Imperfect Competition and the Transmission of Shocks: The Network Matters

Ayumu Ken Kikkawa[1] Glenn Magerman[2] Emmanuel Dhyne[3]

[1]University of Chicago [2]ECARES (ULB) [3]National Bank of Belgium

February 2018

RIETI

Motivation

- Domestic firm-to-firm trade in Belgium $\simeq 1.5 \times$ value added.
- High concentration in firms' inputs. For the majority of Belgian firms,
  - the number of suppliers is 28 or less.
  - the largest supplier accounts for 27% or more of input purchases.
- What are the implications of oligopolistic competition and endogenous networks for the transmission of shocks in the aggregate?

This paper

- Presents two facts from Belgian firm-to-firm trade data.
  1. Firm-level markups correlated with firms' downstream sales shares within customer firms.

This paper

- Presents two facts from Belgian firm-to-firm trade data.
  1. Firm-level markups correlated with firms' downstream sales shares within customer firms.
  2. Firms experience larger churn of suppliers when exposed to larger import supply shocks.

This paper

- Presents two facts from Belgian firm-to-firm trade data.
  1. Firm-level markups correlated with firms' downstream sales shares within customer firms.
  2. Firms experience larger churn of suppliers when exposed to larger import supply shocks.

- Develops a model of firm-to-firm trade.
  1. Oligopolistic competition (pairwise variable markups).

This paper

- Presents two facts from Belgian firm-to-firm trade data.
  1. Firm-level markups correlated with firms' downstream sales shares within customer firms.
  2. Firms experience larger churn of suppliers when exposed to larger import supply shocks.

- Develops a model of firm-to-firm trade.
  1. Oligopolistic competition (pairwise variable markups).
  2. Endogenous networks with fixed costs.

This paper

- Presents two facts from Belgian firm-to-firm trade data.
  1. Firm-level markups correlated with firms' downstream sales shares within customer firms.
  2. Firms experience larger churn of suppliers when exposed to larger import supply shocks.

- Develops a model of firm-to-firm trade.
  1. Oligopolistic competition (pairwise variable markups).
  2. Endogenous networks with fixed costs.

  - In the benchmark case (without these two elements), firm-level variables are sufficient in calculating aggregate response to shocks.

This paper

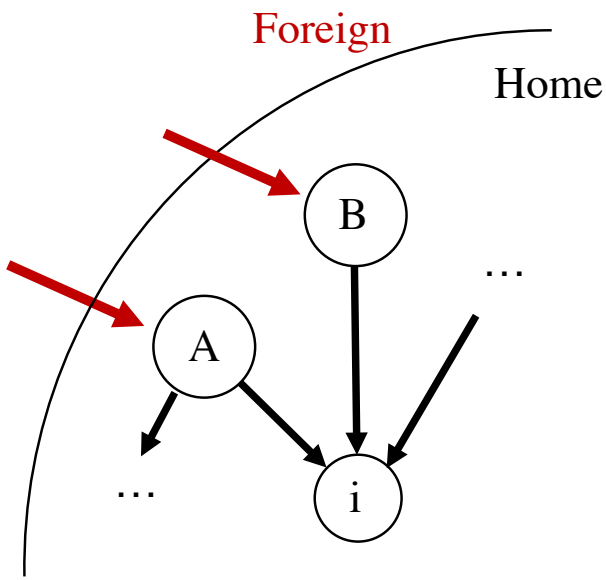
- Presents two facts from Belgian firm-to-firm trade data.
  1. Firm-level markups correlated with firms' downstream sales shares within customer firms.
  2. Firms experience larger churn of suppliers when exposed to larger import supply shocks.

- Develops a model of firm-to-firm trade.
  1. Oligopolistic competition (pairwise variable markups).
  2. Endogenous networks with fixed costs.
  - In the benchmark case (without these two elements), firm-level variables are sufficient in calculating aggregate response to shocks.

- Analyzes the aggregate responses to a foreign price reduction.
  - Oligopolistic competition with fixed networks (full data).
  - Oligopolistic competition with endogenous networks (model simulation).

Networks and shock transmission

- Analyzes how consumer price index responds to a uniform foreign price reduction.



Oligopolistic competition

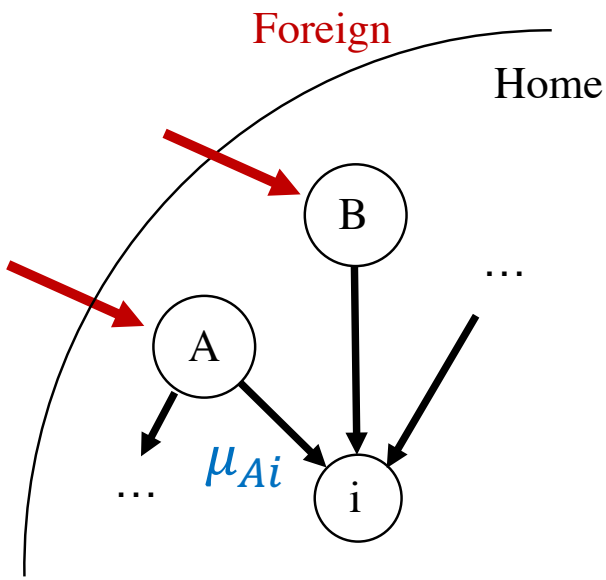
-
-

Endogenous networks

-

Networks and shock transmission

- Analyzes how consumer price index responds to a uniform foreign price reduction.



Oligopolistic competition

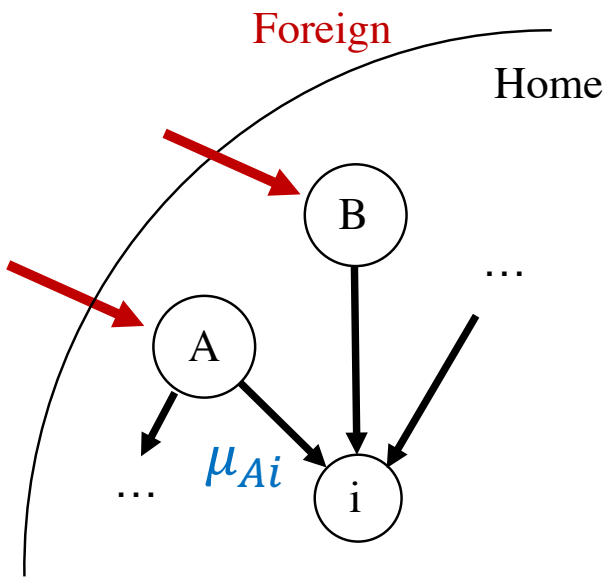
- Attenuate: $\Delta\mu_{Ai} > 0$.
-

Endogenous networks

-

Networks and shock transmission

- Analyzes how consumer price index responds to a uniform foreign price reduction.



Oligopolistic competition

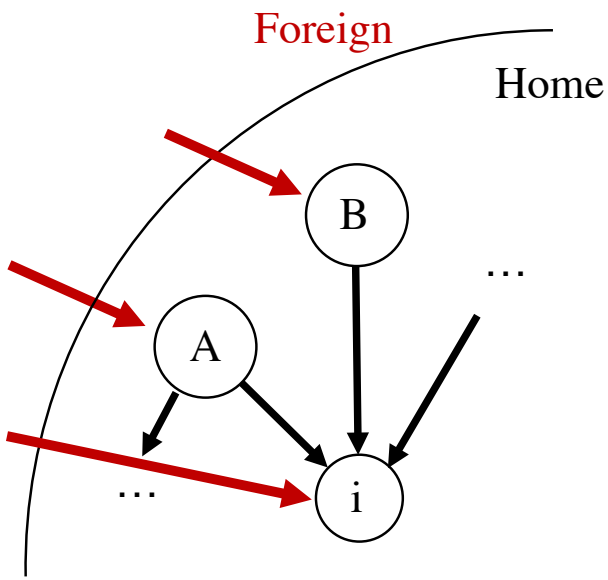
- Attenuate: $\Delta\mu_{Ai} > 0$.
- Amplify: $\Delta\mu_{Ai} < 0$.

Endogenous networks

-

Networks and shock transmission

- Analyzes how consumer price index responds to a uniform foreign price reduction.



Oligopolistic competition

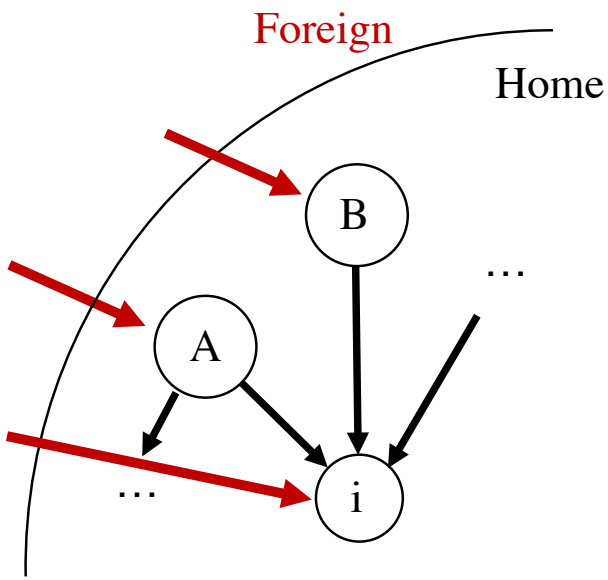
- Attenuate: $\Delta\mu_{Ai} > 0$.
- Amplify: $\Delta\mu_{Ai} < 0$.

Endogenous networks

- Amplify: firms become importers.

Networks and shock transmission

- Analyzes how consumer price index responds to a uniform foreign price reduction.



Oligopolistic competition

- Attenuate: $\Delta\mu_{Ai} > 0$.
- Amplify: $\Delta\mu_{Ai} < 0$.

Endogenous networks

- Amplify: firms become importers.

- Full model predicts aggregate movements four times as large as those from the benchmark case.

Facts

Model

Structural analysis

Facts - Roadmap

1. Introduce dataset.

2. Firms' competition within each customer's inputs.
   - Concentration of suppliers.
   - Firm's markup higher if firm has high input shares within customers.

3. Supplier-customer linkages over time.
   - Large churn.
   - Firms change suppliers in response to shocks.

National Bank of Belgium Business-to-Business Transaction Dataset

- Panel of VAT-id to VAT-id transactions among the universe of Belgian firms, over years 2002-2014 (Dhyne, Magerman and Rubinova, 2015).

- Match VAT-ids with primary sector (NACE 4-digit), annual accounts and country-product (CN 8-digit) level international trade dataset.

▸ Aggregation VAT-ids into firms ▸ Sampling ▸ Industrial composition ▸ Descriptive B2B statistics

Facts - Roadmap

1. Introduce dataset.

2. Firms' competition within each customer's inputs.
   - Concentration of suppliers. ▸ Details
   - Firm's markup higher if firm has high input shares within customers.

3. Supplier-customer linkages over time.
   - Large churn.
   - Firms experience larger churn of suppliers when exposed to larger import supply shocks.

Markups and input shares

Are firms' markups higher when they have higher downstream sales shares?

- Markups at the firm level.
  - μ_i: sum of firm's sales over sum of variable inputs.
  - Robustness with markups via De Loecker and Warzynski (2012).

- Measure of how much share firm has within its customers' goods inputs.
  - $\overline{s_{i\cdot}^m}$: firm i's weighted average input shares within its customers.
  - Firm i's share within customer j's inputs: $s_{ij}^m = \frac{\text{Sales}_{ij}}{\text{InputPurchases}_j}$.

$$\overline{s_{i\cdot}^m} = \sum_{j \in W_i} \frac{\text{InputPurchases}_j}{\sum_{k \in W_i} \text{InputPurchases}_k} s_{ij}^m.$$

- Control for firm-level market shares within sectors.

Markups and input shares

$$\mu_{i,t} = \beta \, \text{SctrMktShare}_{i,t} + \gamma \, \overline{s^m_{i\cdot,t}} + \varphi \, X_{i,t} + \delta_t + \epsilon_{i,t}.$$

	Firm-level markups		
	(1)	(2)	(3)
$\text{SctrMktShare}_{i,t}$ (4-digit)	0.0929^{***}	0.0430^{***}	0.0686^{***}
	(0.00928)	(0.00963)	(0.0129)
Average input share $\overline{s^m_{i\cdot,t}}$	0.298^{***}	0.182^{***}	0.173^{***}
	(0.0130)	(0.00938)	(0.00925)
N	1099496	1089209	1070602
Year FE	Yes	Yes	Yes
Sector FE (4-digit)	Yes	No	No
Firm FE	No	Yes	Yes
Controls	Yes	No	Yes
R2	0.0994	0.619	0.625

Notes: The coefficients are X-standardized. $*p < 0.10, **p < 0.05, ***p < 0.01$. Standard errors are clustered at the NACE 2-digit-year level. Controls include firms' indegree, outdegree, employment, total assets, and age.

▸ Robustness

Facts - Roadmap

1. Introduce dataset.

2. Firms' competition within each customer's inputs.
   - Concentration of suppliers.
   - Firm's markup higher if firm has high input shares within customers.

3. Supplier-customer linkages over time.
   - Large churn. ▸ Details
   - Firms experience larger churn of suppliers when exposed to larger import supply shocks.

Changes in linkages

Do firms change their domestic suppliers in response to foreign price change?

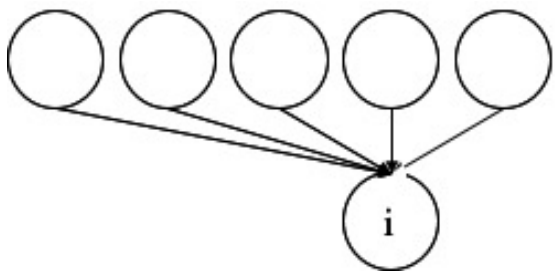
Changes in linkages

Do firms change their domestic suppliers in response to foreign price change?

$$\Delta Y_i = \beta\, \Delta CS_i + \gamma\, X_{i,t_0} + \delta_{s(i)} + \epsilon_i.$$

- ΔY_i is the share of continuing/added domestic suppliers.

t_0: 5 suppliers.



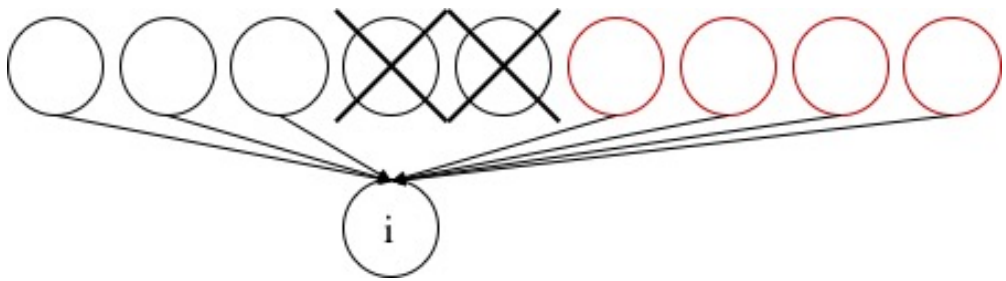
Changes in linkages

Do firms change their domestic suppliers in response to foreign price change?

$$\Delta Y_i = \beta\, \Delta CS_i + \gamma\, X_{i,t_0} + \delta_{s(i)} + \epsilon_i.$$

- ΔY_i is the share of continuing/added domestic suppliers.

t_1: 7 suppliers. Dropped 2, added 4.



Continuing suppliers: 3/5, added suppliers: 4/5.

Changes in linkages

Do firms change their domestic suppliers in response to foreign price change?

$$\Delta Y_i = \beta\, \Delta CS_i + \gamma\, X_{i,t_0} + \delta_{s(i)} + \epsilon_i.$$

- ΔY_i is the share of continuing/added domestic suppliers.
- ΔCS_i is the firm's change in Chinese sourcing. ▸ Why China?

$$\Delta CS_i = \frac{\Delta V_{China,i}}{\text{TotalInput}_{i,t_0}}.$$

Changes in linkages

Do firms change their domestic suppliers in response to foreign price change?

$$\Delta Y_i = \beta\, \Delta CS_i + \gamma\, X_{i,t_0} + \delta_{s(i)} + \epsilon_i.$$

- ΔY_i is the share of continuing/added domestic suppliers.
- ΔCS_i is the firm's change in Chinese sourcing. ▸ Why China?

$$\Delta CS_i = \frac{\Delta V_{China,i}}{\text{TotalInput}_{i,t_0}}.$$

- Instrument ΔCS_i with changes in Chinese exports to non-EU rich countries.

$$\Delta IV_i = \sum_k \frac{V_{ALL,i,k,t_0}}{\text{TotalInput}_{i,t_0}} \Delta \frac{V_{China,Rich,k}}{V_{World,Rich,k}}.$$

- Identification assumption: Firms' within sector variations of input compositions at t_0 are not correlated with unobservable characteristics that affect linkage forming decisions.

Larger churn of suppliers as larger ΔCS

Table: Shares of continuing and added (incumbent and new) suppliers (value)

	(1) Continuing suppliers	(2) Added suppliers	(3) Added suppliers: Incumbent firms	(4) Added suppliers: New firms
ΔCS	-0.128^{***}	0.110^{***}	0.0973^{***}	0.0128^{***}
	(0.0283)	(0.0334)	(0.0316)	(0.00366)
N	56146	56146	56146	56146
1st Fstat	32.48	32.48	32.48	32.48
Controls	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses. $*p < 0.10, **p < 0.05, ***p < 0.01$. The coefficients of the second stage results are X-standardized. Controls include firm age and employment size in 2002 with sector fixed effects (NACE 2-digit) and geographic fixed effects (NUTS 3). The same controls are used in the first stage results. ΔCS is the firm's average yearly increase of Chinese imports from 2002 to 2012 scaled by its total inputs in 2002. ΔCS is instrumented by the weighted sum of the sectoral change in Chinese goods' share in developed countries' total imports from 2002 to 2012. Standard errors are clustered at the NACE 2-digit-NUTS 3 level.

▸ OLS ▸ first stage ▸ customers ▸ in numbers ▸ statistics of churn in linkages

Facts

Model

- Model of a small open economy with two elements:
  - Oligopolistic competition in firm-to-firm trade.
  - Endogenous network formation.
- Firm-level variables sufficient in a benchmark case without the two.

Structural analysis

Household

- Cobb-Douglas preference over heterogeneous goods and homogenous goods. CES across goods in heterogeneous goods sector. Assume $\sigma > 1$.

$$U = \left(\sum_i \beta_{iH} q_{iH}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}\alpha} Y^{1-\alpha}.$$

- Associated price indices

$$\tilde{P} = \tilde{\alpha} P^{\alpha} p_y^{1-\alpha}$$

$$P = \left(\sum_i \beta_{iH}^{\sigma} p_{iH}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}.$$

- Household's budget constraint

$$E = wL + \Pi,$$

where $\Pi = \sum_i \pi_i$.

Technology

- Firms in the homogenous goods sector: $y_i = l_i^Y$.
- Firms in the heterogeneous goods sector combine labor and goods bundle with CES. Goods bundle is another CES aggregate of suppliers' and foreign goods. Assume $\eta, \rho > 1$.

$$c_i = \phi_i^{-1} \left(\omega_l^\eta w^{1-\eta} + \omega_m^\eta p_{mi}^{1-\eta} \right)^{\frac{1}{1-\eta}}$$

$$p_{mi} = \left(\sum_{j \in Z_i} \alpha_{ji}^\rho p_{ji}^{1-\rho} + I_{Fi} \alpha_{Fi}^\rho p_F^{1-\rho} \right)^{\frac{1}{1-\rho}}.$$

- Z_i is the set of i's suppliers and I_{Fi} is an indicator for importers.

Market structure

- Homogenous goods sector.
  - Assume perfect competition and free trade.

Market structure

- Homogenous goods sector.
  - Assume perfect competition and free trade.
- Heterogenous goods sector.
  - Firms set monopolistic competitive prices in the final demand market.
    - Exports

$$p_{iH} = \frac{\sigma}{\sigma - 1} c_i.$$

Market structure

- Homogenous goods sector.
  - Assume perfect competition and free trade.
- Heterogenous goods sector.
  - Firms set monopolistic competitive prices in the final demand market.
    - Exports

$$p_{iH} = \frac{\sigma}{\sigma - 1} c_i.$$

  - Firm i sets price p_{ij} to maximize profits from sales to j, taking as given $\{Z_j, I_{Fj}, I_{jF}\}$, prices of the other suppliers $\{p_{kj}\}$, c_j, and q_j.

$$p_{ij} = \frac{\varepsilon_{ij}}{\varepsilon_{ij} - 1} c_i$$

$$\varepsilon_{ij} = \rho \left(1 - s_{ij}^m\right) + \eta s_{ij}^m.$$

    - Firms' maximization problem
    - Alternative specifications

Linkage formation

- Firm j pays labor fixed cost $f_{Dj} \sim F_D(\cdot)$ when sourcing from another firm, pays $f_{Fj} \sim F_{IM}(\cdot)$ when importing, pays $f_{jF} \sim F_{EX}(\cdot)$ when exporting.

- Firm j chooses $\{Z_j, I_{Fj}, I_{jF}\}$ to maximize net profits, taking as given other firms' sourcing decisions.

$$\max_{Z_j, I_{Fj}, I_{jF}} \pi_j^{var}(Z_j, I_{Fj}, I_{jF}) - \sum_{i \in Z_j} w f_{Dj} - I_{Fj} w f_{Fj} - I_{jF} w f_{jF}.$$

Equilibrium under fixed networks

- Taking as given the foreign demand shifter, foreign price and the network structure $\{Z_i, I_{Fi}, I_{iF}\}$, the equilibrium under fixed networks is the set of variables $\left\{w, p_y, P, E, c_i, \{\mu_{ij}\}, \{q_{ij}\}, q_{iH}, q_{iF}, l^Y\right\}$.

- They satisfy
  - household's utility maximization problem.
  - firms' cost minimization problems.
  - firms' profit maximization problems.
  - household's budget constraints and trade balance condition. ▸ Aggregation

- Take homogenous good's price as the numeraire, $w = p_y = 1$.

▸ Firm

Equilibrium under endogenous networks

- In addition to the equilibrium under fixed networks, the network structure $\{Z_i, I_{Fi}, I_{iF}\}$ satisfy firms' domestic sourcing and international trade participation problems.

- Focus on a pairwise stable equilibrium where firms sequentially make their sourcing decisions.

  - The most productive firm makes its sourcing decision first. Then the second most productive firm makes its decision, and so on.

- Firm j decides $\{Z_j, I_{Fj}, I_{jF}\}$ taking as given aggregate demand, its customers' unit costs and total production, and other firms' sourcing decisions.

Benchmark case

Consider the global change in the domestic price index given an exogenous change in foreign price. In a special case of the model, firm-level variables become sufficient statistics.

Lemma
Assume (1) only composite final consumption goods are exported, (2) Cobb-Douglas both in preference and in technologies, (3) perfect competition ($p_i = c_i$), and (4) exogenous and fixed network. Then the change in price index, $\hat{P}$, can be expressed solely by firm-level observables.

$$\ln \hat{P} = \sum_i \frac{p_i q_i}{\alpha E + Exp} s_{Fi} \ln \hat{p}_F.$$

- Intuition
- Network irrelevance with common CES parameter
- Network irrelevance in Acemoglu, Carvalho, Ozdaglar and Tahbaz-Salehi (2012)

Facts

Model

Structural analysis

Structural analysis - Roadmap

Estimate the model and analyze how aggregate price index P changes in response to a reduction in foreign price p_F.

Structural analysis - Roadmap

Estimate the model and analyze how aggregate price index P changes in response to a reduction in foreign price p_F.

1. Estimate σ, η, and ρ.
2. Counterfactual analysis, under fixed networks.
    1. Start with the benchmark case where firm-level info sufficient.
    2. Constant markups with estimated $\sigma, \rho, \eta > 1$, fixed networks.
    3. Variable markups with oligopolistic competition, fixed networks.
3. Estimate parameters for endogenous networks.
    - Productivity distribution.
    - Fixed cost parameters for $F_D(\cdot)$, $F_{IM}(\cdot)$ and $F_{EX}(\cdot)$.
4. Counterfactual analysis, under endogenous networks.
    4. Full model, with variable markups and endogenous networks.

Structural analysis - Roadmap

Estimate the model and analyze how aggregate price index P changes in response to a reduction in foreign price p_F.

1. Estimate σ, η, and ρ.
2. Counterfactual analysis, under fixed networks.
    1. Start with the benchmark case where firm-level info sufficient.
    2. Constant markups with estimated $\sigma, \rho, \eta > 1$, fixed networks.
    3. Variable markups with oligopolistic competition, fixed networks.
3. Estimate parameters for endogenous networks.
    - Productivity distribution.
    - Fixed cost parameters for $F_D(\cdot)$, $F_{IM}(\cdot)$ and $F_{EX}(\cdot)$.
4. Counterfactual analysis, under endogenous networks.
    4. Full model, with variable markups and endogenous networks.

Estimating the CES parameters

- Markups are functions of CES parameters (η, ρ, σ) and observables s_{ij}^m.

$$\mu_{iH} = \mu_{iF} = \frac{\sigma}{\sigma - 1}$$
$$\mu_{ij} = \frac{\varepsilon_{ij}}{\varepsilon_{ij} - 1}$$
$$\varepsilon_{ij} = \rho\left(1 - s_{ij}^m\right) + \eta s_{ij}^m.$$

- Firm's total input costs equal sum of firm's sales divided by destination-specific markups.

$$c_i q_i = \sum_j \frac{p_{ij} q_{ij}}{\mu_{ij}} + \frac{p_{iH} q_{iH}}{\mu_{iH}} + \frac{p_{iF} q_{iF}}{\mu_{iF}} + \xi_i.$$

- ξ_i: measurement errors in firms' labor costs (component of $c_i q_i$).

Estimates

- Estimate (η, ρ, σ) by solving:

$$\min_{\eta,\rho,\sigma} \sum_i \left[c_i q_i - \left(\sum_j \frac{p_{ij} q_{ij}}{\mu_{ij}} + \frac{p_{iH} q_{iH}}{\mu_{iH}} + \frac{p_{iF} q_{iF}}{\mu_{iF}} \right) \right]^2 .$$

	η	ρ	$\frac{\sigma}{\sigma-1}$
Estimate	1.27	2.78	1.25
s.e.	1.07	0.31	0.05

	η (Labor and goods)	ρ (Firms' goods in production)	σ (Firms' goods in consumption)
Implied value	1.27	2.78	4.99

▸ Assuming Cournot competition ▸ Accounting for capital

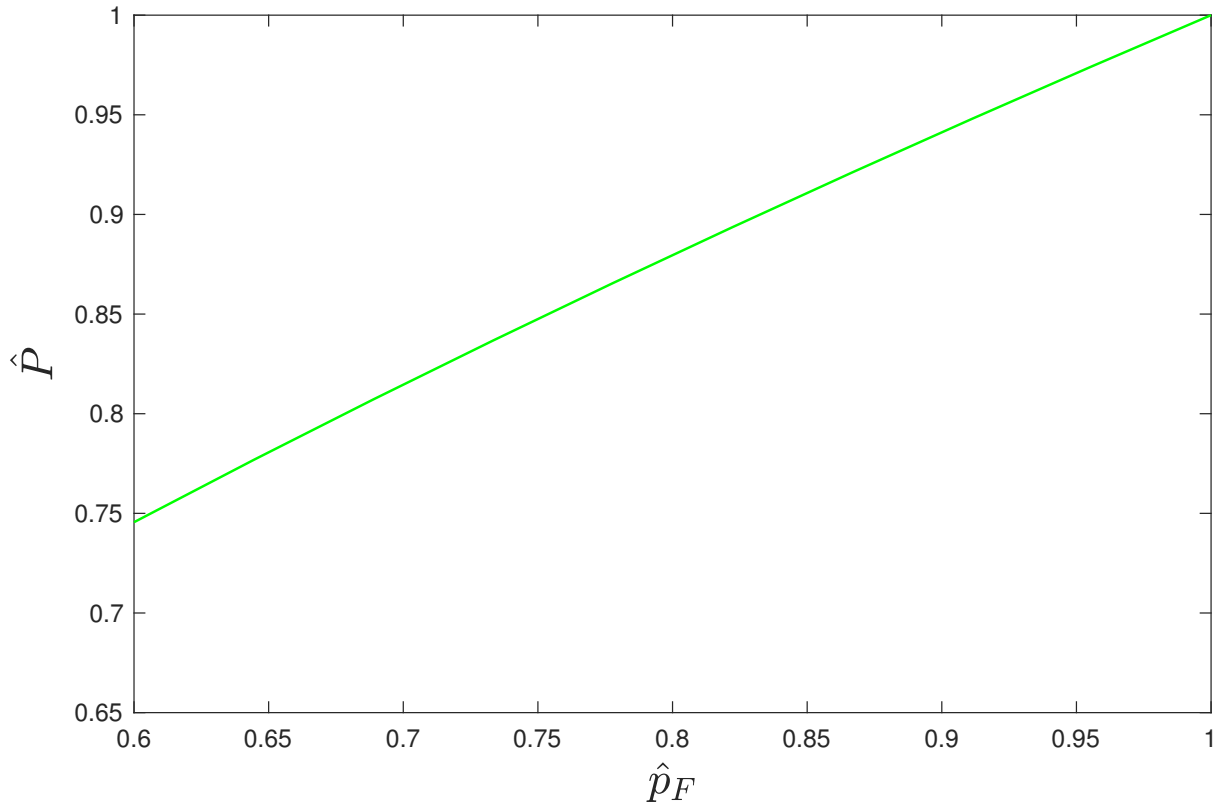
Structural analysis - Roadmap

Estimate the model and analyze how aggregate price index P changes in response to a reduction in foreign price p_F.

1. Estimate σ, η, and ρ.
2. Counterfactual analysis, under fixed networks.
    1. Start with the benchmark case where firm-level info sufficient.
    2. Constant markups with estimated $\sigma, \rho, \eta > 1$, fixed networks.
    3. Variable markups with oligopolistic competition, fixed networks.
3. Estimate parameters for endogenous networks.
    - Productivity distribution.
    - Fixed cost parameters for $F_D(\cdot)$, $F_{IM}(\cdot)$ and $F_{EX}(\cdot)$.
4. Counterfactual analysis, under endogenous networks.
    4. Full model, with variable markups and endogenous networks.

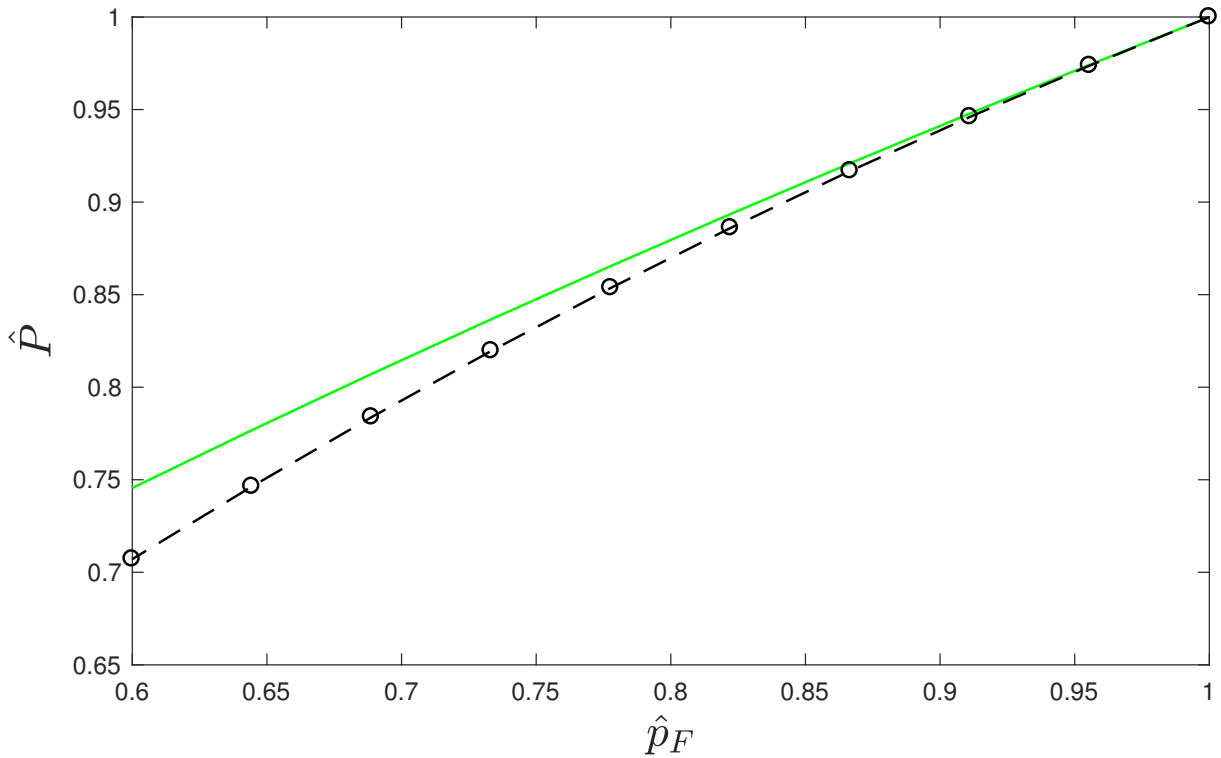
Four cases: $\hat{P}$ (Using full data)

1. Start with the benchmark case where firm-level info sufficient.
   - $\sigma = \rho = \eta = 1$, $p_i = c_i$, fixed network.
   - $\ln \hat{P} = \sum_i \frac{p_i q_i}{\alpha E + Exp} s_{Fi} \ln \hat{p}_F$.



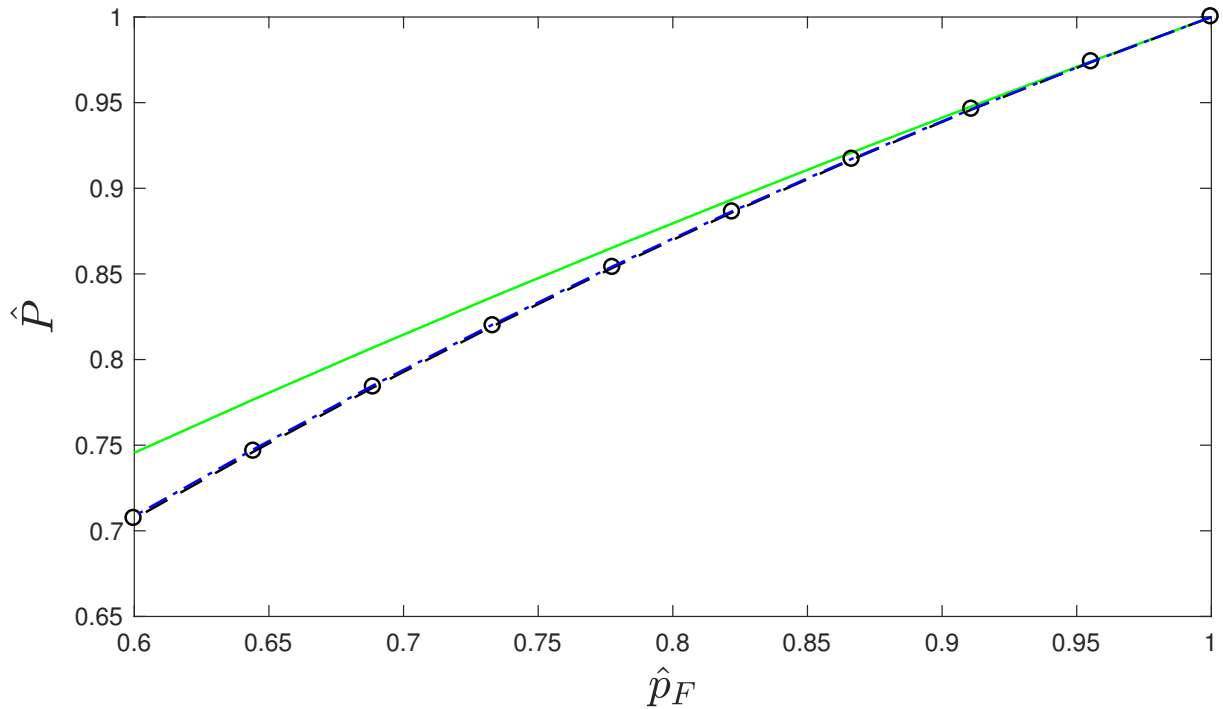
Four cases: $\hat{P}$ (Using full data)

2. Constant markups. ▸ System
   - Estimated values of σ, ρ, η.
   - Increased substitutability across inputs.



Four cases: $\hat{P}$ (Using full data)

3. Variable markups. ▸ System ▸ Decomposition (first order apprx.)
   - Attenuation effect: incomplete price pass through.
   - Pro-competitive effect: markup affected by price changes of other suppliers.

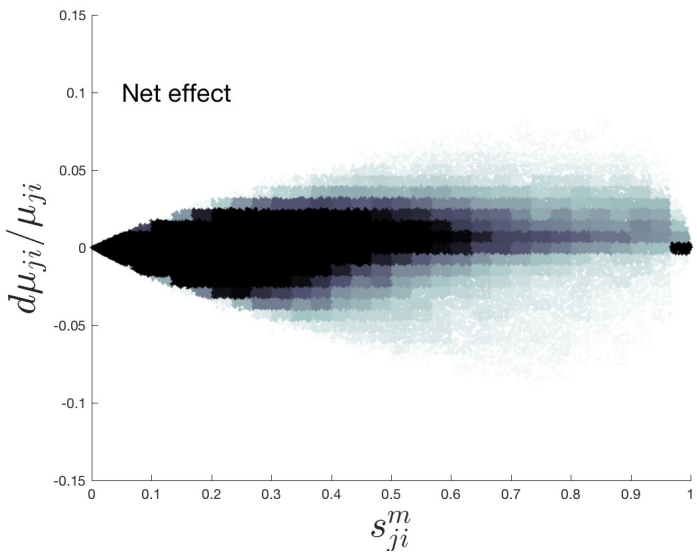


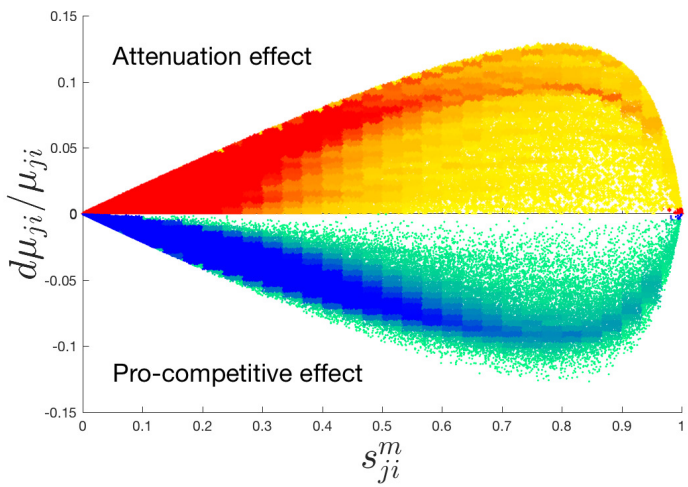
$\hat{P}$: CD, p=c, Fixed Network (Benchmark)
$\hat{P}$: Const Mkup, Fixed Network
$\hat{P}$: Variable Mkup, Fixed Network

Attenuation and pro-competitive effects

$$\frac{\mathrm{d}\mu_{ji}}{\mu_{ji}} = \underbrace{-\Gamma_{ji}\frac{\mathrm{d}c_j}{c_j}}_{\text{attenuation effect}} + \underbrace{\Gamma_{ji}\frac{\mathrm{d}p_{\not j i}}{p_{\not j i}}}_{\text{pro-competitive effect}} .$$

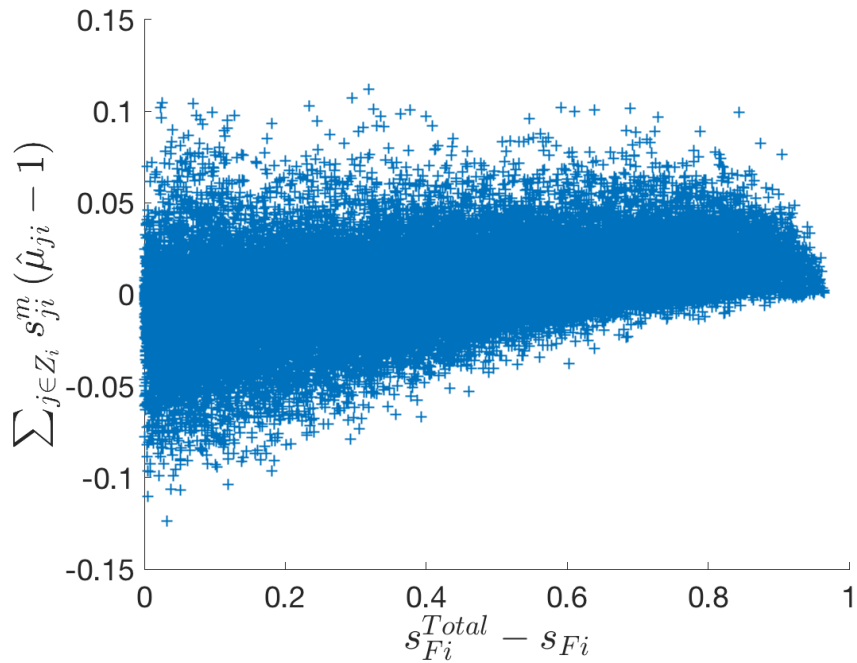
- Maximum magnitudes display hump shape w.r.t. input share s^m_{ji}.
- Exposures to shock $(\frac{\mathrm{d}c_j}{c_j}, \frac{\mathrm{d}p_{\not j i}}{p_{\not j i}})$ determine the magnitudes within same s^m_{ji}.





The net effects

- Average change in markups for firm i: $\sum_{j \in Z_i} s_{ji}^m \left(\hat{\mu}_{ji} - 1\right)$.
- Correlated with measure of *indirect* exposure to shock: $s_{Fi}^{Total} - s_{Fi}$.
- "Total foreign input share": $s_{Fi}^{Total} = s_{Fi} + \sum_k s_{ki} s_{Fk}^{Total}$.



▸ Shock to one firm ▸ Aggregation

Structural analysis - Roadmap

Estimate the model and analyze how aggregate price index P changes in response to a reduction in foreign price p_F.

1. Estimate σ, η, and ρ.
2. Counterfactual analysis, under fixed networks.
    1. Start with the benchmark case where firm-level info sufficient.
    2. Constant markups with estimated $\sigma, \rho, \eta > 1$, fixed networks.
    3. Variable markups with oligopolistic competition, fixed networks.
3. Estimate parameters for endogenous networks. ‣ Other parameters
    - Productivity distribution. ‣ Details
    - Fixed cost parameters for $F_D(\cdot)$, $F_{IM}(\cdot)$ and $F_{EX}(\cdot)$.
4. Counterfactual analysis, under endogenous networks.
    4. Full model, with variable markups and endogenous networks.

Estimating $F_D(\cdot)$, $F_{IM}(\cdot)$ and $F_{EX}(\cdot)$

- Assume log normal distributions for $F_D(\cdot)$, $F_{IM}(\cdot)$ and $F_{EX}(\cdot)$.
- Estimate scale parameters Φ_D^{scale}, Φ_{IM}^{scale} and Φ_{EX}^{scale}, and a common dispersion parameter Φ^{disp}.
- Estimation via Simulated Methods of Moments.
- Moments:
  - Fraction of firms with at least one domestic suppliers, to pin down Φ_D^{scale}.
  - Fraction of importers, to pin down Φ_{IM}^{scale}.
  - Fraction of exporters, to pin down Φ_{EX}^{scale}.
  - Correlation between number of suppliers and customers, to pin down Φ^{disp}.
- Simulate economy with $N = 30$. ‣ One sector model

Estimates and model fit

- Estimates. ▸ Local identification

	Φ_D^{scale}	Φ_{IM}^{scale}	Φ_{EX}^{scale}	Φ^{disp}
Estimate	2.37	21.10	22.76	6.10
s.e.	0.38	0.28	0.33	0.56

- Targeted moments.

	Data	Model
Fraction of firms sourcing from domestic firms	0.98	0.97
Fraction of importers	0.15	0.17
Fraction of exporters	0.09	0.10
Corr(#supplier, #customer)	0.65	0.65

Estimates and model fit

- Non-targeted moments.

	Data	Model
Corr(Sales, #supplier)	0.48	0.24
Corr(Sales, #customer)	0.51	0.33
Corr(Sales_i, Sales_j)	-0.02	-0.06
Median s_{ij}^m	0.18%	0.34%

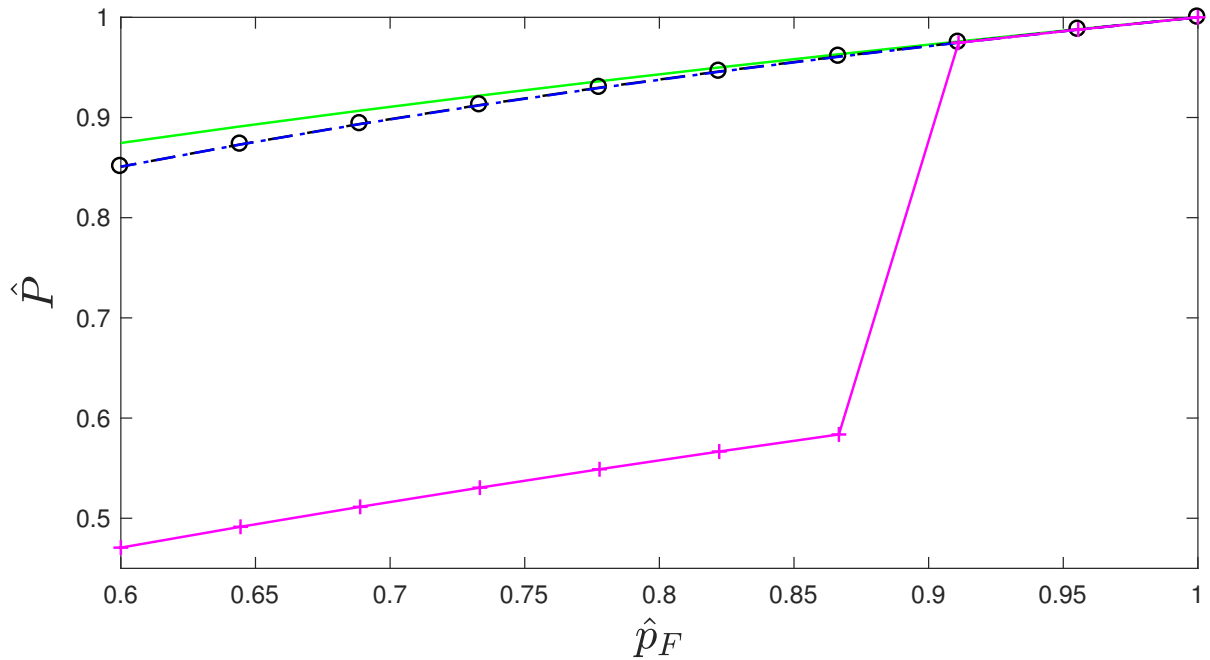
Structural analysis - Roadmap

Estimate the model and analyze how aggregate price index P changes in response to a reduction in foreign price p_F.

1. Estimate σ, η, and ρ.
2. Counterfactual analysis, under fixed networks.
    1. Start with the benchmark case where firm-level info sufficient.
    2. Constant markups with estimated $\sigma, \rho, \eta > 1$, fixed networks.
    3. Variable markups with oligopolistic competition, fixed networks.
3. Estimate parameters for endogenous networks.
    - Productivity distribution.
    - Fixed cost parameters for $F_D(\cdot)$, $F_{IM}(\cdot)$ and $F_{EX}(\cdot)$.
4. Counterfactual analysis, under endogenous networks.
    4. Full model, with variable markups and endogenous networks.

Four cases: $\hat{P}$ (Model simulation)

4. Full model, with endogenous network. ▸ Common CES parameter



$\hat{P}$: CD, p=c, Fixed Network (Benchmark)
$\hat{P}$: Const Mkup, Fixed Network
$\hat{P}$: Variable Mkup, Fixed Network
$\hat{P}$: Variable Mkup, Endog. Network (Full)

Conclusion

Main contributions:

- Established empirical facts suggesting that
  - firms compete with each other within each customer's inputs.
  - firms change linkages in response to shocks.
- Built a model with
  - Oligopolistic competition: attenuation and pro-competitive effect.
  - Endogenous networks: firms become importers.
- Demonstrated their relevance for counterfactual predictions.

Thank you!

APPENDIX

Aggregating VATs to firms

- We group all VAT-id into firms that are either
  - linked with more than 50% of ownership (ownership filings).
  - owned by a common foreign firm (FDI filings).
- In 2012, 896K VAT-ids collapsed to 860K firms. Of those firms, 842K firms consisted of single VAT-ids. The number of VAT-ids for multiple VAT-id firms are as below.

	Mean	10%	25%	50%	75%	90%	max
Num. VAT-id	3	2	2	2	3	4	372

- The 18K firms with multiple VAT-ids account for $\sim 60\%$ of the total output.

Back

Sample of analysis

- Following De Loecker, Fuss and Van Biesebroeck (2014), we restrict the sample of analysis according to the criteria below:
  - Belgian firms with positive labor cost in industries other than government and finance.
  - File positive employment, tangible assets of more than 100 euro, positive total assets for at least one year throughout the period.

Year	Private, non-financial		M	X	Selected sample				
	GDP	Output			Count	V.A.	Sales	M	X
2002	149	411	210	229	122,460	123	586	179	189
2007	192	546	300	314	136,370	157	757	280	269
2012	212	626	342	347	139,605	170	829	296	295

Notes: All numbers except for Count are denominated in billion Euro in current prices. Belgian GDP and output are for all sectors excluding public and financial sector. Data for Belgian GDP, output, imports and exports are from Eurostat.

▸ Back

Industrial composition (2012)

Industry	Count	V.A.	Sales	Imports	Exports
Agriculture	3,704	1.49	9.97	1.71	2.26
Construction	26,364	18.3	46.5	5.00	3.65
Manufacturing	20,385	55.5	322	147	194
Wholesale and Retail	42,999	31.8	245	85.3	54.5
Other Services	43,4985	50.3	125	17.6	17.0
Other	2,658	12.7	80.5	39.8	24.3
Total	139,605	170	829	296	295

Notes: All numbers except for Count are denominated in billion Euro in current prices.

▸ Back

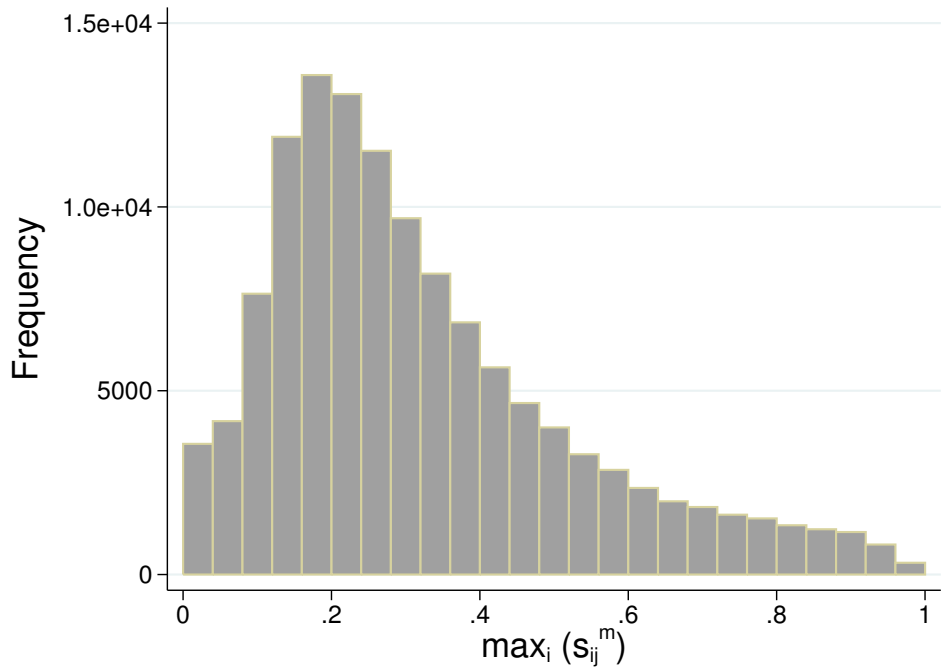
Descriptive statistics (2012)

	Mean	Percentiles				
		10%	25%	50%	75%	90%
$s_{ij}^m = \text{Sales}_{ij}/\text{InputPurchases}_j$	1.62%	0.00%	0.00%	0.18%	0.82%	3.15%
Num. suppliers	45	8	15	28	49	86
Num. customers	45	0	1	7	27	86

▸ Back

Concentration of suppliers

- Majority of Belgian firms have 28 suppliers or less.
- For the majority of Belgian firms, the largest supplier accounts for 27% or more of input purchases. ▸ HHI

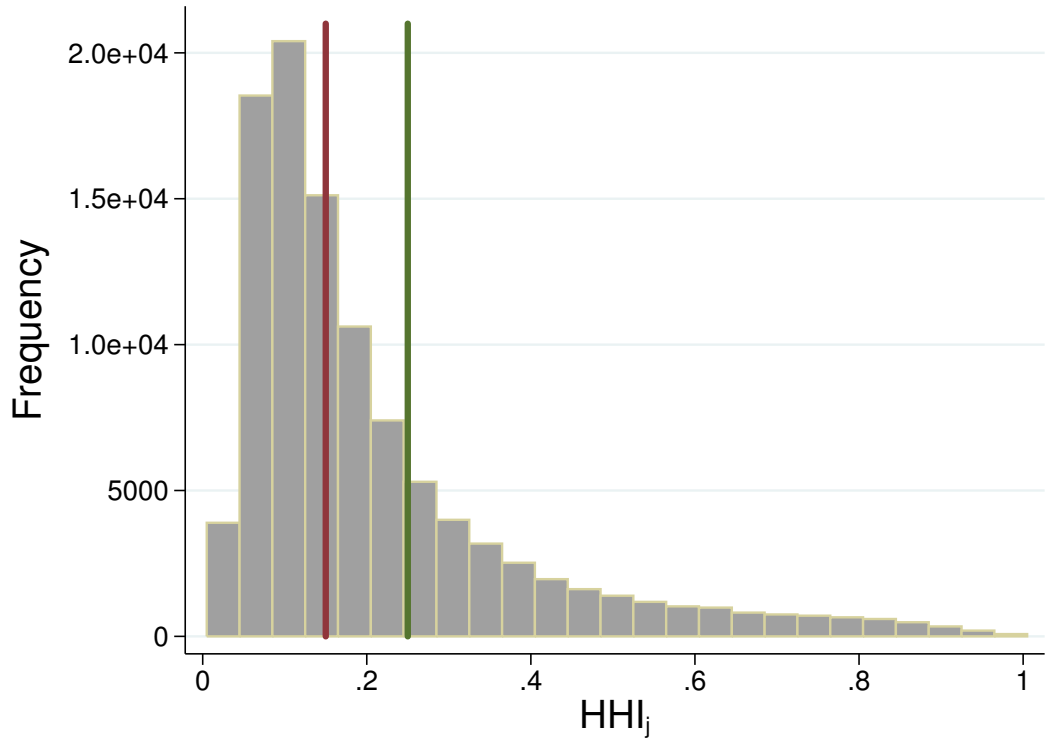


Notes: s_{ij}^m is defined as firm i's goods share among firm j's input purchases from other Belgian firms and abroad. The above histogram shows the distribution of $\max_i \left(s_{ij}^m\right)$, which is the maximum value of s_{ij}^m for each customer firm j in 2012 that has more than 10 suppliers.

▸ Back

HHI of input shares

- For the majority of Belgian firms, the HHI of input shares across suppliers are 0.15 or higher. .



Notes: s_{ij}^{m} is defined as firm i's goods share among firm j's input purchases from other Belgian firms and abroad. The above histogram shows the HHI of s_{ij}^{m} for all customer firms j in 2012 that have more than 10 suppliers. The median value is 0.15. The two vertical lines indicates HHI being 0.15 and 0.25.

▸ Back

Robustness

Positive correlation between μ_i and $\overline{s_{i\cdot}^m}$ robust when

- Alternative measures of μ_i.
  - Estimated firm level markups via De Loecker and Warzynski (2012). ▸ Go
- Alternative measures of $\overline{s_{i\cdot}^m}$.
  - Simple average or median of input shares across customers.
  - Computing input shares within customer's total inputs.
  - Computing input shares within customer's inputs that are classified as same goods.

▸ Back

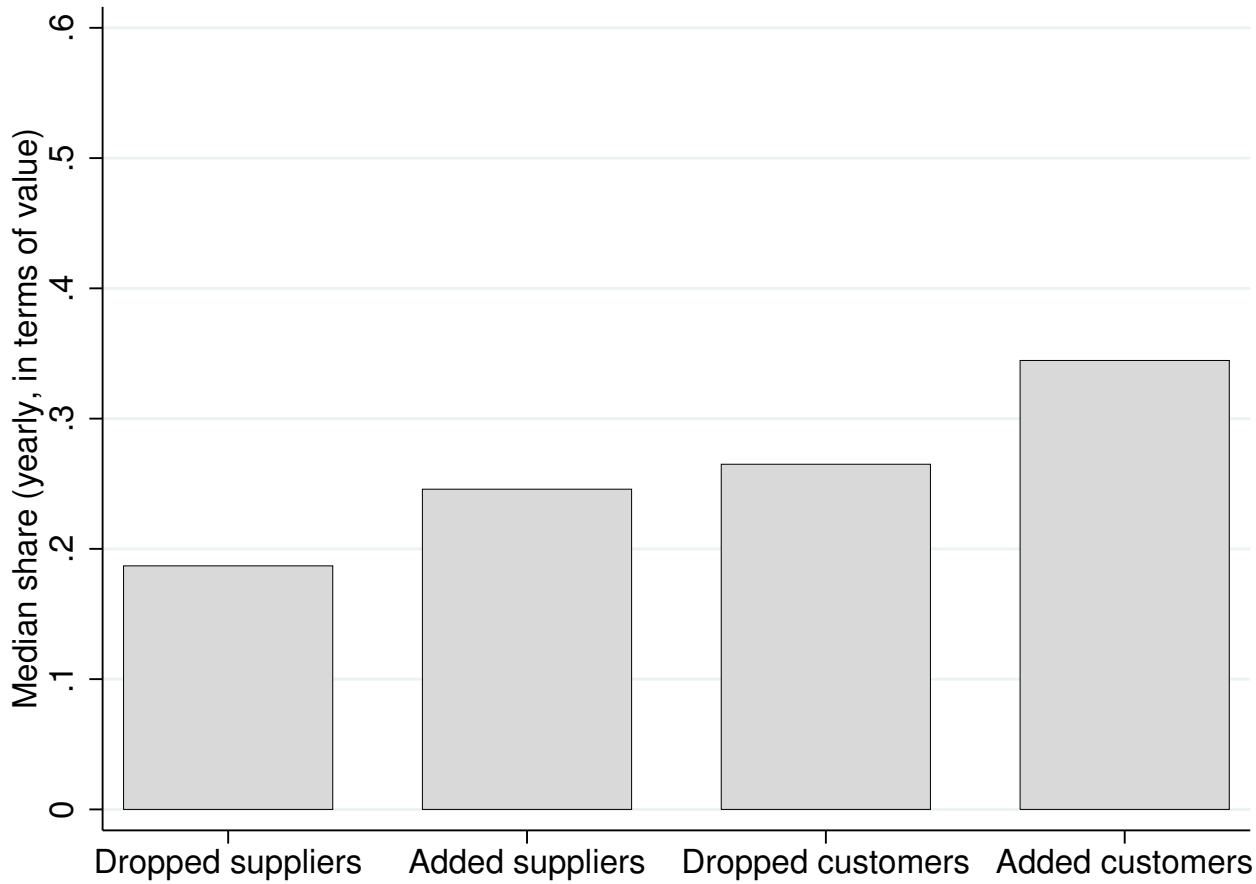
Markups via De Loecker and Warzynski (2012)

	(1)	(2)	(3)
SctrMktShare$_{i,t}$ (4-digit)	0.00395***	-0.00179**	-0.000488
	(0.00122)	(0.000830)	(0.00103)
Average input share $\overline{s^m_{i\cdot,t}}$	0.0690***	0.0117***	0.0112***
	(0.00375)	(0.00139)	(0.00136)
N	602903	584131	584131
Year FE	Yes	Yes	Yes
Sector FE (4-digit)	Yes	No	No
Firm FE	No	Yes	Yes
Controls	Yes	No	Yes
R2	0.629	0.917	0.917

Notes: Standard errors in parentheses. $*p < 0.10, **p < 0.05, ***p < 0.01$. We use firm-level markups recovered using methods from De Loecker and Warzynski (2012) as the LHS variables. The coefficients are X-standardized. Standard errors are clustered at NACE 2-digit-year level.

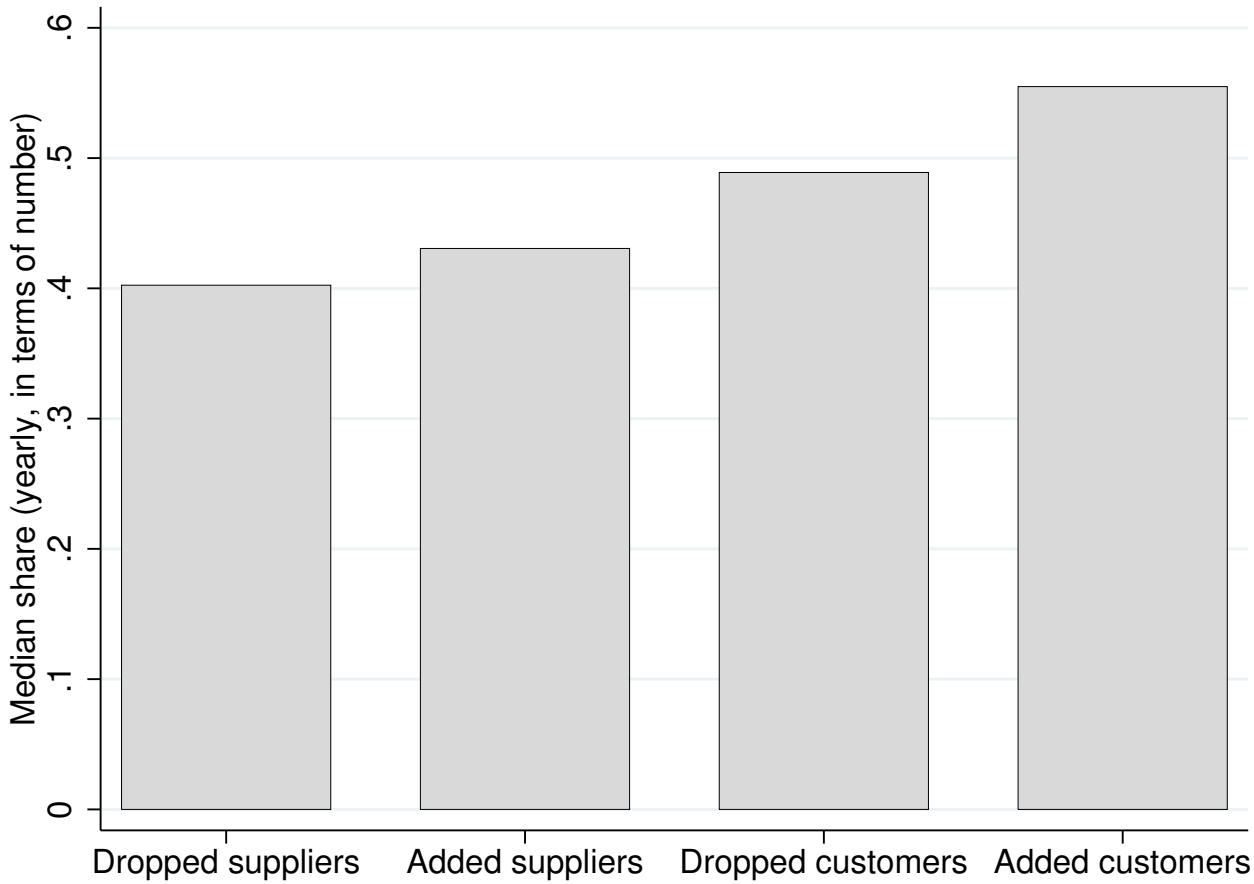
▸ Back

Yearly churn of suppliers and customers



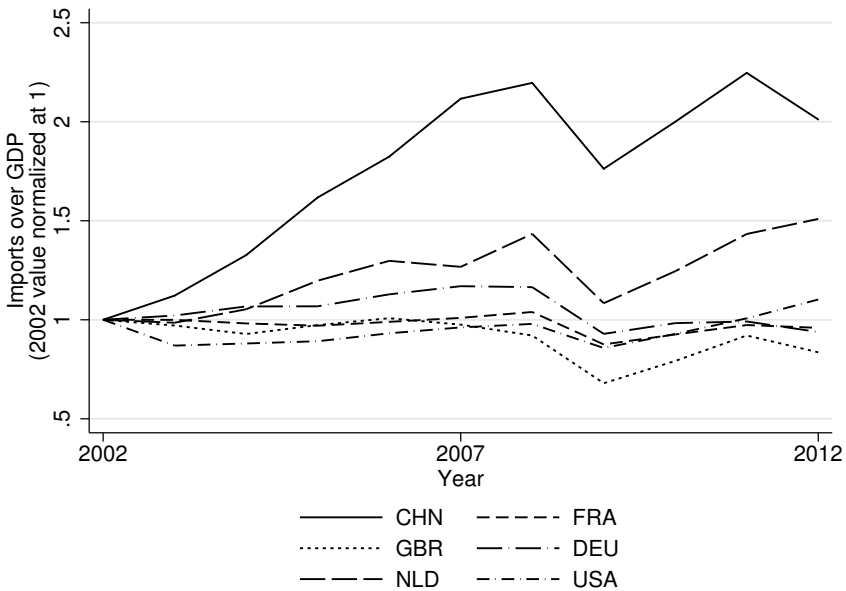
▸ Back ▸ In terms of numbers

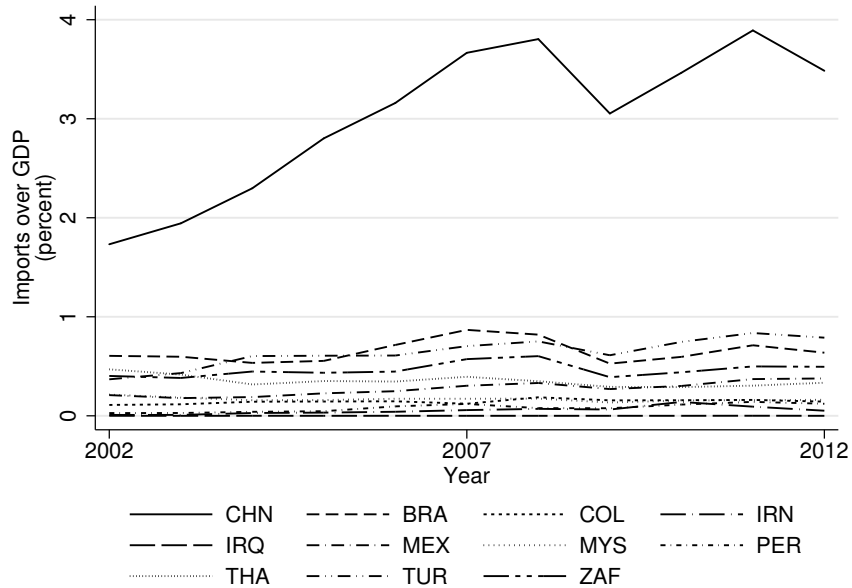
Yearly churn of suppliers and customers



▸ Back

Chinese imports





▸ Back

OLS results

Table: Shares of continuing and added (incumbent and new) suppliers (value)

	(1) Continuing suppliers	(2) Added suppliers	(3) Added suppliers: Incumbent firms	(4) Added suppliers: New firms
ΔCS	-0.00121^{***}	0.0104^{***}	0.00919^{***}	0.00114^{***}
	(0.000390)	(0.000948)	(0.000898)	(0.000112)
N	56146	56146	56146	56146
R2	0.140	0.108	0.100	0.0753
Controls	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses. $*p < 0.10, **p < 0.05, ***p < 0.01$. The coefficients are X-standardized. Controls include firm age and employment size in 2002, with sector fixed effects (NACE 2-digit) and geographic fixed effects (NUTS 3). ΔCS is the firm's average yearly increase of Chinese imports from 2002 to 2012 scaled by its total inputs in 2002. Standard errors are clustered at the NACE 2-digit-NUTS 3 level.

▸ Back

First stage results

	(1) Supplier, value	(2) Customer, value	(3) Supplier, number	(4) Customer, number
ΔIV	0.00370***	0.00377***	0.00370***	0.00377***
	(0.000649)	(0.000660)	(0.000649)	(0.000660)
N	56146	55280	56146	55280
R2	0.0255	0.0256	0.0255	0.0256
F Stat	32.48	32.48	32.74	32.74
Controls	Yes	Yes	Yes	Yes

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the first stage results when ΔCS is regressed on ΔIV. Controls include firm age and employment size in 2002, with sector fixed effects (NACE 2-digit) and geographic fixed effects (NUTS 3). Standard errors are clustered at the NACE 2-digit-NUTS 3 level.

▸ Back

TABLE: Shares of continuing and added (incumbent and new) customers (value)

	(1) Continuing customers	(2) Added customers	(3) Added customers: Incumbent firms	(4) Added customers: New firms
ΔCS	-0.325^{***}	0.314^{***}	0.285^{***}	0.0395^{***}
	(0.0686)	(0.0890)	(0.0815)	(0.00832)
N	55280	55280	55280	55280
1st Fstat	32.74	32.74	32.74	32.74
Controls	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses. $*p < 0.10, **p < 0.05, ***p < 0.01$. The coefficients of the second stage results are X-standardized. Controls include firm age and employment size in 2002 with sector fixed effects (NACE 2-digit) and geographic fixed effects (NUTS 3). The same controls are used in the first stage results. ΔCS is the firm's average yearly increase of Chinese imports from 2002 to 2012 scaled by its total inputs in 2002. ΔCS is instrumented by the weighted sum of the sectoral change in Chinese goods' share in developed countries' total imports from 2002 to 2012. Standard errors are clustered at the NACE 2-digit-NUTS 3 level.

▸ Back

TABLE: Shares of continuing and added (incumbent and new) suppliers (number)

	(1) Continuing suppliers	(2) Added suppliers	(3) Added suppliers: Incumbent firms	(4) Added suppliers: New firms
ΔCS	-0.149^{***}	0.122^{***}	0.119^{***}	0.00275^{***}
	(0.0275)	(0.0236)	(0.0238)	(0.00134)
N	56146	56146	56146	56146
1st Fstat	32.74	32.74	32.74	32.74
Controls	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses. $*p < 0.10, **p < 0.05, ***p < 0.01$. The coefficients of the second stage results are X-standardized. Controls include firm age and employment size in 2002 with sector fixed effects (NACE 2-digit) and geographic fixed effects (NUTS 3). The same controls are used in the first stage results. ΔCS is the firm's average yearly increase of Chinese imports from 2002 to 2012 scaled by its total inputs in 2002. ΔCS is instrumented by the weighted sum of the sectoral change in Chinese goods' share in developed countries' total imports from 2002 to 2012. Standard errors are clustered at the NACE 2-digit-NUTS 3 level.

▸ Back

TABLE: Shares of continuing and added (incumbent and new) customers (number)

	(1) Cont	(2) Added	(3) Incumbent	(4) New
ΔCS	-0.439***	0.571***	0.541***	0.0327***
	(0.0839)	(0.112)	(0.105)	(0.00832)
N	55280	55280	55280	55280
1st Fstat	32.74	32.74	32.74	32.74
Controls	Yes	Yes	Yes	Yes

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: The coefficients are X-standardized. Controls include firm age and employment size in 2002, with sector fixed effects (NACE 2-digit) and geographic fixed effects (NUTS 3). deltaCS is the firm's average yearly increase of Chinese imports from 2002 to 2012 scaled by its total inputs in 2002. deltaCS is instrumented by the weighted sum of the sectoral change in Chinese goods' share in developed countries' total imports from 2002 to 2012. Standard errors are clustered at the NACE 2-digit-NUTS 3 level.

▸ Back

Changes in suppliers and customers

	Yearly avg. (02-12)		10 year (02-12)	
Median	Cont. Share	Added Share	Cont. Share	Added Share
Sup. Number	0.60	0.43	0.22	0.92
Sup. Value	0.81	0.25	0.32	0.92
Cus. Number	0.51	0.55	0.13	0.86
Cus. Value	0.74	0.34	0.19	0.88

▸ Back

International markets

- If $I_{Fi} = 1$, i imports quantity q_{Fi} at an exogenous price p_F.
- If $I_{iF} = 1$, i charges the same price for exports as it does for final demand, $p_{iF} = p_{iH}$.
- Foreign has the same preference of the firms' goods as the representative household, with demand elasticity σ and demand shifter D^*. D^* may include trade costs and tariffs,

$$V_{iF} = \frac{\tau^{1-\sigma} \left(\beta^*_{iH}\right)^{\sigma} p_{iH}^{1-\sigma}}{\left(P^*\right)^{1-\sigma}} E^* = p_{iH}^{1-\sigma} D^*.$$

▸ Back

Firm i's problem

- Embed Atkeson and Burstein (2008) in firm-to-firm trade.
- Firm i sets p_{ij} to maximize profits from sales to j.
  - Takes as given prices of the other suppliers $\{p_{kj}\}$, c_j, and q_j.
  - Takes into account the effect p_{ij} has on m_j and p_{mj}.

$$\max_{p_{ij}} (p_{ij} - c_i) q_{ij}$$

$$s.t.\ p_{ij} q_{ij} = \alpha_{ij}^{\rho} p_{ij}^{1-\rho} p_{mj}^{\rho} m_j$$

$$p_{mj} m_j = \omega_m^{\eta} p_{mj}^{1-\eta} \phi_j^{\eta-1} c_j^{\eta} q_j.$$

Back

Alternative specifications

- Current setup: Firm i sets price p_{ij} taking as given c_j and q_j.

$$p_{ij} = \frac{\varepsilon_{ij}}{\varepsilon_{ij} - 1} c_i$$

$$\varepsilon_{ij} = \rho \left(1 - s_{ij}^m\right) + \eta s_{ij}^m.$$

- Alternatively, take into account the effect on c_j and q_j.
  - Take as given demand shifters that j faces from final demand and from other firms. ▸ Go
  - Assume a constant demand elasticity that j faces. ▸ Go

▸ Back ▸ Sector layer

Firm as tuple

- Firm i is a tuple consisting of
  - core productivity ϕ_i.
  - three draws of fixed costs f_{Di}, f_{Fi} and f_{iF}.
  - saliency parameters β_{iH}, $\{\alpha_{ji}\}$ and α_{Fi}.

▸ Back

Both $\frac{\partial c_j}{\partial p_{ij}} \neq 0$ and $\frac{\partial q_j}{\partial p_{ij}} \neq 0$

- Firm i takes into account the effect of p_{ij} on c_j and q_j.
- But i takes as given the demand shifters of j's goods, D_{jH} and D_{jB} as given:

$$q_j = c_j^{-\sigma} D_{jH} + c_j^{-\rho} D_{jB}.$$

- Then price p_{ij} becomes

$$p_{ij} = \frac{\varepsilon_{ij}}{\varepsilon_{ij} - 1} c_i$$

$$\varepsilon_{ij} = \rho \left(1 - s_{ij}^m\right) + \eta s_{ij}^m + \left(\sigma s_{jH}^q + \rho s_{jB}^q - \eta\right) s_{ij}^m s_{mj}.$$

  - s_{jH}^q is the **quantity** output share of firm j's goods sold to final demand.
  - s_{jB}^q is the **quantity** output share of firm j's goods sold to other firms.

▸ Back

Both $\frac{\partial c_j}{\partial p_{ij}} \neq 0$ and $\frac{\partial q_j}{\partial p_{ij}} \neq 0$

- Firm i takes into account the effect of p_{ij} on c_j and q_j.
- But i assumes that j faces demand elasticity of ν and takes demand shifter D_j as given:

$$q_j = c_j^{-\nu} D_j.$$

- Then price p_{ij} becomes

$$p_{ij} = \frac{\varepsilon_{ij}}{\varepsilon_{ij} - 1} c_i$$

$$\varepsilon_{ij} = \rho \left(1 - s_{ij}^m\right) + \left(\left(1 - s_{mj}\right) \eta + s_{mj} \nu\right) s_{ij}^m.$$

- If $\nu = \eta$, then same as current setup.

▸ Back

Sector layer

- Consider an additional sector layer $s(i)$, in which firm i takes into account the effect of p_{ij} on c_j and q_j. Let δ be the substitutability across sectors.

$$p_{ij} = \frac{\varepsilon_{ij}}{\varepsilon_{ij} - 1} c_i$$
$$\varepsilon_{ij} = \rho \left(1 - s_{ij}^{s(i)}\right) + \delta s_{ij}^{s(i)} \left(1 - s_{s(i)j}^{m}\right) + \eta s_{ij}^{s(i)} s_{s(i)j}^{m},$$

- $s_{ij}^{s(i)}$ is the share of i's goods among j's sector $s(i)$ inputs, and $s_{s(i)j}^{m}$ is the share of sector $s(i)$ inputs among j's intermediate inputs.

▸ Back

Aggregation

- Household's budget constraint:

$$E = wL + \sum_{i \in \Omega} \pi_i .$$

- Trade balance and labor market clearing conditions:

$$[\text{TB}] : 0 = \underbrace{\sum_{i \in \Omega} I_{iF} p_{iH}^{1-\sigma} D^*}_{\text{Hetero. exports}} - \underbrace{\sum_{i \in \Omega} I_{Fi} s_{Fi} c_i q_i}_{\text{Hetero. imports}} + \underbrace{wl^Y - (1-\alpha) E}_{\text{Net exports of homog.}}$$

$$[\text{LMC}] : wL = \sum_{i \in \Omega} s_{li} c_i q_i + \sum_{i \in \Omega} \left(\sum_{j \in Z_i} w f_{Di} + I_{Fi} w f_{Fi} + I_{iF} w f_{iF} \right) + wl^Y$$

▸ Back

Intuition

- $\hat{P}$ is a weighted sum of $\hat{c}_i$, $\ln \hat{P} = \sum_i s_{iH} \ln \hat{c}_i$.

Intuition

- $\hat{P}$ is a weighted sum of $\hat{c}_i$, $\ln \hat{P} = \sum_i s_{iH} \ln \hat{c}_i$.
- Change in firm's unit cost reflects its exposure to the change in foreign price, its suppliers' exposures, and so on.

$$\ln \hat{c}_i = \sum_k s_{ki} \ln \hat{c}_k + s_{Fi} \ln \hat{p}_F .$$

Intuition

- $\hat{P}$ is a weighted sum of $\hat{c}_i$, $\ln \hat{P} = \sum_i s_{iH} \ln \hat{c}_i$.
- Change in firm's unit cost reflects its exposure to the change in foreign price, its suppliers' exposures, and so on.

$$\ln \hat{\boldsymbol{c}} = \left(I - S^{'}\right)^{-1} \boldsymbol{s}_{F.} \ln \hat{p}_F.$$

Intuition

- $\hat{P}$ is a weighted sum of $\hat{c}_i$, $\ln \hat{P} = \sum_i s_{iH} \ln \hat{c}_i$.
- Change in firm's unit cost reflects its exposure to the change in foreign price, its suppliers' exposures, and so on.

$$\ln \hat{\boldsymbol{c}} = \left(I - S^{'}\right)^{-1} \boldsymbol{s}_F . \ln \hat{p}_F .$$

- Firm's sales reflects its sales to final demand, its customers' sales to final demand, and so on.

$$p_i q_i = s_{iH} \left(\alpha E + Exp\right) + \sum_j s_{ij} p_j q_j .$$

Intuition

- $\hat{P}$ is a weighted sum of $\hat{c}_i$, $\ln \hat{P} = \sum_i s_{iH} \ln \hat{c}_i$.
- Change in firm's unit cost reflects its exposure to the change in foreign price, its suppliers' exposures, and so on.

$$\ln \hat{\boldsymbol{c}} = \left(I - S^{'}\right)^{-1} \boldsymbol{s}_{F.} \ln \hat{p}_F.$$

- Firm's sales reflects its sales to final demand, its customers' sales to final demand, and so on.

$$\frac{\boldsymbol{p} \circ \boldsymbol{q}}{\alpha E + Exp} = (I - S)^{-1} \boldsymbol{s}_{.H}.$$

Intuition

- $\hat{P}$ is a weighted sum of $\hat{c}_i$, $\ln \hat{P} = \sum_i s_{iH} \ln \hat{c}_i$.
- Change in firm's unit cost reflects its exposure to the change in foreign price, its suppliers' exposures, and so on.

$$\ln \hat{\boldsymbol{c}} = \left(I - S^{'}\right)^{-1} \boldsymbol{s}_{F.} \ln \hat{p}_F.$$

- Firm's sales reflects its sales to final demand, its customers' sales to final demand, and so on.

$$\frac{\boldsymbol{p} \circ \boldsymbol{q}}{\alpha E + Exp} = (I - S)^{-1} \boldsymbol{s}_{.H}.$$

- The measures of firms' importance as suppliers of goods, and as consumers of goods coincide.

$$\ln \hat{P} = \sum_i \frac{p_i q_i}{\alpha E + Exp} s_{Fi} \ln \hat{p}_F.$$

▸ Back

Assuming common CES parameter

One can relax the Cobb-Douglas assumption and assume common CES parameter $\tilde{\sigma}$.

Proposition
Assume (1) only composite final consumption goods are exported, (2) CES structure with common $\tilde{\sigma}$ in preference and in technologies, (3) perfect competition ($p_i = c_i$), and (4) exogenous and fixed network. Then the change in price index, $\hat{P}$, can be expressed as

$$\hat{P}^{1-\tilde{\sigma}} = \sum_i \frac{p_i q_i}{\alpha E + \text{Exports}} \left(s_{li} + s_{Fi} \hat{p}_F^{1-\tilde{\sigma}} \right).$$

▸ Back

Acemoglu et.al. (2012)

- Acemoglu, Carvalho, Ozdaglar and Tahbaz-Salehi (2012) focus on the variance of changes in aggregate variables, under
  - closed economy,
  - Cobb-Douglas both in preference and in technologies,
  - competitive prices,
  - exogenous and fixed network.

- Firm-level information sufficient when focusing on the changes in aggregate variables.

▸ Back

(η, ρ, σ) under Cournot competition

- When assuming Cournot competition, we have

$$p_{ij} = \frac{\varepsilon_{ij}}{\varepsilon_{ij} - 1} c_i$$

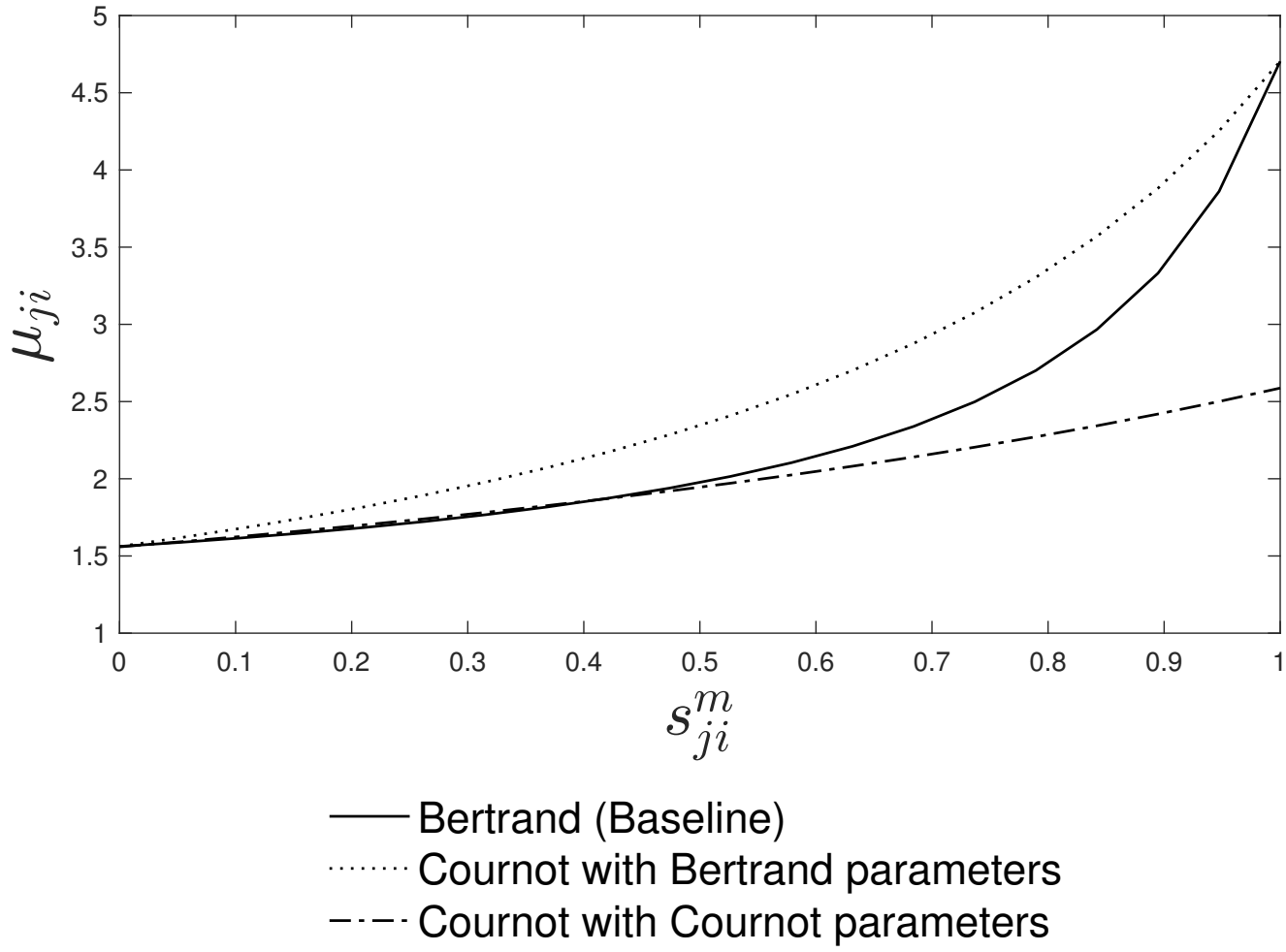
$$\varepsilon_{ij} = \left(\frac{1}{\rho} \left(1 - s_{ij}^m \right) + \frac{1}{\eta} s_{ij}^m \right)^{-1}.$$

- Estimates:

	$\frac{1}{\eta}$	$\frac{1}{\rho}$	$\frac{\sigma}{\sigma-1}$
Estimate	0.62	0.36	1.25
s.e.	0.18	0.04	0.05
	η (Labor and goods)	ρ (Firms' in production)	σ (Firms' in consumption)
Implied value	1.63	2.79	5.00

▸ Markups under Bertrand and Cournot ▸ Back

Markups under Bertrand and Cournot



▸ Back

Accounting for capital

In the model, total input, $c_i q_i$, is an aggregate of labor costs and goods purchases. Here we account for capital inputs by interpreting labor as composite input of labor and capital.

1. Uniformly scale up labor cost, by assuming common labor share.

2. Assume user cost of capital being the depreciation rate and the interest rate, and compute firm level capital rental costs.

▸ Back

Accounting for capital

Common labor share.

	η	ρ	$\frac{\sigma}{\sigma-1}$
Estimate	1.00	3.03	1.25
s.e.	0.66	0.47	0.05

	η (Labor and goods)	ρ (Firms' goods in production)	σ (Firms' goods in consumption)
Implied value	1.00	3.03	4.96

▸ Back

Accounting for capital

Firm level capital costs.

	η	ρ	$\frac{\sigma}{\sigma-1}$
Estimate	1.00	3.59	1.27
s.e.	0.93	0.65	0.04

	η (Labor and goods)	ρ (Firms' goods in production)	σ (Firms' goods in consumption)
Implied value	1.00	3.59	4.77

▸ Back

System of price changes (constant markups)

- Solve for firm level changes in unit costs $\hat{c}_i$:

$$\hat{c}_i^{1-\eta} = s_{li} + s_{mi}\hat{p}_{mi}^{1-\eta}$$
$$\hat{p}_{mi}^{1-\rho} = \sum_{j \in Z_i} s_{ji}^m \hat{c}_j^{1-\rho} + s_{Fi}^m \hat{p}_F^{1-\rho}.$$

- The change in aggregate price index:

$$\hat{P} = \left(\sum_i s_{iH} \hat{c}_i^{1-\sigma} \right)^{\frac{1}{1-\sigma}}.$$

▸ Back

System of price changes (variable markups)

- Solve for firm level changes in unit costs $\hat{c}_i$, and pair level changes in markups $\hat{\mu}_{ji}$:

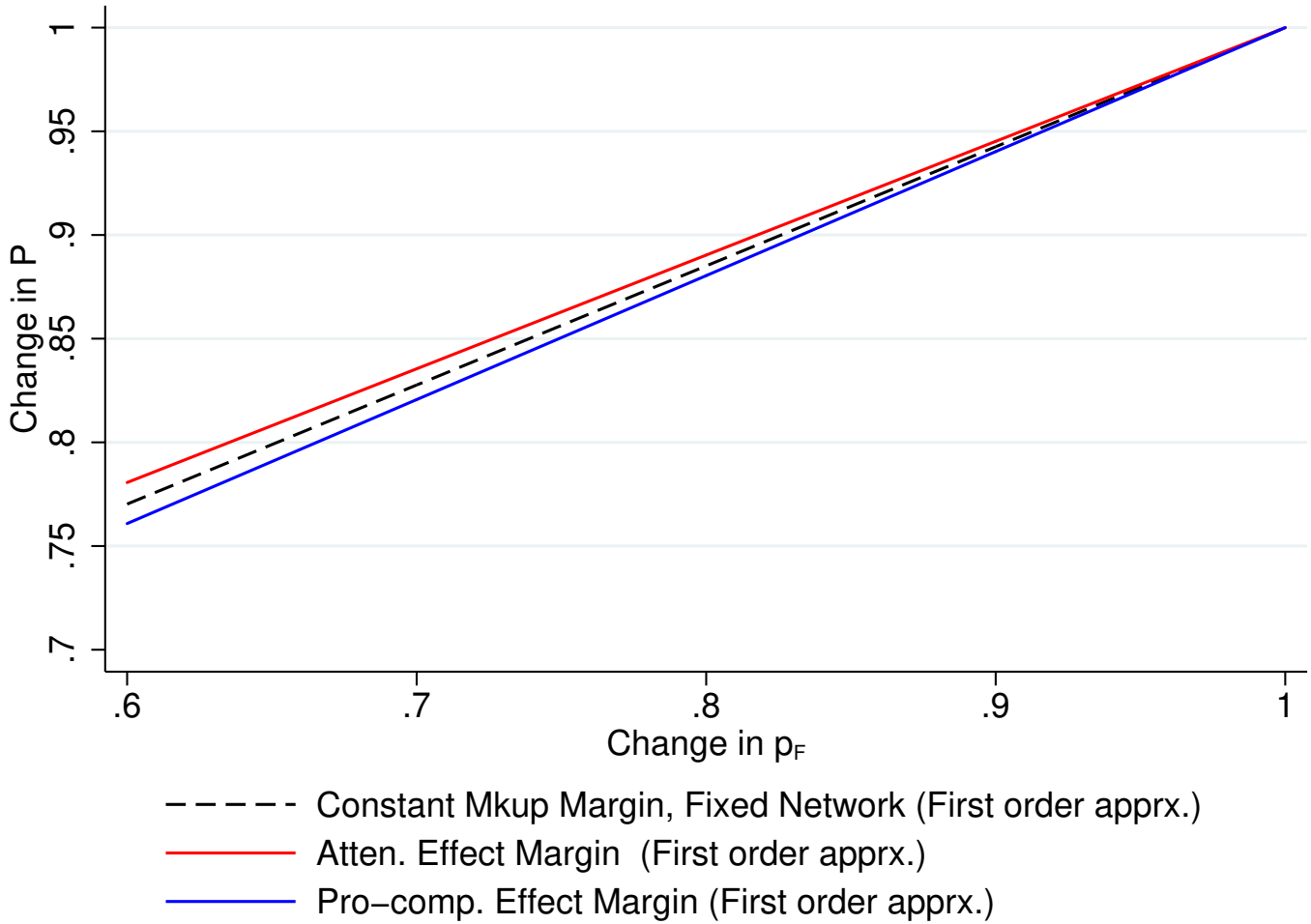
$$\begin{aligned}
\hat{c}_i^{1-\eta} &= s_{li} + s_{mi}\hat{p}_{mi}^{1-\eta} \\
\hat{p}_{mi}^{1-\rho} &= \sum_{j \in Z_i} s_{ji}^m \hat{\mu}_{ji}^{1-\rho} \hat{c}_j^{1-\rho} + s_{Fi}^m \hat{p}_F^{1-\rho} \\
\hat{\mu}_{ji} &= \hat{\varepsilon}_{ji} \frac{\varepsilon_{ji} - 1}{\hat{\varepsilon}_{ji}\varepsilon_{ji} - 1} \\
\varepsilon_{ij} &= \rho\left(1 - s_{ij}^m\right) + \eta s_{ij}^m \\
\hat{\varepsilon}_{ji} &= \frac{1}{\varepsilon_{ji}}\left(\rho\left(1 - s_{ji}^m \hat{s}_{ji}^m\right) + \eta s_{ji}^m \hat{s}_{ji}^m\right) \\
\hat{s}_{ji}^m &= \hat{\mu}_{ji}^{1-\rho} \hat{c}_j^{1-\rho} \hat{p}_{mi}^{\rho-1}.
\end{aligned}$$

- The change in aggregate price index:

$$\hat{P} = \left(\sum_i s_{iH} \hat{c}_i^{1-\sigma}\right)^{\frac{1}{1-\sigma}}.$$

▸ Back

Attenuation and pro-competitive effects



▸ Back

Attenuation and pro-competitive effects

Back

- System of first order approximated price changes.
- Under constant markups:

$$\frac{\mathrm{d}c_i}{c_i} = \sum_{j \in Z_i} s_{ji} \frac{\mathrm{d}c_j}{c_j} + s_{Fi} \frac{\mathrm{d}p_F}{p_F}.$$

- Under variable markups:

$$\frac{\mathrm{d}c_i}{c_i} = \sum_{j \in Z_i} s_{ji} \left(\frac{\mathrm{d}\mu_{ji}}{\mu_{ji}} + \frac{\mathrm{d}c_j}{c_j} \right) + s_{Fi} \frac{\mathrm{d}p_F}{p_F},$$

$$\frac{\mathrm{d}\mu_{ji}}{\mu_{ji}} = \underbrace{-\Gamma_{ji} \frac{\mathrm{d}c_j}{c_j}}_{\text{attenuation effect}} + \underbrace{\Gamma_{ji} \frac{\mathrm{d}p_{\not j i}}{p_{\not j i}}}_{\text{pro-competitive effect}}.$$

  - Γ_{ji}: elasticity of markup μ_{ji} with respect to the supplier's cost c_j.
  - $\frac{\mathrm{d}p_{\not j i}}{p_{\not j i}}$: average price changes of suppliers other than j:

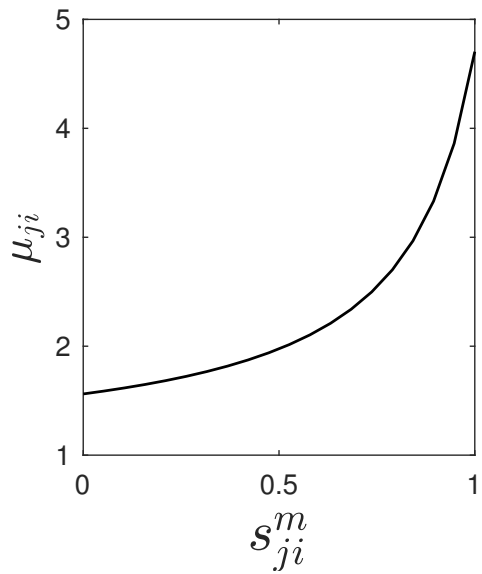
$$\frac{\mathrm{d}p_{\not j i}}{p_{\not j i}} = \frac{\sum_{k \in Z_i, k \neq j} s^m_{ki} \left(\frac{\mathrm{d}\mu_{ki}}{\mu_{ki}} + \frac{\mathrm{d}c_k}{c_k} \right) + s^m_{Fi} \frac{\mathrm{d}p_F}{p_F}}{1 - s^m_{ji}}.$$

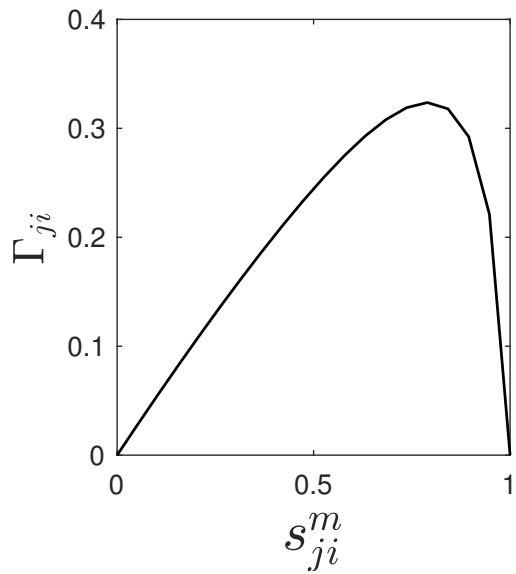
Elasticity Γ_{ji}

Γ_{ji} represents the elasticity of markup μ_{ji} with respect to the supplier's cost c_j:

$$\Gamma_{ji} = -\frac{\partial \mu_{ji}}{\partial c_j}\frac{c_j}{\mu_{ji}} = \frac{\Upsilon_{ji}\left(1 - s_{ji}^m\right)}{1 - \Upsilon_{ji} s_{ji}^m}$$

$$\Upsilon_{ji} = \frac{(\rho - \varepsilon_{ji})(\rho - 1)}{(\varepsilon_{ji} - 1)\varepsilon_{ji} + (\rho - \varepsilon_{ji})(\rho - 1)}.$$





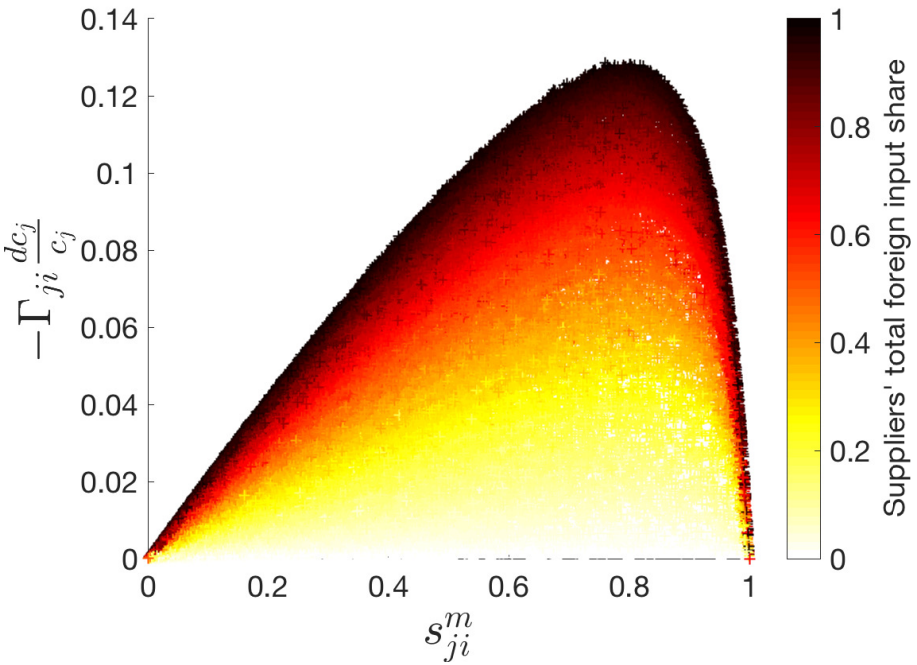
▸ Back

Attenuation effect: $-\Gamma_{ji}\frac{dc_j}{c_j}$

- Variation within the same s_{ji}^m comes from the supplier's cost change.
- Firm's cost change correlated with "total foreign input share", s_{Fj}^{Total}:

$$s_{Fj}^{Total} = s_{Fj} + \sum_k s_{kj} s_{Fk}^{Total}.$$

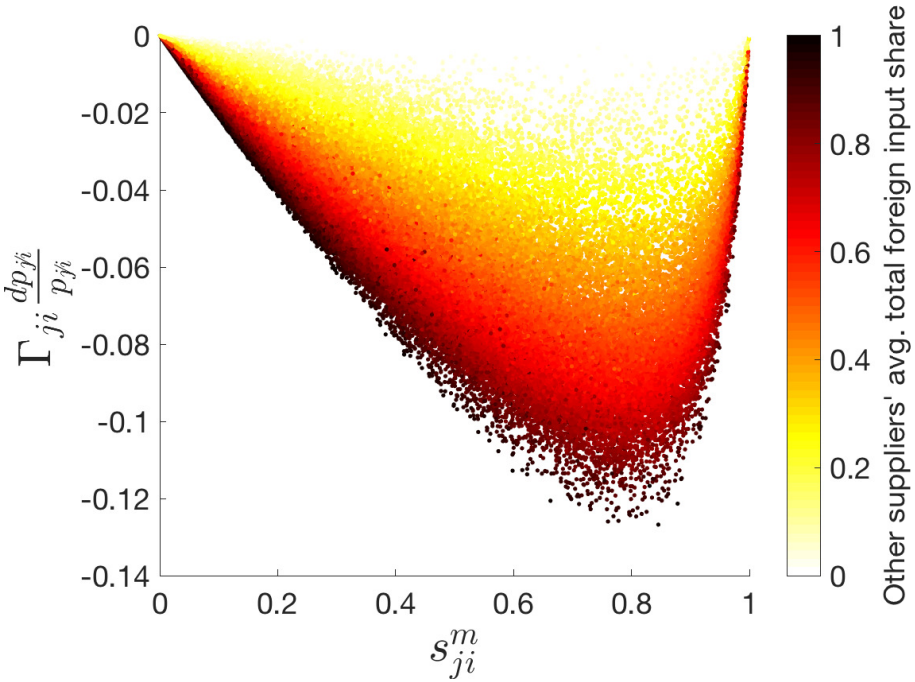
- One-to-one mapping between s_{Fj}^{Total} and $\hat{c}_j$ in benchmark case.



▸ Back

Pro-competitive effect: $\Gamma_{ji} \frac{\mathrm{d}\hat{p}_{\not j i}}{\hat{p}_{\not j i}}$

- Variation within the same s^m_{ji} comes from average cost changes of other suppliers.
- Compute average total foreign input shares for other suppliers.



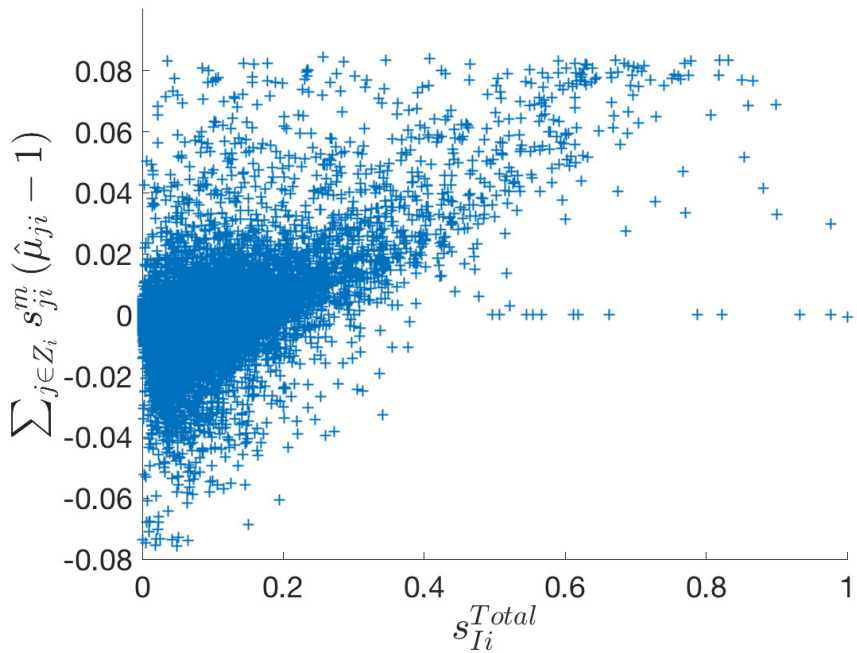
▸ Back

Shock to one firm

- Shock a single importer I, with import price reduction $\hat{p}_F$.
- Stronger correlation between $\sum_{j \in Z_i} s_{ji}^m \left(\hat{\mu}_{ji} - 1\right)$ and s_{Ii}^{Total}.

$$s_{Ii}^{Total} = \sum_{k \in Z_i} s_{ki} s_{Ik}^{Total} \quad \text{if } i \neq I$$

$$s_{Ii}^{Total} = 1 \quad \text{if } i = I.$$



▸ Back

The aggregate effects

- First order approximated change of aggregate price index.
- Under constant markups:

$$\frac{\mathrm{d}P}{P} = \sum_i s_{iH} \left(\sum_{j \in Z_i} s_{ji} \frac{\mathrm{d}c_j}{c_j} + s_{Fi} \frac{\mathrm{d}p_F}{p_F} \right),$$

  where s_{iH} is i's share in final goods consumption.

- Under variable markups:

$$\frac{\mathrm{d}P}{P} = \sum_i s_{iH} \left(\sum_{j \in Z_i} s_{ji} \frac{\mathrm{d}c_j}{c_j} + s_{Fi} \frac{\mathrm{d}p_F}{p_F} \right) + \sum_i s_{iH} s_{mi} \underbrace{\sum_{j \in Z_i} s^m_{ji} \frac{\mathrm{d}\mu_{ji}}{\mu_{ji}}}_{\text{avg. change in markups}}.$$

▸ Back

Other parameters

- Set $\beta_{iH} = \alpha_{ij} = \alpha_{Fi} = 1$.

- Calibrate
  - $\omega_l = 0.3$ and $\omega_m = 0.7$ to match the average labor share (0.34).
  - $\alpha = 0.55$ to match the aggregate share of private and non-financial sectors.
  - $D^* = 10^{14}$ to match the average export share for exporting firms (0.2).
  - $p_F = 5$ to match the average import share for importing firms (0.31).

▸ Back

Recovering productivity distribution

- From the model, we obtain the following equation to recover productivity distribution up to a scale:

$$\ln \phi_i = \frac{1}{\sigma - 1} \ln p_{iH} q_{iH} + \frac{1}{\eta - 1} \ln s_{li} + \ln \left(\frac{\sigma}{\sigma - 1} \omega_l^{\frac{-\eta}{\eta - 1}} P^{-1} \alpha^{\frac{-1}{\sigma - 1}} E^{\frac{-1}{\sigma - 1}} \right).$$

- Variations in $p_{iH} q_{iH}$ reflects the variations in firms' unit costs, which reflect firms' productivities and firms' sourcing capabilities.

- Since wage is common, sourcing capabilities are inversely related to s_{li}.

▸ Back

One sector partial equilibrium model

- Production technology:

$$c_i = \phi_i^{-1} \left(\omega_l^{\eta} w^{1-\eta} + \omega_m^{\eta} p_{mi}^{1-\eta} \right)^{\frac{1}{1-\eta}}$$

$$p_{mi} = \left(\sum_{j \in Z_i} \alpha_{ji}^{\rho} p_{ji}^{1-\rho} + \alpha_{oi}^{\rho} p_o^{1-\rho} + I_{Fi} \alpha_{Fi}^{\rho} p_F^{1-\rho} \right)^{\frac{1}{1-\rho}}.$$

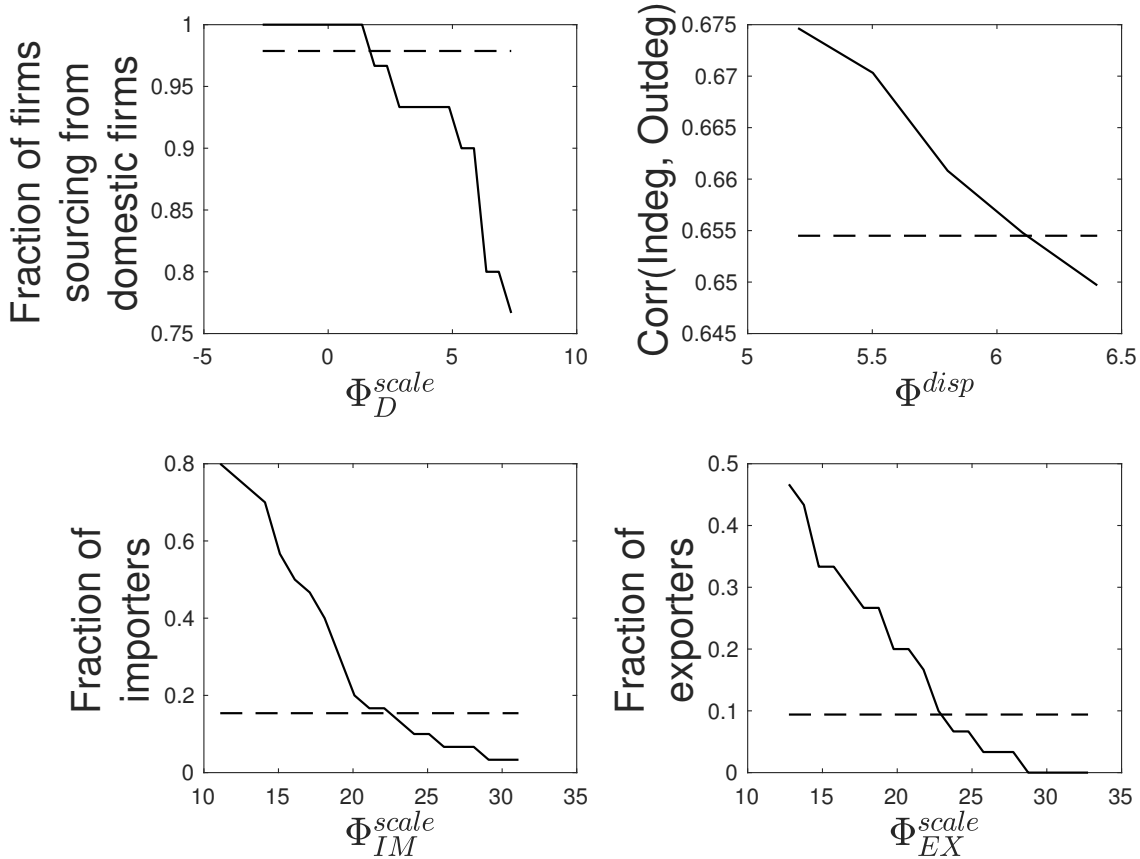
- Monopolistic competition when selling to outside sector:

$$p_{iO} = \frac{\rho}{\rho - 1} c_i.$$

- Estimate fixed costs distributions using data on 2-digit manufacturing sector (3481 firms), where
  - the largest 30 firms account for 99% of output.
  - sales among the largest 30 firms account for 99% of firm-to-firm sales.

Back

Local identification



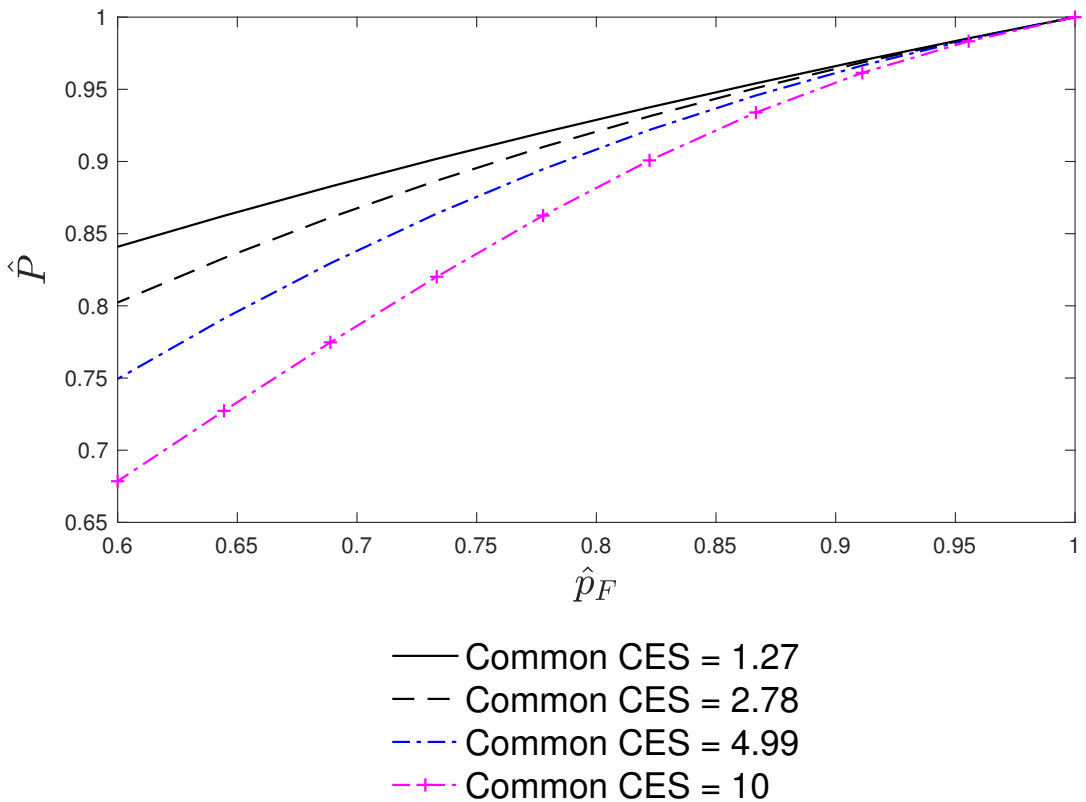
Notes: These figures illustrate local identification of the four fixed cost parameters. In each figure, on the x-axis we plot the parameter to identify, which we vary while fixing all other parameters to their estimated values. On the y-axes we plot the moments we use to identify the parameters. The horizontal lines indicate the observed value of the moment in the data.

▸ Back

Common CES parameter

Network irrelevance result given a common CES parameter $\tilde{\sigma}$:

$$\hat{P} = \left(\sum_{i \in \Omega} \frac{p_i q_i}{\alpha E + \text{Exports}} \left(s_{li} + s_{Fi} \hat{p}_F^{1-\tilde{\sigma}} \right) \right)^{\frac{1}{1-\tilde{\sigma}}} .$$



▸ Back

Acemoglu, Daron, Vasco M. Carvalho, Asuman Ozdaglar, and Alireza Tahbaz-Salehi, "The Network Origins of Aggregate Fluctuations," *Econometrica*, 2012, *80* (5), 1977–2016.

Atkeson, Andrew and Ariel Burstein, "Trade Costs, Pricing to Market, and International Relative Prices," *American Economic Review*, 2008, *98* (5), 1998–2031.

De Loecker, Jan and Frederic Warzynski, "Markups and Firm-Level Export Status," *American Economic Review*, 2012, *102* (6), 2437–2471.

_ , Catherine Fuss, and Johannes Van Biesebroeck, "International competition and firm performance : Evidence from Belgium," *NBB Working Paper Series*, 2014, (269).

Dhyne, Emmanuel, Glenn Magerman, and Stela Rubinova, "The Belgian production network 2002-2012," *National Bank of Belgium Working Paper Series*, 2015, *288*.