Lecture 13: Intraindustry Heterogeneity in Trade Models: Part II

14.581: International Economics I

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Introduction

- In the last lecture, we introduced the Melitz (2003) model of trade with intraindustry heterogeneity.
- This has been one of the most active areas in international trade in the last few years.
- In this lecture, we will provide a brief account of a few recent contributions to this literature.
- We will start with some empirical papers that have further illustrated the role of intraindustry heterogeneity in shaping international trade flows (Helpman, Melitz, and Rubinstein, 2006, Chaney 2006, and Eaton, Kortum, Kramarz, 2005).
- We will then review three interesting variants and extensions of the Melitz model (Bernard, Redding and Schott, 2006, and Melitz and Ottaviano, 2006).
- Finally, we will briefly discuss the alternative approach offered by Bernard, Eaton, Jensen and Kortum (2003).

Helpman, Melitz, and Rubinstein (2006)

- HMY start from the observation that many countries do not trade with each other.
  - close to half of all country pairs do not export to each other and a small fraction exports in one direction only;
  - this is inconsistent with the Helpman-Krugman paradigm (also Armington);
  - but Melitz-type models can easily explain this feature.
- In particular, let $a = 1/\varphi$ be a measure of inverse productivity and define

$$a_{ij} = \left\{ a \mid \pi_{ij}\left(\frac{1}{a}\right) = 0 \right\},$$

  so only firms with inverse productivity $a < a_{ij}$ find it profitable to export from i to j.
- Suppose that the distribution $G(\theta)$ has finite support. That is,

$$\frac{1}{\varphi_{\max}} = a_L < a < a_H = \frac{1}{\varphi_{\min}}.$$

- Provided that $a_L < a_{ij} < a_H$, then some firms export from i to j.
- But the range of $\theta_{\min}$ and $\theta_{\max}$ could be such that no firm finds it profitable to export from i to j.

HMR (2006): Gravity

- Often, when people estimate gravity equations they throw out the nontrading (zero) observations;
  - yet this may bias the estimates, because zero trade flows contain information.
- HMR (2006) propose an estimation method that utilizes information contained in zero trade flows;
  - in the process they identify separately the intensive and extensive margin of trade.
- Suppose there are N_i firms in i that use a bundle of inputs with cost c_i. Demand conditions are as in Melitz (2003).
- Then total exports from i to j will be

$$M_{ij} = \left(\frac{c_i \tau_{ij}}{\alpha P_j} \right)^{1-\varepsilon} Y_j N_i V_{ij},$$

where Y_j is total spending in country j and

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

HMR (2006): Gravity (cted.)

- If we also impose $Y_j = \sum_i M_{ij}$ then we have

$$M_{ij} = \frac{Y_i Y_j}{\sum_i Y_i} \times \frac{\left(\frac{\tau_{ij}}{P_i}\right)^{1-\varepsilon} V_{ij}}{\sum_h \left(\frac{\tau_{hj}}{P_h}\right)^{1-\varepsilon} V_{hj} s_h}, \quad (1)$$

  where s_h is country h's share in world income, $Y_h / \sum_i Y_i$.
- This is a gravity equation with a trade resistance measure

$$\frac{\left(\frac{\tau_{ij}}{P_i}\right)^{1-\varepsilon} V_{ij}}{\sum_h \left(\frac{\tau_{hj}}{P_h}\right)^{1-\varepsilon} V_{hj} s_h}$$

- This generalizes the Anderson van Wincoop (2003) equation to heterogeneous firms
  - note potential asymmetries: by allowing τ_{ij} or V_{ij} to be asymmetric ($V_{ij} \neq V_{ji}$), one can get unbalanced trade, which is a feature of the data.

HMR (2006): Gravity (cted.)

- Assume further that $G(a)$ is (truncated) Pareto, i.e. $G(a) = \frac{a^k - (a_L)^k}{(a_H)^k - (a_L)^k}$.
- With this distribution, V_{ij} is proportional to

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

- Next, let

$$\tau_{ij}^{\varepsilon-1} = D_{ij}^{\gamma} e^{-u_{ij}},$$

where u_{ij} is normally distributed and D_{ij} is the distance between i and j.

- Then taking logs, we can express (1) as follows:

$$m_{ij} = \beta_0 + \lambda_j + \chi_i - \gamma d_{ij} + w_{ij} + u_{ij} \tag{2}$$

for $M_{ij} > 0$,where lower case variables are logs of the capitalized ones, and χ_i and λ_i are (potentially asymmetric) importer and exporter fixed effects.

- Traditional estimates neglect the term w_{ij}, which is unobservable. This creates omitted-variable bias, which typically leads to an overestimate of γ, as well as a sample selection bias, because, although $E\left[u_{ij}\right] = 0$, we have $E\left[u_{ij} \mid M_{ij} > 0\right] \neq 0$.

HMR (2006): Procedure and Results

- HMR (2006) develop a two-step Heckman-type estimation procedure:
  - in the first stage, a Probit equation is specified relating the probability that some firm in i exports in j to certain observable variables;
  - in the second stage, predicted values from the first stage are then used to estimate (2).
- For the procedure to work, one needs a variable that enters the first stage, but not the second stage. HMR argue that religion and measures of the cost of creating a business pass this test.
- The main results of the estimation are that:
  - standard gravity estimates overestimate the effect of distance on trade flows (γ falls by about $1/3$) since they abscribe to the intensive margin an effect that really works through selection into exporting;
  - the bias stemming from firm-level heterogeneity appears empirically more relevant than that relating to the classical Heckman selection bias.

Chaney (2006)

- Chaney (2005) explores the role of the elasticity of substitution across varieties in shaping the relationship between trade barriers and trade flows.
- His main finding is that the presence of heterogeneous firms dramatically changes the predictions generated by standard models with product differentiation but homogenous firms. In particular, he finds that:
  - whereas in models with homogenous firms, high elasticities of substitution are associated with high elasticities of trade flows to trade barriers,
  - in the presence of heterogenous firms, high elasticities of substitution are actually associated with **low** elasticities of trade flows to trade barriers.
- Consider again the Melitz model, but with an outside sector that pins down wages to 1 (as in the home-market literature). Export revenues of firms from i in j are now:

$$r_{ij}(\varphi) = p_{ij}(\varphi) q_{ij}(\varphi) = \tau_{ij}^{1-\sigma} \mu L_j \left(P_j \rho \varphi\right)^{\sigma-1}, \tag{3}$$

- Assume a Pareto distribution for marginal costs, an a number of firms proportional to population (notice tension with zero profits, but this can be dealt with).

Chaney (2006) cted.

- All producers from i with productivity below a certain threshold φ_{ij}^* will not find it profitable to export to j. The threshold is:

$$\varphi_{ij}^* = \left(\frac{\sigma}{\mu L_j}\right)^{1/(\sigma-1)} f_{ij}^{1/(\sigma-1)} \frac{\tau_{ij}}{\rho P_j}.$$

- The price index P_j is given by

$$P_j^{1-\sigma} = \sum_{k=1}^{N} L_k \int_{\varphi_{kj}^*}^{\infty} \left(p_{kj}(\varphi)\right)^{1-\sigma} dG(\varphi) = \sum_{k=1}^{N} L_k \int_{\varphi_{kj}^*}^{\infty} \left(\frac{\tau_{kj}}{\rho\varphi}\right)^{1-\sigma} dG(\varphi).$$

- Chaney notes that given the assumption of a Pareto distribution, it is actually possible to solve for this price index as a function of fundamentals:

$$P_j = \lambda_2 \left(\frac{L_j}{L}\right)^{1/\gamma} L_j^{-1/(\sigma-1)} \theta_j.$$

where $\theta_j^{-\gamma} = \sum_{k=1}^{N} \frac{L_k}{L} \tau_{kj}^{-\gamma} f_{kj}^{(\sigma-1-\gamma)/(\sigma-1)}$, $L \equiv \sum_{k=1}^{N} L_k$ and λ_2 is a constant.

Chaney (2006) cted.

- So export revenues are

$$r_{ij}(\varphi) = \begin{cases} \lambda_3 \left(\frac{\varphi\theta_j}{\tau_{ij}}\right)^{\sigma-1} \left(\frac{L_j}{L}\right)^{(\sigma-1)/\gamma} & \text{if } \varphi \geq \varphi_{ij}^* \\ 0 & \text{otherwise} \end{cases},$$

  where λ_3 is a constant.
- Notice that as in the Krugman's (1980) model, variable trade costs affect export sales with an elasticity of $-(\sigma-1)$.
  - Hence, *conditional on positive exports*, the higher the elasticity of substitution, the larger the response of trade flows to transport costs.
- When computing overall exports from i to j we obtain:

$$T_{ij} = \int_{\varphi_{ij}^*}^{\infty} r_{ij}(\varphi) L_i dG(\varphi) = \mu \frac{L_i L_j}{L} \left(\frac{\tau_{ij}}{\theta_j}\right)^{-\gamma} f_{ij}^{-(\gamma/(\sigma-1)-1)}. \quad (4)$$

- Compare this to a Krugman-style model with homogenous firms, where would instead obtain:

$$\tilde{T}_{ij} = \mu \frac{L_i L_j}{L} \left(\frac{\tau_{ij}}{\widetilde{\theta}_j}\right)^{-(\sigma-1)}. \quad (5)$$

Chaney (2006): Comparison

- Notice the following crucial differences between (4) and (5):
  - The elasticity of T_{ij} with respect to τ_{ij} $(-d \ln T_{ij} / d \ln \tau_{ij})$ is now higher than in the case with homogenous firms, since $\gamma > \sigma - 1$.
  - This same elasticity is now independent of σ.
  - The elasticity of T_{ij} with respect to f_{ij} $(-d \ln T_{ij} / d \ln f_{ij})$ is decreasing in the elasticity of substitution σ.
  - The elasticity of T_{ij} with respect to τ_{ij} and f_{ij} is increasing in γ, and is thus higher in more homogenous sectors.
- In sum, we see that high elasticities of substitution dampen the response of trade flows to trade frictions.
- Key Idea: extensive margin matters and it moves more when elasticity is lower
  - when σ is very high (low), new entrants will capture small (large) market share.
- Chaney shows empirically that the response of trade flows to trade barriers is higher in low σ and high γ sectors.

Eaton, Kortum and Kramarz (2005)

- Both HMR and Chaney emphasize the impact of firm heterogeneity on aggregate (or industry-level) trade flows.
  - yet both use no firm-level data in their analysis.
- Eaton, Kortum and Kramarz (2004) use French level data to provide data consistent with the mechanism inherent in this type of models.
- They indeed show that there is enormous heterogeneity in the export participation of French firms.
  - a very significant number of firms do not export at all;
  - most exporters sell only in one foreign market;
  - the number of firms selling to multiple markets falls off with the number of destinations with an elasticity of -2.5;
  - although French firms sell more in larger market, larger aggregate French sales in a market are largely explained by a larger number of firms selling in those markets.
- Eaton, Kortum and Kramarz (2006) develop an Eaton-Kortum type model which they structurally estimate using this French data.

Bernard, Redding and Schott (2006)

- BRS consider a two-factor, two-sector, two-country world economy, along the lines of Helpman and Krugman (1985). Their main results are:
  - They first show that without barriers to trade, the model aggregates nicely to a standard Helpman-Krugman model with homogenous firms.
  - They solve for an equilibrium with factor price equalization and discuss the implications for entry and exit in comparative advantage vs. comparative disadvantage industries.
  - When introducing costs of exporting, they find that trade liberalization increases the zero-profit productivity cutoff in all industries and countries.
  - But they find that the effect is disproportionately large in comparative advantage industries.
- New features:
  - Two sectors:
$$U = (C_1)^{\alpha_1} (C_2)^{\alpha_2}, \quad \alpha_1 + \alpha_2 = 1,$$
  - Two factors:
$$TC_i(\varphi) = \left[f_i + \frac{q_i(\varphi)}{\varphi} \right] (w_S)^{\beta_i} (w_L)^{1-\beta_i}, \quad i = 1, 2, \tag{6}$$
    where w_S and w_L are the wages of skilled and unskilled workers respectively. It is assumed that $\beta_1 > \beta_2$.

BRS (2006): Sketch of Results

- One can repeat the analysis in Melitz (2003) and conclude that:
  - in the equilibrium of the closed economy, the same ZCP and FE schedules can be derived, the only difference being that they are both multiplied by $(w_S)^{\beta_i} (w_L)^{1-\beta_i}$
  - but this implies that the productivity threshold is common across industries
  - this same threshold is independent of factor endowments and hence is not affected by costless trade integration.
- More interesting results are derived in the case of costly trade:
  - as in Melitz (2003), the ZCP is shifted up and to the right;
  - but the shift is disproportionately higher in each country's comparative advantage (CA) industry.
- Intuition: increase in export opportunities is disproportionate in CA industry $\longrightarrow$ increase in the relative reward of the abundant factor, which is used intensively by the non-exporters in that same industry.
  - This explains why these domestic producers suffer disproportionately more from trade liberalization.
- Interestingly, the model generates endogenous Ricardian differences that reinforce Heckscher-Ohlin comparative advantage forces.

Melitz and Ottaviano (2006)

- So far, we have studied theoretical models in selection into exporting came about through fixed costs of exporting
  - In models with CES preferences and monopolistic competition, this is the only way to generate this.
- We will next will study the work of Melitz and Ottaviano (2006, MO hereafter), who maintain the monopolistic competition assumption but relax the CES assumption.
  - Bernard, Eaton, Jensen, and Kortum (2003) instead stick to the CES assumption, but consider Bertrand competition.
- MO consider a linear demand system across a continuum of varieties (first developed by Ottaviano, Tabuchi, and Thisse, 2002).
  - A key feature is that the price elasticity of residual demand is no longer exogenously fixed and changes with the "toughness" of competition in a market.
- MO (re-) derive the intra-industry reallocation effects in Melitz (2003), but without any action in factor markets and with a new pro-competitive effect of trade: lower markups.
- Welfare gains from trade related to (i) higher product variety, (ii) higher average productivity, (iii) lower markups.

Melitz and Ottaviano (2006) cted.

- The model is similar to Melitz (2003), but with a different demand system.
- Preferences are defined over a continuum of differentiated varieties $i \in \Omega$ and a (numeraire) homogeneous good:

$$U = q_0^c + \alpha \int_{i \in \Omega} q_i^c \, di - \frac{1}{2}\gamma \int_{i \in \Omega} (q_i^c)^2 \, di - \frac{1}{2}\eta \left(\int_{i \in \Omega} q_i^c \, di \right)^2 .$$

  - γ is an index of product differentiation; when $\gamma = 0$, the differentiated varieties are perfect substitutes, and as γ increases consumers care more and more about the consumption distribution across varieties.
  - α and η govern the substitutability of varieties with the numeraire good. Larger α or lower η shift out demand for differentiated varieties.
- Consider for now a closed economy inhabited by L consumers, so that total demand for a differentiated variety is $q_i = L q_i^c$.
- Notice that marginal utilities are bounded, so there exists a threshold price level over which demand is "choked":

$$q_i^c = \frac{1}{\gamma} \left(\alpha - p_i - \eta Q^c \right); \quad Q^c = \int_{i \in \Omega} q_i^c \, di.$$

MO (2006): Technology and Firm Behavior

- The homogenous good is produced one-to-one with labor so $w = 1$.
- Production of differentiated varieties is as in Melitz (2003):
  - firms must pay sunk investment cost f_E to enter, at which point their unit cost c of production is unknown;
  - firm productivity is then learned/revealed: this is a draw from a common cost distribution $G(c)$ with support on $[0, c_M]$;
  - differently from Melitz (2003), there are no further overhead costs.
- The setup is one with monopolistic competition: firms maximize profits taking N and $\bar{p}$ as given, and there is free entry into the industry.
- Letting $c_D \equiv \alpha - \eta Q^c$, firm behavior is as follows:

$$p(c) = \frac{1}{2}(c_D + c) \qquad \text{prices}$$

$$\mu(c) = p(c) - c = \frac{1}{2}(c_D - c) \qquad \text{markups}$$

$$r(c) = \frac{L}{4\gamma}\left[(c_D)^2 - c^2\right] \qquad \text{revenues}$$

$$\pi(c) = \frac{L}{4\gamma}(c_D - c)^2 \qquad \text{profits}$$

MO (2006): Equilibrium

- Notice that relative to other firms, more productive firms (lower c):
  - set lower prices but higher markups (productivity gain is not entirely passed on to consumers);
  - are bigger: higher output and revenue;
  - earn higher profit.
- Furthermore, c_D is an inverse measure of the "toughness" of the market.
- Assuming a Pareto distribution for $1/c$ with shape parameter k, one can use the free entry condition to solve for c_D:

$$c_D = \left(\frac{\gamma\phi}{L}\right)^{\frac{1}{k+2}},$$

  where $\phi = 2(k+1)(k+2)c_M^k f_E$.
- Note that the threshold c_D is lower (and thus toughness and average productivity is higher) when:
  - L is higher, that is, the market is bigger;
  - γ is lower, that is, varieties are closer substitutes;
  - c_M is lower (better distribution of cost draws);
  - f_E is lower, that is, lower sunk costs.

MO (2006): Effects of Trade

- Notice that larger markets (or an integrated world economy with costless trade) features:
  - Lower average markups and prices (this is despite the fact that average productivity goes up and more productive firms set higher markups: the reason is the endogenous change in the cutoff c_D).
  - Bigger firms (higher average output and sales per firm).
  - More profitable firms.
  - Higher welfare (this is a combination of the product variety, price and variance effects).
  - Lower variance of productivity, price, and markups.
  - Higher variance of firm size (output and sales).
- Welfare: effects go beyond the standard Krugman-style variety effects and the Melitz-style reallocation effects. In particular, we now have an additional *pro-competitive* effect.
- MO also extend the model to the case of costly trade:
  - can generate selection into exporting even with just iceberg transport costs;
  - trade does not completely integrate markets; bigger markets attract more firms and induce a "tougher" competitive environment;
  - unilateral vs. multilateral liberalization.

Bernard, Eaton, Jensen, and Kortum (2003)

- BEJK) develop an alternative model of firm heterogeneity along the lines of the model of comparative advantage of Eaton and Kortum (2002).
- There exist a fixed set of goods in the world economy and firms compete worldwide to supply these goods
  - as a result, some firms may be productive enough to service their domestic economy, but not productive enough to export.
- Unlike in the original Eaton and Kortum paper, BEJK introduce Bertrand competition, which leads to endogenous markups.
- The salient results from the their model are that:
  - even without fixed export costs, the model delivers a link between efficiency and measured productivity (more efficient producers have a relatively high cost advantage over their closest competitors and can charge higher markups);
  - more efficient producers tend to charge lower prices and tend to be bigger even in their domestic market (this is because more efficient producers are also more likely to have more efficient rivals and are therefore forced to charge lower prices);
  - more efficient producers are more likely to beat out rivals in foreign markets, and are thus more likely to export.