ASYMMETRIC TRADE FLOWS AND THEIR IMPLICATIONS FOR COMPETITIVENESS, EFFICIENCY AND TRADE

YOUNGJAE LEE
Department of Agricultural Economics and Agribusiness
Louisiana State University AgCenter
242A Martin D. Woodin Hall
Baton Rouge, LA 70803-5606
Phone: 225-578-2712
Fax: 225-578-2716
E-Mail: YLee@agcenter.lsu.edu

P.LYNN KENNEDY
Department of Agricultural Economics and Agribusiness
Louisiana State University AgCenter
181 Martin D. Woodin Hall
Baton Rouge, LA 70803-5606
Phone: 225-578-2726
Fax: 225-578-2716
E-Mail: LKennedy@agcenter.lsu.edu

Selected Paper prepared for presentation at the 2016 Agricultural & Applied Economics Association Annual Meeting, Boston, Massachusetts, July 31-August 2

Asymmetric Trade Flows and Their Implication for Competitiveness, Efficiency and Trade

Abstract: *The asymmetric trade flow of agricultural goods can serve as a clue to help understand unobservable agricultural competitiveness, infrastructural efficiency for exports, and net openness to imports. In order to identify these three factors from agricultural trade data, we adapt a trade model developed by Eaton and Kortum. Unlike Eaton and Kortum, we interpret specific country dummy variables as proxies representing these three factors. This study makes four important findings. First, agricultural trade flow is strongly related to net openness to imports but less to agricultural competitiveness. Second, agricultural competitiveness is more related to land endowments than economic development. Third, economic development improves infrastructural efficiency for agricultural exports. Finally, existing agricultural import restrictions are shown to be punitive.*

Key words**:** *agricultural competitiveness, gross and net openness to imports, gross competitiveness, infrastructural efficiency.*

JEL codes**:** F11, F13, F14, F18, O19, Q17, Q54.

1. Introduction

Agricultural trade data reveals asymmetric trade flows. Such asymmetry in the flow of goods can be explained through resource endowments, economic development, and market openness. For example, consider two countries; country *L* is a land-locked, land abundant country while country *S* is a small island country. Naturally, country *L* is more efficient in producing agricultural products than is country *S* while country *S* is more efficient in producing fishery products than is country *L*. Given this, the relative and absolute price of agricultural products is lower in country *L* than in country *S* and the opposite holds for fishery products. Despite the fact that each of these countries has both absolute and comparative advantage in an industry, there is no trade between these two countries because trade costs, given the poor market infrastructure, are greater than the difference in prices between the two countries.

As economies develop they improve their market infrastructure, thus reducing the cost of moving their products from domestic producer to a foreign final consumer. Under this circumstance, each country can specialize in producing the good for which its opportunity cost is lowest, creating opportunities for gains from trade between the two countries. Without trade barriers, the two countries maintain their trade balance at the equilibrium point. Later, country *S* imposes a tariff on imports from country *L,* while country

L maintains no trade barrier. This unbalanced market openness shocks the trade balance between the two countries, generating asymmetric trade flow, *i.e.*, more from country *S* and less from country *L*.

Based on this simple illustration, this study emphasizes three possibilities as follows: 1) resource endowments determine agricultural competitiveness, 2) economic development promotes market efficiency, and 3) market openness determines agricultural trade flow. Knowing that resource endowments, economic development, and market openness are more complex in the real world, we attempt to describe how these three factors can explain asymmetric agricultural trade flows.

In the traditional gravity trade model, trade cost is treated as symmetric, implying that costs in moving agricultural products from country *L* to country *S* is equal to costs in moving from country *S* to country *L*. Recently, however, trade economists have examined components of trade costs inducing asymmetric trade flow. Bergstrand, Egger, and Larch (2013) state that, in reality, trade costs (and trade flows) are not bilaterally symmetric. They confirmed asymmetric effects of national borders in bilateral trade between the U.S. and Canada by using an alternative trade model allowing for asymmetric bilateral trade costs.

Trade costs are defined as the difference between the marginal cost of production by the domestic producer and the price paid by the end user in a foreign country (Khan and Kalirajan, 2011 and Anderson and van Wincoop, 2004). Based on where trade costs occur, we categorize trade costs as (*i*) *behind the border costs* incurred in the exporting country *j*, $T_{ij}(j,x)$, (*ii*) *between the border costs* incurred between exporting and importing country *j* and *i*, $T_{ij}(b,x)$, and (*iii*) *beyond the border costs* incurred in the importing country *i*, $T_{ij}(i,x)$. Then, the end user in the importing country *i* pays $\$1\times T_{ij}(j,x)\times T_{ij}(b,x)\times T_{ij}(i,x)$ for an agricultural good *x* whose marginal cost of production is \$1 per unit in exporting country *j*.[1] One important point is that $T_{ij}(b,x)$ depends upon the distance, d_{ij}, between *j* and *i*, implying symmetry because the distance and insurance premium on identical sea routes is equal regardless of the direction of trade. On the contrary, $T_{ij}(j,x)$ and $T_{ij}(i,x)$ are asymmetric because they are affected by policy-induced factors (such as tariff and non-tariff barriers) and market-induced factors (such as marketing costs and retailer/wholesaler margins).[2]

If between the border costs comprise the majority of trade costs, trade costs will be approximately symmetric. However, trade costs are asymmetric if behind and/or beyond the border costs comprise the majority of trade costs. Traditionally, the standard gravity approach to modeling trade costs assumes that trade costs are symmetric, *i.e.*, trade costs are a function of distances between borders. Recent studies, however, show that advances in technology reduce transportation costs, but overall trade costs are still high (Khan and Kalirajan, 2011; Alvarez and Lucas, Jr., 2006; Anderson and Wincoop, 2004; Bordo, 2002; and Bruce, 1997). This implies that behind or beyond the border costs may be a relatively larger component than between the border costs. In this case, asymmetric trade costs will control bilateral trade flows.

According to agricultural trade data, trade flows between high income countries are much greater than those between low income countries. This implies that the standard gravity model is not the optimal approach when high and low income countries are included in the same analysis. For example, symmetry restricts flexibility in explaining trade flows because the price paid by the end user in an importing country is determined not only by marginal costs but also by trade costs. Also, trade costs are affected differently by the importer and exporter, resulting in a violation of the symmetric condition. In this context, it is more important to illustrate an individual country's marginal cost and asymmetric components of trade costs affecting trade flows. However, an individual country's marginal cost and asymmetric components of trade costs must be estimated because they cannot be directly observed.

In this challenge, based on trade model developed by the previous studies (Eaton and Kortum, 2002; Waugh, 2010; and Reimer and Li, 2010) we try to derive bilateral trade share equation as a function of distance, marginal cost, behind the border cost, and beyond the border cost. Then, the three non-geographical variables in the bilateral trade share equation are defined by parameters determining individual country's agricultural competiveness, infrastructural competiveness, and market openness. In order to achieve the objectives, this study is conducted as follows. The following section presents the theoretical framework, discussing agricultural prices, trade share, and rents. In the third section, three observations from agricultural trade data and their implication in asymmetric trade flows are discussed. In section four, we examine about where asymmetric trade flows come from and the effects on agricultural trade flows of asymmetric components of trade costs. In section five, we conduct empirical analysis in which we estimate individual country's marginal cost, behind the border cost, and beyond the border cost. To identify the implications of asymmetric components of trade costs for international agricultural trade, two different counterfactuals are simulated in section six. The final section concludes the paper with recommendations for further research.

2. Theoretical Framework

Consider a world economy composed of *N* countries. An individual country *j* produces a set of agricultural goods, $q_j(x)$, which are tradable. There is a continuum of agricultural goods indexed by $x \in [0,1]$. It is assumed that the primary (non-produced) factor of agricultural production is land and an individual country *j* is endowed with an endowment of agricultural land, L_j, and total factor productivity, $z_j(x)$, varies across agricultural goods with a common density, θ. To produce agricultural goods in an individual country *j*, land and productivity are combined by the following production technology function:

$$q_j(x) = z_j(x)^{\theta} f(L_j).$$

In order to produce a given agricultural good *x*, the land requirement depends upon the level of productivity with constant proportionality, $z_j(x)^{\theta}$.

Reimer and Li (2010) noted that there is a relatively permanent difference in weather, soil quality, or technology across countries and that one country will be relatively more productive than another (and vice versa) at producing various pairs of agricultural goods, which can thus create an environment conducive to agricultural trade in the international market. With land being the primary factor of agricultural production, agricultural productivity can be defined as output per acre *i.e.*, yield. Yield is a weather-induced random variable which is distributed independently and exponentially with the yield parameter, λ. Each country's mean yield is proportional to λ_j^{θ}, with the constant of proportionality independent of the country. Then, the marginal cost of producing agricultural goods is $mc_j = r_j / \lambda_j^{\theta}$, where r is the rental rate of agricultural land.[3] So, a country with a relatively smaller r / λ^{θ} is, on average, more efficient at producing a bundle of agricultural goods. θ controls the dispersion of efficiency levels, *i.e.*, a larger (smaller) θ results in more (less) variation in efficiency levels relative to the mean. As θ increases (decreases), it increases (decreases) the likelihood that the marginal costs of the two countries producing the same agricultural good will be different, thus leading to the creation of more (fewer) incentives to trade. In this sense, θ controls the degree of comparative advantage.

The end user in a foreign country *i* has symmetric preferences with respect to bundles of agricultural goods, with utility given by

$$U_i = \left[\int_0^1 q(x)^{\frac{\eta-1}{\eta}} dx \right]^{\frac{\eta}{\eta-1}}.$$

The consumer's problem is that of maximizing utility for a given budget by purchasing a bundle of agricultural goods $q(x)$ from all n number of countries. Then, agricultural trade occurs in the following manner. The final users purchase each agricultural good from the lowest price across all countries. Four factors influence which country's agricultural good is the lowest price: (*i*) marginal cost, (*ii*) behind the border cost, (*iii*) between the border cost, and (*iv*) beyond the border cost. Therefore, agricultural trade depends not only on agricultural productivity but also trade costs. Furthermore, trade costs depend not only on distance but also importer and exporter costs. In the following sections, we describe how agricultural prices, trade shares, and rents are determined.

2.1 Price Index for Aggregate Agricultural Products

Due to the incidence of trade costs, there exists a gap between the price paid by the end consumer in importing country *i* and the marginal cost of production in exporting country *j*. Therefore, agricultural price in country *i* will be affected by marginal cost parameters (λ_j, θ, and r_j) and bilateral trade costs (τ_{ij}). The price index for country *i* can be derived using the moment-generating function for extreme value distribution (Eaton and Kortum, 2002) as follows:

$$(1) \qquad p_i = \left[\Gamma\left(\frac{\theta + 1 - \eta}{\theta} \right) \right]^{1/(1-\eta)} \times \left\{ \sum_{j=1}^{N} \left(r_j \tau_{ij} \right)^{-1/\theta} \lambda_j \right\}^{-\theta},$$

where Γ is the Gamma function used to express certain types of definite integrals.[4]

In equation 1, τ_{ij} is the trade cost from country *j* to country *i*. The definition of price shows proportional relationships between price and marginal cost, and price and trade costs. In supplying agricultural goods to the final user in the importing country at $1 per unit which is the lowest price, the marginal cost of the good in an exporting country is $1/\tau_{ij}$ per unit. If trade costs increase to $\tau_{ij}^{1} > \tau_{ij}$, then the country cannot export their product because the country cannot reduce the marginal cost below $1/\tau_{ij}$.

2.2 Agricultural Trade Share

X_{ij} is country *i*'s expenditure share on agricultural goods from country *j*. It is also the fraction of all agricultural goods that country *i* imports from country *j*. Since there is a continuum of agricultural goods, computing this fraction is reduced to finding the probability that country *j* is the low-cost supplier to country *i* given the joint distribution of efficiency level and trade costs for any agricultural good *x*. Keeping this in mind, the expression for country *j*'s agricultural trade share with country *i* is expressed as:

$$(2) \qquad X_{ij} = \frac{\left(r_j \tau_{ij} \right)^{-1/\theta} \lambda_j}{\sum_{l=1}^{N} \left(r_l \tau_{il} \right)^{-1/\theta} \lambda_l}.$$

Note that the sum across *j* for fixed *i* must add up to one, *i.e.*, $X_i = \sum_j X_{ij} = 1$. The definition of trade share shows an inverse relationship between trade share and marginal cost of and trade cost of exporting country *j* and a proportional relationship between trade share and marginal cost of and trade cost of all the other rival countries.

2.3 Rent

The total value of agricultural goods produced in country *k* is equal to $r_k L_k$. Also, the total expenditure on agricultural goods in country *k* can be defined as $\alpha_k r_k L_k$. Here, the parameter $\alpha_k > 1$ represents the notion that agricultural consumption is greater than agricultural production in country *k*, implying country *k* is a net importer of agricultural goods. The parameter $\alpha_k < 1$ represents the idea that agricultural production is greater than agricultural consumption in country *k*, implying country *k* is a net exporting country. Finally, the parameter $\alpha_k = 1$ represents the idea that agricultural production is equal to agricultural consumption in country *k*, implying country *k* is a zero trade balancing country. Also, imports are defined as $Imports = \alpha_k r_k L_k \sum_{j \neq k}^{n} X_{kj}$, which is the total value of agricultural goods that country *k* consumes from abroad. Similarly, exports are defined as $Exports = \sum_{i \neq k}^{n} \alpha_i r_i L_i X_{ik}$, which is the total value of agricultural goods that countries abroad purchase from country *k*. Then, the rent of a zero trade balancing country *k*, $\alpha_k r_k L_k \sum_{j \neq k}^{n} X_{kj} = \sum_{i \neq k}^{n} \alpha_i r_i L_i X_{ik}$ is ,

(3) $$r_k = \sum_{i \neq k}^{n} \frac{\alpha_i L_i X_{ik}}{\alpha_k L_k (1 - X_{kk})} r_i .$$

3. Observations in Agricultural Trade Flow

This study reviews the observations of agricultural trade data to understand asymmetric components of trade cost across countries. As implied by asymmetry in bilateral agricultural trade flows, trade costs could be asymmetric. As a benchmark, this study considers a base year of 2001. Twenty-three countries and two-hundred fifteen individual agricultural goods are in the sample, which represents almost 90 percent of total agricultural expenditures in each country. Trade share, X_{ij}, is constructed as $X_{ij} = \frac{m_{ij}}{A_i - e_i + m_i}$, and home share, X_{ii}, calculated as $X_{ii} = 1 - \sum_{j \neq i}^{N} X_{ij}$, where m_{ij} is the value of agricultural goods that country i imports from country j: A_i is the total value of agricultural production in country i, e_i is the total value of agricultural exports of country i to the world: and m_i is the total value of agricultural imports of country i from the world. Table 1 presents a matrix of trade shares for twenty-three countries.

[Place Table 1 Approximately Here]

3.1 Home Bias

Home bias means that countries consume most of their domestically produced agricultural goods, *i.e.*, X_{ii} data. Home bias in the data is seen by considering the large values lying along the diagonal of table 1 relative to off-diagonal entries. Home bias for agricultural goods is shown to decrease with an increase in income. This is different than Waugh's findings for manufactured goods. In the agricultural trade data, the home bias of high, middle, and low income countries are on average 0.79, 0.84, and 0.91, respectively. A regression of the logarithm of X_{ii} on the logarithm of per capita GDP in 2001 has a slope coefficient of -0.05 and is different from zero statistically. The statistics show that high income countries purchase more from foreign producers than do low income countries.[5]

3.2 Asymmetry in the Agricultural Trade Matrix

Table 1 shows that the import share of country i from country j is not equal to the import share of country j from country i, i.e., $X_{ij} \neq X_{ji}$. For example, the import share of the U.S. from Canada is 5.01% while the import share of Canada from the U.S. is 39.76%, indicating asymmetric trade flows. Also, most bilateral trade takes place between high income countries. Table 1 shows that bilateral trade share of agricultural goods between high income countries is 88.42% while bilateral trade share of agricultural goods between middle (low) income countries is reduced to 6.17% (1.68%). Table 1 also shows asymmetric trade flows in these three classifications. For example, the average import shares of high income countries from middle and low income countries are relatively similar 0.39% and 0.32%, respectively, while average import shares of middle and low income countries from high income country are relatively more divergent with 0.96% and 0.75%, respectively.

3.3 Prices Difference between High and Low Income Countries

215 disaggregated observations of price data of 23 countries were obtained from the Food and Agriculture Organization of United Nation (FAO, 2001). The baskets of these goods are the same across 23 countries. According to per capita GDP, 23 countries are divided into three different categories *i.e.*, high income country, middle income country, and low income country. Average prices of each agricultural good are calculated in three groups. Sixty-two of the original 215 agricultural goods are eliminated because the prices of the agricultural goods are not obtained in all of the three groups. Using 153 average prices in each of the three groups, figure 1 is obtained. Figure 1 shows that aggregate agricultural prices are different between the relatively rich and the relatively poor countries.

[Place Figure 1 Approximately Here]

3.4 Implication of Agricultural Trade Data

The three observations make a straight forward implication in modeling trade cost. Dividing trade share by home share yields the following relationship between trade share normalized by home share, marginal cost of production, and trade cost:

(4) $$\frac{X_{ij}}{X_{ii}} = \left(\tau_{ij}\right)^{-1/\theta} \times \left(\frac{mc_j}{mc_i}\right)^{-1/\theta}.$$

Equation (4) is essentially an arbitrage condition. It indicates that if $mc_i > mc_j$, then country *i* has the incentive to purchase relatively more goods from country *j* because they are cheaper. Alternatively, if trade costs between country *i* and *j* are large, then country *i* has fewer incentives to purchase a good from country *j*. In order to describe where violations of symmetric trade flows come from, equation (4) can be divided by the opposing expression relating countries *i* and *j* as follows:

(5) $$\left(\frac{X_{ij}}{X_{ji}}\frac{X_{jj}}{X_{ii}}\right) = \left(\frac{\tau_{ij}}{\tau_{ji}}\right)^{-1/\theta} \times \left(\frac{mc_j}{mc_i}\right)^{-2/\theta}.$$

In a symmetric world, the term $\left(X_{ij} / X_{ji}\right)\left(X_{jj} / X_{ii}\right)$ always equals one. Therefore, it can be inferred that the deviation from symmetric trade flows occurs for two reasons: (1) marginal costs of production of agricultural goods are different, or (2) trade costs between the two countries are different. If each country has similar marginal costs of production, *i.e.*, $mc_j / mc_i = 1$, asymmetric trade flow comes from trade cost. As discussed in the previous section, trade costs might be asymmetric because behind and beyond the border costs are different and relative magnitude of between the border cost is decreasing with advance in technology. If the behind the border cost is a major factor in asymmetric trade flow, then asymmetric trade flow comes from the exporter. In contrast, if the beyond the border cost is a key factor in asymmetric trade flow, then asymmetric trade flows come from the importer. The next section will seek to determine where asymmetric trade flows come from by examining agricultural trade data.

4. Asymmetry in Agricultural Trade Flow

4.1 Empirical Examination

In this section, we provide three examples of fitting the bilateral trade share into trade data. The first is a standard gravity approach in which trade costs are assumed to be symmetric. The other two examples are related to asymmetric approaches. The second is an exporter approach by which we assume trade costs contingent on behind the border cost. The last approach is an importer approach by which trade costs are assumed to be contingent on beyond the border costs.

For illustrative purposes, let us assume that there are only three countries and that country *H* is a high income country and countries *M* and *L* are a middle and low income country, respectively. Also, assume throughout the example that (*i*) the high income country exports more to other relatively high income countries than to relatively low income country, (*ii*) the high income country, however, equally imports from both countries, and (*iii*) countries *M* and *L* do not trade with one another. These assumptions are generally consistent with the observed agricultural trade data. For further convenience, we assume that (*i*) all countries have the same land endowment with $mc_H = mc_M = mc_L$, (*ii*) land is the only factor of production, and (*iii*) country *H*'s land rent and yield are normalized to one, *i.e.*, $r_H = 1$ and $\lambda_H = 1$. Then, the matrix depicts the set of bilateral trade shares normalized by the importing countries' home share and can be expressed as:

$$\begin{pmatrix} 1 & \left(\frac{\tau_{MH}}{mc_M}\right)^{\frac{-1}{\theta}} & \left(\frac{\tau_{LH}}{mc_L}\right)^{\frac{-1}{\theta}} \\ \left(\tau_{HM} mc_M\right)^{\frac{-1}{\theta}} & 1 & 0 \\ \left(\tau_{HL} mc_L\right)^{\frac{-1}{\theta}} & 0 & 1 \end{pmatrix} \text{ where } \left(\tau_{HM} mc_M\right)^{\frac{-1}{\theta}} = \left(\tau_{LH} mc_L\right)^{\frac{-1}{\theta}} \text{ and } \left(\frac{\tau_{MH}}{mc_M}\right)^{\frac{-1}{\theta}} > \left(\frac{\tau_{LH}}{mc_L}\right)^{\frac{-1}{\theta}}.$$

In the first approach, symmetry in trade flow restricts the parameter space so $\{\tau_{HM}, \tau_{MH}\} = \bar{\tau}_M$, $\{\tau_{HL}, \tau_{LH}\} = \bar{\tau}_L$, and $\bar{\tau}_M \neq \bar{\tau}_L$. Since country *H* exports more to country *M* than to country *L*, $X_{MH} > X_{LH}$, and imports the same shares from both countries, $X_{HM} = X_{HL}$, the symmetry assumption on trade flow implies that the trade cost for country *L* to import from country *H* must be greater than that of country *M*, *i.e.*, $\tau_{MH} < \tau_{LH}$. Using equation (1), the aggregate price in countries *M* and *L* is $p_M = \Theta\left\{mc_M^{-1/\theta} + \tau_{MH}^{-1/\theta}\right\}^{-\theta} < p_L = \Theta\left\{mc_L^{-1/\theta} + \tau_{LH}^{-1/\theta}\right\}^{-\theta}$. The relatively lower income country must have a higher aggregate price relative to the relatively higher income country. This example is quantitatively inconsistent with the data: comparable aggregate price for agricultural goods is $p_M > p_L$.

The second approach (exporter approach) restricts the parameter space so $\{\tau_{MH}, \tau_{LH}\} = \bar{\tau}$, *i.e.*, countries *M* and *L* face the same cost to import from country *H*. Since $X_{MH} > X_{LH}$ and $X_{HM} = X_{HL}$, the trade cost of country *L* to import from country *H* must be same with country *M*, *i.e.*, $\tau_{MH} = \tau_{LH}$. Therefore, the aggregate price in countries *M* and *L* is $p_M = p_L$. The aggregate price of agricultural goods in the relatively higher income country must be equal to that of the relatively lower income country. This example is also quantitatively inconsistent with the data.

The third approach (importer approach) restricts the parameter space so $\{\tau_{HM}, \tau_{HL}\} = \bar{\tau}$, *i.e.*, country *H* faces the same cost to import from countries *M* and *L*. Since $X_{MH} > X_{LH}$ and $X_{HM} = X_{HL}$, the trade cost of country M to import from country H must be less than that of country L, *i.e.*, $\tau_{MH} < \tau_{LH}$. Therefore, the aggregate price in countries M and L is $p_M > p_L$. The relatively higher income country must have a higher aggregate price of agricultural goods as compared to the relatively lower income country. This result is consistent with the data. Therefore, the trade data suggests that the asymmetry of agricultural trade flows comes from beyond the border costs incurred by importers.

4.2 Asymmetric Components of Trade Costs

Based on this finding, we seek to identify unobservable marginal cost, behind the border costs, and beyond the border costs. In an attempt to do this, we redefine equation (4) as follows:

$$(6) \qquad log\left(\frac{X_{ij}}{X_{ii}}\right) = \delta_{ij}^{i} S_i - \delta_{ij}^{j} S_j - \frac{1}{\theta} log\, T_{ij}(b,x),$$

where S_i and S_j are destination and source-country dummy variables, and $\delta_{ij}^{i} = \frac{1}{\theta}\left[log(mc_i) - log\, T_{ij}(i,x)\right]$ represents the effect on logarithmic normalized trade share of marginal cost of and beyond the border cost of the importer, and $\delta_{ij}^{j} = \frac{1}{\theta}\left[log(mc_j) + log\, T_{ij}(j,x)\right]$ represents the effect on logarithmic normalized trade share of marginal cost of and behind the border cost of the exporter, and logarithmic between the border cost is a function of distance and border share, $log\, T_{ij}(b,x) = d_k + b_{ij}$.

Subtracting δ_{ij}^{j} from δ_{ij}^{i}, we obtain an equation representing asymmetric components of trade cost as follows:

$$(7) \qquad log\, T_{ij}(j,x) + log\, T_{ij}(i,x) = -\theta\left(\delta_{ij}^{j} + \delta_{ij}^{i}\right).$$

According to the importer approach, we assume that behind the border cost is a fraction of beyond the border cost. Then, behind the border cost is defined as follows:

$$(8) \qquad T_{ij}(j,x) = \left[T_{ij}(i,x)\right]^{\rho_{ij}},$$

where ρ_{ij} represents the relationship between behind and beyond the border costs of agricultural good *x* exported by country *j* to country *i*.

Next we calibrate marginal cost, behind the border cost, and beyond the border cost as follows:

(9) $$mc = e^{\frac{\theta\left(\rho_{ij}\delta_{ij}^{i}-\delta_{ij}^{j}\right)}{1+\rho_{ij}}},$$

(10) $$T_{ij}\left(j,x\right) = e^{\frac{-\theta\rho_{ij}\left(\delta_{ij}^{i}+\delta_{ij}^{j}\right)}{1+\rho_{ij}}}, \text{ and}$$

(11) $$T_{ij}\left(i,x\right) = e^{\frac{-\theta\left(\delta_{ij}^{i}+\delta_{ij}^{j}\right)}{1+\rho_{ij}}},$$

where δ_{ij}^{i} is a parameter representing the effect of the importer on trade share (we call δ_{ij}^{i} as gross openness to imports) and δ_{ij}^{j} is a parameter representing the effect of the exporter on trade share (we call δ_{ij}^{j} as gross competitiveness for exports).

Since $\delta_{ij}^{i} = \frac{1}{\theta}\left[log\left(mc_i\right) - log\,T_{ij}\left(i,x\right)\right]$ and $\delta_{ij}^{j} = \frac{1}{\theta}\left[log\left(mc_j\right) + log\,T_{ij}\left(j,x\right)\right]$, we can separate net openness into imports, $\delta_{ij}^{T_{ij}(i,x)}$, and agricultural competitiveness of importer, $\delta_{ij}^{mc_i}$, from gross openness parameter, δ_{ij}^{i}. Also, we can separate infrastructural competitiveness, $\delta_{ij}^{T_{ij}(j,x)}$, and agricultural competitiveness of exporter, $\delta_{ij}^{mc_j}$, from gross competitiveness parameter, δ_{ij}^{j}. Then, the effects on the trade share of agricultural competitiveness, net openness to imports, and infrastructural competitiveness for exports can be obtained by using the definition of semi-elasticity in equation (6) as follows:

(12) $$\Delta\left(\frac{X_{ij}}{X_{ii}}\right) = \left(e^{\delta_{ij}^{mc_i}} - 1\right)\frac{X_{ij}^{0}}{X_{ii}^{0}}$$ importer effect of agricultural competitiveness on trade share,

(13) $$\Delta\left(\frac{X_{ij}}{X_{ii}}\right) = \left(e^{\delta_{ij}^{T_{ij}(i,x)}} - 1\right)\frac{X_{ij}^{0}}{X_{ii}^{0}}$$ importer net openness effect on trade share,

(14) $$\Delta\left(\frac{X_{ij}}{X_{ii}}\right)=\left(e^{\delta_{ij}^{mc_j}}-1\right)\frac{X_{ij}^0}{X_{ii}^0}$$ exporter effect of agricultural competitive on trade share, and

(15) $$\Delta\left(\frac{X_{ij}}{X_{ii}}\right)=\left(e^{\delta_{ij}^{T_{ij}(j,x)}}-1\right)\frac{X_{ij}^0}{X_{ii}^0}$$ exporter infrastructural competitiveness effect on trade share,

where X_{ij}^0 and X_{ii}^0 represent trade and home share when $S_i = 0$ and $S_j = 0$, respectively.

5. Empirical Analysis

If data is available for trade cost, τ_{ij}, marginal cost, mc, and trade share, X_{ij}, equation (4) can be used to estimate θ. The difficulty encountered here is that trade cost, τ_{ij}, and marginal cost, mc, are unobserved. Eaton and Kortum, however, suggest that an estimate of τ_{ij} is possible with use of a simple arbitrage argument and disaggregated price data. So, we use a proxy for trade costs obtained as:

(16) $$log\hat{\tau}_{ij} = \max_x 2\{log\ p_i(x) - log\ p_j(x)\},$$

where *max* 2 denotes the second highest value in a set of disaggregated prices.[6]

With $\hat{\tau}_{ij}$ calibrated from equation (16), we assume that overall marginal cost is the same across all 23 countries in estimating θ in equation (4).[7] To construct estimates of equation (16), producer-level price data for the year 2001 are obtained from the Food and Agriculture Organization. For tradable agricultural goods, this dataset has two hundred fifteen categories for the twenty three countries in the dataset. The bilateral trade data are also from 2001 and constructed in the same manner as describe in the previous section. To summarize, equation (4) is estimated with a proxy for trade cost drawn from equation (16) utilizing ordinary least squares (OLS) omitting the intercept term. The regression yields an estimate of -3.3421. This implies a $\hat{\theta}$ of 0.2992 which is similar to that estimated by Waugh (0.1818) but is much less than those estimated by Eaton and Kortum (from 2.86 to 3.60) and Reimer and Li (from 2.83 to 4.96). These similarities and differences come from the difference in definition of price (equation 1) and trade share (equation 2). This study used the same definitions of price and trade share as Waugh to determine the degree of comparative advantage. This estimated value is used throughout the remainder of this paper.

To identify the effect on trade share of destination, source-country, and geographic barrier, we start at equation (6). For estimation, we use proxies for between the border costs because between the border costs are related to proximity factors, such as distance and shared border.[8] Distance is accounted for by using six dummy variables representing different intervals of great-circle distance between capitals. The associated coefficient, d_k with $k = 1,2,\ldots,6$, is the effect of distance between i and j lying in the k^{th} distance interval. Intervals are in miles: [0, 375); [375, 750); [750, 1500); [1500, 3000); [3000, 6000); and [6000, maximum]. The variable b_{ij} captures the effect of a shared border in which $b_{ij} = 1$ if i and j share a common border and zero otherwise. Substituting these for $log\,T_{ij}(b,x)$ in equation (6), we formulate the regression equation as follows:

$$(17) \qquad log\left(\frac{X_{ij}}{X_{ii}}\right) = \delta_{ij}^{i} S_i - \delta_{ij}^{j} S_j - \frac{1}{\theta} d_k - \frac{1}{\theta} b_{ij} - \frac{1}{\theta} \xi_{ij}\,.$$

The error term ξ_{ij} has implications for potential reciprocity in geographic barriers, *i.e.*, the possibility that the disturbance related to shipments from j to i is positively correlated to the disturbance concerning shipments from i to j.[8] Therefore, we estimate equation (17) by generalized least squares (GLS). In estimation, we impose $\sum_i S_i = 0$ and $\sum_j S_j = 0$ without overall intercept to avoid the dummy variable trap. Trade share and home share data are constructed from a detailed trade matrix database for twenty-three countries (FAO, 2001). Among these countries, imports from the other twenty-two countries as a share of total imports are 57% on average.

Table 2 summarizes the empirical results estimated by generalized least squares with 515 observations. In terms of fitting bilateral trade flows, this model performs well. For example, the model's adjusted R^2 is 0.96 and most of p-values of the estimated coefficients are significant at the 1% level. The coefficients in the upper portion of table 2 indicate how distance and border affect normalized trade share. As with the gravity literature, distance is an impediment while a common border serves as a catalyst for bilateral trade flow. The estimates reported in table 2 are generally consistent with those estimated by Eaton and Kortum (2002), Waugh (2010), and Reimer and Li (2010). However, our results indicate that a distance of less than 375 miles has a relatively small impact on trade share. Trade share is affected when trading partners are separated by more than 375 miles. For example, distances less than 375 mile reduces trade share by 39% while distances between 375 and 750 miles reduces trade share by 312%. The negative sign and successively larger magnitudes on the distance dummies suggest that freight costs and possibly other fixed components of transport costs (insurance premium, holding costs for agricultural goods in transit, inventory cost due to buffering the variability of delivery dates, and preparation costs associated with shipment size and so on) may be a particularly important impediment to trade in global agricultural markets. The border share dummy variable coefficient is positive which implies that if trading partners share a common border, trade share increases by 8%. However, the estimated coefficient is not significant at 10% level.

For destination-country effects (representing gross openness to imports), our results show that the countries most open to imports are Canada, Australia, and the United States with a respective 62%, 31%, and 29% higher trade share than average. This implies that final users of agricultural goods in these countries likely pay less than final users in the other countries. The countries least open to imports are India, Ethiopia, and China with a respective 51%, 45%, and 40% lower trade share than average. This implies that final users in these countries likely pay more than final users in the other countries. In order to illustrate the relationship between gross openness and economic development, we scatter estimates of destination-country against per capita GDP. Figure 2.1 shows a proportional and strong relationship between two parameters. Also, the logarithm of δ_{ij}^{i} was regressed on the logarithm of y_i. Here y_i is per capita GDP in 2001. The intercept is -7.77 and the slope coefficient is 0.77. Both are estimated at $\alpha = 0.01$. The regression illustrates that the larger the per capita GDP, the larger the gross openness to imports, which could reflect a variety of factors, including lower tariffs and non-tariff barriers.

In considering source-country effects (representing gross competitiveness for exports), the most efficient exporting countries are the United States and Brazil with a respective 184% and 122% higher than average trade share. This implies that the agricultural industry in these countries works more efficiently as compared to those of the other countries. The least efficient exporting countries are Ethiopia, Morocco, and Bulgaria with a respective 56%, 54%, and 54% lower trade share than average. This implies that the agricultural industry in these countries works less efficiently as compared to those of the other countries. The relationship between gross competitiveness and economic development is presented in Figure 2.2. This shows a proportional but not strongly relationship between the two parameters. In addition, the logarithm of δ_{ij}^{j} is regressed on the logarithm of y_i. The intercept is -0.68 and the slope coefficient is 0.53. However, neither is significant at the 10% level. This result can be more specified by isolating marginal cost and infrastructural efficiency parameters from the gross competitiveness parameter. This issue is discussed in the following section.

5.1 Estimation of Marginal Cost, Behind and Beyond the Border Costs

The regression formulated by equation (17) provides us with values of parameters δ_{ij}^{i} and δ_{ij}^{j}. These estimated parameter values are put into equations (9), (10), and (11). Following this route, we successively estimate unobservable marginal cost, behind the border costs, and beyond the border costs.

Table 3 shows estimated values of marginal cost by which an inverse index (mc^{-1}) can be obtained to represent agricultural competitiveness. Lower marginal cost represents higher agricultural competitiveness. For example, the agricultural competiveness of the United States is higher than that of Japan because the marginal cost of the United States (0.55) is lower than that of Japan (1.37). The countries having the lowest marginal costs are the United States and Brazil with 0.550 and 0.551, respectively. The countries having the highest marginal costs are Morocco and Russia with 1.691 and 1.556, respectively. Figure 3.1 plots estimated agricultural competiveness (mc^{-1}) against per capita GDP. A relationship between agricultural competiveness and economic development is difficult to find. For example, the marginal cost of a high income country (Japan) is higher than that of a low income country (Brazil). However, agricultural competiveness increased with land size. For example, the marginal cost of relatively large countries such as the United States, Brazil, Argentina, China, and India is lower than those of relatively small countries such as Japan, Korea, and Greece. In order to determine the relationship between agricultural competiveness and economic development, the former variable is regressed on the latter. This regression result did not indicate a significant relationship between the two variables. However, when agricultural competiveness was regressed on land size, the results indicate that land size and agricultural competitiveness are positively correlated. This implies that agricultural competitiveness is closely related to economies of scale.

Table 3 shows estimated values of behind the border cost by which an inverse index $(T_{ij}(j,x))^{-1}$ can be obtained to represent infrastructural competitiveness for exporting agricultural goods. Lower behind the border costs represent more efficient infrastructure for agricultural exports which will promote agricultural exports. For example, although marginal costs of the United States (0.550) and Brazil (0.551) are similar, the average import share of 22 countries from the United States (5.29) is higher than that from Brazil (2.10). This may imply that infrastructural competitiveness of the United States is stronger than that of Brazil because behind the border costs of the United States (0.640) are lower than those of Brazil (0.820). The countries having the lowest behind the border costs are the United States and Canada with 0.640 and 0.678, respectively. The countries having the largest behind the border costs are Ethiopia and Bulgaria with 1.518 and 1.453, respectively. Figure 3.2 plots estimated infrastructural competiveness ($T_{ij}(j,x)^{-1}$) against per capita GDP. High-income countries appear to have a more efficient infrastructure for agricultural exports which could reflect a variety of factors, including better developed transportation and institutional networks. In order to statistically measure the relationship between infrastructural competiveness and economic development, the former variable is regressed on the latter. This regression result shows that when income increased by 1%, infrastructural competiveness increased by 0.83% (a result that was statistically significant at the 1% level). As shown in the previous section, gross competitiveness exhibited no correlation with economic development. However, when agricultural competitiveness and infrastructural efficiency are separated from gross competitiveness, infrastructural efficiency is closely related to economic development while agricultural competitiveness is closely related to economies of scale, *i.e.*, land size. This result, then, implies that economic development is more closely related to improvement of market infrastructure for agricultural exports than to improvement of agricultural competitiveness which is related to economy of scale. As a result, we can conclude that agricultural exports in high income countries are promoted by better market infrastructure.

Table 3 also shows estimated values of beyond the border costs by which an inverse index $(T_{ij}(i,x))^{-1}$ can be obtained to represent net openness to imports of agricultural goods. Lower beyond the border costs represent more access of exporters to the importing country. As a result, higher net openness will promote agricultural imports. For example, although agricultural competiveness of the United States $\left(mc_{us}^{-1} = 1.82\right)$ is higher than that of China $\left(mc_{us}^{-1} = 1.54\right)$, the average import share of the United States from 22 countries (0.61) is higher than that of China (0.17). This may imply that the import barriers of China are more restrictive than those of the United States because the beyond the border costs of China (0.960) are higher than those of the United States (0.409). The countries having the lowest beyond the border costs are the United States and Canada with 0.409 and 0.460, respectively. The countries having the greatest beyond the border costs are Ethiopia and Bulgaria with 2.303 and 2.112, respectively. Figure 3.3 plots estimated net openness to imports $(T_{ij}(j,x)^{-1})$ against per capita GDP. High-income countries appear to be more open to imports, which could reflect a variety of factors including lower tariffs and non-tariff barriers. In order to statistically measure their relationship, net openness was regressed on economic development. This regression result shows that when income increases by 1%, net openness increases by 1.67% (a result that was statistically significant at the 1% level).

In this study, we include four EU member countries such as France, Italy, Spain, and Greece. Although EU member countries have common economic policy, the behind and beyond the border costs of Greece is different from those of the other three member countries. As discussed, behind and beyond the border costs can be affected by not only policy-induced factors (such as tariffs and non-tariff barriers) but also market-induced factors (such as marketing costs and retailer/wholesaler margins). According to the results, Greece shows an inefficient market structure compared with the other EU member countries because the behind and beyond the border costs are very high compared with those of France, Italy, and Spain.

Up to this point the analysis examined destination-country effects (gross openness), source-country effects (gross competitiveness), the marginal cost effect (agricultural competitiveness), behind the border cost effects (infrastructural efficiency for agricultural exports), and beyond the border cost effects (net openness to imports). This examination shows that economic development is related to reduced trade restrictions and improved market infrastructure while agricultural competiveness is related to land size. In the next section, we conduct counterfactual analysis in two different scenarios. In scenario 1, beyond the border costs are reduced to the level of U.S. beyond the border costs in order to identify the effect of an increase in market access. Conversely, in scenario 2, beyond the border costs are increased to the level of Ethiopian beyond the border costs in order to identify the effect of a decrease in market access.

6. Counterfactual Analysis

Trade costs have been shown to be the key component in explaining asymmetric agricultural trade flows. As discussed in the previous section, counterfactuals are evaluated in terms of two criteria. One criterion utilized is the increase in market access. Lower beyond the border costs positively affect trade share in individual countries, which reflects a lower price of imported agricultural goods. The other criterion is a decrease in market access. Higher beyond the border costs negatively affect trade share in individual countries which, in turn, reflects a higher price of imported agricultural goods. In counterfactual 1, a change in the trade share is calibrated to determine what happens if each country reduces their beyond the border costs. In counterfactual 2, trade share is calibrated to determine what happens if each country increases their beyond the border costs.

6.1 Limitations of the Model

Before discussing the results of counterfactual simulations, the parameterization of counterfactuals simulation should be described in order to make it clear that the simulation results represent trade share implication of net openness to imports given very restrictive conditions. For example, counterfactual simulations are conducted as follows. Using agricultural trade data, we determined the initial trade share, $\hat{X}_{ij}$, and net trade parameter, $\hat{\alpha}_i$. Also, trade cost, τ_{ij}, as a regressor is obtained by taking the second highest relative price of individual agricultural good between importing country *i* and exporting country *j*. As discussed, $\hat{\delta}_{ij}^{j}$ and $\hat{\delta}_{ij}^{i}$ are estimated by the regression formulated in equation (17). Then, the values of marginal cost, behind the border costs, and beyond the border costs are calculated at $\hat{\theta} = 0.2992$ and $\hat{\rho}_{ij} = 0.5$ using equations (9), (10), and (11), respectively.

6.2 Major Results

In counterfactual simulations, a change in net openness has consecutive effects on gross openness and then trade share. For example, a change in beyond the border costs $\left(\Delta T_{ij}(i,x)\right)$ influences gross openness $\left(\Delta\delta_{ij}^{i}\right)$ and trade share $\left(\Delta X_{ij}\right)$. In agricultural trade, countries implement trade restrictions most of which are related to import restriction. This import restriction deters trade flow in international agricultural markets. Given current levels of import restrictions, the average trade share of twenty-three countries used in this study is 15.4%. The countries having the lowest trade shares are India, Ethiopia, and China with 1.8%, 2.2%, and 3.6%, respectively. The countries having the greatest trade shares are Canada, Uruguay, and Mexico with 51.4%, 33.7%, and 25.6%, respectively. In this counterfactual simulation, the effects of reduction and increase of beyond the border cost on trade share are identified.

In counterfactual 1, beyond the border costs of 22 countries are reduced to the lowest beyond the border cost of the United States to quantify the effect of an increase in net openness. Table 4 presents the simulation results. When beyond the border costs are decreased to the level of the United States, average trade share increases by 335%. As a result, the average trade share of 23 countries increases from 15.4% to 53.3%. Most of the increase in trade share appears in low income countries, while the least increases occur in high income countries. Among the high income countries, the largest increase in trade share occurs in Greece, Korea, and Japan with 436%, 368%, and 302%, respectively, reflecting the fact that these countries currently impose restrictive import barriers.

In counterfactual 2, beyond the border costs of 22 countries are increased to the highest beyond the border cost of Ethiopia to quantify the effect of a decrease in net openness. Table 4 presents these simulation results. When beyond the border costs are increased to the level of Ethiopia, average trade share decreases by 63%. As a result, the average trade share of the 23 countries decreases from 15.4% to 4.7%. This magnitude of decrease is relatively small as compared to the results of counterfactual 1. This implies that current levels of beyond the border costs are high, which reflects a currently high level of import restrictions.

7. Conclusions

The Ricardian model implies that countries will tend to produce and export goods in which they have comparative advantage (Feenstra, 2003). If every country specializes in this manner, the trade share of each trading country would increase to the point where its welfare would be maximized (Jabara and Thompson, 1980). However, this implication applies only to a purely integrated market in which there are no trade costs. Anderson and Wincoop (2004), however, indicate that international trade costs are quite large and highly variable across goods and countries. In particular, trade costs of agricultural goods are significantly higher than those of other commodities (Khan and Kalirajan, 2011; Kalirajan, 2007; Brenton et al, 2001; and Messerlin and Zarrouk, 2000). These higher trade costs distort comparative advantage in the production and export of agricultural goods. According to this study, less developed countries, on average, have significantly larger trade costs than do more developed countries, which may explain why the majority of agricultural trade occurs between high income countries.

As noted, trade costs comprise a large share of the price paid by a foreign end user. Trade costs, unfortunately, cannot be observed directly from trade data. However, agricultural trade costs can be derived from an economic model linking trade flows to observable and unobservable variables. Inference has mainly used the gravity approach which does well in representing the impacts of economic development (often using GDP as a principal measurement) and distance between two economic units in bilateral trade flows. However, symmetric restrictions on trade costs in the standard gravity approach have provoked controversy amongst international economists because empirical examples conflict with the symmetry assumption (Balisteri and Hillberry, 2007).

Recent studies show that bilateral trade can be influenced by asymmetric trade costs. One example is Eaton and Kortum (2001 and 2002). However, their study did not separate the effects of marginal cost, behind the border costs, and beyond the border costs on trade flows. In this study, we sought to identify these effects of marginal cost, behind the border costs, and beyond the border costs on trade flows. For example, agricultural competitiveness (indicated by an inverse index for marginal cost) is more dependent on land size and less dependent on economic development. However, infrastructural competiveness (indicated by an inverse index for behind the border costs) and net openness (indicated by an inverse index for beyond the border costs) are dependent on economic development. This implies that most agricultural trade induced by high income countries is closely related to the development of market infrastructure and the reduction of trade barriers while agricultural productivity is closely related to economies of scale.

As indicated in the previous section, this study indicates that beyond the border costs are a key factor affecting trade flows. Based on this finding, two counterfactual simulations are analyzed to quantify the effects on trade flow of net openness to imports. The two counterfactual simulations indicate that the current level of import restrictions is restrictive.

Finally, this model may be used as a novel approach to analyze individual agricultural goods with detailed market information in order to identify more useful market information. For example, agricultural trade cost is highly linked with geographical distance and imperfect market integration. Technical trade costs (transportation cost, storage cost in transit, and so on) are incurred mostly by the former and institutional and political trade costs are generated mainly from the latter. Institutional trade costs can be divided into direct institutional trade costs (tariffs, quotas, and trade costs associated with the exchange rate system) and indirect institutional trade costs (transport infrastructure, law enforcement, related property rights institutions, and informational institutions). The political trade costs are often incurred from import bans and embargos based on national interests. These trade costs of individual agricultural good can be quantitatively measured by using our model supplemented with specific market information. Therefore, research can be conducted for a variety of agricultural goods to identify the composition of these asymmetric trade costs and their implications for international agricultural markets.

Table 1. Agricultural Trade Share, X_{ij}, in Percent for 23 Countries - FAO, 2001

		High Income Countries								Middle Income Countries								Low Income Country						
		C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
C01	U.S.	86.63	9.34	39.76	0.96	1.48	3.41	2.96	0.81	8.06	1.17	21.56	1.69	1.07	0.51	3.66	1.05	4.47	8.73	0.49	2.04	1.68	0.32	1.13
C02	Japan	0.15	80.51	0.13	0.05	0.02	0.43	0.02	0.01	0.49	0.01	0.01	0.00*	0.00*	0.01	0.01	0.01	0.03	0.00*	0.00*	0.01	0.20	0.00*	0.01
C03	Canada	5.01	1.62	48.62	0.20	0.35	0.57	0.42	0.21	0.57	0.09	2.10	0.15	0.65	0.13	1.20	0.37	0.28	0.34	0.21	2.33	0.27	0.19	0.03
C04	France	0.96	0.80	1.84	81.24	8.59	0.57	7.29	3.20	0.26	0.33	0.16	1.56	0.30	0.27	0.18	0.51	1.30	0.71	0.79	2.49	0.15	0.06	0.73
C05	Italy	0.85	0.32	1.47	4.45	77.09	1.14	1.54	2.68	0.07	0.38	0.08	2.66	0.61	0.17	0.05	0.31	0.75	0.42	0.37	0.08	0.04	0.02	0.03
C06	Australia	0.86	2.06	1.78	0.37	1.29	89.48	0.13	0.03	2.14	0.03	0.29	0.26	0.53	0.03	0.16	1.14	0.12	0.84	0.12	0.20	0.55	0.26	0.08
C07	Spain	0.38	0.08	0.48	6.96	3.74	0.46	80.81	0.93	0.08	0.38	0.28	0.83	0.78	0.15	0.07	0.15	0.73	1.01	0.16	0.74	0.01	0.01	0.00*
C08	Greece	0.07	0.03	0.16	0.14	1.12	0.24	0.20	89.80	0.05	0.03	0.03	0.79	0.62	0.02	0.01	0.04	0.31	1.45	1.63	0.05	0.00*	0.01	0.01
C09	Korea	0.08	0.47	0.11	0.01	0.01	0.13	0.01	0.02	82.99	0.02	0.02	0.00*	0.00*	0.01	0.00*	0.00*	0.11	0.04	0.00*	0.00*	0.07	0.00*	0.01
C10	Argentina	0.31	0.10	0.43	0.45	1.38	0.12	2.07	0.46	0.50	90.47	0.29	0.42	16.13	5.04	4.61	2.58	0.46	0.69	0.29	1.66	0.27	0.44	0.00
C11	Mexico	2.78	0.29	1.48	0.13	0.07	0.22	0.28	0.05	0.03	0.15	74.44	0.07	0.08	0.06	0.15	0.03	0.09	0.02	0.05	0.03	0.01	0.01	0.00
C12	Hungary	0.02	0.07	0.03	0.17	0.54	0.02	0.10	0.10	0.07	0.01	0.00*	85.22	0.00*	0.00*	0.00*	0.01	0.49	0.03	0.46	0.06	0.00*	0.00*	0.00
C13	Uruguay	0.03	0.00*	0.31	0.03	0.05	0.00*	0.11	0.00*	0.01	0.64	0.13	0.00*	66.34	0.74	0.27	0.14	0.02	0.07	0.00*	0.00*	0.01	0.00*	0.00
C14	Brazil	0.51	0.59	1.20	2.24	1.42	1.13	2.27	0.54	1.09	5.93	0.26	4.96	12.32	92.63	0.38	0.85	4.22	0.66	1.99	2.45	0.30	0.17	0.04
C15	Peru	0.12	0.01	0.13	0.08	0.04	0.04	0.36	0.00*	0.01	0.05	0.05	0.05	0.02	0.02	89.20	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00
C16	South Africa	0.06	0.18	0.35	0.26	0.22	0.15	0.22	0.04	0.21	0.06	0.00	0.09	0.17	0.01	0.00*	91.88	0.15	0.09	0.25	0.01	0.03	0.01	0.00
C17	Russia	0.04	0.02	0.02	0.02	0.43	0.04	0.08	0.33	0.03	0.00*	0.00*	0.19	0.00*	0.00*	0.00*	0.00*	83.76	0.00	0.07	0.29	0.01	0.00*	0.00*
C18	Turkey	0.16	0.04	0.11	0.47	0.65	0.23	0.32	0.31	0.06	0.11	0.02	0.53	0.11	0.07	0.01	0.07	0.64	84.28	0.57	0.28	0.01	0.02	0.02
C19	Bulgaria	0.02	0.00*	0.04	0.05	0.08	0.03	0.05	0.21	0.00*	0.01	0.02	0.10	0.00*	0.00*	0.00*	0.00*	0.11	0.24	92.25	0.07	0.00*	0.00*	0.00
C20	Morocco	0.02	0.01	0.19	0.90	0.05	0.01	0.19	0.00*	0.01	0.00*	0.00*	0.03	0.00*	0.00*	0.00	0.00*	0.21	0.00*	0.00*	86.43	0.00*	0.00*	0.00
C21	China	0.57	3.27	1.04	0.42	1.07	1.31	0.38	0.12	2.82	0.08	0.17	0.20	0.19	0.07	0.04	0.43	0.79	0.27	0.17	0.73	96.36	0.21	0.01
C22	India	0.34	0.13	0.30	0.36	0.25	0.28	0.18	0.12	0.43	0.04	0.07	0.21	0.05	0.03	0.00*	0.41	0.97	0.13	0.11	0.03	0.03	98.24	0.06
C23	Ethipia	0.01	0.03	0.02	0.03	0.05	0.01	0.01	0.02	0.00*	0.00	0.00*	0.00*	0.00	0.00	0.00	0.00*	0.00*	0.00*	0.00*	0.02	0.00*	0.02	97.83

i. Entry in column *i*, row *j*, is the fraction of agricultural goods country *i* imports from country *j*.

ii. Zeroes with stars indicate the value is less than 5×10^{-3}.

iii. Zeroes without stars are zeroes in the data.

Table 2. Geographic and Country-Specific Etimates and Their % Effects on Trade Share

Observations Used		TSS	SSR	MSE			
515		26260	830	1.79			
Geographic barriers	Estimated Parameter	p-value	% Effect				
d_1 [0, 375)	-1.11	< 0.01	-39				
d_2 [375, 750)	-4.73	< 0.01	-312				
d_3 [750, 1500)	-5.11	< 0.01	-361				
d_4 [1500, 3000)	-6.13	< 0.01	-526				
d_5 [3000, 6000)	-7.30	< 0.01	-790				
d_6 [6000, maxium)	-7.61	< 0.01	-876				
b_{ij} Shared border	0.28	0.84	8				
	Destination Country				Source Country		
Country	δ^i_{ij}	p-value	% Effect		δ^j_{ij}	p-value	% Effect
United States	0.99	< 0.01	29		3.49	< 0.01	184
Japan	0.83	< 0.01	24		-1.16	< 0.01	-29
Canada	2.10	< 0.01	62		1.79	< 0.01	71
France	0.70	< 0.01	20		1.73	< 0.01	68
Italy	0.89	< 0.01	26		0.89	< 0.01	31
Australia	1.08	< 0.01	31		1.88	< 0.01	76
Spain	0.73	< 0.01	21		0.73	< 0.01	24
Greece	-0.67	0.02	-21		-0.65	0.02	-18
Korea	0.56	0.04	16		-1.41	< 0.01	-34
Argentina	-0.50	0.07	-16		2.14	< 0.01	89
Mexico	-0.11	0.69	-4		0.37	0.19	12
Hungary	0.09	0.75	2		-1.68	< 0.01	-40
Uruguay	0.37	0.18	10		-1.12	< 0.01	-29
Brazil	-0.67	0.02	-21		2.66	< 0.01	122
Peru	-0.95	< 0.01	-29		-1.69	< 0.01	-40
South Africa	-0.04	0.88	-2		0.19	0.51	6
Russia	0.66	0.02	19		-1.89	< 0.01	-43
Turkey	-0.49	0.08	-16		-0.42	0.13	-12
Bulgaria	-1.17	< 0.01	-36		-2.57	< 0.01	-54
Morocco	0.03	0.91	0		-2.62	< 0.01	-54
China	-1.31	< 0.01	-40		1.51	< 0.01	57
India	-1.66	< 0.01	-51		0.55	0.05	18
Ethiopia	-1.47	< 0.01	-45		-2.71	< 0.01	-56

Note 1: For estimated d, the implied % effect on trade cost is $100 \times [\text{Exp}(-\theta \times d)-1)]$ with $\theta = 0.2992$

Note 2: TSS is total sum of squares, SSR is residual sum of squares, and MSE is mean square error

Note 3: Estimated by GLS with 515 observations, Adjusted R^2 is 0.96.

Table 3. Marginal Cost, Behind and Beyond the Border Cost

		at θ = 0.2992 and ρ_{ij} = 0.5	
	mc	$T_{ij}(j,x)$	$T_{ij}(i,x)$
United States	0.550	0.640	0.409
Japan	1.370	1.033	1.068
Canada	0.863	0.678	0.460
France	0.758	0.785	0.616
Italy	0.915	0.837	0.701
Australia	0.765	0.745	0.554
Spain	0.931	0.865	0.748
Greece	1.065	1.140	1.300
Korea	1.402	1.088	1.185
Argentina	0.621	0.850	0.722
Mexico	0.919	0.975	0.950
Hungary	1.411	1.172	1.373
Uruguay	1.299	1.078	1.161
Brazil	0.550	0.820	0.672
Peru	1.275	1.302	1.694
South Africa	0.960	0.986	0.971
Russia	1.556	1.131	1.279
Turkey	1.035	1.095	1.198
Bulgaria	1.487	1.453	2.112
Morocco	1.691	1.294	1.675
China	0.649	0.980	0.960
India	0.759	1.116	1.247
Ethipia	1.483	1.518	2.303

Table 4. Counterfactuals 1 and 2: Decrease and Increase in Beyond the Border Cost

	Benchmark	*Counterfactual 1*		*Counterfactual 2*	
	X^0_{ij}/X^0_{ii}	X^1_{ij}/X^1_{ii}	$\Delta(X^1_{ij}/X^1_{ii})$	X^2_{ij}/X^2_{ii}	$\Delta(X^2_{ij}/X^2_{ii})$
U.S.	0.134	0.134	0	0.011	-92
Japan	0.195	0.784	302	0.064	-67
Canada	0.514	0.606	18	0.051	-90
France	0.188	0.339	81	0.028	-85
Italy	0.229	0.502	119	0.041	-82
Australia	0.105	0.163	55	0.014	-87
Spain	0.192	0.461	140	0.038	-80
Greece	0.102	0.547	436	0.045	-56
Korea	0.170	0.796	368	0.065	-62
Argentina	0.095	0.217	128	0.018	-81
Mexico	0.256	0.869	240	0.072	-72
Hungary	0.148	0.857	480	0.069	-53
Uruguay	0.337	0.858	155	0.125	-63
Brazil	0.074	0.151	105	0.013	-83
Peru	0.108	0.850	687	0.069	-36
S.Africa	0.081	0.285	251	0.024	-71
Russia	0.162	0.849	423	0.070	-57
Turkey	0.157	0.748	376	0.061	-61
Bulgaria	0.078	0.839	983	0.068	-12
Morocco	0.136	0.915	574	0.086	-37
China	0.036	0.126	245	0.010	-72
India	0.018	0.089	404	0.007	-59
Ethipia	0.022	0.267	1128	0.022	0
Average	0.154	0.533	335	0.047	-63

Note 1. In Counterfactual 1, all countries' beyond the border costs are reduced to 0.409.

Note 2. In Counterfactual 2, all countries' beyond the border costs are increased to 1.483.

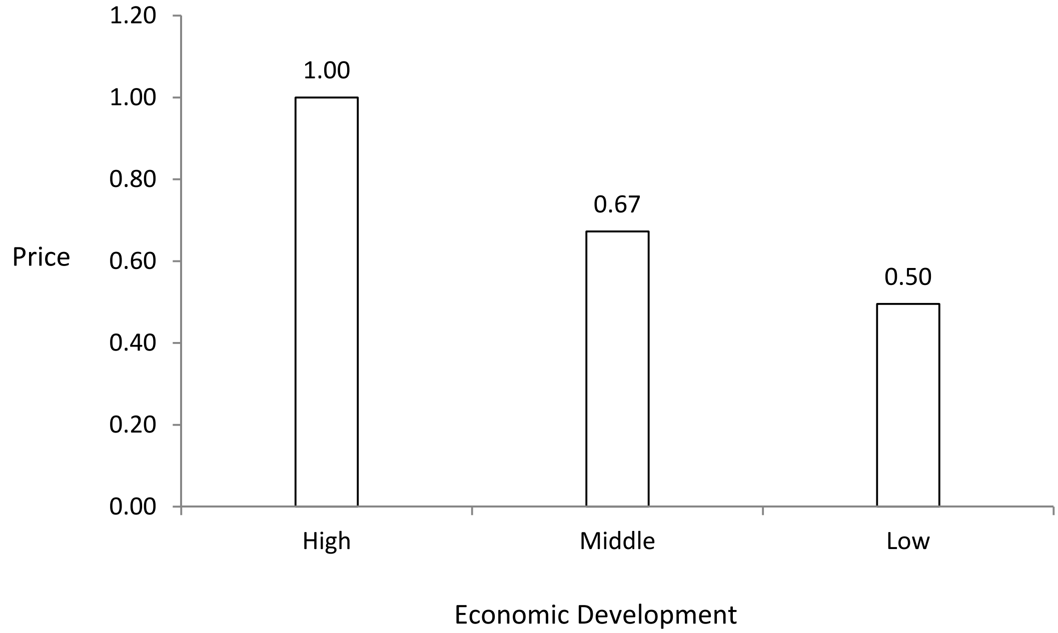

Figure 1. Agricultural Price and Economic Development

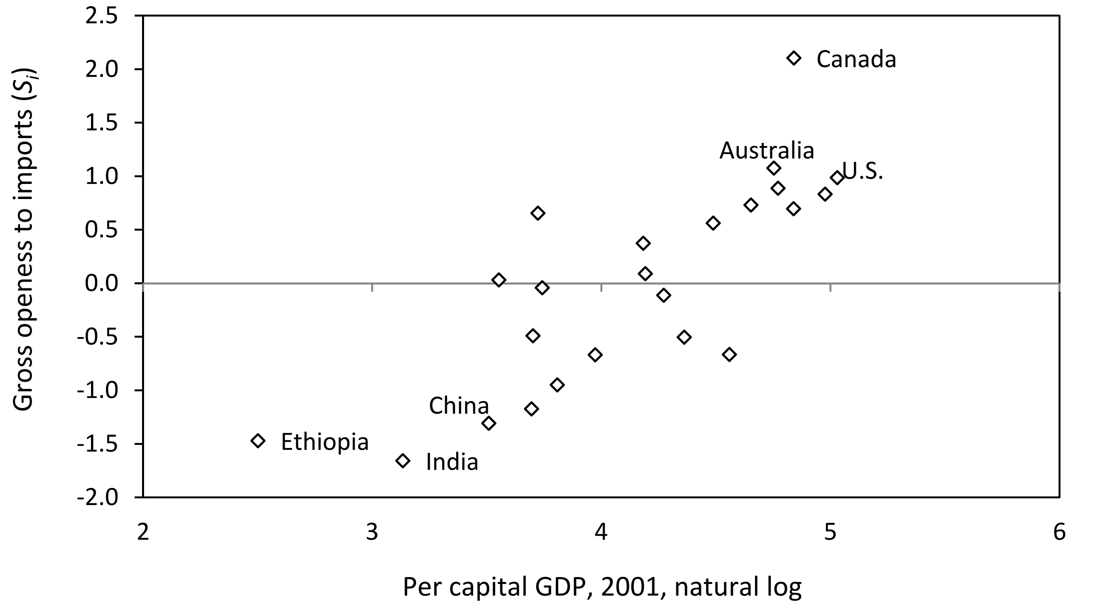

Figure 2.1 Gross openess and Per capital GDP

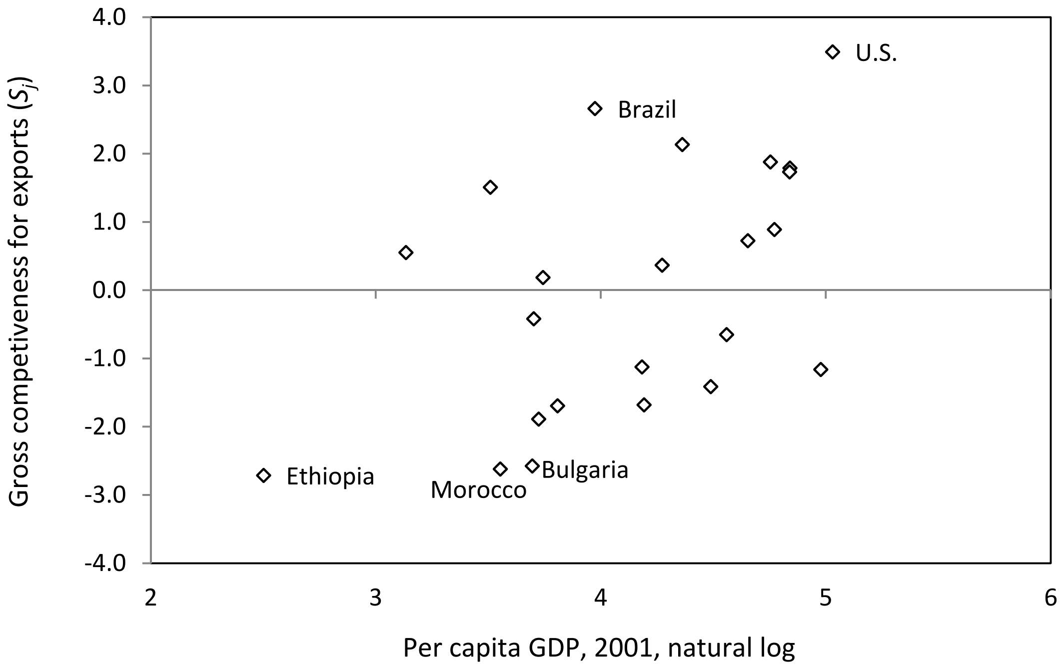

Figure 2.2 Gross competiveness and Per capita GDP

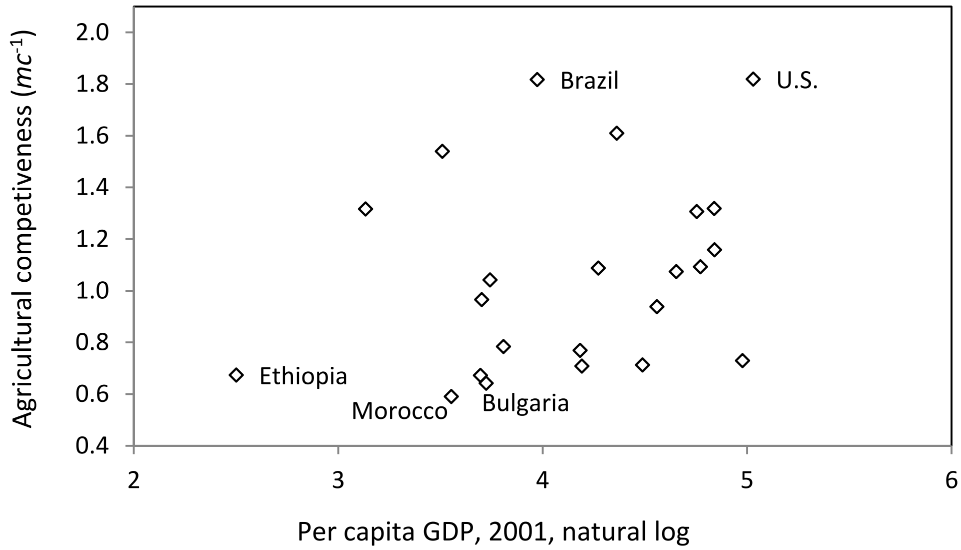

Figure 3.1 Agricultural Competitiveness and Per capiata GDP

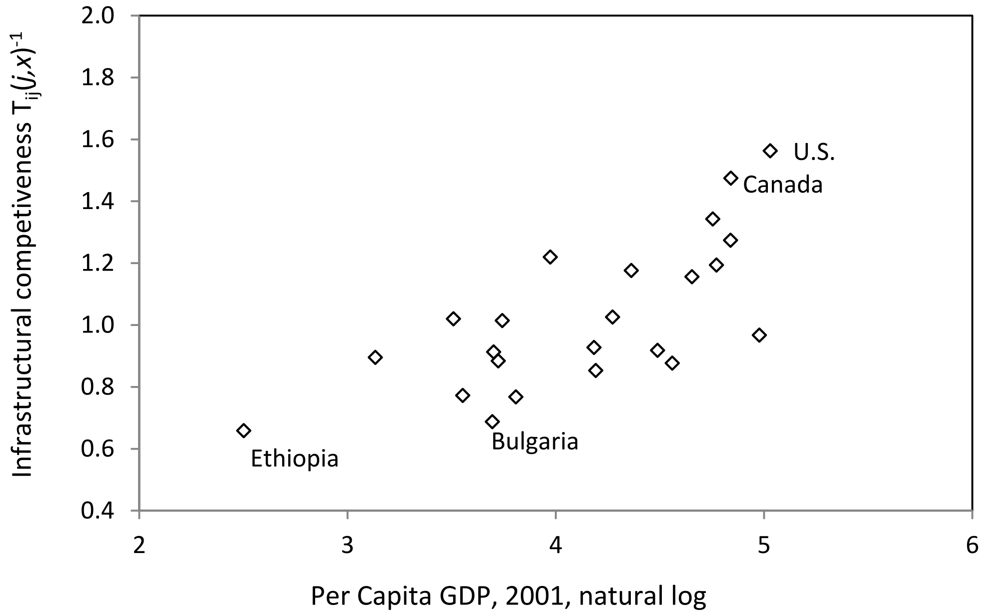

Figure 3.2 Infrastructural Competitiveness and Per capita GDP

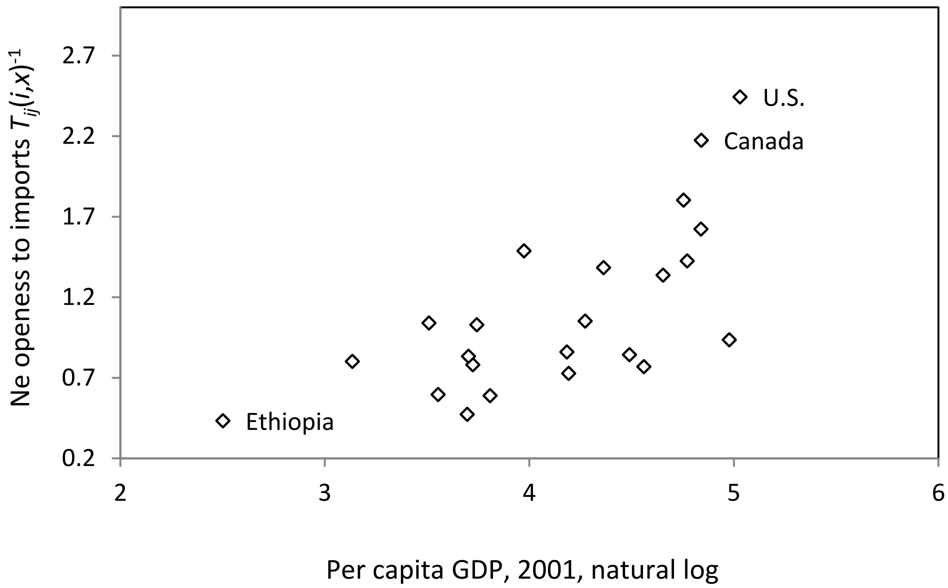

Figure 3.3 Net Openess and Per capita GDP

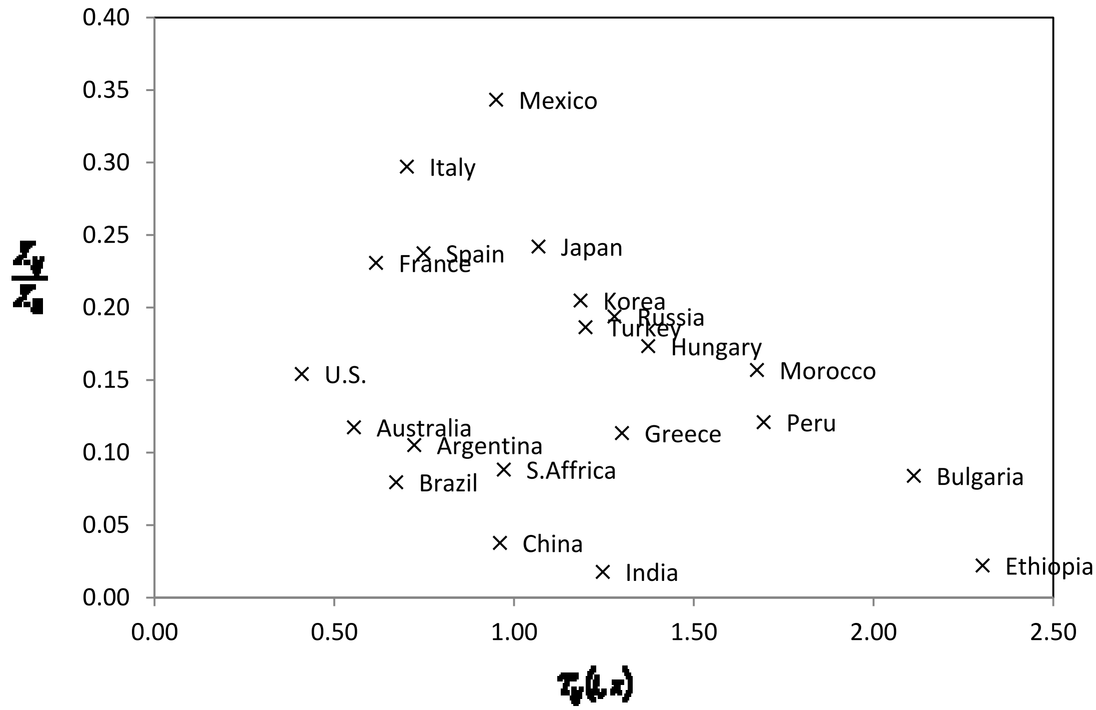

Figure 4.1 Relationship between Trade Share (X_{ij}/X_{ii}) and Beyond the Border Cost ($T_{ij}(i,x)$)

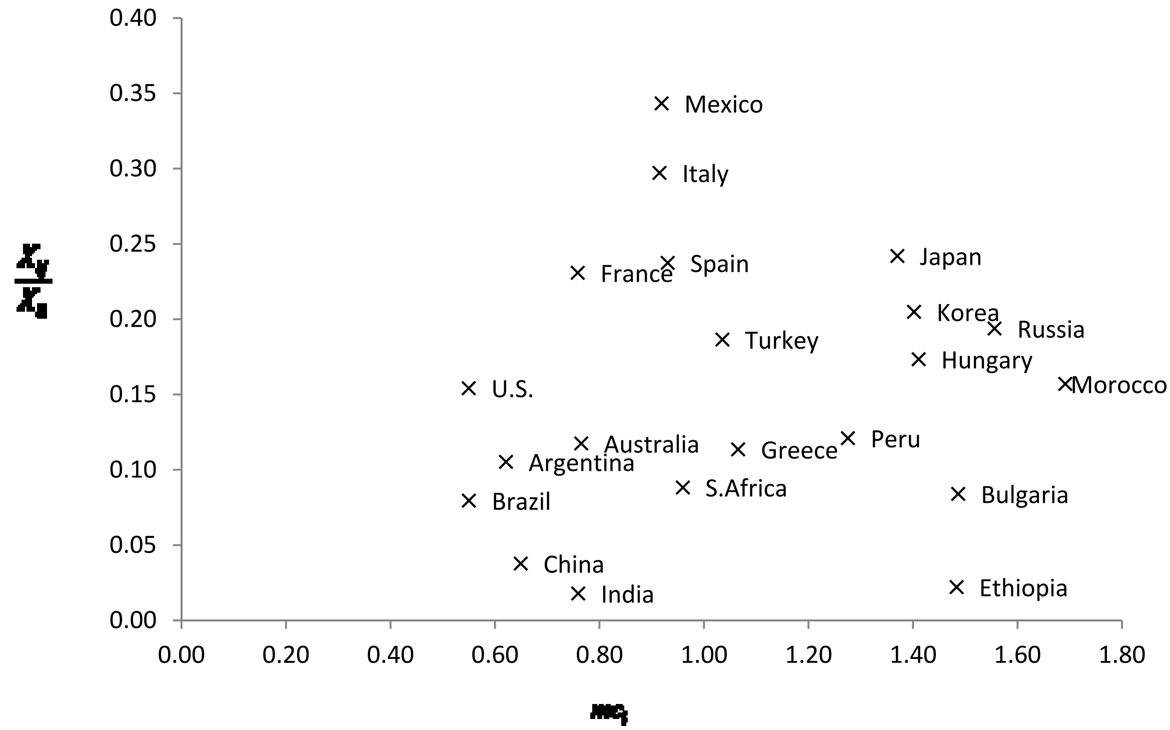

Figure 4.2 Relationship between Trade Share (X_{ij}/X_{ii}) and Marginal Cost (mc_i)

Footnote 1

For example, let us assume that marginal cost is $1 in producing one unit of an agricultural product in exporting country and tax equivalents are 21% for behind the border cost, 44% for between the border cost, and 55% for beyond the border cost. Then FOB price (marginal cost + behind the border cost) is $1×1.44=$1.44. CIF price (FOB price + between the border cost) is $1.44×1.21=$1.74. The retail price paid by a final consumer in importing country is $1.74×1.55=$2.70. As a result, $2.70 represents about 170% of *ad valorem* tax equivalent [{$\$1 \times T_{ij}(j,x) \times T_{ij}(b,x) \times T_{ij}(I,x) - 1$} × 100%].

Footnote 2.

Suppose that the home country has a more efficient market structure to export than foreign country. The costs incurred in moving from producer to dock (f.o.b.) at the port of embarkation is less than those of foreign country so that the behind the border costs are asymmetry in two trading countries. Also, suppose that the home country has less marketing costs or margin in selling the imported good than those of the importing country. The cost incurred in moving from cargo (c.i.f.) to an end user of home country is less than those of foreign country.

Footnote 3.

Reimer and Li (2010) indicated that in reality, this corresponds to the entire bundle of resources associated with land.

Fooотnote 4.

See Eaton and Kortum (2002) p1749.

Footnote 5.

According to Waugh's study, however, the slope coefficient of manufacturing goods was 0.12, implying that high income countries purchase slightly more from home than low income countries.

Footnote 6.

The idea here is that it must be the case that, for any given agricultural good *x* at a disaggregated level, $p_i(x)/p_j(x) \le \tau_{ij}$, otherwise there would be an opportunity for arbitrage. This implies that an estimate of τ_{ij} is the maximum of relative prices over agricultural goods *x*. Eaton and Kortum (2002) use this approach generating their preferred estimate of θ. They argue that this approach helps alleviate any measurement error and find that their estimates of τ_{ij}, when computed with the second-order statistic, are more correlated with the normalized bilateral trade shares, $\left(X_{ij} / X_{jj}\right)$, than when computed using the first-order statistic.

Footnote 7.

This assumption may be too strong for individual agricultural goods. However, the overall marginal cost of all agricultural goods produced in each country can be similar because each country can specialize in producing relatively efficient agricultural products for export and can import other agricultural products in which they are relatively less efficient agricultural producers. This assumption is supported by the data, which shows that all twenty-three countries simultaneously export and import.

Footnote 8.

We initially included regional free trade agreement dummy variables, common market dummy variables for EU member countries, and common language dummy variables in the model. However, most of these variables are not significant and affected negatively on both goodness of fit of the model and *p*-values of coefficients. According to this finding, we added only border share dummy variable in the model.

Footnote 9.

See Eaton and Kortum (2002), p. 1761 and Reimer and Li (2010), p 1029.

Appendix I. Agricultural Goods Prices

	Agricultural Goods	High	Per Capita GDP Middle US$ per 1000kg	Low
001	Agave Fibres Nes	1320	738	138
002	Almonds, with shell	1049	1155	1233
003	Apples	563	472	318
004	Apricots	925	654	263
005	Asparagus	3426	1871	295
006	Ass Live Weight	243	335	522
007	Avocados	916	414	186
008	Bananas	618	457	253
009	Barley	211	147	153
010	Beans, dry	1249	705	443
011	Beans, green	886	437	200
012	Beeswax	1989	2857	1693
013	Berries Nes	2272	1758	105
014	Biological Duck Meat	1620	1551	1128
015	Biological Goose Meat	2108	1439	1284
016	Biological Turkey Meat	1114	1438	1352
017	Bird meat, nes	1414	949	2852
018	Broad beans, horse beans, dry	337	550	410
019	Buffalo Live Weight	1699	1808	931
020	Buffalo meat	3468	3637	1748
021	Buffalo milk, whole, fresh	592	461	304
022	Cabbages and other brassicas	334	189	128
023	Camel Live Weight	950	1048	862
024	Camel meat	1235	1968	1583
025	Canary seed	219	238	39
026	Carobs	200	482	169
027	Carrots and turnips	327	269	169
028	Cashew nuts, with shell	170	328	574
029	Cassava	766	200	107
030	Castor oil seed	1631	223	161
031	Cattle Live Weight	2012	1217	900
032	Cattle meat	3695	2856	1703
033	Cauliflowers and broccoli	589	319	171
034	Cereals, nes	160	339	497
035	Cherries	2844	1678	895
036	Chestnuts	1209	1226	922

	Agricultural Goods	High	Per Capita GDP Middle US$ per 1000kg	Low
037	Chick peas	570	656	296
038	Chicken Live Weight	917	1237	1108
039	Chicken meat	1320	1591	1597
040	Chicory roots	649	95	871
041	Chillies and peppers, dry	2282	1387	562
042	Chillies and peppers, green	1382	530	364
043	Citrus fruit, nes	989	390	151
044	Coconuts	951	153	93
045	Coffee, green	5401	2902	851
046	Cotton lint	1253	737	1356
047	Cottonseed	133	343	175
048	Cow milk, whole, fresh	320	295	269
049	Cow peas, dry	402	734	491
050	Cucumbers and gherkins	700	287	185
051	Currants	988	501	230
052	Dates	1767	1086	318
053	Duck meat	1866	1789	1366
054	Eggplants (aubergines)	619	262	160
055	Figs	1126	765	314
056	Fruit Fresh Nes	1377	373	168
057	Fruit, tropical fresh nes	737	209	733
058	Game meat	1977	1073	1357
059	Garlic	2064	1301	532
060	Ginger	2488	1015	449
061	Goat Live Weight	1644	1375	988
062	Goat meat	3187	2876	1823
063	Goat milk, whole, fresh	476	462	341
064	Goose and guinea fowl meat	2562	1874	1741
065	Gooseberries	1333	1186	835
066	Grapefruit (inc. pomelos)	228	329	335
067	Grapes	986	400	271
068	Groundnuts, with shell	1086	686	483
069	Hazelnuts, with shell	1139	2074	245
070	Hen eggs, in shell	1112	1201	1307
071	Honey, natural	3539	3093	2164
072	Horse Live Weight	1109	686	589
073	Horse meat	2238	1830	868
074	Leeks, other alliaceous veg	876	391	324
075	Leguminous vegetables, nes	497	286	203

	Agricultural Goods	High	Per Capita GDP Middle US$ per 1000kg	Low
076	Lemons and limes	314	317	203
077	Lentils	434	487	297
078	Lettuce and chicory	708	419	108
079	Linseed	205	508	301
080	Maize	157	240	149
081	Maize, green	437	275	274
082	Mangoes, mangosteens, guavas	636	358	209
083	Meat nes	2427	1720	709
084	Meat of Asses	3485	670	2321
085	Meat Oth Camelids	109	1591	336
086	Millet	252	241	350
087	Mustard seed	223	343	1098
088	Nuts, nes	1168	1256	1723
089	Oats	121	124	130
090	Okra	1322	807	336
091	Olives	810	555	360
092	Onions (inc. shallots), green	642	339	235
093	Onions, dry	276	269	260
094	Oranges	345	309	217
095	Other Bastfibres	534	206	531
096	Other melons (inc.cantaloupes)	604	259	204
097	Palm oil	618	402	563
098	Papayas	551	237	597
099	Peaches and nectarines	853	649	318
100	Pears	568	327	374
101	Peas, dry	212	476	323
102	Peas, green	983	329	429
103	Persimmons	855	538	327
104	Pig Live Weight	1380	1020	999
105	Pig meat	1886	1427	1439
106	Pineapples	636	272	282
107	Pistachios	1943	6075	640
108	Plums and sloes	980	400	454
109	Potatoes	218	259	238
110	Pulses, nes	741	698	563
111	Pumpkins, squash and gourds	448	260	168
112	Quinces	729	265	237
113	Quinoa	4182	2339	512
114	Rabbit - Live weight	2719	1135	1209

	Agricultural Goods	High	Per Capita GDP Middle US$ per 1000kg	Low
115	Rabbit meat	3740	1509	1834
116	Rapeseed	259	206	231
117	Raspberries	4078	1377	441
118	Rice, paddy	560	307	273
119	Roots and Tubers, nes	1766	813	281
120	Rye	127	123	176
121	Safflower seed	224	141	204
122	Seed cotton	1167	538	457
123	Sesame seed	5345	1813	550
124	Sheep Live Weight	1553	1470	971
125	Sheep meat	3219	2845	1917
126	Sheep milk, whole, fresh	745	519	341
127	Silk-worm cocoons, reelable	8763	5880	11213
128	Sisal	63	345	765
129	Sorghum	237	128	179
130	Sour cherries	1145	625	2018
131	Soybeans	550	270	266
132	Spinach	728	291	100
133	Stone fruit, nes	2414	217	238
134	Strawberries	2151	1807	1419
135	String beans	3034	1988	246
136	Sugar beet	54	74	19
137	Sugar cane	83	82	105
138	Sunflower seed	285	319	245
139	Sweet potatoes	433	288	111
140	Tangerines, mandarins, clem.	519	316	205
141	Taro (cocoyam)	1355	460	149
142	Tea	19008	1475	829
143	Tobacco, unmanufactured	4150	3654	2015
144	Tomatoes	720	385	277
145	Triticale	154	106	1098
146	Turkey meat	1473	1493	1534
147	Vegetables fresh nes	724	297	161
148	Vetches	171	261	209
149	Walnuts, with shell	1552	1692	905
150	Watermelons	401	253	128
151	Wheat	212	178	178
152	Wool, greasy	1111	1067	863
153	Yams	2378	935	185
	Average	1379	914	683

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