A Welfare Analysis of Occupational Licensing in U.S. States

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Overview

What are the welfare consequences of occupational licensing?

- Fundamental gaps in our understanding:
  1. What considerations determine which jobs should be licensed?
  2. What reduced-form estimates are sufficient for welfare analysis?
  3. What are the welfare implications of actual U.S. licensing rules?
- Context: Rising policy attention to licensing and potential reforms

“Too often, policymakers do not carefully weigh costs and benefits when making decisions about whether or how to regulate a profession through licensing.”

– U.S. Council of Economic Advisers, Jul 2015

“[O]verly burdensome licensure requirements weaken competition without benefiting the public.”

– Former U.S. Labor Sec. Alex Acosta, 8 Jan 2018, WSJ

Overview

Welfare consequences of licensing are theoretically ambiguous:

- Costly restriction on labor supply
- Yet there may be countervailing benefits:
  1. *Investment*: Correct underinvestment by offering costly signal
  2. *Selection*: Screen out workers of low unobservable quality

  → Higher consumer WTP for goods produced by licensed workers

Rich environment for testing theory:

- Occupational licensing is a state issue in U.S. (often delegated)
- Much within-occupation variation in licensing across states

→ Exploit variation across state–occupation cells as "diff-in-diff"

Preview of Results

- **Reduced form:** Effects of licensing on licensed occupation
  - Hourly wage: **+15%**
  - Hours per worker: **+3%** (= +1.4 hours per week)
  - Employment: **-29%**
- **Welfare effect:** Net loss of **12%** of occupational surplus
  - Opportunity cost of licensing: **11%** of lifetime PV labor income

    → Forced investment in occupation-specific human capital
  - Workers and consumers bear **70%** and **30%** of incidence
    - *Workers:* Higher wages offset about **60%** of opportunity cost
    - *Consumers:* WTP increases offset about **80%** higher prices

Related Literature

- **Theory**
  - Canonical models portray licensing as costly quality signal:
    Akerlof (1970), Leland (1979), Shapiro (1986)

  → Capture story of such models in an estimable framework
  - We build upon recent structural models of labor markets:
    Suárez-Serrato Zidar (2016), Harasztosi Lindner (2017), Hsieh et al (2018)

  → "PF" approach related to mandatory benefits lit (Summers 1989):
  Use sufficient statistics to evaluate welfare and incidence

- **Empirics**
  - *Wages and Labor Supply:* Kleiner & Krueger (2010, 2013), DePasquale & Stange (2016), Blair & Chung (2018)
  - *Quality:* Kleiner & Kudrle (2000), Angrist & Guryan (2008), Larsen (2013), Anderson et al (2016), Kleiner et al (2016), Barrios (2018)

  → Revisit welfare questions that sparked interest in licensing:
  Friedman & Kuznets (1945), Stigler (1971)

Roadmap

1. Model
2. Welfare and Incidence
3. Data and Identification
4. Reduced-Form Estimates
5. Structural Estimation
6. Conclusion

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Model Intuition

A state government licenses an occupation. Now what?

- Labor supply falls due to cost of mandatory training
- Labor demand rises due to higher WTP for occupational labor

In our model, 3 margins of response to licensing:

1. Consumer substitution
2. Intensive labor supply: weekly hours per worker
3. Extensive labor supply: occupation choice

In equilibrium:

- Consumption falls if WTP effect less than wage increase
- Employment falls if wage increase less than training cost

Model Setup

- Labor trading economy: no firms or industries
- Occupations $j = 1, \ldots, M$
- Workers $i = 1, \ldots, N$ in occupations J_i
- Occ. preferences are i.i.d. Type I EV with dispersion $\sigma > 0$
- Workers are ex-ante identical & differ ex-post only in preferences
- Numeraire good: index an arbitrary wage to $w_0 = 1$

- **Two types of human capital**: Years of schooling y_i and training τ_j
  - Workers choose y_i freely, but gov't mandates τ_j to enter j
  - y_i raises individual productivity, but τ_j operates collectively

$\rightarrow$ Market failure: No credible individual signal of τ_j investment

Worker Problem

$$\max_{\{c_{ij}\},h_i,y_i,J_i} \left\{ \log \left[\left(\sum_{j=1}^{M} q_j c_{ij}^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}} - \frac{\psi}{1+\eta} h_i^{1+\eta} \right] - \rho(y_i + \tau_{J_i}) + a_{iJ_i} \right\}$$

$$\text{s.t.} \ \sum_{j=1}^{M} w_j c_{ij} \leq A_{J_i}(y_i) w_{J_i} h_i$$

where

- c_{ij}: consumption of labor from occ j, traded at price w_j
- h_i: hours of worker i
- y_i: years of schooling (effective labor supply function $A_{J_i}(y_i)$)
- a_{iJ_i}: idiosyncratic preference of i for occupation J_i
- q_j: WTP shifter for occupation j

$\rightarrow$ nested structure: consumption, labor hours, schooling, occ. choice

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Willingness to Pay

Two potential channels by which licensing may affect private WTP:

- Labor quality: Consumers value τ_j
- Selection on type: Licensing affects $E[a_{iJ_i}|J_i = j]$

Assume WTP function is log-linear in investment/selection effects:

$$\log q_j = \kappa_{0j} + \kappa_1 \tau_j + \kappa_2 \log \mathbb{E}[a_{iJ_i}|J_i = j]$$

$$\begin{aligned}\frac{\partial \log q_j}{\partial \tau_j} &= \kappa_1 + \kappa_2 \frac{\partial \log \mathbb{E}[a_{iJ_i}|J_i = j]}{\partial \tau_j} \\ &= \kappa_1 + \frac{\kappa_2}{\sigma} \frac{\partial \log s_j}{\partial \tau_j} \equiv \alpha\end{aligned}$$

$\rightarrow$ WTP effect collapses to a constant

Definition

Given parameters $\{\sigma, \eta, \varepsilon, \psi, \kappa_1, \kappa_2\}$ *and a policy* $\{\tau_j\}$, *an* ***equilibrium*** *is defined by endogenous quantities* $\{\{J_i, h_i, y_i, \{c_{ij}\}_{\forall j}\}_{\forall i}, \{w_j, q_j\}_{\forall j}\}$ *such that:*

1. *Workers optimize: For all* i, *occupation* J_i, *hours* h_i, *schooling years* y_i *and consumption* $\{c_{ij}\}$ *solve workers' problems.*
2. *Market clearing: Wages* w_j *are set so labor markets clear.*
3. *Beliefs are confirmed: For all* j, *willingnesses to pay* q_j *are such that the WTP equation holds.*

Step-by-Step Derivation

Comparative Statics (WTP effect $\alpha = 0$ case)

1. The occupation's gross wage rises, but its net wage falls:

$$\frac{\partial \log w_j}{\partial \tau_j} \in (0, \rho)$$

2. Workers exit the occupation:

$$\frac{\partial \log s_j}{\partial \tau_j} < 0$$

3. Hours per worker in occupation rise:

$$\frac{\partial \log h_{i:J_i=j}}{\partial \tau_j} > 0$$

General: $\alpha \neq 0$

When Licensing Affects WTP ($\alpha \neq 0$)

- If licensing raises WTP, licensing raises wages and hours more, offsets supply effect on employment shares:

$$\frac{\partial^2 \log w_j}{\partial \tau_j \partial \alpha} > 0, \frac{\partial^2 \log h_{i:J_i=j}}{\partial \tau_j \partial \alpha} > 0, \frac{\partial^2 \log s_j}{\partial \tau_j \partial \alpha} > 0$$

- There exists an $\bar{\alpha} < \infty$ such that, for all $\alpha \geq \bar{\alpha}$,

$$\frac{\partial \log w_j}{\partial \tau_j} > \rho, \frac{\partial \log s_j}{\partial \tau_j} > 0$$

$\rightarrow$ With strong WTP effect, licensing lifts net wage and employment

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Welfare: Does Licensing Help or Hurt on the Margin?

Consumer welfare effect: Change in price level $P = \left(\sum_j q_j^{\varepsilon} w_j^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}$

$$\frac{\partial \log \mathcal{W}^C}{\partial \tau_j} = -\frac{1+\eta}{\eta} \frac{\partial \log P}{\partial \tau_j}$$
$$= \frac{1+\eta}{\eta} \frac{s_j}{\varepsilon - 1} \frac{\partial \log w_j h_j}{\partial \tau_j}$$

$\rightarrow$ Infer by revealed preference from wage bill (= consumption)

Worker welfare effect: Change in net wage of inframarginal workers

$$\frac{\partial \log \mathcal{W}^L}{\partial \tau_j} = \frac{s_j}{\sigma} \cdot \frac{\partial \log s_j}{d\tau_j}$$

$\rightarrow$ Infer by revealed preference from occupation choice

Sufficient Statistics for Welfare Analysis of Licensing

Effects of licensing on employment and wage bill are sufficient:

$$\widehat{\mathcal{W}}_j = \underbrace{\frac{1}{\sigma}\frac{\partial \log s_j}{\partial \tau_j}}_{=\widehat{\mathcal{W}^L}} + \underbrace{\frac{1+\eta}{\eta(\varepsilon - 1)}\left(\frac{\partial \log w_j h_j}{\partial \tau_j}\right)}_{=\widehat{\mathcal{W}^C}}$$

- True in any model w/ rep. agent, CRS prod'n, perfect competition

Licensing raises welfare if and only if:

$$\rho < \frac{1+\eta}{\eta}\frac{\alpha\varepsilon}{\varepsilon - 1}$$

- Simple welfare economics of licensing: ρ and α
- Compare WTP gain to social cost of training (Summers 1989)

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Data: Licensing

Since January 2015, 3 questions on licensing/certification added to basic monthly U.S. Current Population Survey:

Q1 "Do you have a currently active professional certification or a state or industry license?"

Q2 "Were any of your certifications or licenses issued by the federal, state, or local government?"

Q3 "Is your certification or license required for your job?"

- Following BLS, we define *licensed* as yes to Q1 and Q2: holding an active certification or license that is state-issued
- Requiring yes to Q3 leads to counterfactually low licensing rates

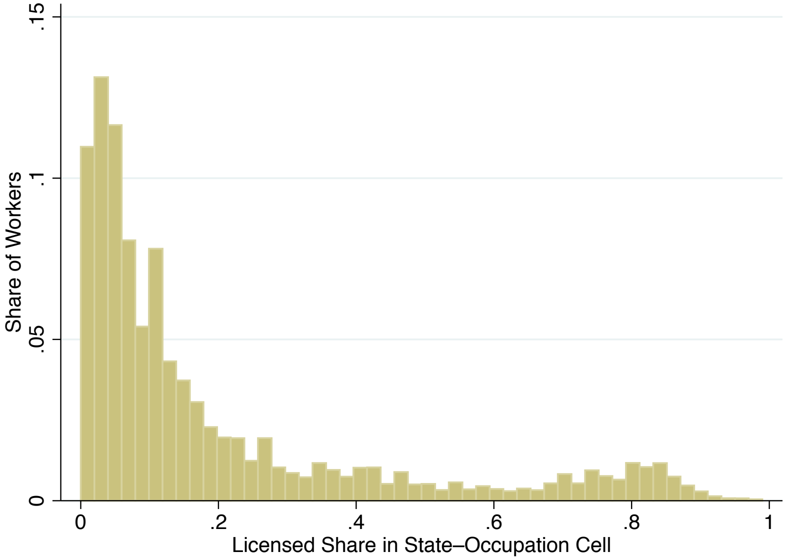
Data: Licensing

- By this definition: **22.6%** of workers age 16–64 are licensed
- Use 48 months of basic monthly CPS (Jan ‘15 – Dec ‘18):
  - Workers N = 624,697
  - 50 states x 483 occupations $\approx$ 22,580 state–occc *cells*
- **Policy proxy:** leave-out state–occ licensed share w/ shrinkage

$$\%\text{License}_i = \frac{\widehat{\alpha_o} + \sum_{i' \in W_{os}: i' \neq i} \text{License}_{i'}}{\widehat{\alpha_o} + \widehat{\beta}_o + N_{os} - 1}$$

$\rightarrow$ empirical Bayes approach for $\widehat{\alpha_o}$ and $\widehat{\beta}_o$: beta–binomial model parameters, estimated by method of moments for each occupation

- Imperfect correspondence of licensing regs & Census occs
  $\rightarrow$ values of licensed share between 0 and 1



Beta-Binomial Model Examples of Occupations Self Report vs. Ground Truth

Empirical Specification

We regress a worker outcome y_i on the leave-i-out licensed share:

$$y_i = \alpha_o + \alpha_s + \beta \cdot \text{\% Licensed}_i + \mathbf{X}_i' \gamma + u_i$$

- α_o, α_s: state & occupation FE $\rightarrow$ two-way design
    - Example: MA versus CT, o_1 versus o_2: $(y_{o_1}^{MA} - y_{o_2}^{MA}) - (y_{o_1}^{CT} - y_{o_2}^{CT})$
- $\mathbf{X}_i$: Controls to rule out some basic confounds
    - Cells for predetermined demographic traits (age bin, sex, race, ...)
    - Industry FE, survey month–year FE

What Are the Marginally Licensed Occupations?

ANOVA: 90% occupation, $<$1% state, 10% residual (SD = 7.1 p.p.)

Occupation			% Licensed	
Name	Code	Employment	Mean	Std. Dev.
Brokerage clerks	5200	4,000	40.0	37.7
Dispensing opticians	3520	47,000	30.8	28.9
Elevator installers	6700	31,000	41.4	23.6
Electricians	6355	770,000	43.9	15.4
		…		
Lawyers	2100	1,030,000	82.8	3.4
Registered nurses	3255	2,900,000	83.2	2.4
Economists	1800	29,000	1.6	2.3
Cashiers	4720	3,000,000	2.1	1.5

Identification

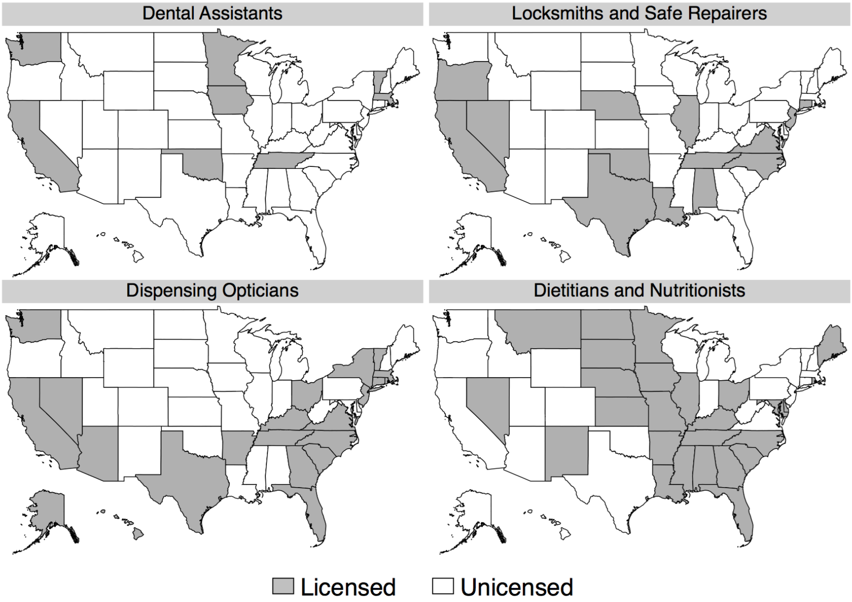
Assumption:

Two-way policy diffs unrelated to two-way diffs in potential outcomes

$$[u_{o_1,s_1} - u_{o_2,s_1} - u_{o_1,s_2} + u_{o_2,s_2}]$$
$$\perp\!\!\!\perp$$
$$[\%L_{o_1,s_1} - \%L_{o_2,s_1} - \%L_{o_1,s_2} + \%L_{o_2,s_2}]$$

Potential concerns and how we address them:

1. Other labor regulations and institutions (Besley Case 2000)
   - State–occ certification and union rate controls
   - Predict employment from state occupation mix and demography
   - Add FE for state $\times$ occ group, Census division $\times$ occ
2. Selection into licensed occupations? Finkelstein et al. (2019)
   - Assume equal intensity of selection on HH and individual unobs.
3. True policy variation? Use only large diffs in licensing rates



Self-Report vs. Ground Truth

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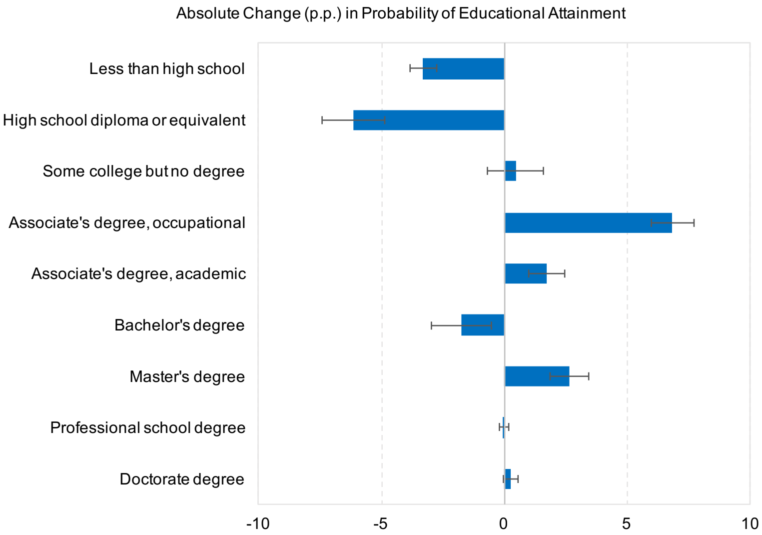
Result 1: Licensing's Investment Requirement Binds

	DV: Years of Education		
	Licensed = 1	% Licensed in Cell	
	(1)	(2)	(3)
	0.383***	0.418***	0.371***
	(0.011)	(0.057)	(0.055)
Workers	514,290	514,290	514,290
State–Occ. Cells	20,321	20,321	20,321
Fixed Effects	Yes	Yes	Yes
Controls	Yes	No	Yes

- Masks changes in occupational specificity of human capital
- Understates induced investment if some training unmeasured

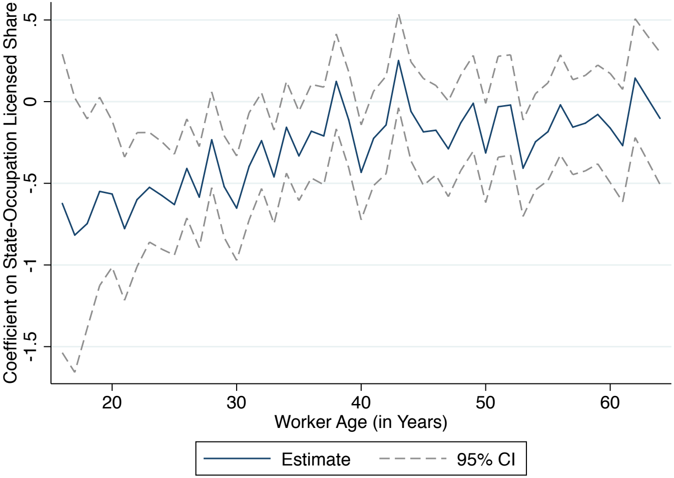
Result 1: Licensing's Investment Requirement Binds



→ Licensing usually requires associate's, master's, etc., not HS/BA

Result 1: Licensing's Investment Requirement Binds

$$\mathbb{E}[\text{Emp}_{os,a}|\%\text{Licensed}_{os}] = \exp(\alpha_{o,a} + \alpha_{s,a} + \beta_a \cdot \%\text{Licensed}_{os})$$



→ Licensing delays occupational entry by about 1.4 years

Result 2: Licensing Raises Wages

	DV: Log Hourly Wage		
	Licensed = 1	% Licensed in Cell	
	(1)	(2)	(3)
	0.154***	0.226***	0.149***
	(0.005)	(0.026)	(0.023)
Workers	289,291	289,291	289,291
State–Occ. Cells	20,273	20,273	20,273
Fixed Effects	Yes	Yes	Yes
Controls	Yes	No	Yes

Result 3: Licensing Raises Hours

	DV: Log Hours Per Week		
	Licensed = 1	% Licensed in Cell	
	(1)	(2)	(3)
	0.039***	0.044***	0.032***
	(0.002)	(0.010)	(0.010)
Workers	514,290	514,290	514,290
State–Occ. Cells	20,321	20,321	20,321
Fixed Effects	Yes	Yes	Yes
Controls	Yes	No	Yes

$\rightarrow$ ratio of wage effect to hours effect implies sensible $1/\eta$ = 0.21

Result 4: Licensing Reduces Employment

	DV: Cell Employment	
	% Licensed in Cell	
	OLS (Log Count)	Poisson (Count)
	(1)	(2)
	-0.294***	-0.268***
	(0.065)	(0.061)
State–Occ. Cells	20,321	20,321
Fixed Effects	Yes	Yes

Welfare Analysis Without Structural Estimation

Worker welfare: Employment decline implies $\Delta\mathcal{W}^L < 0$

- Magnitude of worker welfare change scaled by σ

Consumer welfare: Wage bill decline implies $\Delta\mathcal{W}^C < 0$

- $\widehat{\Delta w_j} + \widehat{\Delta h_{i:J_i=j}} + \widehat{\Delta s_j} = 0.149 + 0.032 - 0.294 = -0.113$ (SE $= 0.123$)
- Magnitude of consumer welfare change scaled by ε

What can we learn from structural estimation?

- Decompose LD and LS shifts
- Assess reasonableness of implied structural parameters
- Estimate other quantities of interest (e.g., license cost)

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Structural Estimation: Setup

Goal: Recover structural parameters $\boldsymbol{\theta}$ from moments $\hat{\boldsymbol{\beta}}$ and calibrated parameters (occ. preference dispersion σ, consumption elasticity ε).

Approach: Use classical minimum distance estimator

$$\hat{\boldsymbol{\theta}} = \arg\min_{\boldsymbol{\theta}} \left\{ [\hat{\boldsymbol{\beta}} - \boldsymbol{m}(\boldsymbol{\theta})]' \hat{\boldsymbol{V}}^{-1} [\hat{\boldsymbol{\beta}} - \boldsymbol{m}(\boldsymbol{\theta})] \right\},$$

Estimation: Use comparative statics $\boldsymbol{m}(\boldsymbol{\theta})$ and our 4 main estimates

$$\hat{\boldsymbol{\beta}} \quad \rightarrow \quad \boldsymbol{\theta}$$

- $\widehat{w_j}$: Log wage
- $\widehat{h_{i:J_i=j}}$: Log hours per worker
- $\widehat{s_j}$: Log employment
- $\widehat{a_i}$: Years of age

- α: WTP effect
- ρ: Return on education
- $1/\eta$: Frisch LS elasticity
- $\bar{\tau}$: Years of training

Constructive Identification

Structural Estimation: Calibration

- Occupational preference dispersion $\sigma \in \{2, 3, 4\}$
  - Hsieh et al 2018: 2.0 (high-level occupation categories)
  - Cortes & Gallipoli 2014: 3.23 (2-digit Census occ codes)
- Occupational labor demand elasticity $\varepsilon \in \{2, 3, 4\}$
  - Autor et al 1998: 1.5 (skilled–unskilled labor substitution)
  - Kline & Moretti 2014: 1.5 (local labor demand)
  - Hamermesh 1993: Surveys occupation-specific estimates
- Adjust ρ for occupation/state transition rate of 11.2 percent

Reference Points for Estimated Parameters

Structural Estimates of Model Parameters

	Baseline (1)	Low σ (2)	High σ (3)	Low ε (4)	High ε (5)
Calibrated Parameters					
Occ. Pref. Dispersion (σ)	3	2	4	3	3
Demand Elasticity (ε)	3	3	3	2	4
Estimated Parameters					
WTP Effect (α)	0.061*	0.061*	0.061*	0.035	0.074**
	(0.032)	(0.032)	(0.032)	(0.031)	(0.034)
Return to Schooling ($\tilde{\rho}$)	0.084	0.114	0.069	0.084	0.084
	(0.074)	(0.085)	(0.068)	(0.074)	(0.074)
Intensive Margin Elasticity ($1/\eta$)	0.199**	0.199**	0.199**	0.199**	0.199**
	(0.081)	(0.081)	(0.081)	(0.081)	(0.081)
Licensing Cost in Years ($\overline{\tau}$)	1.350***	1.350***	1.350***	1.350***	1.350***
	(0.478)	(0.478)	(0.478)	(0.478)	0.478)

Structural Estimates of Welfare Effects of Licensing

	Baseline (1)	Low σ (2)	High σ (3)	Low ε (4)	High ε (5)
Calibrated Parameters					
Occ. Pref. Dispersion (σ)	3	2	4	3	3
Demand Elasticity (ε)	3	3	3	2	4
Welfare Effects					
Worker	-0.081***	-0.121***	-0.061***	-0.081***	-0.081***
	(0.018)	(0.028)	(0.014)	(0.018)	(0.018)
Consumer	-0.035	-0.035	-0.035	-0.070	-0.023
	(0.038)	(0.038)	(0.038)	(0.076)	(0.025)
Social	-0.116**	-0.157**	-0.096*	-0.151	-0.104**
	(0.055)	(0.064)	(0.051)	(0.093)	(0.043)

- Licensing appears to reduce worker & consumer welfare
- Imprecise estimates on consumer side (hard to sign wage bill effect)

Structural Estimates of Licensing Incidence

	Baseline (1)	Low σ (2)	High σ (3)	Low ε (4)	High ε (5)
Calibrated Parameters					
Occ. Pref. Dispersion (σ)	3	2	4	3	3
Demand Elasticity (ε)	3	3	3	2	4
Incidence Analysis					
Worker Share (γ^L)	0.697***	0.775***	0.633***	0.535**	0.775***
	(0.185)	(0.153)	(0.203)	(0.218)	(0.153)
Cost as Share of Income ($\bar{\ell}$)	0.113*	0.154**	0.093	0.113*	0.113*
	(0.062)	(0.065)	(0.061)	(0.062)	(0.062)
Share of Cost Offset	0.579***	0.503***	0.627***	0.579***	0.579***
	(0.061)	(0.063)	(0.058)	(0.061)	(0.061)
WTP-Adj. Price Change	0.029	0.029	0.029	0.059	0.020
	(0.032)	(0.032)	(0.032)	(0.063)	(0.021)
Share of Price Change Offset	0.809***	0.809***	0.809***	0.618	0.873***
	(0.221)	(0.221)	(0.221)	(0.441)	(0.147)

Roadmap

1. Model
2. Welfare and Incidence
3. Data and Identification
4. Reduced-Form Estimates
5. Structural Estimation
6. **Conclusion**

Conclusion

1. Marginal net welfare impact of occupational licensing is negative
   - Welfare cost of supply restriction $>$ welfare gain from higher WTP
   - Neither workers nor consumers fully compensated

2. Two potentially compelling theoretical arguments for licensing:
   - Missing technology: Workers lack credible quality signal
     - $\rightarrow$ Classic story: underinvestment in quality, excess entry
     - We evaluate this argument: Consumers insufficiently value signal
     - Remains plausible for inframarginal occupations: surgeons?
   - Externalities: Positive marginal social WTP for quality
     - $\rightarrow$ Return on human capital is inefficiently low, even w/ full information
     - We do not evaluate this argument: Assumed social WTP = 0
     - Plausible for some occupations: demolition engineers?

Appendix

Occupational Licensing 101

Occupational license: "a credential awarded by a government agency that constitutes legal authority to do a specific job"

– U.S. definition (GEMEnA)

- Not:
  - certification (mandatory, not voluntary)
  - business license (worker/occupation, not firm/industry)
- Labor market institution covering 1 in 5 U.S. workers
- Examples of licensed occupations in the U.S.:
  - lawyer
  - truck driver
  - physician assistant
  - dentist
  - school teacher
  - barber

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Step 1: Labor Demand (Consumption)

Worker i's demand for j:

$$c_{ij} = \left(\frac{w_j}{Pq_j}\right)^{-\varepsilon} \frac{A_{J_i}(y^*_{J_i})w_{J_i}h^*_i}{P}$$

Demand for j:

$$c_j = \sum_i c_{ij} = N\left(\frac{w_j}{q_j}\right)^{-\varepsilon} \sum_{j'} \frac{s_{j'}A_{j'}(y^*_{j'})w_{J_i}h^*_i}{P^{1-\varepsilon}}$$

Response of demand for j to licensing j:

$$\frac{\partial \log c_j}{\partial \tau_j} = \varepsilon\left(\alpha - \frac{\partial \log w_j}{\partial \tau_j}\right)$$

Key parameters: Substitution elasticity ε and WTP effect α

Step 2: Labor Supply (Hours)

Hours per worker: Equalizes wage and marginal disutility of labor

$$h_i = \psi^{-1/\eta} w_{J_i}^{1/\eta} \quad \rightarrow \quad \frac{\partial \log h_{i:J_i=j}}{\partial \tau_j} = \frac{1}{\eta} \frac{\partial \log w_j}{\partial \tau_j}$$

Key parameters: Preference dispersion σ, intensive LS elasticity η

Step 3: Schooling

Years of schooling: Choices reflect productivity gain vs. delay cost

$$\rho = \exp\left(\frac{1+\eta}{\eta} \cdot \frac{A'_{J_i}(y_i^*)}{A_{J_i}(y_i^*)}\right) - 1$$

Schooling is outside option $\rightarrow \rho$ is required return on training time τ_j

Cost of licensing as a share of lifetime income:

$$\ell_j = \rho \tau_j$$

Step 4: Labor Supply (Occupation)

Hours per worker: Equalizes wage and marginal disutility of labor

$$h_i = \psi^{-1/\eta} w_{J_i}^{1/\eta} \quad \rightarrow \quad \frac{\partial \log h_{i:J_i=j}}{\partial \tau_j} = \frac{1}{\eta} \frac{\partial \log w_j}{\partial \tau_j}$$

Employment share: Workers choose occupations with max utility

$$s_j = \frac{e^{-\rho\sigma(y_j^* + \tau_j)} \left(A_j(y_j^*) w_j\right)^{\frac{\sigma(1+\eta)}{\eta}}}{\sum_{j'} e^{-\rho\sigma(y_{j'}^* + \tau_{j'})} \left(A_{j'}(y_{j'}^*) w_{j'}\right)^{\frac{\sigma(1+\eta)}{\eta}}} \rightarrow \frac{\partial \log s_j}{\partial \tau_j} = \sigma \left(\frac{1+\eta}{\eta} \frac{\partial \log w_j}{\partial \tau_j} - \rho \right)$$

Supply: Sum of intensive + extensive margins

$$h_j = \sum_{i:J_i=j} h_i \quad \rightarrow \quad \frac{\partial \log h_j}{d\tau_j} = \frac{\partial \log h_{i:J_i=j}}{d\tau_j} + \frac{\partial \log s_j}{d\tau_j}$$

Key parameters: Preference dispersion σ, intensive LS elasticity η

Comparative Statics (WTP effect $\alpha \neq 0$ case)

1. The occupation's gross wage rises, but its net wage change is ambiguous:

$$\frac{\partial \log w_j}{\partial \tau_j} = \frac{\alpha\eta\varepsilon + \rho\sigma\eta}{1 + \sigma(1+\eta) + \eta\varepsilon} > 0, \quad \gtrless \rho$$

2. The number of workers in the occupation may rise or fall:

$$\frac{\partial \log s_j}{\partial \tau_j} = \frac{\alpha\varepsilon\sigma(1+\eta) - \rho\sigma(1+\eta\varepsilon)}{1 + \sigma(1+\eta) + \eta\varepsilon} \gtrless 0$$

3. Hours per worker in occupation rise:

$$\frac{\partial \log h_{i:J_i=j}}{\partial \tau_j} = \frac{\alpha\varepsilon + \rho\sigma}{1 + \sigma(1+\eta) + \eta\varepsilon} > 0$$

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Method of Moments for Beta–Binomial Model

Beta–binomial model of licensed share in occupation o and state s:

$$p_o \sim \text{Beta}(\alpha_o, \beta_o)$$
$$L_{os} \sim \text{Binom}(N_{os}, p_o).$$

Moments of beta distribution:

$$\mu_{1o} = \mathbb{E}[p_o] = \frac{\alpha_o}{\alpha_o + \beta_o}$$
$$\mu_{2o} = \mathbb{E}[p_o^2] = \frac{\alpha_o \beta_o}{(\alpha_o + \beta_o)(\alpha_o + \beta_o + 1)}$$

Invert moment formulae for distribution parameters:

$$\widehat{\alpha_o} = \frac{\mu_{1o}^2 - \mu_{1o}^3 - \mu_{1o}\mu_{2o}}{\mu_{2o}}$$
$$\widehat{\beta}_o = -\frac{\mu_{1o}^2 - \mu_{1o}^3 - \mu_{1o}\mu_{2o}}{\mu_{1o}^2 - \mu_{1o}^3 - 2\mu_{1o}\mu_{2o}}$$

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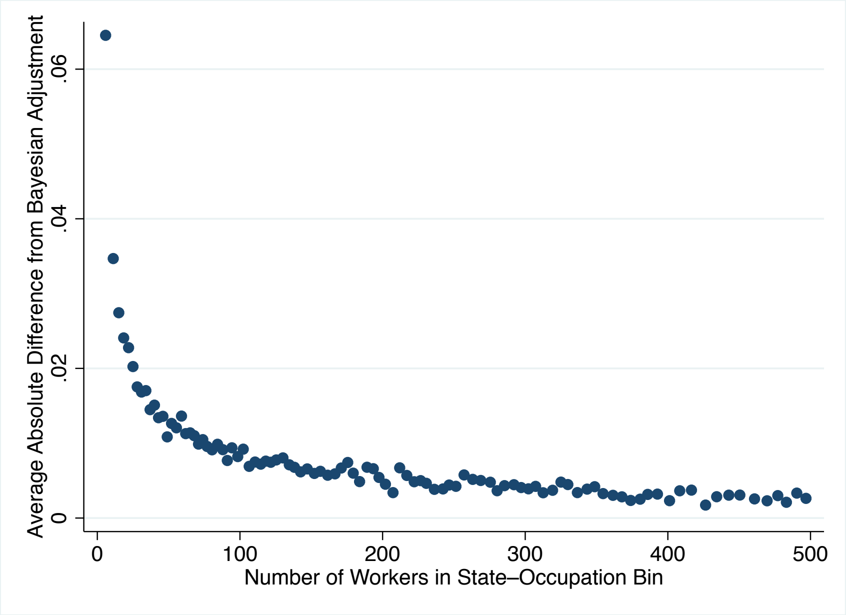
Average Absolute Difference from Bayesian Adjustment
0
.02
.04
.06
0
100
200
300
400
500
Number of Workers in State–Occupation Bin

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Method of Moments for Beta–Binomial Model

- How much sampling error in state–occupation licensed shares?

$$\sigma_{u_i} = \sqrt{\frac{(\widehat{\alpha_o} + \sum_{i' \in W_{os}, i' \neq i} \text{License}_i)(\widehat{\beta}_o + N_{os} - 1 - \sum_{i' \in W_{os}, i' \neq i} \text{License}_i)}{(\widehat{\alpha_o} + \widehat{\beta}_o + N_{os} - 1)^2(\widehat{\alpha_o} + \widehat{\beta}_o + N_{os})}}$$

$\rightarrow$ Not much at all:

- Median worker in cell w/ σ_{u_i} of 1.7 p.p. (95th pctile = 4.7 p.p.)
- Attenuation bias $\approx$ 7% (will present estimates uncorrected for EIV)

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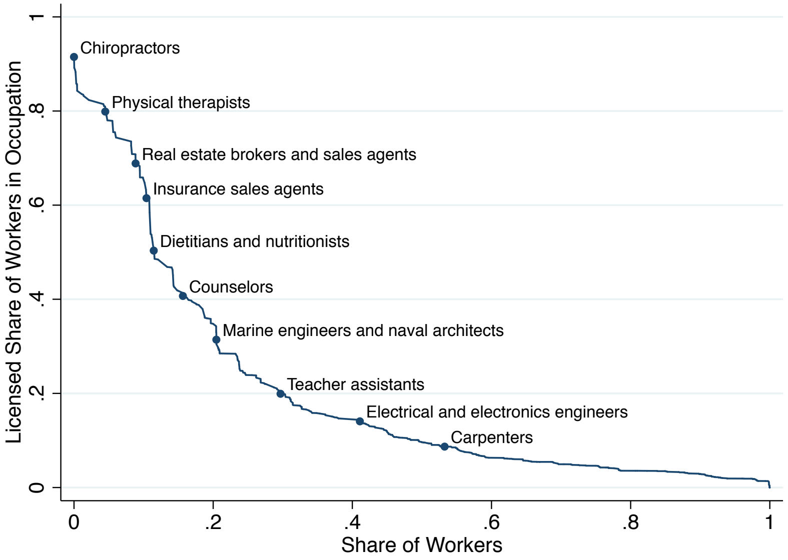
Chiropractors
Physical therapists
Real estate brokers and sales agents
Insurance sales agents
Dietitians and nutritionists
Counselors
Marine engineers and naval architects
Teacher assistants
Electrical and electronics engineers
Carpenters
Licensed Share of Workers in Occupation
0
.2
.4
.6
.8
1
Share of Workers

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Is Self-Reported Licensing Status Reliable?

Licensed share of workers:

- 32 “universally licensed” occs. (Gittleman et al 2018): 66.2%
- 451 other occupations: 13.2%

Why so many intermediate values?

- Misalignment of occupation definitions
- License held for other (non-primary) occupation
- Survey misresponse (e.g., 33% of LPNs say they are unlicensed)

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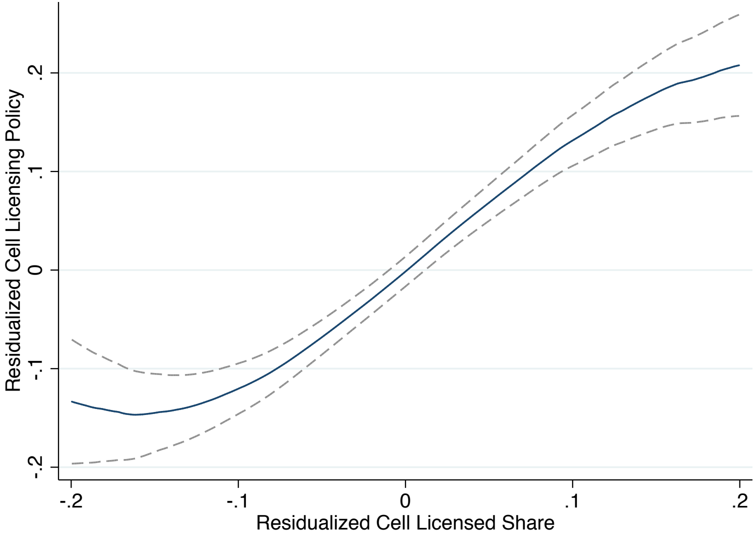
Is Self-Reported Licensing Status Reliable?



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Regression Weights by Occupation

Can interpret our estimator of effect of licensing as average of heterogenous treatment effects Δ_{os} of licensing occupation o in state s

$$\beta = \sum_{o,s} \omega_{os} \Delta_{os}$$

where

$$\Delta_{os} = E[y_i(1) - y_i(0) | \, i \in W_{o,s} : L_i = 1]$$
$$\omega_{os} = \frac{\lambda_{os} \% L_{os} (\% L_{os} - \% L_o - \% L_s + \% L)}{\sum_{os} \lambda_{os} \% L_{os} (\% L_{os} - \% L_o - \% L_s + \% L)},$$

- De Chaisemartin & D'Haultfoeuille 2019: ω_{os} sometimes $\notin [0, 1]$!
- Our application: $\sum_s \omega_{os} \in [0, 1]$ for all o

$\rightarrow$ Interpret as convex combination of occupation-level TEs, but require homogeneity assumption on TEs within-occupation

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Top 10 Regression Weighted Occupations

Occupation		Influence		
Name	Code	Treat. Eff. Weight	Workers Per 10,000	Ratio
Panel A: Most Influential Occupations				
Electricians	6355	0.0414	61.3	6.74
Nursing, psychiatric, and home health aides	3600	0.0282	146.2	1.93
Patrol officers	3850	0.0243	53.4	4.55
Pipelayers, plumbers, etc.	6440	0.0214	44.4	4.82
Teacher assistants	2540	0.0179	70.9	2.52
Construction managers	0220	0.0169	65.4	2.59
Social workers	2010	0.0151	58.1	2.60
Personal and home care aides	4610	0.0150	93.2	1.61
Dental assistants	3640	0.0143	22.1	6.48
Automotive service technicians and mechanics	7200	0.0137	67.1	2.04
Panel B: Most Overweighted Occupations				
Brokerage clerks	5200	0.0014	0.3	42.63
Emergency management directors	0425	0.0030	0.7	40.66
Aircraft assemblers	7710	0.0013	0.5	27.16
Fire inspectors	3750	0.0046	1.7	26.94
Opticians, dispensing	3520	0.0098	3.7	26.10
Explosives workers	6830	0.0018	0.7	25.74
Manufactured building and home installers	7550	0.0013	0.5	24.91
Funeral service workers	4460	0.0017	0.7	24.85
Ambulance drivers and attendants, ex. EMTs	9110	0.0025	1.0	24.50
Septic tank servicers and sewer pipe cleaners	6750	0.0019	0.8	24.32

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Robustness: Labor Supply/Demand Confounds?

Predicted labor supply: By demographic cell k:

$$\widehat{N_{os}^S} = \sum_k \underbrace{\frac{N_{ok} - N_{osk}}{N_k - N_{sk}}}_{=\widetilde{s_{ok}}} N_{sk}$$

Predicted labor demand:

1. Let M be a state–occ matrix of employment shares. Define also submatrix $M_{-o^*,-s^*}$, which deletes column o^* and row s^*.
2. Take first k principal components of $M_{-o^*,-s^*}$. Use PC rotation to predict PC scores for all occupations but o^* in the hold-out state s. Augment the matrix of PC scores with these predicted scores; call it $P_{-o^*} = [p_{ks}]$.
3. Using P_{-o^*}, estimate regression for a fixed occ o^* in states s:

$$s_{o^*s} = \sum_k \beta^k p_{ks} + e_s.$$

4. For hold-out observation (o^*, s^*), predict $\widehat{s_{o^*s^*}} = \sum_k \widehat{\beta}^k p_{ks^*}$.
5. Repeat for all (o, s). Write as $\widehat{N_{os}^D}$.

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Constructive Identification of Structural Parameters

$$\underbrace{\begin{bmatrix} \widehat{w}_j \\ \widehat{h}_i \\ \widehat{s}_j \\ \widehat{a}_i \end{bmatrix}}_{=\hat{\boldsymbol{\beta}}} = \underbrace{\frac{\overline{\tau} \cdot \widehat{\%\text{Licensed}}_j}{1 + \sigma(1+\eta) + \eta\varepsilon} \begin{bmatrix} \rho\sigma(1+\eta) + \alpha\eta\varepsilon \\ \rho\sigma(1+\eta)/\eta + \alpha\varepsilon \\ \sigma(1+\eta)(\alpha\varepsilon - \rho(\varepsilon + 1/\eta)) \\ 1 + \sigma(1+\eta) + \eta\varepsilon \end{bmatrix}}_{=\boldsymbol{m}(\boldsymbol{\theta})}$$

$$\eta = \widehat{w}_j / \widehat{h}_i$$

$$\overline{\tau} = \widehat{a}_i$$

$$\alpha = \widehat{w}_j + \frac{1}{\varepsilon}(\widehat{s}_j + \widehat{h}_i)$$

$$\rho = \widehat{w}_j - \frac{\widehat{w}_j \widehat{s}_j}{\sigma(\widehat{w}_j + \widehat{h}_j)}$$

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Reference Points for Estimated Parameters

- Return on education $\rho \in [0.05, 0.20]$
  - Card 1999, Heckman et al 2018 (surveys of literature)
  - Adjusted for transition rate: 11.2% of licensed workers switch occ or state annually
- Intensive margin labor supply elasticity $1/\eta$
  - Chetty 2012: 0.33 (survey of literature)
- Training time $\overline{\tau}$
  - Carpenter et al 2017: 0.98 years (102 lower-income occupations)

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