The Granular Origins of Aggolomeration

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December 15, 2023
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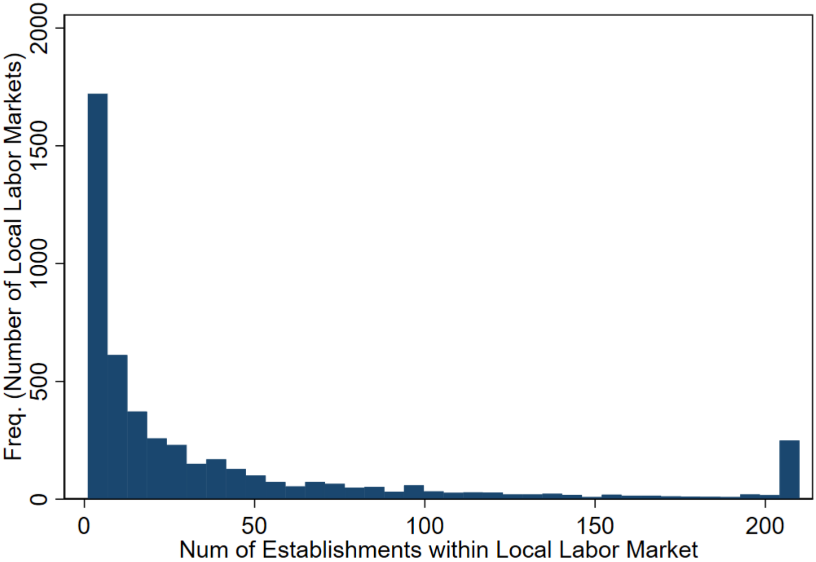
Median Local Labor Market has 13 Plants



Note* Cut at top 5% percentile of 210

Motivation

- Individual firms play a key role in local labor markets
  - Kodak in Rochester, Toyota in Toyota, Microsoft for engineers in Seattle
  - Japanese local labor market (2-digit mfg $\times$ CZ): median of 13 plants
    - Percentiles: p25=3, p10=1
    - 3-digit $\times$ CZ: p50=3, p25=1
- Firm-specific shocks can have a big impact on the whole labor market
  - People can end up unemployed because a single firm had a bad year
  - Firms can have a tough time finding workers to expand

What We do

1. A new model of a local labor market with a finite number of firms subject to idiosyncratic shocks
   - Show that there are increasing returns to scale
   - Derive three testable empirical predictions that speak directly to the mechanism

2. Tests of the empirical predictions in Japanese administrative data
   - The variance of the log wage bill decreases in the size of the labor market
   - The variance of log firm employment increases in the size of the labor market
   - Firms with a larger employment share respond less to demand shocks

3. A quantitative model of economic geography to quantify the mechanism

Related Literature

- Labor Market Pooling: Theory: Marshall (1890), Krugman (1991), Duranton and Puga (2004), Stahl and Walz (2001); Empirics: Overman and Puga (2010), Nakajima and Okazaki (2012), Almeida and Rocha (2018)
  This paper: Stylized model for empirical predictions, direct quantification of the mechanism
- Granularity: Gabaix (2011), Hottman, Redding, Weinstein (2016), Gaubert and Itskhoki (2021)
  This paper: Spatial implications, relevant for medium-sized cities, not just small towns
- Job Search in Large/Thick Markets: Moretti and Yi (WP), Andersson et al. (2014), Gan and Zhang (2006)
  This paper: Similar implications, different mechanism
- Japan: Nakamura (1985), Tabuchi and Yoshida (2000), Nakajima et al. (2012), Miyauchi (2018)

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Baseline Model

The Model

- Small, open region with E establishments (firms) and a mass ℓ of workers
- **Ex-ante** homogeneous firms (for now)
- In a pre-period, the state of the world $s \in \mathcal{S}$ is revealed which determines firm productivity
- Firms then choose labor to maximize profits taking wages and prices as given

$$\ell_e(s) \in \underset{\ell'}{\operatorname{argmax}} \quad a_e(s) f\left(\ell'\right) - w(s)\ell'$$

  where $a_e(s)$ are iid across firms, $f(x) = x^\eta$
- Workers inelastically supply labor

$$\ell = \sum_e \ell_e(s)$$

Today's Plan

Baseline Model

- Model Characterization
- Empirical Prediction

Empirical Evidence

- Data
- Facts across Local Labor Market
- Causal Analysis across Establishments

Quantitative Model of Granularity

- Model
- Calibration

Characterization: Expected Production

- Labor demand is characterized by the FOC

$$a_e(s)f'(\ell_e(s)) = w(s)$$

- Wages adjust to clear the labor market in every state of the world s

$$w(s) = \eta\ell^{\eta-1}\left[\sum_{e\in\mathcal{E}}(z_e a_e(s))^{\frac{1}{1-\eta}}\right]^{1-\eta}$$

- Then expected production is

$$Y(\ell,\mathcal{E}) = \mathbb{E}\left[\ell^{\eta}\left[\sum_{e\in\mathcal{E}}(z_e a_e(s))^{\frac{1}{1-\eta}}\right]^{1-\eta}\right]$$

Increasing returns to scale

Proposition

If $Var(a_e(s)) > 0$, then expected production has increasing returns to scale.
In math, for any $\ell > 0$, $E \in \mathbb{N}$, and $\alpha > 1$ so that $\alpha E \in \mathbb{N}$,

$$Y(\alpha\ell, \alpha E) > \alpha Y(\ell, E).$$

Comments:

- Larger markets are more productive!
- Without uncertainty, no benefit to being in a larger labor market

Sketch of proof when $\alpha = 2$

- Two separate labor markets each with E establishments and ℓ workers $\implies$ double the production.
- The competitive equilibrium is efficient so if we can do better, the market will do better.
- Idiosyncratic firm shocks $\implies$ sometimes the wages in labor market 1 will be higher
- Move a small number of workers from labor market 2 to labor market 1 when wages are higher. This must increase production.

Firm Side Intuition: In response to shock to $a_e(s)$

- Recall labor demand is

$$a_e(s)f'(\ell_e(s)) = w(s)$$

Firm Side Intuition: In response to shock to $a_e(s)$

- Recall labor demand is
$$a_e(s)f'(\ell_e(s)) = w(s)$$
- Suppose that there is one firm. It must always hire everyone even if unproductive
$$a_e(s)f'(\ell) = w(s)$$

Firm Side Intuition: In response to shock to $a_e(s)$

- Recall labor demand is
$$a_e(s)f'(\ell_e(s)) = w(s)$$
- Suppose that there is one firm. It must always hire everyone even if unproductive
$$a_e(s)f'(\ell) = w(s)$$
- Suppose that there are many firms so that wages are constant. Firms can adjust labor as they wish
$$a_e(s)f'(\ell_e(s)) = w$$

Disappearing Agglomeration

Proposition

As the labor market becomes infinitely large, production converges to constant returns to scale.
In math, suppose that $\ell > 0$, $E > 0$ *and* $\alpha > 1$. *Then*

$$\frac{Y(\alpha\kappa\ell, \alpha\kappa E)}{\alpha Y(\kappa\ell, \kappa E)} \to 1$$

as $\kappa \to \infty$.

Comments:

- By using models with a continuum of firms, we miss this force.
- The agglomeration force is not log-linear

New Reason for Spatial Policy

Proposition

Adding new firms increases expected production more than the profits those firms would earn.
In math, for $\alpha > 1$,

$$\mathbb{E}[\sum_{e \in \alpha\mathcal{E} \setminus \mathcal{E}} \pi_e(s)] < Y(\ell, \alpha\mathcal{E}) - Y(\ell, \mathcal{E}),$$

where $\pi_e(s) = z_e a_e(s) \ell_e(s)^{\eta} - w(s)\ell_e(s)$ *are the profits earned when there are* $\alpha\mathcal{E}$ *set of firms operating.*

Comments:

- If the firm entry is somewhat elastic, under-entry
- Violates FWT because it's not Walrasian entry: firms internalize the increase in wages when they enter

Today's Plan

Baseline Model
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- Empirical Prediction

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- Causal Analysis across Establishments

Quantitative Model of Granularity
- Model
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Cross-sectional Implications of the Model

Proposition

To a first-order log-linear approximation around a symmetric equilibrium:

- *The variance of log wage bill is decreasing E:*

$$Var(\log w(s)\ell) \approx \frac{\sigma^2}{E};$$

- *The variance of log employment for an establishment is increasing in E:*

$$Var(\log \ell_e(s)) \approx \frac{\sigma^2}{(1-\eta)^2}\left(1 - \frac{1}{E}\right)$$

where $\sigma^2 = var(\log a_e(s))$.

Comparative Statics Implied by the Model

Proposition

In response to a productivity shock, firms that have a larger share of the labor market expand less.
In math:

$$\Delta \log \ell_e(s) \approx \frac{1}{1-\eta}\left[1-\mu_e\right] \Delta \log a_e(s)$$

where $\mu_e = \frac{\ell_e(s)}{\sum_{e'} \ell_{e'}(s)}$ *is the share of labor hired by establishment* e

Comments:

- In larger labor markets, firms are a smaller share of the market and so can expand without issue

Robustness

- Imperfect mobility across establishments and labor markets ▸ Details
- Monopsony power ▸ Details
- Labor hoarding/employer insurance ▸ Details
- Wage rigidity ▸ Details

Empirical Evidence

Today's Plan

Data

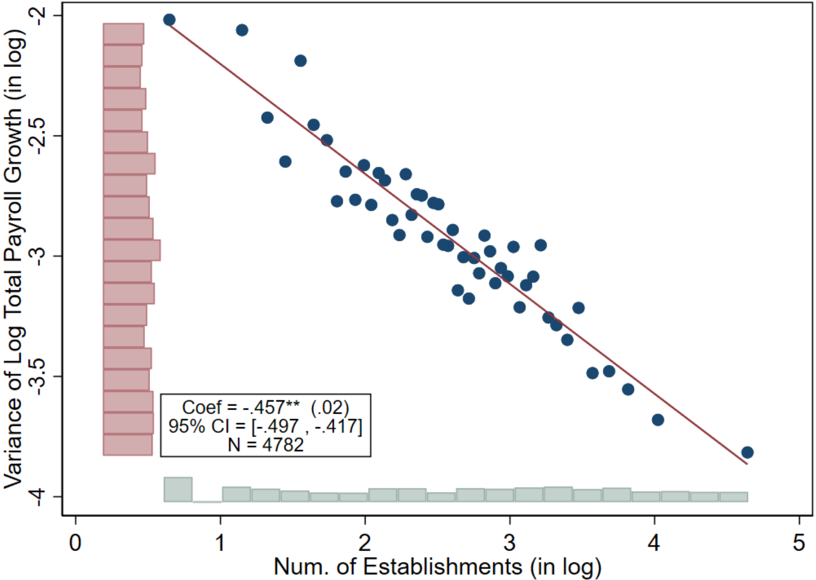
- Japanese Census of Manufactures (CoM)
  - Annual survey of all manufacturing establishments with at least 4 employees
  - For 2011, 2016 (Economic Census)
  - Employment, product sales, export sales by establishment
- Sample Construction: 724,417 unique establishments
  - 1986-2016
  - Manufacturing
  - Must appear for at least 5 years consecutively
- Local Labor Market:
  - JSIC 2 digit manufacturing industry $\times$ commuting zone
  - 25 unique 2-digit manufacturing industries
  - 256 commuting zones

Today's Plan

Fact 1: Volatility of Log Total Payment to Labor

- For each LLM,
  - Compute one-year log growth of total payroll in each year
  - Take LLM-level variance over time
- Correlation with number of establishments in each LLM

Fact 1: Volatility of Log Total Payment to Labor ▸ HHI



Fact 2: Volatility of Establishment-level Employment

- Establishments in larger markets adjust employment more flexibly?
  - Variance of log growth in establishment-level employment
- First residualize estab. yearly employment year FEs

$$\ln \ell_{e,t} = \eta_t + \varepsilon^{\ell}_{e,t}$$

- Second, compute yearly change

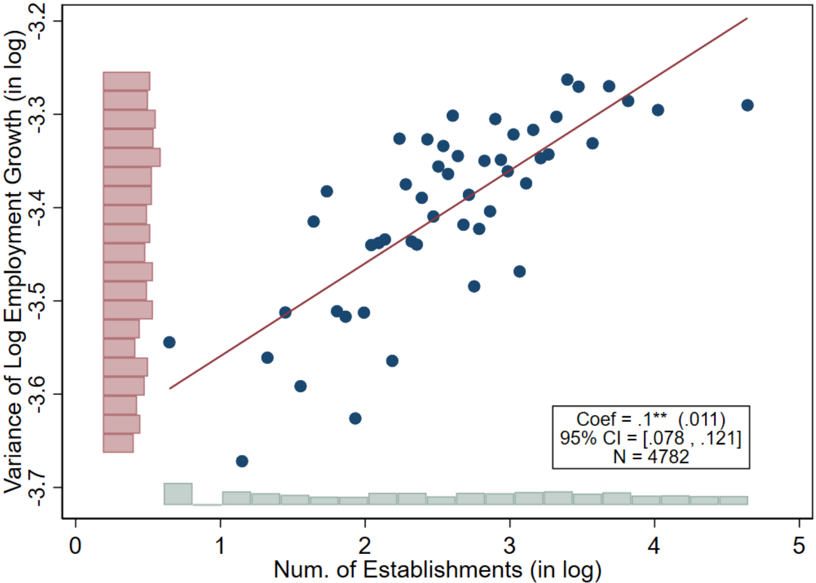
$$\Delta\varepsilon^{\ell}_{e,t,t+1} \equiv \hat{\varepsilon}^{\ell}_{e,t+t} - \hat{\varepsilon}^{\ell}_{e,t}$$

- Then residualize by estab. employment and estab-age FEs

$$\Delta\varepsilon^{\ell}_{e,t,t+1} = \gamma \ln \ell_{e,t} + \eta_{age(e)} + \zeta_{e,t,t+1}$$

- Finally take variance $Var(\hat{\zeta}_{e,t,t+1})$ across time

Fact 2: Volatility of Estab-level Employment ‣ HHI



Today's Plan

Causal Analysis: Empirical Specification

- Specification

$$\Delta \ln \ell_{e,t,t+1} = \beta_1 \Delta\mu_{e,t,t+1} + \beta_2 \left(\Delta\mu_{e,t,t+1} \cdot s_{e,t-1}\right) + \mathbf{X}'_{e,t}\Gamma + \zeta_e + \zeta_t + \varepsilon_{e,t}, \quad (1)$$

  where $\Delta \ln \ell_{e,t}$ is the change in employment.

- $\Delta\mu_{e,t,t+1}$: the shift-share demand shock

$$\Delta\mu_{e,t,t+1} = \overline{\text{EXP}_e} \times \left(\sum_c \overline{\omega_{e,c}} \cdot \Delta REX^{JPN}_{c,t,t+1}\right) \quad (2)$$

  - $\overline{\text{EXP}_e}$: median export ratio
  - $\overline{\omega_{e,c}}$ median exposure of establishment e to country c from product mix
  - $\Delta REX^{JPN}_{c,t,t+1}$ is the change in real exchange rate of the currency

JPY Appreciation Decreases Establishments' Employment

Regression without the interaction term for the proof of concept of the shock

***Table*: Effects of JPY Depreciation on Employment Growth**

	Dep. Var.: Log Changes			
			Employment by Types	
	Sales	Employment	Regular	Non-Regular
AREER Shock				
Observations	1,164,363	1,164,363	1,164,363	1,164,363
Covariates	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Establishment FEs	✓	✓	✓	✓

JPY Appreciation Decreases Establishments' Employment

Regression without the interaction term for the proof of concept of the shock

Table: Effects of JPY Depreciation on Employment Growth

	Dep. Var.: Log Changes			
			Employment by Types	
	Sales	Employment	Regular	Non-Regular
AREER Shock	-3.46			
	(0.17)			
Observations	1,164,363	1,164,363	1,164,363	1,164,363
Covariates	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Establishment FEs	✓	✓	✓	✓

JPY Appreciation Decreases Establishments' Employment

Regression without the interaction term for the proof of concept of the shock

***Table*: Effects of JPY Depreciation on Employment Growth**

	Dep. Var.: Log Changes			
			Employment by Types	
	Sales	Employment	Regular	Non-Regular
AREER Shock	-3.46	-0.25		
	(0.17)	(0.09)		
Observations	1,164,363	1,164,363	1,164,363	1,164,363
Covariates	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Establishment FEs	✓	✓	✓	✓

JPY Appreciation Decreases Establishments' Employment

Regression without the interaction term for the proof of concept of the shock

***Table*: Effects of JPY Depreciation on Employment Growth**

	Dep. Var.: Log Changes			
			Employment by Types	
	Sales	Employment	Regular	Non-Regular
AREER Shock	-3.46	-0.25	-0.29	
	(0.17)	(0.09)	(0.12)	
Observations	1,164,363	1,164,363	1,164,363	1,164,363
Covariates	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Establishment FEs	✓	✓	✓	✓

JPY Appreciation Decreases Establishments' Employment

Regression without the interaction term for the proof of concept of the shock

***Table*: Effects of JPY Depreciation on Employment Growth**

	Dep. Var.: Log Changes			
			Employment by Types	
	Sales	Employment	Regular	Non-Regular
AREER Shock	-3.46	-0.25	-0.29	-2.62
	(0.17)	(0.09)	(0.12)	(0.23)
Observations	1,164,363	1,164,363	1,164,363	1,164,363
Covariates	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Establishment FEs	✓	✓	✓	✓

Establishments with Larger Share responds Less

***Table*: Effects of JPY Depreciation on Employment Growth**

	Dep. Var.: Log Changes in Non-Regular Emp.			
	(1)	(2)	(3)	(4)
AREER Shock	-2.62			
	(0.23)			
AREER Shock $\times$ Payroll Share				
Observations	1,164,363	1,164,363	1,164,363	1,164,363
Covariates	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Establishment FEs	✓	✓	✓	✓

Establishments with Larger Share responds Less

***Table*: Effects of JPY Depreciation on Employment Growth**

	Dep. Var.: Log Changes in Non-Regular Emp.			
	(1)	(2)	(3)	(4)
AREER Shock	-2.62	-2.98		
	(0.23)	(0.27)		
AREER Shock $\times$ Payroll Share		3.35		
		(1.26)		
Observations	1,164,363	1,164,363	1,164,363	1,164,363
Covariates	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Establishment FEs	✓	✓	✓	✓

Establishments with Larger Share responds Less

***Table*: Effects of JPY Depreciation on Employment Growth**

	Dep. Var.: Log Changes in Non-Regular Emp.			
	(1)	(2)	(3)	(4)
AREER Shock	-2.62	-2.98	-0.31	
	(0.23)	(0.27)	(0.44)	
AREER Shock $\times$ Log Payroll			-1.08	
			(0.14)	
AREER Shock $\times$ Payroll Share		3.35	8.26	
		(1.26)	(1.41)	
Observations	1,164,363	1,164,363	1,164,363	1,164,363
Covariates	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Establishment FEs	✓	✓	✓	✓

Establishments with Larger Share responds Less

***Table*: Effects of JPY Depreciation on Employment Growth**

	Dep. Var.: Log Changes in Non-Regular Emp.			
	(1)	(2)	(3)	(4)
AREER Shock	-2.62	-2.98	-0.31	-0.55
	(0.23)	(0.27)	(0.44)	(0.44)
AREER Shock $\times$ Log Payroll			-1.08	-1.12
			(0.14)	(0.15)
AREER Shock $\times$ Payroll Share		3.35	8.26	
		(1.26)	(1.41)	
AREER Shock $\times$ (Payroll Share $>$ 3%)				2.43
				(0.50)
Observations	1,164,363	1,164,363	1,164,363	1,164,363
Covariates	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Establishment FEs	✓	✓	✓	✓

Quantitative Model of Granularity

Today's Plan

The Model Overview

- Small open economy
  - N regions $n \in \mathcal{N}$
  - continuum of sectors $j \in \mathcal{J}$
- Timing of the Model:
  1. Continuum of firms m_{nj} can pay a fixed cost ψ to *attempt* an entrance in sector j
  2. Random, finite number of firms enter E_{nj} (Poisson)
  3. Firms get an ex-ante productivity draw z_{nje} (Pareto)
  4. Workers decide where to live n, and how much to invest in sector-specific skills s_{nj}
  5. Firm ex-post productivity shocks revealed $a_{nje}(s)$ (Log-normal)
  6. Workers move labor across establishments and sectors subject to migration frictions

▸ Worker: Location Choice ▸ Worker: Skill Choice ▸ Worker: Ex-Post Labor Choice ▸ Firm

Equilibrium

- Firms:
  - earn zero expected profits, conditional on trying to enter;
  - maximize profits taking as given wages, conditional on entering.
- Workers:
  - choose the utility-maximizing location;
  - choose sector-specific skills to maximize expected utility;
  - choose where to work to maximize utility.

Today's Plan

Intended Calibration

Description	Parameter	Value	Source
Short run labor elasticity across sectors	ν	0.42	Berger et al. (2022)
Short run labor elasticity across firms	κ	10.85	Berger et al. (2022)
Long run labor elasticity across sectors	$\overline{\nu}$	1	Burstein et al. (2020)
Elasticity of production to labor	η	0.5	Labor Share (CoM)
Ex-ante firm prod. tail	λ	2.8	Direct from Regression
Ex-post shock log variance	σ^2	0.25	Variance of log wages
Migration elasticity	θ	3	Redding (2016)
Congestion externality	γ_u	-0.25	Redding (2016)
Production externality	γ_z	0.0025	Combes et al. (2011)

Size of Externality

1. Agglomeration Externality: Elasticities of wages to the population

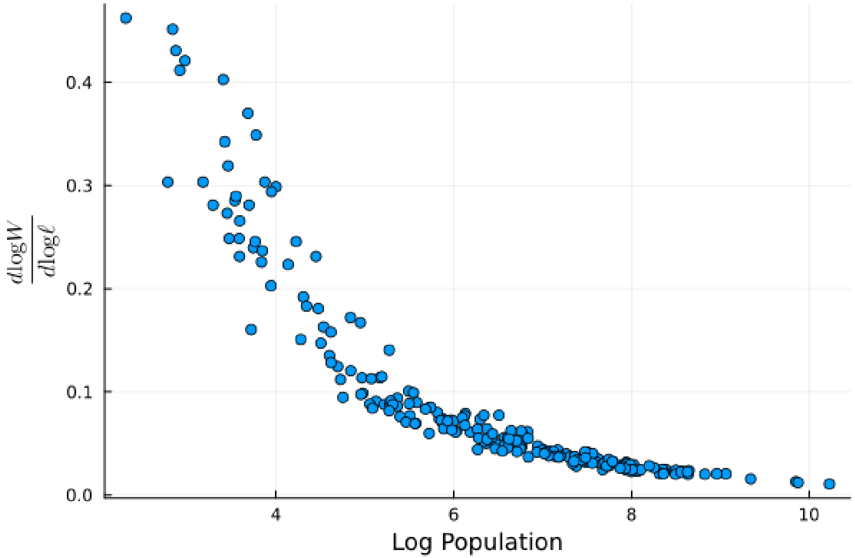
$$\frac{d\log W_n}{d\log \ell_n} := \frac{\gamma_z + \frac{\Psi'(m_n)m_n}{\Psi(m_n)} - (1-\eta)}{1 - \frac{\Psi'(m_n)m_n}{\Psi(m_n)}},$$

2. Firm Entry Wedge: The percentage difference between expected profits and the expected benefits on production.

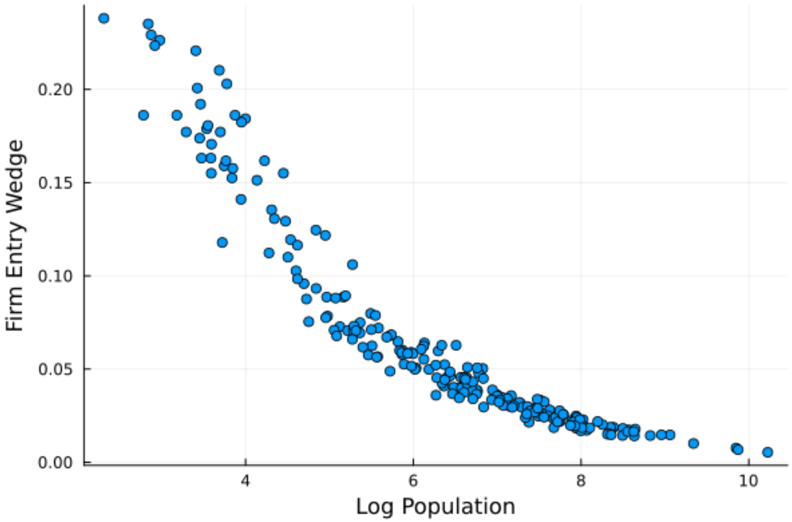
$$\frac{\frac{\Pi_n}{m_n}}{\psi_n} - 1 := \frac{1-\eta}{\frac{\Psi'(m_n)m_n}{\Psi(m_n)}} - 1,$$

where $\Pi_n \equiv (1-\eta)Y_n$ is the expected profit

Aggolomeration Externality is 0.4 in Small Locations



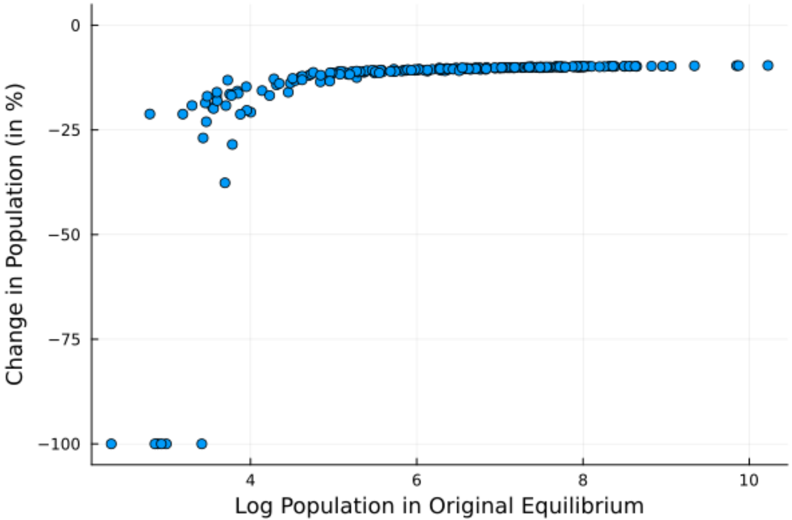
Firm in Small Locations Capture Less than 80% of Production Benefits



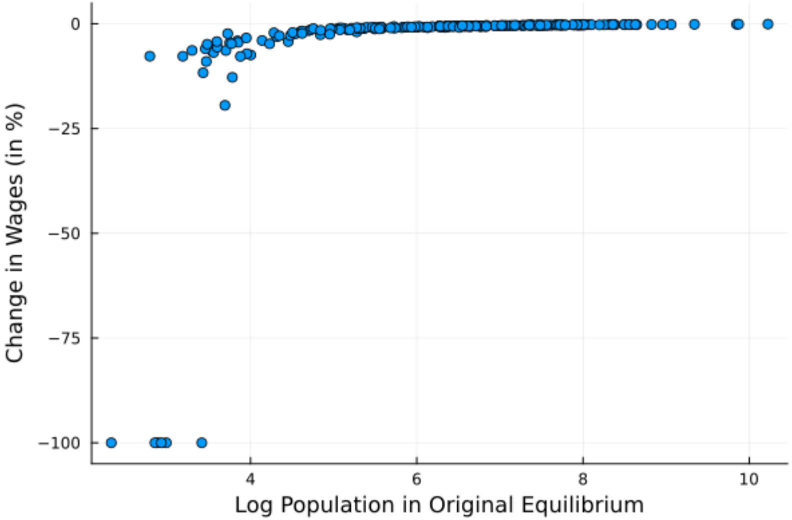
Counterfactual

- The Japanese working-age population is decreasing
  - NRPSSR: 87 million in 1995, 75 million in 2020, 70 million in 2032
- Simulate 10% drop in population (which is not a crazy scenario)
- See changes in
  1. Population
  2. Wages

Initially Smaller Locations Become Even Smaller



Initially Smaller Locations Hit Harder



Tokyo: 9.6% drop in population but 0.1% drop in wages (externality is small)

Conclusion

- Granularity is an important reason for agglomeration
- Standard economic geography models miss this and give incorrect counterfactual predictions because of it
    - Effects of Demographic Changes on Spatial Distribution
- Lots left to do!
    - How does granularity affect skill acquisition?
    - What is the optimal industrial mix?

Appendix

Imperfect Mobility Across Establishments and Labor Markets

- **Key Assumption:** easier to move across establishments within a labor market than moving across labor markets
- We show that this is the case
- We account for this in our quantitative model

▸ back

Monopsony Power

- Another force for agglomeration
  - Firms would rather open in small labor markets
  - Workers would rather live in large labor markets
  - Workers "usually" win the tug of war since larger labor markets are more efficient
- Makes our mechanism stronger because distortions are especially bad for good shocks
- Variance of wages understates our mechanism

back

Labor Hoarding/Employer Insurance

- If firms have monopsony power, then they should
    1. Hold onto workers during bad years so they can have them when they need them
    2. Provide wage insurance for workers so wages represent “average” contribution
- Both cases strengthen our mechanism
    - In larger labor markets, monopsony power is lower, easier to find workers when you need them, less need for insurance
- Variance of wages understates gains

back

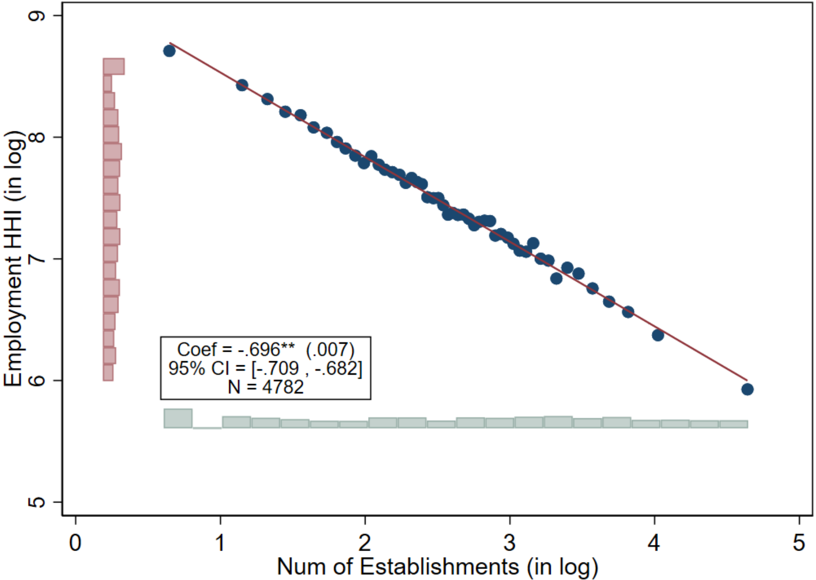
Wage Rigidity

- In large labor markets, variance of marginal product is low
  - Wage rigidity rarely matters
- In small labor markets, will matter a lot!
- Even more inefficient because people become unemployed rather than underemployed
- Wage variance understates the mechanism.

back

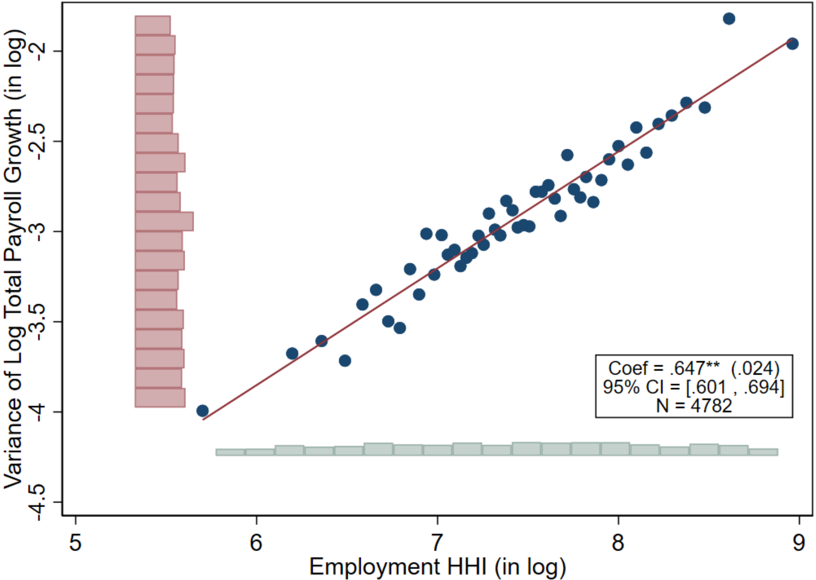
Number of Establishments and HHI

▸ Back



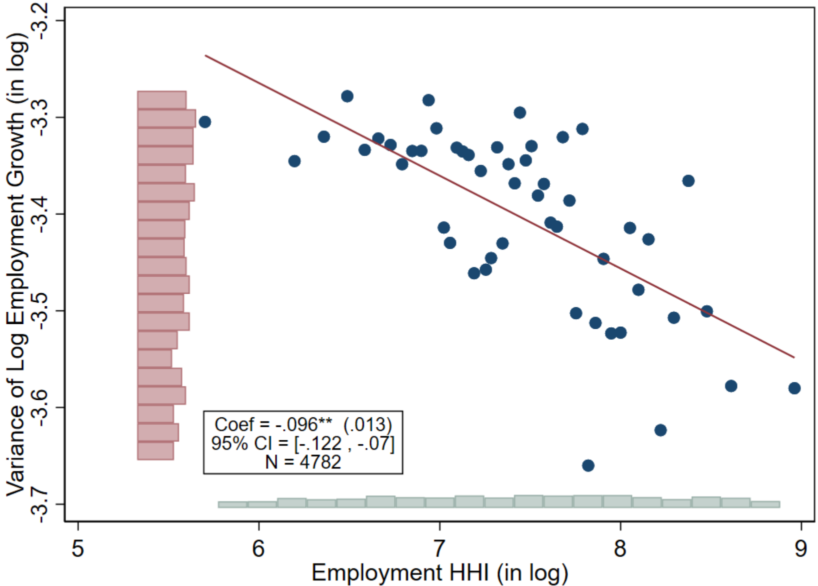
Fact 1: Volatility of LLM-level Payroll

Back



Fact 2: Volatility of Establishment-level Employment

Back



Today's Plan

Appendix
- Quantitative Model

Workers - Location Choice ▸ Back

- Fundamental utility of location n is

$$U_n = u_n W_n$$

- Amenities are also subject to spillovers (congestion, $\gamma_u < 0$)

$$u_n = \overline{u}_n(\ell_n)^{\gamma_u}.$$

- Workers have Fréchet utility shocks over the different locations

$$\ell_n = \left(\frac{U_n}{U}\right)^{\theta} \ell$$

where

$$U = \left[\sum_n (U_n)^{\theta}\right]^{\frac{1}{\theta}}$$

Workers - Ex-ante Skills Choice ‣ Back

- Workers choose skill investments to maximize expected wages

$$\{s_{nj}\}_{j\in\mathcal{J}} \in \underset{s'_j}{\operatorname{argmax}} \; W_n(\{s'_j\})$$

$$s.t. \quad 1 = \int_{\mathcal{J}} (s'_j)^{\frac{1+\overline{\nu}}{\overline{\nu}-\nu}} dj$$

- This takes as given number of firms in each sector and ex-ante productivity shocks z_{nje}
- ν is the short-run elasticity across sectors
- $\overline{\nu} > \nu$ is the long-run elasticity across sectors
- Denote solution by W_n

Workers - Ex-post Labor Choice

Back

- After the shocks are revealed, workers maximize earnings, taking wages and skills as given

$$
\begin{aligned}
L_{nje}(s), L_{nj}(s) \in & \underset{L'_{je}, L'_j}{\operatorname{argmax}} \int_{\mathcal{J}} \left[\sum_{e \in \mathcal{E}_{nj}} w_{nje}(s) L'_{je} \right] dj \\
s.t. \quad L'_j = & \left[\sum_{e \in \mathcal{E}_{nj}} b_{nje}^{-1/\kappa} \left(L'_{je} \right)^{\frac{1+\kappa}{\kappa}} \right]^{\frac{\kappa}{1+\kappa}} \\
1 = & \left[\int_{\mathcal{J}} s_{nj}^{-1/\nu} \left(L'_j \right)^{\frac{1+\nu}{\nu}} \right]^{\frac{\nu}{1+\nu}}
\end{aligned}
$$

- Denote solution by $W_n(\{s_{nj}\})$

Firms ▸ Back

Firms maximize profits by taking wages as given

$$\pi_{nje}(s) = \max_{\ell'(s)} \quad z_{nje} a_{nje}(s) \ell'(s)^{\eta_j} - w_{nje}(s)\ell'(s)$$

Free entry is

$$\psi = \frac{1}{m_{nj}} \mathbb{E}\left[\sum_{e}^{E_{nj}} \pi_{nje}(s) \middle| m_{nj} \right]$$

- Entry is Poisson

$$\mathbb{P}[E_{nj} = k] = \frac{(m_{nj})^k e^{-m_{nj}}}{k!}$$

- Ex-ante shocks are distributed Pareto

$$z_{nje} \sim \mathcal{P}(z_{nj}, \lambda); \quad z_{nj} = \bar{z}_{nj}(\ell_n)^{\gamma_z}$$

- Ex-post shocks are distributed log-normal

$$a_{nje}(s) \sim \mathcal{LN}\left(-\sigma^2/2, \sigma^2\right)$$