The Origins of Firm Heterogeneity: A Production Network Approach

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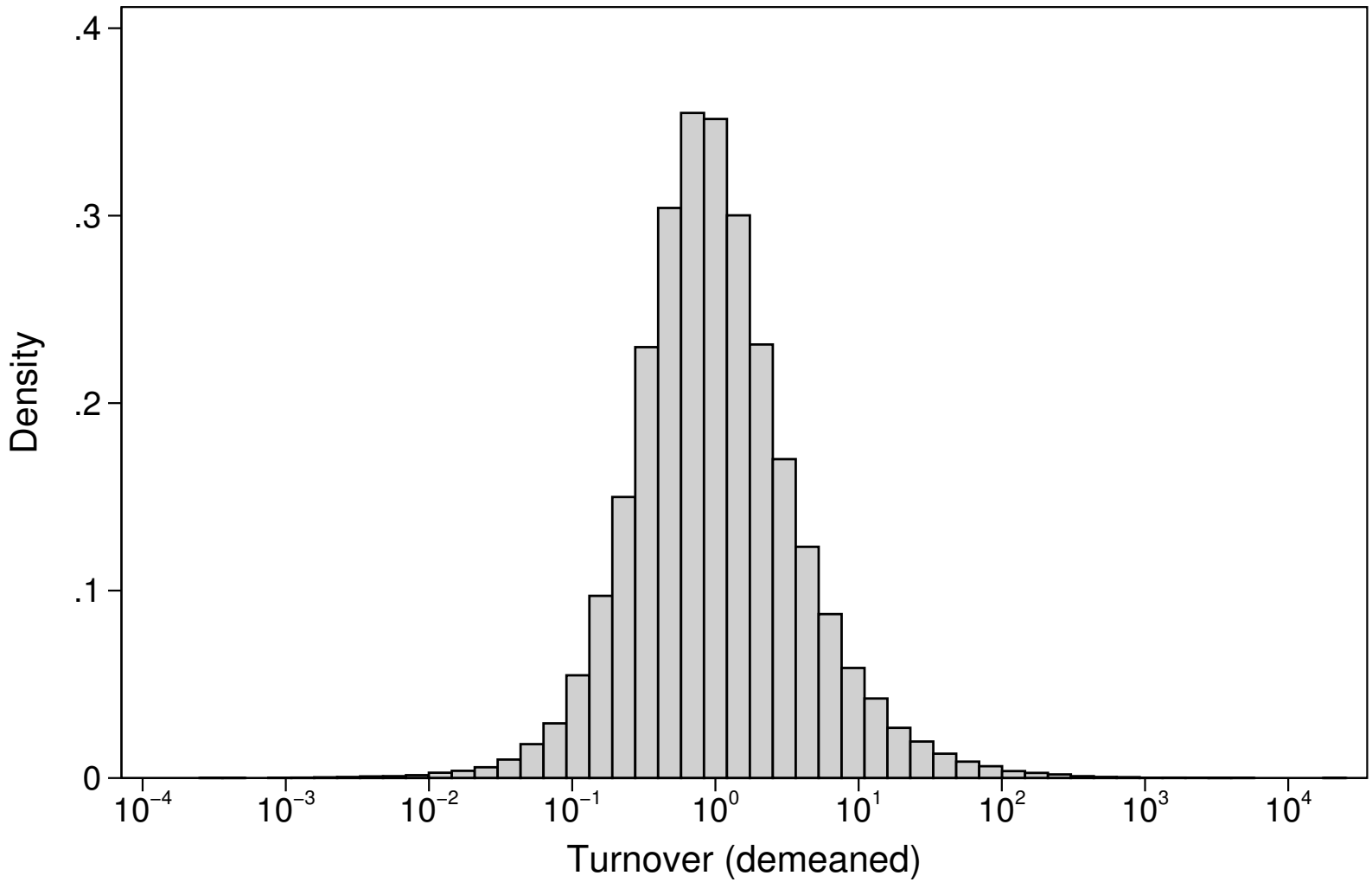
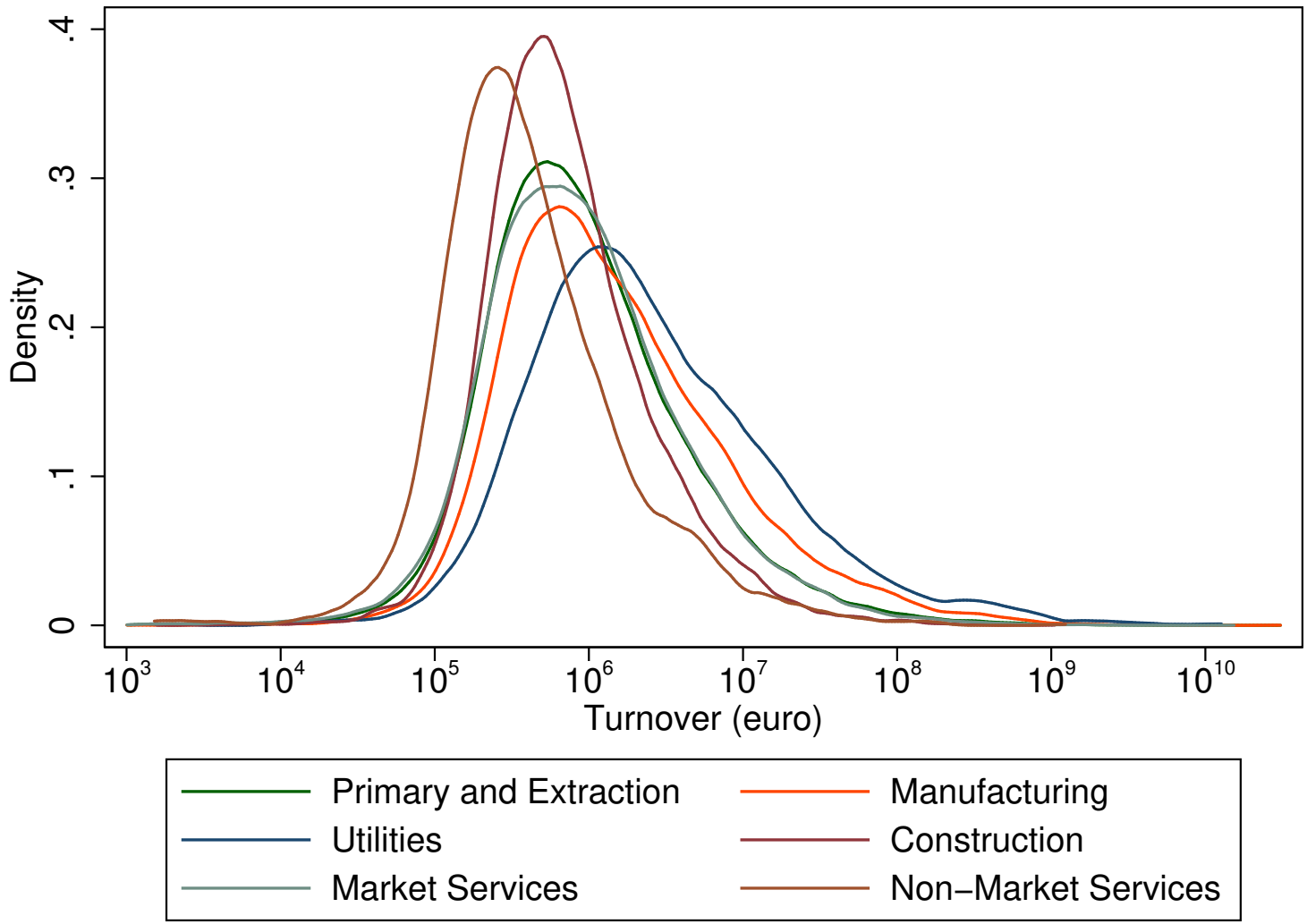
The Firm Size Distribution



Belgium 2014: $P90/P10 \approx 36$

The Firm Size Distribution



Belgium 2014: within sectors

Motivation

Why are firms big or small?

Firm size distribution is fundamental for

- Micro: firm survival, performance, innovation
- Trade: import and export activity, welfare gains
- Macro: granularity, aggregate productivity, shocks and volatility
- Labor: employment, wage and income inequality

Sources of Firm Size Heterogeneity

Prior literature: focus on one-sided heterogeneity in supply (productivity) or demand (consumer preferences)

- largely anonymous upstream suppliers and downstream buyers in frameworks with firm-to-firm trade

But firms are part of buyer-supplier production networks!

- firms buy inputs from other firms, sell to other firms & final consumers

This paper: What is the role of the production network in explaining the firm size distribution?

- number of buyers and suppliers
- characteristics of buyers and suppliers
- buyer-supplier match characteristics

Main Contributions

- Establish new facts about complete domestic production network
  - buyers, suppliers and seller-buyer matches matter for firm size
- Model two-sided heterogeneity in a (pre-determined) production network
  - firms are both buyers and sellers
  - own unit costs depend on suppliers' unit costs
  - own sales depend on customers' sales
- Use model and production network data to identify firm fundamentals and perform exact model-based decomposition of firm sales
  - Downstream (final demand, # customers, capability of customers)
  - Upstream (production capability, # suppliers, capability of suppliers)
  - Role for buyer-supplier match quality
- Use estimates and embed model in GE to perform counterfactuals

Main Results

1. Downstream factors explain the vast majority of firm size heterogeneity (82%), while upstream factors contribute less (18%)
2. Downstream component is mostly driven by network sales rather than final demand, while upstream component is dominated by own production capability rather than network purchases
3. Within network components, number of buyers/suppliers and allocation of sales/purchases towards capable, well-matched partners dominate average partner capability

Note: agnostic firm size decomposition, taking production network as given

- no restriction on magnitude of different margins
- minimal assumptions

Related Literature

- Firm size heterogeneity
  - skewness, granularity: Gibrat (1931), Gabaix (2011), Syverson (2011)
  - trade: Bernard et al. (2012), Gaubert & Itskhoki (2016), Arkolakis et al. (2012), Melitz & Redding (2015)
- Sources of firm heterogeneity:
  - own supply: Jovanovic (1982), Hopenhayn (1992), Sutton (1997), Melitz (2003), Luttmer (2007), Arkolakis (2016), Bloom et al. (2016)
  - upstream supply: Goldberg et al. (2010), Manova & Zhang (2011), Antras et al. (2015)
  - demand: Foster et al. (2015), Fitzgerald et al. (2016)
  - upstream & downstream: Hottman, Redding & Weinstein (2016)
- Production networks:
  - firm-to-firm trade: Bernard et al. (forthcoming a,b), Eaton et al. (2016), Lim (2016), Magerman et al. (2016), Dhyne et al. (2015)
- Two-sided heterogeneity:
  - gravity, labor markets: Helpman et al. (2008), Kramarz et al. (2016), Abowd, Kramarz and Margolis (1999), Card et al. (2015)

Today

- Data
- Model & exact decomposition
- Estimation
- Results
- Sensitivity
- *GE & welfare counterfactuals*
- Conclusions

Firm Balance Sheets & Domestic Production Network

- Belgium Central Balance Sheet Office (2002-2014)
  - Total sales S_i, input purchases M_i, employment, labor costs, location, NACE 4-digit industry
- Belgium NBB B2B Transactions Dataset (2002-2014)
  - Sales relationships among all VAT-liable firms in Belgium
  - Sales from firm i to firm j worth x euro in year t within Belgium
  - All sectors except financial services, all annual sales $m_{ij} \geq$€250
- Merge based on unique firm VAT ID

Fact 1a: Firm size is dispersed and skewed

Firm sales (€ mil, 2014)

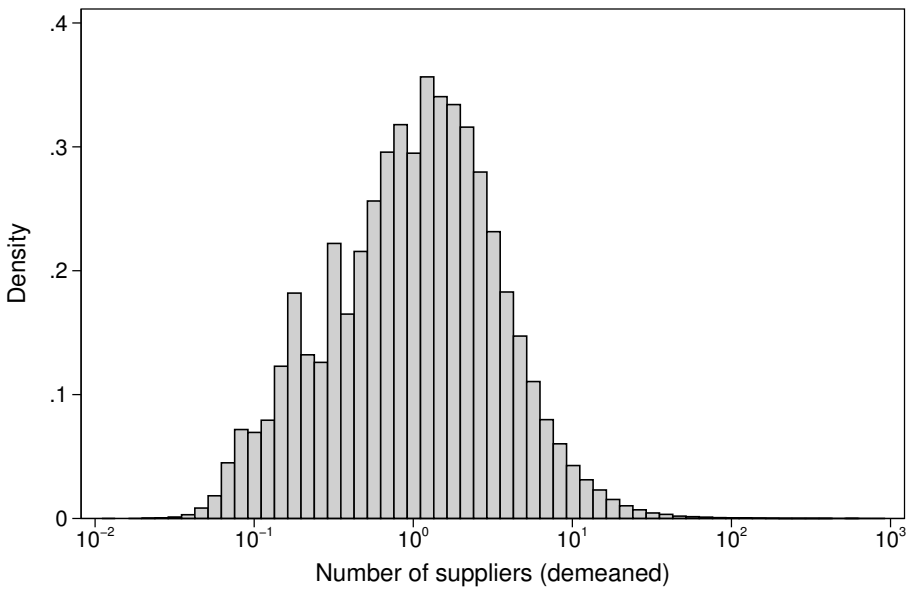
- Top 10% firms account for 84% of aggregate sales
- 90th/10th percentile ratio >36

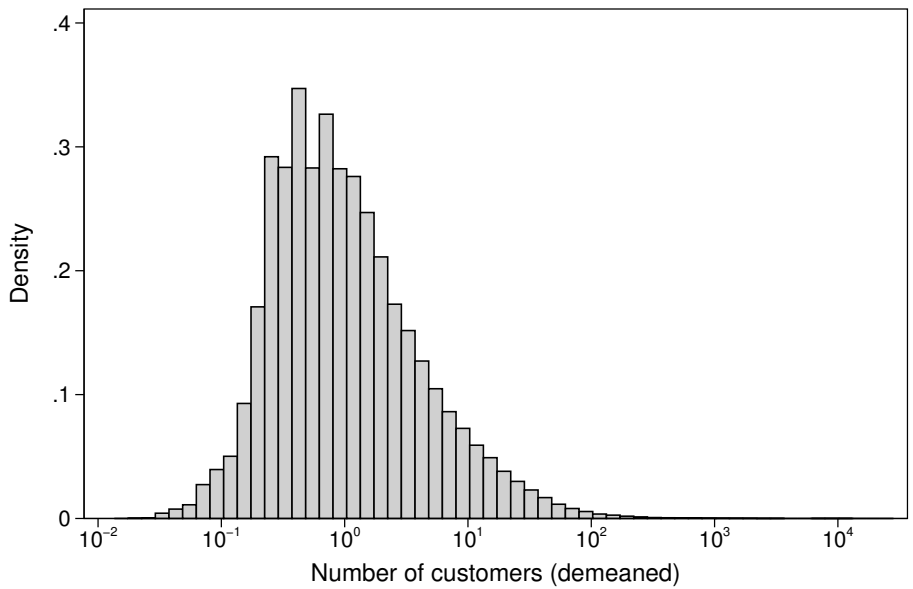
Sector	NACE	N	Mean	St Dev	10th	50th	90th	99th
Primary & Extraction	01-09	3,063	11.9	433	0.2	0.7	4.8	52
Manufacturing	10-33	18,086	14.4	251	0.2	1.1	13.8	202
Utilities	35-39	897	39.2	443	0.3	1.9	25.7	496
Construction	41-43	20,206	2.3	13.4	0.2	0.6	3.6	25.9
Market Services	45-82	65,323	5.5	79.8	0.2	0.8	6.3	63.8
Non-Market Services	84-99	2,333	2.2	26.2	0.1	0.3	2.6	24.9
All		109,908	6.7	145	0.2	0.8	6.6	78.3

Fact 1b: # firm connections is dispersed and skewed

Number of buyers and suppliers per firm (2014)

- 859,733 firms (590,271 sellers and 840,607 buyers)
- in-degree median, mean, st dev: 9, 21, 50
- out-degree median, mean, st dev: 4, 29, 394
- Top 1% firms transact with more than 400 buyers and 177 sellers





Fact 1c: Firm-to-firm sales are dispersed and skewed

17.3 million firm-to-firm sales relationships (€, 2014)

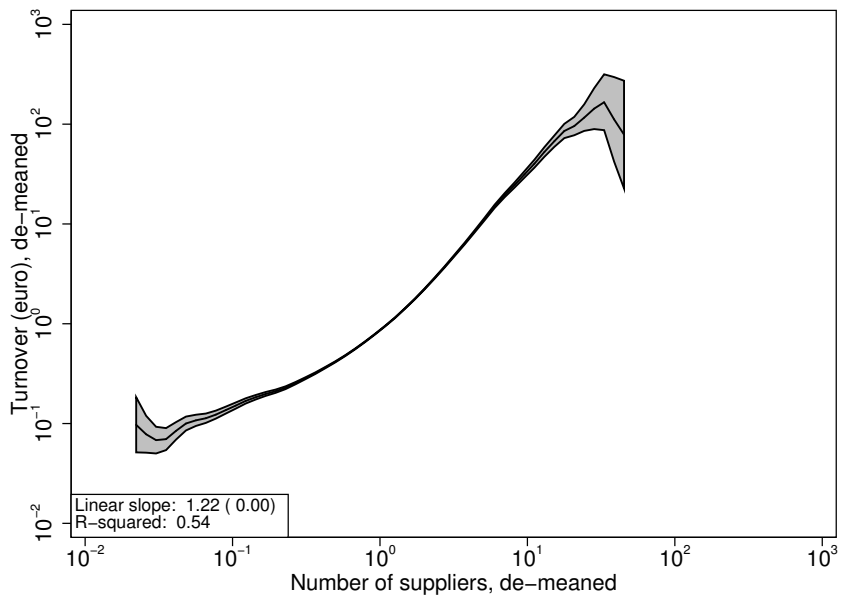
- Top 10% relationships account for 92% of value

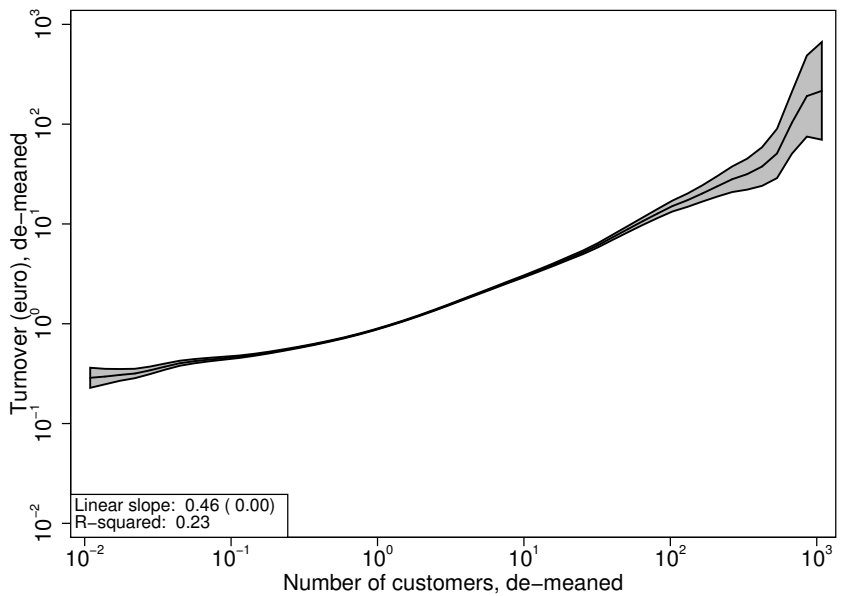
Sector of seller	N (mil)	Mean (€)	St Dev	10th	50th	90th	99t
Primary and Extraction	0.61	39,898	5,409,863	419	2,490	33,789	387,57
Manufacturing	2.76	44,303	2,007,421	359	1,661	25,436	411,37
Utilities	0.53	59,953	7,410,682	366	1,388	11,560	281,18
Construction	1.53	24,500	386,201	375	1,926	27,186	339,52
Market Services	11.56	24,373	2,886,213	341	1,266	15,579	224,36
Non-Market Services	0.32	8,036	318,863	315	996	8,396	92,73
All	17.30	28,893	2,988,881	348	1,392	18,280	269,15

Fact 2: Bigger firms have more buyers and suppliers

Total firm sales against firm connections (2014)

- Local polynomial regression with industry average at (1,1)

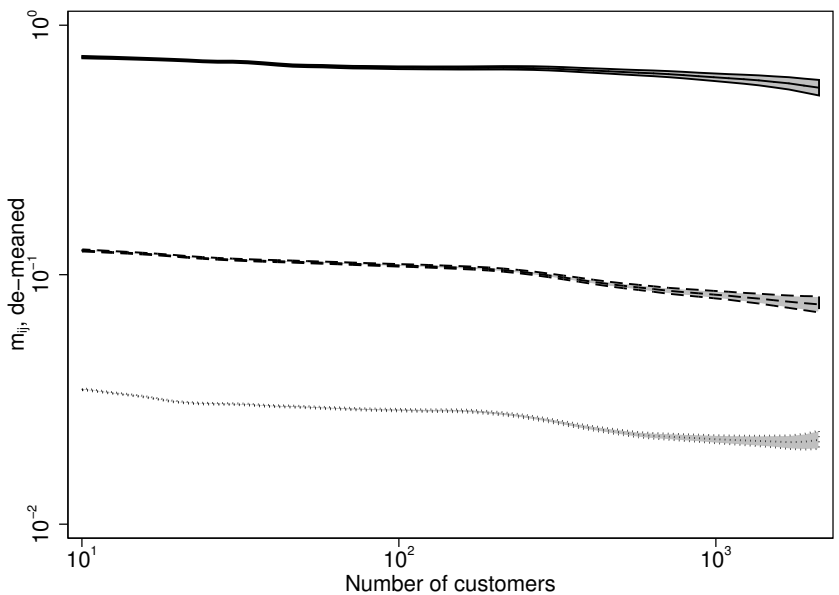




Fact 3: Sales distribution does not vary with # buyers

10th, 50th, 90th percentile of firm sales across buyers against firm connections (2014)

- Local polynomial regressions with industry average at (1,1)



Model Overview

Goal: understand role of production network for firm size heterogeneity

- Take network as pre-determined
- Map model parameters to observed and estimable firm attributes
- Derive model-based exact firm size decomposition

Key ingredients: two-sided heterogeneity in a buyer-supplier network

- Heterogeneous firm productivity/quality and firm-to-firm match quality
- Firms use labor and inputs from upstream suppliers to produce for final demand and downstream buyers
- Minimal set of assumptions (add a few more for GE)

The Model

Assumption

The production function is

$$y_i = \kappa z_i l_i^{\alpha} v_i^{1-\alpha}$$

$$v_i = \left(\sum_{k \in \mathcal{S}_i} (\phi_{ki} \nu_{ki})^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}$$

- Marginal costs, input price index, and prices

$$c_i = \frac{w^{\alpha} P_i^{1-\alpha}}{z_i}, \qquad P_i^{1-\sigma} = \sum_{k \in \mathcal{S}_i} (p_{ki}/\phi_{ki})^{1-\sigma}, \qquad p_{ij} = \tau_{ij} c_i$$

- Firm-to-firm sales

$$m_{ij} = \left(\frac{\phi_{ij}}{p_{ij}} \right)^{\sigma-1} P_j^{\sigma-1} M_j$$

Assumption

Demand (taste) & supply (mark-up, trade cost) shifters are

$$\phi_{ij} = \phi_i \tilde{\phi}_{ij}$$
$$\tau_{ij} = \tau_i \tilde{\tau}_{ij}$$

- Rewrite firm-to-firm sales as $m_{ij} = \psi_i \theta_j \omega_{ij}$ with

$$\psi_i \equiv \left(\frac{\phi_i}{\tau_i c_i} \right)^{\sigma-1}, \qquad \theta_j \equiv P_j^{\sigma-1} M_j, \qquad \omega_{ij} \equiv \left(\frac{\tilde{\phi}_{ij}}{\tilde{\tau}_{ij}} \right)^{\sigma-1}$$

- Firm-to-firm sales depend on seller's production capability, buyer's sourcing capability and match quality

The Reflection Problem

- Seller effect ψ_i embodies technology of its suppliers
- Given estimates of $\Psi = \{\psi_i, \theta_j, \omega_{ij}\}$ and data on (M_i, α), can back out own *production capability* $\tilde{z}_i$:

$$\tilde{z}_i \equiv \left(\frac{\phi_i z_i}{\kappa \tau_i w^{\alpha}}\right)^{\sigma-1} = \psi_i \left(\frac{\theta_i}{M_i}\right)^{1-\alpha}$$

- Intuition:
  - Cheap inputs $\longrightarrow$ low input price index $P_i^{\sigma-1} = \theta_i / M_i$
  - To get $\tilde{z}_i$, seller effect ψ_i must be adjusted down
- Implication for seller and buyer effect (*sourcing capability*): $corr\left(\psi_i, \theta_i / M_i\right) < 0$

The Exact Decomposition

- Fraction of sales and purchases within the network: $1/\beta_i^c$ and $1/\beta_i^s$
  - sales outside network: final domestic demand + exports
  - purchases outside network: imported inputs

- Total sales can be expressed as:

$$\ln S_i = \ln \psi_i + \ln \xi_i + \ln \beta_i^c$$

$$\xi_i \equiv \sum_{j \in \mathcal{C}_i} \theta_j \omega_{ij}$$

- Variance decomposition, using $\Psi = \{\psi_i, \theta_j, \omega_{ij}\}$ estimates & β_i^c data
  - Regress each component on $\ln S_i$
  - Coefficients give share of firm size variation explained by each margin

Downstream Decomposition

- The downstream parameter ξ_i can be expressed as:

$$\ln \xi_i = \ln n_i^c + \ln \bar{\theta}_i + \ln \Omega_i^c$$

$$\bar{\theta}_i \equiv \left(\prod_{j \in \mathcal{C}_i} \theta_j \right)^{1/n_i^c}$$

$$\Omega_i^c \equiv \frac{1}{n_i^c} \sum_{j \in \mathcal{C}_i} \omega_{ij} \frac{\theta_j}{\bar{\theta}_i}$$

- Variance decomposition, using $\Psi = \{\psi_i, \theta_j, \omega_{ij}\}$ estimates & n_i^c data
  - Regress each component on $\ln \xi_i$

Upstream Decomposition

- The upstream parameter (seller effect) ψ_i can be expressed as:

$$\ln \psi_i = \ln \tilde{z}_i + (1-\alpha)\left[\ln n_i^s + \ln \bar{\psi}_i + \ln \Omega_i^s + \ln \beta_i^s\right]$$

$$\bar{\psi}_i \equiv \left(\prod_{k \in \mathcal{S}_i} \psi_k\right)^{1/n_i^s}$$

$$\Omega_i^s \equiv \frac{1}{n_i^s} \sum_{k \in \mathcal{S}_i} \omega_{ki} \frac{\psi_k}{\bar{\psi}_i}$$

- Variance decomposition, using $\Psi = \{\psi_i, \theta_j, \omega_{ij}\}$ estimates & $\{M_i, \alpha, n_i^s, \beta_i^s\}$ data
  - Regress each component on $\ln \psi_i$

Estimation

- Step 1: Estimate $\Psi = \{\psi_i, \theta_j, \omega_{ij}\}$ from production network data
- Step 2: Use Ψ estimates and observed firm data to calculate unobserved firm size components
- Step 3: Perform exact firm size decomposition

Estimation: Step 1

- Estimate seller and buyer FE by OLS

$$\ln m_{ij} = \ln \psi_i + \ln \theta_j + \ln \omega_{ij}$$

- $\ln \psi_i \approx$ average market share of i among her customers
- $\ln \theta_j \approx$ average market share of j among her suppliers

$$E\left[s^{i\prime} r\right] = 0 \qquad \forall i \tag{1}$$
$$E\left[b^{j\prime} r\right] = 0 \qquad \forall j \tag{2}$$

  - $S = \left[s^1, .., s^{N_s}\right]$ is $N^* \times N_s$ seller FE design matrix.
  - $B = \left[b^1, .., b^N\right]$ is $N^* \times N_b$ buyer FE design matrix.
  - r is $N^* \times 1$ vector of $\ln \omega_{ij}$.
  - Eq (1): For each seller, average $\ln \omega_{ij}$ across buyers is zero.
  - Eq (2): For each buyer, average $\ln \omega_{ij}$ across sellers is zero.

Estimation: Step 1 Exogenous Mobility

- Conditional exogenous mobility:
  - Assignment of suppliers to customers exogenous wrt ω_{ij}
- Exogenous mobility holds if firms match based on:
  - Seller and buyer characteristics, $\ln \psi_i$ and $\ln \theta_j$
  - Fixed search-and-match costs (e.g., Bernard et al. forthcoming, Lim 2016)
  - Pair-wise shocks unrelated to ω_{ij} (e.g., Eaton et al. 2015)
- Exercise 1: Asymmetry test - Card et al. (2015)
- Exercise 2: Include covariates for ω_{ij}

Estimation: Step 1 Avalanching

- ≥ 2 customers $\longrightarrow$ seller effect $\ln \psi_i$
- ≥ 2 suppliers $\longrightarrow$ buyer effect $\ln \theta_i$
- Avalanching: firm A dropped $\longrightarrow$ firm B too few links $\longrightarrow$ B dropped as well
- Only main network component used

Raw Data			Estimation Sample			
# Links	# Sellers	# Buyers	Links	Value	Sellers	Buyers
17,304,408	590,271	840,607	99%	95%	74%	88%

Table: Avalanching (2014)

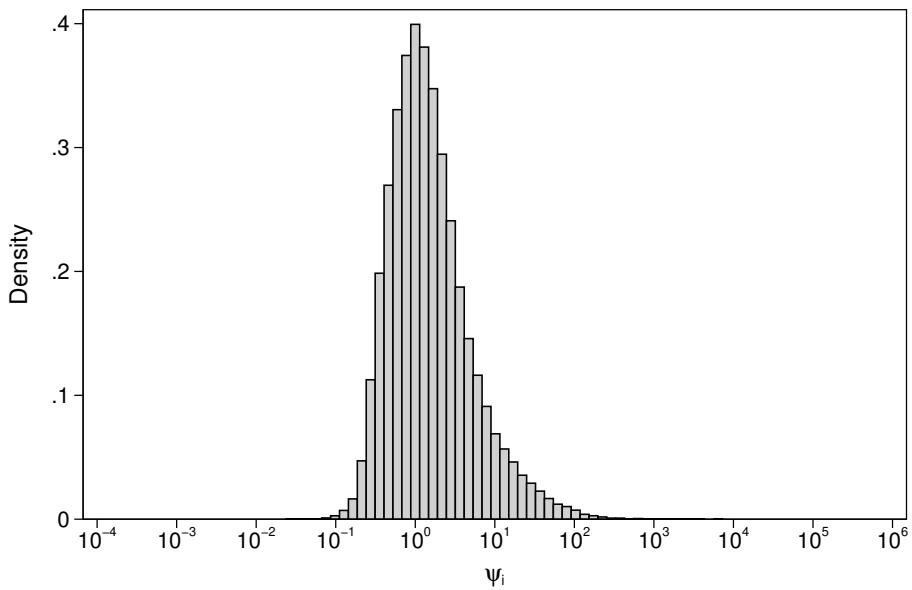
Estimation: Steps 2 & 3

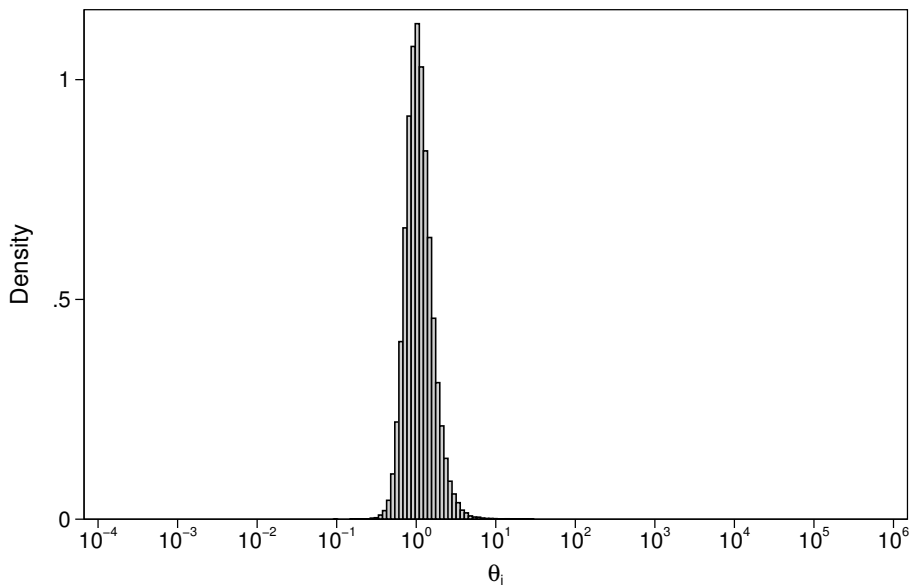
- Step 2:
  - Use estimates Ψ and observables ($\ln S_i$, $\ln M_i$, $\ln \beta_i^c$, $\ln \beta_i^s$, $\ln n_i^c$, $\ln n_i^s$, $\mathcal{C}_i$ and $\mathcal{S}_i$) to get unobservables ($\ln \xi_i$, $\ln \tilde{z}_i$, $\ln \bar{\psi}_i$, $\ln \bar{\theta}_i$, $\ln \Omega_i^s$ and $\ln \Omega_i^c$)
  - Firms with missing S_i and M_i still part of Step 1, but not Steps 2 and 3
  - NACE 4-digit industry parameters: α = total wage bill / total production costs, w = total wage bill / total employment
- Step 3:
  - Demean all size components by NACE 4-digit industry average
  - Regress each demeaned component on demeaned $\ln S_i$, $\ln \psi_i$ or $\ln \xi_i$

Results: Distribution of Seller and Buyer Effects

Estimating seller, buyer and match effects from firm-to-firm sales:

$$\ln m_{ij} = \ln \psi_i + \ln \theta_j + \ln \omega_{ij}$$



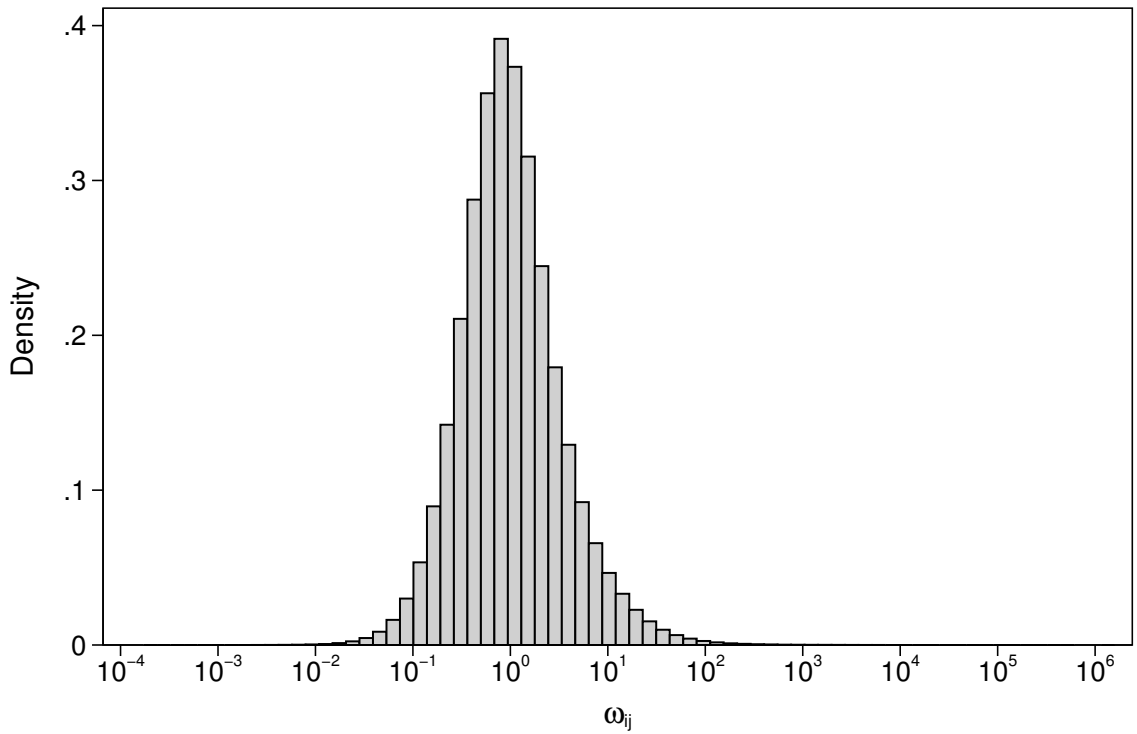


$$sd\left(\ln \psi_i\right) = 1.05,\ sd\left(\ln \theta_i\right) = .50,\ corr\left(\ln \psi_i, \frac{\ln \theta_i}{M_i}\right) = -.13^{***}$$

Results: Distribution of Match Quality

Estimating seller, buyer and match effects from firm-to-firm sales:

$$\ln m_{ij} = \ln \psi_i + \ln \theta_j + \ln \omega_{ij}$$



$$R^2 = .43, \; sd\left(\ln \omega_{ij}\right) = 1.20$$

Results: Main Decomposition

Decomposing total firm sales:

$$\ln S_i = \ln \psi_i + \ln \xi_i + \ln \beta_i^c$$

	N	Upstream $\ln\psi_i$	Downstream $\ln\xi_i$	Final Demand $\ln\beta_i^c$
$\ln S_i$	94,357	$.18^{***}$	$.81^{***}$	$.01^{***}$

Note: Significance: * < 5%, ** < 1%, *** <0.1%.

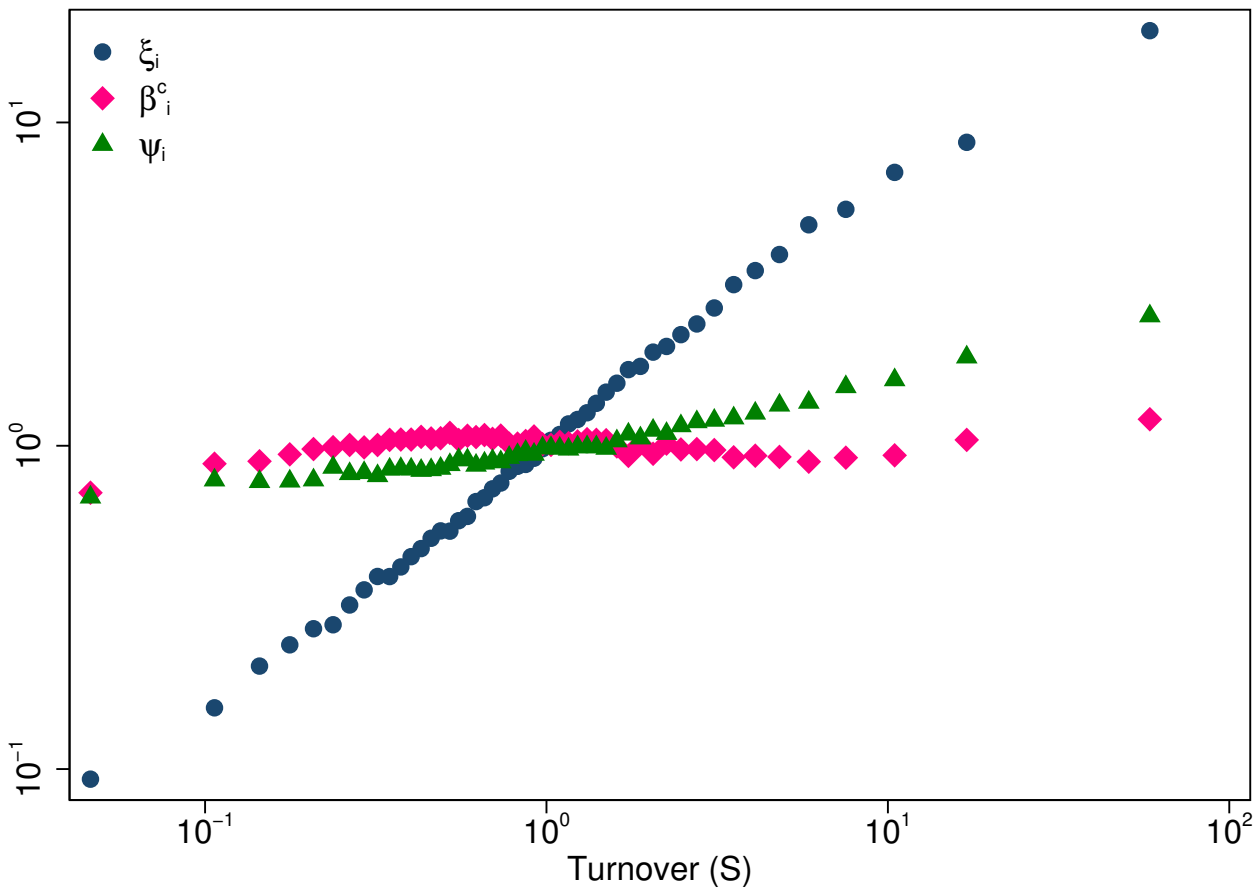
Table: Overall decomposition (2014)

- Final demand contributes trivially to size variation → network is key
- Size dispersion mostly explained by downstream component (network demand)
- Upstream component (supply) matters, but much less

Results: Main Decomposition

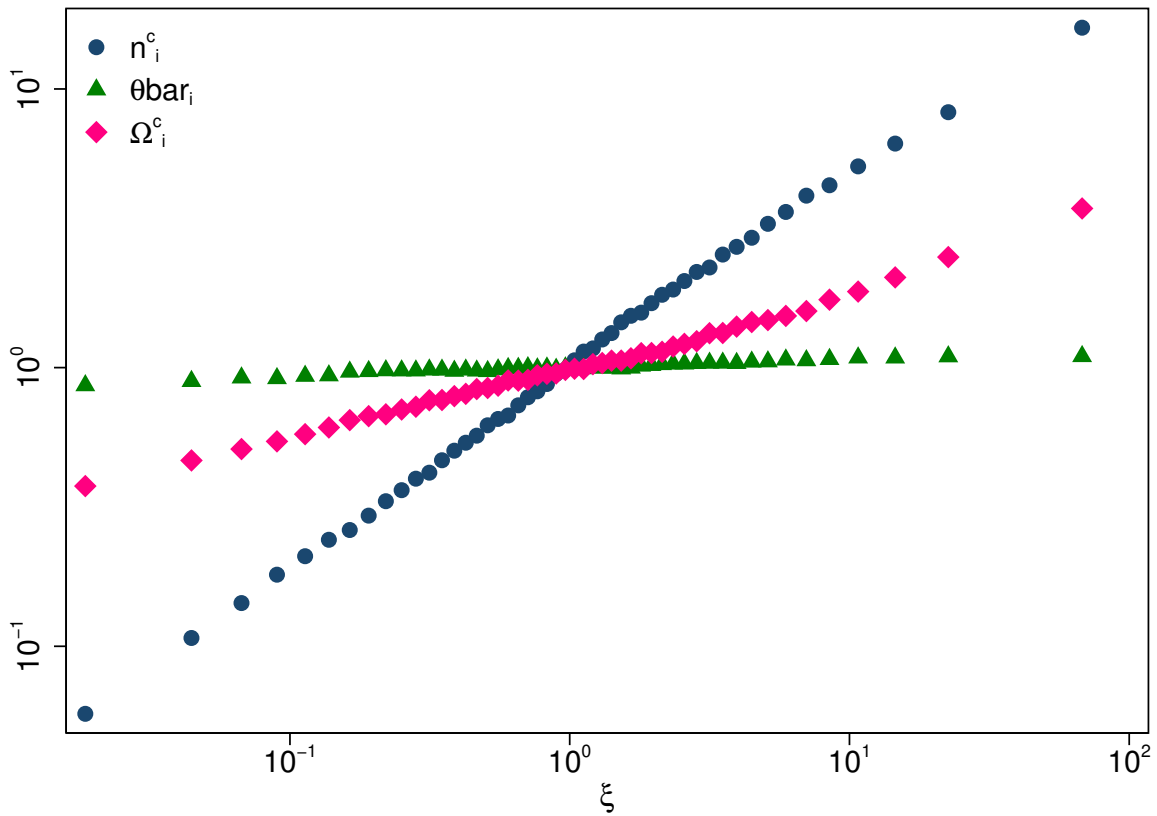
Contribution of size margins is stable across 20 size bins

$$\ln S_i = \ln \psi_i + \ln \xi_i + \ln \beta_i^c$$



Results: Downstream Decomposition

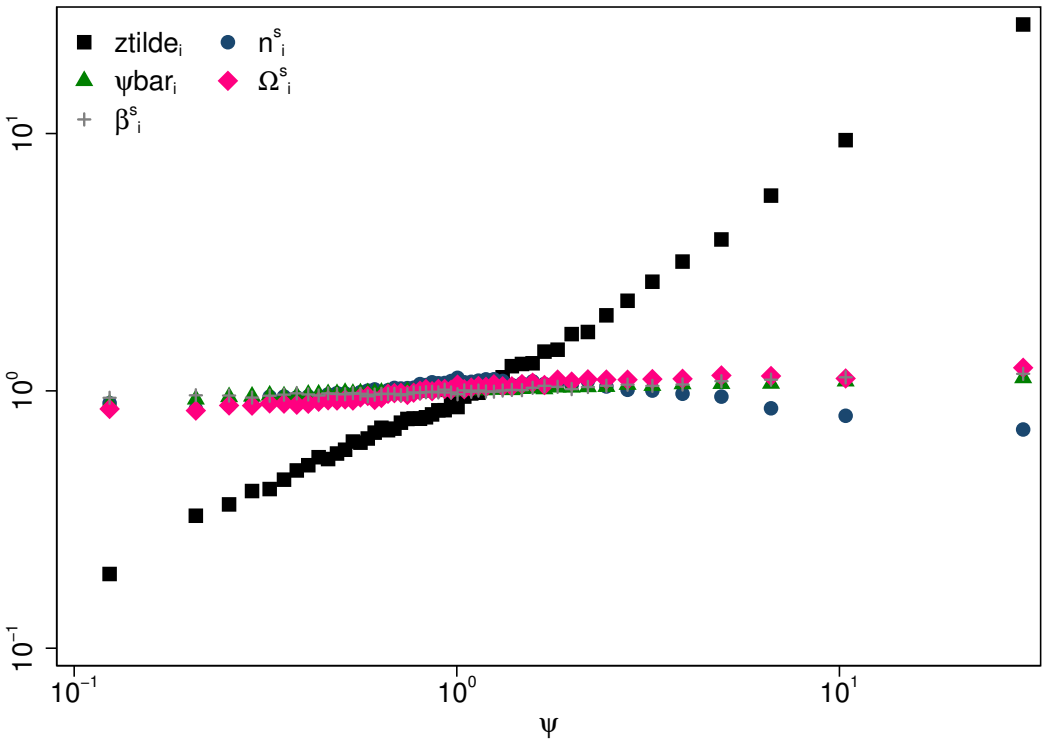
$$\ln \xi_i = \underset{.71}{\ln n_i^c} + \underset{.03}{\ln \bar{\theta}_i} + \underset{.26}{\ln \Omega_i^c}$$



- Bigger firms have more customers and sell more to their capable, well-matched customers ... but do not have more capable customers

Results: Upstream Decomposition

$$\ln \psi_i = \underset{.85}{\ln \tilde{z}_i} + (1-\alpha)\Big(\underset{-.01}{\ln n_i^s} + \underset{.04}{\ln \bar{\psi}_i} + \underset{.08}{\ln \Omega_i^s} + \underset{.04}{\ln \beta_i^s}\Big)$$



- Supply-side fundamentals mostly driven by own production capability
- Bigger firms source more from their capable, well-matched suppliers ... but do not have more or more capable suppliers

Extensions & Robustness

- Exogenous mobility test
- Cross-section over time
- Firm growth over time
- Variation across industries
- Observables for ω_{ij} : Distance

Exogenous Mobility Test

- Empirical test in the spirit of Card et al. (2015)
- Under exogenous mobility, we have

$$E\left[\ln m_{ij} - \ln m_{ik}\right] = -E\left[\ln m_{ik} - \ln m_{ij}\right] = \ln \theta_j - \ln \theta_k$$

- Under endogenous mobility, moves from big to small may not lead to (a large) decline if moves are driven by unobserved shocks

Exogenous Mobility Test

Procedure:

- Estimate Ψ for the 2005 cross-section ($t = 0$)
- Group firms into quartiles based on $\ln \theta_j$: q_k, $k = 1, 2, 3, 4$
- *Upgraders*: Firms that have at least one q_1 buyer in $t = 0$ and add at least one q_4 buyer in $t = 1$
  - Calculate $\ln m_{ij(q_4),t=1} - \ln m_{ij(q_1),t=0}$, where $j(q_k)$ denotes a customer in the q_k'th quartile
  - Form the average of all possible combinations: $\bar{\Delta}_i^{Up}$
  - Take the average of $\bar{\Delta}_i^{Up}$ across all upgraders
- *Downgraders*: Calculate $\bar{\Delta}_i^{Down}$ symmetrically
- Preliminary results: $\left|\bar{\Delta}_i^{Down}\right| > \bar{\Delta}_i^{Up}$

Extensions: Cross-Section Over Time

Year	N	Upstream $\ln\psi_i$	Downstream $\ln\xi_i$	Final Demand $\ln\beta_i^c$
2002	81,410	.17***	.78***	.05***
2003	83,817	.17***	.78***	.05***
2004	85,174	.18***	.78***	.04***
2005	86,617	.17***	.78***	.04***
2006	88,714	.17***	.79***	.04***
2007	91,172	.18***	.79***	.03***
2008	92,465	.18***	.79***	.03***
2009	92,528	.17***	.79***	.04***
2010	92,903	.17***	.79***	.04***
2011	94,282	.18***	.80***	.03***
2012	95,558	.18***	.79***	.03***
2013	94,324	.18***	.80***	.02***
2014	94,357	.18***	.81***	.01**

Table: Results by year (2002-2014)

Extensions: Firm Growth

Assess contribution of production network to firm growth over time

- Estimate Ψ in 2002 ($t = 0$) and 2014 ($t = 1$)
- Calculate change in every firm size component
- Decompose change in overall firm size $\Delta \ln S_i$ into margins
- Growth decomposition sample:
  - Only survivors with non-missing θ_i and ψ_i in both years
  - But account for adding/dropping of relationships, e.g. the terms $\Delta \ln \psi_i$ and $\Delta \ln \xi_i$ change because of extensive margin

Extensions: Firm Growth

Firm Size Component		Sales S_i	Downstream ξ_i	Upstream ψ_i
Upstream Network Supply	ψ_i	.09***		
Downstream Network Demand	ξ_i	.81***		
Final Demand	β_i^c	.10***		
# Customers	n_i^c		.61***	
Avg Customer Capability	$\bar{\theta}_i$		.01***	
Customer Covariance	Ω_i^c		.38***	
Production Capability	$\tilde{z}_i$			.98***
# Suppliers	n_j^s			-.03***
Avg Supplier Capability	ψ_i			.01***
Supplier Covariance	Ω_i^c			.03***
Outside-Network Supply	β_i^s			.01***
N		41,185	41,185	41,185

Table: Firm growth decomposition (2002-2014)

Extensions: Variation Across Sectors

NACE	Industry	N	Upstream ψ_i	Downstream ξ_i	Final Demand β_i^c
01-09	Primary and Extraction	2,838	.24***	.79***	-.03**
10-33	Manufacturing	16,905	.26***	.75***	-.01**
35-39	Utilities	852	.15***	.81***	.04**
41-43	Construction	19,008	.12***	.99***	-.10**
45-82	Market Services	53,604	.18***	.77***	.04**
84-96	Non-Market Services	1,150	.12***	.84***	.04

Table: Results by NACE-4 industry (2014)

General Equilibrium

Close the model with 2 additional assumptions in order to perform counterfactual analyses

- CES final demand with same elasticity of substitution σ
  - Consumers supply labor inelastically
  - They are shareholders of the firms
  - Income is $X = wL + \Pi$, where Π is aggregate profits
- Constant (but potentially heterogeneous) mark-ups
  - Constant ratio of input purchases to sales, $\mu_i \equiv M_i/S_i = (1-\alpha)/Markup_i$

GE: Solution Method

1. Own input costs depend on suppliers' input costs: use estimates of $\tilde{z}_i$ and ω_{ij} in *backward fixed point*:

$$\tilde{P}_j = \sum_{i \in \mathcal{S}_j} \left(\frac{p_{ij}}{\phi_{ij}} \right)^{1-\sigma} = \sum_{i \in \mathcal{S}_j} \tilde{P}_i^{1-\alpha} \tilde{z}_i \omega_{ij}, \quad \tilde{P}_j = P_j^{1-\sigma}$$

2. Own sales depend on buyers' sales: use (i) estimates of $\tilde{z}_i$ and ω_{ij}, (ii) data on μ_j and (iii) solution for $\tilde{P}_j$ in *forward fixed point*:

$$S_i = \tilde{z}_i \tilde{P}_i^{1-\alpha} \left(\frac{X}{\tilde{\mathcal{P}}} + \sum_{j \in \mathcal{C}_i} \frac{\mu_j S_j}{\tilde{P}_j} \omega_{ij} \right),$$

where $\tilde{\mathcal{P}}$ is the final demand price index

Next steps: Counterfactuals, e.g. shocks to z_i, ω_{ij}, network structure

Conclusions

- Production network data and exact decomposition framework yield new insights:
  - Firm sales dispersion is almost entirely attributed to production network, rather than final demand
  - It is mostly driven by downstream component
  - Upstream component matters, but is small
- This begs the question: How do firms attract suppliers and customers?
  - Bigger role for supply-side fundamentals when accounting for endogenous network formation?
  - Link between production and sourcing capability?

Future Work

- Endogenous network formation
  - how firm fundamentals determine matching with buyers and suppliers
- Aggregate implications of firm size heterogeneity
  - role of different size drivers for growth and income inequality
  - propagation and welfare impact of idiosyncratic and macro shocks

Appendix: Statistics on Firm Size Components (2014)

Firm Size Component	Estimated?	N	Mean	Median	St Dev
Total Sales, $\ln S_i$		94,357	0.000	-0.112	1.318
Overall Decomposition of $\ln S_i$					
Upstream Supply, $\ln \psi_i$	Y	94,357	0.000	-0.130	1.000
Downstream Network Demand, $\ln \xi_i$	Y	94,357	0.000	0.002	1.627
Final Demand, $\ln \beta_i^c$		94,357	0.000	-0.261	1.199
Upstream Decomposition of $\ln \psi_i$					
Production Capability, $\ln \tilde{z}_i$	Y	94,357	0.000	-0.108	1.294
# Suppliers, $\ln n_i^s$		94,357	0.000	-0.000	0.773
Avg Supplier Capability, $\ln \bar{\psi}_i$	Y	94,357	0.000	-0.016	0.215
Supplier Covariance, $\ln \Omega_i^s$	Y	94,357	0.000	-0.069	0.635
Outside-Network Supply, $\ln \beta_i^s$		94,357	0.000	-0.118	0.537
Downstream Decomposition of $\ln \xi_i$					
# Customers, $\ln n_i^c$		94,357	0.000	-0.006	1.366
Avg Customer Capability, $\ln \bar{\theta}_i$	Y	94,357	0.000	-0.033	0.318
Customer Covariance, $\ln \Omega_i^c$	Y	94,357	0.000	-0.127	0.739

Appendix: Correlation Matrix (2014)

Firm Size Component	$\ln S_i$	$\ln \psi_i$	$\ln \xi_i$	$\ln \beta_i^c$	$\ln \tilde{z}_i$	$\ln n_i^s$	$\ln \bar{\psi}_i$	$\ln \Omega_i^s$	$\ln \beta_i^s$	$\ln n_i^c$	$\ln \bar{\theta}_i$	$\ln \Omega_i^c$
Total Sales, $\ln S_i$	1											
Usptream Supply, $\ln \psi_i$	0.25	1										
Downstream Network Demand, $\ln \xi_i$	0.65	0.14	1									
Final Demand, $\ln \beta_i^c$	0.01	-0.36	-0.52	1								
Production Capability, $\ln \tilde{z}_i$	-0.52	0.64	-0.58	-0.30	1							
# Suppliers, $\ln n_i^s$	0.76	-0.02	0.62	0.00	-0.61	1						
Avg Supplier Capability, $\ln \bar{\psi}_i$	0.19	0.28	0.01	-0.04	0.02	0.02	1					
Supplier Covariance, $\ln \Omega_i^s$	0.65	0.18	0.39	0.04	-0.40	0.36	0.17	1				
Outside-Network Supply, $\ln \beta_i^s$	0.10	0.08	0.00	0.04	-0.08	-0.14	-0.13	-0.27	1			
# Customers, $\ln n_i^c$	0.46	-0.31	0.85	-0.37	-0.61	0.55	-0.07	0.26	-0.02	1		
Avg Customer Capability, $\ln \bar{\theta}_i$	0.21	0.21	0.15	-0.15	0.05	0.07	0.06	0.11	0.09	-0.18	1	
Customer Covariance, $\ln \Omega_i^c$	0.46	0.18	0.57	-0.41	-0.18	0.33	0.13	0.32	-0.01	0.09	0.24	1

Note: All correlations are significant at 5% except those strictly below 0.01.