The Inner Beauty of Firms

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A Modern Day Pin Factory

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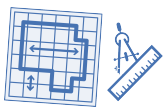

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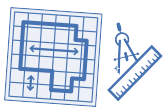

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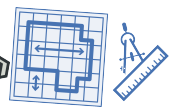

Questions

- How do firms choose their internal structure?
- What are the implications for markets and government policy?
  - Differences in initial internal structure (heterogeneity)
  - Reorganization in response to policy (endogeneity)

Road Map

1. Patterns in Salon Internal Organization
2. A Model of Internal Organization
3. Theory: What Forces Shape Internal Organization?
4. Identification and Estimation
5. Policy Experiments

Table of Contents

Data

- Salon management software company founded in 2016
- Clients concentrated in New York City and Los Angeles, but scattered salons throughout US
- Observe 13 million assignments of services to hair stylists across hundreds of salons from 2016 to Q3 2021

A Raw Data Snapshot

Firm	Salon	App.	Cust.	Service	Staff	Time Stamp	Price	Duration
1	1A	123	Blake	Advanced Cut	Rosy	3/26/2021 16:15	100	72
1	1A	123	Blake	Full Head - Highlights	Rosy	3/26/2021 16:15	243	127
1	1A	123	Blake	Treatment Add On (Olaplex)	Rosy	3/26/2021 16:15	39	72
2	2A	9982	Grace	Women's Cut	Tyler	3/17/2021 11:00	225	43
2	2A	9982	Grace	Single Process	Ben	3/17/2021 11:00	200	77

Creating A Firm-Quarter Data Set

- 20,560 unique text descriptions of services.
- Hired a certified cosmetologist via UpWork to classify into 6 categories.
- Services are aggregated to form one representative product per firm-quarter.
  - A firm's **price** is the sum of service prices divided by total customers.
  - A firm's **required labor** is the sum of durations divided by total customers.
  - A firm's **task-mix** is the fraction of labor classified as each task.

Firm-Quarter Statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Revenue	4,558	213,201.30	248,359.90	5	58,912.5	271,236.5	2,559,703
Price	4,558	199.73	135.16	0.20	111.71	261.88	3,180.44
Employees	4,558	13.38	10.79	1	6	17	92
Customers	4,558	1,159.23	1,098.45	1	397	1,619	16,768
Task Categories	4,558	4.45	0.86	1	4	5	5
Labor per. Customer	4,558	2.15	1.63	0.10	1.52	2.57	61.33

Table of Contents

What is an Organization Structure?

Definition 1

A firm's organization structure (B_j), is a matrix where element (i, k) is the fraction of labor assigned to worker i and task k.

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A firm's organization structure (B_j), is a matrix where element (i, k) is the fraction of labor assigned to worker i and task k.

"Employee" Salon

Employee	Tasks: Cut	Color	Dry	
A	1/2	0	0	1/2
B	0	1/4	0	1/4
C	0	0	1/4	1/4
Tot.	1/2	1/4	1/4	

"Chair Renter" Salon

	Tasks: Cut	Color	Dry	
A	1/6	1/12	1/12	1/3
B	1/6	1/12	1/12	1/3
C	1/6	1/12	1/12	1/3
Tot.	1/2	1/4	1/4	

Task-Mix

What is Organizational Complexity?

Definition 2

The complexity of an organization structure B_j is:

$$I(B_j) = \sum_{i,k} B_j(i,k) log\left(\frac{B_j(i,k)}{\sum_{k'} B_j(i,k') \sum_{i'} B_j(i',k)}\right)$$

- Intuition: the amount of instructions that must be communicated within the firm to implement B_j
- 1 Measure Many Interpretations: Manager Attention Task-Specialization

Complexity of the Two Structures

"Employee" Salon

Employee	Tasks: Cut	Color	Dry	
A	1/2	0	0	1/2
B	0	1/4	0	1/4
C	0	0	1/4	1/4
Tot.	1/2	1/4	1/4	

"Chair Renter" Salon

	Tasks: Cut	Color	Dry	
A	1/6	1/12	1/12	1/3
B	1/6	1/12	1/12	1/3
C	1/6	1/12	1/12	1/3
Tot.	1/2	1/4	1/4	

Exactly match tasks and workers

If cut send "0" assign to A

If color send "01" assign to B

If dry send "10" assign to C

$\frac{1}{2}(1bit) + \frac{1}{4}(2bit) + \frac{1}{4}(2bit) = 1.5$

Randomly match tasks and workers

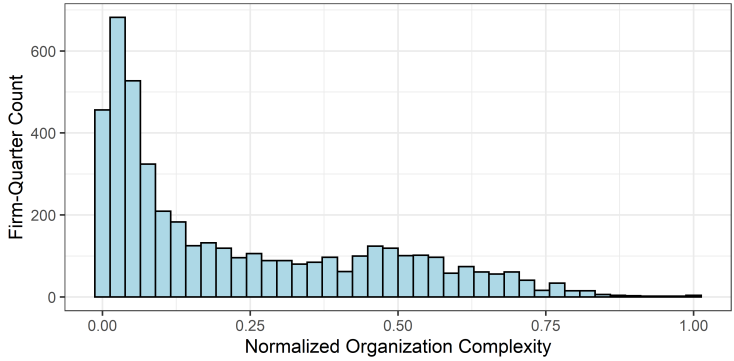
If cut send nothing roll dice

If color send nothing roll dice

If dry send nothing roll dice

$\frac{1}{2}(0bit) + \frac{1}{4}(0bit) + \frac{1}{4}(0bit) = 0$

Fact 1: Complexity varies significantly across firms and varies little across time.

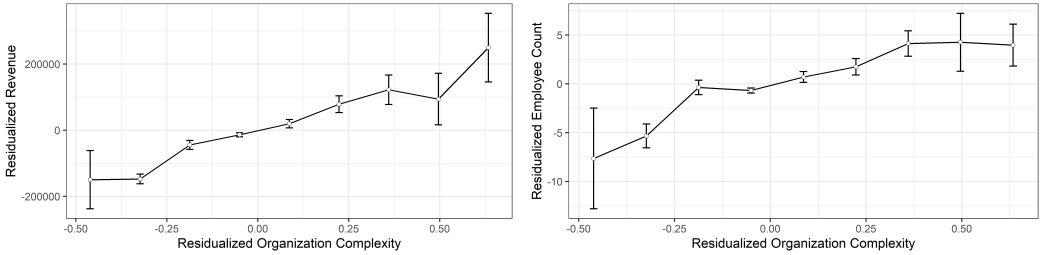


$$I_{j,t} = \bar{I}_j + \bar{I}_t + e_{j,t}$$

$$\underset{.0516}{Var(I_{j,t})} = \underset{.0464}{Var(\bar{I}_j)} + \underset{.0002}{Var(\bar{I}_t)} + 2\underset{-.0009}{Cov(\bar{I}_j, \bar{I}_t)} + \underset{0.0059}{Var(e_{j,t})}$$

Takeaway: Evidence of a time-invariant and firm-specific org. cost.

Fact 2: Complex salons have higher revenue and employment

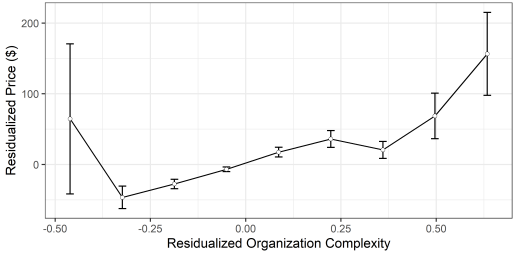


(a) Revenue (b) Employees

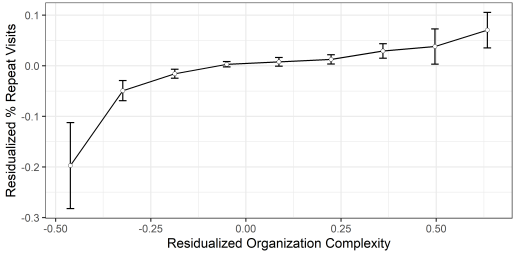
Regressions | Manhattan | Manhattan Regs. | Customers and Visits

Takeaway: There is an organizational competitive advantage.

Fact 3: Complex salons have higher prices and repeat customers



(a) Prices



(b) Repeat Customers

Takeaway: This advantage operates through quality NOT quantity.

Table of Contents

Model

Firm Task-Mix

$$\alpha_j = \begin{pmatrix} \frac{1}{3} & \frac{1}{3} & \frac{1}{3} \end{pmatrix}$$

Firm Organization Cost

$$\gamma_j I(B_j)$$

Worker Skills θ

$$\begin{pmatrix} \theta_1(1) & \theta_1(2) & \theta_1(3) \\ \theta_2(1) & \theta_2(2) & \theta_2(3) \\ \theta_3(1) & \theta_3(2) & \theta_3(3) \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Worker Wages w

$$\begin{pmatrix} w_1 \\ w_2 \\ w_3 \end{pmatrix} = \begin{pmatrix} 25 \\ 20 \\ 15 \end{pmatrix}$$

Model

Firm Task-Mix

$$\alpha_j = \begin{pmatrix} \frac{1}{2} & \frac{1}{4} & \frac{1}{4} \end{pmatrix}$$

Organization Costs

$$\gamma_j I(B_j) = \gamma_j \cdot 0$$

$$B_j = \begin{pmatrix} \frac{1}{6} & \frac{1}{12} & \frac{1}{12} \\ \frac{1}{6} & \frac{1}{12} & \frac{1}{12} \\ \frac{1}{6} & \frac{1}{12} & \frac{1}{12} \end{pmatrix}$$

Product Quality

$$\xi_j(B_j) = \frac{1}{6} \cdot 1 + \frac{1}{12} \cdot 1 + \frac{1}{12} \cdot 1 = \frac{1}{3}$$

Wage Bill

$$W(B_j) = \frac{1}{3} \cdot 25 + \frac{1}{3} \cdot 20 + \frac{1}{3} \cdot 15 = 20$$

Model

Firm Task-Mix

$$\alpha_j = \begin{pmatrix} \frac{1}{2} & \frac{1}{4} & \frac{1}{4} \end{pmatrix}$$

Organization Costs

$$\gamma_j I(B_j) = \gamma_j \cdot 1.5$$

$$B_j = \begin{pmatrix} \frac{1}{2} & 0 & 0 \\ 0 & \frac{1}{4} & 0 \\ 0 & 0 & \frac{1}{4} \end{pmatrix}$$

Product Quality

$$\xi_j(B_j) = \frac{1}{2} \cdot 1 + \frac{1}{4} \cdot 1 + \frac{1}{4} \cdot 1 = 1$$

Wage Bill

$$W(B_j) = \frac{1}{2} \cdot 25 + \frac{1}{4} \cdot 20 + \frac{1}{4} \cdot 15 = 21.25$$

More Model Details

- Firms also set their price p_j
- Consumer demand given price and quality: $D_j(p_j, \xi(B_j))$
- Price $\implies$ quantity produced $\implies$ labor demanded
- Wages must clear the labor market
- Perfect competition in labor market, oligopoly in product market

The Firm's Profit-Maximization Problem

$$\pi_j = D_j \Big[p_j - MC_j \Big]$$

The Firm's Profit-Maximization Problem

$$\pi_j = D_j \Big[p_j - MC_j \Big]$$

$$\pi_j = \max_{p_j, B_j \in \mathbb{B}_j} D_j(p_j, \xi(B_j)) \Big[p_j - \gamma_j I(B_j) - W(B_j) \Big]$$

Summary of the Model

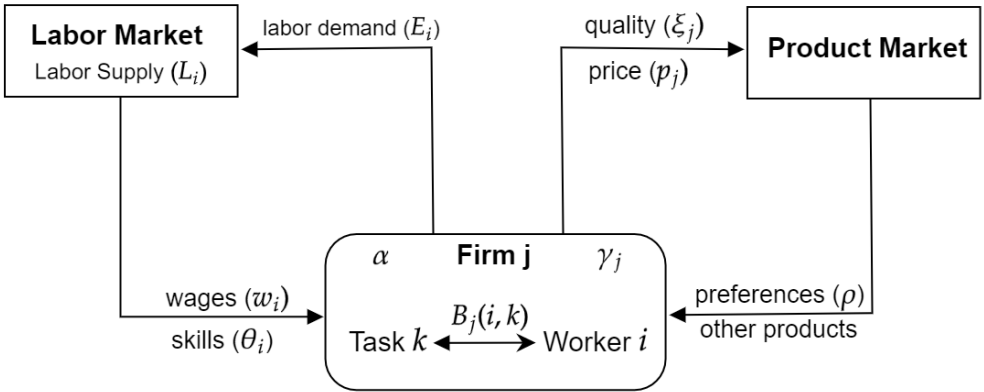
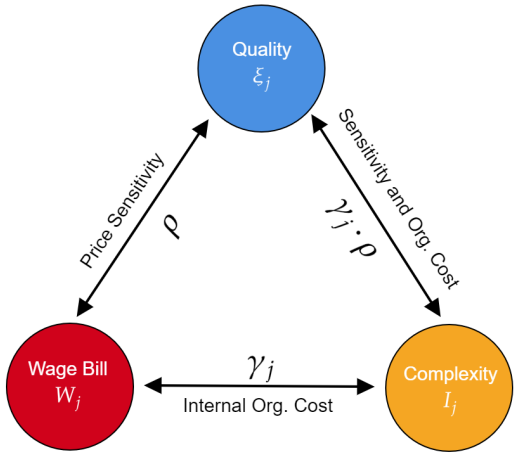


Table of Contents

The Complexity-Wage-Quality Trade-Off

$$\min_{B_j \in \mathbb{B}} I(B_j) + \gamma_j^{-1} W(B_j) - (\gamma_j \rho)^{-1} \xi(B_j)$$



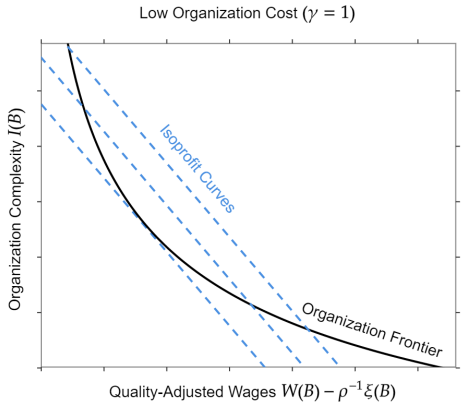
Organization Frontier

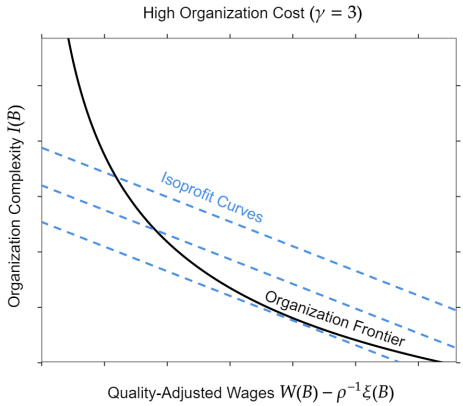
$$\min_{B_j \in \mathbb{B}} \underbrace{I(B_j)}_{\text{complexity}} + \gamma_j^{-1} \left[\underbrace{W(B_j) - \rho^{-1} \xi(B_j)}_{\text{quality-adjusted wages}} \right]$$

Definition

The organization frontier is the set of organization structures which minimize complexity for some quality-adjusted wages.

Choosing an Organizational Structure

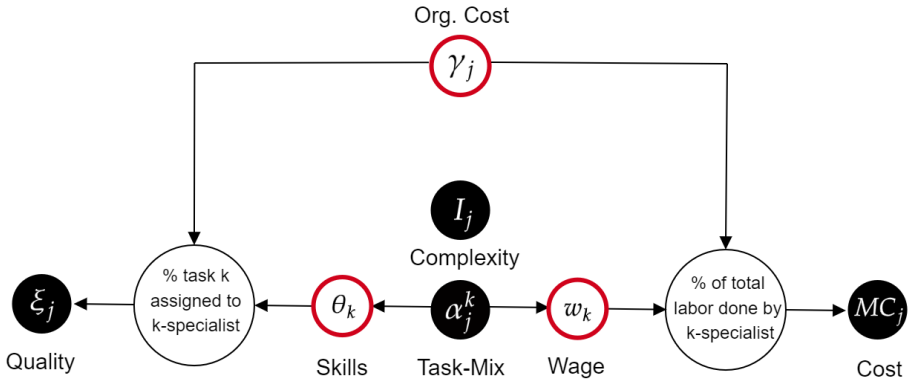




Back

Table of Contents

Identification Problem



Identification: Organization Costs γ_j

Consider 2 salons:

- Tasks performed are the same ($\alpha_1 = \alpha_2$)

Identification: Organization Costs γ_j

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Consider 2 salons:

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- In the same product market (consumer preferences are the same)

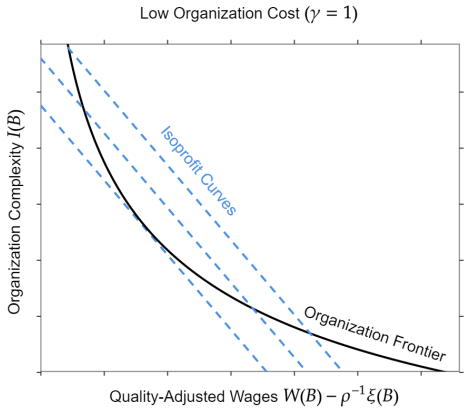
Identification: Organization Costs γ_j

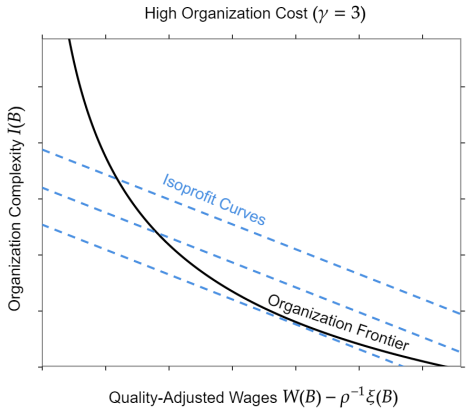
Consider 2 salons:

- Tasks performed are the same ($\alpha_1 = \alpha_2$)
- In the same labor market (wages and skills are the same)
- In the same product market (consumer preferences are the same)
- But Salon 1 is more complex ($I_1 > I_2$)

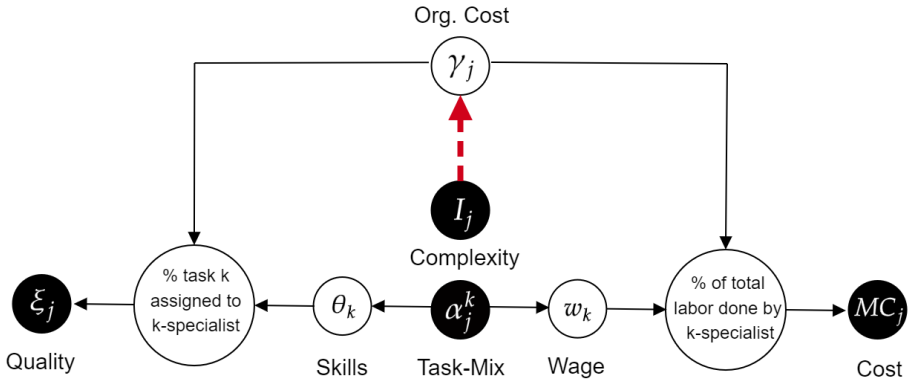
Identification: Organization Costs γ_j

Consider 2 salons:





Identification: Firm-Specific Organization Costs γ_j



Identification: Wages and Skills

- We can use l_j (observed) to obtain γ_j (unobserved)
- What about wages and skills?
- We can use the interaction of complexity and task intensity:

$$l_j \cdot \alpha_j(k) \text{ \& Quality} \implies \theta_k$$

$$l_j \cdot \alpha_j(k) \text{ \& Marginal Cost} \implies w_k$$

Identification: Wages and Skills

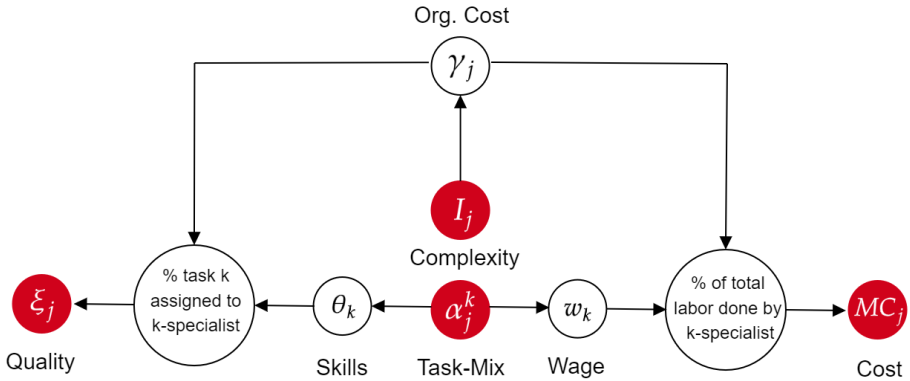


Table of Contents

Task Parameter Estimates

	Associated Specialist			
Task	Skill Gap	Wage	Skill Base	Material Cost
Administrative	43.29*	26.99	-16.16	-147.60*
	(21.66)	(63.75)	(14.58)	(13.47)
Blowdry/Etc.	141.69*	20.91	-70.56*	12.39
	(36.67)	(40.22)	(13.57)	(16.65)
Color/Highlight/Wash	60.03*	37.75*	-9.69	56.49*
	(21.24)	(7.00)	(11.97)	(15.79)
Haircut/Shave	32.45*	16.96*	.	.
	(13.07)	(8.32)	.	.
Nail/Spa/Eye/Misc.	66.48	81.16	-252.58*	-1061.12*
	(37.72)	(53.52)	(11.47)	(10.73)

Standard errors from 500 bootstrap replications in parentheses.
* indicates significance at the 0.05 level.

Equilibrium Task Specialization Across Workers

All Tasks

Specialty v.s. Other Tasks

Equilibrium Task Specialization Across Firms

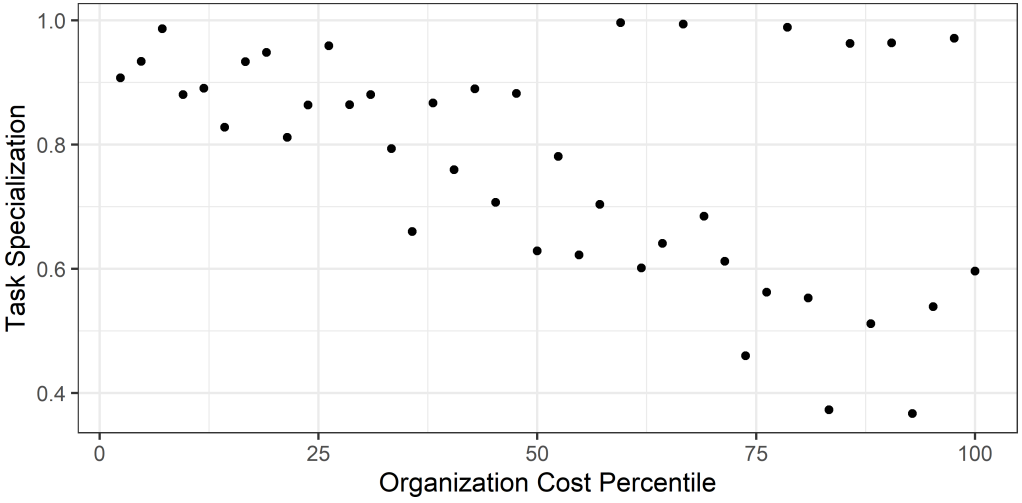
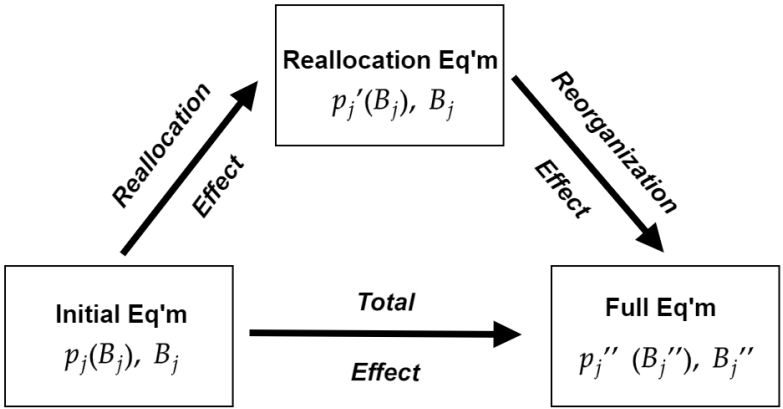


Table of Contents

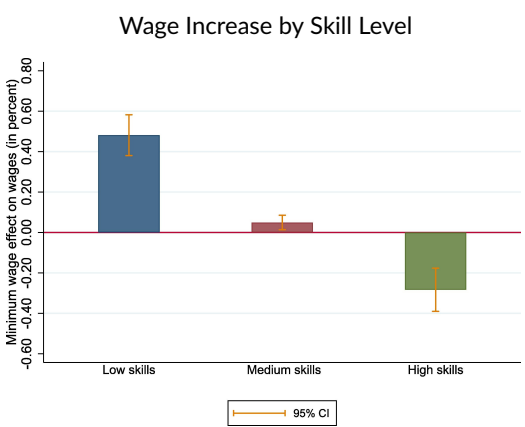
What is a Counterfactual Policy Experiment?

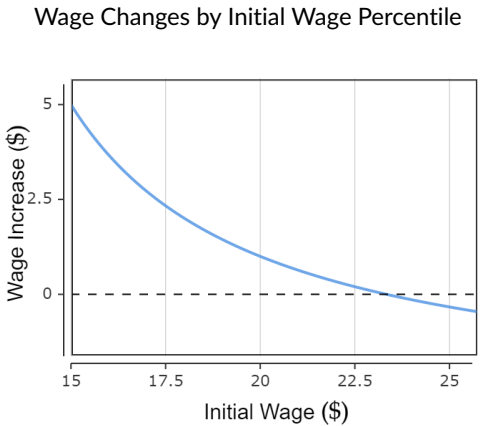
- We developed and estimated the model.
- We now use the model to see how the economy responds to policy changes.
- A policy experiment involves changing a piece of the model.
- We then solve for a new equilibrium (wages, internal structures, prices, etc.)

Decomposing the Effects of a Policy



Minimum Wage In Other Models





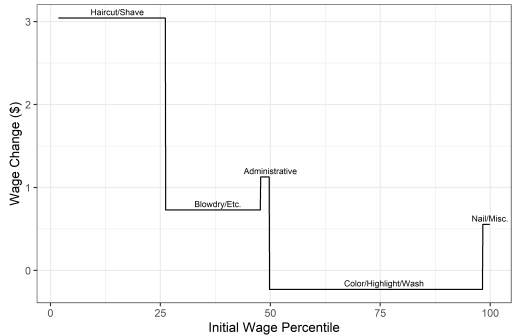
Left is from Gregory and Zierahn (2022), right is stylized example

Minimum Wage Increase from $15 to $20

Wages Changes

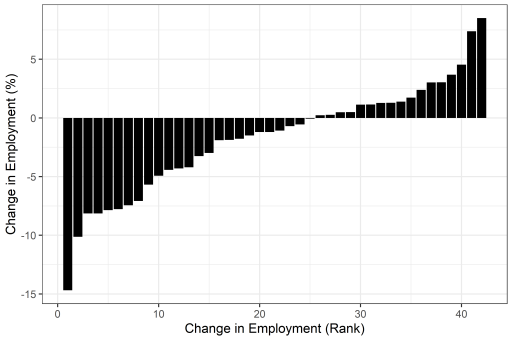
Type	Wage Change	Total Wages Gained/Lost
Haircut/Shave - UNEMPLOYED	-100.00%	-$600,240
Haircut/Shave - EMPLOYED	17.95%	$1,528,205
Color/Highlight/Wash	-0.61%	-$228,453
Blowdry/Style/Treatment/Extension	3.48%	$323,374
Administrative	4.17%	$47,154
Nail/Spa/Eye/Misc.	0.68%	$19,319

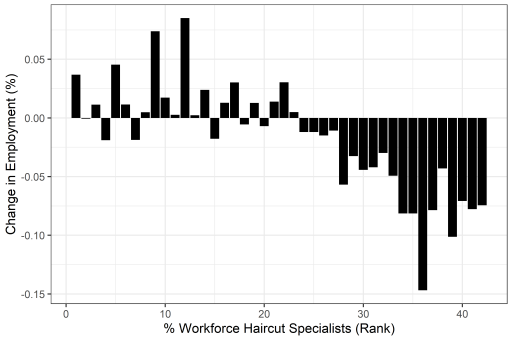
Wage Changes by Initial Wage Percentile



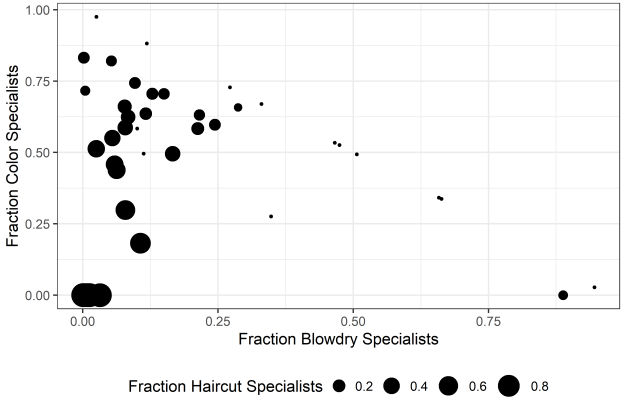
Employment and Wages | Technical Details

The Reallocation Effect





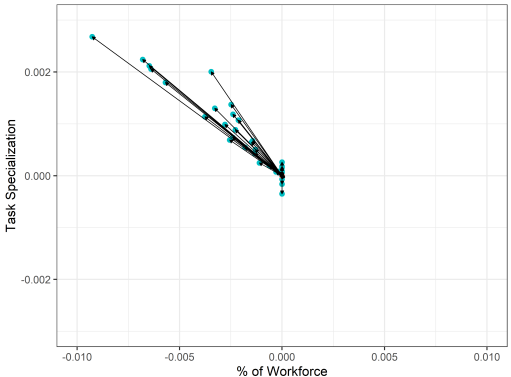
The Reallocation Effect: Wage Spillovers



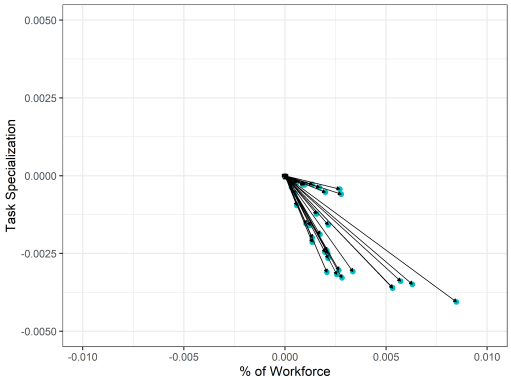
	Reallocation Change	
Type	Employment	Wage
Haircut/Shave	-5.85%	17.95%
Color/Highlight/Wash	0%	-1.13%
Blowdry/Style/Treatment/Extension	0%	4.63%

The Reorganization Effect

Haircut Specialists (Binding)



Color Specialists (Non-Binding)



The Reorganization Effect: Wage Spillovers

Type	Reorganization Change		
	Employment	Task-Spec.	Wage
Haircut/Shave	-0.73%	0.12%	0%
Color/Highlight/Wash	0%	-0.33%	0.52%
Blowdry/Style/Treatment/Extension	0%	0.03%	-1.15%
Administrative	0%	0.03%	-1.05%
Nail/Spa/Eye/Misc.	0%	-0.00%	0.10%

Service Sales Tax Elimination (4.5% to 0%)

Firm Choices

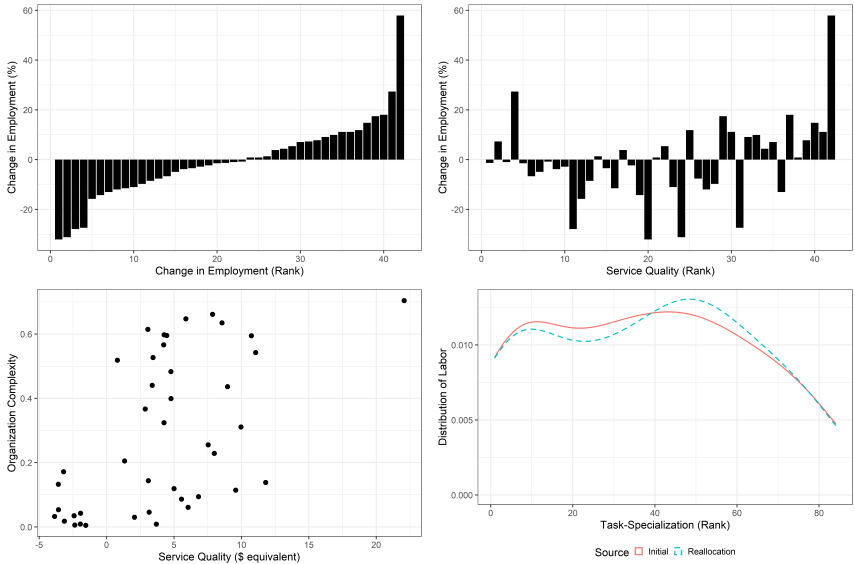
Statistic	Total
Avg. Price	8.68%
Avg. Complexity	5.53%
Avg. Quality	10.03%
Task Specialization	1.83%

Welfare

Source	Change	Percent Change
Salon Profit	$942,740	0.58%
Consumer Welfare	-$494,199	-0.30%
Wages	$11,603,777	7.12%
Tax Revenue	-$11,739,300	-7.20%
Total Welfare	$313,017	0.19%

Effects by Worker Type

Sales Tax Elimination Reallocation Effect



Sales Tax Elimination Reorganization Effect

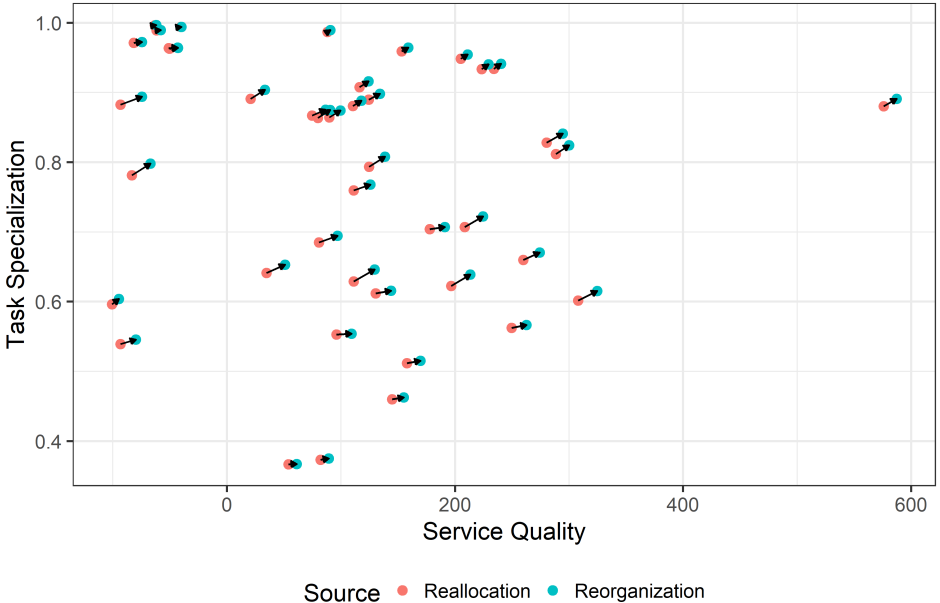


Table of Contents

Model: Salons and Workers

J Salons

- Salon-specific internal organization cost $\gamma_j \geq 0$
- Leontief task-based production function with task-mix parameter $\alpha \in \mathbb{R}_+^K$
  - Producing 1 unit requires assigning α_k labor to task k. Normalize $\sum_k \alpha_k = 1$
  - I allow for firm-specific task-mix in structural model

N Worker Types

- Skill set $\theta_i = \{\theta_{i,1}, ...\theta_{i,k}, ...\theta_{i,K}\}$
- Inelastic total labor supply L_i and wage w_i determined in equilibrium

Model: Salon Choices and Consumers

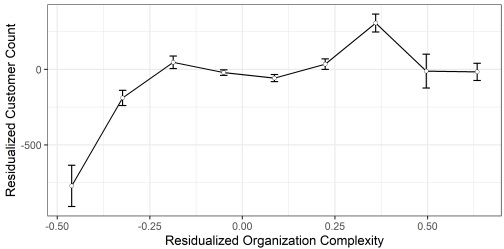
Salon Choices

- Org. structure $B_j \in \Delta^{N \times K}$ s.t. $\sum_i B_j(i,k) = \alpha_k$
  - Product Quality: $\xi(B_j) = \sum_{i,k} \theta_{i,k} B_j(i,k)$
  - Per-Unit Wage Bill: $W(B_j) = \sum_{i,k} w_i B_j(i,k)$
  - Per-Unit Internal Organization Cost: $\gamma_j I(B_j)$ where $I(B_j)$ is complexity
- Price $p_j \in \mathbb{R}_+$

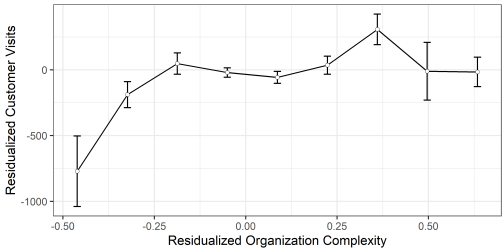
Mass M Consumers

- Utility for good j: $u_{z,j} = \xi(B_j) - \rho p_j + \epsilon_{z,j}$, $\epsilon \sim$ i.i.d. Type-1 E.V.

Relationship Between Complexity and Customers/Visits



(a) Customers



(b) Visits

Back

Firm Size and Complexity Regressions

Dependent Variables:	Revenue	Employees	Utilized Labor	Customers	Visits
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
Org. Complexity	347549.2***	9.75**	26481	334.6	731.7
	(79546.2)	(3.016)	(35653.2)	(259.6)	(450.1)
Fixed-effects					
Quarter-Year	Yes	Yes	Yes	Yes	Yes
County	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	4,558	4,558	4,558	4,558	4,558
R^2	0.32465	0.34319	0.28918	0.34901	0.35004

Standard-errors clustered at the salon level.

*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05*

Back

Manhattan Firm Size and Complexity Regressions

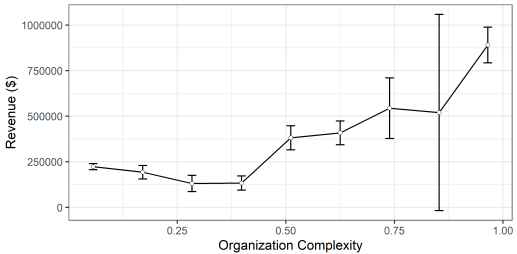
Dependent Variables:	Revenue	Employees	Utilized Labor	Customers	Visits
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
Org. Complexity	430406.6*	12.55	-17733.9	277.2	876.9
	(179977.4)	(6.531)	(70765.2)	(600)	(907.1)
Fixed-effects					
Quarter-Year	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	595	595	595	595	595
R^2	0.33485	0.21039	0.20359	0.44164	0.48831

Clustered standard-errors in parentheses

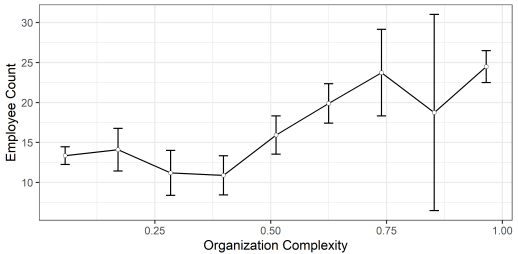
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05*

Back

Fact 2: Complex salons have higher revenue and employment



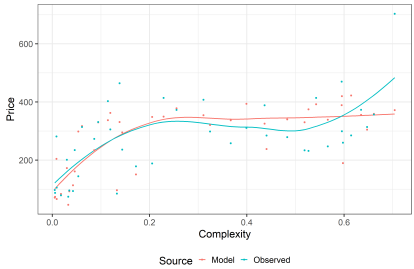
(a) Revenue

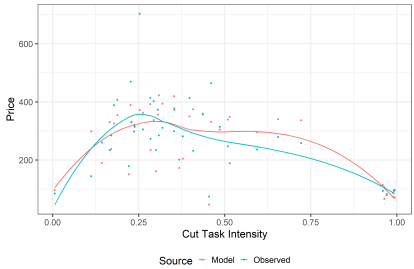


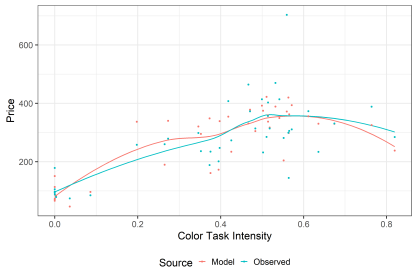
(b) Employees

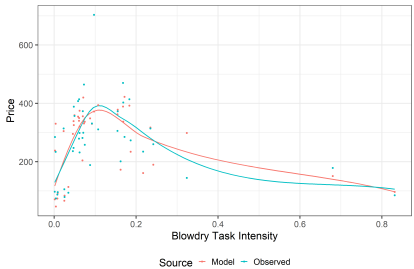
Back

Fit: Supply Side Relationships









Validation: The Task Content of Jobs

Model generated jobs:

$$b_j(i,k) = \alpha_k \frac{exp(-\gamma^{-1} w_i + (\rho\gamma)^{-1}\theta_{i,k})}{\sum_{i'} E_j(i') exp(-\gamma^{-1} w_{i'} + (\rho\gamma)^{-1}\theta_{i',k})}$$

	Total Variance		Between Firm Variance	
Task	Model	Observed	Model	Observed
Haircut/Shave	0.1110	0.1268	0.0597	0.0597
Color/Highlight/Wash	0.1127	0.1105	0.0365	0.0365
Blowdry/Style/Treatment/Extension	0.0472	0.0194	0.0111	0.0111
Administrative	0.0098	0.0080	0.0063	0.0063
Nail/Spa/Eye/Misc.	0.0120	0.0171	0.0050	0.0050

Cost of Median Complexity Organization Across Firms