An Anatomy of International Trade:
Evidence from French Firms
(preliminary work in progress)

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The Project

- Long-term project: a better model for quantitative international trade.
- This talk: very simple model captures these regularities, reveals underlying connections between them, and suggests others.
- Future potential payoff: (i) refine model of trade, (ii) quantify cost of entry, (iii) quantify gains from variety, (iv) simulate gains from market integration.
The Data

- Data on nearly all French firms.
- Merged with Customs declarations on firm exports.
- Exports by firm for each foreign market (focus on 113 countries, including France itself).
- So far, 1986 cross-section in manufacturing (over 200,000 firms).
- Aggregating firm data by market, lines up well with aggregate figures on French exports by market. But, 20% undercounting.
Dissection I: Markets per Firm

• Typical French firm sells only in France: only 40,000 export.
• Typical exporter sells in only one or two foreign markets.
• Distinctive shape of markets-per-firm distribution (Figure 1).
• Firms penetrating more markets are much larger (Figure 2).
firms penetrating at least that many markets

Figure 1: Frequency of Selling in Multiple Markets
Figure 2: Firm Size and Market Penetration
Dissection II: Firms per Market

- Huge variation in French entry (exporters) $J_{nF}$ across markets $n$ (Figure 3).

- Variation in $J_{nF}$ related to market size $X_n$, and French market share $\pi_{nF}$:

  $$\ln J_{nF} = +\beta_S \ln \pi_{nF} + \beta_X \ln X_n$$

  with $\beta_S = .87$ and $\beta_X = .62$ ($R^2 = .90$). BEJK (2003) predicts $\beta_S = 1$, but wildly off predicting $\beta_X = 0$.

- Huge variation in sales among firms exporting to a particular market (Figure 4).
Figure 2b: Firm Size and Popularity of Market
Figure 4: Distribution of Sales by Market
Challenges, Opportunities, and Strategies

- Challenge of extreme heterogeneity and fragmented markets.

- Yet some striking regularities.

- In earlier unpublished work, we generalized BEJK (2003) to incorporate fixed entry costs.

- For key regularities, stripped down version of Melitz (2003) is not bad, as we discovered recently!

- Simpler model is a good baseline: crystal clear predictions, easy to diagnose failures.

Simplest Model

- Dixit-Stiglitz preferences and monopolistic competition as in Krugman (1981).
- Combined with heterogeneity in firm efficiencies as in Melitz (2003).
- Fixed cost of entry per market and Pareto distribution of efficiencies as in Helpman, Melitz, and Yeaple (2004) and Ruhl (2004).
- Strip out all dynamics and many results from EK (2002) and BEJK (2003) carry through.
I. Countries as Consumers

- Countries \( n = 1, \ldots, N \).
- Continuum of goods in \( n \), indexed \( j \in [0, J_n] \).
- Market size \( X_n \) (aggregate expenditure).

- Expenditure on good \( j \):
  \[
  X_n(j) = X_n \left[ \frac{p_n(j)}{P_n} \right]^{-(\sigma-1)}, \sigma > 1.
  \]

- If good not supplied to \( n \), set \( p_n(j) = \infty \).
- Price level:
  \[
  P_n = \left[ \int_0^{J_n} p_n(j)^{-(\sigma-1)} \, dj \right]^{1/(\sigma-1)}.
  \]
II. Countries as Producers

- Firm in country $i$ with efficiency $z$ has unit cost $w_i/z$.
- Delivers to country $n$ at cost $d_{ni}w_i/z$.
- Country $i$ has $T_i z^{-\theta}$ firms with efficiency greater than $z$.

- Firms in $i$ that can supply a good to $n$ at cost less than $c$:

$$J_{ni}(c) = T_i (w_id_{ni})^{-\theta} c^\theta$$

- Across all sources:

$$J_n(c) = \sum_{i=1}^{N} T_i (w_id_{ni})^{-\theta} c^\theta = \Phi_n c^\theta$$
III. Market Structure and Entry

• A firm chooses to supply a unique good \( j \).

• Decides which countries to sell in, paying entry cost \( E_n \) for each \( n \) it enters.

• If firm decides to enter country \( n \), maximizes profit there by charging \( p_n(j) = [\sigma/(\sigma - 1)]c_n = \overline{mc}_n \).

• Enters market \( n \) iff it can supply at cost less than \( \overline{c}_n \):

\[
E_n = \left( X_n / \sigma \right) \left[ \frac{\overline{mc}_n}{P_n} \right]^{-(\sigma - 1)}.
\]

• Given \( \overline{c}_n \), price level is

\[
P_n = \left[ \int_{0}^{\overline{c}_n} (\overline{mc})^{-(\sigma - 1)} dJ_n(c) \right]^{-1/(\sigma - 1)}.
\]
Familiar Results

\begin{itemize}
  \item Fraction of $J_n = J_n(c_n)$ that $n$ imports from $i$ ($\sigma$ irrelevant):
    \[ \pi_{ni} = J_{ni}(c_n) / J_n(c_n) = T_i(w_i d_{ni})^{-\theta} / \Phi_n \]
  \item Fraction of firms entering $n$ with cost below $c$ ($i$ is irrelevant):
    \[ J_{ni}(c) / J_{ni}(c_n) = (c / c_n)^\theta \]
  \item Fraction of firms entering $n$ selling less than $x$ there:
    \[ F(x) = 1 - \left( \frac{x}{\sigma E_n} \right)^{-\theta/(\sigma-1)} . \]
  \item Sales in $n$ independent of $i$ means $X_{ni} / X_n = \pi_{ni}$. 
\end{itemize}
Results on Firms per Market

• Number of firms from $i$ entering $n$: $J_{ni} = \frac{X_{ni}}{X_n}J_n$.

• Mean sales of firms entering $n$: $\bar{x}_n = \frac{\sigma E_n}{1 - \frac{\sigma - 1}{\theta}}$.

• Since $X_n = \bar{x}_n J_n$:

$$J_{ni} = \frac{1 - \frac{\sigma - 1}{\theta}}{\sigma} \left( \frac{X_{ni}}{X_n} \right) \left( \frac{X_n}{E_n} \right) = \frac{1 - \frac{\sigma - 1}{\theta}}{\sigma E_n} X_{ni}.$$ 

• Let $x(p)_n$ be $p$’th sales percentile in $n$. Thus:

$$\ln \frac{x(p)_n}{\bar{x}_n} = -\frac{(\sigma - 1)}{\theta} \ln(1 - p) + \ln(1 - \frac{(\sigma - 1)}{\theta}).$$
Results on Markets per Firm

- Market hierarchy for firms from $i$: if enter market $n$ then enter all $n'$ for which $J_{n'i} \geq J_{ni}$.
- Let $J_{i}^{(1)} \geq J_{i}^{(2)} \geq \ldots \geq J_{i}^{(N)}$ be the ordered $J_{ni}$. Then $J_{i}^{(k)}$ is number of firms selling to at least $k$ markets.
- A more efficient firm from $i$ will sell to at least as many markets as a less efficient firm from there.
- Suppose $J_{n'i} = J_{i}^{(k)}$. For some market $n$ more popular than $n'$, let $x_{ni}^{(k)}$ be mean sales in $n$ of firms from $i$ selling to at least $k$ markets:
  \[
  x_{ni}^{(k)} = \frac{\sigma E_n}{1 - \frac{\sigma-1}{\theta} \left( \frac{J_{i}^{(k)}}{J_{ni}} \right)^{-(\sigma-1)/\theta}}.
  \]
- Examine by setting both $i$ and $n$ to be France.
Testing the Implications

- Entry and market size (Figure 5). Implies $E_n$ increasing with elasticity of .36 in $X_n$. (Note French data point).

- Normalized sales (export) distributions (Figure 6). Implies $\frac{\sigma - 1}{\theta} = 1.78$ (inadmissable, but slope approaches $-1$ in the tail).

- Market hierarchies (Figure 7). Not bad, but obvious violations (nearly half of firms selling to only two markets do not sell to Belgium).

- Sales in France and export penetration (Figure 8). Wow! Implies $\frac{\sigma - 1}{\theta} = .65$ (In BEJK, $\sigma = 3.75, \theta = 3.60$ so $\frac{\sigma - 1}{\theta} = .76$).

- Implications of Figures 6 and 8 are at odds.
Figure 6: Distribution of Sales, by Market Size
firms selling to k or more markets

Figure 7: Market Hierarchy for French Firms
Figure 8: Firm Size and Frequency of Multiple Markets

average sales in French market ($ millions) vs. firms selling to k or more markets
Figure 8b: Firm Size and Popularity of Market
Generalizing the Model I

• Problem: concavity and thick tails apparent in Figure 6, normalized sales distributions.

• Potential solution I: introduce another reason, $\alpha$, for firms to be big:

$$X_n(j) = \alpha(j)X_n \left[ \frac{p_n(j)}{P_n} \right]^{-(\sigma-1)}, \sigma > 1.$$ 

• Turns out that $\alpha$ is irrelevant. Large $\alpha$ firms have lower cost threshold for entry. Resulting distribution of sales is unchanged.
Generalizing the Model II

- Potential solution II: introduce a reason, $\beta$, for firms to sell small amounts, $E_n(j) = \beta(j)E_n$.
- Variation in $\beta$ alters sales distribution, leaving other implications in tact.

- Fraction of firms in $n$ selling more than $x$:

$$
\left[ \int_0^{x/\sigma E_n} (x/\sigma E_n)^{-\theta/(\sigma-1)} dG(\beta) + \int_{x/\sigma E_n}^\infty \beta^{-\theta/(\sigma-1)} dG(\beta) \right] / \Gamma,
\Gamma = \int_0^\infty \beta^{-\theta/(\sigma-1)} dG(\beta).
$$

- Choose $G(\beta)$ to fit normalized sales distributions (Figures 6a-6c).
- Also helps explain tiny lower support of distributions.
Figure 6a: Distribution of Sales (all markets)
Figure 6b: Distribution of Sales (top 25% mkts.)
Figure 6b: Distribution of Sales (lowest 25%)
Accomplished So Far

- Simple model does well making sense of the most basic facts from EKK (2004).
- Reduces facts about French exporters per market to a simple entry-market size relationship.
- Reduces facts about variation in firm-level export volumes to a common shaped size distribution as it appears in different markets.
- Connects facts about the popularity of markets and facts about markets per firm, via market hierarchy.
- Connects facts about the frequency of penetrating multiple export markets to facts about sales in France as they vary with export penetration.
- More implications that we have not yet tabulated.
Room for Improvement

- Obvious problems:
  - strong hierarchy prediction is violated
  - can’t capture geographic patterns in export destinations.
  - bad model of firm variation in output per worker.

- EK (2002) and BEJK (2003) with entry costs as in EKK (2004a) may help along each of these dimensions, but is less transparent. Potentially more parsimonious explanation of Figure 5.

- Fundamental distinction: can firms differentiate their product, or do they face competitors for their own product line? Does more entry lead to more competition?
What Next?

- Estimate parameters of the simple model with heterogeneous entry costs: \( (\sigma - 1)/\theta, G(\beta), \sigma E_n, E_n = \eta(X_n)^\gamma \) given data on \( X_n \) and \( X_{nF} \).
- Use estimates to assess gains from variety, and potential gains from market integration.
- Document geographic patterns at firm level. Is there a compelling argument for a richer model.
- If yes, build model that nests Melitz and BEJK, estimate it, and assess gains from variety and market integration.
- ...Dynamics of market entry, foreign direct investment.