The Inner Beauty of Firms

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Pin Factories in 18th Century France

Adam Smith in *The Wealth of Nations*

"One man draws out the wire, another straights it, a third cuts it, a fourth points it...Those ten persons, therefore, could make among them upwards of forty-eight thousand pins in a day...But if they had all wrought separately and independently...they certainly could not each of them have made twenty, perhaps not one pin in a day"

- There was a spectrum of specialization across competing workshops.
- There were both specialists and generalists in the "pin" labor market.
- Pin makers tried to subdivide the longest task, but ultimately found a single worker more efficient.

Hair Salons in 21st Century Los Angeles

Westwood Barber Shop

[redacted]
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.

[redacted]
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

[redacted]
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.

[redacted]
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.

Summary of Paper

1. Do similar firms assign tasks similarly?

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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 at 1 firm and substitutes at another. Workforce skill diversity does not always rise with productivity. (Industry Equilibrium) These imply a sales tax cut raises productivity and a min. wage hike generates new wage spillovers.

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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

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- Tasks 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.

What is an Organization?

Definition

A firm's organization (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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Tasks

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

Worker Share (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)

Worker Share (E)

Measuring Internal Task-Specialization

Construct a generalist benchmark ($B^G(i,k)$):

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				
B				
C				
Tot.				

Worker Share (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
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	Tasks			
	Cut	Color	Dry	
A				
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Measuring Internal Task-Specialization

Hold fix who is employed (worker share):

Tasks

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

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Measuring Internal Task-Specialization

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

Tasks

	Cut	Color	Dry	
A	.1	.2	.1	.4
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Tasks

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Worker Share (E)

Task-Mix (α)

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:

$$\underbrace{I(B, B^G)}_{\text{Kullback-Leibler divergence}} := \sum_{i,k} B(i,k) log\left(\frac{B(i,k)}{.B^G(i,k)}\right)$$

The S-index

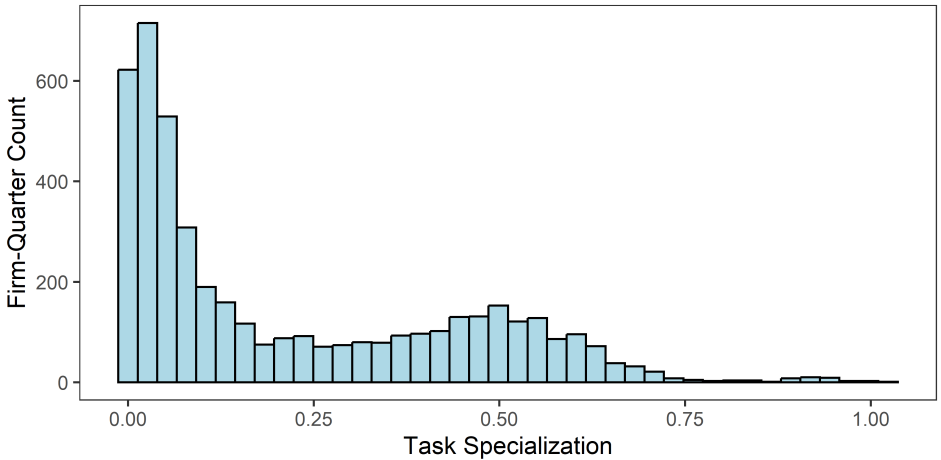
A firm is task-specialized if it is "far" from the counterfactual generalist firm.

Definition 2

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

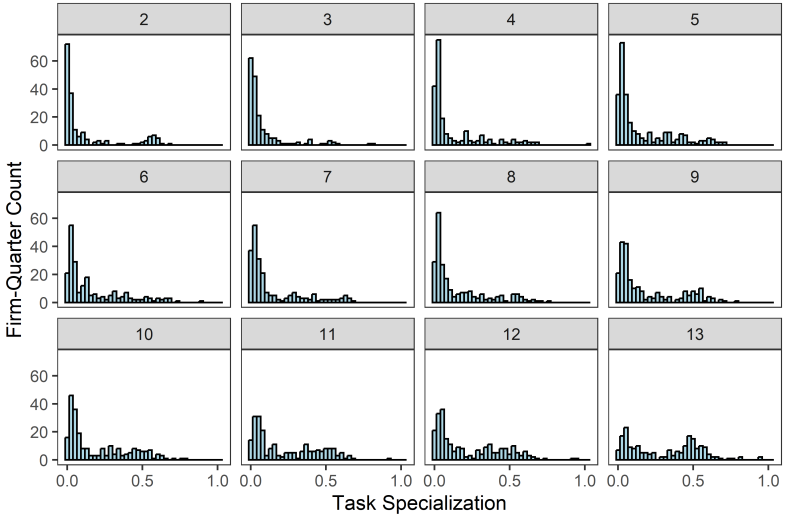
$$\underbrace{I(B, B^G)}_{\text{Kullback-Leibler divergence}} := \sum_{i,k} B(i,k) log\left(\frac{B(i,k)}{\underbrace{\alpha_k}_{\text{task-mix}} \cdot \underbrace{E_i}_{\text{labor demand}}}\right)$$

Fact 1: The S-index (Roughly) Follows a Power Law



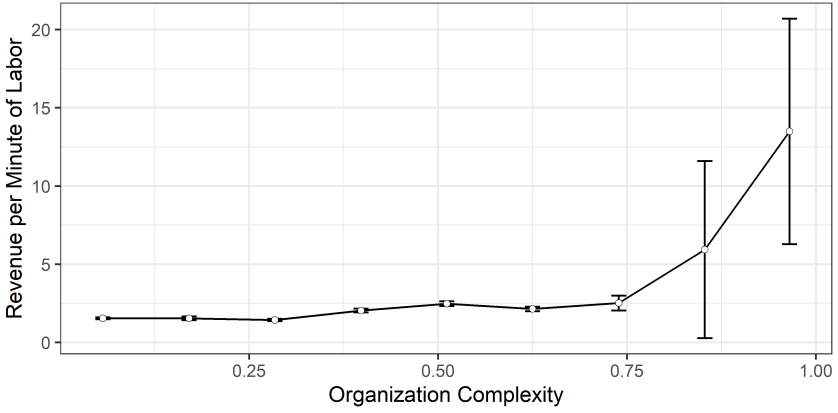
Takeaway: Specialization is heterogeneous, and full specialization rarely occurs.

Fact 1: The S-Index (Roughly) Follows a Power Law



Takeaway: The power-law persists even within firm size.

Fact 2: High S-index Salons are More Productive



Regression Version

Takeaway: A 1 std. dev. increase in the s-index is associated with a $0.50-$0.80 increase in revenue per minute of labor.

Fact 3: The S-Index is Correlated with Other Potentially Productive Management Practices

Outcome	No FE	FE
Teamwork	0.738	0.653
	(.044)	(.049)
Unique Service Names	0.145	0.114
	(.053)	(.048)
Unique Discounts	0.182	0.102
	(.064)	(.044)
Prebook Adoption	-0.279	-0.189
	(.048)	(.169)
Tip Adoption	-0.307	-0.323
	(.055)	(.212)
Staff Requested Adoption	-0.080	0.100
	(.040)	(.173)

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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 $A_j \in \mathbb{R}_+^M \times \mathbb{R}_+^K$ (how each worker spends 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 A is γ_j times minimum info. required to communicate A 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 assignment

Equilibrium

- Firm strategies $\{p_j, E_j, A_j\}_{j=1}^{J}$ 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

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Communication is Task-Specialization

Proposition

The communication required to implement the profit-maximizing B^* is equal to the observed s-index. Both are strictly decreasing in γ_j for all values of firm-level heterogeneity $(\alpha_j, \nu_j, \omega_j)$ until they reach 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

Simple Example

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

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

- Wage-adjusted quality:

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

Equilibrium Worker Jobs

Definition

A worker's job is their distribution of time across tasks.

Theorem

The job and 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.*

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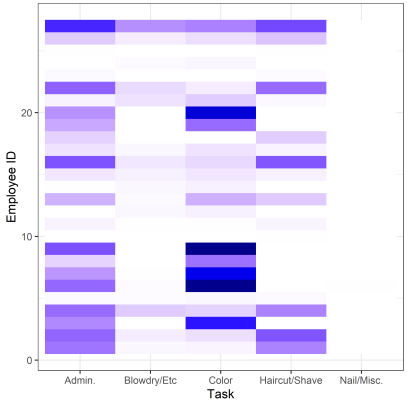
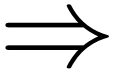
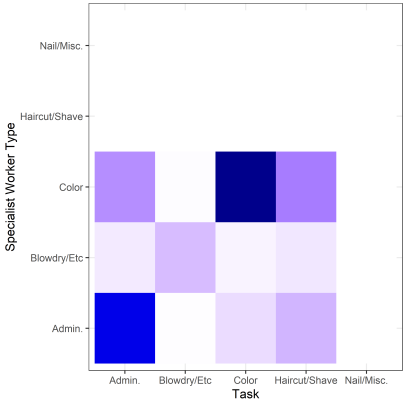
Worker Skills are Unobserved, So B_j^* is Unobserved



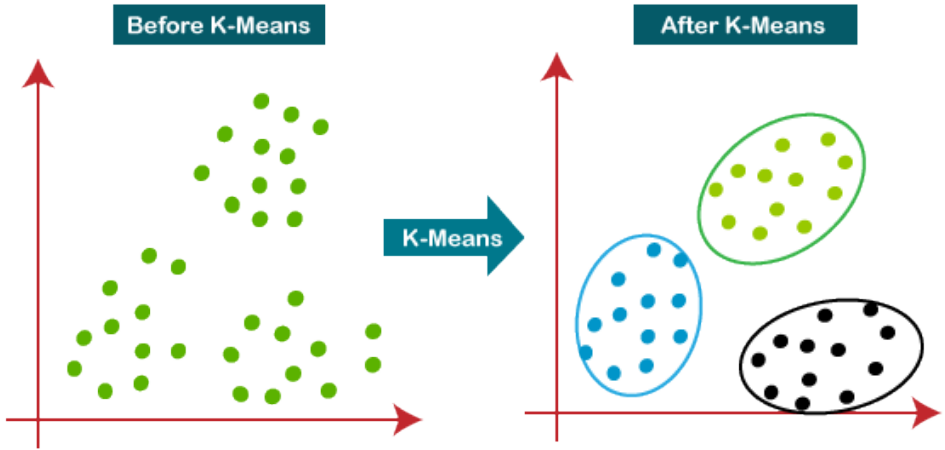




What We Have (jobs $b_j(m)$)

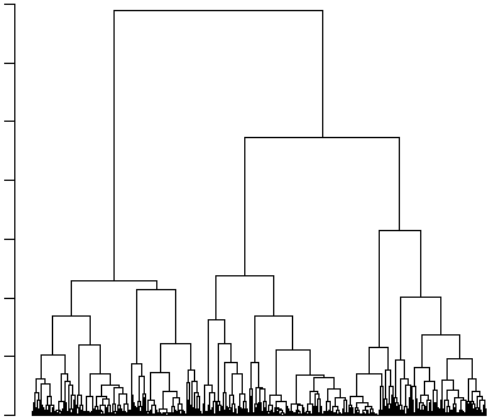
What We Want (B_j^*)

Classifying Workers Within Firms

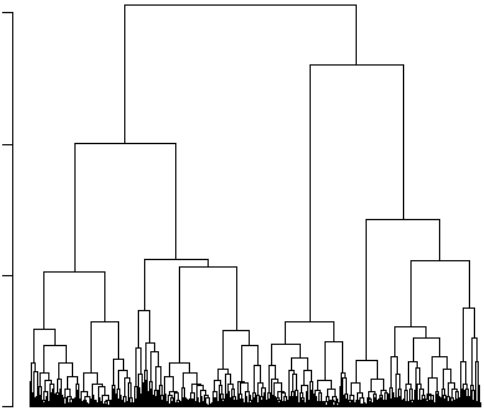


Illustrative Image. Source: Pranshu Sharma, Analytics Vidha

Classifying Workers Across Firms

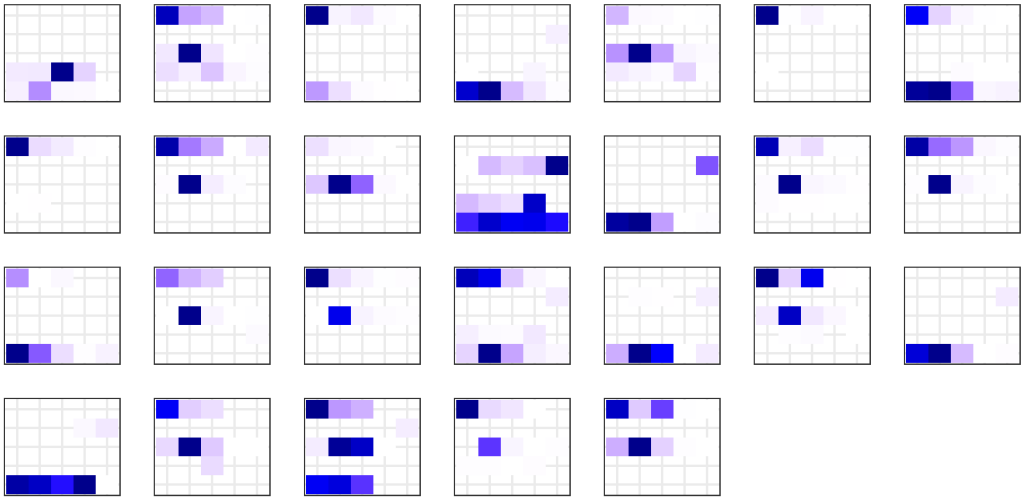


Manhattan (2018-2021)

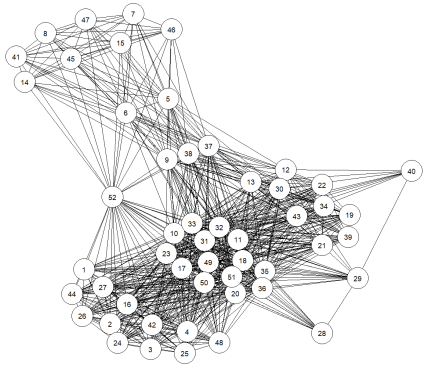


Los Angeles (2018-2021)

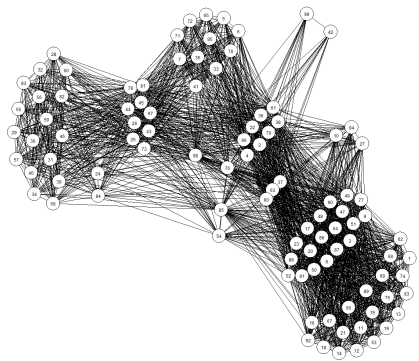
Organizations are Now Data



Communication Cost (γ_j) By "Leaping" Across Firms



Manhattan (2019 Q1-Q4)



Los Angeles (2019 Q1-Q4)

After this estimation is basically two linear regressions!

Summary of Estimation Procedure

- Cluster workers within firm based on their job's task content.
- Cluster workers across firms using their job's task content relative to coworkers.
- Obtain relative org. costs of a connected set of firms.
- Estimate Θ, ρ via 2SLS of relative market shares on prices and orgs.
- Estimate wages and material costs using OLS of relative market shares on prices and orgs.
- Invert s-index via contraction mapping to get γ_j for set-aside firms.

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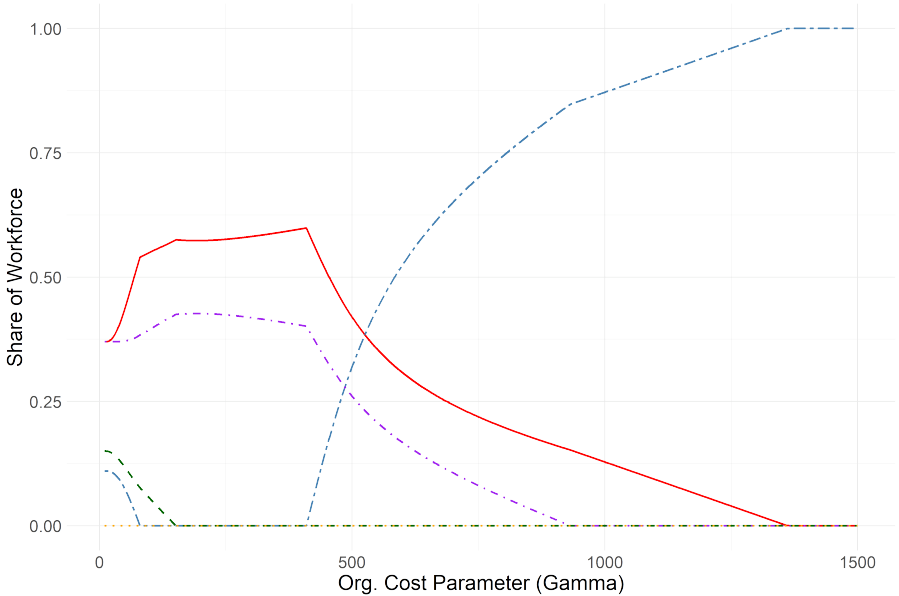
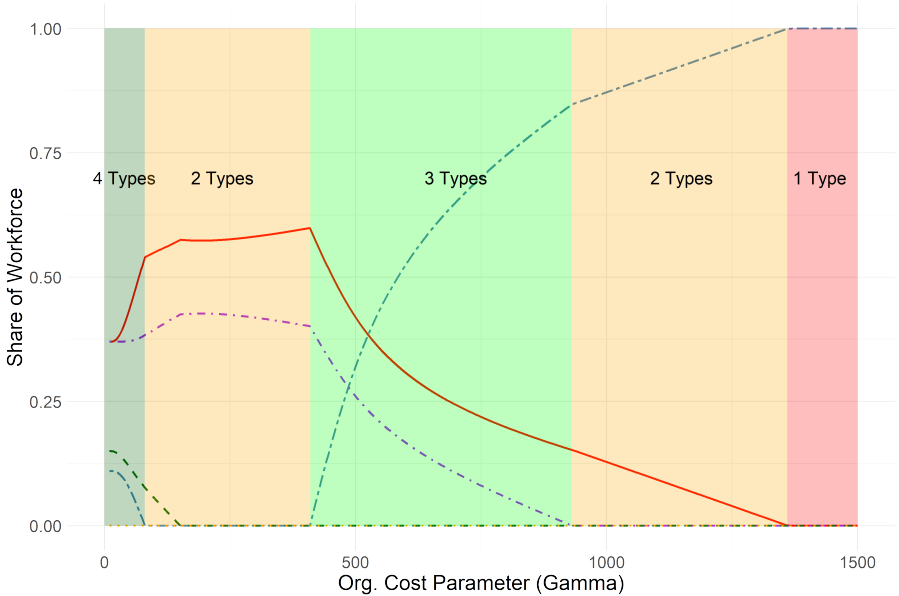
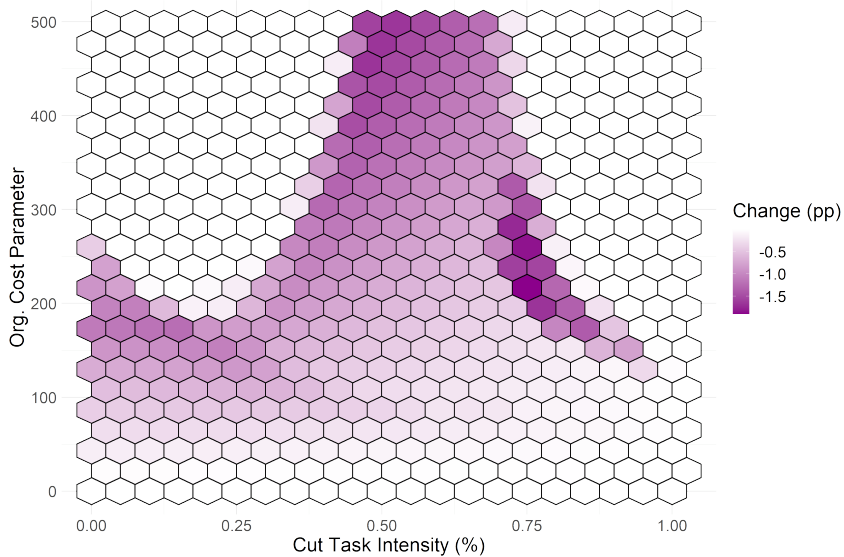
Workforce Diversity



Workforce Diversity

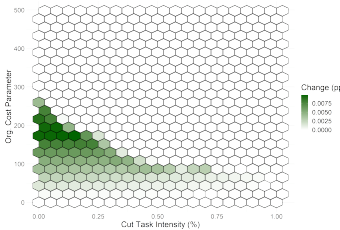


Own Wage Elasticity of Labor Demand

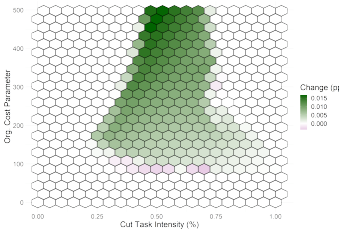


From a $1 increase in Skill Set 5's wage.

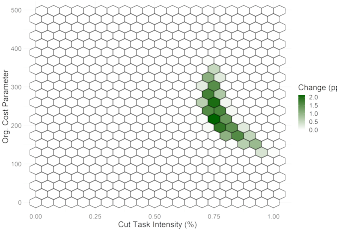
Cross Wage Elasticity of Labor Demand



Skill Set 1



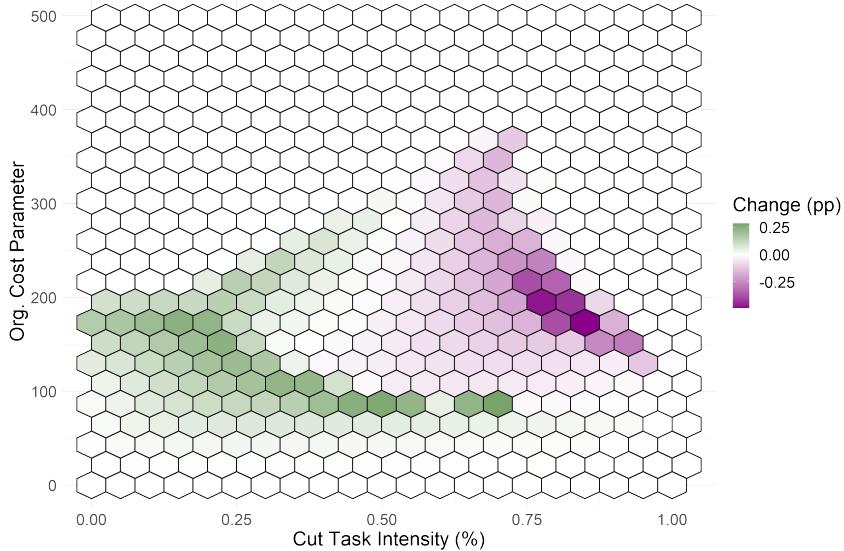
Skill Set 2



Skill Set 3

From a $1 increase in Skill Set 5's wage.

Complements at Some, Substitutes at Others



From a $1 increase in Skill Set 5's wage.