Per Capita Income, Market Access Costs, and Trade Volumes

Alexander Tarasov

Penn State University

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What do we learn from trade data?

- After controlling for aggregate income, countries with higher per capita income trade more (Hummels and Klenow (2002)).
- There are a number of zeros in bilateral trade flows.
- Both variable and fixed costs of trade are important.
  - Fixed costs can explain the many zeros in bilateral trade flows (Anderson and Wincoop (2004)).

What does theory suggest?

- Existing quantitative general equilibrium models of trade do not square all those features of the data.
What this work does

A general equilibrium model of trade that qualitatively and *quantitatively* captures the features of the data discussed:

- An association between the cost of access to foreign markets (fixed costs of trade) and country development level
- An estimation procedure: separate effects of variable and fixed costs of trade are identifiable
  - difference between actual and simulated bilateral trade volumes is minimized
  - the restriction: the number of zeros in the sample
Theory:

- Lower fixed costs of trade *relative* to other costs $\implies$ greater trade volumes

- If more developed countries have lower relative fixed costs of trade, then they export and import more
Empirics:

- Parameter estimates reveal a strong relationship between fixed costs of exporting and country development level.
- This relationship helps to explain many zero trade flows in the data.
- Simulated trade elasticities w.r.t. total income and income per capita are close to those in the data.
- Aggregate spending on access to foreign markets on average constitutes around the half of the total export profits (EKK (2008)).
The Model

A variation of the Melitz model of trade with firm heterogeneity and monopolistic competition:

- $N$ asymmetric countries
- Labor is the only factor of production
- Free entry into the industry (there is one "average" industry)
- Each firm produces a distinct variety of a differentiated good
- Variable and fixed costs of trade
The Model

Sequence of Actions

1. A continuum of ex-ante identical potential entrants
2. To enter into the industry, firms have to pay the cost of entry (the cost of a prototype or paper work)
3. After incurring the cost of entry, a firm specific productivity $\theta (\sim G(\theta) \text{ on } [\theta_L, \theta_H])$ is realized $\implies$ firm heterogeneity
4. Decision about serving a certain market $j$ is made
The Model

Consumption and Production

- A representative consumer in country $j$ maximizes
  \[ Q_j = \left( \int_{\omega \in \Omega_j} q_j^{\sigma-1} (\omega) d\omega \right)^{\frac{\sigma}{\sigma-1}}. \]

- Productivity of a firm in country $i$: $\theta Z_i$ ($Z_i$ is country $i$ development level)

- Given the demand function:
  \[ \pi_{ij}(\theta) = C \left( \frac{Z_i}{w_i \tau_{ij}} \right)^{\sigma-1} \frac{w_j L_j}{P_j^{1-\sigma}} \theta^{\sigma-1}, \]

where $\tau_{ij}$ ($\tau_{ii} = 1$) is iceberg transportation costs from $i$ to $j$ and $C = \frac{1}{\sigma} \left( \frac{\sigma-1}{\sigma} \right)^{\sigma-1}$. 


The Model

Trade Volumes

- Fixed costs of trade $\implies$ only most productive firms find it profitable to export
- The cutoff $\theta_{ij}$ solves
  \[
  \pi_{ij}(\theta_{ij}) = f_{ij} \iff \theta_{ij} = \frac{w_i}{Z_{ij}} \tau_{ij} \left( \frac{1}{C} \frac{P^1_j}{w_jL_j} \right) \frac{1}{\sigma-1} f_{ij}^{\frac{1}{\sigma-1}}
  \]
- The total value of exports from country $i$ to country $j$ is given by
  \[
  X_{ij} = M_{ei} \int_{\theta_{ij}}^{\theta_H} r_{ij}(\theta) \, dG(\theta).
  \]
The Model

Market Access Costs

A *novel* approach for the construction of fixed costs:

\[
 f_{ij} = \begin{cases} 
 w_i f_d + w_i \frac{f_x}{Z_i^\delta}, & \text{if } j \neq i, \\
 w_i f_d, & \text{otherwise}. 
\end{cases}
\]

where $\delta$ describes how the country specific development level $Z_i$ affects the fixed costs of exporting.

The cost of entry in country $i$:

\[
 f_{ei} = w_i f_e.
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The Model

Equilibrium

Given \( \{ f_d, f_x, \delta, f_e, \tau_{ij}, \sigma, G(\cdot), Z_i, L_i \}_{i,j=1..N} \) and the consumer preferences, an equilibrium is \( \{ p_{ij}(\theta), P_i, M_{ei}, \theta_{ij}, w_i \}_{i,j=1..N} \) that satisfies:

1) Given the demand function, \( \{ p_{ij}(\theta) \}_{i,j=1..N} \) are determined by the firm maximization problem

2) \( \{ P_i \}_{i=1..N} \) is the set of CES price indexes

3) Expected profits of a given firm are equal to zero: free entry condition

4) \( \{ \theta_{ij} \}_{i,j=1..N} \) satisfy the zero profit condition

5) Trade is balanced
The Model

Equilibrium

- The set \( \{ w_i, P_i, M_{ei}\}_{i=1..N} \) is sufficient to determine all other endogenous variables in the model.

- To find the equilibrium, we need to solve:

\[
\begin{align*}
P_i^{1-\sigma} &= \sum_{j=1}^{N} M_{ej} \int_{\theta_{ji}}^{\theta_{ji}} p_{ji}^{1-\sigma}(\theta) dG(\theta), \\
\sum_{j=1}^{N} M_{ei} \int_{\theta_{ij}}^{\theta_{ij}} r_{ij}(\theta) dG(\theta) &= \sum_{j=1}^{N} M_{ej} \int_{\theta_{ij}}^{\theta_{ij}} r_{ji}(\theta) dG(\theta),
\end{align*}
\]

where \( p_{ij}(\theta), \pi_{ij}(\theta), r_{ij}(\theta), \) and \( \theta_{ij} \) are expressed in terms of \( \{ w_i, P_i, M_{ei}\}_{i=1..N} \).
The Model

Cross-Country Comparison: Setting

- Two countries: \( Z_1, Z_2, L_1, \) and \( L_2 \) are such that \( Z_1 > Z_2 \) \( \iff \) \( w_1 > w_2 \), \( L_1 < L_2 \), and \( w_1 L_1 = w_2 L_2 \) in the equilibrium.

- The countries are geographically symmetric with respect to the rest of the world; i.e., \( \tau_{1j} = \tau_{2j} \) and \( \tau_{j1} = \tau_{j2} \) for all \( j > 2 \).

- \( \tau_{12} \) and \( \tau_{21} \) are such that the countries do not trade with each other in the equilibrium.
Proposition

If $\delta > 0$, then country 1 has higher trade to GDP ratio in the equilibrium.

Intuition

Remember:

$$ f_{ij} = \begin{cases} 
  w_i f_d + w_i \frac{f_X}{Z_i}, & \text{if } j \neq i, \\
  w_i f_d, & \text{otherwise}
\end{cases} $$

$$ f_{ei} = w_i f_e $$

If $\delta > 0$, firms in country 1 face lower fixed costs of trade relative to the other fixed costs (since $Z_1 > Z_2$).
Estimation/Calibration

Data

Sample: the hundred largest countries in terms of GDP (for 1995)

- Total income and population size: World Bank (2007)
- Cultural and geographical trade barriers: Centre d’Etudes Prospectives et d’Informations Internationales (2005)
The distribution of firm productivities (Helpman, Melitz and Rubinstein (2007), Johnson (2007)):

\[ G(\theta) = \frac{1}{\theta^k_L} - \frac{1}{\theta^k} \quad \text{on} \quad [\theta_L, \theta_H], \]

where \( \infty \geq \theta_H > \theta_L > 0 \) and \( k > \sigma - 1 \).

Variable trade costs:

\[ \tau_{ij} = 1 + \gamma_0 D_{ij}^{\gamma_1} B_{ij}^{\gamma_2} LNG_{ij}^{\gamma_3} NAF_{ij}^{\gamma_4} EU_{ij}^{\gamma_5} \quad \text{for} \quad j \neq i. \]
Estimation

Parameters

The set of parameters in the model:

\[ \{ \gamma_0, \gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, f_x, \delta, f_e, f_d, \sigma, k, \theta_L, \theta_H \} . \]

Two types of the parameters:

1. \( \{ f_e, f_d, \sigma, k, \theta_L, \theta_H \} \) are not identifiable from the bilateral trade data and mostly taken from the previous literature

2. \( \{ \gamma_0, \gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, f_x, \delta \} \) are estimated
BEJK (2003), Broda and Weinstein (2006): $\sigma = 3.8$

- The firm productivity distribution:
  - Ghironi and Melitz (2004), Bernard, Redding and Schott (2007): $k = 3.4$
  - $\theta_L = 1$
  - $\theta_H = 20$

- Helpman, Melitz and Rubinstein (2007): $f_d$ is fixed at zero

- $f_e$ is normalized to unity
Estimation

Estimation Procedure

- Denote $\Theta = \{\gamma_0, \gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, f_x, \delta\}$
- For given $\Theta$ and $\{Z_i, L_i\}_{i=1..N}$ we can generate bilateral trade flows: $X_{ij}(Z, L, \Theta)$
- $\hat{\Theta}$ is the solution of

$$\min_{\Theta} \sum_{i,j:i \neq j} \left( X_{ij}^o - X_{ij}(Z, L, \Theta) \right)^2$$

subject to

$$\Psi(Z, L, \Theta) = 0,$$

where $\Psi(Z, L, \Theta)$ stands for the difference between the simulated and the actual number of zeros.
The Model

Estimation

Estimation Procedure: Development Levels

- \{Z_i\}_{i=1..N} are not observable
  - from the equilibrium equations: \( w = w(Z, L, \Theta) \) \( \implies \) by inverting this function: 
    \[ Z = Z(w, L, \Theta) \]

- \( \hat{\Theta} \) is the solution of

  \[
  \min_{\Theta} \sum_{i,j:i\neq j} (X_{ij}^0 - X_{ij}(Z(w, L, \Theta), L, \Theta))^2
  \]

  subject to 

  \[
  \Psi(Z(w, L, \Theta), L, \Theta) = 0.
  \]
Estimation

Results: Estimates

Table: Parameter Estimates

<table>
<thead>
<tr>
<th>$\gamma_0$</th>
<th>$\gamma_1$</th>
<th>$\gamma_2$</th>
<th>$\gamma_3$</th>
<th>$\gamma_4$</th>
<th>$\gamma_5$</th>
<th>$f_x$</th>
<th>$\delta$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.49</td>
<td>0.14</td>
<td>0.76</td>
<td>0.97</td>
<td>0.78</td>
<td>0.94</td>
<td>2.15</td>
<td>0.67</td>
<td>81%</td>
</tr>
</tbody>
</table>

- $\delta > 0$: a strong association between fixed costs of trade and development level
- The percentage of "true" zeros is 35% (9% in the benchmark model!)
### Estimation

**Results: Trade Elasticities**

<table>
<thead>
<tr>
<th>Estimator:</th>
<th>Data (OLS)</th>
<th>Model (OLS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable:</td>
<td>$\ln T_i$</td>
<td>$\ln T_i(\hat{\theta})$</td>
</tr>
<tr>
<td>Log of GDP</td>
<td>0.85**</td>
<td>0.69**</td>
</tr>
<tr>
<td>(0.03)</td>
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<td></td>
</tr>
<tr>
<td>Log of GDP per capita</td>
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<td>0.22**</td>
</tr>
<tr>
<td>(0.04)</td>
<td>(0.02)</td>
<td></td>
</tr>
<tr>
<td>The percentage of &quot;true&quot; zeros:</td>
<td>100%</td>
<td>35%</td>
</tr>
<tr>
<td>Observations:</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*Table: Trade Elasticities and Zeros*
Results: the Magnitude of Fixed Costs of Trade

- The ratio of the aggregate fixed costs of exporting to the aggregate export profits:
  \[
  FC_{Ri} = \frac{M_{ei} \sum_{j \neq i}^N (1 - G(\theta_{ij})) f_{ij}}{M_{ei} \sum_{j \neq i}^N \int_{\theta_{ij}}^{\theta_{ij}} \pi_{ij}(\theta) dG(\theta)}
  \]

- The ratios vary from 0.32 (for Iceland) to 0.64 (for India) with the mean equal to 0.45
  - the total costs of access to foreign markets on average constitute around the half of the total export profits
  - similar result is established in EKK (2008)
### Estimation

#### Results: the Benchmark Model

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<td>0.04</td>
<td>0.31</td>
<td>0.75</td>
<td>0.82</td>
<td>0.72</td>
<td>1.06</td>
<td>122.7</td>
<td>0</td>
<td>73%</td>
</tr>
</tbody>
</table>

- $R^2$ falls from 81% to 73%
- The percentage of "actual" zeros is only 9%! 
# Estimation/Calibration

## Results: Comparison

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<tr>
<th>Dependent variable:</th>
<th>Data</th>
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<th>Model ($\delta = 0$)</th>
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Concluding Remarks

This paper:

- separate effects of per capita income and population size on trade volumes
- the estimation procedure controls for different effects of variable and fixed costs of trade on trade volumes and trade zeros

Future research:

- the model underestimates trade volumes of large population countries
  - a homogenous good (or the second industry) \(\Rightarrow\) the trade elasticities and differences in factor endowments