms in the model translate to the restriction that all jobs in the "same market" follow the same production function.

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As such, only jobs that are similar enough for human capital to be highly transferrable should be considered as being in the same "market."

In other words, empirical analysis using this model requires a first-stage categorization of jobs in order to estimate the points shown in graph.

Defining Labor Markets

I have attempted to categorize jobs in the following ways:

1. Principal component analysis (PCA) on O*NET skills and abilities.
   Graphs
2. Spectral clustering using the Department of Labor transitions data.
   Graphs
3. Spectral clustering using ACS conditional match likelihood based on degree-field.
   Graphs

Proxy Wage Schedule

Even though the model uses the simple wage schedule, I cannot use realized wages to estimate the true wage schedule because of all other wage determinants such as bargaining, unobserved constraints, etc.

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I order occupations lexicographically over the share of citizen workers' education attainment and quantify the order in quantiles.

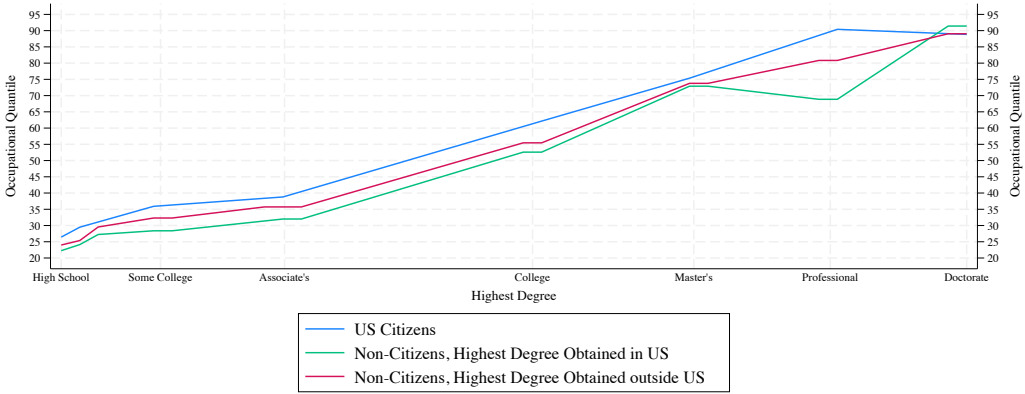
Occupatioal Quantiles

Table 1.2: Occupational Quantile Example

Occupation	Doc./Pro.	MA	BA	Assoc.	HS	<HS	Occ. Quantile
Surgeon	99.5	0.5	0	0	0	0	100
Postsecondary Teacher	37.8	33.2	19.4	2.4	6.8	0.4	97.1
Sales Managers	1.0	10.8	50.2	7.5	29.5	1.0	61.0
Respiratory Therapists	0.9	3.1	25.0	56.6	14.1	0.3	59.5
Fence Erectors	0	0.7	3.7	4.4	69.4	21.8	3.0
Earth Drillers, not Oil	0	0.2	4.0	6.0	76.3	13.5	2.4

Estimated Proxy Wage Schedule

Figure 1.5: Estimated "Wage Schedule" by Citizenship, Single Male Age 25-64

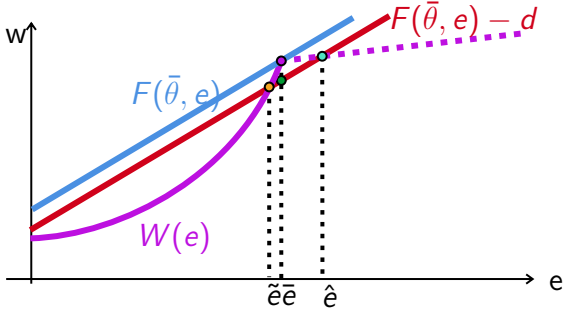


Notes: Occupational quantile represents the lexicographic order of the shares of U.S. citizen workers' education attainment of Doctorate/Professional, Master's, College, Associate's, and High School. Graph values are smoothed predicted values from separate estimating equations that controls for (1) The interaction of education level and a quadratic specification of experience, (2) Occupational clusters, (3) Year, state, and county FEs, and (4) Quadratic specification of years in the U.S. for immigrants.

Non-citizens have lower experience | New Equilibrium

Identification Challenges

- Identifying $\bar{e}$, $\tilde{e}$, and $\hat{e}$ is hard Esitmates.
- Estimating $d = W(\bar{e}) - F(\bar{\theta}, \bar{e})$ with $F\left(\bar{\theta}, \bar{e}\right), F\left(\bar{\theta}, \tilde{e}\right) - d$, and $F\left(\bar{\theta}, \hat{e}\right) - d$.
  - Discrete education attainment.
  - Capped outcomes.
- Estimating the proportion of $\bar{\theta}$ productivity immigrants at $\tilde{e}$ and $\hat{e}$.



Future Steps

- Estimate the cost gap d and the proportion of $\bar{\theta}$ productivity immigrants at $\tilde{e}$ and $\hat{e}$.

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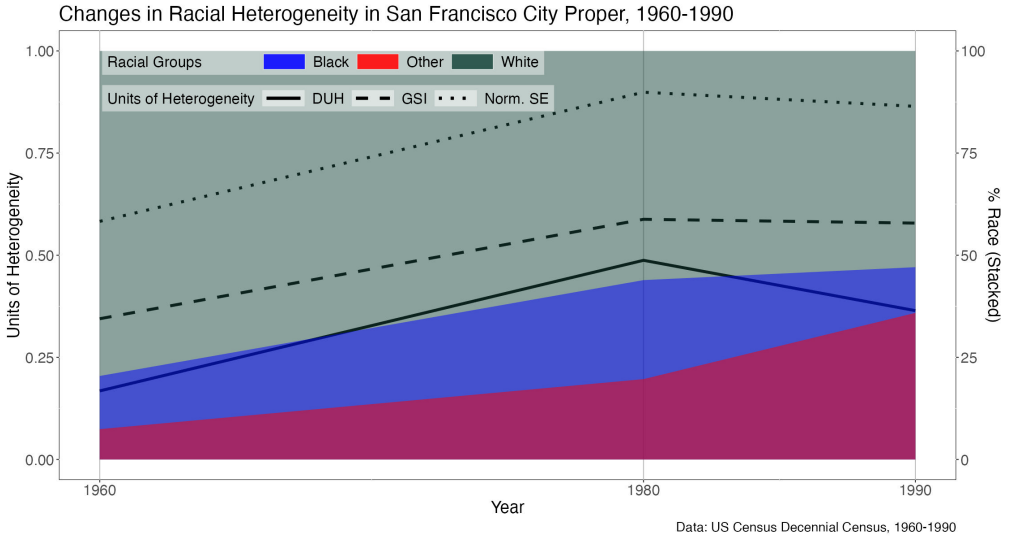
- Estimate the cost gap d and the proportion of $\bar{\theta}$ productivity immigrants at $\tilde{e}$ and $\hat{e}$.
- Counterfactual analysis with increases in d—The new \$100,000 H-1B fee.
  - May be able to look at which H-1B jobs on the wage schedule became (un)available after policy takes effect in the 2025-2026 cycle.
- Adopt the model to consider taste-based and statistical discrimination in the US labor market.
  - Similar to assimilation literature, I can account for years in the US labor market.

Questions?

Chapter 2

Descriptive Units of Heterogeneity:
An Axiomatic Approach to Measuring Heterogeneity

Empirical Motivation



What is Heterogeneity in a System?

A system $s = (s_1, s_2, \ldots)$ is an ordered tuple of non-negative real numbers that is not the null tuple. Denote the set of all such systems $\mathcal{S}$.

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- The length of s as $|s|$.
- The "total population" of s as $||s||_1 = \sum_{g=1}^{|s|} s_g$.
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A function $\Phi : \mathcal{S} \to \mathbb{R}$ is a measure of heterogeneity if, $\forall s, s' \in \mathcal{S}$,

$$\Phi(s) \geq \Phi(s') \iff s \text{ is weakly more heterogeneous } (\succsim) \text{ than } s'.$$

Repurposed Measures of Heterogeneity

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Problem: If we treat heterogeneity as a distributional property without value-judgments, then there are cases when dispersion and deconcentration are insufficient.

Descriptive Units of Heterogeneity

Let σ of s be the permutation of s such that $\sigma_1 \geq \sigma_2 \geq \cdots \geq \sigma_{|s|}$. σ is called the *ordered system* of s.

Define

$$\hat{\sigma}_1 = \frac{\sigma_1}{||s||_1} \text{ and } \tilde{\sigma}_g = \frac{\sigma_g}{||s||_1 - \sigma_1}$$

The Descriptive Units of Heterogeneity (DUH) is defined as:

$$DUH_p(s) = \frac{ln(\hat{\sigma}_1)}{ln(|s|)} \cdot \left[\left(\sum_{g=2}^{|s|} \left| \tilde{\sigma}_g - \frac{1}{|s|-1} \right|^p \right)^{\frac{1}{p}} - 1 \right]$$

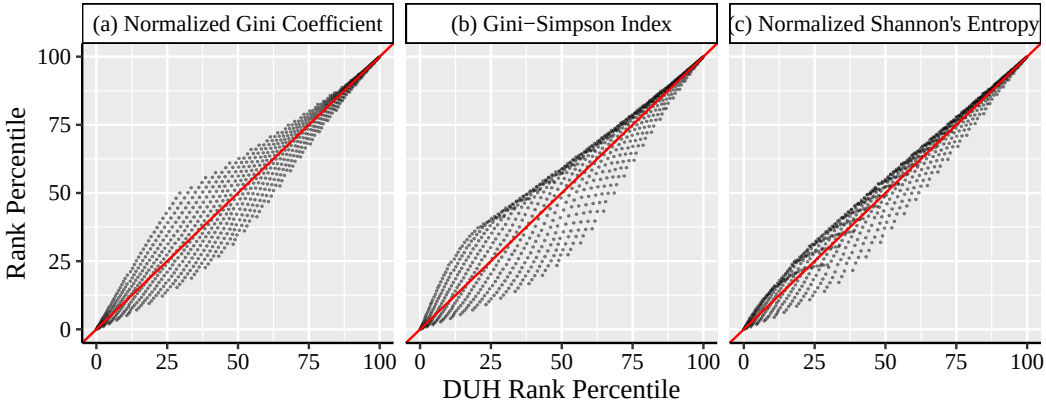
Existing Measures Satisfy Some Axioms

Table 2.3: Measures and Axioms

Type	Axiom	Gini	DUH	HHI	SE
Fundamental	Group Symmetry	✓	✓	✓	✓
	Scale Invariance	✓	✓	✓	✓
	Principle of Transfers	✓	✓	✓	✓
Characterization	Independence	×	✓	✓	✓
	Principle of Proportional Transfers	×	✓	×	×
	Contractibility	✓	✓	×	×
	Unity	×	✓	×	×
	Expandability	×	×	✓	✓
	Replication Principle	×	×	✓	×
	Shannon's Additivity	×	×	×	✓

Comparing Measures

Figure 2.6: Rank Correlation between Measures over Systems with $|\sigma| = 3$ and $||\sigma||_1 = 100$



Practical Example

Questions?

Chapter 3

Law Law Land:
The Effects of Sanctuary City Policies

Motivation

Sanctuary city policies limit *local law enforcement*'s participation in immigration enforcement with Immigration and Customs Enforcement (ICE) or Customs and Border Protection (CBP).

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Thwarting sanctuary city policies have been a major goal of both of Donald Trump's presidencies (Executive Office of the President, 2017, 2025).

- Texas legislature outlawed sanctuary city policies in 2017.
- Los Alamitos, CA (2018) and Huntington Beach, CA (2025) declared themselves non-sanctuary.
- Trump administration suing California (2017), Chicago, Illinois, and New York State (2025).
- San Francisco suing the Trump administration (2025).

A National Discussion Focused on Crime

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Opponents of the policies have claimed:

- The policy is a threat to public safety (Center for Immigration Studies, 2015).
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- The policy increases county-level labor force participation, median household income, and decrease unemployment (Wong, 2017).

Important Questions

By looking at sanctuary Metropolitan Statistical Areas (MSAs) from 2008 to 2017, I examine how sanctuary city policies affect

- Individual migration decisions.
- City demographics and socioeconomic outcomes.
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  No effect.
- Crime reporting behavior and victimization.
  Increase reporting and decrease violent crime victimization.

The Role of Sanctuary City Policies

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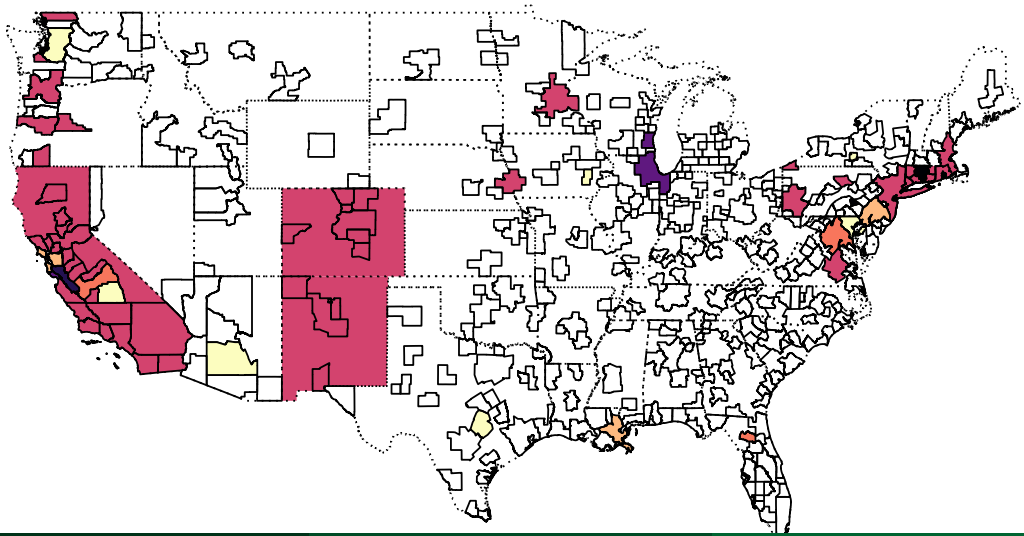
- County jails cannot honor a detainer issued by ICE instead of a judge.

Sanctuary city policies do NOT:

- Actively hinder ICE/CBP investigations and operations.
- Provide social benefits to undocumented immigrants.

The Distribution of Sanctuary Cities

Predictors



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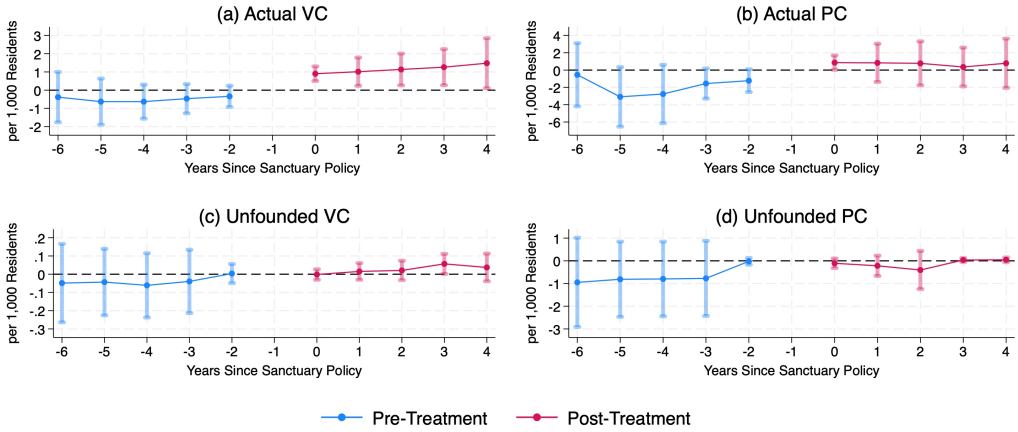
- Better crime reporting (Martinez et al., 2017; Martinez-Schuldt et al., 2021).
- Little resources spent on immigration enforcement.

$\Rightarrow$ Potentially better policing.

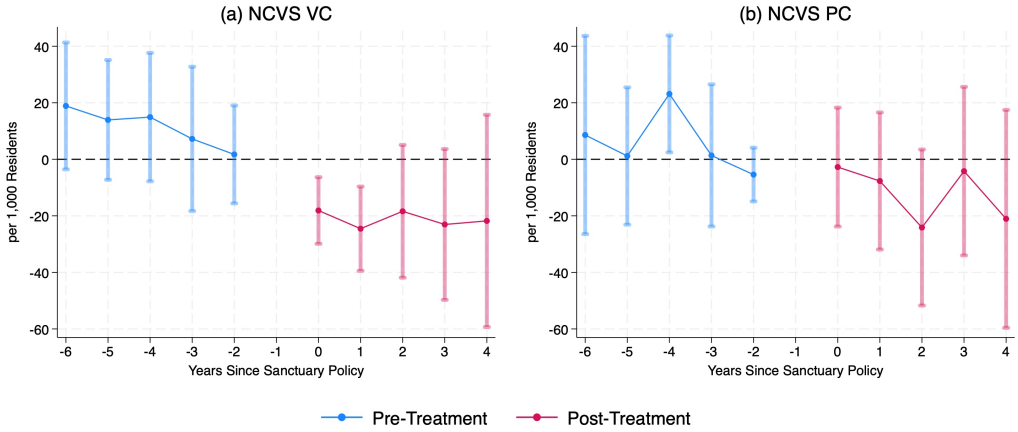
Effects on Reported Crime

Figure 3.7: Estimated ATT Across Policy Timeline, Reported Crime



Effects on Crime Victimization

Figure 3.8: Estimated ATT Across Policy Timeline, Crime Victimization Same Sample UCR



Questions?

Thank You!

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Population Moments

Table A4: Summary Statistics of Workers Age 25-64 in the US, 2011-2019

Highest Degree		High School			Associate's			College	
Citizenship	Citizen	Nat. Citizen	Non-citizen	Citizen	Nat. Citizen	Non-citizen	Citizen	Nat. Citizen	Non-citizen
% Workforce	19.9	1.8	2.3	8.8	0.8	0.4	21.2	2.3	1.4
% Single	25	14.8	28.3	21.2	15.1	21.3	26	17.3	21.1
% Married	54.8	67.9	58.3	60.1	67.6	62.5	62	69.9	68.6
Spouse's Citizenship									
% Citizen	59.4	15.2	11.4	63.3	20	20.9	64.1	20.8	16.5
% Nat. Citizen	1.3	38	10.6	1.8	38.6	13	2.3	41.1	10.7
% Non-citizen	1.2	15.4	38.9	1.2	10.4	30.1	1.3	9.1	40.5
Birthplace Official Language									
% Not English		80.1	87.5		74.8	74.5		72.1	64.3
% English		18.4	11.5		23.1	22.7		26.1	33.6
% Mixed		1.4	1.1		2.1	2.9		1.8	2
Median Value									
Age	46	47	39	44	46	41	42	45	39
Years in US		24	14		25	14		23	9
Occ. Quantile	32.5	32.4	22.4	51	47.3	40.5	73	71.9	65.2

Population Moments

Table A5: Summary Statistics of Workers Age 25-64 in the US, 2010-2019

Highest Degree		Master's			Professional			Doctorate	
Citizenship	Citizen	Nat. Citizen	Non-citizen	Citizen	Nat. Citizen	Non-citizen	Citizen	Nat. Citizen	Non-citizen
% Workforce	8.5	1.1	0.8	2.2	0.3	0.2	1.2	0.3	0.2
% Single	19.8	12.1	20.5	18.2	13.9	19.9	17.3	9.7	18.5
% Married	68.1	76.2	73.6	71.4	76.1	71.5	71.9	81.2	76.1
Spouse's Citizenship									
Citizen	67.8	22.4	13.1	69.9	26	15	68.8	22.5	13.1
Nat. Citizen	2.9	46.3	7.9	4	44.5	9.8	4.5	50.7	6.4
Non-citizen	1.5	8	51.3	1.6	6.5	45.4	2.4	7.4	54.1
Birthplace Official Language									
% Not English		62	50.2		63.8	59.2		68	71.2
% English		35.8	48		34.2	39.4		29.6	27.4
% Mixed		2.3	1.8		2	1.4		2.5	1.4
Median Value									
Age	44	46	37	45	47	39	46	49	39
Years in US		23	8		25	8		24	10
Occ. Quantile	83	80	79	98.9	98.9	95.6	97.1	96.8	96.8

New Separating Equilibrium

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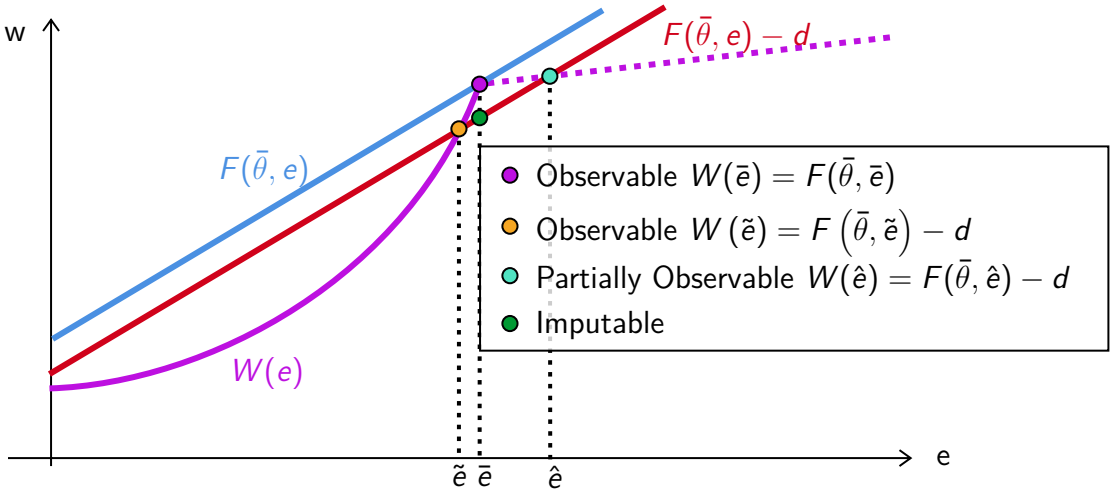
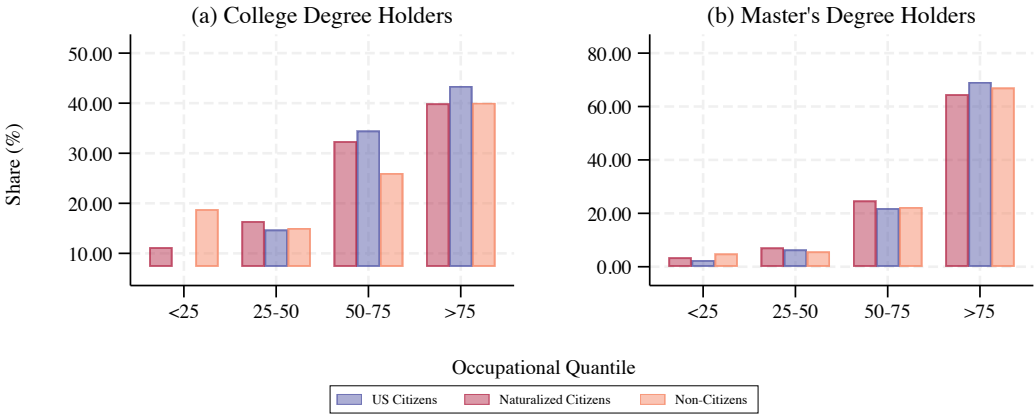


Figure A9: Educational Mismatch of Male Immigrants at High Degree Levels, 2010-2019



Notes: Data from American Community Survey-5% from 2010 to 2019. Occupational quantile represents the lexicographic order of jobs over the shares of U.S. citizen workers' education attainment of Doctorate/Professional, Master's, College, Associate's, and High School.

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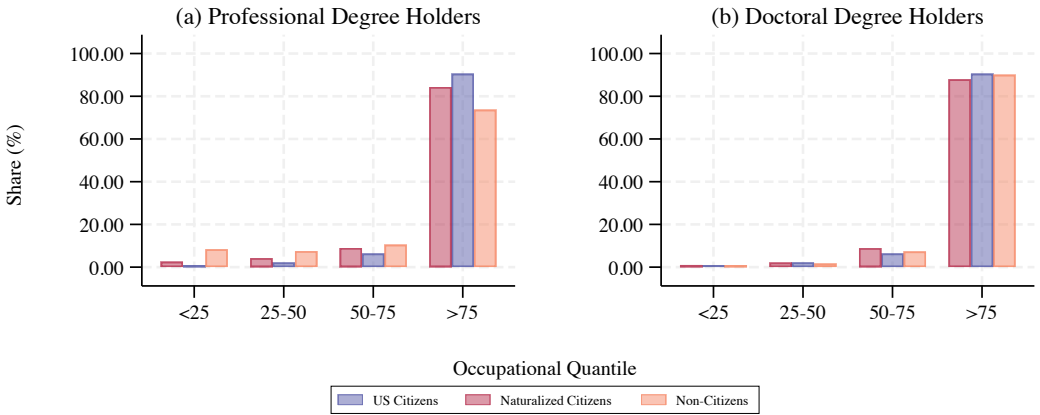
Figure A10: Educational Mismatch of Male Immigrants at High Degree Levels, 2010-2019



Notes: Data from American Community Survey-5% from 2010 to 2019. Occupational quantile represents the lexicographic order of jobs over the shares of U.S. citizen workers' education attainment of Doctorate/Professional, Master's, College, Associate's, and High School.

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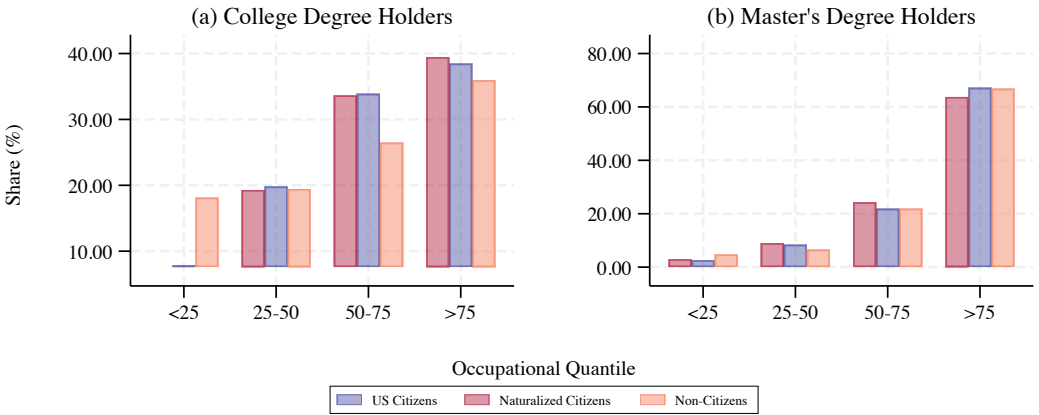
Figure A11: Educational Mismatch of Single Immigrants at High Degree Levels, 2010-2019



Notes: Data from American Community Survey-5% from 2010 to 2019. Occupational quantile represents the lexicographic order of jobs over the shares of U.S. citizen workers' education attainment of Doctorate/Professional, Master's, College, Associate's, and High School.

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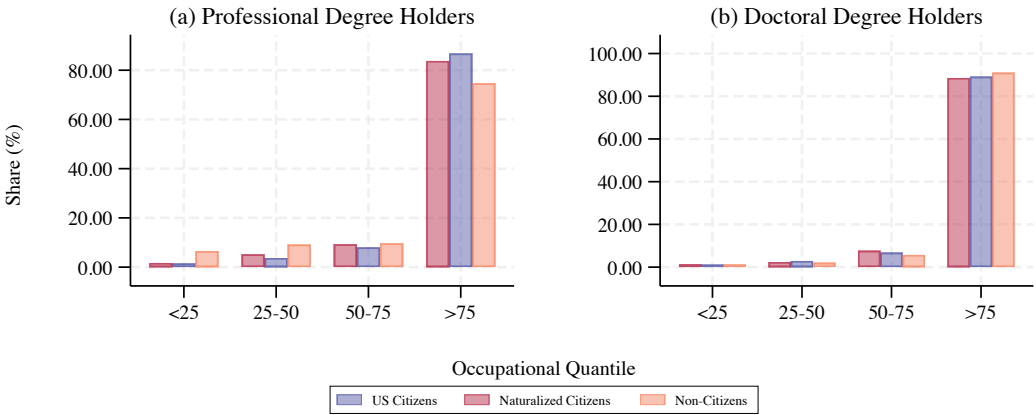
Figure A12: Educational Mismatch of Single Immigrants at High Degree Levels, 2010-2019



Notes: Data from American Community Survey-5% from 2010 to 2019. Occupational quantile represents the lexicographic order of jobs over the shares of U.S. citizen workers' education attainment of Doctorate/Professional, Master's, College, Associate's, and High School.

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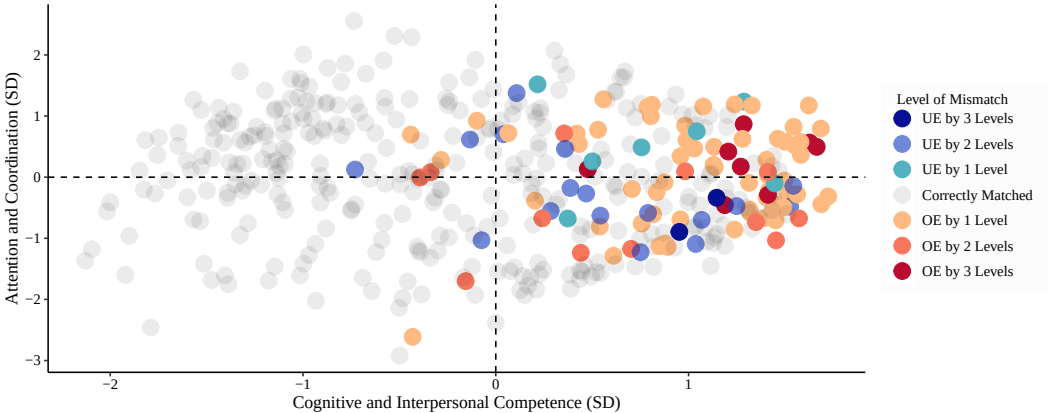
Figure A13: Educational Mismatch of Non-Citizens, Highest Degree Obtained in US



Notes: Level of mismatch is the difference between the modal degree of a non−citizen worker, whose highest degree is obtained inside the United States, and the modal degree of a citizen worker. The degree levels, from highest to lowest, are: Doctorate, Professional, Master's, Bachelor's, Associates, High School, and less than High School.

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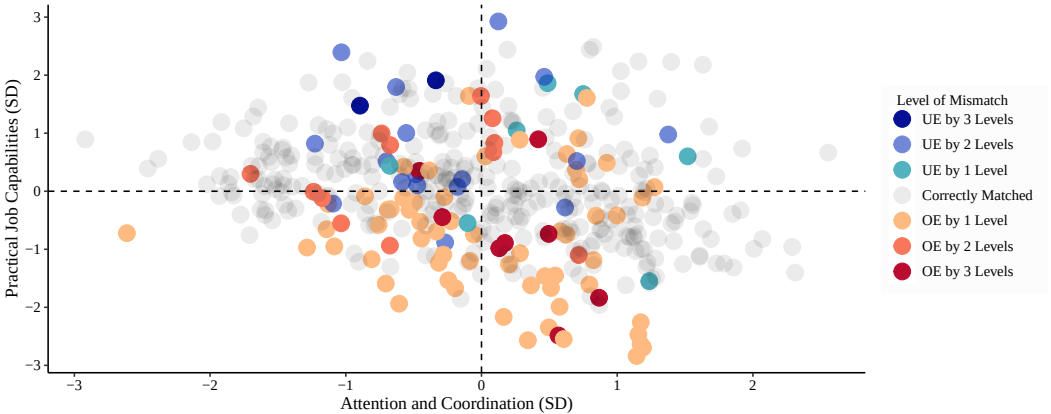
Figure A14: Educational Mismatch of Non-Citizens, Highest Degree Obtained in US



Notes: Level of mismatch is the difference between the modal degree of a non−citizen worker, whose highest degree is obtained inside the United States, and the modal degree of a citizen worker. The degree levels, from highest to lowest, are: Doctorate, Professional, Master's, Bachelor's, Associates, High School, and less than High School.

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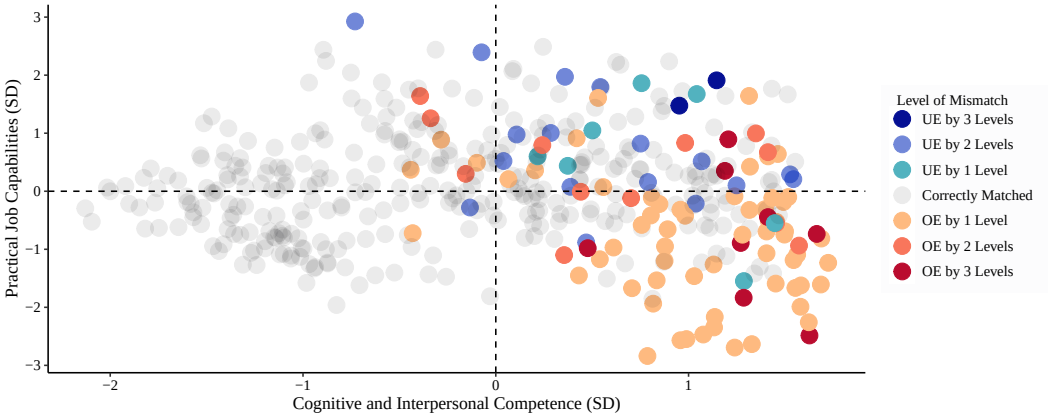
Figure A15: Educational Mismatch of Non-Citizens, Highest Degree Obtained in US



Notes: Level of mismatch is the difference between the modal degree of a non−citizen worker, whose highest degree is obtained inside the United States, and the modal degree of a citizen worker. The degree levels, from highest to lowest, are: Doctorate, Professional, Master's, Bachelor's, Associates, High School, and less than High School.

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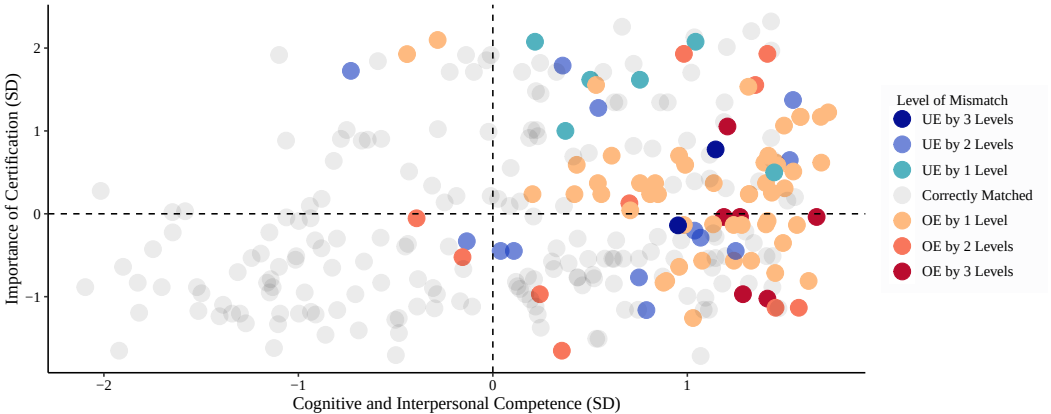
Figure A16: Educational Mismatch of Non-Citizens, Highest Degree Obtained in US



Notes: Level of mismatch is the difference between the modal degree of a non−citizen worker, whose highest degree is obtained inside the United States, and the modal degree of a citizen worker. The degree levels, from highest to lowest, are: Doctorate, Professional, Master's, Bachelor's, Associates, High School, and less than High School.

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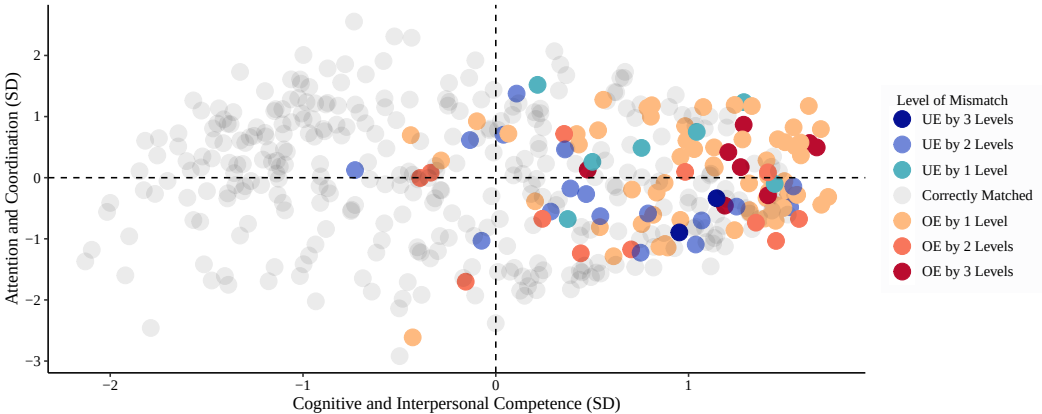
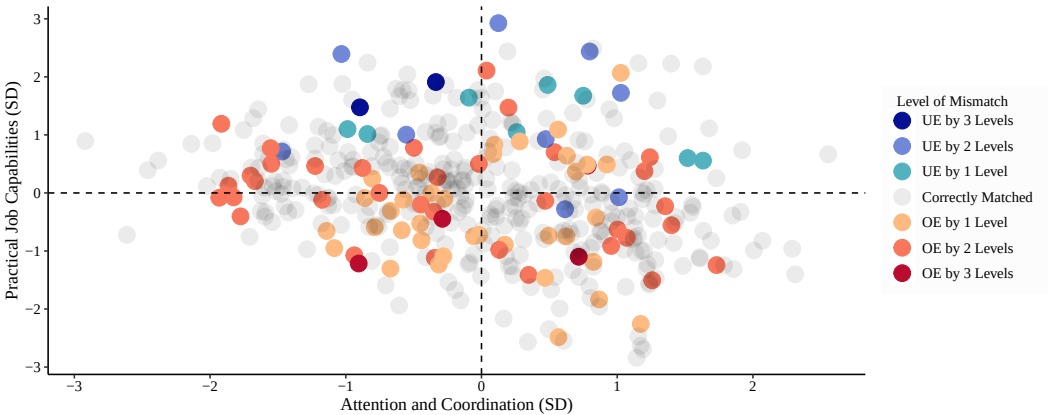
Figure A17: Educational Mismatch of Non-Citizens, Highest Degree Obtained outside US



Notes: Level of mismatch is the difference between the modal degree of a non−citizen worker, whose highest degree is obtained outside the United States, and the modal degree of a citizen worker. The degree levels, from highest to lowest, are: Doctorate, Professional, Master's, Bachelor's, Associates, High School, and less than High School.

Figure A18: Educational Mismatch of Non-Citizens, Highest Degree Obtained outside US



Notes: Level of mismatch is the difference between the modal degree of a non−citizen worker, whose highest degree is obtained outside the United States, and the modal degree of a citizen worker. The degree levels, from highest to lowest, are: Doctorate, Professional, Master's, Bachelor's, Associates, High School, and less than High School.

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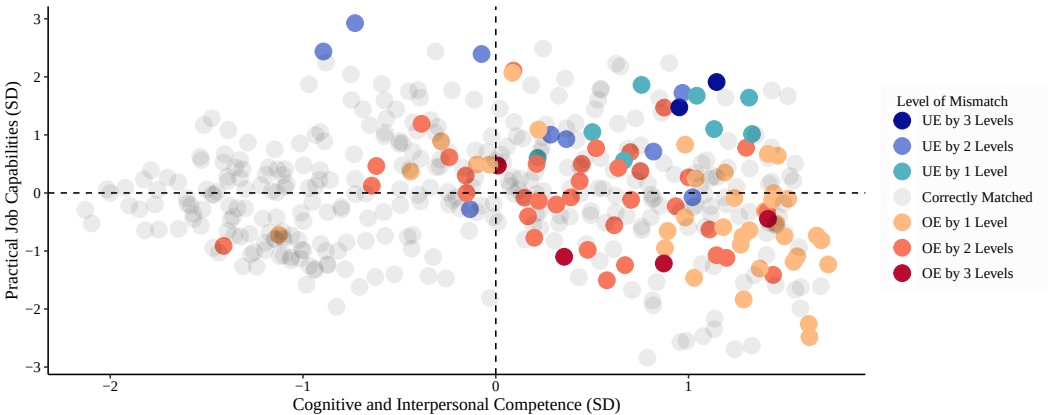
Figure A19: Educational Mismatch of Non-Citizens, Highest Degree Obtained outside US



Notes: Level of mismatch is the difference between the modal degree of a non−citizen worker, whose highest degree is obtained outside the United States, and the modal degree of a citizen worker. The degree levels, from highest to lowest, are: Doctorate, Professional, Master's, Bachelor's, Associates, High School, and less than High School.

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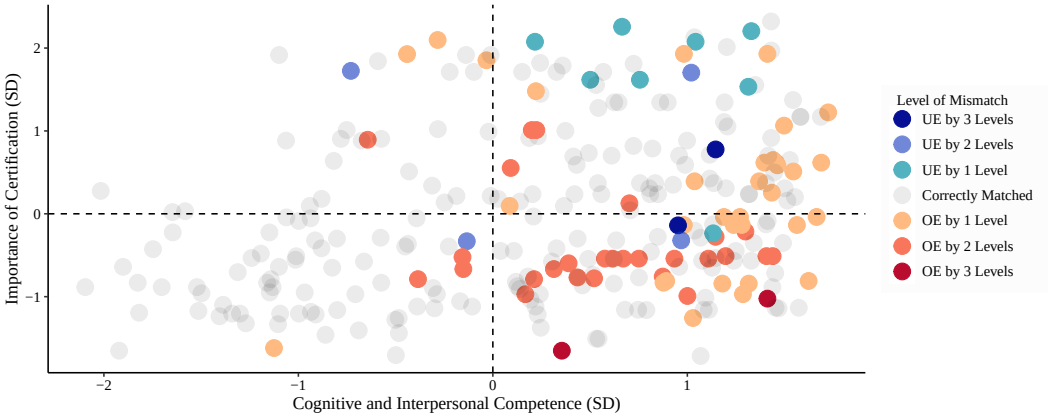
Figure A20: Educational Mismatch of Non-Citizens, Highest Degree Obtained in US



Notes: Level of mismatch is the difference between the modal degree of a non−citizen worker, whose highest degree is obtained outside the United States, and the modal degree of a citizen worker. The degree levels, from highest to lowest, are: Doctorate, Professional, Master's, Bachelor's, Associates, High School, and less than High School.

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Figure A21: Spectral Clusters from DOL Transitions

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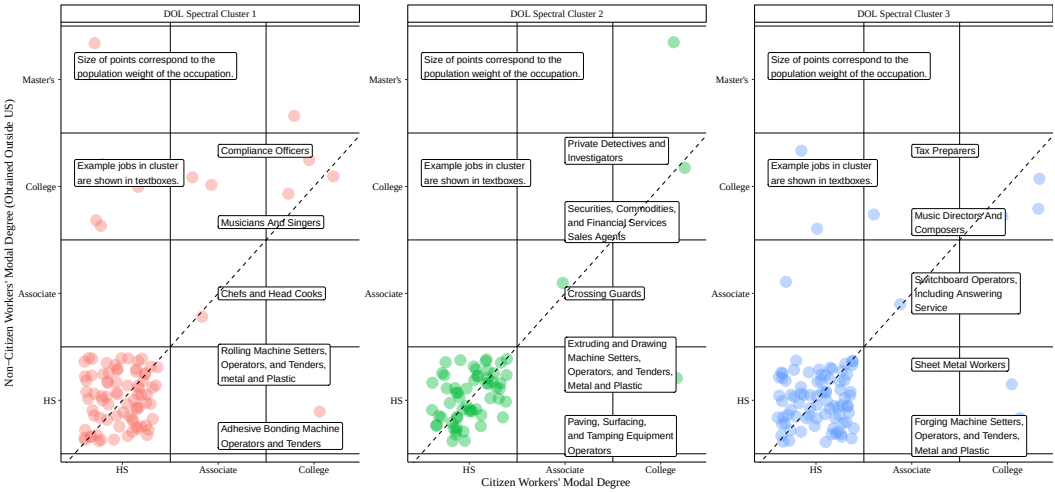

Figure A22: Spectral Clusters from ACS Conditional Likelihoods

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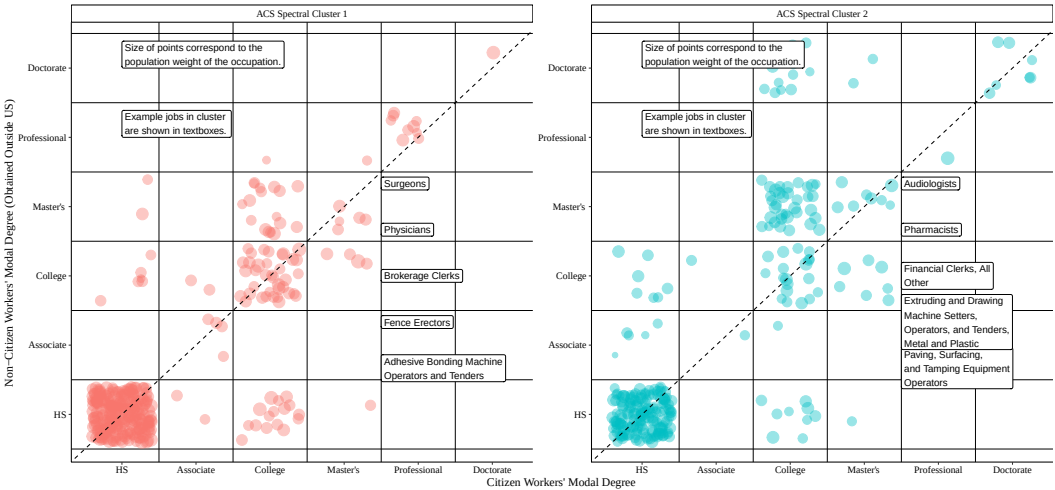
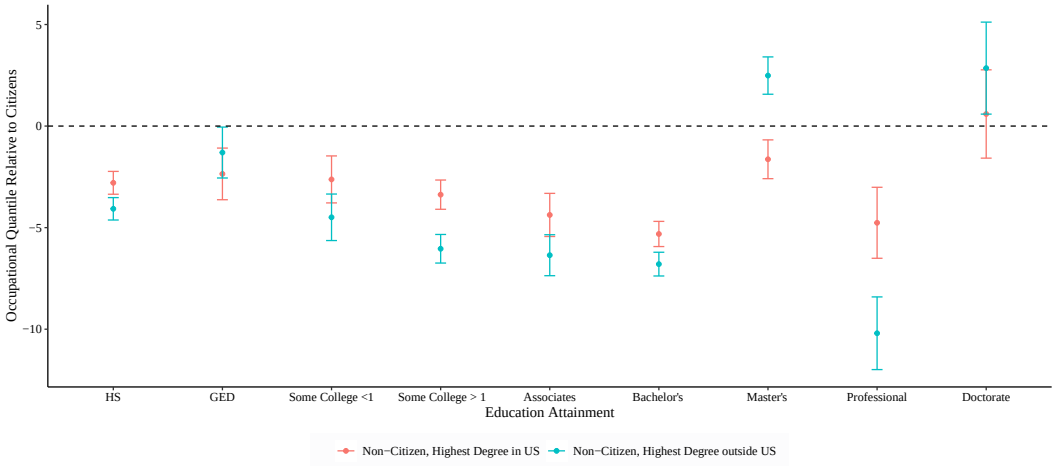


Figure A23: Estimated Deviations in Mean Occupational Quantile by Education Level for Immigrant Workers, 2010-2019 Back

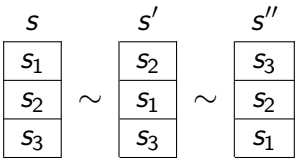


Notes: 95% confidence intervals are shown in graph.

[GSYM] Group Symmetry Back

For any permutation $\pi(s)$ of s, $\Phi(s) = \Phi(\pi(s))$.

For example, take $s, s', s'' \in \mathcal{S}$,



[INV] Scale Invariance Back

A measure of heterogeneity Φ satisfies the property of Scale Invariance if for any system s and a scalar $\lambda \in \mathbb{R}_{++}$, $\Phi(s) = \Phi(\lambda \cdot s)$.

For example, take $s, s' \in \mathcal{S}$, $\lambda \in \mathbb{R}_{++}$,

s		s'
s_1	$\sim$	λs_1
s_2		λs_2
s_3		λs_3

[PT] Principle of Transfers

Back

Let σ be the ordered system of s. Let $e_i^{|s|}$ be an ordered tuple of length $|s|$ such that its i^{th} element is some ε and the rest are 0. A measure of heterogeneity Φ satisfies the Principle of Transfers if $\forall i < j \leq |\sigma|$ and $\varepsilon \in \mathbb{R}_+$,

$$\begin{cases} \sigma_i - \sigma_j \geq 2\varepsilon \\ \sigma_i - \sigma_{i+1} \geq \varepsilon \\ \sigma_{j-1} - \sigma_j \geq \varepsilon \end{cases} \quad \text{together imply } \Phi(\sigma) < \Phi\left(\sigma - e_i^{|s|} + e_j^{|s|}\right).$$

[PT] Principle of Transfers

Back

Let σ be the ordered system of s. Let $e_i^{|s|}$ be an ordered tuple of length $|s|$ such that its i^{th} element is some ε and the rest are 0. A measure of heterogeneity Φ satisfies the Principle of Transfers if $\forall i < j \leq |\sigma|$ and $\varepsilon \in \mathbb{R}_+$,

$$\begin{cases} \sigma_i - \sigma_j \geq 2\varepsilon \\ \sigma_i - \sigma_{i+1} \geq \varepsilon \\ \sigma_{j-1} - \sigma_j \geq \varepsilon \end{cases} \quad \text{together imply } \Phi(\sigma) < \Phi\left(\sigma - e_i^{|s|} + e_j^{|s|}\right).$$

$$\underset{\begin{array}{|c|}\hline \sigma_1 \\ \hline \sigma_2 \\ \hline \sigma_3 \\ \hline \end{array}}{\sigma} \prec \underset{\begin{array}{|c|}\hline \sigma_1 - \varepsilon \\ \hline \sigma_2 + \varepsilon \\ \hline \sigma_3 \\ \hline \end{array}}{\sigma'} \prec \underset{\begin{array}{|c|}\hline \sigma_1 - \varepsilon \\ \hline \sigma_2 \\ \hline \sigma_3 + \varepsilon \\ \hline \end{array}}{\sigma''}, \quad \text{i.e. } \Phi(\sigma) < \Phi(\sigma') < \Phi(\sigma''),$$

[IND] Independence

Back

Let σ be the ordered system of s. A measure of heterogeneity $\Phi(s)$ satisfies Independence if it is a composite function of $\phi : \mathcal{S} \to \mathbb{R}$ and $\psi : \mathcal{S} \to \mathbb{R}$ such that $\psi(s) = \psi\left(c, \sigma_2, \ldots, \sigma_{|s|}\right), \forall c \in \mathbb{R}_{++}$.

[PPT] Principle of Proportional Transfers

Back

Let σ be the ordered system of s. Let $e_i^{|s|}$ be an ordered tuple of length $|s|$ such that its i^{th} element is some ε and the rest are 0. A measure of heterogeneity $\Phi(s)$ satisfies the Principle of Proportional Transfers if $\forall \varepsilon \in \mathbb{R}_+$, $\exists \alpha \in \mathbb{R}_{++}$

$$\begin{cases} \frac{\sigma_1 - \varepsilon}{||s||_1} = \left(\frac{\sigma_1}{||s||_1}\right)^{\alpha} \\ \sigma_1 - \varepsilon \geq \sigma_2 + \tilde{\sigma}_2 \cdot \varepsilon \end{cases} \quad \text{together imply } \Phi\left(\sigma - e_1^{|s|} + \sum_{g=2}^{|s|} \tilde{\sigma}_g \cdot e_g^{|s|}\right) = \alpha \cdot \Phi(\sigma).$$

In other words, *holding the order of groups constant*, a transfer from the largest group proportionally to the minority groups that reduces $\hat{\sigma}_1$ to $(\hat{\sigma}_1)^{\alpha}$ increases heterogeneity by a factor of α.

PPT Example

Back

$$\begin{array}{c|c} \sigma & \sigma' \\ \hline \tilde{\sigma}_1 & \hat{\sigma}_1^{\alpha} \\ \hline \hat{\sigma}_2 & \hat{\sigma}_2 + \frac{\hat{\sigma}_2}{\hat{\sigma}_2+\hat{\sigma}_3}\left(\hat{\sigma}_1 - \hat{\sigma}_1^{\alpha}\right) \\ \hline \hat{\sigma}_3 & \hat{\sigma}_3 + \frac{\hat{\sigma}_3}{\hat{\sigma}_2+\hat{\sigma}_3}\left(\hat{\sigma}_1 - \hat{\sigma}_1^{\alpha}\right) \\ \hline \end{array} \prec .$$

A measure Φ satisfying GSYM, INV, and PPT would yield:

$$\Phi\left(\sigma\right) < \alpha\Phi\left(\sigma\right) = \Phi\left(\sigma'\right).$$

[CON] Contractibility Back

Let s be an arbitrary system. Let s' be the concatenation of s and the tuple (0) such that $s' = (s, 0)$. Let σ and σ' denote the ordered systems of s and s'. A measure of heterogeneity Φ satisfies Contractibility if

$$\sigma_2 > 0 \;\Rightarrow\; \Phi(\sigma') < \Phi(\sigma).$$

[UNI] Unity

Back

Let σ be the ordered system of s. A measure of heterogeneity Φ satisfies Unity if

$$\Phi(s) = 0 \iff \hat{\sigma}_1 = 1$$

and

$$\Phi(s) = 1 \iff \hat{\sigma}_1 = \hat{\sigma}_2 = \cdots = \hat{\sigma}_{|s|} = \frac{1}{|s|}$$

Empirical Example: Racial Heterogeneity

Table A6: The Progression of Racial Composition and Racial Heterogeneity of a Hypothetical City

Share (%)	Decade			
	1	2	3	4
White	60%	65%	66%	69%
Black	34%	26%	22%	17%
Other	6%	9%	11%	14%
DUH	0.235	0.257	0.284	0.315
Gini	0.460	0.440	0.450	0.450
GSI	0.521	0.502	0.499	0.475
Norm. GSI	0.781	0.753	0.749	0.713
Norm. SE	0.767	0.771	0.778	0.758

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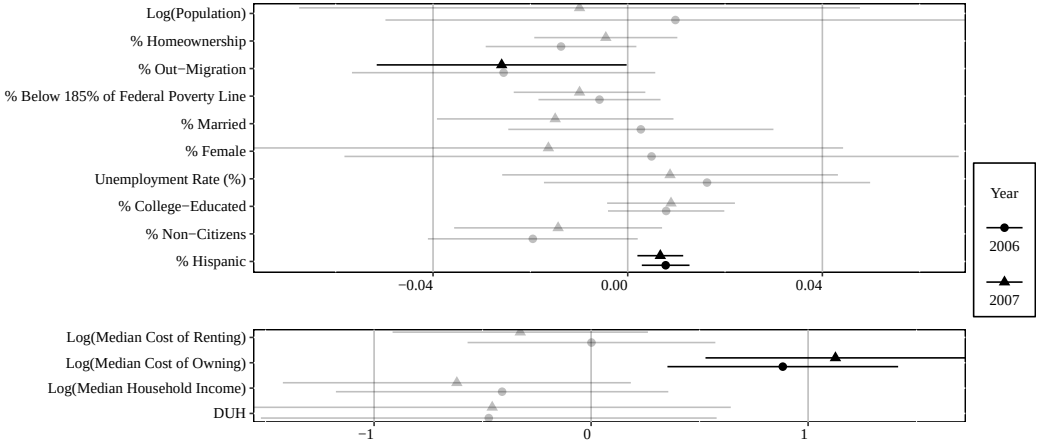
Predictors of Sanctuary City Policies

Figure A24: AME of City Char. on Probability of Becoming Sanctuary by 2017 Back



Black markers are point estimates with p−value less than 0.05.

NCVS Sample

Figure A25: Estimated ATT Across Policy Timeline, Reported Crime Back