The Inner Beauty of Firms

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June 25, 2024

Motivation

► There are productivity differences across similar firms.

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Coase, (1928) *The Nature of the Firm*

"As D. H. Robertson points out, we find 'islands of conscious power in this ocean of unconscious co-operation like lumps of butter coagulating in a pail of buttermilk.'"

▶ One aspect of "conscious power" is the assignment of tasks within the firm.

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"As D. H. Robertson points out, we find 'islands of conscious power in this ocean of unconscious co-operation like lumps of butter coagulating in a pail of buttermilk.'"

- ▶ One aspect of "conscious power" is the assignment of tasks within the firm.

- ▶ Long literature in organizational economics suggests firms will differ in their ability to exert "conscious power."

Two Research Questions

▶ Can task assignments within the firm explain productivity differences?

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▶ If firms decide how to assign work, and they differ in their ability to do so, how do the impacts of traditional economic policies change?

Summary of Paper

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     Answer: Specialized salons are more productive because they produce higher quality services.

3. How does heterogeneous and endogenous internal organization shape 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 in the same market. (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:

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

Tasks

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
Tot.	.4	.35	.25	

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

Worker Share (E)

Task-Mix (α)

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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Task-Mix (α)

Worker Share (E)

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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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 Follows a Power Law
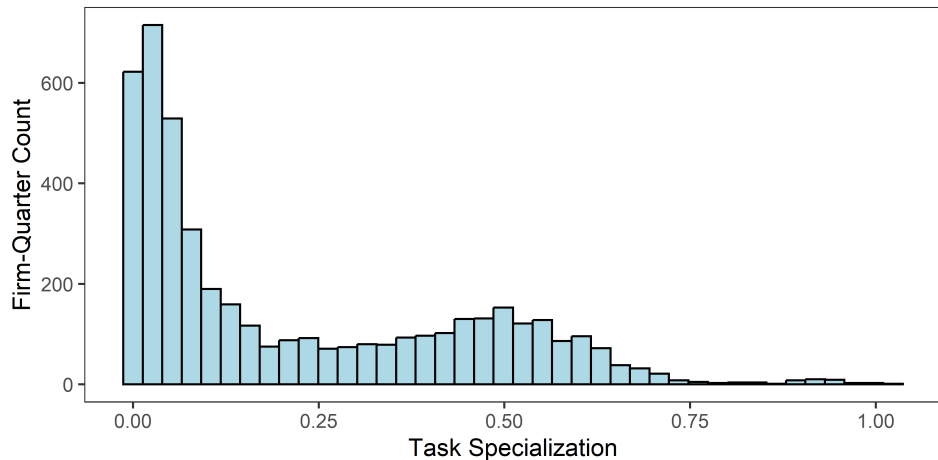
Takeaway: Specialization is heterogeneous, and full specialization rarely occurs.

Fact 1: The S-Index Follows a Power Law
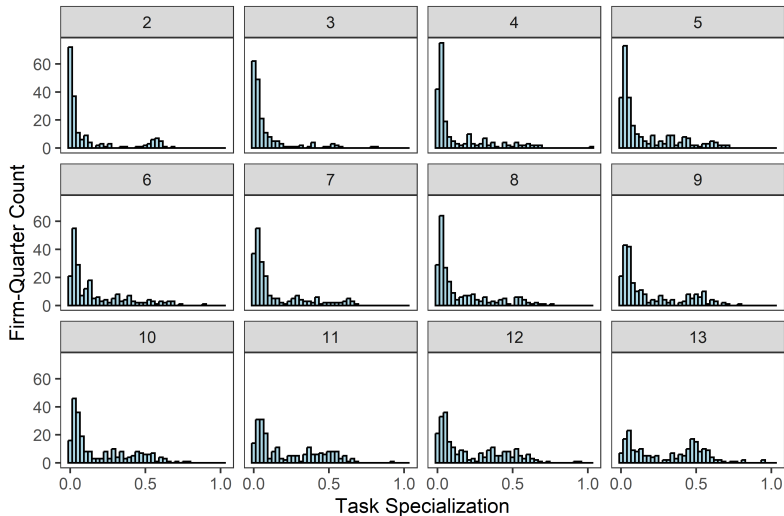
Takeaway: The power-law persists even within firm size.

Fact 2: Task Specialized Salons are More Productive
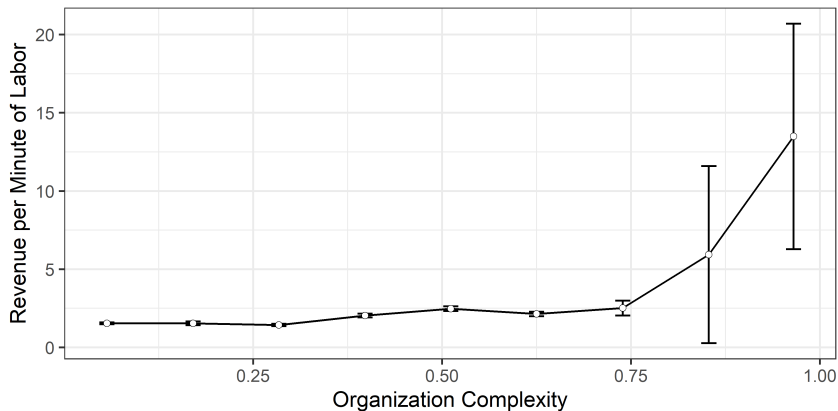
Regression Version   Was Staff Requested?

Takeaway: Specialized salons appear more productive even among a selected subset of peers.

Fact 3: Task-specialized salons produce higher quality services
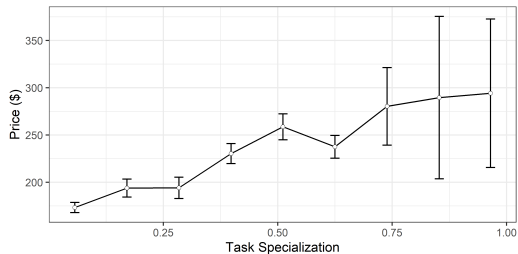
(a) Prices
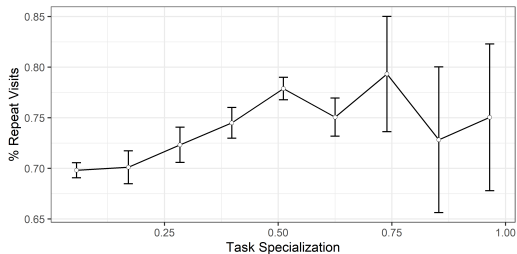
(b) Repeat Customers

Manhattan Only   Within Firm Size   Within-Visit Specialization

Takeaway: Specialization-productivity relationship is mediated by quality upgrading rather than marginal cost reductions. Theory

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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
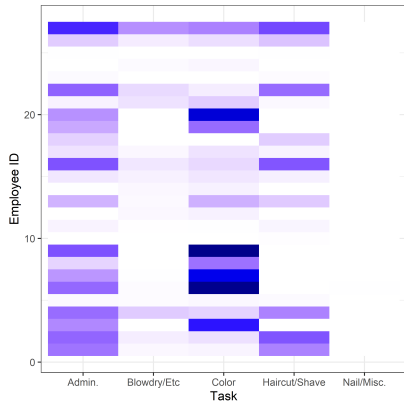
What We Have (jobs $b_j(m)$)   What We Want (B_j^*)
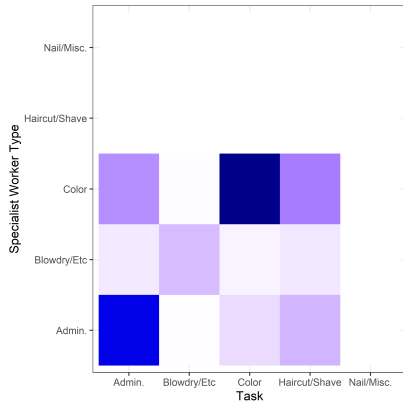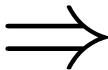
Classifying Workers Within Firms
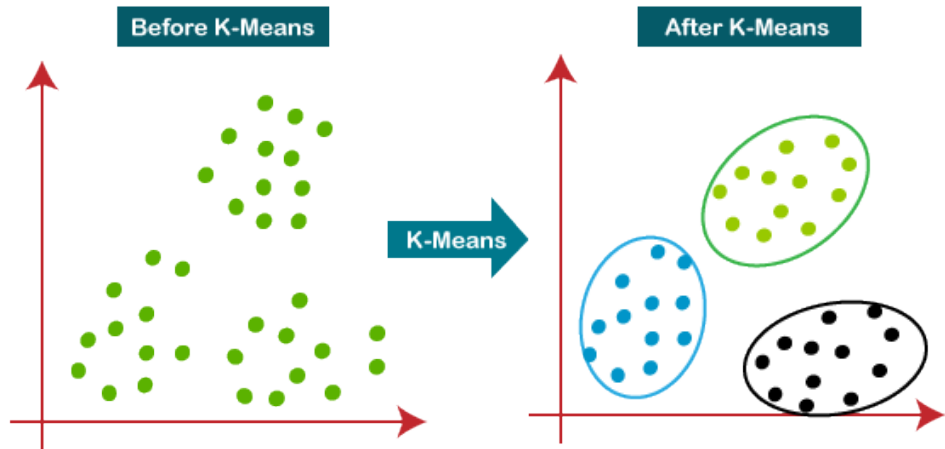
Illustrative Image. Source: Pranshu Sharma, Analytics Vidha

Classifying Workers Across Firms
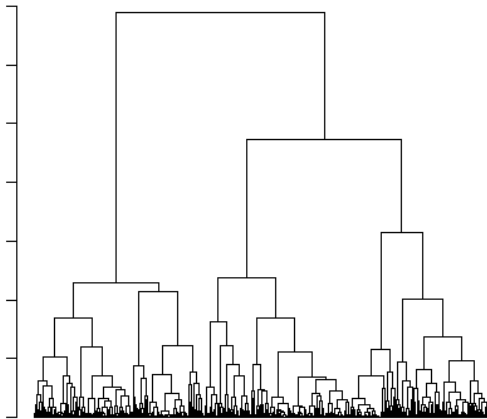
Manhattan (2018-2021)　　　　Los Angeles (2018-2021)
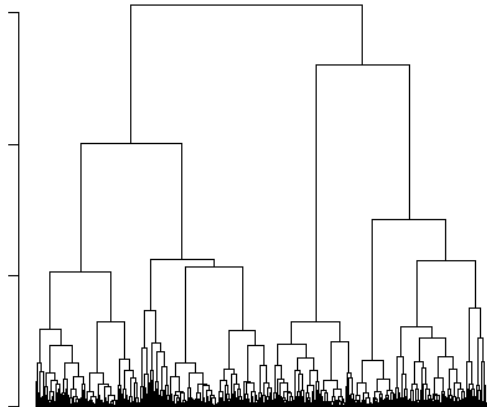
Organizations are Now Data
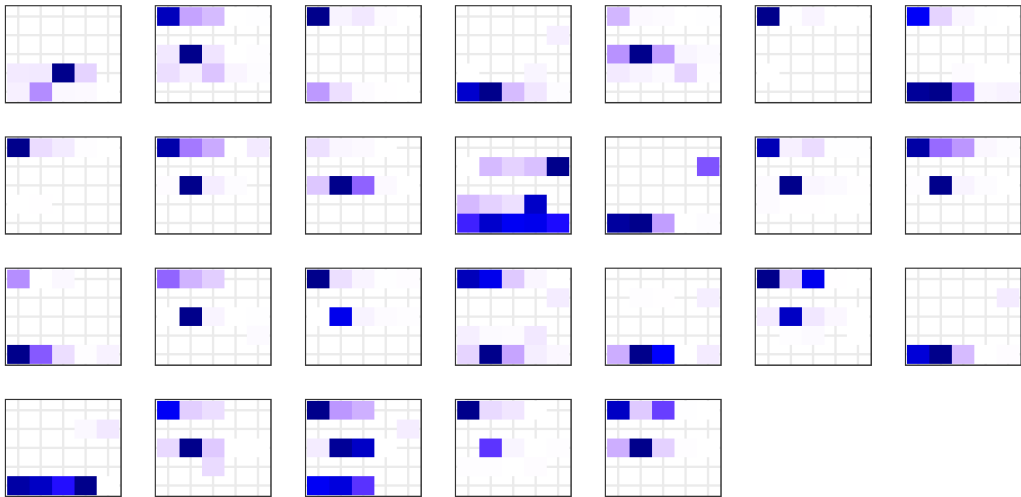
Communication Cost (γ_j) By "Leaping" Across Firms
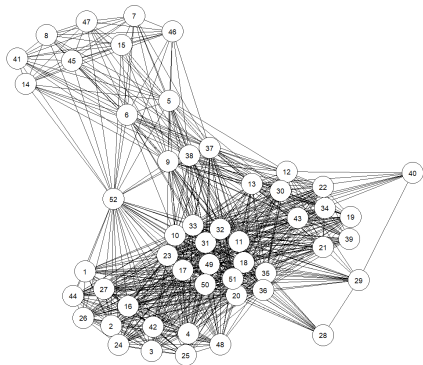
Manhattan (2019 Q1-Q4)   Los Angeles (2019 Q1-Q4)
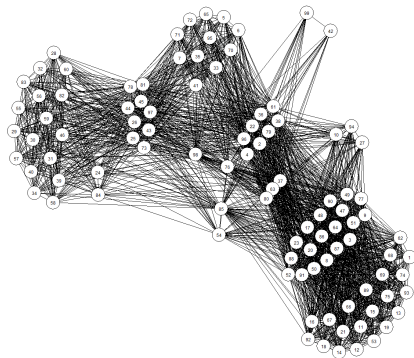
After this estimation is basically two linear regressions!

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
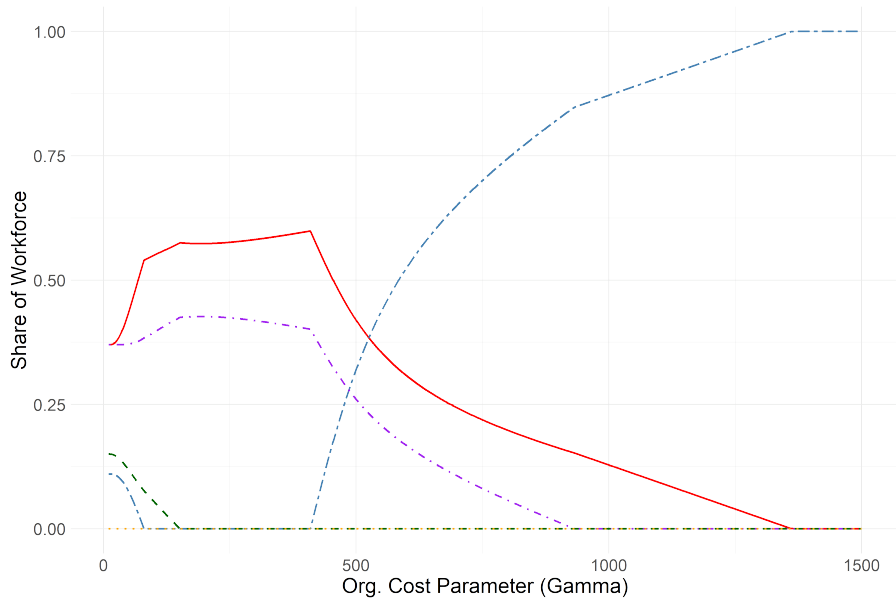
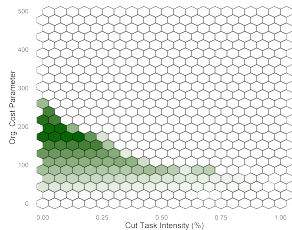# Workforce Diversity
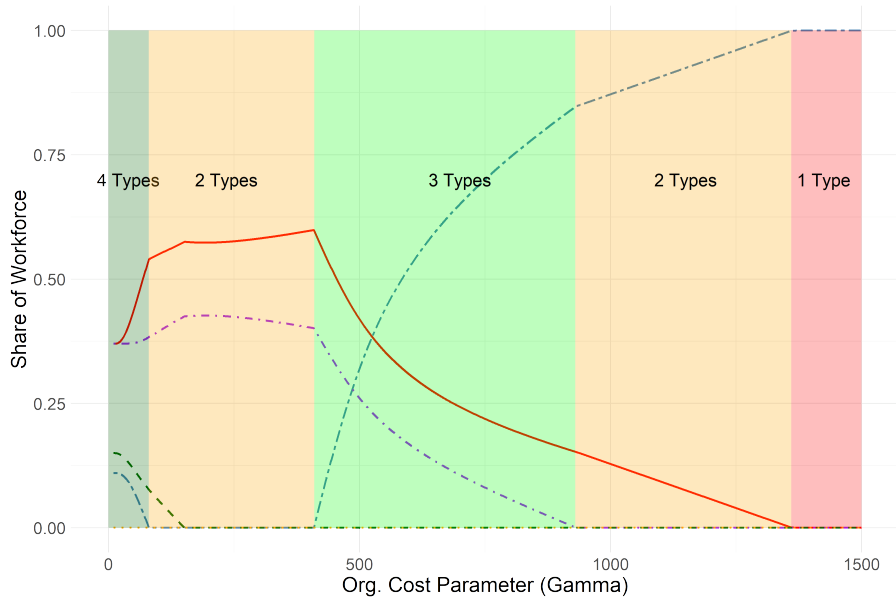
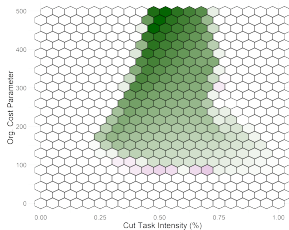# Own Wage Elasticity of Labor Demand
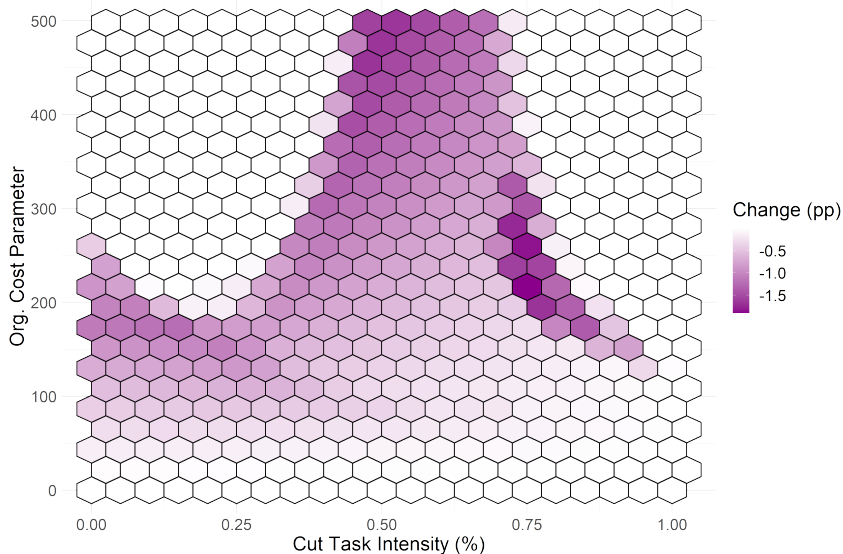
From a $1 increase in Skill Set 5's wage.
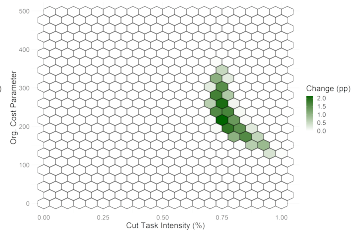
Cross Wage Elasticity of Labor Demand
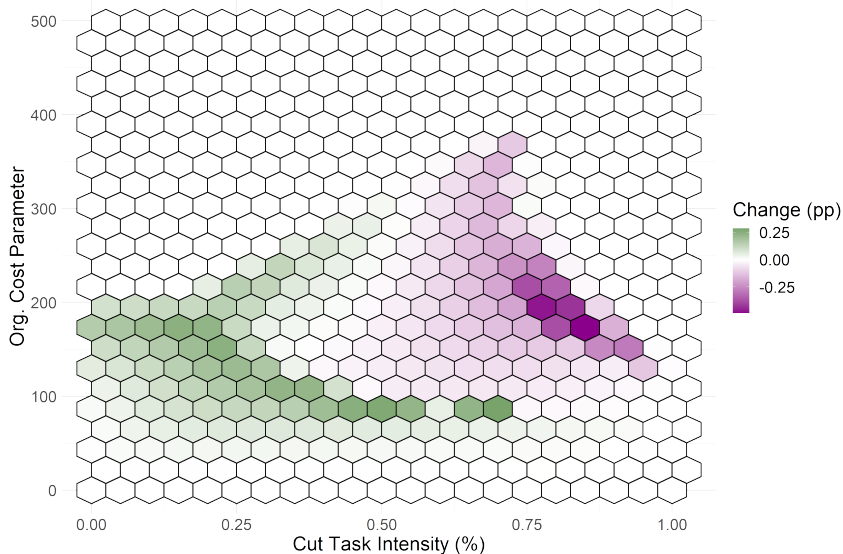

Skill Set 1   Skill Set 2   Skill Set 3

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.