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. Firm entry and exit: Bilbiie et al. (2007), Ghironi and Melitz (2005)
  2. Firm shocks: Gabaix (2011) emphasizes large firms

- 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 manufacturing sales growth over 1990–2007:

1. Derives a decomposition of aggregate sales growth into its extensive and intensive components

2. Presents a simple multi-sector 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. Sector and sector-destination iii. Country ("macroeconomic")

3. Uses estimates to measure each margin’s and component’s contribution to aggregate fluctuations (measured by variance of aggregate sales growth)
1. The *extensive margin* contributes approximately 46% of year-to-year variation of total sales growth, while the *intensive margin* has a greater contribution to aggregate fluctuations: 72%

2. The relative variance of the estimated components to that of total sales growth are:
   i. “Idiosyncratic”: 0.40
   ii. Sectoral: 0.40
   iii. Macroeconomic: 0.20

3. The breakdown for *domestic* and *export* sales is similar, though idiosyncratic is the largest component for exports.
Related Literature

- The extensive margin:

- The importance of firms and sectors:
  - Firms: “granular” or “fundamental” volatility of Gabaix (2011) and Carvalho and Gabaix (2010); Castro et al. (2010)

- Open economy context:
  - Firms: granularity examined by Canals et al. (2007) and di Giovanni and Levchenko (2011)
1. Decompose *aggregate* growth into intensive and extensive margins
1. Decompose *aggregate* growth into intensive and extensive margins

2. Decompose *firm* growth into (i) firm-level idiosyncratic, (ii) sectoral, and (iii) country ("macroeconomic") component
Aggregation Exercise Roadmap

1. Decompose \textit{aggregate} growth into intensive and extensive margins

2. Decompose \textit{firm} growth into (i) firm-level idiosyncratic, (ii) sectoral, and (iii) country ("macroeconomic") component

3. Implications of 1 and 2 for aggregate fluctuations (volatility)
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:

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

- The aggregate growth rate, \( \gamma_{At} \), can then be broken down into contributions from the intensive and extensive margins
Aggregate growth can be decomposed into the two margins:

\[ \gamma_{At} \equiv \ln \sum_{f,n \in I_t} x_{fnt} - \ln \sum_{f,n \in I_{t-1}} x_{fnt-1} \]

\[ = \ln \left( \frac{\sum_{f,n \in I_{t/t-1}} x_{fnt}}{\sum_{f,n \in I_{t/t-1}} x_{fnt-1}} \right) - \left( \ln \left( \frac{\sum_{f,n \in I_{t/t-1}} x_{fnt}}{\sum_{f,n \in I_t} x_{fnt}} \right) - \ln \left( \frac{\sum_{f,n \in I_{t/t-1}} x_{fnt-1}}{\sum_{f,n \in I_{t-1}} x_{fnt-1}} \right) \right) \]

\[ = \tilde{\gamma}_{At} - \ln \frac{\lambda_{t,t}}{\lambda_{t,t-1}}, \]

where \( I_{t/t-1} \) is the set of firm × destination pairs active in both \( t \) and \( t - 1 \) and \( \lambda_{t,t} (\lambda_{t,t-1}) \) is the share of output produced by this intensive sub-sample of firms in period \( t \) \((t - 1)\).
A Motivating Model of Firm Sales Growth

- We wish to decompose firm’s sales growth between $t - 1$ and $t$ into (i) firm-specific idiosyncratic, (ii) sectoral, and (iii) country (“macroeconomic”) components. To motivate the exercise, we set up a multi-sector heterogeneous firms model in the spirit of Melitz (2003) and Eaton et al. (2011).

- Preferences:

$$U_{nt} = \prod_{j=1}^{J} \left( C^j_{nt} \right)^{\alpha^j_{nt}},$$

where $C^j_{nt}$ is consumption of sector $j$ in country $n$ at time $t$, and $\alpha^j_{nt}$ is a time-varying demand shock for sector $j$ in country $n$. 

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A Motivating Model of Firm Sales Growth

Each sector $j$ is a CES aggregate of $\Omega_{nt}^j$ varieties available in country $n$ at time $t$, indexed by $f$:

$$C_{nt}^j = \left[ \sum_{\Omega_{nt}^j} (\omega_{fnt})^{\frac{1}{\sigma}} C_{nt}^j (f) \frac{\sigma - 1}{\sigma} \right]^{\frac{\sigma}{\sigma - 1}}$$

where $\omega_{fnt}$ is a time-varying demand shock for variety $f$ in market $n$.
A Motivating Model of Firm Sales Growth

- The firm:
  - Sells a unique CES variety ⇒ has market power
  - Is characterized by a time-varying marginal cost $a_{fnt}$ (the inverse of productivity)
  - Uses an input bundle, specific to a sector, with cost $c_{nt}^j$

⇒ Sales by French firm $f$ (residing in country $d$) to market $n$ in period $t$:

$$x_{fnt} = \omega_{fnt} \frac{\alpha_{nt}^j Y_{nt}}{(P_{nt}^j)^{1-\sigma}} \left( \frac{\sigma}{\sigma - 1} \tau_{nd}^j c_{dt}^j a_{fdt} \right)^{1-\sigma}, \quad (1)$$

where $\tau_{nd}^j$ is the iceberg cost of selling from France to country $n$ in sector $j$, and we normalize $\tau_{dd}^j = 1$
Sales Decomposition/Estimating Equations

- Take log differences/growth rates of (1) to arrive at the estimating equation:

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

where \( \gamma_{fnt} \) is the growth rate of sales of firm \( f \) to some market \( n \) and

\[
\begin{align*}
\delta_{nt} &= \Delta\log Y_{nt} \quad \text{(macro shock)} \\
\delta_{jnt} &= \Delta\log \alpha^j_{nt} + (1 - \sigma)(\Delta\log c^j_{dt} - \Delta\log P^j_{nt}) \quad \text{(sector shock)} \\
\varepsilon_{fnt} &= \Delta\log \omega_{fnt} + (1 - \sigma)\Delta\log a_{fdt} \quad \text{(idio shock)}
\end{align*}
\]
Sales Decomposition/Estimating Equations

- Equation (2) can be stacked for each year, allowing us to estimated a panel regression where

\[ \hat{\delta}_{nt} : \text{Country-time fixed effect} \quad \text{(macro shock)} \]
\[ \hat{\delta}_{jnt} : \text{Country-sector-time fixed effect} \quad \text{(sector shock)} \]
\[ \hat{\epsilon}_{fnt} : \text{Residual for firm-destination-time} \quad \text{(idio shock)} \]

- Estimated each year using OLS
We further break down the sectoral and idiosyncratic shocks into a common (France) and destination-specific components:

\[ \delta_{jnt} = \delta_{jt}^{1} + \delta_{jnt}^{2} \]

\[ \delta_{jt}^{1} = (1 - \sigma) \Delta \log c_{jt}^{j} \quad \text{(cost shock)} \]

\[ \delta_{jnt}^{2} = \Delta \log \alpha_{nt}^{j} - (1 - \sigma) \Delta \log P_{nt}^{j} \quad \text{(demand shock)} \]

and

\[ \varepsilon_{fnt} = \varepsilon_{ft}^{1} + \varepsilon_{fnt}^{2} \]

\[ \varepsilon_{ft}^{1} = (1 - \sigma) \Delta \log a_{fdt} \quad \text{(cost shock)} \]

\[ \varepsilon_{fnt}^{2} = \Delta \log \omega_{fnt} \quad \text{(demand shock)} \]
Aggregated Volatility

- Define aggregate volatility as

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

where \( \gamma_{At} \) 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.
We decompose volatility between the two margins as

$$\sigma_A^2 = \tilde{\sigma}_A^2 + \sigma_\lambda^2 - 2\text{Cov}(\tilde{\gamma}_A t, g_\lambda t),$$

where $\sigma_\lambda^2$ is the variance of the extensive margin growth rate, $\tilde{\sigma}_A^2$ is the variance of the intensive margin growth rate $\tilde{\gamma}_A t$, and $\text{Cov}(\tilde{\gamma}_A t, g_\lambda t)$ is the covariance between the two.
Given the estimated firm-level regressions, we further break down the aggregate variance of the intensive margin. Write the annual sales growth as

$$\tilde{\gamma}_{At} \equiv \sum_{f,n} w_{fnt} - 1 \gamma_{fnt}$$

$$= \sum_n w_{nt} - 1 \delta_{nt} + \sum_{j,n} w_{jnt} - 1 \delta_{jnt} + \sum_{f,n} w_{fnt} - 1 \varepsilon_{fnt},$$

where $w$’s are weights of sales in market $n$; sector-market $jn$; and firm-market $fn$ to total sales.
Intensive Margin and Macroeconomic, Sectoral, and Firm-Specific Idiosyncratic Shocks

Then, the variance of the intensive margin is

\[ \tilde{\sigma}^2_{At} \equiv \sum_{g,m} \sum_{f,n} w_{gmt-1} w_{fnt-1} \text{Cov} \left( \gamma_{gmt} , \gamma_{fnt} \right) \]

\[ = \sum_{m} \sum_{n} w_{mt-1} w_{nt-1} \text{Cov} \left( \delta_{mt} , \delta_{nt} \right) \]

Macroeconomic Volatility

\[ + \sum_{j,m} \sum_{k,n} w_{jmt-1} w_{knt-1} \text{Cov} \left( \delta_{jmt} , \delta_{knt} \right) \]

Sectoral Volatility

\[ + \sum_{g,m} \sum_{f,n} w_{gmt-1} w_{fnt-1} \text{Cov} \left( \varepsilon_{gmt} , \varepsilon_{fnt} \right) + \text{COV}_t \]

Idiosyncratic Volatility

Note: there is time variation because weights vary over time
Data Description

- Firm-level domestic and export sales data for the French manufacturing sector 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

- Resulting dataset is at the firm-destination level, which allows us to better identify different factors driving sales growth
Data Description

- 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
- 18% of firms exported at some point in whole economy, and 42% in manufacturing sector
- The mean net entry rate is 1.2%, which when converted to a five-year rate (5.9%), lines up well with Dunne et al. (1988)
Aggregate Growth of Total Sales, Value Added and GDP

Manufacturing

All sectors
Aggregate Growth of Exports

**Manufacturing**

**All sectors**

![Graph of growth rates for Export sales and Exports (IFS) for Manufacturing](image)

![Graph of growth rates for Export sales and Exports (IFS) for All sectors](image)
## Results Summary for Whole Sample Period

- **Margin breakdown:**

<table>
<thead>
<tr>
<th></th>
<th>Aggregate</th>
<th>Intensive</th>
<th>Extensive Domestic</th>
<th>Extensive Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>0.0441</td>
<td>0.0282</td>
<td>0.0159</td>
<td>0.0104</td>
</tr>
<tr>
<td><strong>St. Dev.</strong></td>
<td>0.0305</td>
<td>0.0258</td>
<td>0.0207</td>
<td>0.0159</td>
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<tr>
<td><strong>Corr. w/Agg.</strong></td>
<td>0.7426</td>
<td>0.5483</td>
<td>0.5099</td>
<td>0.6088</td>
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</table>
### Results Summary for Whole Sample Period: Manufacturing

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>St. Dev.</th>
<th>Contribution</th>
<th>Correlation</th>
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</thead>
<tbody>
<tr>
<td>Actual</td>
<td>0.0241</td>
<td>1.0000</td>
<td>1.0000</td>
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<tr>
<td>Idiosyncratic</td>
<td>0.0165</td>
<td>0.6826</td>
<td>0.7074</td>
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<tr>
<td>Sectoral</td>
<td>0.0159</td>
<td>0.6577</td>
<td>0.6461</td>
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<tr>
<td>Macroeconomic</td>
<td>0.0113</td>
<td>0.4700</td>
<td>0.3035</td>
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</tbody>
</table>
## Results Summary for Whole Sample Period: Manufacturing

<table>
<thead>
<tr>
<th></th>
<th>Total Sales</th>
<th>Domestic Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) St. Dev.</td>
<td>(2) Contribution</td>
</tr>
<tr>
<td>Actual</td>
<td>0.0241</td>
<td>1.0000</td>
</tr>
<tr>
<td>Idiosyncratic</td>
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<td>0.4700</td>
</tr>
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## Intensive Volatility Results Summary for Whole Sample

**Period: Manufacturing**

### Total Sales

<table>
<thead>
<tr>
<th></th>
<th>(1) St. Dev.</th>
<th>(2) Contribution</th>
<th>(3) Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>0.0241</td>
<td>1.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>Idiosyncratic</td>
<td>0.0165</td>
<td>0.6826</td>
<td>0.7074</td>
</tr>
<tr>
<td>Sectoral</td>
<td>0.0159</td>
<td>0.6577</td>
<td>0.6461</td>
</tr>
<tr>
<td>Macroeconomic</td>
<td>0.0113</td>
<td>0.4700</td>
<td>0.3035</td>
</tr>
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### Domestic Sales

<table>
<thead>
<tr>
<th></th>
<th>(1) St. Dev.</th>
<th>(2) Contribution</th>
<th>(3) Correlation</th>
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<tbody>
<tr>
<td>Actual</td>
<td>0.0174</td>
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<tr>
<td>Idiosyncratic</td>
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<td>Sectoral</td>
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<td>0.7711</td>
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<tr>
<td>Macroeconomic</td>
<td>0.0095</td>
<td>0.5434</td>
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### Export Sales

<table>
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<th>(1) St. Dev.</th>
<th>(2) Contribution</th>
<th>(3) Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
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<tr>
<td>Idiosyncratic</td>
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<td>Sectoral</td>
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<tr>
<td>Macroeconomic</td>
<td>0.0033</td>
<td>0.3734</td>
<td>0.3269</td>
</tr>
</tbody>
</table>
Volatility of Intensive Sales Growth and Components: Manufacturing
Volatility of Intensive Sales Growth and Components for Export Sales: Manufacturing

![Graph showing volatility of intensive sales growth and components for export sales.](image-url)
Idiosyncratic Component and Firm-Size Distribution
Robustness Checks

- Temporal Aggregation
  - Look at sales growth over 3 year period
  - Intensive and extensive variance contributions are similar to annual estimates
  - Variance contributions across idiosyncratic, sectoral and macroeconomic similar as baseline

- Potential firm-level heterogeneity in reaction to sector and/or country shocks:
  \[ \gamma_{fnt} = \delta_{nt} + \delta_{jnt} + \beta_1 \text{Size}_{fnt} + \beta_2 \text{Size}_{fnt} \times \delta_{jnt} + \varepsilon_{fnt}, \]
  where \( \text{Size} \) is either share \( w_{fnt} \) or quintile dummy of distribution of sales

- Results are robust
Empirical evidence on role of firms in aggregate fluctuations is still relatively scarce

The extensive margin is an important contributor to annual sales growth on average, but more of year-to-year variation is explained by the intensive margin

Further disaggregation shows that both firm-level idiosyncratic and sectoral shocks explain a bulk of aggregate sales volatility
Next Steps

- Currently extending the analysis to the whole economy
- Adding more structure to the analysis
  - Linkages across firms and sectors (e.g., I-O)
  - Mapping the estimated shocks to economic variables (e.g., exchange rate fluctuations)
- Exploiting other firm-level characteristics to better understand what drives firm dynamics and the implications for the aggregate economy