Matching and Agglomeration:

Theory and Evidence from Japanese Firm-to-Firm Trade

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Economic Activities are Geographically Concentrated

GDP Share of Tokyo Prefecture: **18%** ($\leftrightarrow$ 0.5% of area, 7% of population)

Various theories of agglomeration of economic activity

- e.g., labor pooling, knowledge spillovers, industrial linkages (Marshall '20)

This paper: **Firms find input suppliers more easily in denser areas**

1. Firm-level Evidence?
2. Quantitatively important?

1. Do firms find suppliers more easily in denser areas upon **unanticipated** supplier bankruptcies?

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Data: Yearly panel of firm-to-firm trade data in Japan

Main Findings:

1. Buyers only imperfectly recover suppliers, but the matching rate $\uparrow$ in geographic supplier density
2. Treated buyers are more likely to exit
3. Unanticipated supplier bankruptcies do *not* decrease supplier matching rate of *other neighboring buyers* (i.e., no crowding-out)

$\Longrightarrow$ **Increasing** returns to scale in matching

2. Quantifying IRS in Firm-to-Firm Matching

- Model: stochastic firm-to-firm matching for input trade + Melitz
  - Firms make sales (="export") to various locations to match with buyers
  - Matching rate with sellers ↑ in number of sellers, but not affected by other buyers

- Estimate matching rate elasticity and production gain of a match from the impacts of unanticipated supplier bankruptcies

- Quantification: IRS in matching explains...
  - **20~30%** of population-density-premium of value-added per worker and real wages
  - **~20%** of total welfare gains of highway networks, **~40%** of welfare gains outside Tokyo

Literature

- Agglomeration (Empirics)
  - Firm-to-firm matching: Holmes '99
  - Firm-to-*worker* matching: Blanchard & Diamond '89, '90; Petrongolo '01; Bleakley & Lin '12; Jaeger '16; Macaluso '17
- Agglomeration (Theory)
  - Firm-to-firm matching (no cross-location trade): Diamond '82; Helsley & Strange '90
  - Input-output linkages (no matching): Krugman & Venables '95; Venables '96; Helsley & Strange '14
- Quantitative Spatial Models: Ahlfeldt et al '14; Kline & Moretti '14; Allen & Arkolakis '14; Faber & Gaubert '16; Redding & Rossi-Hansberg '16; Nagy '17
- Models of firm-to-firm matching and trade: Eaton, Kortum, Kramarz '16; Eaton et al '16; Lim '16; Bernard et al '16; Sugita et al '16; Furusawa et al '17; Tintelnot et al '17; Bernard and Moxnes '18; Oberfield '18

Outline

Outline

Data

- Yearly panel of firm-to-firm trade in Japan from 2007-16
  - Provided by a credit reporting agency (TSR)
  - Covers 70% of all firms in Japan representativeness
  - Covers all sectors (manufacturing, retail and wholesales, construction)
  - Precise locations of headquarters and establishments

- Each firm reports up to 24 major suppliers and buyers each year (interview / survey-based) distribution
  - Limitations:
    - ★ Only extensive margin
    - ★ Trade information only available at *firm* (not *establishment*) level
  - Exclude links with ownership linkages (≈3%)
  - Use buyer-reported supplier-linkage
    (include supplier-reported buyer-linkage for robustness)

Data (Ctd.)

- List of bankruptcies with their primary reasons detail
  - Pick **"unanticipated reasons"** (1.5% of all bankruptcies)
  - *"Unanticipated accidental problems such as the death of representatives, flood disaster, fire, earthquake, traffic accident, fraud, theft, embezzlement, etc."*
  - About 80% of firms immediately exit

Diff-in-Diff with Matched Trt. and Ctrl. Firms

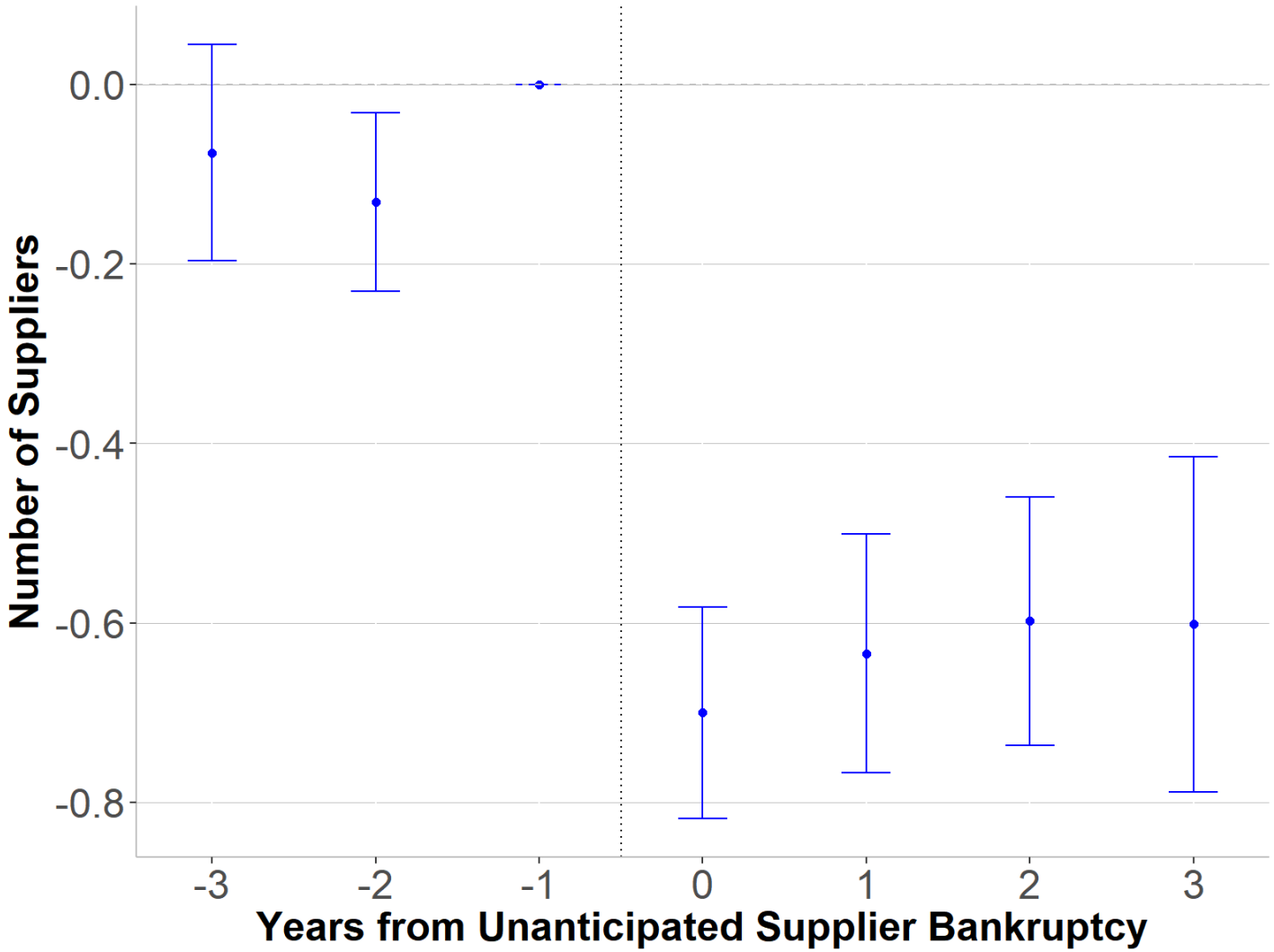
$$Y_{igt} = \sum_{s=\ldots,-2,0,1,\ldots} \beta^s 1\left[s = t - BankruptYear_g\right] \times Trt_i + \eta_{gt} + \xi_{ig} + \epsilon_{igt},$$

- i: (buyer-side) firm, t: year
- $Trt_i = 1$ if firm i faces unanticipated supplier bankruptcy
- Y_{igt}: number of suppliers, exit, sales,...
- g: group of matched ctrl. and trt. firms (same municipality, have a supplier in same 4-digit industry) balance

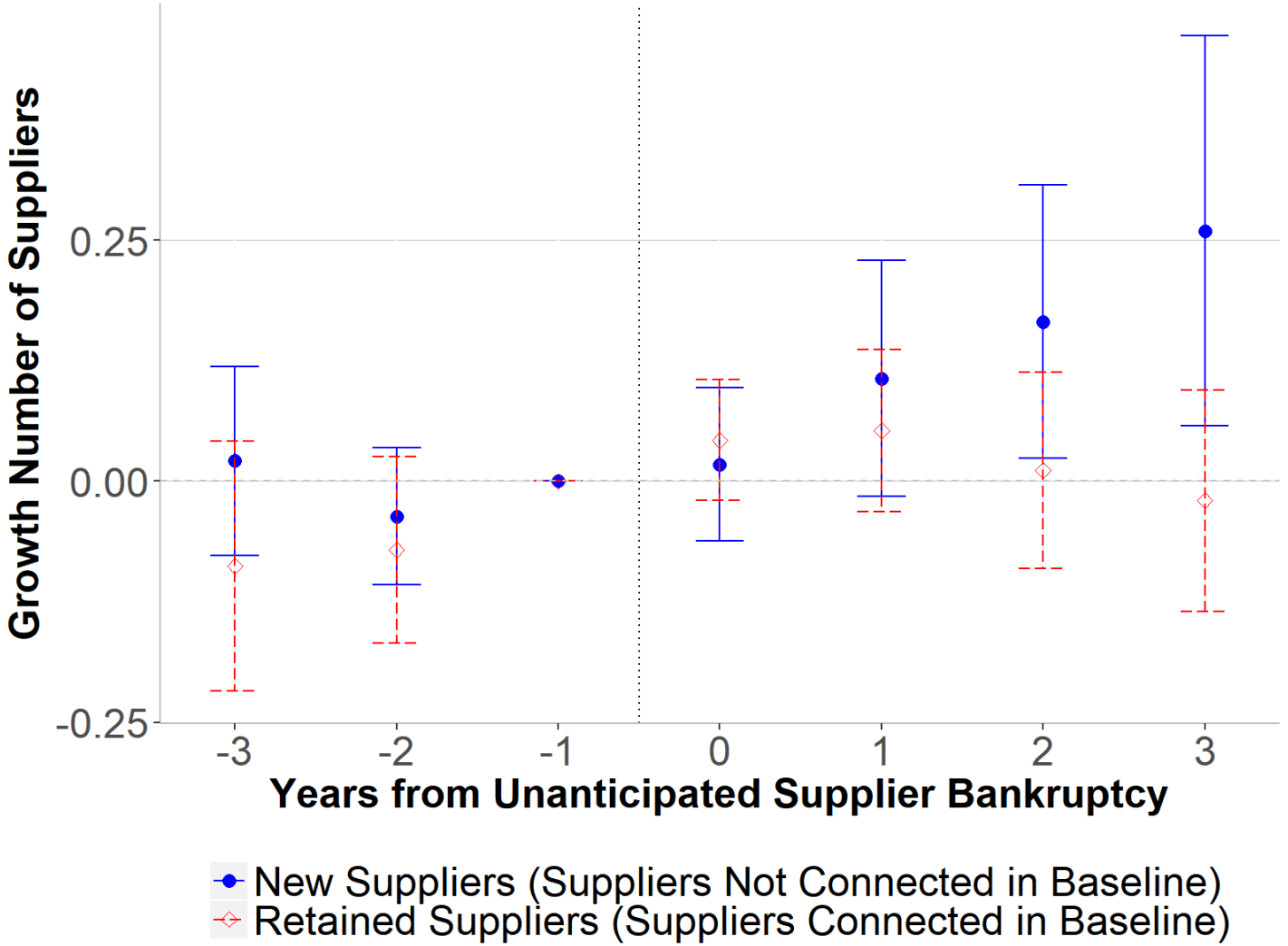
- Sample: 447 treatment buyer-side firms (with 167 bankrupting suppliers), ~10,000 control firms
- Std. err. clustered at supplier level, regression weighted at group g

representativeness of treatment firms

Treatment Firms Only Imperfectly Recover Suppliers



Treatment Firms Slowly Rematch with New Suppliers



new matching concentrated in same 4-digit ind. | separation with suppliers used for grouping trt and ctrl

Higher Rate of Matching with Higher Supplier Density

	New Suppliers		
	(1)	(2)	(3)
Trt x 1[t - BankruptYear = 0 or 1]	0.08*		
	(0.04)		
Trt x 1[t - BankruptYear = 0 or 1] x log Seller Density (Std.)	0.10**	0.22***	0.25
	(0.04)	(0.07)	(0.16)
Trt x 1[t - BankruptYear = 2 or 3]	0.23***		
	(0.07)		
Trt x 1[t - BankruptYear = 2 or 3] x log Seller Density (Std.)	0.14**	0.43***	0.53**
	(0.07)	(0.12)	(0.21)
Trt x Post x Buyer Prefecture FE		X	X
Trt x Post x Supplier Industry FE			X

- Seller Density $\equiv$ density of firms in bankrupting supplier's industry with a buyer in firm i's headquarter prefecture in baseline year (std. to mean 0, std. err. 1)

no pretrends birthplace IV other density measures ohter robustness

Summary of Reduced-Form Evidence

1. Imperfect recovery of suppliers, but matching rate $\uparrow$ in supplier density

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   - 3 pp ↑, relative to control mean of 6 pp (after 3 years)
   - No impact on sales conditional on survival

Summary of Reduced-Form Evidence

1. Imperfect recovery of suppliers, but matching rate ↑ in supplier density
2. Supplier bankruptcy increases exit probability table
   - 3 pp ↑, relative to control mean of 6 pp (after 3 years)
   - No impact on sales conditional on survival
3. Supplier bankruptcy has no impact on supplier matching of *other buyers in near locations* table
   - ↔ labor market (unemployed workers crowd out to fill a job vacancy)
     e.g. Petrongolo and Pissarides '01
   - Interpretation: Suppliers can supply to multiple buyers simultaneously

Implies **increasing returns to scale in matching**

Outline

Model Overview

- Basic environment: **multi-location multi-sector Melitz-model**
- Add: **Stochastic firm-to-firm matching for input trade**
  - Firms match with input sellers (= "exporters" a la Melitz) following a "matching technology" (i.e., Diamond '82; Mortensen and Pissarides '94)
  - Matching rate $\uparrow$ in input seller density, but not affected by buyer density
  - If unmatched, purchase inputs through fringe intermediaries (costly)
- Today: Single-sector model

Set-up

- Multiple locations: $i, j, n \in N$
  - Exogenous population: L_i
- Single-sector
  - Firms match with at most one supplier at a time, but suppliers can be matched with multiple buyers
  - Multiple sector version (with generic IO linkages): one-to-many matching within each input sector
- Time: t (continuous)
  - Focus on steady-state equilibrium in aggregate variables

Production Technology

- Unit cost of firm f in location i in period t:

$$c_{ft} = \frac{1}{\varphi_f} w_i^{1-\gamma} p_{ft}^{\gamma}$$

  - exogenous productivity: φ_f
  - wage: w_i
  - input cost: p_{ft} (source from matched suppliers or go through fringe intermediaries; explained later)

- Measure of firms: $\mu[\varphi_f > \varphi] = B_i \varphi^{-\theta}$
  - B_i: measure of "entrepreneurs"
  - Determined by free-entry condition with fixed cost F_i

Final Goods Market

- At each period, pay a fixed cost (in labor) f_j^F to make sales (="export") in location j
- Ice-berg trade cost τ_{nj}^F
- Monopolistic competition to representative consumers with CES utility

Input Goods Market: Sellers

- Pool of input sellers and buyers (producers) in location j match through a "matching technology"

- Sellers:
  - Fixed cost f_j^I to enter in j in each period as a pool of potential sellers
  - Post price $p = \psi c \tau_{nj}^I$
    - ★ c: seller's contemporaneous unit cost
    - ★ τ_{nj}^I: iceberg trade cost (n: seller's production location)
    - ★ ψ: constant mark-up ratio (exogenous) microfoundation
  - If match with a buyer, this price is enforced until relationship ends

Input Goods Market: Buyers

- Buyers: firms producing in location j
- Buyers meet with a supplier in sector k at Poisson rate $\eta \left(S_j^I / Z_j \right)^{\lambda}$ (if unmatched)
  - S_j^I: measure of input sellers
  - Z_j: geographic area of location j
- Upon match, decide to form an exclusive relationship at the seller's posted price
- Exogenous separation rate: ρ_j

Input Goods Market: Fringe Intermediaries

- Firms without a supplier can source inputs from a local fringe intermediary
  - Intermediaries accesses a random input seller in the same location
  - Incur χ iceberg cost
  - No profit for intermediaries
- Note: If $\chi \gg 1$, input buyers and suppliers always form a relationship whenever they match

Free-Entry Condition of Entrepreneurs

- Recall measure of firms: $\mu[\varphi_f > \varphi] = B_i \varphi^{-\theta}$
- $B_{i,k}$ is determined to equilibriate the aggregate profit with total fixed cost payment

$$\Pi_i = w_i F_i B_i$$

Model Predicts a Gravity Equation

- Power law productivity distribution + constant mark-up rule gives a gravity equation of input trade:

$$\pi_{ij}^{I} = \frac{\Gamma_i \left(\tau_{ij}^{I}\right)^{\theta}}{\sum_{i' \in N} \Gamma_{i'} \left(\tau_{i'j}^{I}\right)^{\theta}}$$

$$\Gamma_i = B_i w_i^{-\theta\gamma} \left\{ 1 + \underbrace{\Lambda_i(S^I)}_{\text{S.S. match prob.}} \underbrace{\left(\chi^{(1-\gamma)\theta} - 1\right)}_{\text{cost adv. if matched}} \right\} \left(\overline{c}_i^{I}\right)^{-(1-\gamma)\theta}$$

- Note: gravity driven entirely by extensive margin (Chaney '08)

Steady-State Equilibrium Conditions

Equilibrium satisfies...

1. Total expenditure and trade balancing: $\{X_i^F, X_i^I, Y_i^F, Y_i^I, w_i\}$
2. Zero-profit condition for marginal input sellers: $\{S_i^I, \overline{c}_i^I\}$
3. Gravity equations for final and input goods: $\{\pi_{ij}^F, \pi_{ij}^I\}$
4. Free entry conditions for entrepreneurs: $\{B_i\}$
5. Input cost advantage: $\{\Gamma_i\}$

Circular Causation: Input Seller Entry $\rightleftarrows$ Input Demand

- **Backward Linkage** (zero profit condition of marginal sellers)**:**

$$\underbrace{S_i^I}_{\text{input seller}} = \frac{(1-\gamma)\psi}{f_i^I w_i} \underbrace{Y_i^I}_{\text{input demand}}$$

- **Forward Linkage**
  (input cost advantage + gravity + entrepreneur's free entry)**:**

$$Y_i = Y_i \left(\underbrace{\eta (S_i^I / Z_i)^{\lambda}}_{\text{supplier matching rate}} , \underbrace{\chi}_{\text{cost advantage per match}} \right)$$

Outline

Estimation of matching rate elasticity λ and production gain of a match χ

- Simulate a "natural experiment" of unanticipated supplier bankruptcies given $\{\lambda, \chi\}$
  - Interpret supplier bankruptcy as exogenous supplier separation
  - For each treatment firm, simulate what would happen if it were and it were not treated
    - ⋆ Matching with a new supplier at rate $\eta \left(S^I_{j,k}/Z_j\right)^{\lambda}$
    - ⋆ Sales growth depends on χ
- Choose $\{\lambda, \chi\}$ that replicates the reduced-form impacts
- Results: $\lambda = 0.4$, $\chi = 1.1$

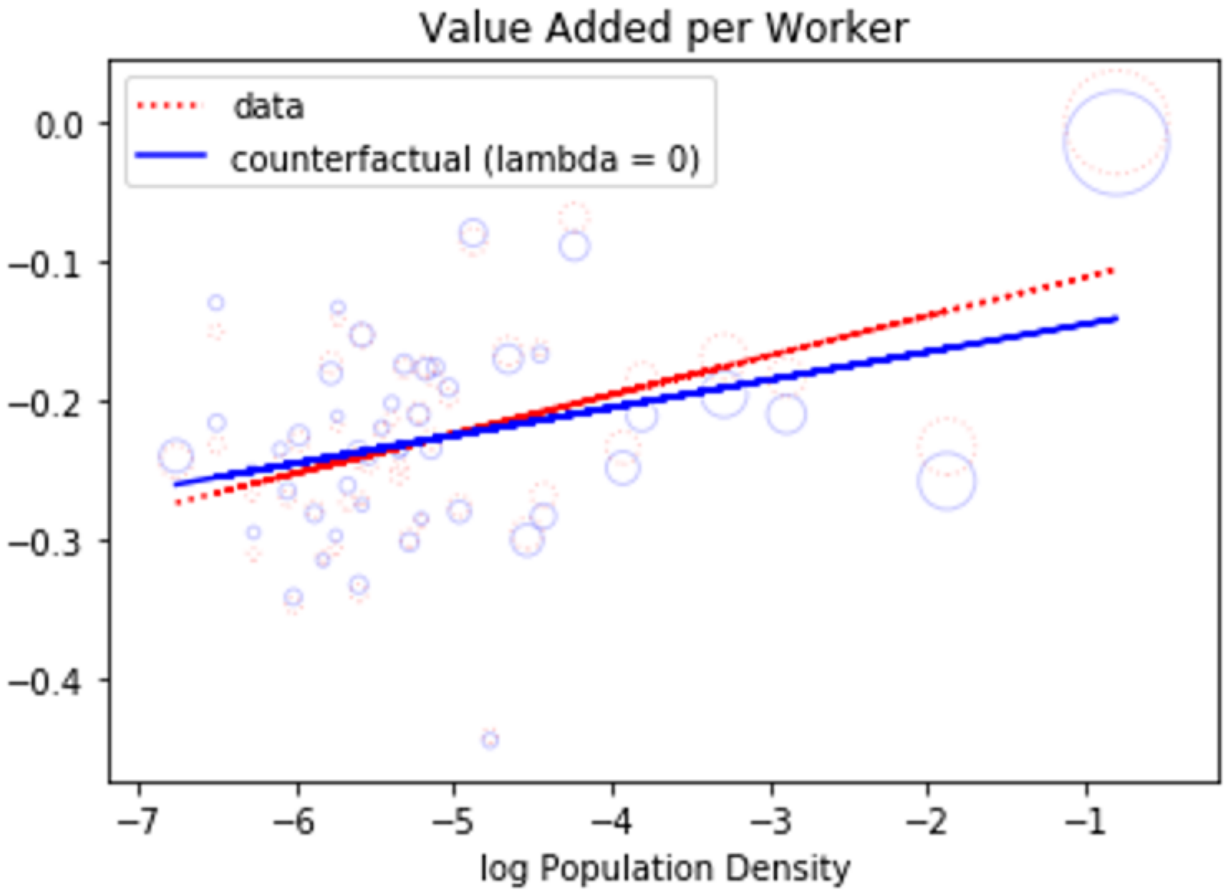
Calibration of Other Parameters

- Counterfactuals through "hat algebra" approach (Dekle, Eaton, Kortum '08)
- Parameters
  - trade elasticity $\theta = 6$
  - $\{\gamma_{k,m}, \gamma_{k,L}, \alpha_k\}$: from IO table
- Baseline variables from firm-to-firm trade data in 2009
  - $\{\pi^I_{ij,k}\}$: from extensive margin of input trade share
  - Assume $\pi^F_{ij,k} = \pi^I_{ij,k}$
  - Steady-state prob. of having a supplier in each sector $\{\Lambda_{i,km}\}$ and separation rate $\{\rho_{i,km}\}$
- 47 prefectures, 33 main two-digit sectors

Counterfactual 1: How Much does IRS in Matching Explains Population-Density Premium?

- Shut down IRS in matching
  - Set supplier matching rate as $\overline{v}_k$ ($\leftrightarrow v_{i,k} = \eta \left(S^I_{i,k} / Z_i \right)^{\lambda}$ in baseline)
- How much of the observed positive correlation between population density and the following outcomes would decline?
  - location-sector productivity (origin gravity fixed effects)
  - value-added per worker
  - real wages

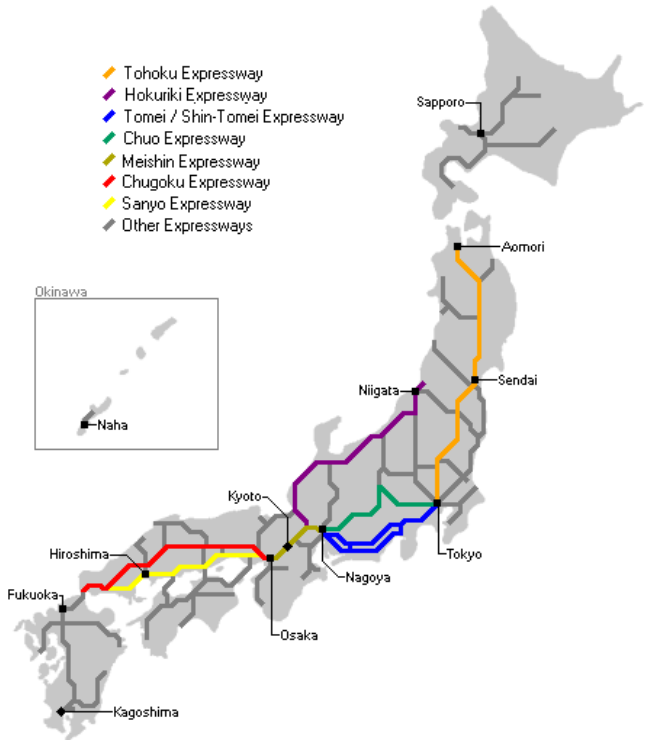
IRS in Matching Explains 27% of Density-Premium of Value-Added per Worker



- Other density premium: productivity by 17%↓, real wages by 19%↓

Counterfactual 2: Welfare Implications of Highways

- Japanese highways developed since '60; Huge policy debate about welfare implications, particularly for remote areas (e.g., Okuda and Hayashi, 1994)

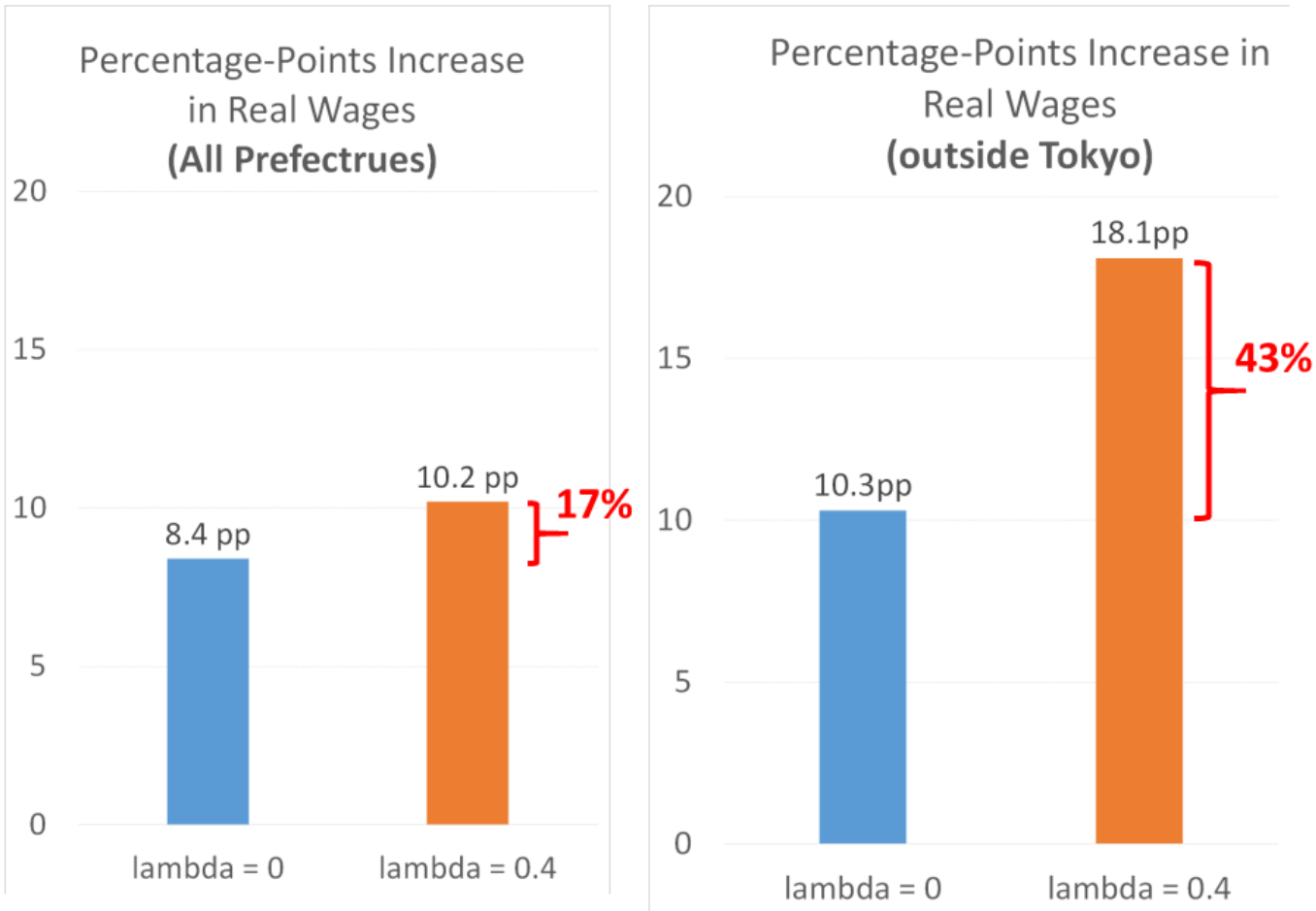


- How much welfare gains and distributional consequences do we miss, if we ignore the IRS in firm-to-firm matching?

Counterfactual 2: Welfare Implications of Highways

- Calibrate the model with highways, predict the equilibrium change without highways
  - $\hat{\tau}^F_{ij,k} = \hat{\tau}^I_{ij,k} = \frac{\text{Travel Time with Highway}}{\text{Travel Time without Highway}}$ (from GoogleMaps API)
  - About 40% travel time reduction for a typical prefecture pair
- Compare the welfare gains with $\lambda = 0.4$ versus $\lambda = 0$

IRS in Matching Explains 17% of Total Welfare Gains from Highways, and 43% of that outside Tokyo



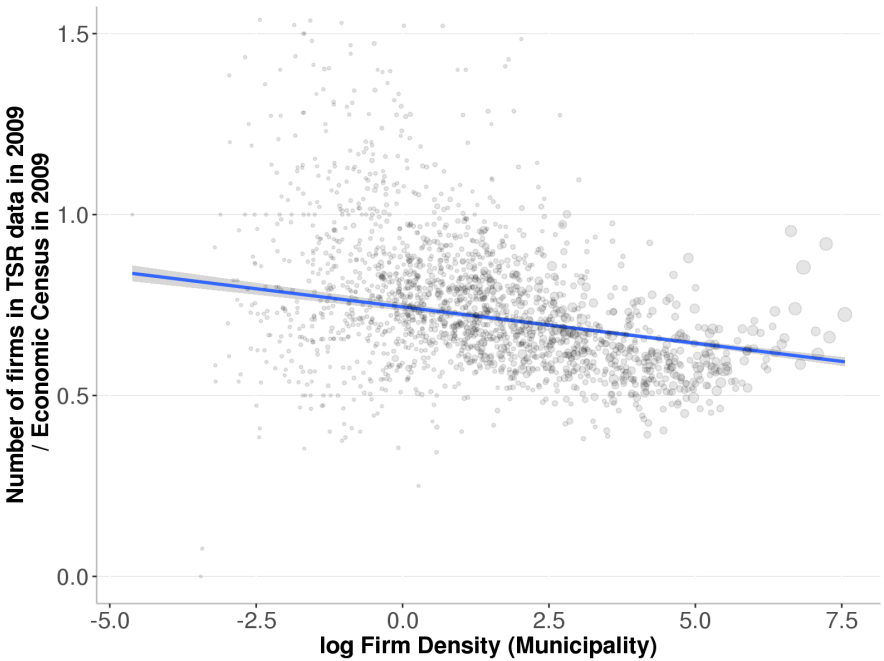
Conclusion

- Reduced-form evidence of IRS in firm-to-firm matching based on the impacts of unanticipated supplier bankruptcy on new supplier matching
- Build a new structural model that translates the reduced-form estimates to equilibrium distribution of economic activity
  - Key: circular causation between **input seller density** and **downstream input demand**
  - Large quantitative implications for geographic economic disparities
- Further understanding sources and consequences of firm-to-firm trade matching frictions first-order agenda!

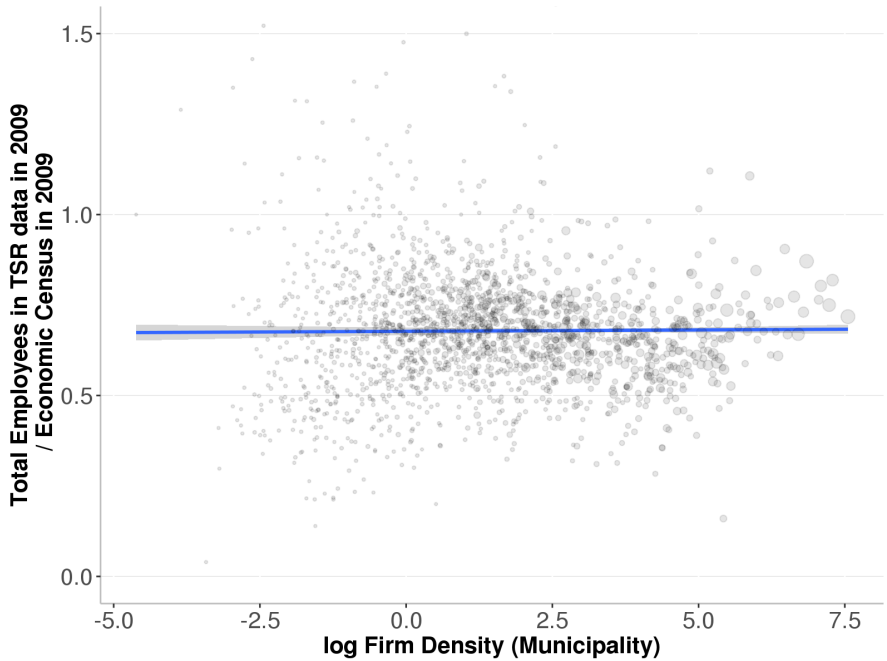
Appendix

Representativeness across Locations

(A) Number of Firms



(B) Total Employees



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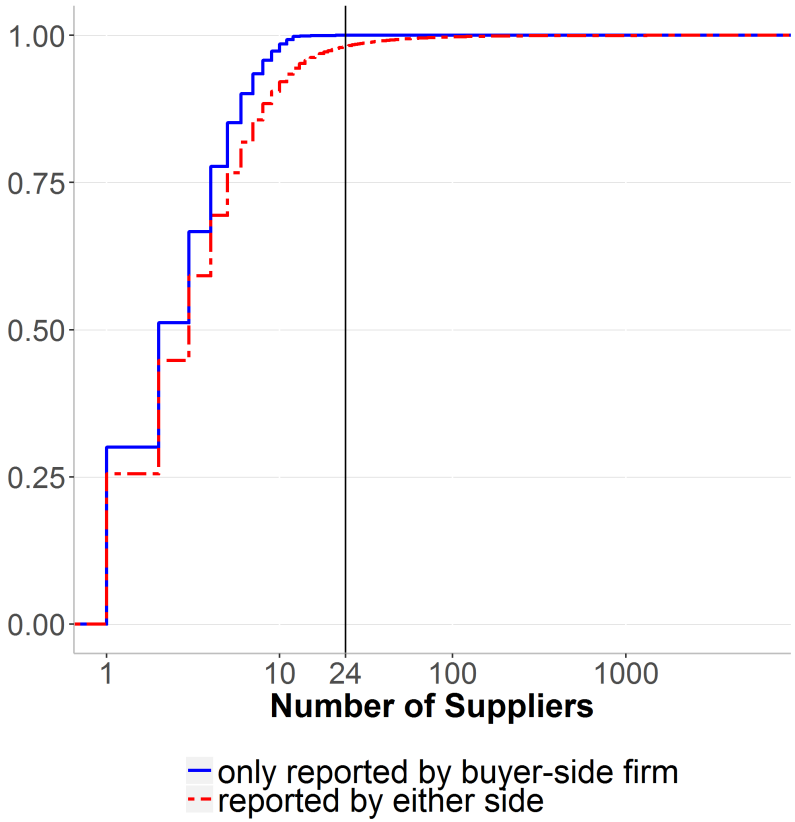
Distribution of Number of Suppliers



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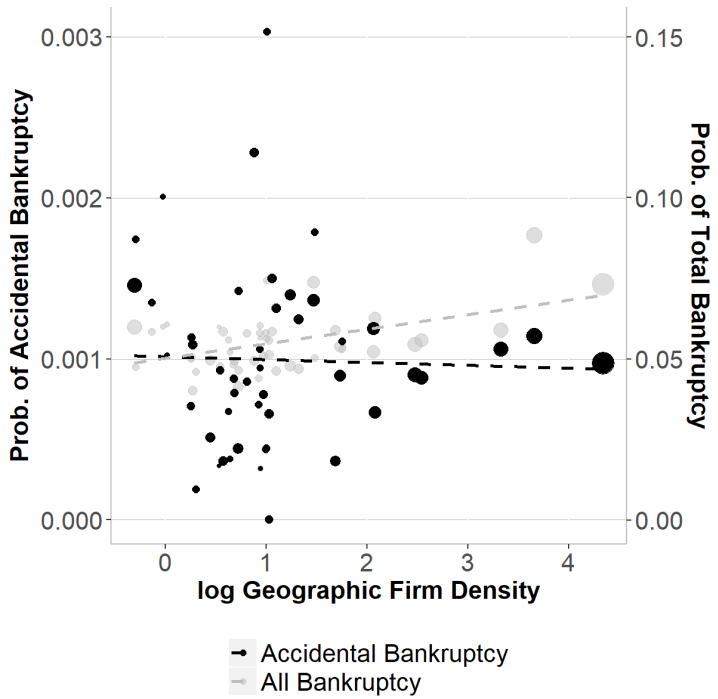
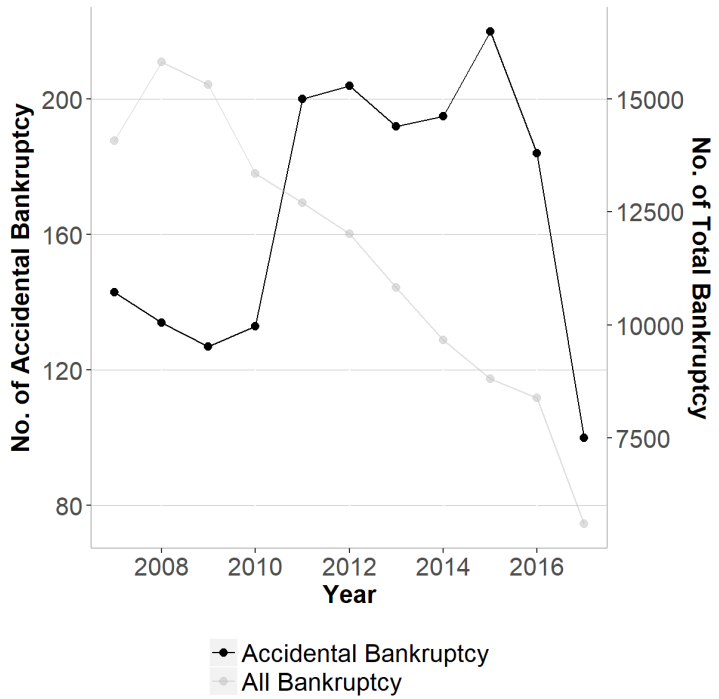
Patterns of Unanticipated Accidental Bankruptcies

(A) Geographic Density

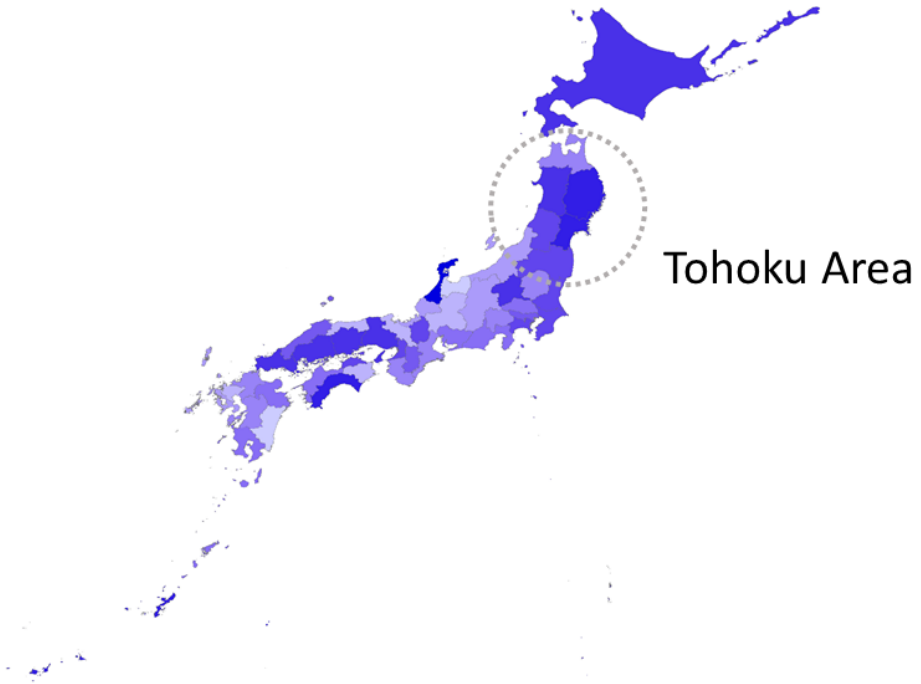


(B) Time Trend



Map of Unanticipated Bankruptcies

(C) Map of the Probability of Accidental Bankruptcies



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Reported Reasons of Bankruptcies

Reason of Bankurptcy	Freq.	Freq. (At Least One Buyer)
Unanticipated Reasons	1548	325
Sales Decline	75492	12861
Accumulation of Debt	11111	2851
Spillovers from Other Bankruptcy	6793	1519
Shortage of Capital	6038	1371
Management Failure	5346	894
Unknown	4184	694
Over-Investment in Capital	875	280
Deterioration of Credit Conditions	589	229
Difficulty in Collecting Account Receivables	543	162
Over-Accumulation of Inventory	98	36
Total	112617	21222

Unanticipated Reasons*: "Unanticipated accidental problems such as the death of representatives, flood disaster, fire, earthquake, traffic accident, fraud, theft, embezzlement, etc."* go back

Balance Between Control and Treatment

Variable	Control	Treatment	p-value of diff.
Growth Number of Suppliers	0.19	0.31	0.06 *
log Sales	12.60	12.43	0.07 *
log Sales Growth	-0.01	-0.01	0.96
log Employment	2.60	2.48	0.1
log Employment Growth	-0.01	-0.01	0.93
Solvency Score	49.04	48.36	0.07 *

go back

New Matching Concentrated in Same Industry

	New Suppliers		
	All	Within 4-digit Ind.	Within 2-digit Ind.
	(1)	(2)	(3)
Trt x 1[t - BankruptYear = 2 or 3]	0.22***	0.07***	0.10***
	(0.07)	(0.02)	(0.03)
Control Mean	0.79	0.08	0.17

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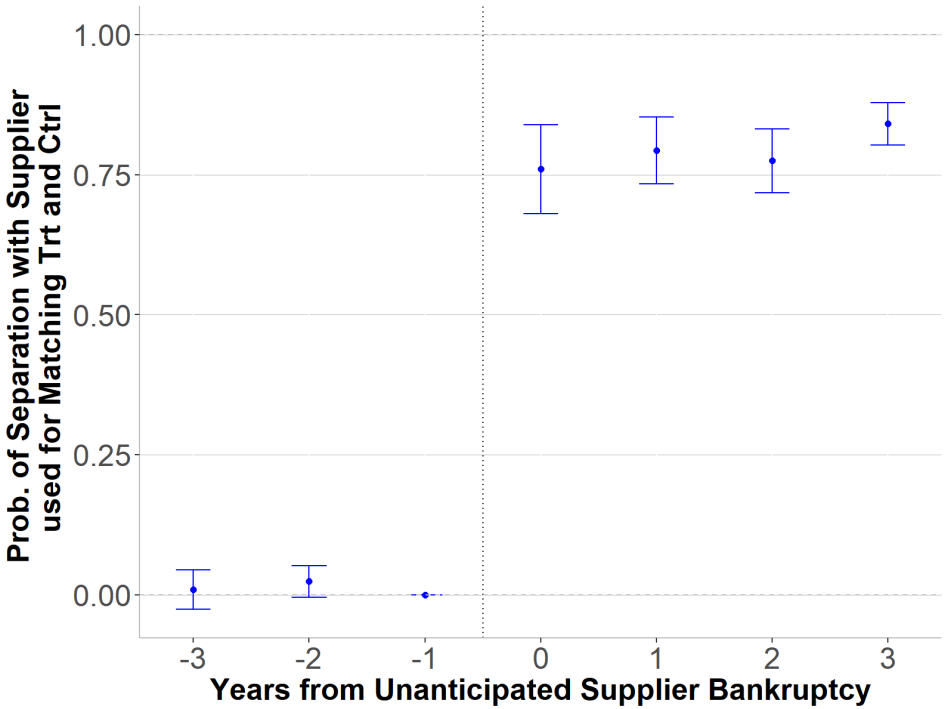
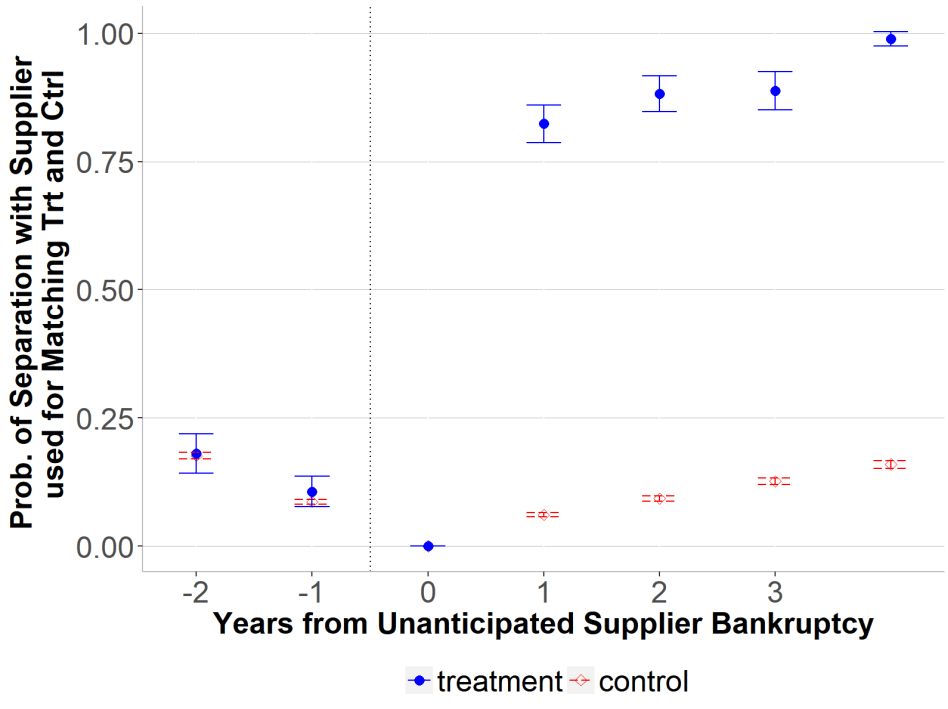
Impact on Separation with a Supplier used to Match Ctrl. and Trt.





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Substantial Rematching with Suppliers *Selling* in Buyer's Location

	New Suppliers		
	All	HQ in Same Mun.	Supply to Same Mun.
	(1)	(2)	(3)
Trt x 1[t - BankruptYear = 2 or 3]	0.22***	0.07***	0.13***
	(0.07)	(0.02)	(0.04)
Control Mean	0.79	0.07	0.29

Number of municipalities: 1719

No Pretrends

	New Suppliers		log Sales	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
Trt x 1[t - BankruptYear = -1 or -2]	−0.003	−0.003	0.02	0.02
	(0.04)	(0.04)	(0.01)	(0.01)
Trt x 1[t - BankruptYear = -1 or -2] x log Seller Density (Std.)	−0.004	0.03	−0.02	−0.03
	(0.04)	(0.04)	(0.02)	(0.02)
Observations	44,028	44,023	43,633	43,628

go back

Control Trt x Location and Industry FE

	New Suppliers		
	OLS	IV	IV
	(1)	(2)	(3)
Trt x 1[t - BankruptYear = 0 or 1] x log Seller Density (Std.)	0.09**	0.10**	0.09*
	(0.04)	(0.05)	(0.06)
Trt x 1[t - BankruptYear = 2 or 3]	0.10	0.10	0.10
	(0.07)	(0.08)	(0.08)

go back

Other Density Measures

	New Suppliers					
	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
Trt x 1[t - BankruptYear = 0 or 1]	0.06	0.06	0.06	0.06	0.06	0.06
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Trt x 1[t - BankruptYear = 0 or 1] x log Seller Density (Std.)	0.09**	0.11**	0.08**	0.13**	0.10**	0.10**
	(0.04)	(0.04)	(0.04)	(0.06)	(0.04)	(0.05)
Trt x 1[t - BankruptYear = 2 or 3]	0.22***	0.22***	0.22***	0.22***	0.22***	0.22***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Trt x 1[t - BankruptYear = 2 or 3] x log Seller Density (Std.)	0.09	0.09	0.11	0.13	0.15**	0.11
	(0.06)	(0.07)	(0.07)	(0.10)	(0.07)	(0.08)
Definition of Seller Density	2-digit Ind.	2-digit Ind.	Municipality	Municipality	Local Headquarters	Local Headquarters
Observations	99,447	99,436	99,447	99,436	99,447	99,436

go back

Other Robustness

	New Suppliers		
	IV	IV	IV
	(1)	(2)	(3)
Trt x 1[t - BankruptYear = 0 or 1]	0.06	0.07	0.09
	(0.04)	(0.05)	(0.06)
Trt x 1[t - BankruptYear = 0 or 1] x log Seller Density (Std.)	0.09*	0.10*	0.13**
	(0.05)	(0.06)	(0.07)
Trt x 1[t - BankruptYear = 2 or 3]	0.20***	0.24***	0.31***
	(0.08)	(0.08)	(0.10)
Trt x 1[t - BankruptYear = 2 or 3] x log Seller Density (Std.)	0.11	0.09	0.14
	(0.08)	(0.09)	(0.10)
Specification	Excl. Exiting Firms	Excl. Tokyo	Sampling Adjustment
Observations	94,783	67,584	99,436

go back

Heterogeneous Impacts on Exit

	Bankruptcy	Voluntary Exit	Merged	Existence Unknown
	(1)	(2)	(3)	(4)
Trt x 1[t - BankruptYear = 0 or 1]	0.01*	−0.01	0.004*	−0.0001
	(0.01)	(0.004)	(0.002)	(0.003)
Trt x 1[t - BankruptYear = 2 or 3]	0.02*	−0.001	0.01	0.01
	(0.01)	(0.01)	(0.004)	(0.01)
Control Mean 3 Years After Bankruptcy	0.034	0.033	0.005	0.015
Number of Treated Firms	447	447	447	447
Number of Bankrupting Suppliers	167	167	167	167
Number of Control Firms	14,630	14,630	14,630	14,630
Observations	99,447	99,447	99,447	99,447

go back

Treatment Firms Exit More, But No Effect in Sales
Conditional on Survival

	Exit	log Sales (cond. Survival)	log Sales (incl. Exit)
	(1)	(2)	(3)
Trt x 1[t - BankruptYear = 2 or 3]	0.03*	0.001	−0.38*
	(0.02)	(0.02)	(0.20)
Control Mean	0.087	12.582	11.443

different forms of exit heterogeneous effects

Heterogeneous Impacts on Exit

	Bankruptcy	Voluntary Exit	Merged	Existence Unknown
	(1)	(2)	(3)	(4)
Trt x 1[t - BankruptYear = 0 or 1]	0.01*	−0.01	0.004*	−0.0001
	(0.01)	(0.004)	(0.002)	(0.003)
Trt x 1[t - BankruptYear = 2 or 3]	0.02*	−0.001	0.01	0.01
	(0.01)	(0.01)	(0.004)	(0.01)
Control Mean 3 Years After Bankruptcy	0.034	0.033	0.005	0.015
Number of Treated Firms	447	447	447	447
Number of Bankrupting Suppliers	167	167	167	167
Number of Control Firms	14,630	14,630	14,630	14,630
Observations	99,447	99,447	99,447	99,447

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Evaluating "Quality" of Match

	Exit		log Sales (incl. Exit)	
	(1)	(2)	(3)	(4)
Number of Suppliers	−0.06	−0.07*	0.75	0.87*
	(0.04)	(0.04)	(0.47)	(0.51)
Number of Suppliers x log Seller Density (Std.)		−0.01		0.33
		(0.05)		(0.62)
Observations	29,576	29,572	28,886	28,882

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Testing Crowding-Out

- Results so far: matching frictions important
  - This does *not* necessarily imply for agglomeration benefit if buyers in near geographic proximity **crowd-out** each other
  - Often documented in labor market (Petrongolo and Pissarides '01)

Testing Crowding-Out

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- Study impact **on other buyers in near geographic proximity**:

$$Y_{igt} = \sum_s \beta^s 1\left[s = t - BankruptYear_g\right] \times NeighborTrt_i + \eta_{gt} + \xi_{ig} + \epsilon_{igt},$$

  - $NeighborTrt_i$: neighbor of i faces unanticipated supplier bankruptcy
  - group g: same as before (same municipality, have a supplier in same 4-digit industry)
  - Exclude firms which are directly hit by supplier bankruptcy

Evidence of No Crowding-Out

	Number of Suppliers		
	(1)	(2)	(3)
Neighbor Trt × 1[t - BankruptYear = 2 or 3]	0.06	0.01	0.05
	(0.10)	(0.08)	(0.06)
Degree Grid Size for Defining Neighbor Trt	0.005	0.01	0.05

other outcomes

Evidence of No Crowding-Out

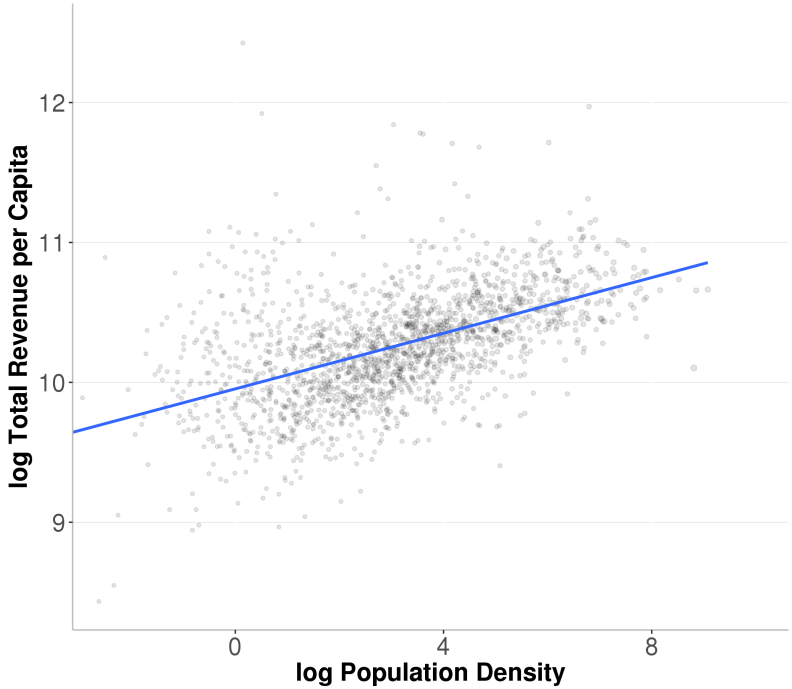
	Number of Suppliers		
	(1)	(2)	(3)
Neighbor Trt × 1[t - BankruptYear = 2 or 3]	0.06	0.01	0.05
	(0.10)	(0.08)	(0.06)
Degree Grid Size for Defining Neighbor Trt	0.005	0.01	0.05

other outcomes

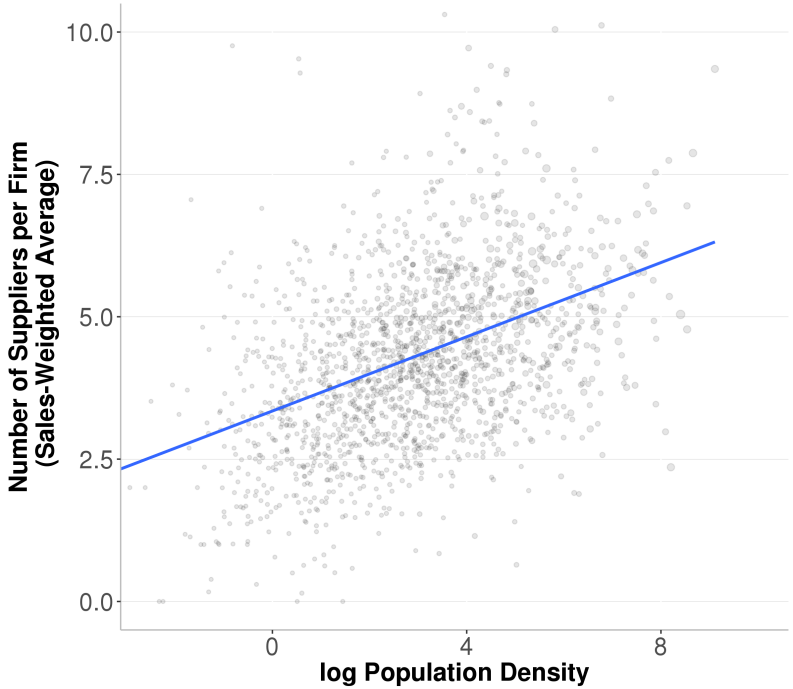
- Interpretation: Suppliers can simultaneously supply to multiple buyers in the same area
- $\longleftrightarrow$ labor market (a job vacancy can be filled by nearby workers)

Suggestive Evidence of Agglomeration Benefit

(A) Revenue per Worker



(B) No. of Suppliers per Firm



Endogeneity Issues: Firms in denser areas...

1. may have higher demand for external suppliers
2. may be better at looking for suppliers

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Set-up

- Multiple locations: $i, j, n \in N$
  - Exogenous population: L_i
- Multiple sectors: $k, m \in K$
  - Generic I-O linkages with CD production technology
  - All firms produce both input and final goods, and use input goods for production
  - Firms match with at most one supplier within sector at a time, but suppliers can be matched with multiple buyers
- Time: t (continuous)
  - Focus on steady-state equilibrium in aggregate variables

Production Technology

- Unit cost of firm f in location i and sector m in period t:

$$c_{ft} = \frac{1}{\varphi_f} w_i^{\gamma_{L,m}} \prod_{k \in K} p_{ft,k}^{\gamma_{km}}$$

  - exogenous productivity: φ_f
  - wage: w_i
  - input cost: $p_{ft,k}$ (source from matched suppliers or go through fringe intermediaries; explained later)

- Measure of firms: $\mu[\varphi_f > \varphi] = B_{i,k}\varphi^{-\theta}$
  - $B_{i,k}$: measure of "entrepreneurs"
  - Determined by free-entry condition with fixed cost $F_{i,k}$

Final Goods Market

- At each period, pay a fixed cost (in labor) $f^F_{j,k}$ to make sales (="export") in location j
- Ice-berg trade cost $\tau^F_{nj,k}$
- Monopolistic competition to representative consumers with CES utility

Input Goods Market: Sellers

- Pool of input sellers and buyers (producers) in location j match through a "matching technology"

- Sellers:
  - Fixed cost $f^I_{j,k}$ to enter in j in each period as a pool of potential sellers
  - Post price $p = \psi_{km} c \tau^I_{nj,k}$
    - ★ c: seller's contemporaneous unit cost
    - ★ $\tau^I_{nj,k}$: iceberg trade cost (n: seller's production location)
    - ★ ψ_{km}: constant mark-up ratio (exogenous) microfoundation
  - If match with a buyer, this price is enforced until relationship ends

Input Goods Market: Buyers

- Buyers: firms producing in location j
- Buyers meet with a supplier in sector k at Poisson rate $\eta \left(S^I_{j,k} / Z_j \right)^{\lambda}$ (if unmatched)
  - $S^I_{j,k}$: measure of input sellers
  - Z_j: geographic area of location j
- Upon match, decide to form an exclusive relationship at the seller's posted price
- Exogenous separation rate: $\rho_{j,km}$

Input Goods Market: Fringe Intermediaries

- Firms without a supplier can source inputs from a local fringe intermediary
  - Intermediaries accesses a random input seller in the same location
  - Incur χ iceberg cost
  - No profit for intermediaries
- Note: If $\chi \gg 1$, input buyers and suppliers always form a relationship whenever they match

Free-Entry Condition of Entrepreneurs

- Recall measure of firms: $\mu[\varphi_f > \varphi] = B_{i,k}\varphi^{-\theta}$
- $B_{i,k}$ is determined to equilibriate the aggregate profit with total fixed cost payment

$$\Pi_{i,k} = w_i F_{i,k} B_{i,k}$$

Model Predicts a Gravity Equation

- Power law productivity distribution + constant mark-up rule gives a gravity equation of input trade:

$$\pi^{I}_{ij,m} = \frac{\Gamma_{i,m}\left(\tau^{I}_{ij,m}\right)^{\theta}}{\sum_{i' \in N}\Gamma_{i',m}\left(\tau^{I}_{i'j,m}\right)^{\theta}}$$

$$\Gamma_{i,m} = B_{i,m} w_i^{-\theta\gamma_{L,m}} \prod_{k \in K}\left\{1 + \underbrace{\Lambda_{i,km}(S^{I}_{i,k})}_{\text{S.S. match prob.}} \underbrace{(\chi^{\gamma_{km}\theta} - 1)}_{\text{cost adv. if matched}}\right\}\left(\overline{c}^{I}_{i,k}\right)^{-\gamma_{km}\theta}$$

- Note: gravity driven entirely by extensive margin (Chaney '08)

Steady-State Equilibrium Conditions

Equilibrium satisfies...

1. Total expenditure and trade balancing: $\{X^F_{i,k}, X^I_{i,k}, Y^F_{i,k}, Y^I_{i,km}, w_i\}$
2. Zero-profit condition for marginal input sellers: $\{S^I_{i,k}, \overline{c}^I_{i,k}\}$
3. Gravity equations for final and input goods: $\{\pi^F_{ij,k}, \pi^I_{ij,k}\}$
4. Free entry conditions for entrepreneurs: $\{B_{i,k}\}$
5. Input cost advantage: $\{\Gamma_{i,m}\}$

Circular Causation: Input Seller Entry $\rightleftarrows$ Input Demand

- **Backward Linkage** (zero profit condition of marginal sellers)**:**

$$\underbrace{S^I_{i,k}}_{\text{input seller}} = \sum_{m \in K} \frac{(1-\gamma_{km})\,\psi_{km}}{f^I_{i,k} w_i} \underbrace{Y^I_{i,km}}_{\text{input demand}}$$

- **Forward Linkage**
  (input cost advantage + gravity + entrepreneur's free entry)**:**

$$Y_{i,km} = Y_{i,km}\left(\underbrace{\eta (S^I_{i,k}/Z_i)^{\lambda}}_{\text{supplier matching rate}}, \underbrace{\chi}_{\text{cost advantage per match}}\right)$$

Forward Linkage: Formal Conditions

- Input cost advantage

$$\Gamma_{i,m} = B_{i,m} w_i^{-\theta\gamma_{L,m}} \prod_{k \in K} \left\{ 1 + \underbrace{\Lambda_{i,km}(S^I_{i,k})}_{\text{S.S. match prob.}} \underbrace{(\chi^{\gamma_{km}\theta} - 1)}_{\text{cost adv. if matched}} \right\} \left(\overline{c}^I_{i,k}\right)^{-\gamma_{km}\theta}$$

- Gravity equations for final goods

$$\pi^F_{ij,m} = \frac{\Gamma_{i,m} B_{i,m} \left(\tau^F_{ij,m}\right)^{\theta}}{\sum_{i' \in N} \Gamma_{i',m} B_{i,m} \left(\tau^F_{i'j,m}\right)^{\theta}}$$

- Free entry condition

$$\Pi_{i,m} = w_i F_{i,m} B_{i,m}$$

Input Goods Prices: Precise Assumption

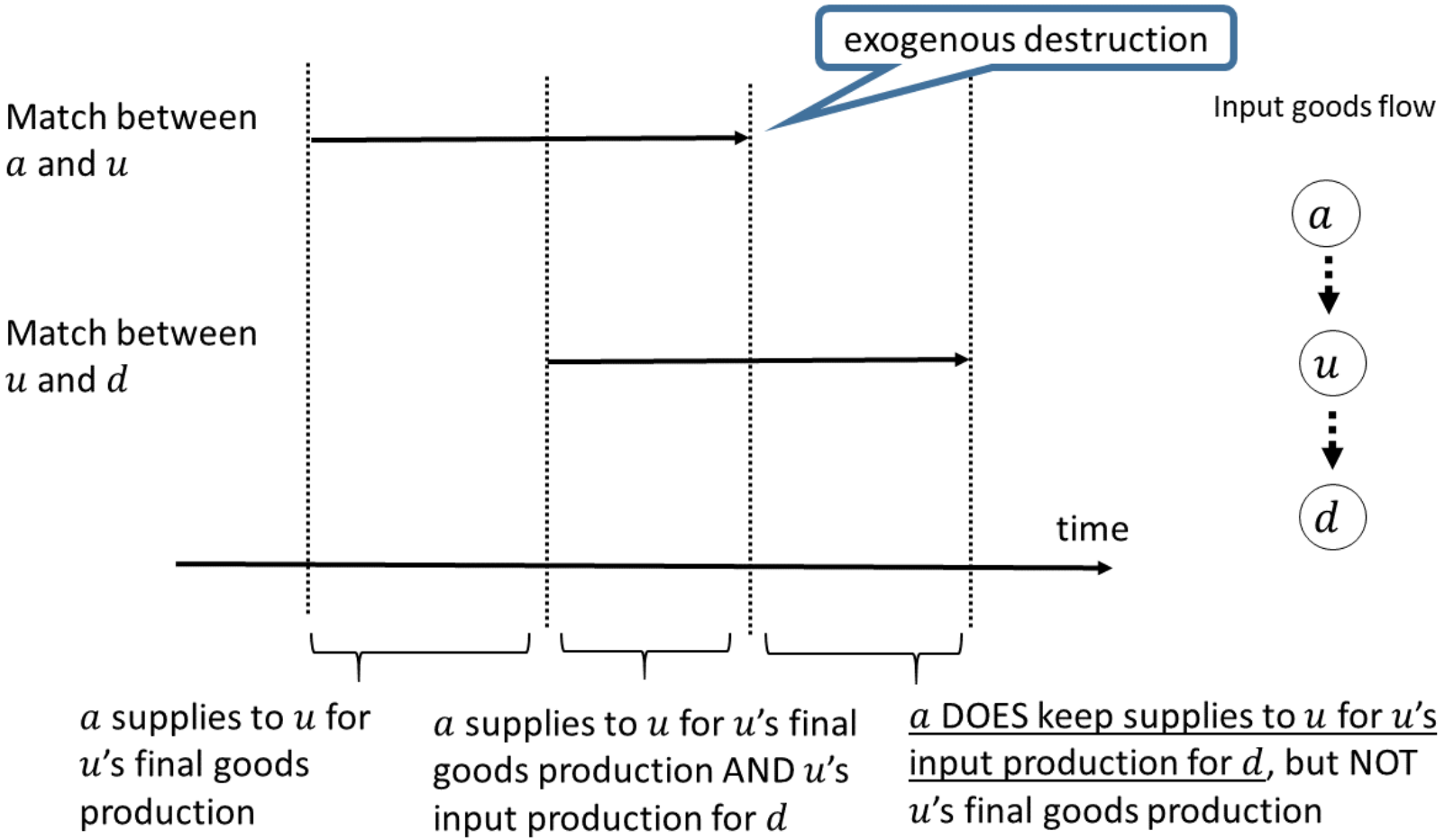
Assumption: u's suppliers (and indirect suppliers) at t^* supply input goods for u's input production for d as long as u and d are matched picture

Input Goods Prices: Precise Assumption

Assumption: u's suppliers (and indirect suppliers) at t^* supply input goods for u's input production for d as long as u and d are matched picture

Implication: PV of profit only depends on c_{ut^*} (at the point of t^*), and so is entry decision as input seller

Timing of Separation and Input Goods Supply



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