Plants and Productivity in International Trade

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Overview

Aim of the paper

A model of **International Trade** to analyze the **Producer Level**

Three Crucial Elements:

- Heterogeneity of Plants
- Coexistence of exporters and purely domestic producers
- Imperfect Competition with variable markups

Literature

- Empirical literature examining international trade at the level of individual producers
- Alternative to Melitz (2003) theoretical model
- **Ricardian model** $\longrightarrow$ Dornbusch, Fischer, Samuelson (1977)
- **Extension to N countries**$\longrightarrow$ Eaton and Kortum (2002)

$\Rightarrow$ **Imperfect Competition**

Exporter Facts

- 14% of US manufacturing production is exported
- Only 21% of all plants report exports
- Even exporting plants sell mostly at home
- On average exporting plants are much bigger

Exporter Facts continued

- Exporting not an industry phenomenon
- Large productivity differences within industries
- Higher Productivity among exporters
- Factor intensity even less informative about the productivity advantage of exporters than industry

Basic Setup

- N countries
- continuum of goods $j \in [0, 1]$
- Constant elasticity of substitution $\sigma > 0$

Demand

Expenditure on good j in country n:

$$X_n(j) = x_n \left(\frac{P_n(j)}{p_n} \right)^{1-\sigma} \tag{1}$$

where

- $P_n(j)$ is the price of good j in country n
- x_n total expenditure
- $p_n = \left[\int_0^1 P_n(j)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$ price index for country n

Production and Transportation

- The k'th most efficient producer of good j in country i can convert on bundle of input into a quantity $Z_{ki}(j)$
- Iceberg assumption on transportation costs: $d_{ni} \geq 1$

Triangle Inequality on geographic barrier parameters:

$$d_{ni} \leq d_{nk} d_{ki}, \forall k \tag{2}$$

Production and Transportation continued

- Inputs are mobile within countries, but not between countries
- w_i is the cost of an input bundle in country i

The k'th most efficient producer of good j in country i can export one unit of output to country n at cost:

$$C_{kni}(j) = \left(\frac{w_i}{Z_{ki}(j)} \right) d_{ni} \tag{3}$$

Under perfect competition:

$$C_{1n}(j) = \min_i \{C_{1ni}(j)\} \tag{4}$$

Bertrand Competition

- Each market is served by the lowest cost supplier of each good j
- Constrained not to charge more than the second-lowest cost of supplying the market

$$C_{2n}(j) = \min_i \left\{ C_{2ni^\star}(j), \min_{i \neq i^\star} C_{1ni}(j) \right\} \tag{5}$$

The price of good j in market n:

$$P_n(j) = min\left\{ C_{2n}(j), \bar{m} C_{1n}(j) \right\} \tag{6}$$

A Probabilistic Formulation

Need to know $Z_{1i}(j)$ and $Z_2(j) \Rightarrow$ random variables drawn from probability distributions (eg Frechet)
Joint distribution of $Z_{1i}(j)$ and $Z_{2i}(j)$:

$$F_i(z_1, z_2) = Pr[Z_{1i} \leq z_1, Z_{2i} \leq z_2] = [1 + T_i(z_2^{-\theta} - z_1^{-\theta})]e^{-T_i z_2^{-\theta}} \tag{7}$$

for $0 \leq z_2 \leq z_1$

- $\theta > 1$, governs gains from trade due to comparative advantage
- T_i governs absolute advantage

Probabilistic Formulation continued

The joint distribution of the lowest cost C_{1n} and second lowest cost C_{2n}

$$G_n(c_1, c_2) = Pr[C_{1n} \leq c_1, C_{2n} \leq c_2] = 1 - e^{-\Phi_n c_1^\theta} - \Phi_n c_1^\theta e^{-\Phi_n c_2^\theta} \tag{8}$$

for $c_1 \leq c_2$, where the cost parameter Φ_n:

$$\Phi_n = \sum_{i=1}^{N} T_i (w_i d_{ni})^{-\theta} \tag{9}$$

Analytic Results

- The probability π_{ni} that country i is the low cost supplier to n for any particular good is just i's contribution to the cost parameter Φ_n:

$$\pi_{ni} = T_i(w_i d_{ni})^{-\theta}/\Phi_n \tag{10}$$

- The distribution $G_n(c_1, c_2)$ applies not only to the first- and second-lowest costs of supplying a good to country n regardless of source, but also to those costs conditional on the nationality of the low-cost supplier

Analytic Results continued

- The markup $M_n(j) = P_n(j)/C_{1n}(j)$ is the realization of a random variable M_n drawn from a Pareto distribution truncated at the monopoly markup:

$$H_n(m) = Pr[M_n \leq m] = \begin{cases} 1 - m^{-\theta} & 1 \leq m < \overline{m} \\ 1 & m \geq \overline{m} \end{cases} \quad (11)$$

- Assuming $\sigma < 1 + \theta$, the exact price index in country n implied by (1)is:

$$p_n = \gamma \Phi_n^{-1/\theta} \quad (12)$$

Analytic Results continued

- The share that country n spends on goods from country i is also the fraction of goods it purchases from there:

$$\frac{x_{ni}}{x_n} = \pi_{ni} \tag{13}$$

  This relationship provides the link between the model and data on aggregate bilateral trade
- The share of variable costs in aggregate revenues is $\theta/(1+\theta)$. This share applies to the set of active producers in any source country i

Efficiency and Measured Productivity

- Comparisons of measured productivity across plants reflect only differences in their markups
- conditional on a level of efficiency z_1, the distribution of the markup is:
  $H_n(m|z_1) = Pr[M_n \leq m|z_1] =$
  $$\begin{cases} 1 - e^{-\Phi_n w 1^{-\theta}(m^{\theta}-1)} & 1 \leq m < \overline{m} \\ 1 & m \geq \overline{m} \end{cases}$$
- A plant with a higher efficiency is likely to have a higher markup as well

Efficiency and Exporting

Consider the best potential producer of good j from country i:

- In order to sell **at home**, $Z_{1i}(j)$ must satisfy:
  $Z_{1i}(j) \geq Z_{1k}(j)\frac{w_i}{w_k d_{ik}} \forall k \neq i$
- But to sell in some **other market n**:
  $Z_{1i}(j) \geq Z_{1k}(j)\frac{w_i d_{ni}}{w_k d_{nk}} \forall k \neq i$

$\Rightarrow$ Variation in underlying efficiency explains the coexistence of exporting plants and plants that sell only to the domestic market

Efficiency and Size

Exporting plants tend to have higher domestic sales than plants that don't export:

- Greater efficiency raises the probability of exporting **and** it will likely result in a lower domestic price
- for $\sigma > 1$ lower prices translate into more spending

Quantification

- Fitting the model to bilateral trade among the US and 46 major trade partners
- Simulation Approach
- Reformulation of the model as an algorithm, which uses data on aggregate trade shares and expenditures to simulate plant level statistics
- Estimation of the two heterogeneity parameters θ and σ to make the simulated data match the actual productivity advantage of exporters
- Report how well the other moments of the simulated data line up with the remaining facts discussed in section 1

General Equilibrium

- Assume that there is a tradable nonmanufactured good produced in each country n competitively with labor productivity W_n which serves as numeraire
- The manufacturing sector in country n thus faces an elastic labor supply at wage W_n
- Given wages, manufacturing price levels in different countries are connected through trade in intermediates

Counterfactuals

Consider two aggregate shocks to the world trading regime:

1. A 5% world-wide decline in geographic barriers
   - Productivity measure increases by 4.7%
   - Over 3% of US plants exit
   - Net job loss is 1.3%
2. A 10% exogeneous appreciation of the US wage relative to wages in other countries
   - measured US manufacturing productivity rises by 4.2%
   - Together substitution, reallocation and exit generate a 13% fall in manufacturing employment

Criticism

- Distribution of markups invariant to country characteristics and geographic barriers (Melitz and Ottaviano)
- No international trade barriers
- Homogeneous labor
- No industry specific parameters
- No dynamics

Possible Extensions

- Trade policies
- Exports vs FDI (Helpman, Melitz, Yeaple)
- Productivity growth of exporters vs purely domestic producers (Bernard, Jensen)
- Export destinations (Eaton, Kortum, Kamarz)
- Small Economy Case

Conclusion

- Combination of Micro and Macro level data
- Explains the coexistence of exporters and purely domestic producers
- Many extensions possible

Questions, Comments, Criticism?

Reference

Bernard, Eaton Kortum 'Plants and Productiviy in International Trade' American Economic Review, September 2003