Trade Liberalization and Endogenous Quality Choice in Food and Agricultural Trade

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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
  - Trade liberalization and quality sorting: Amiti and Khandelwal (2013), Fan et al. (2014)
  - Endogenous quality choice model: Baldwin and Harrigan (2011), Johnson(2012), Kugler and Verhoogen (2012)

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

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

$$x(\omega) = p(\omega)^{-\sigma} q(\omega)^{(\sigma-1)} A \quad where \quad A = EP^{(\sigma-1)} \tag{2}$$

  - P is aggregated price index
  - E is aggregated consumption
- Firms are heterogeneous in (1) productivity (a) and (2) product quality (q)
  - J countries, N_j 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)

$$q = a^{\theta-1} \quad where \quad \theta - 1 > 0$$

$\theta - 1$ is "quality elasticity" or "scope for quality differentiation"

- Profit and zero-profit condition

$$\pi_{ij}(a) = \frac{1}{\sigma}(\frac{\sigma}{\sigma-1})^{1-\sigma}(\frac{\tau_{ij}c_j}{a^{\theta}P_i})^{(1-\sigma)}E_i - f_{ij} \tag{3}$$

- Effect of fixed and variable trade cost : Both depends on parameter θ
  - Positive if $\theta > 1$,

$$\frac{\partial a^*_{ij}}{\partial f_{ij}} = \frac{1}{\theta(\sigma-1)} f_{ij}^{\frac{1}{\theta(\sigma-1)}-1}[\frac{1}{\sigma-1}(\frac{\sigma}{E_i})^{1/(\sigma-1)}\frac{\tau_{ij}c_j}{P_i}]^{1/\theta} > 0$$

$$\frac{\partial a^*_{ij}}{\partial \tau_{ij}} = \frac{1}{\theta}\tau_{ij}^{(1/\theta)-1}[(\frac{1}{\sigma-1})(\frac{\sigma f_{ij}}{E_i})^{1/(\sigma-1)}(c_j/P_i)]^{1/\theta} > 0$$

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

$$V_{ij} = \begin{cases} \int_{a_{ij}^*}^{a_H} a^{(\sigma-\theta)} dG(a), & \text{for } a_{ij}^* \leq a_H \\ 0, & \text{otherwise} \end{cases} \tag{4}$$

  Then, trade value

$$M_{ij} = (\frac{\sigma}{\sigma - 1})^{1-\sigma} (\frac{c_j \tau_{ij}}{P_i})^{1-\sigma} E_i N_j V_{ij} \tag{5}$$

- Use trade value to infer the relationship between trade costs and cutoff productivity

$$\frac{\partial M_{ij}}{\partial \tau_{ij}} = -\sigma^{1-\sigma} (\sigma - 1)^{\sigma} (\frac{c_j \tau_{ij}}{P_i})^{-\sigma} \tau_{ij}^{-\sigma} E_i N_j V_{ij} < 0$$

$$\frac{\partial M_{ij}}{\partial \tau_{ij}} = \frac{\partial M_{ij}}{\partial a_{ij}^*} * \frac{\partial a_{ij}^*}{\partial \tau_{ij}} < 0$$

Empirical estimation

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

1. Selection equation

$$\rho_{hij} = Pr(T_{hij} = 1) = \Phi(\xi_j^* + \xi_h^* + \gamma_1^* lnDIST_{ij} + \gamma_2^* ADJ_{ij} + \gamma_3^* COMLANG_{ij} + \gamma_4^* lnRTA_{ij} + \kappa_1^* Gov_i + \kappa_2^* SPS_{hij}) \quad (6)$$

2. Trade equation

$$lnm_{hij} = \psi_0 + \psi_{ih} + \psi_{jh} + \gamma_1 lnDIST_{ij} + \gamma_2 ADJ_{ij} + \gamma_3 COMLANG_{ij} + \gamma_4 lnRTA_{ij} + ln(exp[\delta(\hat{z}_{hij}^* + \hat{\bar{\lambda}}_{hij}^*) - 1) + \beta_{u\eta}\hat{\bar{\lambda}}_{hij}^* + e_{hij} \quad (7)$$

$$where \quad \beta_{u\eta} \equiv corr(u_{hij}\eta_{hij})/(\sigma_u/\sigma_\eta)$$

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

$\hat{\bar{\lambda}}_{hij}^*$: 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

	OLS	PPML	Probit (Mij>0)	Hetero firm NLS
ln Dist	-1.225***	-0.736***	-0.358***	-0.976***
	(0.012)	(0.020)	(0.005)	(0.338)
ADJ	1.014***	0.738***	0.700***	0.372**
	(0.032)	(0.039)	(0.019)	(0.159)
LANG	0.690***	0.349***	0.318***	0.493
	(0.022)	(0.042)	(0.009)	(0.076)
RTA	0.650***	0.963***	0.166***	0.530***
	(0.023)	(0.045)	(0.010)	(0.051)
SPS			-0.075***	
			(0.025)	
Governance			1.178***	
			(0.016)	
Delta				0.598***
				(0.107)
Inv Mills ratio				0.088
				(0.823)
Importer FE	No	No	No	No
Exporter FE	No	No	Yes	No
Product FE	No	No	Yes	No
Importer-product FE	Yes	Yes	No	Yes
Exporter-product FE	Yes	Yes	No	Yes
Observations	106,462	279,799	279,799	106,462
Wald chi2	-	-	73,895	
Adj R-squared	0.5845	-	0.3112	0.6074

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

$$Z_{hij} \equiv \frac{\frac{1}{\sigma}(\frac{\sigma}{\sigma-1})^{1-\sigma}(\tau_{hij}c_{hj}a^{-\theta})^{1-\sigma}E_{hi}P_{hi}^{\sigma-1}}{f_{hij}} = (\frac{a_{hij}}{a_L})^{-\theta(1-\sigma)} \tag{8}$$

- Ratio of export profit to fixed cost
- The reduced from of selection equation

$$lnz_{hij} = \xi_0 + \xi_{hi} + \xi_{hj} - \gamma d_{hij} - \kappa\phi_{hij} + \eta_{hij} \tag{9}$$

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

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

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

$$\rho_{hij} = Pr(T_{hij} = 1|observedvariables) = Pr(T_{hij} = 1|\xi_0 + \xi_{hi} + \xi_{hj} - \gamma d_{hij} - \kappa\phi_{hij} > -(v_{hij} + u_{hij}) \tag{10}$$

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

* indicates estimates divided by the standard deviation of $(v_{hij} + u_{hij})$

Appendix: Selection equation

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

$$where \quad V_{hij} = \frac{k a_L^{k-\theta(1-\sigma)}}{k - \theta(1-\sigma)(a_H^k - a_L^k)} W_{hij}$$

$$W_{hij} \quad indicatesmax \left\{ (\frac{a_{hij}}{a_L})^{k-\theta(1-\sigma)} - 1, 0 \right\}$$

$$Therefore \quad lnm_{hij} = \psi_0 + \psi_{ih} + \psi_{jh} + \gamma lnd_{hij} + w_{hij} + u_{hij}$$

- Since $Z_{hij} = \frac{a_{hij}}{a_L}^{-\theta(1-\sigma)} \longrightarrow W_{hij} = Z_{hij}^{k-\theta(1-\sigma)/\theta(1-\sigma)} - 1$

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

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

- Trade equation

$$\begin{aligned} lnm_{hij} = \psi_0 + \psi_{ih} + \psi_{jh} + \gamma_1 lnDIST_{ij} + \gamma_2 ADJ_{ij} + \gamma_3 COMLANG_{ij} + \\ \gamma_4 lnRTA_{hij} + ln(exp[\delta(\hat{z}^*_{hij} + \hat{\hat{\lambda}}^*_{hij}) - 1) + \beta_{u\eta}\hat{\hat{\lambda}}^*_{hij} + e_{hij} \end{aligned} \tag{11}$$

Appendix: Trade equation

- Trade equation

$$lnm_{hij} = \psi_0 + \psi_{ih} + \psi_{jh} + \gamma_1 lnDIST_{ij} + \gamma_2 ADJ_{ij} + \gamma_3 COMLANG_{ij} + \gamma_4 lnRTA_{hij} + ln(exp[\delta(\hat{z}^*_{hij} + \hat{\bar{\lambda}}^*_{hij}) - 1) + \beta_{u\eta}\hat{\bar{\lambda}}^*_{hij} + e_{hij} \quad (12)$$

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

Parameter	Value	Source
Elasticity of substitution (σ)	3.38[1]	Bernard et al. (2003) Broda and Weinstein (2006)
Shape of parameter of the Pareto productivity distribution (k)	4	Bernard, Redding, Schott (2009)
Quality parameter (θ)	1.335 1̃.420	Crino and Epifani (2010)

[1] Geometric mean of sigma for agricultural and food industries(SITC 001 112)

Appendix: Robustness check

- Non parametic estimation to control joint normality assumption

	Hetero firm	Indicator Variables	
	NLS	(50 bin)	(100 bin)
ln Dist	-0.976***	-1.044***	-0.972***
	(0.090)	(0.023)	(0.034)
ADJ	0.372**	0.563***	0.429***
	(0.174)	(0.046)	(0.068)
LANG	0.493	0.603***	0.547***
	(0.085)	(0.028)	(0.045)
RTA	0.530***	0.510***	0.476***
	(0.062)	(0.025)	(0.046)
Delta	0.598***		
	(0.121)		
Inv Mills ratio	0.088		
	(0.224)		
Importer-product FE	Yes	Yes	Yes
Exporter-product FE	Yes	Yes	Yes
Observations	106,462	106,462	106,462
Wald chi2			
R-squared	0.6074	0.6104	0.6108

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1