Trade Liberalization and Endogenous Quality Choice in Food and Agricultural Trade

Jihyun Eum and Ian Sheldon

Selected Paper prepared for presentation at the International Agricultural Trade Research Consortium’s (IATRC’s) 2016 Annual Meeting: Climate Change and International Agricultural Trade in the Aftermath of COP21, December 11-13, 2016, Scottsdale, AZ.

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Jihyun Eum and Ian Sheldon

Dept. of Agricultural, Environmental and Development Economics
Ohio State University

IATRC 2016 Annual Meeting, Scottsdale AZ
Introduction

- Trade standards exist to protect safety and environment: importance of food safety and its quality has been emphasized

- Stylized facts
  - Hidden causes and consequences of international trade at country-level can be interpreted with firm heterogeneity
  - Differences in productivity among firms causes changes in trade participation

- Literature review
Research Question and Contribution

- Illustrate heterogeneous firm trade model with endogenous quality choice
- Estimate model with agricultural and food trade data
  - Evaluate the determinants of bilateral trade
  - Analyze the effect of food safety standards as a fixed trade cost
- Contribution
  - Introduce the impact of selection into exporting with consideration of product quality in agricultural and food trade
  - Advanced standards data: World Integrated Trade Solution (WITS) and Integrated Trade Intelligence Portal (I-TIP) from WTO
Theoretical Background

Preferences

\[ U = \left[ \int_{\omega \in \Omega} (q(\omega)x(\omega))^{(\sigma - 1)/\sigma} d\omega \right]^{\sigma/((\sigma - 1)} \quad \text{where} \quad \sigma > 1 \quad (1) \]

\[ x(\omega) = p(\omega)^{-\sigma} q(\omega)^{\sigma - 1} A \quad \text{where} \quad A = EP^{\sigma - 1} \quad (2) \]

- P is aggregated price index
- E is aggregated consumption

Firms are heterogeneous in (1) productivity (a) and (2) product quality (q)

- J countries, Nj firms under monopolistic competition
- Marginal cost of production: \( \frac{c_j}{a} \)
- Firms choose optimal domestic price(\( p_j \)) and export price(\( p_{ij}^x \))

\[ p_j = \frac{\sigma}{\sigma - 1} (c_j / a) \quad \& \quad p_{ij}^x = \frac{\sigma}{\sigma - 1} \frac{c_j \tau_{ij}}{a} \]
Theoretical Background

- Productivity and quality are linked as below (Baldwin and Harrigan, 2011)

\[ q = a^{\theta - 1} \quad \text{where} \quad \theta - 1 > 0 \]

\( \theta - 1 \) is “quality elasticity” or “scope for quality differentiation”

- Profit and zero-profit condition

\[
\pi_{ij}(a) = \frac{1}{\sigma} \left( \frac{\sigma}{\sigma - 1} \right)^{1-\sigma} \left( \frac{\tau_{ij} C_j}{a^{\theta} P_i} \right)^{(1-\sigma)} E_i - f_{ij}
\]

Effect of fixed and variable trade cost: Both depends on parameter \( \theta \)

- Positive if \( \theta > 1 \),

\[
\frac{\partial a_{ij}^*}{\partial f_{ij}} = \frac{1}{\theta (\sigma - 1)} f_{ij}^{(1/\sigma - 1)} \left[ \frac{1}{\sigma - 1} \left( \frac{\tau_{ij} C_j}{E_i} \right)^{1/(\sigma - 1)} \frac{P_i}{P_j} \right]^{1/\theta} > 0
\]

\[
\frac{\partial a_{ij}^*}{\partial \tau_{ij}} = \frac{1}{\theta} \tau_{ij}^{(1/\theta) - 1} \left[ \left( \frac{1}{\sigma - 1} \right) \left( \frac{\sigma f_{ij}}{E_i} \right)^{1/(\sigma - 1)} \left( \frac{c_j}{P_i} \right) \right]^{1/\theta} > 0
\]
Comparative Statistics Results

- Productivity “a” follows pdf $g(a)$ and cdf $G(a)$: assume truncated Pareto distribution $[a_L, a_H]$
- Cut-off productivity $a_{ij}^*$ where $\pi_{ij}(a_{ij}^*) = 0$
- Trade volume
  \[
  V_{ij} = \begin{cases} \int_{a_{ij}^*}^{a_H} a^{(\sigma - \theta)} dG(a), & \text{for } a_{ij}^* \leq a_H \\ 0, & \text{otherwise} \end{cases}
  \]  (4)
  Then, trade value
  \[
  M_{ij} = \left( \frac{\sigma}{\sigma - 1} \right)^{1-\sigma} \left( \frac{C_j \tau_{ij}}{P_i} \right)^{1-\sigma} E_i N_j V_{ij}
  \]  (5)
- Use trade value to infer the relationship between trade costs and cutoff productivity
  \[
  \frac{\partial M_{ij}}{\partial \tau_{ij}} = -\sigma^{1-\sigma} (\sigma - 1)^\sigma \left( \frac{C_j \tau_{ij}}{P_i} \right)^{-\sigma} \tau_{ij}^{-\sigma} E_i N_j V_{ij} < 0
  \]
  \[
  \frac{\partial M_{ij}}{\partial \tau_{ij}} = \frac{\partial M_{ij}}{\partial a_{ij}^*} \frac{\partial a_{ij}^*}{\partial \tau_{ij}} < 0
  \]
Empirical estimation

- Two-stage estimation (Helpman et al., 2008)
- Disaggregated product-importer-exporter level

1. Selection equation

\[ \rho_{hij} = Pr(T_{hij} = 1) = \Phi(\xi^*_j + \xi^*_h + \gamma^*_1 \ln DIST_{ij} + \gamma^*_2 ADJ_{ij} + \gamma^*_3 COMLANG_{ij} + \gamma^*_4 \ln RTA_{ij} + \kappa^*_1 Gov_i + \kappa^*_2 SPS_{hij}) \]  

2. Trade equation

\[ \ln m_{hij} = \psi_0 + \psi_{ih} + \psi_{jh} + \gamma_1 \ln DIST_{ij} + \gamma_2 ADJ_{ij} + \gamma_3 COMLANG_{ij} + \gamma_4 \ln RTA_{ij} + \ln(\exp[\delta(\hat{z}^*_{hij} + \hat{\lambda}^*_{hij}) - 1]) + \beta_{u\eta} \hat{\lambda}^*_{hij} + e_{hij} \]  

where \[ \beta_{u\eta} \equiv \text{corr}(u_{hij}\eta_{hij})/(\sigma_u/\sigma_\eta) \]

\[ \ln(\exp[\delta(\hat{z}^*_{hij} + \hat{\lambda}^*_{hij}) - 1]) : \text{correct for absence of extensive margin ( # of exporting firms through expected probability) } \]

\[ \hat{\lambda}^*_{hij} : \text{inverse Mills Ratio for correcting sample selection error} \]
Data

- Cross section data for 2012
- Food and agricultural product trade value and quantity data from FAO, trade cost data from CEPII, standards data from Worldbank and WTO
  - Exclusion restrictions should determine probability of exporting but not affect trade value
    - Governance indicators: quality of regulations, governmental efficiency, rule of law (Worldbank)
    - Sanitary and phytosanitary standards (SPS) data from WITS and I-TIP
## Estimation Results

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>PPML</th>
<th>Probit (Mij&gt;0)</th>
<th>Hetero firm NLS</th>
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<tr>
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<td>-0.358***</td>
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<td>SPS</td>
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<td>279,799</td>
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Clustered robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
Estimation Results

- Estimates follow theoretical expectation
  - Trade determinants (distance, adjacency, language)
  - SPS negatively influence trade flows
- Conventional gravity model estimation would be biased upward
- By introducing non-linear coefficient delta and inverse Mills ratio, coefficients of trade determinants become consistent
Conclusion

- Effect of trade costs depend on “scope for quality differentiation”
  - Product quality as well as firm productivity are determinants of export threshold
  - Increasing in trade costs reduces extensive margin by increasing export threshold
- Empirical evidence supports argument that fixed costs, SPS, negatively affect probability exporting
  - Ignoring control of heterogeneity and sample selection leads to bias in estimating effect of variable trade cost
Appendix: Selection equation

- Latent variable

\[ Z_{hij} \equiv \frac{1}{\sigma} \left( \frac{\sigma}{\sigma-1} \right)^{1-\sigma} \left( \tau_{hij} c_{hj} a^{-\theta} \right)^{1-\sigma} E_{hi} P_{hi}^{-\sigma-1} \]

\[ = \left( \frac{a_{hij}}{a_L} \right)^{-\theta(1-\sigma)} \tag{8} \]

- Ratio of export profit to fixed cost

- The reduced from of selection equation

\[ \ln z_{hij} = \xi_0 + \xi_{hi} + \xi_{hj} - \gamma d_{hij} - \kappa \phi_{hij} + \eta_{hij} \tag{9} \]

\[ (1 - \sigma) \ln \tau_{hij} = \gamma d_{hij} + u_{hij} \quad \& \quad \ln(f_{hij}) = \vartheta_{hi} + \vartheta_{hj} + \kappa \vartheta_{hij} + v_{hij} \]

\[ \eta_{hij} \sim N(0, \sigma_u^2 + \sigma_v^2) \]

- Since \( z_{hij} \) is not observed directly, we set up indicator function \( T_{hij} \)

\[ \rho_{hij} = Pr(T_{hij} = 1 | \text{observed variables}) = Pr(T_{hij} = 1 | \xi_0 + \xi_{hi} + \xi_{hj} - \gamma d_{hij} - \kappa \phi_{hij} > -(v_{hij} + u_{hij}) \tag{10} \]

\[ \Phi(\xi_0^* + \xi_{hi}^* + \xi_{hj}^* - \gamma^* d_{hij} - \kappa^* \phi_{hij}) = \Phi(z_{hij}^*) = \Phi(X_{hij} \vartheta^*) \]

* indicates estimates divided by the standard deviation of \((v_{hij} + u_{hij})\)
Appendix: Selection equation

\[ M_{hij} = \left( \frac{c_{hj} \tau_{hij}}{P_{hi}} \right)^{1-\sigma} E_{hi} N_{hj} V_{hij} \]

where \[ V_{hij} = \frac{ka_{k}^{k-\theta(1-\sigma)}}{k - \theta(1 - \sigma)(a_{H}^{k} - a_{L}^{k})} W_{hij} \]

\[ W_{hij} \text{ indicates } \max \left\{ \left( \frac{a_{hij}}{a_{L}} \right)^{k-\theta(1-\sigma)} - 1, 0 \right\} \]

Therefore \[ \ln m_{hij} = \psi_{0} + \psi_{ih} + \psi_{jh} + \gamma \ln d_{hij} + w_{hij} + u_{hij} \]

- Since \( Z_{hij} = \frac{a_{hij}}{a_{L}} - \theta(1-\sigma) \rightarrow W_{hij} = Z_{hij}^{k-\theta(1-\sigma)}/\theta(1-\sigma) - 1 \)

\[ \hat{w}_{hij} = \ln(\exp\left[\delta(\hat{z}_{hij}^* + \lambda_{hij}^*) - 1\right]) \quad \hat{\eta}_{hij} = \phi(\hat{z}_{hij}^*)/\Phi(\hat{z}_{hij}^*) \quad \hat{z}_{hij}^* = \hat{z}_{hij} + \eta_{hij}^* \]

\( \delta = \sigma_{\eta}(k - \theta(1 - \sigma))/\theta(1 - \sigma) \)

- Trade equation

\[ \ln m_{hij} = \psi_{0} + \psi_{ih} + \psi_{jh} + \gamma_{1} \ln DIST_{ij} + \gamma_{2} ADJ_{ij} + \gamma_{3} COMLANG_{ij} + \gamma_{4} \ln RTA_{hij} + \ln(\exp[\delta(\hat{z}_{hij}^* + \hat{x}_{hij}^*) - 1]) + \beta_{un} \hat{\lambda}_{hij} + e_{hij} \]  

(11)
Appendix: Trade equation

Trade equation

\[ \ln m_{hi} = \psi_0 + \psi_{ih} + \psi_{jh} + \gamma_1 \ln \text{DIST}_{ij} + \gamma_2 \text{ADJ}_{ij} + \gamma_3 \text{COMLANG}_{ij} + \gamma_4 \ln \text{RTA}_{hi} + \ln (\exp[\delta(\hat{z}^*_{hi} + \hat{\lambda}^*_{hi}) - 1]) + \beta_u \eta \hat{\lambda}_{hi} + e_{hi} \]

(12)

\[ \delta = \sigma_\eta (k - \theta (1 - \sigma))/\theta (1 - \sigma) \]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elasticity of substitution ((\sigma))</td>
<td>3.38(^1)</td>
<td>Bernard et al. (2003)</td>
</tr>
<tr>
<td>Shape of parameter of the Pareto productivity distribution ((k))</td>
<td>4</td>
<td>Bernard, Redding, Schott (2009)</td>
</tr>
<tr>
<td>Quality parameter ((\theta))</td>
<td>1.335 (\bar{1}.420)</td>
<td>Crino and Epifani (2010)</td>
</tr>
</tbody>
</table>

\(^1\) Geometric mean of sigma for agricultural and food industries (SITC 001 112)
Appendix: Robustness check

- Non parametric estimation to control joint normality assumption

<table>
<thead>
<tr>
<th></th>
<th>Hetero firm NLS</th>
<th>Indicator Variables (50 bin)</th>
<th>Indicator Variables (100 bin)</th>
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</thead>
<tbody>
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<td>-0.972***</td>
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<td>(0.090)</td>
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<td>ADJ</td>
<td>0.372**</td>
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<td>0.493</td>
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<td>0.6108</td>
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