EC791 - International Trade
The Extensive Margin of Trade: Empirical Studies

Stefania Garetto
Introduction: What is the Extensive Margin of Trade?

Trade liberalizations affect trade flows in different ways:

- **Intensive Margin**: trade is less costly, so quantities traded increase.
- **Extensive Margin**: trade is less costly, so more firms trade, more goods are traded.

These notes focus on three important papers about the extensive margin of adjustment following trade liberalization:

Eaton, Kortum, and Kramarz (2011)

- Present VERY DETAILED firm-level data on the exporting behavior of French firms.

- Develop a Melitz-type model where countries are heterogeneous in terms of their size, fixed and variable costs of trade, and entry costs. To better match the data, the model also features idiosyncratic demand shocks and market-specific entry shocks.

- The model is estimated using simulated method of moments: simulate an artificial dataset and find the set of parameters that minimize the “distance” between real data and simulated data.

- The estimated model is used for counterfactual experiments on the micro-level effects of unilateral and multilateral trade liberalizations.
Data on sales of French manufacturing firms in **113 destinations** (including France) in 1986:
- about 230,000 firms, of which about 34,000 are exporters.

**Empirical regularities:**

1. **The size of a destination market** matters:
   - The **number of French firms** selling to a market increases with the **size** of that market\(^1\) (extensive margin).
   - The **amount of sales per firm** into a market increases with the **size** of that market (intensive margin).

---

\(^1\)Here size is defined as absorption = total production + imports - exports.
The figure shows the number of firms selling in each market, plotted against market size (absorption).
The figure shows the 95th, 75th, 50th, and 25th percentile sales in each market, plotted against market size. Market size is defined as absorption: total production plus imports minus exports. Source: Eaton, Kortum and Kramarz (2011).

Panel C: Sales Percentiles

The 95th, 75th, 50th, and 25th percentiles of sales are plotted against market size (in billions of dollars). The source is Eaton, Kortum and Kramarz (2011).
2. **Sales distributions** are very similar, even in countries of different size and with different extent of French participation:
   - sales distributions resemble Pareto distributions for large firms (upper tail);
   - sales distributions depart from Pareto distributions for small firms. In the data there are **many exporters selling very small amounts**.

3. Firms selling to **more foreign markets** (and to less “popular” ones) exhibit on average **higher domestic sales**.

4. Exporters sell disproportionately large amounts in France (**home bias**):

5. Export intensity increases with the number of firms selling to a destination.
Exporters selling to more foreign markets exhibit on average higher domestic sales.
Export Participation by Country (cont.)

Plot of average domestic sales of firms selling to \( k \) or more markets against the number of firms selling to \( k \) or more markets. Few, very large firms sell to a large number of countries (up to 108 out of 113). Most exporters sell to only one foreign country.

Plot of average domestic sales of firms selling to a market against the number of firms selling to that market. Very large firms sell to the least popular markets, while much smaller firms sell to more popular markets. Source: Eaton, Kortum and Kramarz (2011).
Export intensity is higher in more popular markets.

The classical gravity literature estimates the effect of trade barriers on trade flows by regressing trade flows on (GDP and) distance: by construction, gravity regressions can be run only for positive trade flows.
The classical **gravity literature** estimates the effect of trade barriers on trade flows by regressing trade flows on (GDP and) distance: by construction, gravity regressions can be run **only for positive trade flows**.

This is problematic because:

- standard gravity regressions do not take into account the information contained in the **zeros** of the trade matrix, hence
- standard gravity regressions fail to take into account **selection**, so they only capture the intensive margin of trade.
The classical gravity literature estimates the effect of trade barriers on trade flows by regressing trade flows on (GDP and) distance: by construction, gravity regressions can be run only for positive trade flows. This is problematic because:

- standard gravity regressions do not take into account the information contained in the zeros of the trade matrix, hence
- standard gravity regressions fail to take into account selection, so they only capture the intensive margin of trade.

Building on insights from the Melitz’ model, HMR develop an estimation framework that allows to estimate separately the effects of both intensive and extensive margin: “generalized gravity equation”.
In a sample of 158 countries in 1996:

- **zeros are pervasive:** about half of the country-pairs in the sample DO NOT TRADE with one another! ("sparsity" of the trade matrix);

- the rapid growth in trade that we observe since 1970 is almost entirely due to growth in trade volumes between countries that were already trading in 1970;

- the average volume of trade between “old” trading partners\(^2\) in 1996 is about 35 times the average volume of trade between “new” trading partners.

\(^2\)Countries that were already trading in 1970.
A Melitz-type model with asymmetric countries and bilateral, possibly asymmetric fixed and variable costs of trade generates:

- **zero trade flows** in both directions between some countries;
- **asymmetric trade flows** between some countries:
  - zero flows in one direction and positive flows in the other, or positive flows in both directions but of different size.
- **a gravity equation** with third-country effects.
A Melitz-type model with asymmetric countries and bilateral, possibly asymmetric fixed and variable costs of trade generates:

- **zero trade flows** in both directions between some countries;
- **asymmetric trade flows** between some countries:
  - zero flows in one direction and positive flows in the other, or positive flows in both directions but of different size.
- a **gravity equation** with third-country effects.

The **generalized gravity equation** shows that standard gravity estimates:

1. confuse the effect of the intensive margin and of the extensive margin of trade;
2. do not account for **selection** (because they use information only from the country pairs for which positive trade flows are observed);
3. are affected by an **omitted variable problem** related to the extensive margin: the generalized gravity specification includes a term that controls for the **fraction of firms** that exports.
HMR (2008): Model

- Countries are indexed by \( j = 1, \ldots, J \).
- Preferences in country \( j \):
  \[
  U_j = \left[ \int_{l \in B_j} (x_j(l))^\alpha dl \right]^{1/\alpha}
  \]
  where \( \alpha \in [0, 1] \) and \( B_j \) is the endogenous set of products available in \( j \).
- Demand:
  \[
  x_j(l) = p_j(l)^{-\varepsilon} P_j^{\varepsilon-1} Y_j
  \]
  where \( \varepsilon \equiv 1/(1-\alpha) \), \( P_j \) is the ideal price index, and \( Y_j \) is the expenditure level in \( j \).
- \( N_j \equiv \) number of firms from \( j \).
- \( c_ja \) is the firm-specific unit cost of producing a good in \( j \): \( a \sim G(a) \),
  \( G(a) : [a_L, a_H] \to [0, 1] \).
HMR (2008): Model (cont.)

- Bilateral fixed costs of exporting from $j$ to $i$: $c_j f_{ij}$, with $f_{jj} = 0$ and $f_{ij} > 0 \forall i \neq j$.
- Bilateral iceberg costs of exporting from $j$ to $i$: $\tau_{ij}$, with $\tau_{jj} = 1$ and $\tau_{ij} > 1 \forall i \neq j$.
- Prices: $p_{ij}(a) = \tau_{ij} c_j a / \alpha$.
- Profits from sales from $j$ to $i$:

$$
\pi_{ij}(a) = (1 - \alpha) \left( \frac{\tau_{ij} c_j a}{\alpha P_i} \right)^{1-\varepsilon} Y_i - c_j f_{ij}
$$

($f_{jj} = 0 \Rightarrow$ all $N_j$ firms from $j$ sell at least in $j$).
- Define cutoff cost for exports from $j$ to $i$:

$$
a_{ij} \equiv \{ a \in [a_L, a_H] : \pi_{ij}(a_{ij}) = 0 \}
$$

then only firms with $a \leq a_{ij}$ (a mass $G(a_{ij})$) export from $j$ to $i$. If $G(a_{ij}) = 0$, there are no exports from $j$ to $i$. 

(fixed costs of exporting from $j$ to $i$: $c_j f_{ij}$, with $f_{jj} = 0$ and $f_{ij} > 0 \forall i \neq j$.
Define $V_{ij}$ as the average cost of firms selling from $j$ to $i$:

\[
V_{ij} = \begin{cases} 
\int_{a_L}^{a_{ij}} a^{1-\varepsilon} dG(a) & \text{if } a_{ij} \geq a_L \\
0 & \text{otherwise}
\end{cases}
\]

Value of $i$’s imports from $j$:

\[
M_{ij} = \left( \frac{c_j \tau_{ij}}{\alpha P_i} \right)^{1-\varepsilon} Y_i N_j V_{ij} \tag{1}
\]

where:

\[
P_i = \left[ \sum_{j=1}^{J} \left( \frac{c_j \tau_{ij}}{\alpha} \right)^{1-\varepsilon} N_j V_{ij} \right]^{1/(1-\varepsilon)}.
\]
The model:

1. is consistent with **zero trade flows** in both directions for some country pairs;
2. is consistent with **asymmetric trade flows** between some countries (either zero in one direction and positive in the other, or positive in both directions but different volumes).
3. generates **gravity equation with third country effects** (via the price index). Taking logs\(^3\) of (1):

\[
m_{ij} = (\varepsilon - 1) \ln \alpha - (\varepsilon - 1) \ln c_j + n_j + (\varepsilon - 1) p_i + ... \\
...y_i + (1 - \varepsilon) \ln \tau_{ij} + v_{ij}.
\]  

\(^3\)Lower-case letters denote the log of the upper-case letters.

Assume $G(a) = \frac{a^k - a^L}{a^H - a^L}$ with $k > \varepsilon - 1$ (truncated Pareto distribution). Then:

$$V_{ij} = \frac{ka_L^{k-\varepsilon+1}}{(k-\varepsilon+1)(a^H - a^L)}W_{ij}$$

where:

$$W_{ij} = \max \left\{ \left( \frac{a_{ij}}{a_L} \right)^{k-\varepsilon+1} - 1, 0 \right\}.$$ 

Equation (2) can be rewritten more conveniently as:

$$m_{ij} = \beta_0 + \lambda_j + \chi_i - \gamma d_{ij} + w_{ij} + u_{ij}$$ (3)

where:

- $\beta_0 = (\varepsilon - 1) \ln \alpha + \ln[(ka_L^{k-\varepsilon+1})/((k-\varepsilon+1)(a^H - a^L))]$;
- $\lambda_j = n_j - (\varepsilon - 1) \ln c_j$ is an exporting country fixed effect;
- $\chi_i = (\varepsilon - 1)p_i + y_i$ is an importing country fixed effect;
- Variable trade costs are modeled as: $\tau_{ij}^{\varepsilon-1} \equiv D_{ij}^\gamma e^{-u_{ij}}$, where $D_{ij}$ is the distance between $i$ and $j$, and $u_{ij} \sim N(0, \sigma_u^2)$. 

\[ m_{ij} = \beta_0 + \lambda_j + \chi_i + \gamma d_{ij} + w_{ij} + u_{ij}. \]

- The term \( w_{ij} \) controls for the **fraction of firms** (possibly zero) **exporting** from \( j \) to \( i \). The inclusion of \( w_{ij} \) in the regression is important! Without \( w_{ij} \), it is erroneous to interpret \( \gamma \) as the elasticity of trade volumes to trade barriers.
- By neglecting \( w_{ij} \), the \( \hat{\gamma} \) estimated by the standard gravity equation is a “mixture” of the intensive and extensive margin.
- The results of the standard gravity equation are biased in two respects:
  1. **Omitted variable**: the term \( w_{ij} \) is neglected.
  2. **Selection**: the regression is run only for country pairs with positive trade flows.
The term $w_{ij}$ is not observable. Define a related latent variable:

$$Z_{ij} = \frac{(1 - \alpha) \left( \frac{\alpha P_i}{c_j \tau_{ij}} \right)^{\epsilon - 1} Y_i a_L^{1-\epsilon}}{c_j f_{ij}}.$$  

$Z_{ij}$ is the ratio of variable profits to fixed export costs for the most productive exporter from $j$ to $i$.

Exports are positive iff $Z_{ij} > 1$, hence:

$$W_{ij} = Z_{ij}^{(k-\epsilon+1)/(\epsilon-1)} - 1.$$  

Assume the following functional form for the fixed cost:

$$f_{ij} = \exp\{\phi_{EX,j} + \phi_{IM,i} + \kappa \phi_{ij} - \nu_{ij}\}$$

$$\nu_{ij} \sim N(0, \sigma_v^2).$$
Taking logs, we can rewrite (4) as:

\[ z_{ij} = \gamma_0 + \xi_j + \zeta_i - \gamma d_{ij} - \kappa \phi_{ij} + \eta_{ij} \]  

(5)

where:

- \( \gamma_0 = \ln[(1 - \alpha)] + (1 - \varepsilon)\ln(a_L) - \ln(\alpha) \);  
- \( \xi_j = -\varepsilon \ln c_j + \phi_{EX,j} \) is an exporter fixed effect;  
- \( \zeta_i = (\varepsilon - 1)p_i + y_i - \phi_{IM,i} \) is an importer fixed effect;  
- \( \eta_{ij} = u_{ij} + v_{ij} \sim N(0, \sigma_u^2 + \sigma_v^2) \).

Define:

\[ T_{ij} \equiv \begin{cases} 1 & \text{if } j \text{ exports to } i \\ 0 & \text{otherwise} \end{cases} \]

Let \( \rho_{ij} \) denote the probability that \( j \) exports to \( i \), conditional on observables. Divide (5) by \( \sigma_\eta^2 \equiv \sigma_u^2 + \sigma_v^2 \), and define the Probit equation:

\[ \rho_{ij} = \text{prob}\{T_{ij} = 1|\text{observables}\} = \Phi \left( \frac{\gamma_0 + \xi_j + \zeta_i - \gamma d_{ij} - \kappa \phi_{ij}}{\sigma_\eta^2} \right) \]

(6)

where \( \Phi \) is the c.d.f. of a standardized Normal distribution.
\[ \rho_{ij} = \text{prob}\{T_{ij} = 1|\text{observables}\} = \Phi \left( \frac{\gamma_0 + \xi_j + \zeta_i - \gamma d_{ij} - \kappa \phi_{ij}}{\sigma^2} \right). \]

Let \( \hat{\rho}_{ij} \) be the predicted value from (6).

Let \( \hat{z}^*_{ij} = \Phi^{-1}(\hat{\rho}_{ij}) \) be the predicted value of \( z^*_{ij} = z_{ij}/\sigma_\eta \).

Then:

\[ \hat{W}_{ij} = \max\{ (\hat{Z}^*_{ij})^\delta - 1, 0 \}, \]

where \( \delta \equiv \sigma_\eta (k - \varepsilon + 1)/(\varepsilon - 1) \).

\( \hat{W}_{ij} \) is a consistent estimate of \( W_{ij} \) (unconditional expectation of \( W_{ij} \)).
Recall generalized gravity equation:

\[ m_{ij} = \beta_0 + \lambda_j + \chi_i + \gamma d_{ij} + w_{ij} + u_{ij}. \]

Consistent estimation requires:

1. to control for **sample selection** (of country pairs into trading partners)
Recall generalized gravity equation:

\[ m_{ij} = \beta_0 + \lambda_j + \chi_i + \gamma d_{ij} + w_{ij} + u_{ij}. \]

Consistent estimation requires:

1. to control for **sample selection** (of country pairs into trading partners) \( \Rightarrow \) add Heckman (1979) correction for sample selection \( \beta_{u\eta} \hat{\eta}^{*}_{ij} \), where \( \beta_{u\eta} \equiv \text{corr}(u_{ij}, \eta_{ij})(\sigma_u/\sigma_\eta) \), and \( \hat{\eta}^{*}_{ij} \) is the estimate of \( E[\eta_{ij}^{*}|\cdot, T_{ij} = 1] \),
   or: \( \hat{\eta}^{*}_{ij} = \phi(\hat{\eta}^{*}_{ij})/\Phi(\hat{\eta}^{*}_{ij}) \) (density of the error conditional on \( z_{ij} \) being above the cutoff).
Recall generalized gravity equation:

\[ m_{ij} = \beta_0 + \lambda_j + \chi_i + \gamma d_{ij} + w_{ij} + u_{ij}. \]

Consistent estimation requires:

1. to control for **sample selection** (of country pairs into trading partners) \( \Rightarrow \) add Heckman (1979) correction for sample selection \( \beta_{u\eta} \hat{\eta}_{ij}^* \), where \( \beta_{u\eta} = \text{corr}(u_{ij}, \eta_{ij})(\sigma_u/\sigma_\eta) \), and \( \hat{\eta}_{ij}^* \) is the estimate of \( E[\eta_{ij}^* | \cdot, T_{ij} = 1] \), or: \( \hat{\eta}_{ij}^* = \phi(\hat{\eta}_{ij}^*)/\Phi(\hat{\eta}_{ij}^*) \) (density of the error conditional on \( z_{ij} \) being above the cutoff).

2. to control for **endogenous number of exporters** (unobserved firm-level heterogeneity), via the estimation of \( w_{ij} \)
Recall generalized gravity equation:

\[ m_{ij} = \beta_0 + \lambda_j + \chi_i + \gamma d_{ij} + w_{ij} + u_{ij}. \]

Consistent estimation requires:

1. to control for **sample selection** (of country pairs into trading partners) ⇒ add Heckman (1979) correction for sample selection \( \beta_{u\eta} \hat{\eta}_{ij}^\ast \), where 
   \( \beta_{u\eta} = \text{corr}(u_{ij}, \eta_{ij})(\sigma_u/\sigma_{\eta}) \), and \( \hat{\eta}_{ij}^\ast \) is the estimate of \( E[\eta_{ij}^\ast | \cdot, T_{ij} = 1] \), or:
   \( \hat{\eta}_{ij}^\ast = \phi(\hat{\eta}_{ij}^\ast)/\Phi(\hat{\eta}_{ij}^\ast) \) (density of the error conditional on \( z_{ij} \) being above the cutoff).

2. to control for **endogenous number of exporters** (unobserved firm-level heterogeneity), via the estimation of \( w_{ij} \) ⇒ for positive trade flows, use \( \hat{W}_{ij} \), and add Heckman correction to control for the fact that the estimation is done using only positive trade flows: \( \hat{w}_{ij}^\ast \) is the estimate of \( E[w_{ij}^\ast | \cdot, T_{ij} = 1] \), or
   \( \hat{w}_{ij}^\ast = \ln\{\exp[\delta(\hat{z}_{ij}^\ast + \hat{\eta}_{ij}^\ast)] - 1\} \).

The estimating equation becomes:

\[ m_{ij} = \beta_0 + \lambda_j + \chi_i + \gamma d_{ij} + \ln\{\exp[\delta(\hat{z}_{ij}^\ast + \hat{\eta}_{ij}^\ast)] - 1\} + \beta_{u\eta} \hat{\eta}_{ij}^\ast + e_{ij}. \]
HMR (2008): Results

- Probit estimates show that the same variables impacting export volumes from $j$ to $i$ also impact the probability that $j$ exports to $i$.
- Quantitative importance of unmeasured heterogeneity bias: standard gravity estimates are biased upwards, because they attribute higher trade volumes to the intensive margin effect of lower trade barriers only. But higher trade volumes may be due to a larger proportion of exporters as well (extensive margin).
- When quantifying the effects of selection bias versus unmeasured heterogeneity bias, it appears that most of the bias in standard gravity estimates is due to unmeasured heterogeneity.
In models with monopolistic competition and increasing returns to scale, one source of gains from trade is the increase in the number of varieties that consumers have access to.
In models with monopolistic competition and increasing returns to scale, one source of gains from trade is the **increase in the number of varieties** that consumers have access to.

**How important the gains from variety are (quantitatively) for the US?**
Broda and Weinstein (2006)

- In models with monopolistic competition and increasing returns to scale, one source of gains from trade is the increase in the number of varieties that consumers have access to.

- How important the gains from variety are (quantitatively) for the US?

- BW (2006) answer this question by estimating the impact of increased variety (through imports) on aggregate welfare.
Broda and Weinstein define a **variety** in the data as a 7- or 10-digit good category produced in a particular country.

- The number of varieties consumed increased **3-fold** from 1972 to 2001:
  - in 1972, the US imported 71,420 varieties: 7731 goods imported from 9.2 countries;
  - in 2001, the US imported 259,215 varieties: 16,390 goods imported from 15.8 countries;
  - approximately half of the increase is due to an increase in the number of goods, and the other half to an increase in the number of countries of origin.
Use Dixit-Stiglitz preferences to represent how consumers are affected by changes in the number of varieties consumed: tractable and easy to compute, generate demand systems that are easy to estimate (linear in logs):

- nested CES structure allows for different elasticities of substitution in different sectors.

- Construct an **exact price index** to estimate the impact of variety changes on prices and welfare:
  - the exact price index needs to be able to account for **changes in the set of available varieties** over time.

- Compare the exact price index with a conventional price index that does not take into account changes in the set of available varieties: the difference between the two indexes is a measure of the **gains from variety**.
To construct the ideal price index, one needs values for the elasticities of substitution for each sector.

Notice also that the elasticity of substitution is what determines the trade elasticity in Krugman-type models, so is essential to compute gains from trade.

GMM estimation of the elasticities with sensible results:

- estimated elasticities are higher the more finely disaggregated are the sectors;
- more differentiated goods have lower estimated elasticities.

At the 3-digit SITC level, elasticities range from a minimum of 1.08 (cork manufactures) to a maximum of 228.75 (waste paper and paperboard), with a mean value of 6.78 and a median value of 2.54.
With the estimated elasticities, variety growth drives a 28% reduction of the ideal price index.

Consumers are willing to pay 2.6% of their income to access the (larger) set of varieties available in 2001 instead than the one available in 1972.

This is approximately equivalent to say that the welfare gains from variety growth in imports in the US are 2.8 percent of GDP.