The Inner Beauty of Firms

Jacob Kohlhepp

UNC Chapel Hill

September 30, 2024

A Tale of Two Hair Salons

Westwood Barber Shop

1 2

12/10/2014 · Updated review

A lovely stylist named Minoo did an incredible job. She colored my hair, freshened up my bob and gave me a great blow dry. The prices are unbelievable, 25 for color, 20 for haircut and 20 for blow dry.

0 18 12

3/10/2019

Throughly enjoyable quality cut from the delightful owners of the salon. At 81 she cut while he cleaned.

John Frieda Salon

33 65 14

6/9/2011

In addition to seeing a different person for your cut and color all the stylists have assistants and they are usually the ones that take you back for washing and drying if your stylist is busy. I've had days where I swear 4-5 people worked on me like I'm a celebrity or something, which speaking of there are often quite a few getting their hair done as well.

24 54 14

1/23/2013

A cut and color here costs more than a monthly payment for some cars.

Source: Yelp.com. Review text truncated for brevity.

Motivation

- There are (anecdotally) large differences in internal task assignment.
- Org. econ provides many reasons these may be firm-specific: relational contracts, managerial capabilities, communication.
- Can internal organization explain well-documented establishment productivity dispersion?

Summary of Paper

1. Are productivity and task assignment similar among similar establishments?

Summary of Paper

1. Are productivity and task assignment similar among similar establishments?
   - **Method:** Millions of task assignments from salons using the same software.
     Answer: No. Large dispersion in productivity and internal task specialization.

Summary of Paper

1. Are productivity and task assignment similar among similar establishments?
   - **Method:** Millions of task assignments from salons using the same software.
     Answer: No. Large dispersion in productivity and internal task specialization.

2. How is task assignment related to productivity?

Summary of Paper

1. Are productivity and task assignment similar among similar establishments?
   - **Method:** Millions of task assignments from salons using the same software.
     Answer: No. Large dispersion in productivity and internal task specialization.

2. How is task assignment related to productivity?
   - **Method:** Task Data + Sales Data
     Answer: Task specialized salons are more productive and engage in other potentially productive management practices.

Summary of Paper

1. Are productivity and task assignment similar among similar establishments?
   - **Method:** Millions of task assignments from salons using the same software.
     Answer: No. Large dispersion in productivity and internal task specialization.

2. How is task assignment related to productivity?
   - **Method:** Task Data + Sales Data
     Answer: Task specialized salons are more productive and engage in other potentially productive management practices.

3. How does heterogeneous and endogenous internal organization shape our understanding of the economy?

Summary of Paper

1. Are productivity and task assignment similar among similar establishments?
   - **Method:** Millions of task assignments from salons using the same software.
     Answer: No. Large dispersion in productivity and internal task specialization.

2. How is task assignment related to productivity?
   - **Method:** Task Data + Sales Data
     Answer: Task specialized salons are more productive and engage in other potentially productive management practices.

3. How does heterogeneous and endogenous internal organization shape our understanding of the economy?
   - **Method:** An estimated industry equilibrium model with endogenous and heterogeneous internal organization.
     Answer: (Partial Equilibrium) 2 workers can be complements or substitutes depending on salon. Own-wage increases cause productivity spillovers on coworkers. (Industry Equilibrium) Management diffusion and immigration increase productivity, sales tax hikes decrease, inreased concentration is mixed. Neglecting internal organization underestimates productivity effects.

Contribution

Endogenous and Firm-Specific Task Specialization

Lazear 2009 (task-mix); Haanwinckel 2023 (multi-worker firms); Garicano 2000 (vertical workers); Adenbaum 2022 (org. costs); Lindenlaub 2017 (multi-skill workers); Baker, Gibbons, and Murphy 2002 (relational contracts); Garicano and Wu 2012 (knowledge); Meier, Stephenson, and Perkowski 2019 (trust); Martinez et al. 2015 (culture); Alchian and Demsetz 1972, Baker and Hubbard 2003 (monitoring)

Task Assignment as a Determinant of Productivity Dispersion

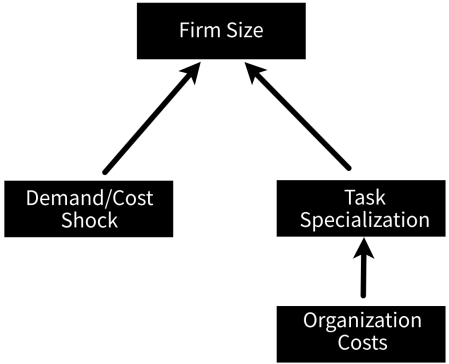
Bassi et al. 2023 (across firms); Minni 2023 (across managers); Bloom and Van Reenen 2007 (management); Syverson 2011 (survey across fields); Kuhn et al. 2023

Estimation of Task-Based Production Functions

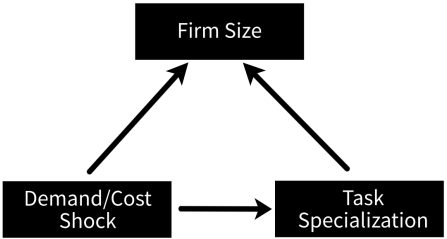
Key features: no wage data, multi-dim. workers, not Hicks neutral

Caliendo et al. 2012 (vertical wage-based approach); Berry, Levinsohn, and Pakes 1995 (demand + firm conduct); Caplin and Nalebuff (1991) (uniqueness); Matêjka and McKay 2015 (key tool); Rubens 2023 (non-Hicks neutral example)

Causal Relationships Between Firm-Size and Specialization



(a) This Paper



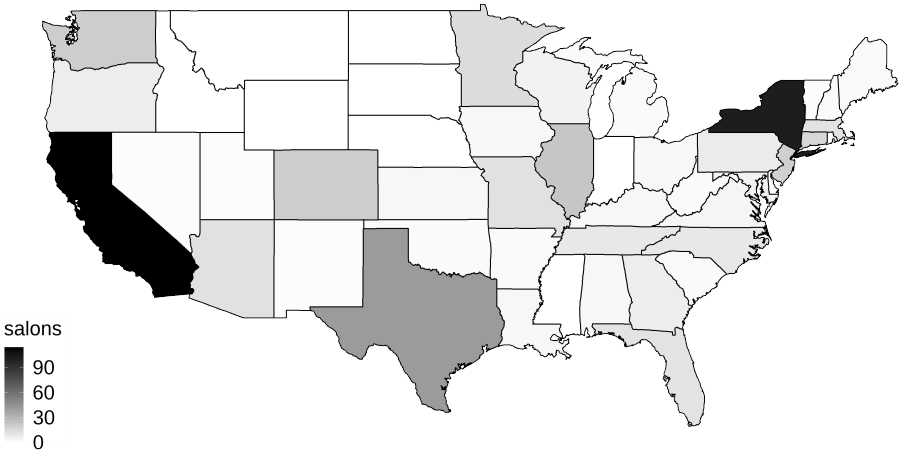
(b) Others

Table of Contents

Data

- Salon management software company founded in 2016
- Nationwide, but clients are concentrated in NYC and LA.
- Observe 10.8 million assignments of tasks to hair stylists across hundreds of salons from 2016 to 2021 Q2

Coverage



A Data Snapshot

Firm	Salon	App.	Cust.	Task	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

A Data Snapshot

Firm	Salon	App.	Cust.	Task	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

- Granular descriptions are categorized into tasks.
- Analyze one representative product (basket of services) per firm-quarter.
- Measure productivity as total revenue per quarter divided by total of all durations (utilized labor).

Table of Contents

What is an Organization?

Definition

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

What is an Organization?

Definition

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

Tasks

	Cut	Color	Dry	
A	.1	.2	.1	.4
B	.1	.1	.1	.3
C	.2	.05	.05	.3
Tot.	.4	.35	.25	

Labor Demand (E)

Task-Mix (α)

Measuring Internal Task-Specialization

Suppose we observe this organization:

	Tasks			
	Cut	Color	Dry	
A	.1	.2	.1	.4
B	.1	.1	.1	.3
C	.2	.05	.05	.3
Tot.	.4	.35	.25	

Task-Mix (α)

Labor Demand (E)

Measuring Internal Task-Specialization

Construct a generalist benchmark ($G(B)$):

Tasks

	Cut	Color	Dry	
A	.1	.2	.1	.4
B	.1	.1	.1	.3
C	.2	.05	.05	.3
Tot.	.4	.35	.25	

Task-Mix (α)

Tasks

	Cut	Color	Dry	
A				
B				
C				
Tot.				

Labor Demand (E)

Measuring Internal Task-Specialization

Hold fix what needs to be done (task-mix):

	Tasks			
	Cut	Color	Dry	
A	.1	.2	.1	.4
B	.1	.1	.1	.3
C	.2	.05	.05	.3
Tot.	.4	.35	.25	

Task-Mix (α)

	Tasks			
	Cut	Color	Dry	
A				
B				
C				
Tot.	.4	.35	.25	

Labor Demand (E)

Measuring Internal Task-Specialization

Hold fix who is employed (Labor Demand):

Tasks

	Cut	Color	Dry	
A	.1	.2	.1	.4
B	.1	.1	.1	.3
C	.2	.05	.05	.3
Tot.	.4	.35	.25	

Tasks

	Cut	Color	Dry	
A				.4
B				.3
C				.3
Tot.	.4	.35	.25	

Labor Demand (E)

Task-Mix (α)

Measuring Internal Task-Specialization

Randomly assign workers to tasks ($G(B_j)(i,k) = E_i \cdot \alpha_k$)

Tasks

	Cut	Color	Dry	
A	.1	.2	.1	.4
B	.1	.1	.1	.3
C	.2	.05	.05	.3
Tot.	.4	.35	.25	

Task-Mix (α)

Tasks

	Cut	Color	Dry	
A	.16	.16	.1	.4
B	.12	.105	.075	.1
C	.12	.105	.075	.3
Tot.	.4	.35	.25	

Labor Demand (E)

The S-index

A firm is task-specialized if it is "far" from the counterfactual generalist firm.

Definition 1

The task-specialization index **(s-index)** of a firm with org. structure B is given by:

$$I(B) := \underbrace{D_{KL}(B|G(B))}_{\text{Kullback-Leibler divergence}} = \sum_{m,k} B(m,k) log\left(\frac{B(m,k)}{G(B)(m,k)}\right)$$

The S-index

A firm is task-specialized if it is "far" from the counterfactual generalist firm.

Definition 2

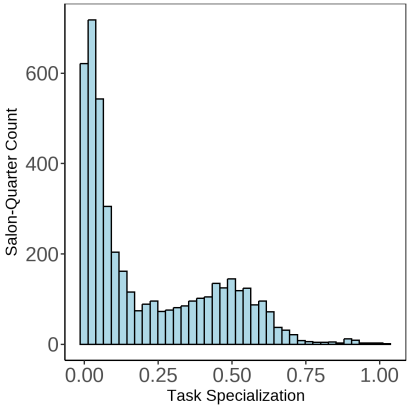
The task specialization index **(s-index)** of a firm with org. structure B is given by:

$$I(B) := \underbrace{D_{KL}(B|G(B))}_{\text{Kullback-Leibler divergence}} = \sum_{m,k} B(m,k) log\left(\frac{B(m,k)}{\underbrace{\alpha_k}_{\text{task-mix}} \cdot \underbrace{E_m}_{\text{labor demand}}}\right)$$

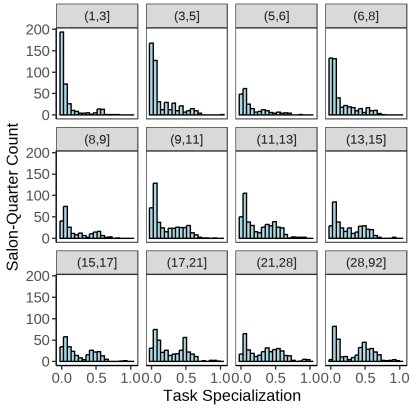
Fact 1: Large dispersion in labor productivity and internal task specialization

Statistic	N	Mean	Min	Pctl(25)	Median	Pctl(75)	Max
Labor Productivity	4,599	1.81	0.003	1.03	1.38	2.05	42.80
S-index	4,599	0.22	0.00	0.03	0.11	0.41	1.02

Fact 1: Large dispersion in labor productivity and internal task specialization



(a) All Salon Quarters



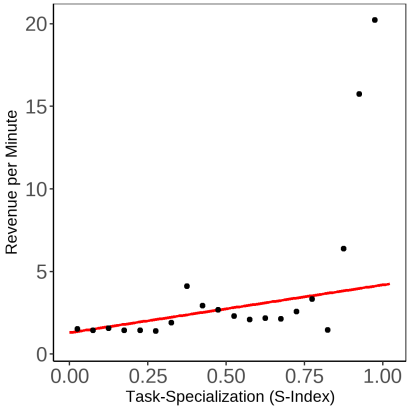
(b) By Number of Employees

Fact 2: Task specialized salons are more productive

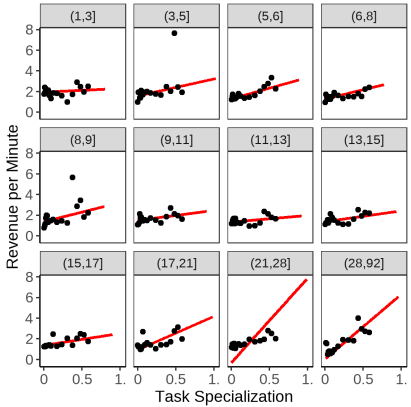
Dependent Variable:	Revenue per Minute (standardized)					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
S-Index	0.1099*	0.1091*	0.1019*	0.0999*	0.1059*	0.0663*
	(0.0555)	(0.0549)	(0.0510)	(0.0499)	(0.0508)	(0.0332)
Task-Mix controls	Yes	Yes	Yes	Yes	Yes	Yes
Fixed-effects						
Zip			Yes	Yes	Yes	
Quarter-Year				Yes	Yes	Yes
Firm Size					Yes	
Zip-Firm Size						Yes
Fit statistics						
R^2	0.05847	0.06368	0.51221	0.52402	0.53741	0.89597

Clustered (Establishment) standard-errors in parentheses

Fact 2: Task specialized salons are more productive



(a) All Salon Quarters



(b) By Number of Employees

Fact 3: Task specialized salons engage in more teamwork and are earlier adopters of software features

	Teamwork	Service Descriptions	Product Discounts	Software Adopted	Tip Feature	Prebook Feature	Request Feature
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
S-Index	0.6551***	0.1167*	0.1107*	-0.2100***	-0.3066***	-0.2790***	-0.0802*
	(0.0492)	(0.0509)	(0.0461)	(0.0476)	(0.0551)	(0.0482)	(0.0397)
Task-Mix	Yes	Yes	Yes				
Fixed-effects							
Zip	Yes	Yes	Yes				
Quarter-Year	Yes	Yes	Yes				
Fit statistics							
R^2	0.78858	0.74935	0.78898	0.04410	0.08819	0.07965	0.00654

Clustered (Establishment) standard-errors in parentheses

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

Table of Contents

Model

Firms: $j = 1, ..., J$

- Firm j communicates 1 bit of info. to employees at cost γ_j (not Hicks neutral)
- Firm j requires $\bar{a}_j$ labor and must assign a fraction $\alpha_j(k)$ to task k
- Firm j has a constant marginal cost: $\alpha_j \cdot c + \omega_j$ (material cost + Hicks neutral)

Workers: $m = 1, ..., M$

- Skill level $\bar{\theta}_m \in \mathbb{R}$, skill set $\theta_m \in \mathbb{R}^K$ and labor supply $l_m \in \mathbb{R}_+$
- Worker m performs task k with quality $\bar{\theta}_m + \theta_m(k)$
- Worker-specific wages $w \in \mathbb{R}_+^M$

Model

Firm Actions

(simultaneously chosen)

- Price $p_j \in \mathbb{R}_+$ (Bertrand-style)
- Relative Labor demand $E_j \in \mathbb{R}_+^M$ (fraction of work done by each worker)
- Task assignment $b_j \in \mathbb{R}_+^M \times \mathbb{R}_+^K$ (how each worker splits their time)

Organization Costs

- Workers know the task-mix of firms (α_j) but their task assignment must be communicated (knowledge hierarchy-style)
- Org. cost of task assignment b_j is γ_j times minimum info. required to communicate b_j to workers

Model

Product Market

- Consumers observe task assignments and prices and purchase based on utility $u_{z,j} = \xi_j + \nu_j - \rho p_j + \epsilon_{z,j}$ with $\epsilon_{z,j}$ i.i.d. Type-1 EV (no purchase normalized to $\epsilon_{z,0}$)
- ξ_j is average quality across all workers and tasks given b_j, E_j

Equilibrium

- Firm strategies $\{p_j, E_j, b_j\}_{j=1}^{J}$ are a Nash Equilibrium under wage w
- Call this a fixed w-subgame
- Wages w are such that the labor market clears in the fixed w-subgame

Table of Contents

Which Worker Heterogeneity Matters?

3 dimensions of worker heterogeneity:

- Labor supply (l_m)
- Skill level ($\bar{\theta}_m$)
- Skill Set ($\theta_m \in \mathbb{R}^K$)

Which Worker Heterogeneity Matters?

3 dimensions of worker heterogeneity:

- Labor supply (l_m)
- Skill level ($\bar{\theta}_m$)
- Skill Set ($\theta_m \in \mathbb{R}^K$)

Which Worker Heterogeneity Matters?

3 dimensions of worker heterogeneity:

- Labor supply (l_m)
- Skill level ($\bar{\theta}_m$)
- Skill Set ($\theta_m \in \mathbb{R}^K$)

Which Worker Heterogeneity Matters?

3 dimensions of worker heterogeneity:

- Labor supply (l_m)
- Skill level ($\bar{\theta}_m$)
- Skill Set ($\theta_m \in \mathbb{R}^K$)

It is without loss to treat firms as assigning tasks to a representative worker of each skill set, $i = 1, ..., N$

Communication is Task-Specialization

Proposition

*The communication required to implement a profit maximizing task assignment is equal to the **observed** s-index (I_j), and is strictly decreasing in γ_j for all values of firm-level heterogeneity ($a_j, \alpha_j, \nu_j, \omega_j$) until it reaches 0.*

- Microfoundation: specialization is costly because it requires communication.
- Can also view directly as a catch-all specialization cost.
- Observed s-index is monotone in unobserved org. cost parameter γ_j

Equilibrium Worker Jobs

Theorem

The task assignment and relative labor demand of a worker w/ skill set i at firm j:

1. ***Characterization:***

$$b_j(i,k) = \alpha_j(k) \frac{exp[\gamma_j^{-1}(\rho^{-1}\theta_i(k) - w(i)]}{\sum_{i'} E_j(i') exp[\gamma^{-1}(\rho^{-1}\theta_{i'}(k) - w(i')]}$$

2. ***Law of Demand:*** *As $w(i)$ rises, $E_j(i)$ falls*
3. ***Incomplete Specialization:*** *All workers spend some time on all tasks* (unless $\alpha_j(k) = 0$)
4. ***Maximum Coworker Diversity:*** *Either # skill sets at firm $\leq$ # tasks, or there exists another profit max. strategy where this is true.*

Simple Example

- Suppose 3 tasks, price sensitivity $\rho = 1$
- 3 worker types with wages $w = (20, 15, 21)$ and skill set:

$$\begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \end{bmatrix} = \begin{bmatrix} 23 & 19 & 15 \\ 15 & 15 & 15 \\ 15 & 19 & 26 \end{bmatrix}$$

- Without org. costs, the firm chooses the best person for each task given wages:

$$\begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \end{bmatrix} - \rho w = \begin{bmatrix} 3 & -1 & -5 \\ 0 & 0 & 0 \\ -6 & -2 & 5 \end{bmatrix}$$

Table of Contents

Data and Identifying Assumptions

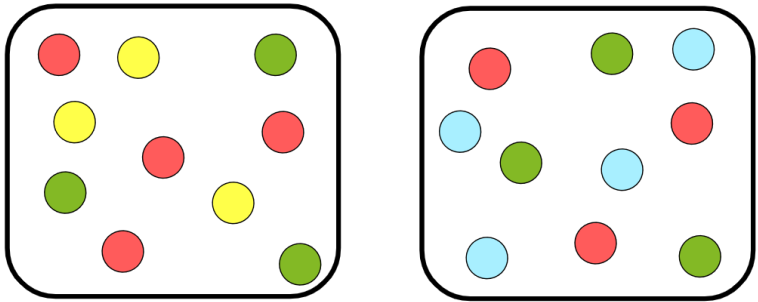
- The econometrician observes worker task assignments ($\{b_m(i,k)\}_{m=1}^{M}$).
- The econometrician observes the required labor, task-mix, price and market share ($\{a_j, \alpha_j, p_j, s_j\}_{j=1}^{J}$) of firms.
- The wage-adjusted skill matrix $\Theta - \rho(we')$ is full rank. (e is a vector of ones)
  - Θ is full-rank already, so this rules out a measure 0 set of wages
- Idiosyncratic quality (ν_j) and cost (ω_j) are mean zero and independent of firm heterogeneity.
- Standard linear GMM rank assumptions.

Identification

Theorem

Wages (w), price sensitivity (ρ), material costs (m) and the skill sets of all workers ($\{\theta_m\}_{m=1}^{M}$) are identified. The organization cost parameters (γ_j) of firms with a strictly positive s-index ($I_j > 0$) are identified. A lower bound on the organization cost parameters of firms with an s-index of 0 is identified.

Grouping Workers By Skill Set Within Firm



- Circles are workers (indexed by m), boxes are salons (indexed by j)
- Colors are unobserved skill set groups of workers, denoted i_m
- We observe only task assignments.

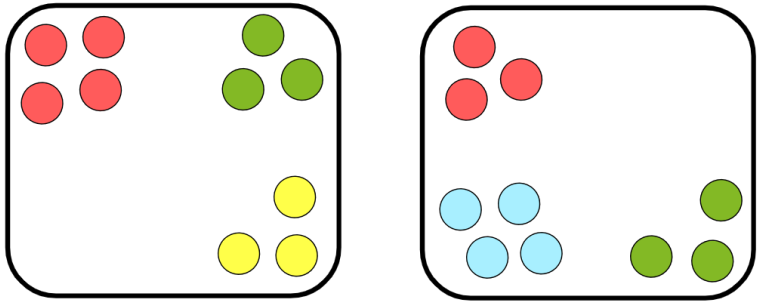
Grouping Workers By Skill Set Within Firm

- Worker 1 in firm j has task assignment:

$$b_j(1,k) = \alpha_j(k)\frac{exp[\gamma_j^{-1}(\rho^{-1}\theta_{i_1}(k) - w(i_1))]}{\sum_{i'} E_j(i')exp[\gamma^{-1}(\rho^{-1}\theta_{i'}(k) - w(i'))]}$$

- If 2 workers are at the same firm, they have the same task assignment if and only if they have the same skill set.

Grouping Workers By Skill Set Within Firm



- Within firm, workers are now grouped correctly.
- But not across firms.

Groupings Workers by Skill Sets Across Firms

- Org. cost and task-mix confound task assignments across firms.

$$b_j(m,k) = \alpha_j(k)\frac{exp[\gamma_j^{-1}(\rho^{-1}\theta_{i_m}(k) - w(i_m))]}{\sum_{i'} E_j(i')exp[\gamma^{-1}(\rho^{-1}\theta_{i'}(k) - w(i'))]}$$

-

Groupings Workers by Skill Sets Across Firms

- Differences in org. cost and task-mix confound grouping across firms.
- Take another worker at firm j but with a different skill set. Call them worker 2:

$$b_j(i_2, k) = \alpha_j(k) \frac{exp(-\gamma_j^{-1} w(i_2) + (\rho\gamma_j)^{-1}\theta_{i_2}(k)))}{\sum_{i'} E_j(i') exp(-\gamma_j^{-1} w(i') + (\rho\gamma)^{-1}\theta_{i'}(k))}$$

Groupings Workers by Skill Sets Across Firms

- Differences in org. cost and task-mix confound grouping across firms.

- Divide the task assignment of worker 1 by that of worker 2 across all tasks:

$$\frac{b_j(i_1,k)}{b_j(i_2,k)} = \frac{\alpha_j(k)\frac{exp(-\gamma_j^{-1}w(i_1)+(\rho\gamma_j)^{-1}\theta_{t_1}(k)))}{\sum_{i'} E_j(i')exp(-\gamma_j^{-1}w(i')+(\rho\gamma)^{-1}\theta_{i'}(k))}}{\alpha_j(k)\frac{exp(-\gamma_j^{-1}w(i_2)+(\rho\gamma_j)^{-1}\theta_{i_2}(k)))}{\sum_{i'} E_j(i')exp(-\gamma_j^{-1}w(i')+(\rho\gamma)^{-1}\theta_{i'}(k))}}$$

Groupings Workers by Skill Sets Across Firms

- Differences in org. cost and task-mix confound grouping across firms.
- This removes most of the firm-level confounding:

$$\frac{b_j(t_1,k)}{b_j(t_2,k)} = \frac{exp(-\gamma_j^{-1}w(i_1) + (\rho\gamma_j)^{-1}\theta_{i_1}(k)))}{exp(-\gamma_j^{-1}w(i_2) + (\rho\gamma_j)^{-1}\theta_{i_2}(k)))}$$

Groupings Workers by Skill Sets Across Firms

- Differences in org. cost and task-mix confound grouping across firms.
- Take logs:

$$log\left(\frac{b_j(i_1,k)}{b_j(i_2,k)}\right) = (\rho\gamma_j)^{-1}\left([\theta_{i_1}(k) - \rho w(i_1)] - [\theta_{i_2}(k) - \rho w(i_2)]\right)$$

Groupings Workers by Skill Sets Across Firms

- Differences in org. cost and task-mix confound grouping across firms.

- Divide the vector by its Euclidean norm:

$$\frac{log\left(\frac{b_j(i_1,k)}{b_j(i_2,k)}\right)}{\left|\left\{log\left(\frac{b_j(i_1,k')}{b_j(i_2,k')}\right)\right\}_{k'=1}^{K}\right|} = \frac{(\rho\gamma_j)^{-1}\Big(\theta_{i_1}(k) - \rho w(i_1) - [\theta_{i_2}(k) - \rho w(i_2)]\Big)}{\left(\sum_{k'}\left[(\rho\gamma_j)^{-1}(\theta_{i_1}(k') - \rho w(i_1) - [\theta_{i_2}(k') - \rho w(i_2)])\right]^2\right)^{1/2}}$$

Groupings Workers by Skill Sets Across Firms

- Differences in org. cost and task-mix confound grouping across firms.

- This removes the org. cost parameter:

$$\frac{log\left(\frac{b_j(i_1,k)}{b_j(i_2,k)}\right)}{\left|\left\{log\left(\frac{b_j(i_1,k')}{b_j(i_2,k')}\right)\right\}_{k'=1}^{K}\right|} = \frac{\left(\theta_{i_1}(k) - \rho w(i_1) - [\theta_{i_2}(k) - \rho w(i_2)]\right)}{\left(\sum_{k'}\left[(\theta_{i_1}(k') - \rho w(i_1) - [\theta_{i_2}(k') - \rho w(i_2)])\right]^2\right)^{1/2}}$$

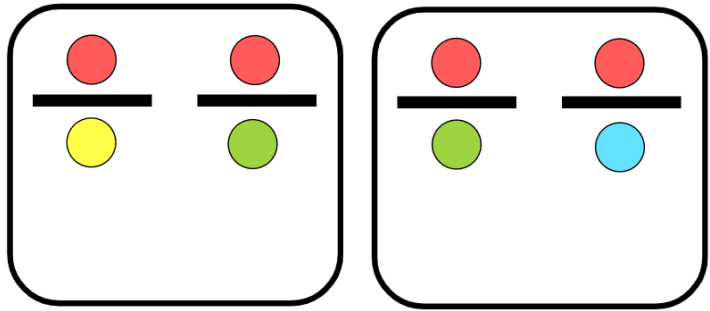
Groupings Workers by Skill Sets Across Firms

- Differences in org. cost and task-mix confound grouping across firms.
- Call these coworker log-ratio vectors.

$$\frac{log\left(\frac{b_j(i_1,k)}{b_j(i_2,k)}\right)}{\left|\left\{log\left(\frac{b_j(i_1,k')}{b_j(i_2,k')}\right)\right\}_{k'=1}^{K}\right|} = \frac{\left(\theta_{i_1}(k) - \rho w(i_1) - [\theta_{i_2}(k) - \rho w(i_2)]\right)}{\left(\sum_{k'}\left[(\theta_{i_1}(k') - \rho w(i_1) - [\theta_{i_2}(k') - \rho w(i_2)])\right]^2\right)^{1/2}}$$

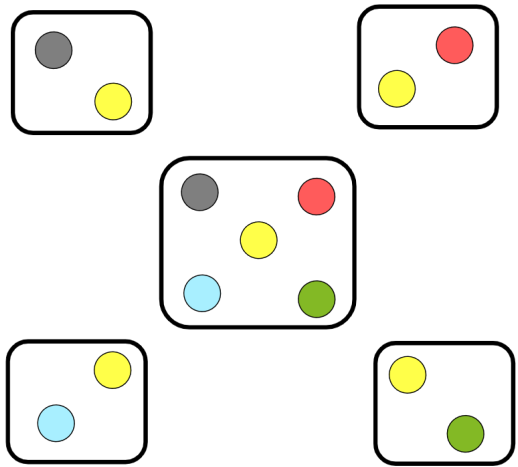
- If a firm employs 5 skill sets, each worker has 4 coworker log ratio vectors.

Grouping Workers By Skill Set Across Firms

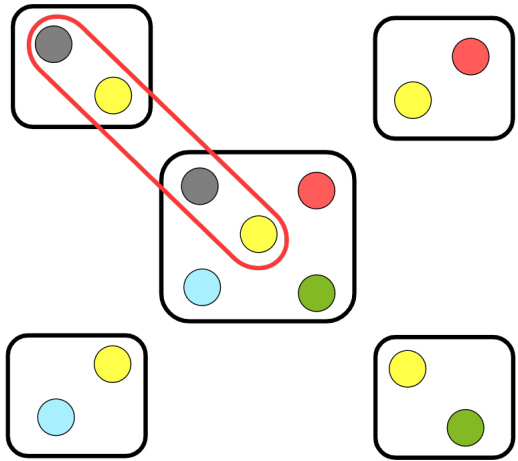


- Compare the coworker log ratios. They will match if and only if the numerator workers AND denominator workers have the same skill set.
- If firms are sufficiently connected in terms of pairs of skill sets, this can be repeated to classify all workers.

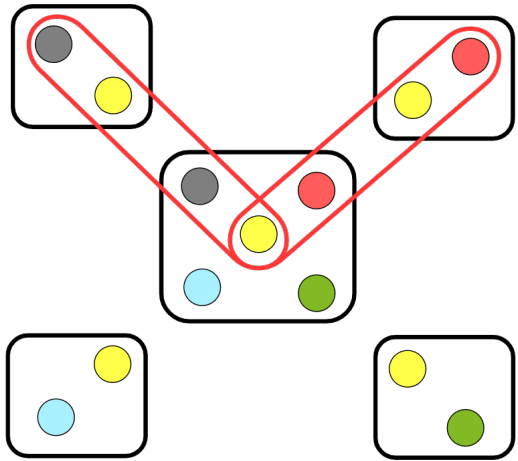
Sufficient Condition: One Firm Has All 5 Skill Sets



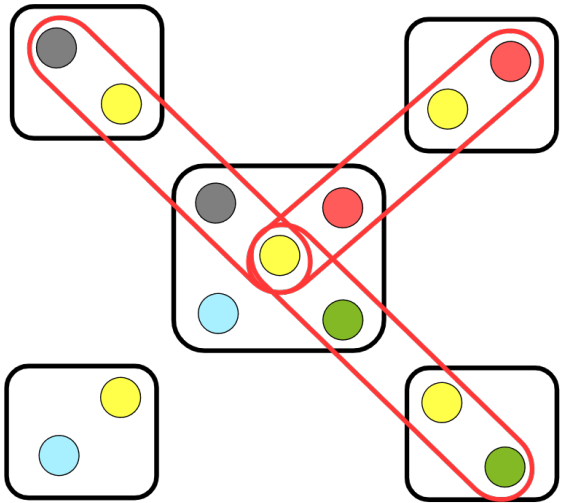
Sufficient Condition: One Firm Has All 5 Skill Sets



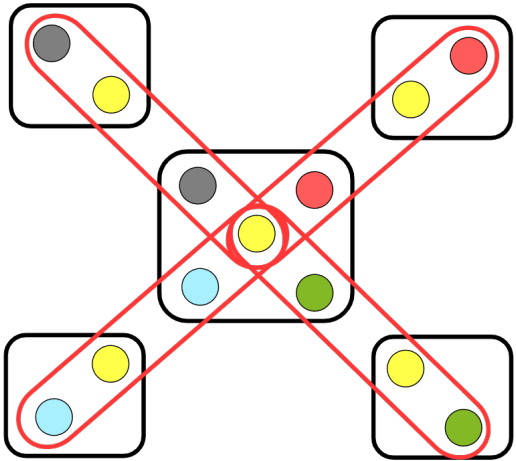
Sufficient Condition: One Firm Has All 5 Skill Sets



Sufficient Condition: One Firm Has All 5 Skill Sets

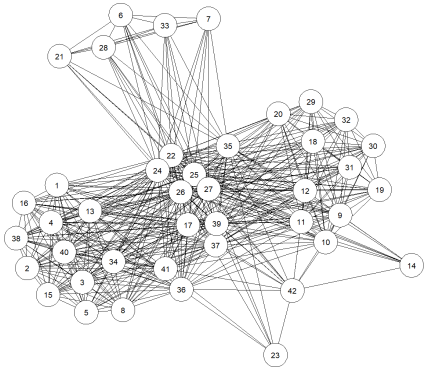


Sufficient Condition: One Firm Has All 5 Skill Sets

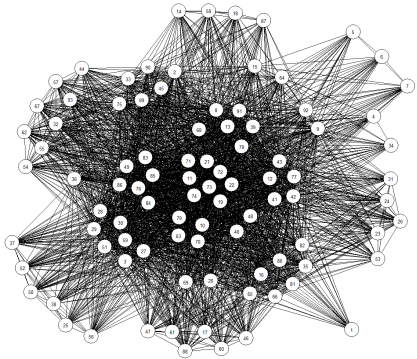


Could impose other conditions (pigeon hole principle).

A Network of Shared Skill Sets

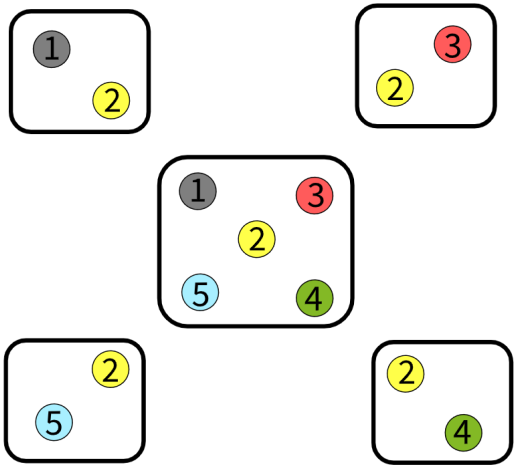


Manhattan (2019 Q1-Q4)



Los Angeles (2019 Q1-Q4)

Worker Skill Set Categories are Identified



Firm-Specific Organization Costs (γ_j)

- Recall our coworker log ratios before we divided by the norm:

$$log\left(\frac{b_j(i_1,k)}{b_j(i_2,k)}\right) = (\rho\gamma_j)^{-1}\Big([\theta_{i_1}(k) - \rho w(i_1)] - [\theta_{i_2}(k) - \rho w(i_2)]\Big)$$

Firm-Specific Organization Costs (γ_j)

- Recall our coworker log ratios before we divided by the norm:

$$log\left(\frac{b_j(i_1,k)}{b_j(i_2,k)}\right) = (\rho\gamma_j)^{-1}\Big([\theta_{i_1}(k) - \rho w(i_1)] - [\theta_{i_2}(k) - \rho w(i_2)]\Big)$$

- We can use this to obtain org. costs $\tilde{\gamma}_j := \gamma_j/\gamma_1$ relative to the firm that employs all 5 skill sets.

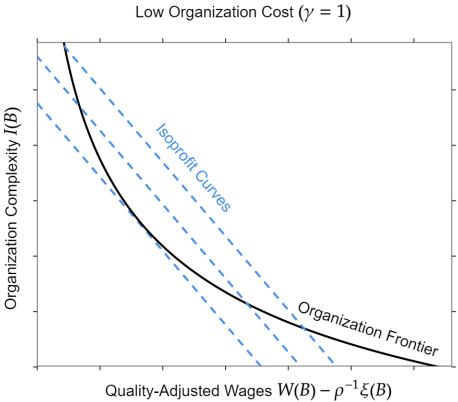
Wages, Skills, Reference Firm Org. Cost, Etc.

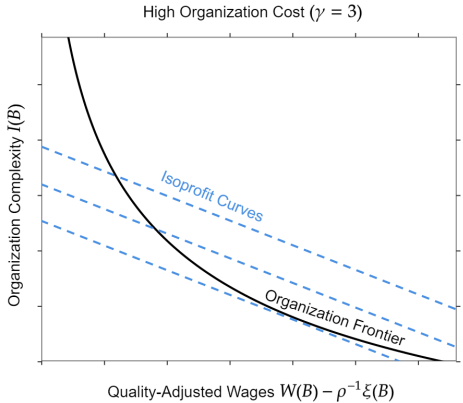
- Demand-side: $log(s_j/s_0) = \sum_{i,k} \theta_i(k) a_j B_j(i,k) - \rho p_j + \nu_j$
- Supply-side: $p_j = \frac{1}{\rho(1-s_j)} + \gamma_1 \tilde{\gamma}_j a_j l_j + w \cdot a_j \cdot E_j + c \cdot \alpha_j + \omega_j$
- Use relative org. costs $\tilde{\gamma}_j a_j l_j$ as instrument for price in demand-side.
- Linear GMM with $K^2 + 1$ equations and $K^2 + 1$ unknowns.
- Adjust prices by markup: $p_j - \frac{1}{\rho(1-s_j)} = \gamma_1 \tilde{\gamma}_j a_j l_j + w \cdot a_j \cdot E_j + c \cdot \alpha_j + \omega_j$
- Linear GMM (OLS) with $2K + 1$ equations and $2K + 1$ unknowns.

Firms that Do Not Perform One task Type

- The prior procedure will not work if one or more task types are not performed.
- But we identified all market parameters and we proved monotonicity of the s-index in γ_j.
- Therefore we can invert the s-index for these firms and recover γ_j (and also the skill sets of their workers).

Monotonicity of S-Index in γ_j





A Globally Convergent Contraction Mapping

The Blahut–Arimoto algorithm (Blahut 1972) can be used to solve for γ_j during inversion:

0. Guess some relative labor demands E^0. Create matrix V: $V_{i,k} = exp[\gamma_j^{-1}(\rho^{-1}\Theta(i,k) - w(i))]$.

1. Compute interim organization structure $B_j(i,k)^t = \alpha_j(k)\frac{V_{i,k}E^t(i)}{\sum_{i'} E_j^t(i')V_{i,k}}$.

2. Compute interim relative labor demands $E_j^{t+1}(i) = \sum_k B(i,k)^t$.

3. If converged, exit; else return to Step 1 and advance t.

It can also be used for solving for counterfactual equilibrium.

Estimation Roughly Follows Identification Proof

- Cook, Los Angeles, and New York from 2018Q1 - 2021Q2 (Exclude COVID)
- Parallel Wage Trends (can classify workers across time for power)
- Recover skill sets from market-share and price 2SLS.
- Guess relative wages.
- Recover all org. costs via inversion. (internal consistency of s-index)
- Repeat until model labor demand and classification step labor demand are similar. (internal consistency of skills and wages)
- Recover relative wages and other parameters from constrained regression (almost OLS) of adjusted prices.

Table of Contents

Los Angeles County Wages and Skills

Skill Set	Wage	Admin.	Blowdry/Style	Color/Etc.	Haircut/Shave	Nail/Misc.
1	-	-0.028	-0.275	0.876	-5.248	-61.626
	-	(4.874)	(2.737)	(1.175)	(1.509)	(29.540)
2	536.753	-5.466	13.326	2.332	-6.157	-9.492
	(210.962)	(3.919)	(10.040)	(1.968)	(2.535)	(2.699)
3	-7.202	0.043	1.570	-0.439	-3.733	-6.118
	(24.149)	(1.343)	(2.155)	(.965)	(.701)	(10.649)
4	20.981	-0.305	3.759	0.751	-5.383	-3.982
5	59.820	0.946	-2.708	1.654	-3.703	-3.676
	(33.640)	(1.662)	(1.189)	(1.108)	(1.232)	(1.419)

- High wage, high skill color/style specialist
-
-

Los Angeles County Wages and Skills

Skill Set	Wage	Admin.	Blowdry/Style	Color/Etc.	Haircut/Shave	Nail/Misc.
1	-	-0.028	-0.275	0.876	-5.248	-61.626
	-	(4.874)	(2.737)	(1.175)	(1.509)	(29.540)
2	536.753	-5.466	13.326	2.332	-6.157	-9.492
	(210.962)	(3.919)	(10.040)	(1.968)	(2.535)	(2.699)
3	-7.202	0.043	1.570	-0.439	-3.733	-6.118
	(24.149)	(1.343)	(2.155)	(.965)	(.701)	(10.649)
4	20.981	-0.305	3.759	0.751	-5.383	-3.982
5	59.820	0.946	-2.708	1.654	-3.703	-3.676
	(33.640)	(1.662)	(1.189)	(1.108)	(1.232)	(1.419)

- High wage, high skill color/style specialist
- Medium wage, medium skill color/haircut specialist
-

Los Angeles County Wages and Skills

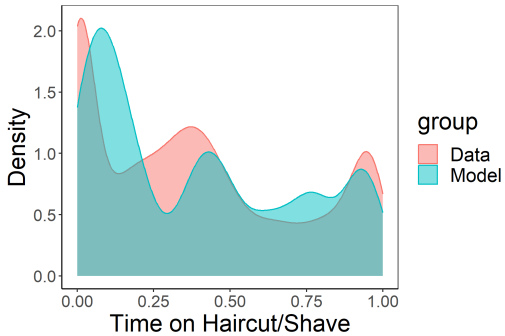
Skill Set	Wage	Admin.	Blowdry/Style	Color/Etc.	Haircut/Shave	Nail/Misc.
1	-	-0.028	-0.275	0.876	-5.248	-61.626
	-	(4.874)	(2.737)	(1.175)	(1.509)	(29.540)
2	536.753	-5.466	13.326	2.332	-6.157	-9.492
	(210.962)	(3.919)	(10.040)	(1.968)	(2.535)	(2.699)
3	-7.202	0.043	1.570	-0.439	-3.733	-6.118
	(24.149)	(1.343)	(2.155)	(.965)	(.701)	(10.649)
4	20.981	-0.305	3.759	0.751	-5.383	-3.982
5	59.820	0.946	-2.708	1.654	-3.703	-3.676
	(33.640)	(1.662)	(1.189)	(1.108)	(1.232)	(1.419)

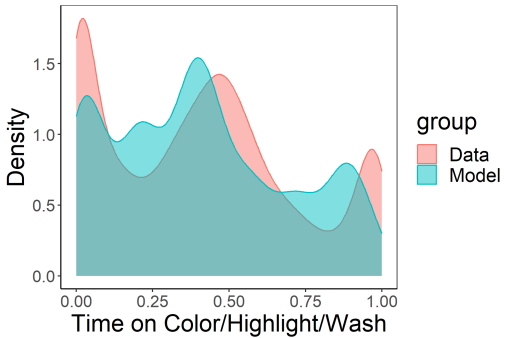
- High wage, high skill color/style specialist
- Medium wage, medium skill color/haircut specialist
- Low wage, low skill generalists

Model Validation: The Task Composition of Salon Jobs

	Task	Variance	Cor. Task 1	Cor. Task 2	Cor. Task 3	Cor. Task 4	Cor. Task 5
Model	1	0.105	1.000	-0.678	-0.392	-0.259	-0.171
Data	1	0.107	1.000	-0.745	-0.260	-0.285	-0.184
Model	2	0.084		1.000	-0.154	-0.164	-0.156
Data	2	0.094		1.000	-0.080	-0.143	-0.234
Model	3	0.033			1.000	-0.013	-0.077
Data	3	0.014			1.000	0.013	-0.083
Model	4	0.019				1.000	-0.039
Data	4	0.019				1.000	-0.026
Model	5	0.014					1.000
Data	5	0.021					1.000

Model Validation: The Task Composition of Salon Jobs





Model Validation: The Task Composition of Salon Jobs

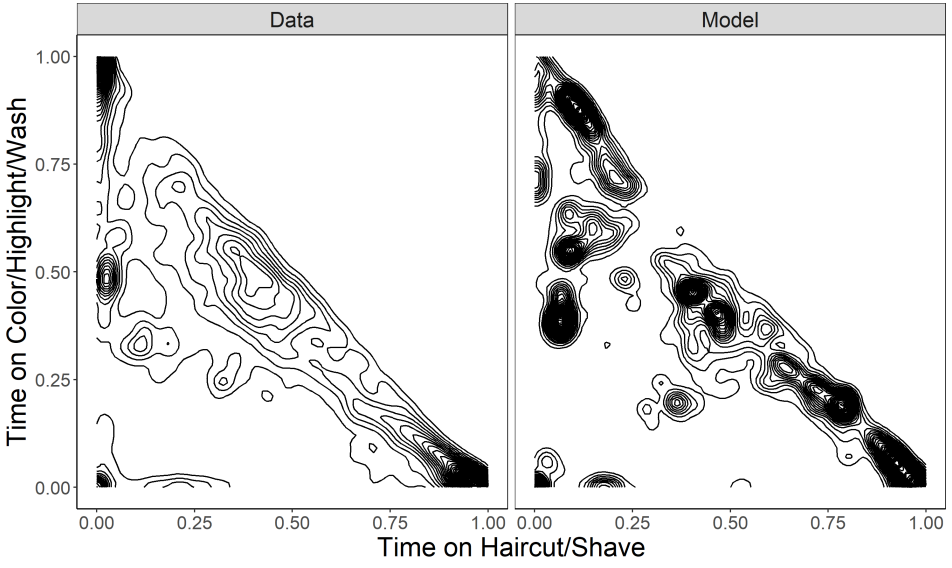
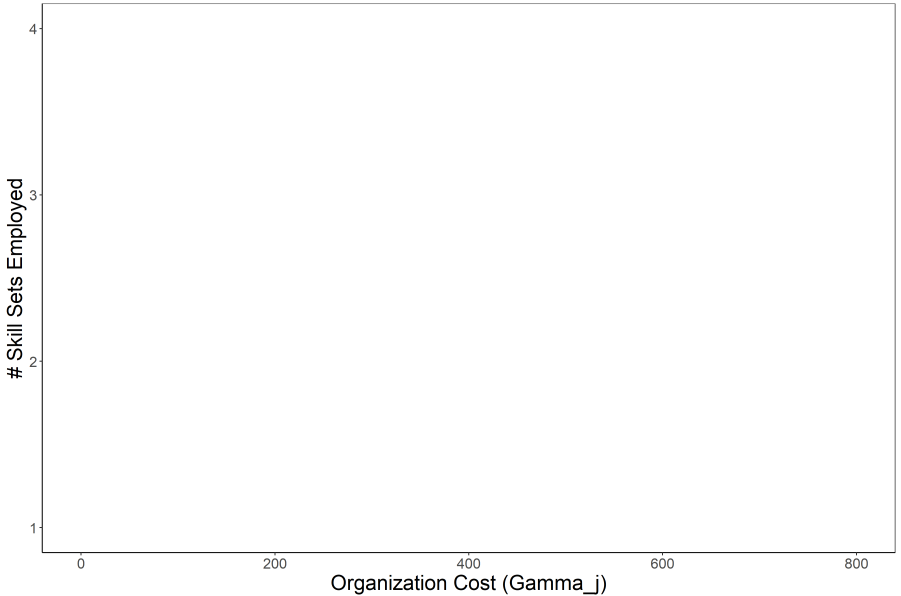
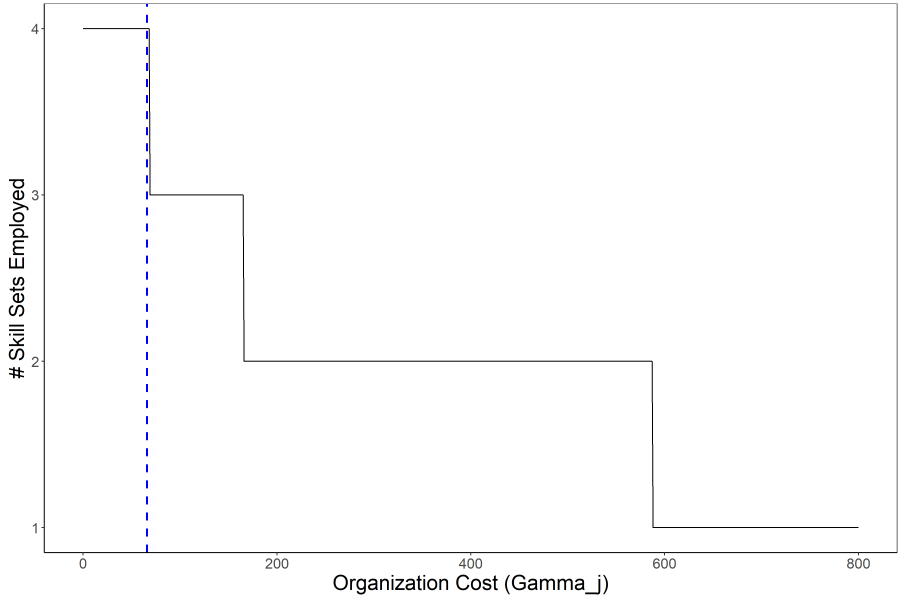


Table of Contents

The Workforce Expansion Path of a Salon

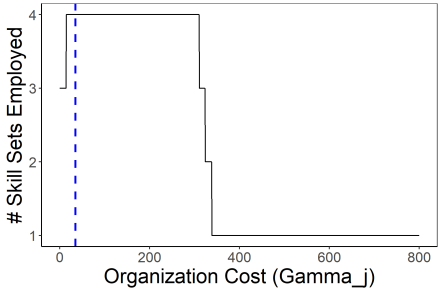


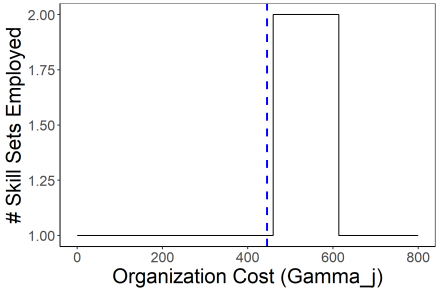
Classic Case: ↑ Productivity $\Longrightarrow$ ↑ Skill Sets

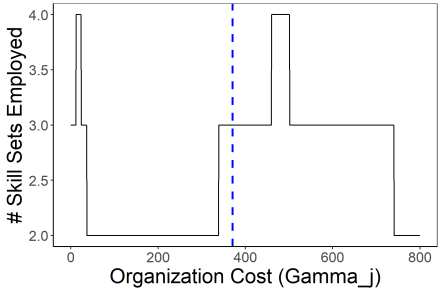


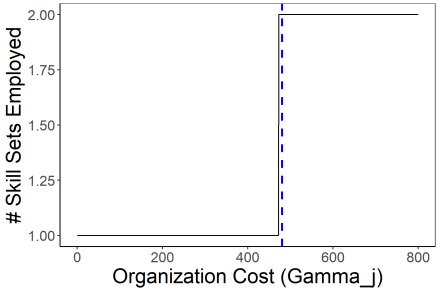
While the Classic Case is Common...

While the Classic Case is Common…So are Exceptions









Labor-Labor Substitution Patterns (Los Angeles)

	Skill Set 1			Skill Set 2			Skill Set 3			Skill Set 4			Skill Set 5		
Skill Set	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.
1	0.00	0.00	-0.52	0.05	0.00	-0.35	0.31	0.00	-0.16	0.33	0.00	-0.21	0.38	0.00	0.00
2	0.11	0.00	-0.18	0.00	0.00	-0.27	0.15	0.00	-0.20	0.18	0.00	0.00	0.00	0.00	-0.13
3	0.04	0.00	-0.15	0.10	0.00	-0.22	0.00	0.00	-0.22	0.14	0.00	-0.10	0.11	0.00	0.00
4	0.55	0.00	-0.33	0.52	0.00	0.00	0.42	0.00	-0.45	0.00	0.00	-0.52	0.41	0.00	-0.02
5	0.80	0.00	0.00	0.00	0.00	-0.39	0.48	0.00	0.00	0.54	0.00	-0.04	0.00	0.00	-0.61

Labor-Labor Substitution Patterns (Los Angeles)

	Skill Set 1			Skill Set 2			Skill Set 3			Skill Set 4			Skill Set 5		
Skill Set	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.
1	0.00	0.00	-0.52	0.05	0.00	-0.35	0.31	0.00	-0.16	0.33	0.00	-0.21	0.38	0.00	0.00
2	0.11	0.00	-0.18	0.00	0.00	-0.27	0.15	0.00	-0.20	0.18	0.00	0.00	0.00	0.00	-0.13
3	0.04	0.00	-0.15	0.10	0.00	-0.22	0.00	0.00	-0.22	0.14	0.00	-0.10	0.11	0.00	0.00
4	0.55	0.00	-0.33	0.52	0.00	0.00	0.42	0.00	-0.45	0.00	0.00	-0.52	0.41	0.00	-0.02
5	0.80	0.00	0.00	0.00	0.00	-0.39	0.48	0.00	0.00	0.54	0.00	-0.04	0.00	0.00	-0.61

- Recall: without org. costs, workers are perfect substitutes.
- Even with fixed task intensities in the same market, two workers can be complements at one firm and substitutes at another.
- In full equilibrium, shocks to one type of worker can have widely different implications for different firms.
- For workers, the impacts of a shock are NOT tied to their position in the original wage distribution.

Labor-Labor Substitution Patterns (Los Angeles)

	Skill Set 1			Skill Set 2			Skill Set 3			Skill Set 4			Skill Set 5		
Skill Set	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.
1	0.00	0.00	-0.52	0.05	0.00	-0.35	0.31	0.00	-0.16	0.33	0.00	-0.21	0.38	0.00	0.00
2	0.11	0.00	-0.18	0.00	0.00	-0.27	0.15	0.00	-0.20	0.18	0.00	0.00	0.00	0.00	-0.13
3	0.04	0.00	-0.15	0.10	0.00	-0.22	0.00	0.00	-0.22	0.14	0.00	-0.10	0.11	0.00	0.00
4	0.55	0.00	-0.33	0.52	0.00	0.00	0.42	0.00	-0.45	0.00	0.00	-0.52	0.41	0.00	-0.02
5	0.80	0.00	0.00	0.00	0.00	-0.39	0.48	0.00	0.00	0.54	0.00	-0.04	0.00	0.00	-0.61

- Recall: without org. costs, workers are perfect substitutes.
- Even with fixed task intensities in the same market, two workers can be complements at one firm and substitutes at another.
- In full equilibrium, shocks to one type of worker can have widely different implications for different firms.
- For workers, the impacts of a shock are NOT tied to their position in the original wage distribution.

Coworker Productivity Spillovers (New York)

	Skill Set 1			Skill Set 2			Skill Set 3			Skill Set 4			Skill Set 5		
Skill Set	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	-0.04	0.00	0.00	0.00	0.00	0.00	-0.05	0.01	0.00	0.00	0.01	0.00	0.00
4	0.01	0.00	-0.05	0.00	0.00	-0.02	0.00	0.00	-0.01	0.17	0.00	0.00	0.02	0.00	0.00
5	0.01	-0.01	-0.18	0.00	-0.01	-0.16	0.06	0.00	0.00	0.04	0.00	-0.02	0.17	0.01	0.00

Coworker Productivity Spillovers (New York)

	Skill Set 1			Skill Set 2			Skill Set 3			Skill Set 4			Skill Set 5		
Skill Set	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	-0.04	0.00	0.00	0.00	0.00	0.00	-0.05	0.01	0.00	0.00	0.01	0.00	0.00
4	0.01	0.00	-0.05	0.00	0.00	-0.02	0.00	0.00	-0.01	0.17	0.00	0.00	0.02	0.00	0.00
5	0.01	-0.01	-0.18	0.00	-0.01	-0.16	0.06	0.00	0.00	0.04	0.00	-0.02	0.17	0.01	0.00

- Own-wage increases tend to increase own productivity (purifying effect).
  - More expensive retained workers are assigned tasks at which they have an advantage.
- Coworker wage increases tend to decrease productivity (sullying effect)
  - As firms layoff workers, coworkers must pick up the slack.
  - The color specialist has to start cutting hair!

Coworker Productivity Spillovers (New York)

	Skill Set 1			Skill Set 2			Skill Set 3			Skill Set 4			Skill Set 5		
Skill Set	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	-0.04	0.00	0.00	0.00	0.00	0.00	-0.05	0.01	0.00	0.00	0.01	0.00	0.00
4	0.01	0.00	-0.05	0.00	0.00	-0.02	0.00	0.00	-0.01	0.17	0.00	0.00	0.02	0.00	0.00
5	0.01	-0.01	-0.18	0.00	-0.01	-0.16	0.06	0.00	0.00	0.04	0.00	-0.02	0.17	0.01	0.00

- Own-wage increases tend to increase own productivity (purifying effect).
  - More expensive retained workers are assigned tasks at which they have an advantage.
- Coworker wage increases tend to decrease productivity (sullying effect)
  - As firms layoff workers, coworkers must pick up the slack.
  - The color specialist has to start cutting hair!

Table of Contents

Reallocation vs. Reorganization

- Reallocation equilibrium: allow firms to adjust prices, but not relative labor demand and task assignments.
  - Firms can adjust the quantity of labor hired but not the composition or utilization of their workforce.
  - This captures how heterogeneity in initial internal organization reallocates labor.
  - Reallocation effects exist in most heterogeneous firm models.
- Reorganization (full) equilibrium: adjustment of prices, relative labor demand and task assignments.
  - Firms can fully adjust, but due to different org. costs all adjust differently.
  - This captures how reorganization within the firm impacts aggregate productivity.
  - Allowing firms to differ in their reorganization is novel.

Counterfactual Shocks

- **Sales Tax Increase.** 4 percentage point increase of the tax on salon services.
- **Management Diffusion.** Each salon learns and then adopts the management practices of the next best salon.
- **Immigration.** 10% increase in the total labor supply of the lowest wage skill set.
- **Increase in Market Concentration.** Half of the salons in each market are removed.[1]

1. This is similar to merging salons with the same characteristics.

Counterfactual Productivity and Specialization Changes

		Reallocation		Reorganization	
County	Counterfactual	S-Index Change	Prod. Change	S-Index Change	Prod. Change
Cook	Immigration	-0.017	0.006	0.017	0.018
New York	Immigration	-0.030	0.015	-0.018	0.015
Los Angeles	Immigration	-0.014	-0.002	0.004	0.022
Cook	Incr. Concentration	0.000	0.000	0.010	0.003
New York	Incr. Concentration	0.000	0.000	-0.013	0.005
Los Angeles	Incr. Concentration	0.002	0.001	-0.008	-0.019
Cook	Management Diffusion	0.000	0.000	0.010	0.000
New York	Management Diffusion	0.000	0.000	0.007	0.000
Los Angeles	Management Diffusion	0.001	0.001	0.045	0.011
Cook	Sales Tax	0.000	0.000	-0.010	-0.002
New York	Sales Tax	0.000	0.000	0.007	-0.006
Los Angeles	Sales Tax	0.000	0.001	-0.047	-0.007

Note: Effects are percent changes from the baseline equilibrium.

Taking Stock of Counterfactuals

- Neglecting reorganization tends to underestimate productivity impacts.
- For immigration, it reverses the sign.
- Aggregate productivity effects mask heterogeneity by worker skills.
- Management diffusion in Los Angeles leads to aggregate $+1.1\%$ but...
  - $+0.6\%$ for skill set 1
  - $+0.0\%$ for skill set 2
  - -1.2% for skill set 3
  - $+2.5\%$ for skill set 4
  - $+1.8\%$ for skill set 5

Conclusion

- **Evidence** of a link between task specialization within the firm and productivity.
- **A model** where organizationally unique firms assign tasks in order to compete.
- **Constructive identification** using task assignment data.
- **Partial equilibrium counterfactuals** go against standard economic intuition.
- **Full equilibrium counterfactuals** show new aggregate productivity implications.