Volatility in the Small and in the Large: The Lack of Diversification in International Trade[1]

Francis Kramarz (CREST-ENSAE and CEPR)
Julien Martin (Université du Québec à Montréal and CEPR)
Isabelle Mejean (CREST-Ecole Polytechnique and CEPR)

June, 2017

[1] This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 714597)

Motivation

- **Does international trade foster or dampen the risk exposure of firms and countries?**
- Specialization of production:
  - ⇒ Trade makes firms and countries more specialized (DFS 1997, di Giovanni Levchenko Rancière 2013)
  - ⇒ In the presence of idiosyncratic supply shocks, specialization increases volatility (di Giovanni & Levchenko 2007, 2012)
- Diversification of demand:
  - ⇒ Trade allows firms and countries to diversify across clients
  - ⇒ In presence of (macro and micro) demand shocks, diversification reduces volatility (Caselli et al. 2016, Kelly et al. 2012)

Motivation

- **Does international trade foster or dampen the risk exposure of firms and countries?**
- Specialization of production:
  - ⇒ Trade makes firms and countries more specialized (DFS 1997, di Giovanni Levchenko Rancière 2013)
  - ⇒ In the presence of idiosyncratic supply shocks, specialization increases volatility (di Giovanni & Levchenko 2007, 2012)
- Diversification of demand:
  - ⇒ Trade allows firms and countries to diversify across clients
  - ⇒ In presence of (macro and micro) demand shocks, diversification reduces volatility (Caselli et al. 2016, Kelly et al. 2012)

Key to this debate :

- **Interplay btw the sources of shocks hitting firms and countries...**

  Micro vs macro shocks, hitting the demand or supply sides of the economy

- **... And the structure of trade networks**

  How much diversification it offers against various sources of shocks

Our paper :

- Integrated empirical study of volatility in international markets
- "Estimate" the sources of shocks hitting individual (firm-to-firm) export transactions

  $\Rightarrow$ supply/demand, micro/macro
- Assess whether these shocks can be / are diversified
- Quantify their end-effect on the volatility of individual and aggregate exports ("in the small" and "in the large")

  $\Rightarrow$ Role of the diversification/concentration of trade networks...

Main results: the role of buyers

- Buyer-related growth components contribute almost as much as seller components to micro volatility
- Sellers with less concentrated export portfolio (within and across countries) have significantly less volatile export sales
- Even large sellers are not very diversified along the buyer dimension / are left quite exposed to buyer-related sources of risk
- As a consequence, buyer-related components also matter significantly in the large

$\Rightarrow$ **Specialization magnifies the impact of a lack of diversification**

Relation to the literature

- Evidence on the structure of firm-to-firm trade
  - Bernard et al. (2014), Carballo et al. (2013) and Eaton et al. (2013)
- Determinants of firm dynamics
  - Comin and Philippon (2006), Thesmar & Thoenig (2011), Decker et al (2014), Fort et al (2013): Firm volatility
  - Foster et al. (2012), Kelly et al. (2013): Role of demand shocks
- The microeconomic origin of aggregate fluctuations
  - Role of the skewness of firms sales: Gabaix (2011) and propagation of shocks along economic networks: Acemoglu et al. (2012). See di Giovanni and Levchenko (2012), di Giovanni et al. (2014) in an open-economy context
  - Identification with exogenous shocks: Carvalho et al. (2014), Barrot and Sauvagnat (2017)

Outline

1 Introduction

2 Data and stylized facts

3 Empirical Strategy

4 Results: Volatility in the small

5 Results: Volatility in the large

6 Conclusion

Our data

- Detailed export data covering the universe of French firms (Source: French Customs)
- Work with data disaggregated by exporter s, destination d (within the EU), importer b, year of the transaction t
- Data cover 11 EU importers over the 1995-2007 period (stylized facts focus on year 2007)
- Data allow us to
  - Observe the microstructure of trade networks and
  - Decompose the volatility of individual and aggregate sales of French exporters, by destination

Stylized facts

- Concentration of trade networks used to characterize the extent to which the existing structure of trade *can* help diversify against risks
- Diversification in the small: Across countries and across buyers within a country
  - 25% of sellers serve a single destination in Europe, less than 5% are active in the 11 EU destinations (but represent 30% of aggregate trade) ▸ Figure
  - 43% of sellers interact with a single buyer within a destination, 12% of firms serve more than 10 buyers (but represent 40% of aggregate trade) ▸ Figure
  - Even the largest firms are not very diversified: Sum of sellers' exports with their main buyer accounts for 90% of aggregate trade
- Diversification in the large: Across countries, buyers and sellers
  - Distribution of exports is very skewed, across exporters, across buyers and across seller-buyer pairs
  - In all three dimensions, higher decile accounts for more than 90% of exports

Outline

1 Introduction

2 Data and stylized facts

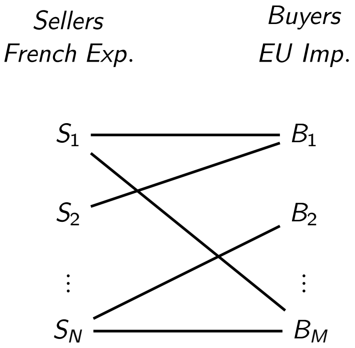
3 Empirical Strategy

4 Results: Volatility in the small

5 Results: Volatility in the large

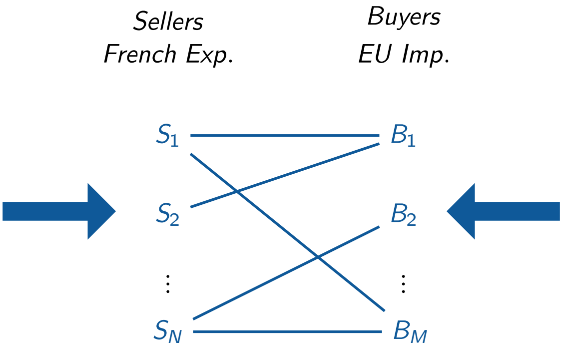
6 Conclusion

Interpretation of the data



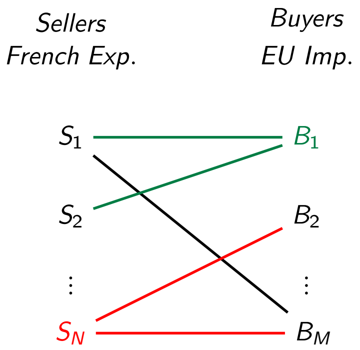
- Bi-partite graph, nodes are sellers and buyers, edges are trade flows

Interpretation of the data



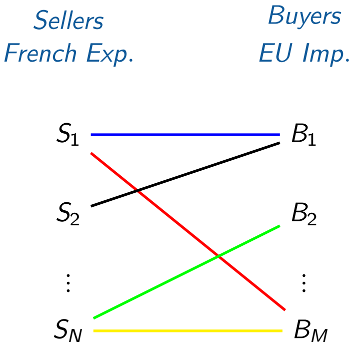
- $g_{sbt} = f_{Ct} + f_{st} + f_{bt} + \nu_{sbt}$
- *Macro* shock (later defined for each destination-sector)
- Everyone is hit

Interpretation of the data



- $g_{sbt} = f_{Ct} + f_{st} + f_{bt} + \nu_{sbt}$
- Seller-specific shock, common to its buyers (eg. productivity shock)
- Buyer-specific shock, common to its sellers (eg. demand shock)

Interpretation of the data



- $g_{sbt} = f_{Ct} + f_{st} + f_{bt} + \nu_{sbt}$
- Shocks specific to each seller-buyer pair (eg. buyer figures out a better way to use the input)
- (seller-buyer shock, match-specific shock, pair-specific shock)

Interpretation of the data

- Structure of networks can be used to identify growth components
  - Macro, Seller-specific, Buyer-related (buyer- and match-specific) components
- Use high-dimensional fixed effects estimator
  - Similar in spirit to the labor literature regarding the dispersion of wages in employer-employee networks
  - Here: Identification is cross-sectional, uses the multiplicity of sellers (buyers) in buyers (sellers)' portfolio for identification
  - Decomposition derived from a PE model Sketch of the model

Summary statistics on the estimated effects

	(1) Mean	(2) Std.Dev	(3) Count	(4) Contrib.	(5) Partial Corr.
Firm-to-firm growth $g_{sb(j)t}$	-.0132	.6887	3,834,655		
Macro component $f_{c(Fj)t}$	-.0519	.0471	4,310	.0055	0.006^a
Seller-specific component f_{st}	.0000	.2688	283,032	.0757	0.118^a
Buyer-specific component $f_{b(j)t}$	.0000	.3601	933,888	.2142	0.248^a
Match-specific residual $\nu_{sb(j)t}$	.0000	.5417	3,834,655	.6326	0.618^a
Buyer input cost $BSIC_{b(j)t}$	.0387	.1417	933,888	.0039	0.010^a

Notes: This table gives the mean (column (1)) and standard deviation (column (2)) of each of the component of seller-buyer growth rates, over the population of estimated effects. The number of estimated effects is displayed in column (3). Column (4) is the median contribution of each growth component to the seller-buyer growth (e.g. $Med(f_{st}/g_{sb(j)t})$). The last column is the regression coefficient of each component on the firm-to-firm growth rate. ^{a} indicates significance at the 1% level.

Outline

1. Introduction
2. Data and stylized facts
3. Empirical Strategy
4. Results: Volatility in the small
5. Results: Volatility in the large
6. Conclusion

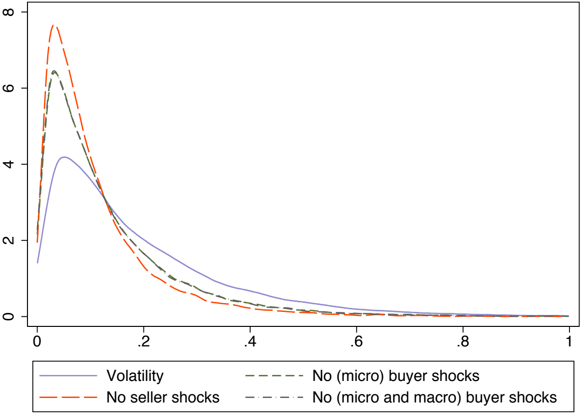
Diversifiable sources of risk

- In the small, the object of interest is the volatility of sales, for each seller

$$
\begin{aligned}
Var(g_{st}) \quad = \quad & \underbrace{Var(f_{st})}_{Non-Diversifiable} + \underbrace{Var\left(\sum_{c \in C_s} w^s_{ct-1} f_{ct}\right)}_{Diversifiable\ Across\ Countries} \\
& + \underbrace{Var\left(\sum_{c \in C_s} \sum_{b \in B_{sc}} w^s_{ct-1} w^{sc}_{bt-1} (f_{bt} + \nu_{sbt} + BSIC_{bt})\right)}_{Diversifiable\ Across\ and\ Within\ Countries} \\
& + \quad Cov
\end{aligned}
$$

- Use "counterfactual experiments" to study how the sources of risk *and* the structure of trade networks shape the volatility in the small

Actual and counterfactual distributions: Muting shocks

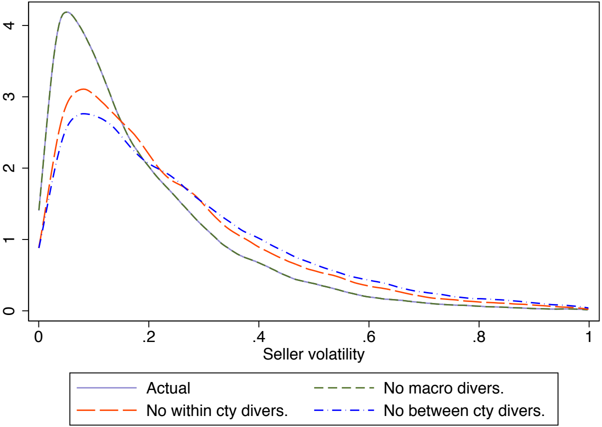


For the median firm, removing seller, (micro) buyer, and (micro and macro) growth components reduces the volatility of sales by 36, 33 and 34%, respectively

The role of diversification within and across countries

- Three thought experiments:
  1. No diversification of the macro components (”No macro divers.”)
     Same number of buyers, all located in the same country
  2. No diversification between countries (”No between cty divers.”)
     Firm’s network restricted to the buyers in its main destination
  3. No diversification within countries (”No within cty divers.”)
     Firm’s network restricted to its main buyer in each destination

Actual and counterfactual distributions: Changing the structure of trade networks



For the median firm, the counterfactual volatilities in the "no macro divers.", "no between cty divers." and "no within cty divers." scenarios are 0, 53 and 36% higher than in reality, respectively.

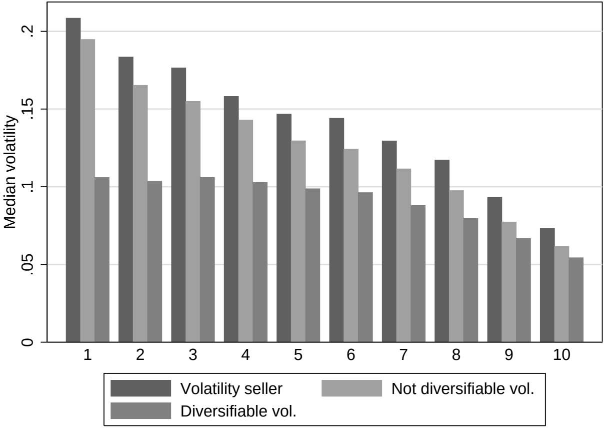
Diversification and the heterogeneity in firm-level volatilities

	Multilateral Total (1)	Multilateral Total (2)	Multilateral Diversifiable (3)	Unilateral Total (4)
ln Herfindahl ac. buyers		0.34***	0.60***	0.17***
		(0.010)	(0.009)	(0.003)
ln Herfindahl ac. destinations		0.11***	0.09***	
		(0.015)	(0.014)	
ln Herf. ac. products		0.01	0.03*	0.04***
		(0.015)	(0.014)	(0.004)
ln value of exports	-0.13***	-0.09***	-0.02***	-0.06***
	(0.003)	(0.003)	(0.003)	(0.001)
ln # years	-0.56***	-0.43***	-0.12***	-0.14***
	(0.015)	(0.015)	(0.015)	(0.005)
Entrant	-0.03**	-0.00	-0.10***	0.03***
	(0.011)	(0.011)	(0.011)	(0.006)
Young exporter	0.00	-0.02*	0.02*	0.01**
	(0.011)	(0.011)	(0.011)	(0.005)
$\mathbb{1} = 1$ if HQ in dest.	0.11***	0.05***	0.08***	0.02**
	(0.018)	(0.018)	(0.016)	(0.009)
$\mathbb{1} = 1$ if aff. in dest.	-0.11**	-0.10**	0.02	-0.02
	(0.048)	(0.045)	(0.041)	(0.020)
Sector $\times$ country FE	No	No	No	Yes
Firm FE	No	No	No	Yes
Observations	29,772	29,772	29,772	106,037
Adjusted R-squared	.149	.213	.227	.491

Notes: Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1, 5 and 10% levels.

- ↑ of the Herfindahl across buyers (resp. destinations) from P25 to P75 ↓ volatility of a firm's sales by 27% (resp. 8%).

Volatility, by decile of firms' size



Notes: This figure represents the median volatility of sellers' exports across deciles of sellers' size. Sellers are grouped into size bins based on their initial size. For each decile, the figure reports the median volatility of sellers, the median volatility attributable to (micro) buyer-related shocks ($Var(\sum_{c\in C_s}\sum_{b\in B_{sc}} w^{s}_{ct-1} w^{sb}_{bt-1}(f_{bt}+\nu_{sbt}))$) and the median volatility induced by seller-specific shocks ($Var(f_{st})$).

Outline

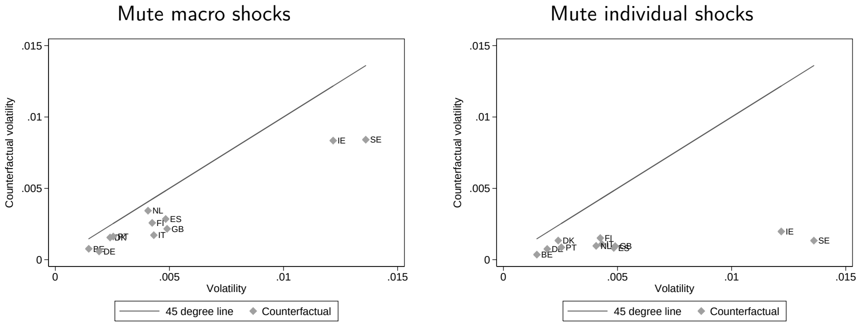
1. Introduction
2. Data and stylized facts
3. Empirical Strategy
4. Results: Volatility in the small
5. **Results: Volatility in the large**
6. Conclusion

Diversifiable sources of shocks

- In the large, the object of interest is the volatility of aggregate sales

$$
\begin{aligned}
Var(g_t) &= \underbrace{Var\left(\sum_c w_{ct-1} f_{ct}\right)}_{Diversifiable\ ac.\ countries} + \underbrace{Var\left(\sum_{s\in S} w_{st-1} f_{st}\right)}_{Diversifiable\ ac.\ sellers} \\
&+ \underbrace{Var\left(\sum_c \sum_{b\in B_c} w_{ct-1} w^c_{bt-1} (f_{bt} + BSIC_{bt})\right)}_{Diversifiable\ ac.\ buyers} \\
&+ \underbrace{Var\left(\sum_c \sum_{s\in S_c} \sum_{b\in B_{sc}} w_{ct-1} w^c_{st-1} w^{sc}_{bt-1} \nu_{sbt}\right)}_{Diversifiable\ ac.\ matches} + Cov
\end{aligned}
$$

Micro vs macro growth components



Notes: The graphs plot the volatility of bilateral French exports against their counterfactual volatility when muting either macro shocks (left panel) or all three individual shocks (right panel).

- In the median destination, removing either macro or all three micro growth components reduces the volatility of export sales by 48 and 76%, respectively
- Micro components explain the cross-country heterogeneity in export volatility

Micro vs macro growth components

	(1) Var (g_{sct})	(2) Var $(.\|f_{ct}=0)$	(3) Var $(.\|f_{st}, f_{bt}, \nu_{sbt}=0)$	(4) Var $(.\|w_{sbt}=1/N_{sb})$
Destination-specific sales				
Median	**.0042**	**.0022**	**.0010**	**.0009**
Multilateral	**.0015**	**.0005**	**.0005**	**.0004**

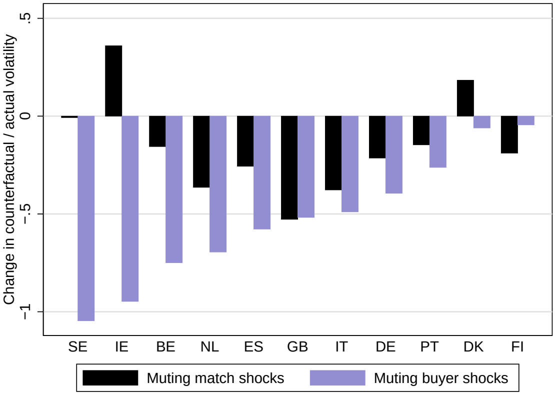
Notes: Column (1) reports the variance of aggregate export growth computed country-by-country and using multilateral sales ("Multilateral" line). Columns (2) and (3) are the variations in these volatilities one would observe in the absence of macro-economic shocks and in the absence of all three individual shocks, respectively. Column (4) is the counter-factual variance computed using all four shocks but assuming individual transactions to be symmetric in size (i.e. $w_{sbt-\mathbf{1}} = w_{t-\mathbf{1}}$, $\forall (s,b)$).

Seller, Buyer and Match-specific components

	(1) Var (g_{sct})	(5) Var $(.\|f_{st}=0)$	(6) Var $(.\|f_{bt}=0)$	(7) Var $(.\|\nu_{sbt}=0)$
Destination-specific sales				
Median	**.0042**	**.0036**	**.0027**	**.0029**
Multilateral	**.0015**	**.0008**	**.0011**	**.0013**

Notes: Column (1) reports the variance of aggregate export growth computed country-by-country and using multilateral sales ("Multilateral" line). Columns (5)-(7) are the counterfactual variations in the absence of seller-specific, buyer-specific and match-specific shocks, respectively.

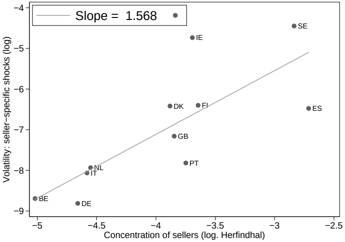
Buyer vs match-specific components



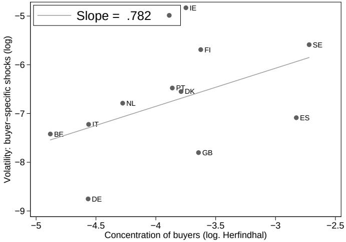
- Relative importance of buyer-specific shocks is driven by the **connectedness in firms' trade networks** Details

Volatility and the diversification of trade networks

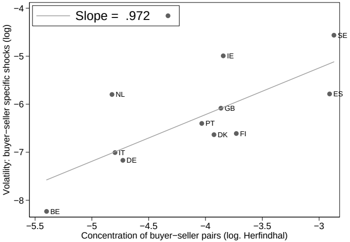
Seller shocks



Buyer shocks



Seller-buyer shocks



The role of diversification within and across countries

- Four (radical) "counterfactual exercises":

1. No diversification of the macro components
   Same number of buyers, all located in Germany
   Volatility of multilateral sales increases by 13%

2. No diversification between countries
   Trade networks restricted to France's main export destination (Germany)
   Volatility of multilateral sales increases by 26%

3. No diversification within countries
   Firms' networks restricted to their main buyer in each destination
   Volatility of multilateral sales increases by 13%

4. Perfect diversification across sellers
   All the seller have the same size
   Volatility of multilateral sales decreases by 67%

Outline

1. Introduction
2. Data and stylized facts
3. Empirical Strategy
4. Results: Volatility in the small
5. Results: Volatility in the large
6. Conclusion

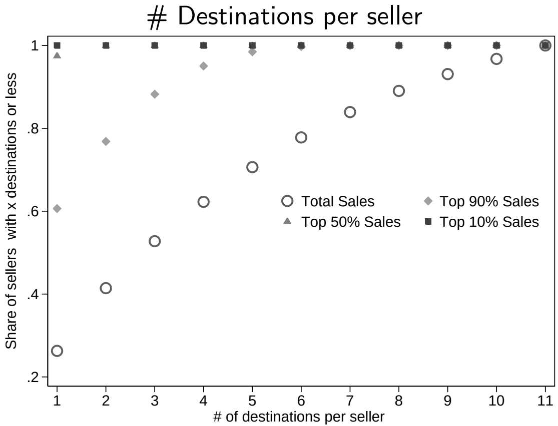
Conclusion

- Forensic account of export volatility at the level of individual firms and in the aggregate
  - Well-identified sources of volatility together with the structure of trade networks explain the volatility of sales
- Buyer-related shocks matter!
  - Most exporters are not diversified along this dimension
  - Firms with a more diversified portfolio display significantly less volatility
  - Lack of diversification also shows up in the aggregate
- Implications for trade and volatility
  - (Diversifiable) demand-related risks are an important component of volatility
    $\Rightarrow$ International trade markets offer natural hedging properties
  - Such diversification is far from perfect, including at the top of the distribution
    $\Rightarrow$ These shocks show up in the aggregate

  $\Rightarrow$ Specialization magnifies the impact of a lack of diversification

Thank You!

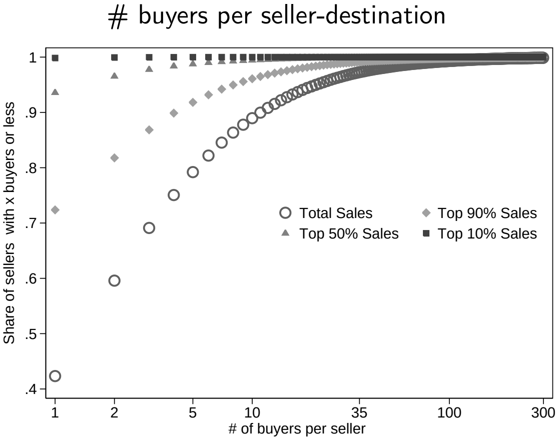
Diversification across destinations



Notes: Proportion of sellers that serve x destination markets or less, in 2007. The distributions labeled "Top X% Sales" are computed restricting the amount of each firm's sales to the X first percentiles of the distribution of sales when destinations are ordered by their decreasing share in the firm's total sales.

Back to the presentation

Diversification within a destination



Notes: Proportion of sellers that serve x buyers or less within a destination, in 2007. The distributions labeled "Top X% Sales" are computed restricting the amount of each firm's sales to the X first percentiles of the distribution of sales when transactions are ordered by their decreasing share in the firm's total sales.

Back to the presentation

Simple partial equilibrium model

- Assumptions

1. A buyer with CES production function faces a CES demand:

$$y_b = \left[z_b \sum_s (z_{sb} x_{sb})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \quad \text{and } y_b = p_b^{-\eta} A$$

2. A seller with linear production function faces her CES demand for inputs:

$$p_{sb} = \frac{\sigma}{\sigma - 1} \frac{1}{z_s Z}$$

3. Fluctuations in Z, A, z_s, z_b and z_{sb} come from iid shocks

Back to the slides

Implications for the dynamics of firm-to-firm trade

- Structural growth equation

$$g_{sbt} = \underbrace{(\sigma-1)d\varepsilon_{Zt} + d\varepsilon_{At} - (\sigma-\eta)d\varepsilon_{Zt}}_{f_{Ct}} + \underbrace{(\sigma-1)d\varepsilon_{z_s t}}_{f_{st}}$$

$$- \underbrace{(\sigma-\eta)\sum_s w_s^b (d\varepsilon_{z_{sb}t} + d\varepsilon_{z_s t})}_{Buyer\ Specific\ Input\ Cost\ BSIC_{bt}} + \underbrace{\sigma d\varepsilon_{z_b t} - \frac{\sigma(\sigma-\eta)}{\sigma-1} d\varepsilon_{z_b t}}_{f_{bt}} + \underbrace{(\sigma-1)d\varepsilon_{z_{sb}t}}_{\nu_{sbt}}$$

components in red are the (dlog of the) input cost index

- BSIC term $\Rightarrow$ eq. cannot be estimated under AKM conditional exogeneity assumption!
- Note that the BSIC term loses its importance when French sellers represent a small enough share of the buyer's input providers

Back to the slides

How to estimate the structural shocks?

Trick: get rid of the price index

$$\tilde{g}_{sbt} = \lambda f_{Ct} + \underbrace{(\sigma - 1)\varepsilon_{z_s t}}_{f_{st}} + \underbrace{\sigma \frac{\sigma - \eta}{\eta - 1}\varepsilon_{z_b t}}_{(1+\lambda) f_{bt}} + \underbrace{(\sigma - 1)\varepsilon_{z_{sb} t}}_{\nu_{sbt}}$$

with $\tilde{g}_{sbt} = g_{sbt} + \lambda g_{bt}$,

$$g_{bt} = \sum_s w_s^b g_{sbt},$$

and $\lambda = \dfrac{\sigma - \eta}{\eta - 1}$

- Can be estimated under AKM (conditional) exogeneity assumption...

$$E(\nu_{sbt} | st, bt) = 0$$

- Structural interpretation requires that we take a stand on λ
  - λ estimated using an additional OG condition implied by the model, namely that $f_{st} \perp f_{bt}$
  - Grid search procedure implies $\lambda = 0.77$

Back to the slides

Details on the estimation strategy

Estimated equation

$$\tilde{g}_{sbt} = \underbrace{(\sigma - 1)\varepsilon_{z_s t}}_{f_{st}} + \underbrace{(-\frac{\sigma(\sigma - \eta)}{\eta - 1})\varepsilon_{z_b t}}_{f_{bt}} + \underbrace{(\sigma - 1)\varepsilon_{z_{sb} t}}_{\nu_{sbt}}$$

$\Rightarrow$ Estimate the structural shocks using AKM $\Rightarrow$ Exogeneity condition:

$$E[\nu_{sbt} | st, bt] = 0$$

- Other methods exist:
  - Choice based on simulations
  - AKM performs better (Corr bw simulated and estimated shocks above .9)
  - But "Sparse network bias": $Corr(\hat{f}_{st}, \hat{f}_{bt}) = -.07$
- Estimate λ using a grid search strategy
  - With the 'true' λ, $E[\nu_{sbt}|st, bt] = 0$, i.e. (given sparse networks) $Corr(\hat{f}_{st}, \hat{f}_{bt}) = -.07$
  - Iterate on λ until the criteria is met (easy to implement since $Corr(\hat{f}_{st}, \hat{f}_{bt})$ is a monotonous function of in λ)

Back to the slides

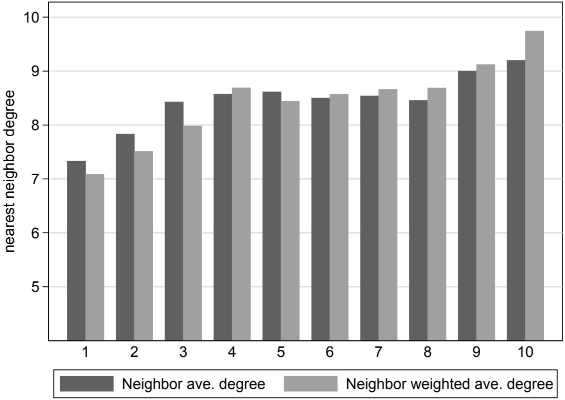
Variance-covariance matrix of shocks

Table: Correlation matrix of the estimated growth components

	(1) $g_{sb(j)t}$	(2) $f_{c(Fj)t}$	(3) f_{st}	(4) $f_{b(j)t}$	(5) $\nu_{sb(j)t}$	(6) $BSIC_{b(j)t}$
$g_{sb(j)t}$	1.0000					
$f_{c(Fj)t}$	.0626	1.0000				
f_{st}	.3028	.0000	1.0000			
$f_{b(j)t}$	.4751	.0000	-.0679	1.0000		
$\nu_{sb(j)t}$	.7864	.0000	.0000	-.0001	1.0000	
$BSIC_{b(j)t}$	.0517	-.0281	-.2523	-.1027	.0000	1.0000

Notes: This table gives the correlation matrix between the growth components, in the panel of firm-to-firm growth rates.

Connectedness in sellers' trade networks

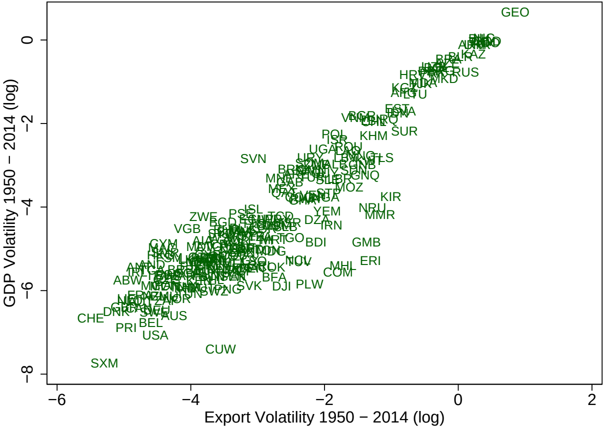


Notes: The graph plots the median connectedness of sellers' networks, by decile of the size distribution. Connectedness, also called nearest neighbor degree, is measured by the mean number of sellers a firm's partners interact with. The weighted version of the indicator is a weighted average of the partners' degree, where each of the seller's partners is weighted by her share in the seller's total sales.

▸ Back to the results

Volatility of exports and GDP

Table: Volatility 1950-2014



Notes: **This table gives the correlation between GDP volatility and export volatility** .