Firms, Destinations, and Aggregate Fluctuations

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Motivation

- What are the microeconomic underpinnings of aggregate fluctuations?
  - Long-standing question in business cycle research, going back at least to Long and Plosser (1983)
- How large a role do firms play in generating or amplifying aggregate volatility?
  1. Gabaix (2011) emphasizes large firms,
  2. Acemoglu et al (2012) emphasize interconnections between firms/sectors
- To date, the empirical evidence of the impact of firms on aggregate fluctuations is scarce

This Paper

Measures the role of individual firms in generating aggregate fluctuations of French sales growth over 1990–2007:

1. Presents a simple model of heterogeneous firms selling to multiple markets to motivate a further decomposition of a *firm's* annual sales growth into several components ("shocks"): i) Firm and firm-destination, ii) Common across firms within a sector / destination (Sectoral and Macro shocks)
2. Uses estimates to measure the contribution of the firm component to *aggregate* fluctuations (measured by variance of aggregate sales growth)
3. Relates the contribution of the firm component to the firm size concentration and the interconnection between firms

Preview of Results

1. More than 90% of the variance in individual growth rates explain by the firm-destination component
2. The contribution of the firm-specific component to aggregate fluctuations is substantial (around 40%), both for the manufacturing sector and for the whole economy
3. The breakdown for *domestic* and *export* sales is similar, though idiosyncratic is a larger component of fluctuations for exports
4. The volatility of the firm-specific component is correlated with the distribution of firm size and the magnitude of IO linkages

Aggregate Sales

- Total aggregate sales by all French firms:

$$X_t = \sum_{f,n \in I_t} x_{fnt},$$

where x_{fnt} is firm f's sales to destination n at time t

- The growth rate of aggregate sales:

$$\gamma_{At} = \ln X_t - \ln X_{t-1}$$

- Focus on the intensive margin ($I_t = I_{t-1}$)

Aggregate Growth

- Aggregate growth then explains by firm-level growth rates:

$$\gamma_{At} = \sum_{f,n} w_{fnt-1}\gamma_{fnt}$$

where w_{fnt-1} is the share of firm f's sales in market n in aggregate sales in period $t-1$ and γ_{fnt} its growth rate between $t-1$ and t

A Motivating Model of Firm Sales Growth

- We show that, in the context of a multi-sector heterogeneous firms model in the spirit of Melitz (2003) and Eaton et al. (2011), individual growth rates write:

$$\gamma_{fnt} = \delta_{nt} + \delta_{jnt} + \varepsilon_{fnt},$$

  where γ_{fnt} is the growth rate of sales of firm f to some market n and δ_{nt}, δ_{jnt} and ε_{fnt} respectively denote a "macro", a "sectoral" and a "firm" shocks

- Macro and sectoral shocks cannot be identified separately:

$$\gamma_{fnt} = \tilde{\delta}_{jnt} + \varepsilon_{fnt}$$

- This can be estimated, year-by-year and destination-by-destination, using OLS with fixed effects to identify sector-destination shocks

Sales Decomposition/Estimating Equations

- What does the firm-component capture?
- In our illustrative model:

$$\varepsilon_{fnt} = \varepsilon^1_{ft} + \varepsilon^2_{fnt}$$
$$\varepsilon^1_{ft} = (1-\sigma)\Delta \log a_{fdt} \quad \text{(cost shock)}$$
$$\varepsilon^2_{fnt} = \Delta \log \omega_{fnt} \quad \text{(demand shock)}$$

- In a more sophisticated model, the firm-component would also capture:
  - The heterogeneous response of firms to common shocks: δ_{nt} and δ_{jnt} would then capture the "mean" response of firms while the heterogeneity would be passed into the "residual"
  - Potential comovements between firms through interconnections (impact of a_{fdt} on the cost of downstream firms)

Sales Decomposition and Aggregate Growth

- Using the previous decomposition, the annual growth rate of intensive sales writes:

$$\gamma_{At} = \sum_{f,n} w_{fnt-1}\gamma_{fnt}$$
$$= \underbrace{\sum_{j,n} w_{jnt-1}\tilde{\delta}_{jnt}}_{Macro,\ Sector} + \underbrace{\sum_{f,n} w_{fnt-1}\delta_{fnt}}_{Firm},$$

  where w's are weights of sales in sector-market jn; and firm-market fn to total sales

- Our purpose is to study to what extent the "Firm" component explains aggregate fluctuations

Aggregate Volatility

- Define aggregate volatility as

$$\sigma_A = \sqrt{\frac{1}{T-1}\sum_{t=1991}^{2007}(\gamma_{At} - \bar{\gamma}_A)^2},$$

where γ_{At} is the growth rate of total sales between $t-1$ and t and $\bar{\gamma}_A \equiv \frac{1}{T}\sum_{t=1991}^{2007}\gamma_{At}$ is the mean growth rate over the sample period

Aggregate volatility and Macroeconomic, Sectoral, and Firm-Specific Shocks

- Then, the variance of the aggregate growth is

$$\sigma_{At}^2 = \sum_{g,m}\sum_{f,n} w_{gmt-1} w_{fnt-1} \text{Cov}\left(\gamma_{gmt}, \gamma_{fnt}\right)$$

$$= \underbrace{\sum_{j,m}\sum_{k,n} w_{jmt-1} w_{knt-1} \text{Cov}\left(\tilde{\delta}_{jmt}, \tilde{\delta}_{knt}\right)}_{Macro/Sectoral\ Volatility}$$

$$+ \underbrace{\sum_{g,m}\sum_{f,n} w_{gmt-1} w_{fnt-1} \text{Cov}\left(\delta_{gmt}, \delta_{fnt}\right)}_{Firm\ Volatility} + COV_t$$

- Note: there is time variation because weights vary over time

Data Description

- Firm-level domestic and export sales data for the universe of French firms over 1990-2007
- Merge two large datasets:
  - Fiscal administration: firm tax forms from BRN and RSI (small firms). BRN covers 1.6 million firms and 52 NAF sectors. Manufacturing has 209 thousand firms and 22 NAF industries, representing 30% of total sales
  - Customs: firm-destination exports
- Trimming procedure to clean outlier growth rates and possible mergers/synthetic exits
  - Extreme growth rates: half or double previous years sales
  - Trimming by upper and lower percentiles

Aggregate Growth of Total Sales, Value Added and GDP

Whole Economy

Manufacturing

Aggregate Growth of Exports

Whole Economy

Manufacturing

Actual Individual Growth and Components: Whole Economy

	I. Total Sales			
	(1)	(2)	(3)	(4)
	Obs.	Mean	St. Dev.	Correlation
Actual	9,856,893	0.0467	0.2601	1.0000
Firm-Specific	9,856,893	0.0000	0.2583	0.9934
Sector-Destination	16,238	0.0763	0.1260	0.1146
	II. Domestic Sales			
	(1)	(2)	(3)	(4)
	Obs.	Mean	St. Dev.	Correlation
Actual	8,031,452	0.0410	0.2266	1.0000
Firm-Specific	8,031,452	0.0000	0.2255	0.9954
Sector-Destination	595	0.0453	0.0.04	0.0957
	III. Export Sales			
	(1)	(2)	(3)	(4)
	Obs.	Mean	St. Dev.	Correlation
Actual	1,825,441	0.0718	0.3723	1.0000
Firm-Specific	1,825,441	0.0000	0.3697	0.9930
Sector-Destination	15,643	0.0775	0.1281	0.1185

Note: 98.7% of the observed variance is explained by the firm-level component.

Actual Individual Growth and Components: Manufacturing Sector

	I. Total Sales			
	(1)	(2)	(3)	(4)
	Obs.	Mean	St. Dev.	Correlation
Actual	2,436,017	0.0542	0.3038	1.0000
Firm-Specific	2,436,017	0.0000	0.3010	0.9908
Sector-Destination	10,269	0.0741	0.0968	0.1357
	II. Domestic Sales			
	(1)	(2)	(3)	(4)
	Obs.	Mean	St. Dev.	Correlation
Actual	1,233,903	0.0378	0.2233	1.0000
Firm-Specific	1,233,903	0.0000	0.2214	0.9917
Sector-Destination	306	0.0414	0.0322	0.1285
	III. Export Sales			
	(1)	(2)	(3)	(4)
	Obs.	Mean	St. Dev.	Correlation
Actual	1,202,114	0.0709	0.3679	1.0000
Firm-Specific	1,202,114	0.0000	0.3651	0.9924
Sector-Destination	9,963	0.0752	0.0980	0.1228

Note: 98.2% of the observed variance explained by the firm-level component.

- The firm component explains the overwhelming majority of the sales variability. But this is not surprising...
- In the firm component, market-specific shocks are more important than shocks that are common across markets within firm

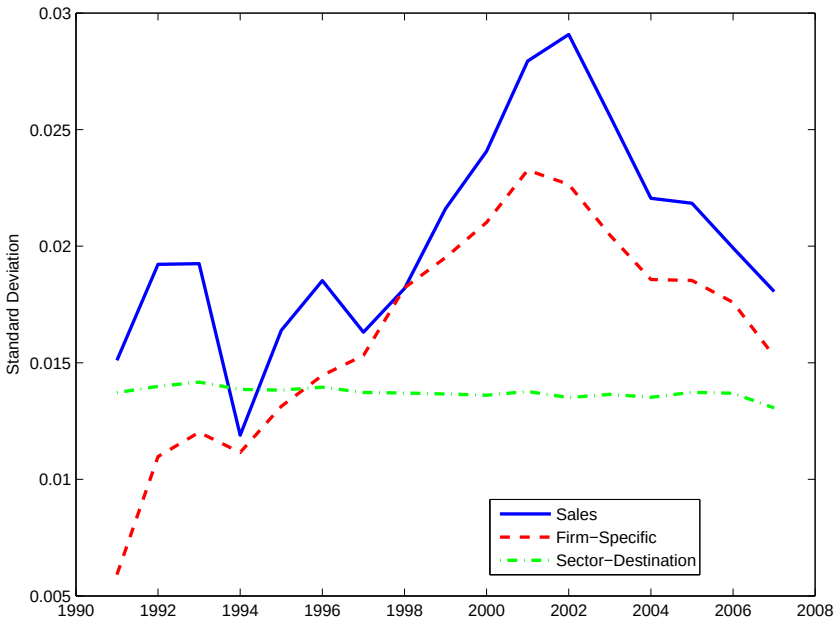
The Aggregate Impact of Firm-Specific Shocks on Aggregate Volatility

	I. Total Sales			
	Whole Economy		*Manufacturing Sector*	
	(1)	(2)	(3)	(4)
	St. Dev.	Relative SD	St. Dev.	Relative SD
Actual	0.0214	1.0000	0.0261	1.0000
Firm-Specific	0.0164	0.7584	0.0165	0.6266
Sector-Destination	0.0137	0.6663	0.0189	0.7394
	II. Domestic Sales			
	Whole Economy		*Manufacturing Sector*	
	(1)	(2)	(3)	(4)
	St. Dev.	Relative SD	St. Dev.	Relative SD
Actual	0.0185	1.0000	0.0195	1.0000
Firm-Specific	0.0139	0.7441	0.0114	0.5778
Sector-Destination	0.0127	0.7148	0.0157	0.8186
	III. Export Sales			
	Whole Economy		*Manufacturing Sector*	
	(1)	(2)	(3)	(4)
	St. Dev.	Relative SD	St. Dev.	Relative SD
Actual	0.0037	1.0000	0.0086	1.0000
Firm-Specific	0.0029	0.7874	0.0062	0.7224
Sector-Destination	0.0016	0.4475	0.0041	0.4909

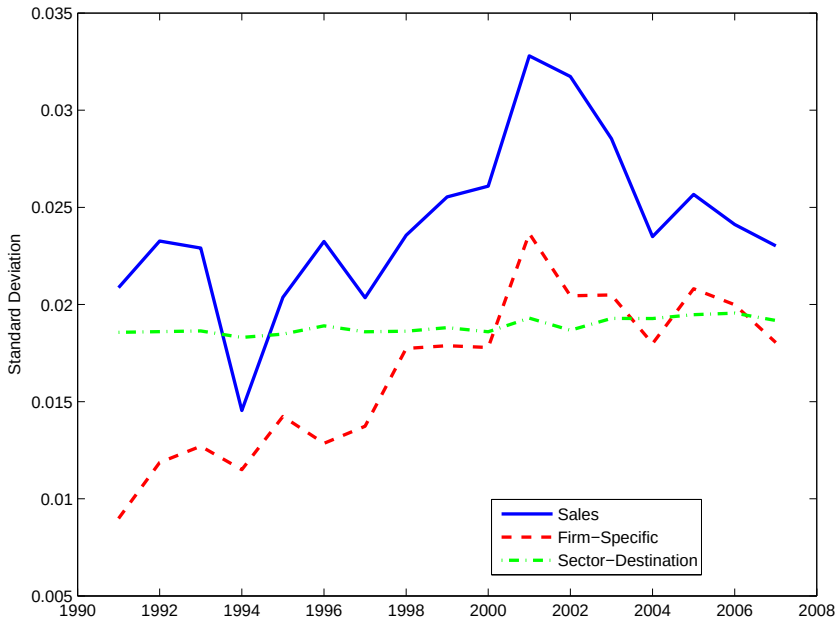
- Contribution of the firm-level component is equivalent to the contribution of *all* sectoral and macro shocks
- The contribution is larger for export sales

The Aggregate Impact of Firm-Level Shocks on Aggregate Volatility

Whole Economy



Manufacturing Sector



- Contribution of firms is increasing over time, both for the manufacturing sector and for the whole economy

Robustness Checks

- Temporal Aggregation
  - Look at sales growth over 3 year period (measurement errors)
  - Variance contribution of firms similar as baseline
- Potential firm-level heterogeneity in reaction to sector and/or country shocks:

$$\gamma_{fnt} = \tilde{\delta}_{jnt} + \beta_1 Size_{fnt} + \beta_2 Size_{fnt} \times \tilde{\delta}_{jnt} + \varepsilon_{fnt},$$

where *Size* is either share w_{fnt} or quintile dummy of distribution of sales

  - Results are robust

Firm's Contribution to Aggregate Fluctuations

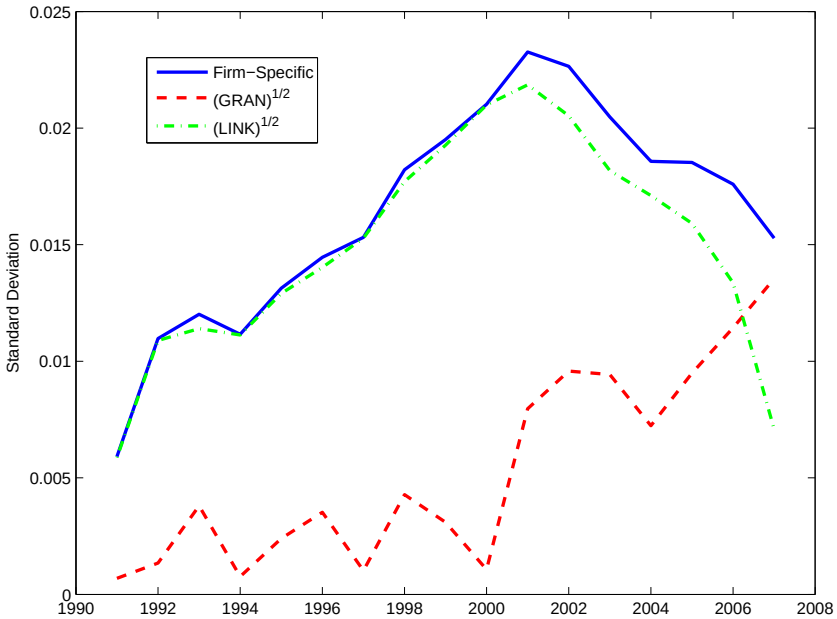
- Recall the definition of the firm-specific volatility

$$\begin{aligned}\sigma_{Ft}^2 &= \sum_{g,m}\sum_{f,n} w_{gmt-1}w_{fnt-1}\text{Cov}(\varepsilon_{gmt},\varepsilon_{fnt}) \\ &= \underbrace{\sum_{f,n} w_{fnt-1}^2\text{Var}(\varepsilon_{fnt})}_{GRAN} + \underbrace{\sum_{g\neq f,m\neq n}\sum_{f,n} w_{gmt-1}w_{fnt-1}\text{Cov}(\varepsilon_{gmt},\varepsilon_{fnt})}_{LINK}\end{aligned}$$

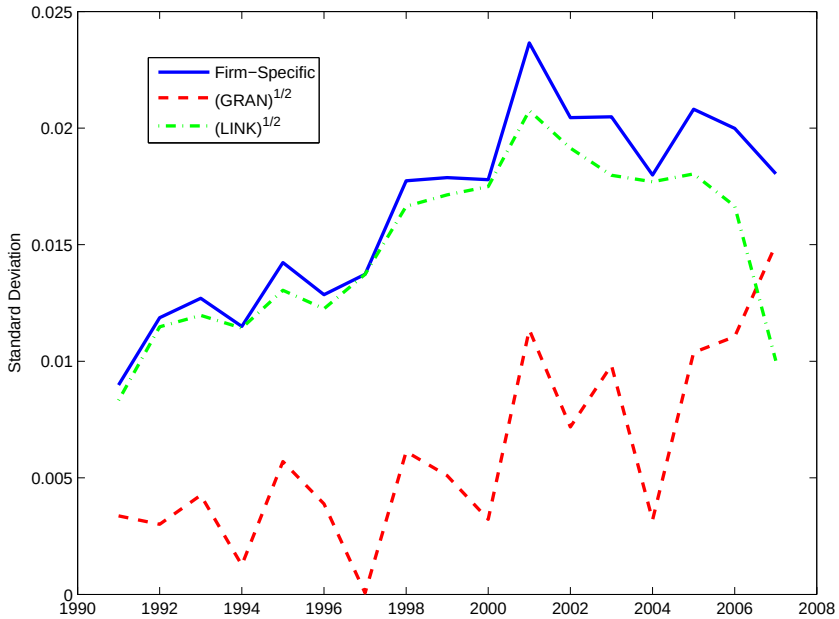
- Role of the variance of individual shocks: Assumed negligible in standard macro (diversification argument). Challenged in the recent literature (e.g. Gabaix, 2011). Role of the distribution of weights
- Role of comovements between firms: Discarded in most of the macro literature. Challenged in the recent literature (e.g. Acemoglu et al, 2012). Role of interconnections between firms

Granularity and Linkages

Whole Economy



Manufacturing Sector



- *LINK* component explains the majority of total firm-level volatility
- Still true at the sectoral level with some heterogeneity (larger role of *GRAN* in the "Petroleum" sector)
- Contribution of *GRAN* increases over time

Contribution of Granularity

- Gabaix: if $\text{Var}(\varepsilon_{fnt}) = \sigma^2 \; \forall (f, n)$

$$GRAN \equiv \sum_{f,n} w_{fnt-1}^2 \text{Var}(\varepsilon_{fnt}) = \sigma^2 Herf_{t-1}$$

- With firms symmetric in size,

$$GRAN = \sigma^2 / N_{t-1}$$

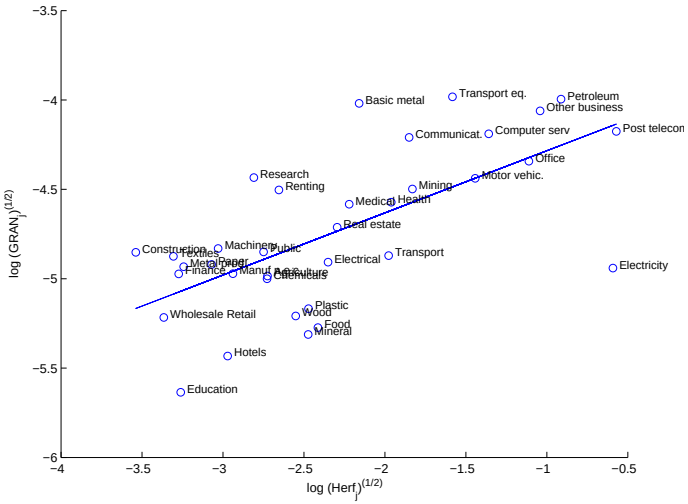
(tends to 0 when N_{t-1} increases)

- For the whole economy, $\sqrt{GRAN}$ 15 times larger than the counterfactual with equal weights

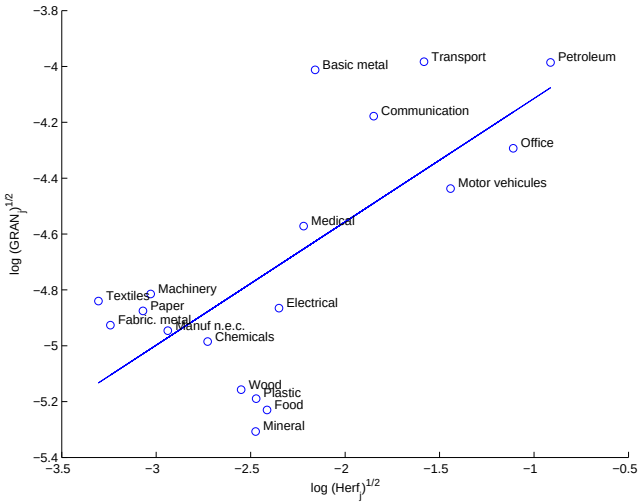
$\Rightarrow$ Firm size distribution matters

Contribution of Granularity (2)

Whole Economy



Manufacturing Sector



Correlation coefficient .57 for the whole economy and .72 for the manufacturing sector.

- At the sector level:

$$GRAN = \sum_j GRAN^j \quad \textit{and} \quad GRAN^j = \sum_{(f,n)\in j} w_{fnt-1}^2 \mathrm{Var}(\varepsilon_{fnt}) = \sigma^2 HERF_{t-1}^j$$

$\Rightarrow$ Sectors more concentrated should display more volatility

- Correlation less than perfect because, in the data, small firms tend to be more volatile

The Role of Linkages

- Acemoglu et al (2012): Model predicts a positive covariance between ε_{fnt} and ε_{gmt} if f and g are connected through IO linkages
- With iid productivity shocks, propagation through the price of inputs:

$$\text{Cov}(\varepsilon_{gmt}, \varepsilon_{fnt}) = (1-\theta)^2(1-\alpha_f)\rho_{fg}\text{Var}(a_{gmt}),$$

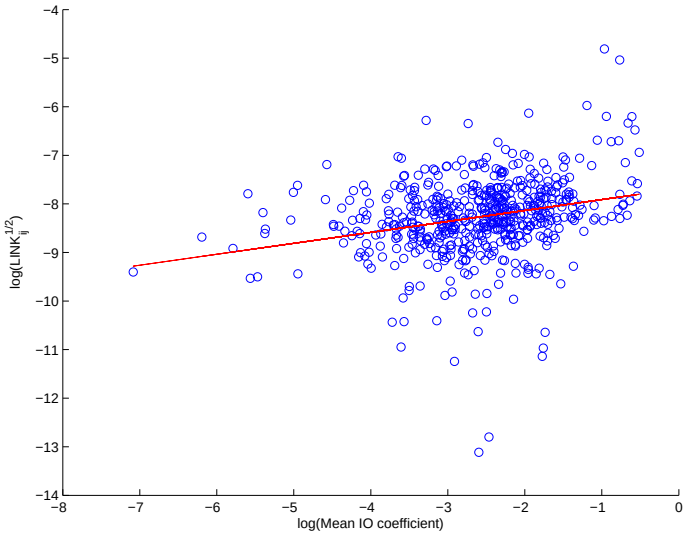
$(1-\theta)$ price elasticity of nominal demand, $(1-\alpha_f)$ share of intermediates in costs, ρ_{fg} share of inputs sources from g

$\Rightarrow$ Covariance increasing in the intensity of linkages

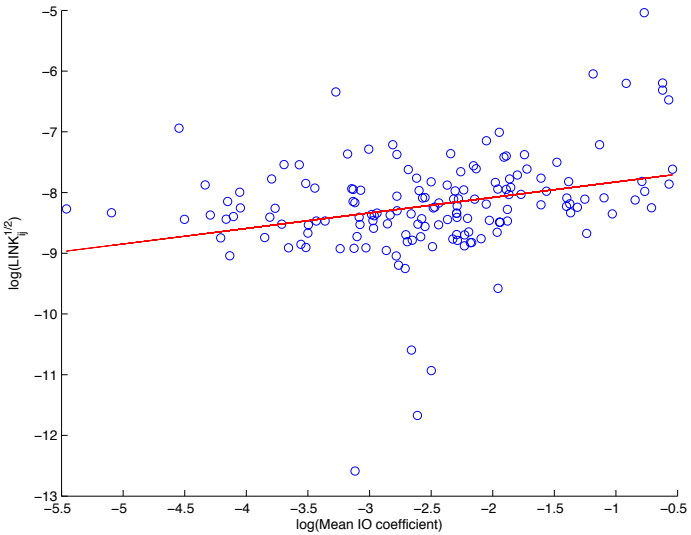
- No firm-level measure of interconnections $\Rightarrow$ Use sectoral IO tables instead
- Sectors more connected through IO linkages should display stronger covariance terms

The Role of Linkages (2)

Whole Economy



Manufacturing Sector



IO coefficient calculated from IO tables, as the mean between sectors i and j
Correlation coefficient .39 for the whole economy and .49 for the manufacturing sector.

- At the sector level:

$$LINK = \sum_{i=1}^{J}\sum_{j=1}^{J} LINK^{ij} \text{ and } LINK^{ij} \equiv \sum_{(f,n)\in i}\sum_{(g,m)\in j} w_{fnt-1} w_{gmt-1} \text{Cov}(\varepsilon_{fnt}, \varepsilon_{gmt})$$

Conclusion

- Empirical evidence on role of firms in aggregate fluctuations is still relatively scarce
- We use a rich panel of firm-level data, by destination, to isolate the contribution of firms to aggregate volatility
- Results suggest that firm-level shocks explain a bulk of aggregate sales volatility
- Role of the market structure: Large firm-level volatility in more concentrated markets
- Two thirds of the firm-specific volatility explain by firm linkages