International Trade Costs and the Intensive and Extensive Margins of Agricultural Trade

Shuwen Duan

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Jason H. Grant, Chair

Everett B. Peterson, Co-Chair

David R. Orden

Wen You

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Essays on International Agricultural Trade Cost and Intensive and Extensive Margins

Shuwen Duan

ABSTRACT

This dissertation describes two essays in empirical international trade, focusing on trade costs and the pattern of trade along the intensive and extensive margins. In the first essay, I study the barriers that impede international trade. In the second paper, I examine the growth of U.S. agricultural trade in detail describing how U.S. agriculture and food trade have expanded along the margins.

The first chapter introduces a relatively straightforward, yet empirically powerful, manipulation of the gravity equation. The gravity model has been dubbed the work horse model of empirical trade, and thus is a suitable foundation from which to derive an indirect measure of largely unobservable “iceberg” trade costs. In this paper, I solve a sector level version of the gravity equation and study the pattern of agricultural trade costs and factors that impede world agricultural trade growth over a long time series, 1986-2011. In addition, I estimate sector-specific elasticities of substitution, which is a key parameter in the computation of trade costs.

In the second essay, I examine the growth of world and U.S. agricultural exports along the intensive and extensive margins of international trade over the period 1986 to 2010. The purpose of this essay is to decompose the growth of world and U.S. agricultural trade using qualitative methods from the marketing literature (i.e., market expansion grids) but modified to fit bilateral trade relationships and a theoretical index to measure the margins of trade at a single point in time. In addition, we examine often overlooked channels by which U.S. agricultural exports have expanded using very detailed agricultural product lines. Using information related to the pattern of a trade rather than trade volume itself, I estimate how much starting a trade relationship with a new partner or in a new product variety matters to agricultural trade growth and then conclude with a set of stylized facts to inform current theory.

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Chapter 1: An Indirect Empirical Assessment of the Market Access in Agricultural Trade

Abstract*: International trade costs are known to be large but difficult to measure. Using a micro-founded gravity equation based on the framework in Novy (2011), this study estimates an indirect measure of multilateral trade costs for tradable goods in agriculture. Using production and bilateral trade data along with estimated values of the elasticity of substitution at the sector level, we find that median global agricultural trade costs were 260 percent ad valorem equivalent in 1989 and have not shown significant trend of declining. There is considerable variation in trade costs among agricultural sectors, especially when sector level elasticities of substitution are considered. Statistical analysis of the determinants of agricultural trade costs shows that geographical distance contributes the majority of variation for world agricultural trade cost explained by our model.*

1. Introduction

Globalization and the potential welfare gains from specialization and trade are considerably diminished due to trade costs and market access difficulties. Obstfeld and Rogoff (2000) claim that the explanation to their "six major puzzles" of macroeconomics hinges on trade costs. Commemorating its 60th anniversary the WTO's World Trade Report estimates that global trade has grown more than 27 fold in volume terms since 1950 (WTO 2007). One important reason for increased trade is the reduction in international trade costs, particularly transportation costs and tariffs.

However, impediments to the free flow of goods across national borders continue to exist and are known to be large but difficult to measure. The general conclusion of recent empirical investigations is that impediments to trade vary dramatically across space and are much larger than what we would expect them to be (Trefler 1993; McCallum 1995; Lee and Swagel 1997; Helliwell 1998; Wei 1996; Hummels 1999; Anderson and Smith 1999; Head and Ries 2001; Anderson and van Wincoop 2001, 2003, 2004; Bown and Crowley 2007; Bown, C.P. and M.A. Crowley 2007; Bradford 2003; Drogué and Bartova. 2006; Fillat and Pardos 2007; Paiva 2008). Anderson and van Wincoop (AvW 2004) corroborated this evidence by surveying the literature on trade costs - defined as all costs associated with getting shipments from origin to final consumers in foreign countries. The authors assert that trade costs are large and equal to a 170 percent *ad valorem* equivalent barrier, even between economies that are seemingly well integrated.

Persistent difficulties in measuring trade costs continue to plague international trade economists (AvW 2004) because of the myriad of policies that can affect commercial exchange - transportation costs, tariffs, language barriers, information and marketing hurdles, cultural asymmetries, institutional costs and currency barriers, non-tariff issues and a host of trade facilitation issues (Alberto and Wilson 2010). AvW (2004) note that the lack of comprehensive information on trade costs with any consistent time and country coverage is both a puzzle and a scandal for the international economics profession. Given the difficulties in constructing a direct measurement of trade costs, the purpose of this chapter is to adopt an indirect assessment; one that compares a nation's international trade to trade taking place within its border - the latter of which serves as an appropriate benchmark to define a seemingly well (or perfectly) integrated zone.

Helliwell and Schembri (2005) note that there are two alternative explanations for border effects: costs to crossing the border itself, and home country preferences coupled with more efficient local transactions. This study focuses on the first explanation, while controlling for the latter factor by using intra-national trade as a benchmark and estimating the elasticity of substitution between home and foreign goods. Several other studies have attempted to measure the border effect (Olper and Raimondi 2008; Fontagné *et al*. 2008). Fontagné *et al*. (2008) focus on market access between the United States, the EU and Japan and find that EU members have 13 times more trade with itself than with another EU country on average. The ratio rises to an implausibly large factor of 32.5 for U.S. imports from the EU. This paper adds to this branch of literature by estimating a bilateral trade cost measure for agriculture and food trade, similar to the border effect, over a long time series and for all country pairs in the database. I then extend this framework by developing an econometric model in an attempt to decompose trade costs into observable trade policy barriers.

Two methods are commonly used to estimate border effects for a large group of countries. The first method estimates a standard gravity model where the estimation sample includes both intra and international trade observations, and a dummy variable on the right-hand side to quantify the border effect (Wei 1996; Nitsch 2000; Head and Mayer 2000; Rose 2002; Evans 2003; Baier and Bergstrand 2009; Chen 2004). The second method uses the ratio of bilateral to internal trade as the dependent variable in a gravity-like specification (Fontagné *et al*. 2008; Olper and Raimondi 2008). Many of these studies find significantly large international border effects, similar to McCallum's (1995) original study between the U.S. and Canada. For example, in one of the first studies to investigate the border effect for European Union (EU) members, Olper and Raimondi (2008) find that intra-national trade is some 66 times greater than international trade even for comparatively well-integrated EU countries. Setting aside some econometric issues that may have yielded this relatively large border effect, there are two main drawbacks in this area of research. First, very few studies control for the elasticity of substitution between home and foreign goods in the calculation of border effects which means their estimates may be biased upwards due to preferences for local products. Second, by design the typical gravity framework used to estimate border effects yields an average treatment effect across all countries and products included in the sample. That is, the border effects framework reveals very little information on bilateral trade costs for a given country-pair and industry.

The method I develop in this paper manipulates the gravity equation to solve for an explicit measure of the bilateral and industry-specific trade costs. The methodology requires no assumption on the symmetry of trade costs as originally formulated by Anderson and van Wincoop (2003). Following the framework pioneered by Head and Ries (2001) and further developed by Novy (2013), I modify the theoretical gravity equation developed by AvW (2004) to solve explicitly for an indirect measure of trade costs at the sector level. The trade cost measures are imputed from data on bilateral trade flows, production statistics, and estimates of the elasticity of substitution between home and foreign goods. Moreover, there are no additional assumption needed to derive the trade cost function - that is, this measure is not tied to one particular theoretical model underlying the gravity equation. Indeed, as Arkolakis, Costinot and Rodríguez-Clare (2012) note, the leading models of international trade flows all generate isomorphic gravity equations. Thus, international trade costs can be derived from the Ricardian model, monopolistic competition and source differentiation, and recent models incorporating heterogeneous firms (Melitz 2003; Bernard *et al.* 2009). The indirect estimation of international trade costs requires a formal model that combines data on trade taking place within and across national borders, which forms one of the key objectives of this chapter. Finally, with this indirect assessment in place, we estimate how and to what degree trade policies explains indirect trade costs

2. Research objective

The overall purpose of this essay is to estimate the height of agricultural trade costs using an indirect approach that is based on trade flows and to determine the importance of observable trade policy barriers in explaining agricultural trade costs. Specifically, this essay has four core objectives. First, in order to understand the pattern of international trade costs, the first objective of this essay is to derive an explicit measure of the trade cost function from a mico-founded gravity framework at the sectoral level. Second, I construct an empirical database that includes bilateral trade and production data, trade policies, and other country characteristics in order to compute the indirect measure of trade costs. This process involves collecting data from different sources and making them compatible within my sample period. Third, to control for possible home biased preferences that may influence the size of international trade costs relative to the benchmark trade costs which are based on countries' internal trade (where data are available), I estimate sector-specific elasticities of substitution. Finally, having computed agricultural trade costs and presenting their pattern across time and countries, the last objective attempts to decompose these costs into observable economic components using information on bilateral tariffs, indicators of non-tariff measures, and the World Bank's trade facilitation data. To my knowledge this study is the first of its kind to estimate possible factors that explain the height of agricultural trade costs.

3. Methodology

In its simplest form, the gravity model, which originally resembled Newton's law of Universal Gravitation, assumes that trade volumes between two countries are proportional to the product of both countries' economic size as measured by their GDP, and inversely proportional to the distance between them (Tinbergen 1962). This basic form is based on the assumption of free trade, frictionless prices, homothetic preferences and no trade barriers. These countries are also specialized in differentiated products. Different authors have extended the gravity model by relaxing several of these assumptions. One of the well-known extensions is by AvW (2003). AvW (2003) argue that variable trade barriers could drive up trade costs and lead to price differences across countries. Omitted variable bias occurs when the role of prices are ignored in the gravity equation. The authors introduce a tariff equivalent, trade cost factor that drives up the price of imported goods, which includes all observable and unobservable trade barriers.

In order to incorporate trade costs into the gravity equation, the authors start with the assumption that all varieties are differentiated by country origin and consumer preferences are represented by Constant Elasticity Substitution (CES) utility function with sigma denoting the elasticity of substitution between all varieties. Maximizing the representative consumer's utility function subject to a budget constraint we get the demand equation for the volume of trade, x_{ij}, which is a function of the price indices and the importer's income y_j. By imposing market clearing under general equilibrium, AvW (2003) solve the gravity equation that includes a trade cost factor and price indices for both countries with the latter often referred to as countries' multilateral resistance. Below, I derive the basic formulation of the gravity equation for use in subsector analysis such as agriculture.

3.1 Gravity equation at sectoral level

I derive a gravity equation at the sector level, starting with a theoretical framework based on CES preferences and the assumption that products are differentiated by country of origin first as suggested by Anderson (1979). My contribution is deriving a gravity equation from a CES preference structure at the sector level and manipulating this derivation to solve for the trade cost factor which we will call τ_{ijk}. The model is similar to the framework in AvW (2003). However, the main differences between my model and the one in AvW (2003) is that at the sector level, we do not assume identical, homothetic preferences across all products. Moreover, since we are deriving the gravity equation at a finer level of classification, we do not need to impose the assumption that each country is specialized in the production of only one good as in AvW (2003). In a multi-country and multi-product world where country $i, j=1, \ldots, N$ produces $k=1, \ldots, K$ products, if c_{ijk} is the consumption of good in sector k by country j's consumer from country i, the CES utility function is as follows:

$$(1) \qquad U_{jk}(c_{ijk}) = \left(\sum_{i=1}^{N} \beta_{ik}^{(1-\sigma_k)/\sigma_k} c_{ijk}^{(\sigma_k-1)/\sigma_k} \right)^{\sigma_k/(\sigma_k-1)}$$

where β_{ik} is a positive distribution or taste parameter, and σ_k is the elasticity of substitution between good *k* from different origins. The goal is to maximize the utility function subject to the following budget constraint:

$$y_{jk} = \sum_{i=1}^{N} p_{ijk} c_{ijk} \qquad (2)$$

where p_{ijk} is the price of product *k* that ships from country *i* to country *j*, and y_{jk} is the total expenditure on product *k* for country *j*. The price term p_{ijk} includes all the trade costs to ship good *k* between country *i* and *j*, and is modeled as a price linkage equation, $p_{ijk} = t_{ijk} p_{ik}$, when the t_{ijk} is the ad valorem equivalent of the trade cost factor. This formation introduces an "iceberg" bilateral trade cost term t_{ijk} and was first introduced by Samuelson (1952). The intuition behind this trade cost term is that for one unit to arrive at country *j*, t_{ijk} unit of products need to be shipped from country *i*. In other words, $t_{ijk} - 1$ unit of the product "melts" because of trade barriers affecting exports from country *i* to *j*. Solving this maximization problem, we can arrive at the following demand function for product *k* in country *j* from country *i*:

$$x_{ijk} = \left(\frac{\beta_{ik} t_{ijk} p_{ik}}{P_{jk}} \right)^{1-\sigma_k} y_{jk} \qquad (3)$$

where $P_{jk} \equiv \left(\sum_{i=1}^{N} (\beta_{ijk} t_{ijk} p_{ik})^{1-\sigma_k} \right)^{1/(1-\sigma_k)}$ is the overall price index for country *j*. Imposing market clearing as in AvW (2003), we can solve for the equilibrium scaled price index as follows:

$$(\beta_{ik} p_{ik})^{1-\sigma_k} = \frac{y_{ik}}{\sum_{j=1}^{N} (t_{ijk} / P_{jk})^{1-\sigma_k} y_{jk}} \tag{4}$$

Plugging the equilibrium scaled price term into the demand function yields:

$$x_{ijk} = \frac{y_{ik} y_{jk}}{y_{wk}} \left(\frac{t_{ijk}}{\Pi_{ik} P_{jk}} \right)^{1-\sigma_k} \tag{5}$$

where $\Pi_{ik} \equiv \left[\sum_{j=1}^{N} (t_{ijk} / P_{jk})^{1-\sigma_k} \cdot (y_{jk} / y_{wk}) \right]^{1/(1-\sigma_k)}$, is the outward multilateral (price) resistance of country *i* defined as the resistance *i* faces shipping products to its partners in the rest of the world in product *k*, x_{ijk} is the value of trade from country *i* to country *j* in product *k*, y_{ik} and y_{jk} are total expenditure of country *i* and *j* on product *k*, and y_{wk} is the world total expenditure on product *k*. Substituting the equilibrium scaled price term into the price index function again, we can arrive at a similar expression for the price index for country *j*, $P_{jk} = \left[\sum_{i=1}^{N} (t_{ijk} / \Pi_{ik})^{1-\sigma_k} \cdot (y_{ik} / y_{wk}) \right]^{1/(1-\sigma_k)}$, which is the analogously defined inward multilateral resistance of country *j* in product *k*.

The two multilateral resistance price terms Π_{ik} and P_{jk} were first introduced by AvW (2003) at the country level. They reflect the price index that indicates the average trade barriers that countries face with all their trading partners in the rest of the world relative to the bilateral trade cost factor (t_{ijk}). Thus, the more resistant *i* and *j* are to trade with their partners in the rest of the world, the higher is bilateral trade between *i* and *j*, other things equal. This product-level gravity model is similar to what AvW (2003) presents at country level. It tells us that at sector level, a country's bilateral trade in one particular sector also depends on the two country's expenditure in this sector and bilateral trade barriers adjusted by their multilateral price resistance terms. However, another key difference between this sector level gravity model from AvW (2003)'s version is that we do not impose symmetric trade cost assumptions, that is, $t_{ijk} \neq t_{jik}$. As a result, we do not have the assumption that a country's outward and inward price resistance price terms are identical ($\mathrm{P}_{ik} \neq \Pi_{ik}$). Using this basic gravity model at sector level, we derive our trade cost measure for all sectors between two countries.

3.2 Constructing border effect measure τ_{ijt}

Since all underlying trade theories from Ricardian framework to Monopolistic competition to heterogeneous firms generate isomorphic gravity equations, we can derive the border effect measure from several theoretical frameworks. As an illustration, here we use the familiar Anderson and Van Wincoop (2003) framework:

(6) $$x_{ijk} = \frac{y_{ik} y_{jk}}{y_{wk}} \left(\frac{t_{ijk}}{\Pi_{ik} \mathrm{P}_{jk}}\right)^{1-\sigma_k}$$

In order to derive our trade cost measure from the AvW (2003) gravity equation, we first need to define a relevant benchmark. Initially, we assume the benchmark is a country's trade inside its own border. Rewriting AvW's (2003) gravity equation to indicate country *i*'s trade with itself yields:

(7) $$x_{iik} = \frac{y_{ik} y_{ik}}{y_{wk}} \left(\frac{t_{iik}}{\Pi_{ik} \mathrm{P}_{ik}}\right)^{1-\sigma_k}$$

and solving for country *i's* multilateral price terms yields:

(8) $$\Pi_{ik} \mathrm{P}_{ik} = \left(\frac{x_{iik} / y_{ik}}{y_{ik} / y_{wk}}\right)^{\frac{1}{\sigma_k - 1}} t_{iik}$$

Multiplying x_{ij} and the reverse flow x_{ji} together,

$$x_{ijk}x_{jik} = (\frac{y_{ik}y_{jk}}{y_{wk}})^2 (\frac{t_{ijk}t_{jik}}{\Pi_{ik}P_{ik}\Pi_{jk}P_{jk}})^{1-\sigma_k} \tag{9}$$

and substituting (9) for country i and j in (10) and rearranging, we arrive at an expression for the ratio of international and internal bilateral trade costs as a function of bilateral trade flows:

$$\frac{t_{ijk}t_{jik}}{t_{iik}t_{jjk}} = (\frac{x_{ijk}x_{jik}}{x_{iik}x_{jjk}})^{1/(1-\sigma_k)} \tag{10}$$

Taking a geometric mean of the trade cost ratio and subtracting one, we arrive at the following *ad-valorem* equivalent measure of trade costs τ_{ijt}:

$$\tau_{ijkt} \equiv (\frac{t_{ijkt}t_{jikt}}{t_{iikt}t_{jjkt}})^{\frac{1}{2}} - 1 = (\frac{x_{iikt}x_{jjkt}}{x_{ijkt}x_{jikt}})^{\frac{1}{2(\sigma_k - 1)}} - 1 \tag{11}$$

where, σ_k is a key parameter in this expression representing the elasticity of substitution between domestic and foreign goods. This trade cost measure is essentially a scaled ratio of trade cost across international borders relative to trade costs within national borders weighted by the elasticity of substitution. One thing worth noting is that τ_{ijkt} is not directional. That is, τ_{ijkt} measures the barrier between country *i* and *j* on average, so that it is a two-way trade cost measure. Intuitively, it measures the bilateral trade cost for both importing and exporting countries. Moreover, τ_{ijkt} captures the barriers of international relative to intra-nation trade without assuming frictionless trade in the former or symmetric trade costs between the latter (Novy 2011). A set of estimates for σ_k

commonly used in the literature is around 8 to 10 (AvW 2004; Hertel et al 2007). For example, Hertel *et al*. (2007) estimate the value of σ_k to be around 9 for wheat and paddy rice, 4 for fruit and vegetables and 8 for meat and dairy products. Following the literature, we begin with σ_k equal to eight to examine a baseline level of global agricultural trade costs. However, our industry classifications may not match the products and sector classifications used in previous studies estimating values for σ_k. Thus, relying solely on literature estimates may introduce some bias in the trade costs estimates. Therefore, one of the final objectives of this essay is to estimate the value of σ_k for the different sectors and industries defined in our sample to add more precision to the imputed trade costs. The estimation approach follows Feenstra (1994) and was further extended by Broda and Weinstein (2006) and Imbs and Méjean (2011). The method is further discussed in the next section.

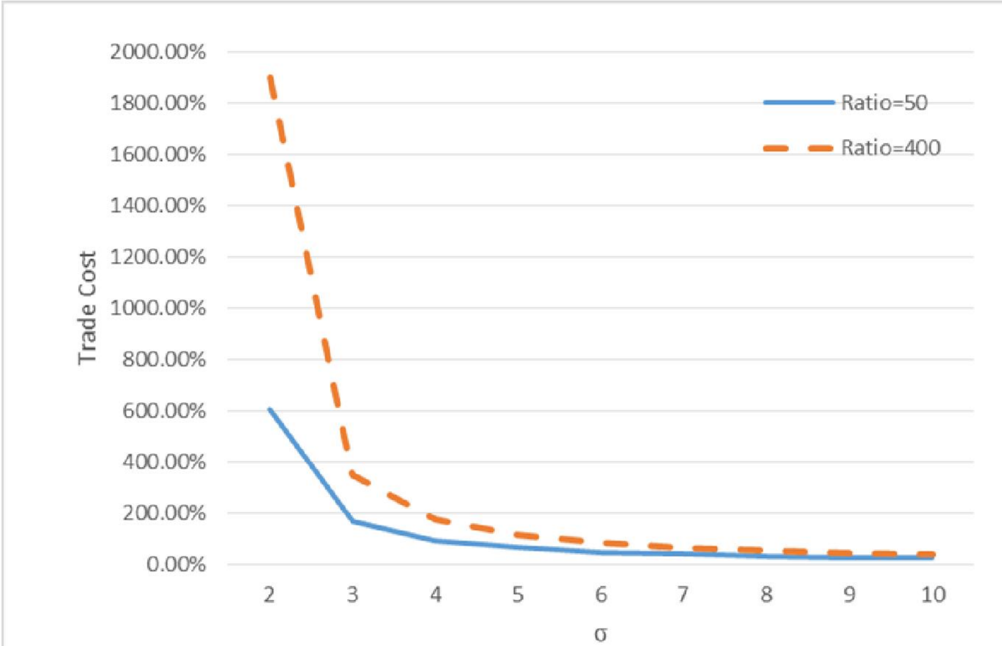
In addition to international trade data, a key component of equation (11) is the x_{iik} and x_{jjk} terms denoting the value of *i* and *j*'s intra-national trade. The intra-national trade x_{iik} is constructed using an accounting identity advocated by Shang-Jin Wei (1996) whereby total exports are subtracted from gross production in comparable industries as follows:

$$x_{iik} = prod_{ik} - exp_{ik} \tag{12}$$

The advantage of equation (11) used to compute τ_{ijtk} is that it is parsimonious in its data requirement and captures all costs associated with crossing international borders (observable and unobservable) relative to trading within a country which is assumed to represent a well-integrated nation. Another advantage of the trade cost measure is that it allows for a time-varying measurement of bilateral trade barriers since trade and production data are more readily available than observable trade cost factors such as bilateral tariffs and non-tariff measures. One of the core objectives of this study is to map FAO production data to corresponding trade values over a long time series to explore how far global agricultural trade costs have declined since the 1980s.

Equation (11) indicates that agricultural trade costs depend on the value of the elasticity of substitution (σ) and the ratio of domestic to international trade ($x_{ii}x_{jj}/ x_{ij}x_{ji}$). Figures 1 and 2 illustrate a hypothetical example of the behavior of trade costs for different elasticity values and the ratio of domestic to international trade. In Figure 1, we hold constant the domestic to international trade ratio at 50 and 400, and increase the elasticity from two to ten in increments of one. In other words, we assume that domestic trade is constant at 50 and 400 times greater than international between these two hypothetical countries and trace out the behavior of international trade costs by varying the elasticity of substitution. Note that the ratios of 50 and 400 approximate well the variation in actual mean and median ratios in the database described in the next section.

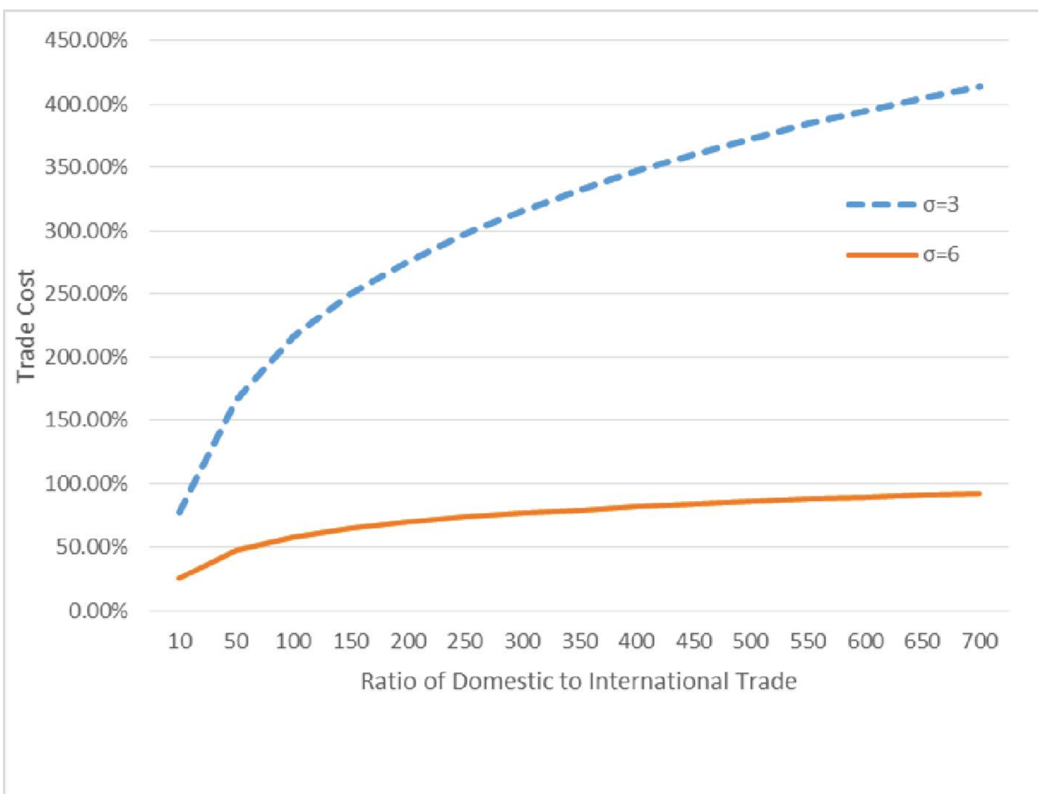
Figure 1: Trade Cost with Constant Domestic to International Trade Ratio



The differences between the two trade costs are larger when the elasticity is smaller and gradually become more similar when the elasticity gets larger and products are more homogeneous. For example, when σ = 2, trade costs are 607.11 percent for the dashed line representing a domestic to international trade ratio of 400 compared to 1900 percent for the solid line representing a domestic to international trade ratio of 50. Conversely, when σ = 10 trade costs are 39.5 percent for the dashed line compared to 24.28 percent for the solid line. Thus, even though the dashed line represents a domestic to international trade ratio that is eight times larger than the solid line (400 vs. 50), trade costs are 3.12 times larger (1900/607.11) when products are more differentiated and the elasticity is 2.0, and only 1.63 times larger (39.5/24.28) when products are more homogeneous and the elasticity is 10.0.

Figure 2 traces out the behavior of trade costs holding constant the elasticity of substitution at three (dashed line) and six (solid line) but varies the ratio of domestic to international trade (from ten to seven hundred). Trade costs still increase as the ratio increases when the elasticity equals six, but at a much slower rate when the elasticity equals three. When $\sigma = 3$, trade costs are 77.83 percent when the domestic to international trade ratio is 10, compared to 414.37 percent when the trade ratio increase to 700. Trade costs are only 5.3 times larger when the trade ratio increases by sixty-nine times. Conversely, trade costs are only 3.6 times larger (92.54/25.89) when domestic to international trade ratio increases from 10 to 700 when products are more homogeneous and the elasticity is six.

Figure 2: Trade Cost with Constant Elasticity



3.3 Estimation of the elasticity of substitution

Feenstra (1994) developed a framework based on Armington assumption and CES demand system to identify the elasticity of substitution across sectors for importers. It is essentially a structural estimator that involves regressing import prices on import quantities. However, the process produces a number of imaginary values due to the computation that involves the square-root operator as shown later in this section. To solve this problem, Broda and Weinstein (2006) further refine the method by adding a search algorithm to find economically feasible estimates.

In order to estimate the elasticity of substitution, first we need to specify the demand and supply equations. Based on the same CES preference structure that we used to derive the gravity equation, the demand equation of country *j* for product in sector *k* from country *i* in time *t* can be written as follows:

$$c_{ijkt} = \left(\frac{\beta_{ikt} p_{ijkt}}{P_{jkt}} \right)^{-\sigma_k} \frac{\beta_{ikt} y_{jkt}}{P_{jkt}} \tag{13}$$

where c_{ijkt} is the consumption of good *k* in country *j* that is imported from country *i;* $P_{jkt} \equiv \left(\sum_{i=1}^{N} (\beta_{ijkt} p_{ijkt})^{1-\sigma_k} \right)^{1/(1-\sigma_k)}$ is the price index for country *j* in sector *k* as derived in previous section. Following Feenstra (1994) and Broda and Weinstein (2006), a simple structured supply curve is imposed:

$$p_{ijkt} = t_{ijkt} \exp(\upsilon_{ijkt}) c_{ijkt}^{\omega_k} \tag{14}$$

where υ_{ijkt} is the production or technological supply shock, t_{ijkt} is the trade cost term and ω_k is the inverse of price elasticity of supply in sector *k*. Define the expenditure share of good *k* imported from country *j* as $s_{ijkt} \equiv \frac{p_{ijkt}c_{ijkt}}{\sum_{i=1}^{N} p_{ijkt}c_{ijkt}}$. The expenditure shares are used rather than quantity for the estimation in order to control for measurement error caused by correlation between quantities and unit values (Kemp 1962). The demand can then be rewritten as:

$$s_{ijkt} = \left(\frac{\beta_{ijkt} p_{ijkt}}{P_{jkt}} \right)^{1-\sigma_k} \tag{15}$$

Following Feenstra (1994), the next step is to eliminate time-specific unobservables by first-differencing prices and shares. In addition, we eliminate the good-specific unobservables by first-differencing again by a reference country *r*'s prices and shares. This reference country is chosen for each importing country such that they have consistently traded in a same group of products throughout the period that we study. The result is two equations that represent demand and supply curves:

$$\Delta_r \ln s_{ijkt} = \Delta \ln p_{ijkt} - \Delta \ln p_{rjkt} = -(\sigma_{jk} - 1)\Delta_r \ln p_{ijkt} + \varepsilon_{rjkt} \tag{16}$$

$$\Delta_r \ln p_{ijkt} = \Delta \ln s_{ijkt} - \Delta \ln s_{rjkt} = \left(\frac{\omega_{jk}}{1+\omega_{jk}} \right) \Delta_r \ln s_{ijkt} + \delta_{rjkt} \tag{17}$$

where $\delta_{rjkt} \equiv \frac{1}{1+\omega_{jk}\sigma_{jk}} \Delta \upsilon_{ijkt}$ is a term that captures movement in technological shocks in sector *k* in country *i.* Utilizing the assumption that supply and demand error terms vary independently across time and products ($E(\varepsilon_{rjkt}\delta_{rjkt})=0$), multiply (16) and (17) we arrive at the following estimable equations:

$$\Delta_r \ln s_{ijkt}{}^2 = \theta_{0jk}\mathrm{I}_{0ijkt} + \theta_{1jk}\left(\Delta_r \ln p_{ijkt}{}^2\right) + \theta_{2jk}\left(\Delta_r \ln s_{ijkt}\ \Delta_r \ln p_{ijkt}\right) + \mu_{ijkt} \tag{18}$$

where $\theta_{0jk}I_{0ijkt}$ is a vector of ones added to control for measurement error in unit values (see Feenstra 1994). Since the unit value and expenditure terms are correlated with the errors, there are endogeneity issues in the estimation equation. To address this issue, we average the estimating equation over *t* to obtain a consistent estimator. Using a bar to denote time averaged variables, the estimating equation then becomes:

$$\overline{\Delta_r \ln s_{ijkt}{}^2} = \theta_{0jk}\mathrm{I}_{0ijk} + \theta_{1jk}\overline{\Delta_r \ln p_{ijkt}{}^2} + \theta_{2jk}\overline{\Delta_r \ln s_{ijkt}\ \Delta_r \ln p_{ijkt}} + \overline{\mu}_{ijk} \tag{19}$$

Furthermore, in order to correct for heteroskedasticity, we follow Feenstra (1994) to weight the estimation equation by the inverse of estimated residuals so that

$\mu_{ijkt} = \dfrac{\varepsilon_{rjkt}\delta_{rjkt}}{1-\rho}$, where $\rho_{jk} \equiv \dfrac{\omega_{jk}(\sigma_{jk}-1)}{1+\omega_{jk}\sigma_{jk}}$. Then we apply the Two-Stage Least Square (2SLS) estimation procedure using the country-sector fixed effects as instrument variables (IVs). Estimates from the 2SLS step can be used to calculate the elasticity of substitution by solving the following two quadratic equations:

$$\hat{\theta}_{1jk} = \frac{\hat{\rho}_{jk}}{(\hat{\sigma}_{jk}-1)^2(1-\hat{\rho}_{jk})}, \quad \hat{\theta}_{2jk} = \frac{2\hat{\rho}_{jk}-1}{(\hat{\sigma}_{jk}-1)(1-\hat{\rho}_{jk})} \tag{20}$$

The corresponding elasticities implied from the model are:

$$\hat{\sigma}_{jk} = \begin{cases} 1+\dfrac{\hat{\theta}_{2jk}+\sqrt{\hat{\theta}_{2jk}^2+4\hat{\theta}_{1jk}}}{2\hat{\theta}_{1jk}} & \text{if } \hat{\theta}_{1jk}>0 \text{ and } \hat{\theta}_{1jk}+\hat{\theta}_{2jk}<1 \\ 1+\dfrac{\hat{\theta}_{2jk}-\sqrt{\hat{\theta}_{2jk}^2+4\hat{\theta}_{1jk}}}{2\hat{\theta}_{1jk}} & \text{if } \hat{\theta}_{1jk}<0 \text{ and } \hat{\theta}_{1jk}+\hat{\theta}_{2jk}>1 \end{cases}, \tag{21}$$

However, this solution cannot consistently give estimates that are valid as the error term is correlated with the variables constructed using prices and expenditure shares. To solve this problem, Broda and Weinstein (2006) suggest a grid search algorithm that minimizes the sum of squared residuals in the estimation equation for the elasticities over an interval of values. Define a set of moment conditions for each good *k,* this method optimizes the estimation equation with the moment condition E($\mu_{ijkt} \mid \beta_{jk}$)=0, where $\beta_{jk} \equiv \begin{pmatrix} \sigma_{jk} \\ \rho_{jk} \end{pmatrix}$. The following GMM objective function utilizes all the moment conditions to obtain the Hansen (1982) estimator:

(22) $$\beta_{jk} = \arg\min_{\beta_{jk} \in B} G(\beta_{jk})' W G(\beta_{jk})$$

where *W* is a weighting matrix and *B* is the set of feasible β_{jk} so that $\sigma_{jk} > 1$, $\rho_{jk} > 0$. Broda and Weinstein (2006) evaluate values between 1.05 and 131.5 at intervals that are five percent apart for U.S. import data. We follow their interval approach for our grid search process.

3.4 Decomposition of border effect measures

In addition to computing the overall height of agricultural trade costs, this study will also provide a first attempt at decomposing agricultural trade costs into observable trade cost components (where data are available). What types of barriers matter in shaping agri-food trade? How much do they explain the international border effects? Using data on bilateral tariffs, indicators of non-tariff measures and World Bank trade facilitation data (Alberto and Wilson 2010), the final objective of this essay is to estimate the relative importance of observable market access barriers in the overall trade cost measure. More specifically, since τ_{ijkt} contains a bilateral, time, and product dimension, it varies across all country pairs for which trade data are available. Initially, I explore the relationship between typical gravity equation factors such as distance, shared borders and common languages and then extend this framework to incorporate familiar border barriers, such as tariffs, where data are available. The baseline model is as follows:

$$\begin{aligned}\tau_{ijkt} &= \beta_0 + \beta_1 \ln(dist_{ij}) + \beta_2 \ln(tariff_{ijkt}) + \beta_3 t + \beta_4 D_{ij}^{language} + \beta_5 D_{ij}^{contiguity} \\ &+ \beta_6 \ln(NTB_{ij}) + \beta_6 \ln(Facilitation_{ij}) + \varepsilon_{ijt}\end{aligned} \tag{23}$$

where $dist_{ij}$ is the distance between two countries and t is the time period indicator. We also include dummies for sharing the same language and border ($D_{ij}^{language}$ and $D_{ij}^{contiguity}$, respectively) and variables for trade policy such as tariff rates and trade facilitation indicators (detailed in the data description in the next section). In particular, we look at how trade facilitation may explain the variation in agricultural trade costs. This decomposition of trade costs differs from the traditional gravity estimation in that it separates the effect of trade frictions and the effect of heterogeneity. In addition, it provides us with directly comparable measures for trade costs between countries at sector level. Finally, we quantify the contribution of each observable trade cost factors using the estimated coefficients following Fields (2003):

$$s_g = \frac{\hat{\beta}_g Cov(g, \tau_{ijt})}{Var(g)} \tag{24}$$

where s_g is the share of variation contribution for each independent variable g to trade cost τ_{ijt}, $\hat{\beta}_g$ denotes the regression coefficient for g, $Cov(g, \tau_{ijt})$ is the covariance between variable g and τ_{ijt}, and $Var(g)$ is the variance for g.

4. Data

This section discusses the data used in conducting the trade cost analysis. The data used involve primarily bilateral trade, production and export statistics in a compatible industry classification. The data are described in three steps: (i) the first part describes the data and processes needed for computing trade costs (τ_{ijkt}). This involves collecting product matched data for countries' bilateral trade, total exports and production in value terms; (ii) the second step presents the data for estimating the elasticity of substitution and data issues related to this procedure; and finally (iii) the final section discusses the remaining variables included in the dataset for decomposing trade costs into observable components.

4.1 Data for computing trade cost measure

The agricultural bilateral trade and production data are retrieved from the Food and Agriculture Organization's (FAO) detailed trade flow and production statistics matrix[1]. We assemble a bilateral dataset of the value of agricultural trade flows covering 26 years of data (1986-2011) and 171 countries. Note that 1986 was the earliest year for which FAO collects agricultural trade data. The FAO reports both reported imports and countries' reported export values, where the former is valued on a CIF (Cost, insurance and freight) basis and the latter is reported on an FOB (free on board) basis. There may be discrepancies in reported values of trade. When computing the trade cost measure, we use import values whenever imports are reported and exports are missing, exports if imports are missing and the maximum of imports or exports if both are reported.

[1] http://faostat3.fao.org/faostat-gateway/go/to/download/T/*/E

Once bilateral trade flow values have been obtained the next step is to estimate a country's trade inside its own border. As discussed in the method section, we use the approach advocated by Novy (2011) and Shang-Jin Wei (1996) to construct countries' intra-national trade using comparable production and export values. However, the value of agriculture production is provided by the FAO in constant 2004-2006 U.S. dollars. Export and bilateral trade values, on the other hand, are reported in nominal values. Thus, we use the exporters' (2005) GDP deflator to convert bilateral agricultural trade to real values. A comprehensive list of GDP deflators can be obtained from the Economic Research Service's (ERS) international macroeconomics database[2].

While the aforementioned database can be used to gauge the height of agricultural trade costs, it does not allow for an investigation of trade costs at the sector level (i.e., sugar, dairy, fruits and vegetables, ect.). Thus, in addition to computing trade costs for total agriculture, we also consider trade costs for ten sub-sectors. In this step we use a unified classification system to aggregate production and trade values for individual products into ten sectors. We follow the WTO's classification of products into 10 Multilateral Trade Negotiations (MTN) categories: meat (MEAT), Dairy (DAIRY), fruit and vegetable (FRT&VEG), coffee and tea (C_T), cereal (CER), oilseed (OILSEED), sugar (SGR), beverages and tobacco (B_T), cotton (COTTON), other agricultural good (OTHAG). These sectors are based on a detailed mapping at the six-digit level of the Harmonized System (HS6). The FAO product categories are based on a detailed description of the product but not a particular system of classification. Thus, we created our own mapping to MTN categories, the details of which are provided in Appendix C.

[2] http://www.ers.usda.gov/data-products/international-macroeconomic-data-set.aspx#.U7MAAfldWWg

There are two advantages for computing the trade cost measures at the sub-sector level. First, at the most disaggregate product level, computation of trade cost measure is difficult to implement because records of positive trade flow does not necessarily occur at both directions in such a fine product level. For example, among all the country-pair and product combination that traded at least once in our sample, only 28% of observations have trade flows in both directions. At the sector level, however, this number raise to 79%. Secondly, the calculation of intra-national flows may also have zeroes or produce negative values at the individual product level. The lack of records for production data, reporting time lag and intermediate trade in total trade also contribute to the amount of negative or zero intra-national trade flow. At the sector level, 35 percent of observations are zero or negative. Computing the trade cost measure requires dropping observations with zero and negative intra-national trade flows which means exports are larger than production. Instead of dropping them, we replace them with country-specific means of the intra-national trade volume for each country throughout the sample period.

Once international and intra-national trade values were gathered and converted to real values, the next step is to compute country pairs' agricultural trade cost measure for each country-pair, year and MTN sector in the sample. The resulting database has 267,743 observations covering trade cost for 5080 country pairs[3] and 10 MTN sectors between 1986 and 2011. It is an unbalanced panel since not every country pair traded with each other in all MTN categories or all years. Overall the global mean of the trade cost measure is 3.06 with standard deviation of 1.83[4].

[3] See Appendix D for the list of countries included in the study.
[4] Computed using the global mean of estimated elasticity of substitution which equals 6.75.

4.2 Data for elasticity estimations

Estimation of the elasticity of substitution requires sector level import values and quantities. In addition to trade flows, we also collect the corresponding quantities (tonnes[5]). For the precision of our estimates, we limit our sample size to a group of countries that have a stable record of trade throughout the sample period that we study. Appendix A lists 36 countries we retain for the elasticity estimation. We then aggregate the product level trade value and quantity into ten sectors again following the WTO's MTN classification system. The estimation procedure requires prices and shares of the importers and corresponding reference countries. Following the literature convention (see Feenstra 1994; Broda and Weinstein 2006; Imbs and Méjean 2011), we use the unit value of product to approximate prices. The unit value is acquired using the values of bilateral trade divided by their volumes. The reference country for each importer is chosen so that it exports consistently in all sectors throughout the sample period or among the largest trading partner in terms of trade value. In addition, we exclude outliers that have annual variations in prices and market shares that exceed five times the median value as suggested in Imbs and Méjean (2011). The resulting dataset covers 36 countries' trade with their partners, which accounts for 60 percent of world total import in the sample period.

[5] There are about 1% of the total observations that uses units other than metric tonnes, such as head and 1000 head. These are usually live animals. However, these observations take up less than three percent of the total trade value. Thus we drop these observations to have a common unit of quantity.

4.3 Policy variables

Variables for decomposing trade cost measures are collected from various sources and merged into the master database. Traditional gravity variables such as geographical distance, dummies for common language and contiguous borders are from CEPII (Centre d'Etudes Prospectives et d'Informations Internationale)[6].

Applied *ad valorem* tariff data are retrieved from the World Integrated Trade Solutions (WITS) web portal but covers a shorter time period (1996-2010). Three types of tariffs are collected: most favored nation (MFN) tariff, applied tariffs and preferential tariff rates. We use the preferential tariff rate whenever the preferential tariff is lower than the MFN rate. Since tariffs are provided at the HS6-digit level, we aggregate tariffs to the MTN sector level using the WTO's concordance between HS 6-digit and the MTN commodity classification system. There are two commonly used aggregation procedures: the trade weighted average tariff and a simple average. The weighted average weights the tariff between the two countries by their respective HS 6-digit commodity shares of their exports to one another in each MTN sector. Thus the products that have larger volumes of trade receive greater weight in the average. However, the trade weighted average tends to bias the measure downward since higher protection measures are likely to result in smaller trade volumes, underscoring the potential endogeneity between tariffs and trade flows.

Simple average tariff rates overcome the endogeneity issues because all products are given equal weight in the calculation of the average. However, simple averages may

[6] http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8

tend to overstate the effective rate of protection since some products may not be traded between country pairs because of supply or demand conditions in one or both markets. Notwithstanding this limitation, we use simple averages in aggregating tariffs for our analysis. Furthermore, because the trade cost measure we derived in the previous section is non-directional, an additional step is necessary to get an average tariff level from country i to j and j to i. Thus, we use the geometric mean of the two tariff rates for country pairs which closely resembles the calculation of the dependent variable.

Although Non-Tariff Barriers (NTBs) feature prominently in international agricultural trade, data for these measures are known to have poor country and time coverage, especially for developing countries (see Kee, Nicita and Olarreaga 2011; De Sousa, Mayer and Zignago 2012). However, in order to gain some understanding of the degree to which NTBs explain the magnitude of agricultural trade costs, we use the frequency and coverage index data of all NTBs made available by De Sousa, Mayer and Zignago (2012) from 1989 to 2001[7]. The authors consider the frequency and coverage ratio of products subject to all NTBs[8] covering 231 exporters and 93 importers and 28 products at ISIC (International Standard Industrial Classification) rev2 3-digit level. For the frequency ratio, they calculate a simple ratio of the number of ISIC products subject to NTBs relative to the total number of products. However, the sample also varies by year. Take the year 2000, for example, where the frequency ratio is only available for 175 exporters and 17 importers. The coverage ratio is a ratio of imports that are affected by NTBs relative to total imports. These two measures give us a general indication of the

[7] http://www.cepii.fr/anglaisgraph/bdd/tradeprod/download.asp

[8] The authors consider five types of NTBs: (1) the ones with a price effect; (2) the ones with a restriction on quantity; (3) restrictions on quality; (4) threatening measures; and (5) ones subject to advance payment.

frequency of NTBs and the share of imports impacted by them at the country level. We also assume that the indicators of NTBs remain the same from 2001 to 2011 to extend the NTB data to the final year in our sample.

The trade facilitation agreement was a major breakthrough in the recent WTO Ministerial meeting concluded in Bali, Indonesia in December, 2013. The new trade facilitation agreement is expected to lower trade costs and promote trade by implementing obligations such as simplifying border procedures and increasing customs efficiency and transparency, especially for developing and least developed countries. Thus, it is instructive to examine the role of trade facilitation in explaining the height and variation of agricultural trade costs. The trade facilitation data is made available by Alberto and Wilson (2010)[9] through the World Banks' Trade Facilitation database. It includes four indicators of trade facilitation covering 101 countries between the year 2004 and 2007. These four indicators are Information, Communication and Technology indicator (ICT), Infrastructure indicator, Border Transparency indicator and Business environment indicator. All of these indices range from zero to one and the higher the indicator, the more trade-promoting is the countries' trade facilitation measures. Again, since our trade cost measure is non-directional, we took a geometric mean for the two countries to create one measure that represents the country-pair trade facilitation level. A detailed description for variables used in the regression are available in Appendix B.

[9]http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTPROGRAMS/EXTTRADERESEARCH/0,,contentMDK:23036644~pagePK:64168182~piPK:64168060~theSitePK:544849,00.html

5. Result

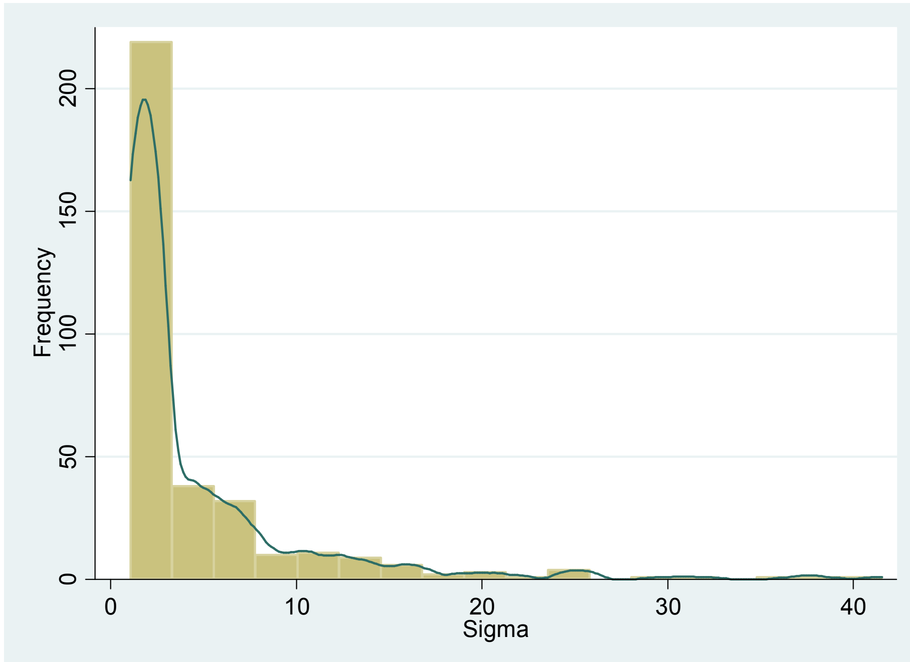
The results are organized as follows. Section 5.1 provides a graphical analysis of the estimated elasticities of substitutions for 10 sectors and 36 importers identified in the previous section (see also Appendix E). In section 5.2, we present the computed trade cost measures for agricultural trade using values of the elasticity of substitution commonly found in the literature (see Anderson and Van Wincoop 2002; Bradford 2004; Helliwell; Haveman *et al*. 2003). Section 5.3 combines the estimated sector-specific elasticities and trade cost measures to present trade cost trends for specific regional groups and sectors. Finally, section 5.4 proceeds to a set of econometric estimations to identify how much observable trade policies explain the variation in agricultural trade costs.

5.1 Elasticity of substitution

This section reports the key parameter in computing the trade cost measure: the elasticity of substitution between home and foreign varieties, σ. In this estimation, we use agricultural trade data for importers at the sector level. This enables us to consider heterogeneity across sectors as well as making it compatible with our trade cost measures. In summary, we estimate import demand elasticities for 36 countries in 10 MTN agricultural sectors[10] using the procedure discussed in section 3.3. Among these estimates, 11 outliers that are larger than three times the standard deviation are dropped. The mean of the total estimates is 6.57, with a standard deviation of 13.53. The median value is 2.09 which suggests that the distribution of the estimated sigmas is skewed left. Indeed, more than 70% of the estimates are below six, as shown in the following figure.

[10] A total of 36*10=360 estimated import elasticity of substitution.

Figure 3: Density distribution of sigma



We also report the sample statistics of the elasticities for two time periods in Table 1. The average elasticity is 9.05 for the period between 1986 and 1998, and 4.68 between 1999 and 2011. This pattern could suggest that agricultural products have become more differentiated over time or that country of origin is playing a greater role in the differentiation of goods. The mean elasticity fell by 50 percent from the first period (1986-1998) to the second period (1999-2011). The median also decrease in the second period (1999-2011), but only by ten percent. The differences in elasticity estimates between the two periods may represent an increasing differentiation between agricultural product varieties in the most recent ten years periods.

Table 1: Sigma for different time periods

Period	*1986-2011*	*(1) 1986-1998*	*(2) 1999-2011*
Mean	6.57	9.05	4.68
Standard deviation	13.53	29.16	5.95

Median	2.09	2.37	2.12

Notes: The sample covers estimated elasticities of substitution for 36 countries and 10 agricultural sectors: B_T, CER, COTTON, C_T, DAIRY, FRT&VEG, MEAT, OILSEED, OTHAG, SGR

Overall our estimates are comparable to the existing empirical literature. Kee, Nicita and Olarreaga (2009) who take a GDP function approach[11] and estimate the import demand elasticities at the HS 6-digit level. Their average estimate is 3.12 with a standard deviation of 14.05. Most papers that use the same estimation approach as we do focus mainly on U.S. import elasticities, especially for manufacturing sectors. For example, Feenstra (1994) use U.S. imports of six manufactured goods for more than twenty years. Among all six sectors, five of them have elasticities lower than 6. Broda and Weinstein (2006) compute elasticities for over 10,000 HS-10 digit categories of U.S. imports, and find the median to be around 3.1. Imbs and Méjean (2011) find their median value to be around 5 for U.S. imports for 56 ISIC sectors. However, since we are focusing on agricultural exports, we expect some differences in our estimates.

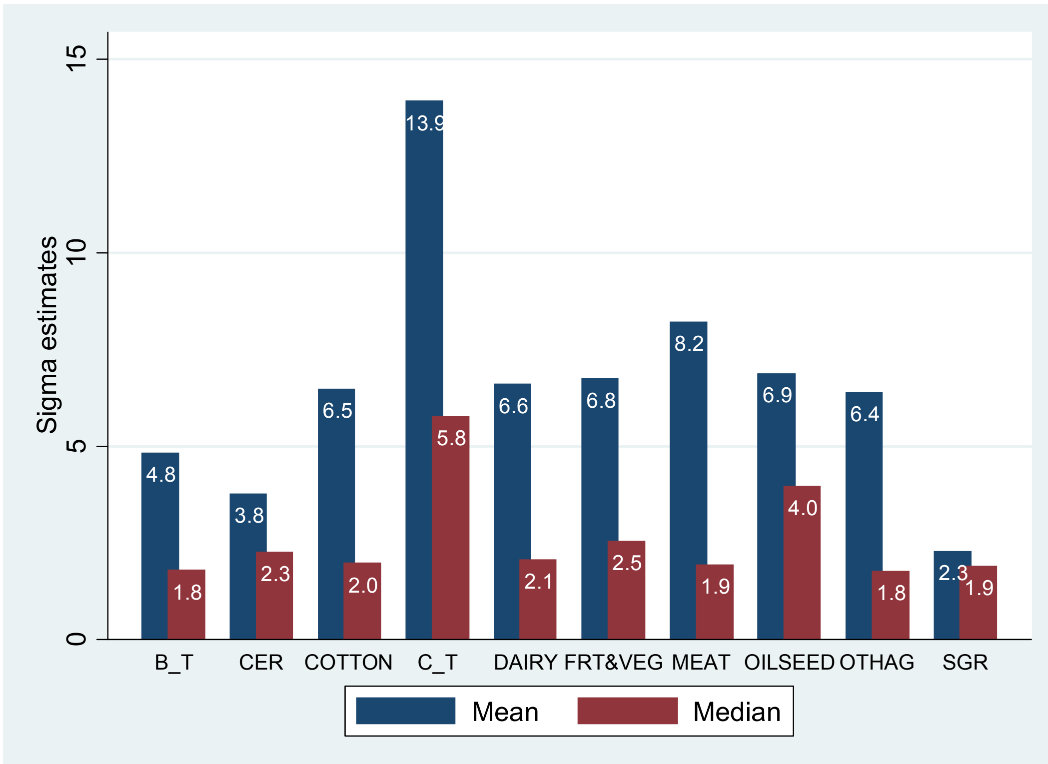
In addition, the level of aggregation, group of importers and years under consideration could also contribute to differences in the level of sigma estimates (See Broda and Weinstein 2006). Next, we summarize the estimates at the sector level and compare them with the sigma estimates in the existing literature where applicable. Figure 4 presents the mean and median of the import elasticity estimates for 10 agricultural sectors according to the WTO's MTN classification. The estimates show substantial variation across sectors ranging from a low of 2.3 for sugar and confectionary products (SGR) to a high of 13.9 for coffee and tea (C_T). Seven out of the ten sectors have

[11] This approach estimate the elasticity by maximizing what Feenstra (2003) calls a GDP-based import demand function.

relatively large differences between the mean and the median (highest difference of 8.1 for coffee and tea).

By estimating the elasticity of substitution, we answer the question of how much quantities would change in aggregate relative to changes in prices. The lower the elasticity of substitution, the more differentiated are the varieties. Thus, we expect its value to be higher for more homogenous goods and lower for more differentiated goods. However, it is important to note that sectors are defined more broadly. For example, the Cereal (CER) sector includes cereal products throughout the supply chain. More processed products such as pasta, bread and pastry tend to be more differentiated than bulk products such as cereal flour, starches and seed. Similarly, Sugar (SGR) includes homogenous product such as cane sugar and a number of differentiated products such as chewing gum, white chocolate and other confectionery products.

Figure 4: Average Elasticity of Substitution at Sector Level



Among our average estimates for the ten sectors: Coffee and Tea (C_T), Oilseed (OILSEED) and Meat (MEAT) are three sectors that have the highest mean elasticity at 13.9, 6.9 and 8.2, respectively. These are sectors that include relatively more homogeneous products such as cocoa, live animals and animal fats. In particular, Coffee and Tea have the highest mean and median elasticities at 13.9 and 5.8 respectively. Dairy (DAIRY), Fruit and Vegetable (FRT&VEG), and Cotton (COTTON) have means slightly above two (2.1, 2.5 and 2.0 respectively) and medians around 6.5 (6.6, 6.8 and 6.5 respectively). These three sectors include relatively more heterogeneous products such as yogurt, cheese and fruit juice. The mean and median for sugar are both among the lowest for all sectors. Although the relatively low value of the sugar elasticity of substitution may come as a surprise, it is in line with the existing literature. Broda and Weinstein

(2006) estimate the elasticities at the 5-digit level of the SITC (Rev. 2). Their sigma estimate for "Sugar and honey" is 2.7 and 4.8 for "Sugar confectionery and preparations, non-chocolate". Using a similar method, Chen and Novy (2012) find the elasticity of substitution to be 2.63 for European countries' sugar sector. Kee, Nicita and Olarreaga (2009) also find their estimates for sugar on the lower end: among the 1,321 estimates for sugar across 117 countries, the median is around 1 and 75% of estimates are below 2.

Table 2 lists the elasticity estimates for Canada (CAN), China (CHN), Japan (JPN) and United States (USA) for each MTN sector. The highest estimates of the elasticity of substitution among all country-sector combinations is the Meat sector in China where σ =101.08. China's demand for Coffee and Tea is also very sensitive to the changes of price. Canada has the highest estimated sigma for Oilseeds (*σ=15.69*) and the U.S. has the highest σ in Cotton (*σ=13*).

Table 2: Countries' Sigma Estimates by Sector (1986-2011)

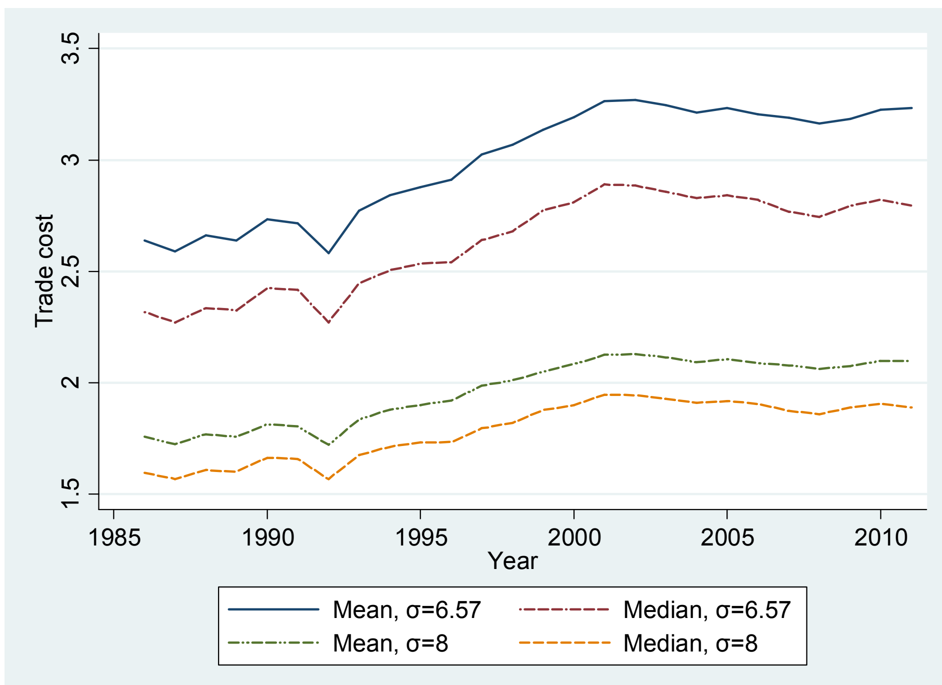
	B_T	*CER*	*COTTON*	*C_T*	*DAIRY*	*FRT&VEG*	*MEAT*	*OILSEED*	*SGR*
CAN	1.75	1.45	8.19	9.87	2.10	1.87	2.51	15.69	1.90
CHN	1.43	4.38	1.16	25.07	2.41	1.30	101.08	1.27	1.85
JPN	5.64	4.64	5.47	1.84	1.39	4.42	1.42	2.32	3.18
USA	9.43	1.93	13.00	3.97	8.07	3.63	5.36	6.99	1.90

Notes: Individual country elasticity of substitution as importer between the period 1986 and 2011. Countries' iso code is listed above are CAN for Canada, CHN for China, JPN for Japan and USA for United States. B_T for beverages and tea, CER for cereal, C_T for coffee and tea, FRT&VEG for fruit and vegetable, SGR for sugar.

5.2 Patterns in Agricultural Trade Costs

In this section, we present our key findings in world agricultural trade costs. Figure 1 traces out the trend of global agricultural trade costs over the sample period 1986-2011, using an elasticity of substitution of 6.57, which reflects the global average of our estimated elasticity of substitution. Plotted are the mean (solid line) and median (dashed line) *ad valorem* equivalent trade cost values covering 133 countries (5,080 country pairs) using equation (10). In 1986, the height of agricultural trade costs was 260 percent on an *ad valorem* equivalent (AVE) basis (σ = 6.57). Trade costs have risen to a level of 320 percent AVE which translates to an increase of more than 20 percent before 2000. The average global agricultural trade cost experienced a significant increase between the late 90s and early 2000s, and have only recently begun to show a decreasing trend shortly after the turn of the century.

Figure 5: International Agricultural trade cost: 1986-2011



Notes: trade cost measure is reported in *ad-valorem equivalent* rates.

Also plotted in Figure 5 are the AVE trade costs for an elasticity of substitution of eight. Notice that while the *ad valorem* trade cost measures are quite sensitive to changes in the degree of substitutability between goods from different countries, the trend is not sensitive to this parameter choice. When $\sigma = 8$ agricultural trade costs averaged 160 percent AVE in 1986 before increasing to nearly 200 percent AVE around 2000, followed by a 2.6 percent decline by 2011.

World agricultural trade has grown more than six fold between 1986 and 2011, which raises questions about why the trend of agricultural trade costs seems to be rising during the initial period of the sample. While this trend seems counterintuitive, several explanations may support this finding. First, although international agricultural trade experienced impressive annual growth rates during 1986-2011 at 7.6 percent comparing to 3.3 percent for total intra-national trade[12], the intra-national trade in total agricultural is still much larger than international trade. By 2011, the total value of world intra-national agricultural trade was still seventy-eight times larger than international trade. Second, as some previous studies show non-tariff barriers (NTB) such as quotas, Technical Barriers to Trade (TBT) and Sanitary and Phyto-Sanitary (SPS) barriers have a much larger impact on agriculture trade than for manufacturing (see Kee, Nicita and Olarreaga 2009; Peterson *et al.* 2013). Indeed, agricultural trade policy is often viewed as more distortive than manufacturing trade barriers (Roberts *et al.* 1999; Meilke *et al.* 2001; Grant and Boys 2012). Countries are reluctant to negotiate the reduction of trade barriers in agriculture for many different reasons, including food security concerns, food safety concerns, political economy reasons and unlike developed countries, agriculture is a key economic sector in low-income countries. Further, it was not until the Uruguay Round of the WTO in 1995 that countries began to include agriculture in the GATT/WTO negotiations. The commitments made in The Agreement on Agriculture for decreasing tariffs, converting all non-tariff barriers into bound tariff equivalents, the elimination of

[12] We calculate compound annual growth rate= $(x_1/x_0)^{1/n} -1$, where n is the number of years

exports subsidies and the codification of subsidies into colored boxes to put a cap on the most distortive farm support programs (Market Access, Export Subsidies, and Domestic Support) were phased in over a period of six years for developed countries and ten years for developing countries. The Uruguay Round also gave countries considerable flexibility in implementing their domestic and trade policy commitments.

Further steps were taken to include developing countries in the ministerial steps in the Doha Rounds that began in November of 2000 for agriculture. However, the process of reforming agricultural price and market distortions has been much slower than the trend in global economic integration. In addition, the lowering of tariff rates may be accompanied by a significant increase in non-tariff measures as substitute protection (see Hoekman and Nicita 2011; OECD 2011; Pawlak 2011). Moreover, the perishable nature of agricultural goods also contributes to higher trade costs. All of these factors are some of the potential reasons that for increasing trend of agricultural trade costs. And as a result, even with countries' effort for lowering the agricultural trade barriers, trade cost in agricultural sectors remains higher than it is in manufacturing counterparts (Duval *et al.* 2012; Arvis *et al.* 2013).

Next, we present sector-level trade costs using the previously estimated values of the elasticity of substitution. The purpose of this exercise is to examine how and to what extent the mean trade costs reported for agricultural trade vary across sectors and whether there are systematic relationships between high and low tariff sectors and the estimated trade costs. Note that because of the large variation in the estimated elasticity of substitution, the level of trade cost show much more heterogeneous picture. Thus, for comparison purposes, we compare results using a single elasticity of substitution value ($\sigma = 8$) alongside trade costs using sector-specific elasticities.

Table 3 lists the average trade costs for 10 sectors in ascending order. On the left two columns are the ranking of trade cost measures across sectors using the sector-specific elasticity of substitution. For comparison, the columns on the right illustrate average trade costs using a single elasticity value of eight.

Table 3: Average Trade Cost for 10 Sectors between 1986 and 2011

Sector-specific sigma		*Sigma=8*	
C_T	0.84	COTTON	1.80
OILSEED	2.64	SGR	1.85
MEAT	2.69	CER	1.89
FRT&VEG	2.75	OTHAG	1.90
COTTON	2.79	FRT&VEG	1.93
DAIRY	2.91	OILSEED	1.93
OTHAG	3.06	DAIRY	1.94
B_T	7.35	B_T	2.06
CER	17.45	C_T	2.16
SGR	1030.52	MEAT	2.85

Note: Trade cost measure are reported as average *ad-valorem* rates across all country pairs and are listed in ascending order.

Several interesting findings emerge. First, there is considerable variation in agricultural trade costs when computed with the sector-specific elasticities of substitution compared to the trade cost values estimated with a constant elasticity of substitution ($\sigma = 8$). Take Dairy for example, the price of cheese that is \$1 a pound in the domestic market will rise by a factor of 2.91 to \$3.91 when it is exported to foreign market. In contrast, the price of coffee only rises by 84 percent on average from \$1 to \$1.84 when we factor in the estimated trade cost factor and the elasticity of substitution in this sector. All of this suggest that product differentiation and the amount of domestic product availability interact with trade flows to determine trade costs. For example, the large trade cost factor for sugar on average illustrates that in general countries produce and distribute sugar within a country rather than across international borders. This fact coupled with a very low elasticity of substitution generates this outcome. To gain further insight consider the following hypothetical example. Suppose that the elasticity of substitution is two which generates a square-root function in the exponent of the trade cost equation (11) ($1/2(\sigma - 1)=0.5$). In order to generate a trade cost factor for sugar of 1,030 percent *ad valorem* equivalent in Table 3, the product of domestic trade ($x_{ii}*x_{jj}$) must exceed the product of international trade ($x_{ij}*x_{ji}$) by a factor of 128. The only way the trade cost factor for sugar can be lower is if the elasticity of substitution is higher or the ratio of domestic to international trade is lower. If, for example, the true value of the elasticity of substitution for sugar is 10 and the ratio of domestic to international trade remains constant, the trade cost factor reduces to a 29 percent *ad valorem* equivalent ($128^{0.0526} - 1 = 0.29$). Conversely, if we hold constant the elasticity of substitution at *2* and assume it is correctly estimated, then the ratio of domestic to international trade would have to fall to a value of 1.68 to generate the same 29 percent *ad valorem* equivalent. Thus, in this framework, trade costs are increasing in the ratio of domestic to international trade and decreasing in the elasticity of substitution.

The average trade cost for all the sectors is around 2 (from 1.8 for Cotton to 2.16 for Coffee and Tea). The only exception is the Meat sector (*2.85*). However, if we use the sector specific elasticities to compute average trade costs, the ranking of trade costs changes. This is because there is not much variation in trade costs when we use a single value for elasticities, whereas the ranking of trade costs using sector-specific elasticities depends entirely on the value of elasticities. Naturally, the sector with highest elasticity of substitution have the lowest trade cost measure. The ranking is reminiscent of Figure 4. The trade cost measure is very sensitive to the level of elasticity and it is negatively correlated with the ranking of sector level sigma. The average trade cost measure for sugar is very high (a factor of 1,030), much higher than all the other sectors. This is due largely to the small value of sigma. However, we are not the only one to find a large trade cost factor for sugar. Chen and Novy (2011) also find that sugar ranks sixth in terms of trade costs among all the 163 4-digit NACE[13] Rev. 1 level industries that they have estimated for the EU countries, at 8,493 percent *ad valorem* equivalent rate. Furthermore, one should be cautious when interpreting the level of trade costs since they are imputed using an estimated parameter measured with error. The individual estimates show considerable variation across importers within a sector. For example, the estimated elasticity for C_T (Coffee and Tea) has a mean of 4.98 and the largest confidence interval (between 4.04 and 24.30 at 95 percent) across all sectors. As illustrated in Figure 1, this could lead to large differences in the level of trade costs when the elasticity is low, but smaller differences when the elasticity is high. Since we are using the mean of the estimates for each sector, we expect there are potential biases created by the uncertainty in the estimated elasticities.

What does this trade cost measure imply? Take the Fruit and Vegetable (FRT&VEG) sector for example. On average, this sector has an *ad valorem* equivalent trade cost measure equal to 2.75. It means that on average the price of a typical fruit and vegetable product will increase by a factor of 2.75 by the time it reaches its export market. To be more specific, an apple that is produced in U.S. and selling for 1$ a pound

[13] Statistical classification of economic activities in the European Communities

in the U.S. domestic market, would rise to $3.75 on average for consumers in foreign markets where the apple is exported.

5.3 Trade cost across region and groups

In this section, we provide a more detailed look at the trade cost measures for specific country groups. Table 4 compares average trade costs for six major geographical areas: Africa, Asia, Europe, North America (North Am), Oceania and Other America (Oth Am). Africa is the area with highest average agricultural trade costs ranging from 359% to 439% *ad valorem* equivalent. In contrast, North American (North Am) is the most integrated area. Despite the relative larger distance, Oceania is the area that has the lowest average agricultural trade cost.

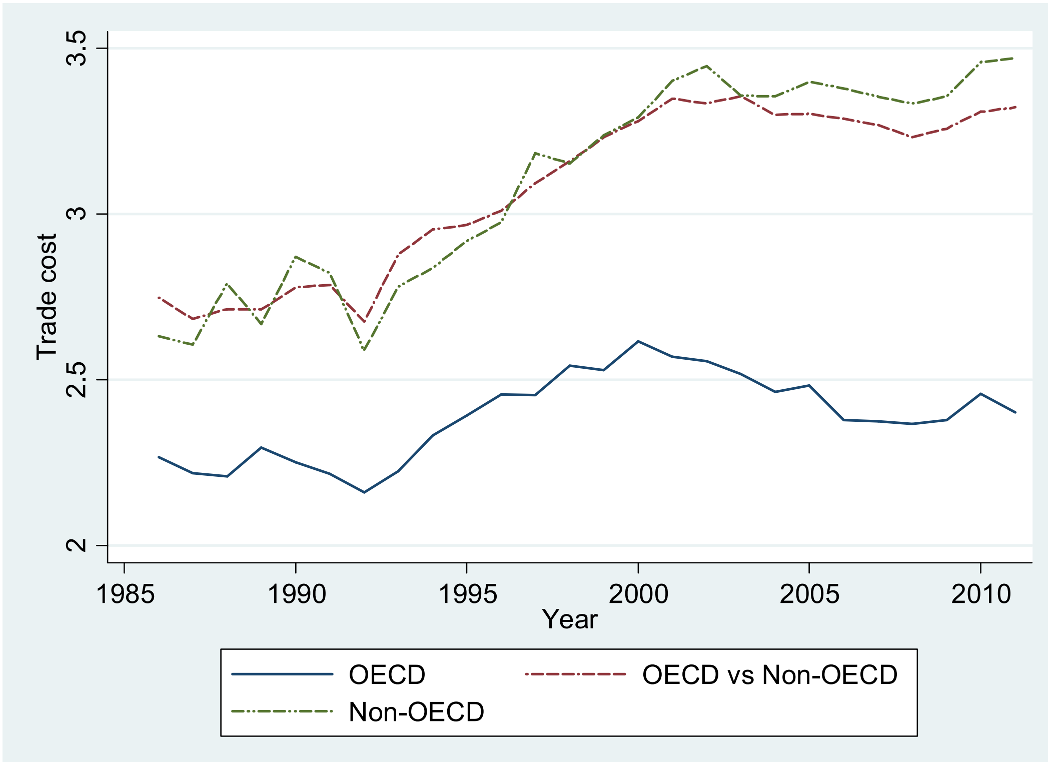
Table 4: Average Agricultural Trade cost measure across regions

	Africa	*Asia*	*Europe*	*North Am*	*Oceania*	*Oth Am*
Africa	359%	379%	366%	409%	430%	439%
Asia		286%	370%	326%	301%	389%
Europe			243%	351%	369%	404%
North Am				101%	265%	281%
Oceania					161%	487%
Oth Am						249%

Note: All regional agricultural trade cost values are reported as *ad-valorem* equivalent rates in percentage.

Dividing the country groups by economic region could provide us with more perspective on how trade costs have evolved among them. To gain some insight, Figure 6 compares agricultural trade costs for OECD and non-OECD members. Three lines are plotted, one for OECD-OECD partners, one for an OECD country trading with a non-OECD partner, and one depicting trade costs between non-OECD partners. OECD country pairs' trade has significantly lower trade costs and more pronounced decrease since 2000 – about a seven percent decrease from 261 percent AVE in 2000 to 240 percent AVE in 2011.

Figure 6: Average Agricultural Trade Cost for OECD and Non-OECD countries

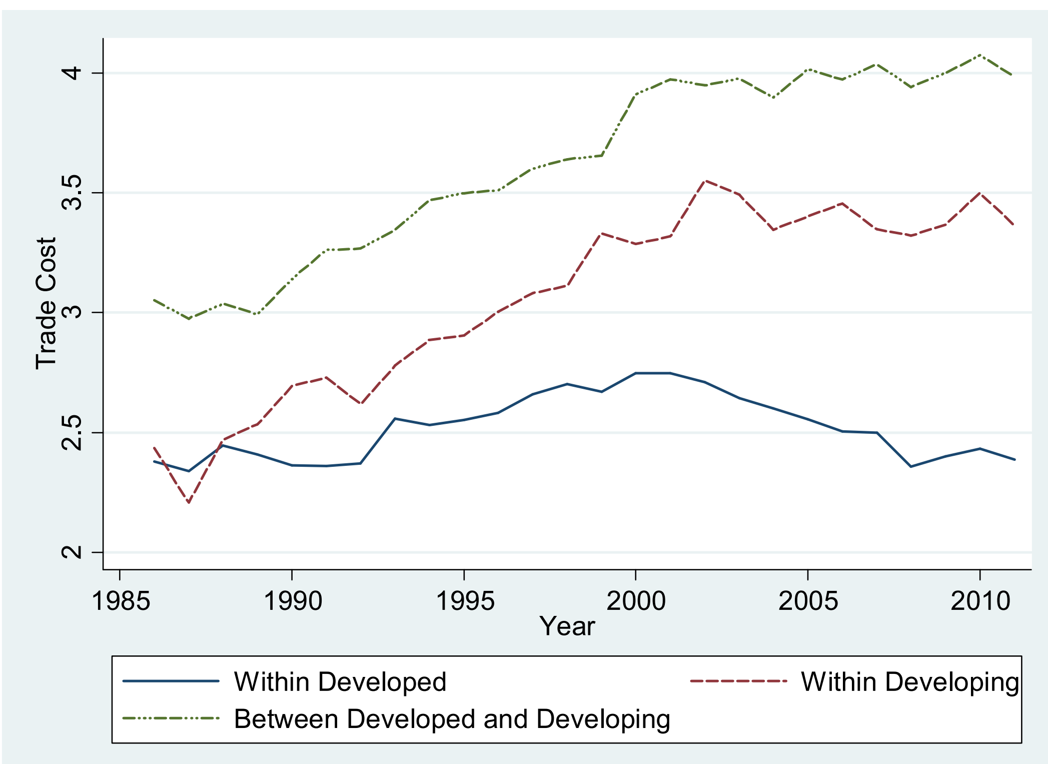


Notes: trade cost measure is reported in *ad-valorem equivalent* rates computed using sector level elasticity of substitution.

Comparatively, non-OECD member trade costs peaked at 340 percent in 2000 before falling slightly to 330 percent AVE in 2010. However, this level is still 50 percent higher than the level of OECD country pairs. In practice, trade costs can vary considerably across goods and readers may recall some specific product lines where the import tax exceeds the average trade costs reported in 2010 of nearly 60 percent AVE for OECD countries. However, it is important to remember that this analysis is intended to represent all trade costs for agricultural goods that affect the production and shipment of products to final destinations in the global market place. This likely includes a host of other trade cost factors other than tariffs and non-tariff measures – the sorts we typically pay closer attention to.

Figure 7 contrasts agricultural trade costs between three groups of countries according to their development status following the WTO classification: (i) country-pairs involving two both developed countries; (ii) country-pairs with one developed and one developing economy; and (iii) country-pairs that are both developing countries. Many of the previous trade costs trends become more apparent. First, the trade cost levels between developed and developing country pairs are almost double that for developed country pairs. The average trade cost for developed and developing countries started off at around the same range, about 240 percent, but by the end of the sample period, the *ad valorem* rate is 50 percent higher for developing countries compared to developed countries.

Figure 7: Average Agricultural Trade Cost for Developed and Developing Country Pairs



Notes: Trade cost is reported as *ad valorem* equivalent computed using sector level elasticity of substitution.

Second, we saw in Figure 5 that agricultural trade costs were on the rise through much of the 1990s. However, according to

Figure 7 much of the rise in agricultural trade costs can be explained by higher trade costs among developing countries and between developed and developing country trade. In fact the lines labeled "Within Developing" and "Between Developed and Developing" show no decreasing trend over the entire sample period. Obviously there is considerable scope to liberalize agricultural trade for developing nations. Finally, it is not surprising to see a similar pattern of agricultural trade cost patterns for developing country pairs and Non-OECD trading partners (Figure 6). As stressed in Josling, Roberts and Orden (2004), developing countries are not as involved in the process of setting standards for most of the Non-Tariff barriers. In addition, trade liberalization for developing countries still has a long way in eliminating Special and Differential Treatment even after the Uruguay Round (see Subramanian and Wei 2007; Grant and Boys 2012). Furthermore, developing countries lack information, training and resources to comply with standards and regulations even if agreements are reached. Disdier, Fontagné and Minouni (2008) find that SPS and TBT measures significantly reduce developing countries exports to OECD countries, but do not affect trade between OECD countries.

5.4 The EU, TPP, BRICs and NAFTA

Next, we look at trade cost patterns for four major regional integration groups: EU[14], TPP [15](Trans-Pacific Partnership), BRICS[16] and the North American Free Trade

[14] EU countries are coded dynamically according to their joining year: Belgium, Germany, France, Italy, Luxembourg, Netherlands from 1953; Denmark, United Kingdom, Ireland since 1973, Greece since 1981, Spain, Portugal since 1986, Austria, Finland, Sweden since 1995; Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Malta, Poland, Slovakia, Slovenia since 2004; Bulgaria, Romania since 2006.
[15] TPP includes Australia, Brunei, Chile, Malaysia, New Zealand, Japan, Peru, Singapore, and Vietnam. Canada and Mexico are not included here.

Agreements (NAFTA) countries. We begin by discussing together the EU, TPP and BRICS nations leaving NAFTA for a more in depth discussion below. Figure 8 plots the average AVE trade costs for trade within the BRICs, EU and TPP countries between 1989 and 2011. Agricultural trade cost within these three groups shows some interesting trends compared to the trend in global trade costs. Trade costs within BRICs countries shows a drastic decrease in the late 1980s, from almost 500 percent AVE to nearly 250 percent. Since then, however, it has remained around 300 percent AVE for the past twenty years. By comparison, agricultural trade cost for EU and TPP countries have been steadily low around the 200 percent AVE range in the sample period, with some fluctuations. Overall, agricultural trade cost for these three important economic groups have not shown significant decreasing trend in the past twenty years despite ongoing agricultural trade liberalization efforts at the multilateral level and through regional integration. However, trade costs in EU countries are the lowest among the three groups below 200 percent AVE throughout the sample years and much lower than the global trade cost in Figure 5 (above 250 percent AVE).

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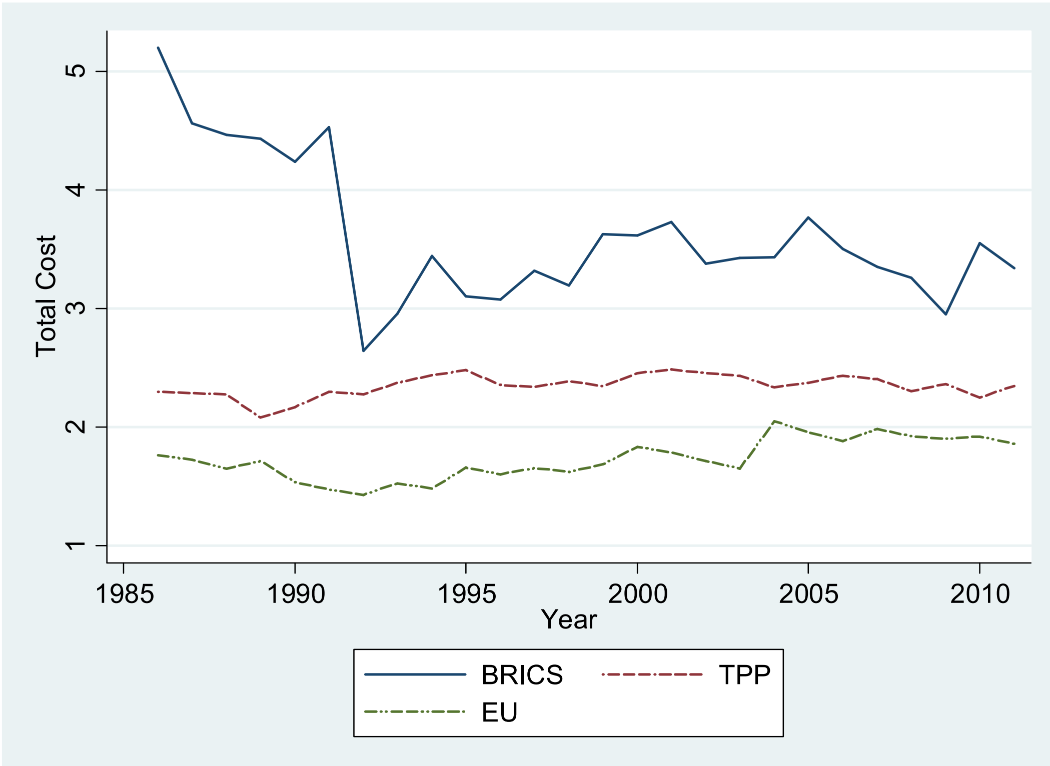
[16] BRICS includes five emerging economies: Brazil, China, India, Russia and South Africa (included in 2010).

Figure 8: Trend of Average Trade Cost for trade within BRICs, TPP and EU



Notes: BRICs includes Brazil, China, India, Russian and South Africa. TPP includes Australia, Brunei, Chile, Malaysia, New Zealand, Japan, Peru, Singapore, and Vietnam. Average trade cost is reported in *ad valorem* equivalent rates. All the average trade cost is computed using σ equals to the mean of σ estimates (σ =6.57) to smooth out the shocks from individual countries.

The average AVE trade cost measures within and between BRICs, TPP and EU countries are illustrated in Table 5 for two periods (1986-1998 and 1999-2011). In addition, the last row of each section presents average agricultural trade cost between U.S. and these country groups. This is important for at least three reasons. First, the U.S. is currently negotiating two of its largest trade agreements with the EU and TPP countries since the signing of the NAFTA agreement in 1994. Second, non-tariff measures such as SPS and TBT issues feature prominently in the negotiations of these agreements. Finally, Brazil, Russia, China, India and South Africa are some of the fastest growing emerging markets and represent important growth areas for U.S. agri-food exports.

Table 5: Average Trade Cost Measure between BRICs, TPP, EU and US: 1986-1998 &1999-2011(σ=6. 58)

		BRICS	TPP	EU
1986-1998	BRICS	349%		
	TPP	280%	226%	
	EU	297%	291%	160%
	USA	233%	182%	265%
1999-2011	BRICS	346%		
	TPP	304%	233%	
	EU	329%	325%	190%
	USA	234%	198%	213%

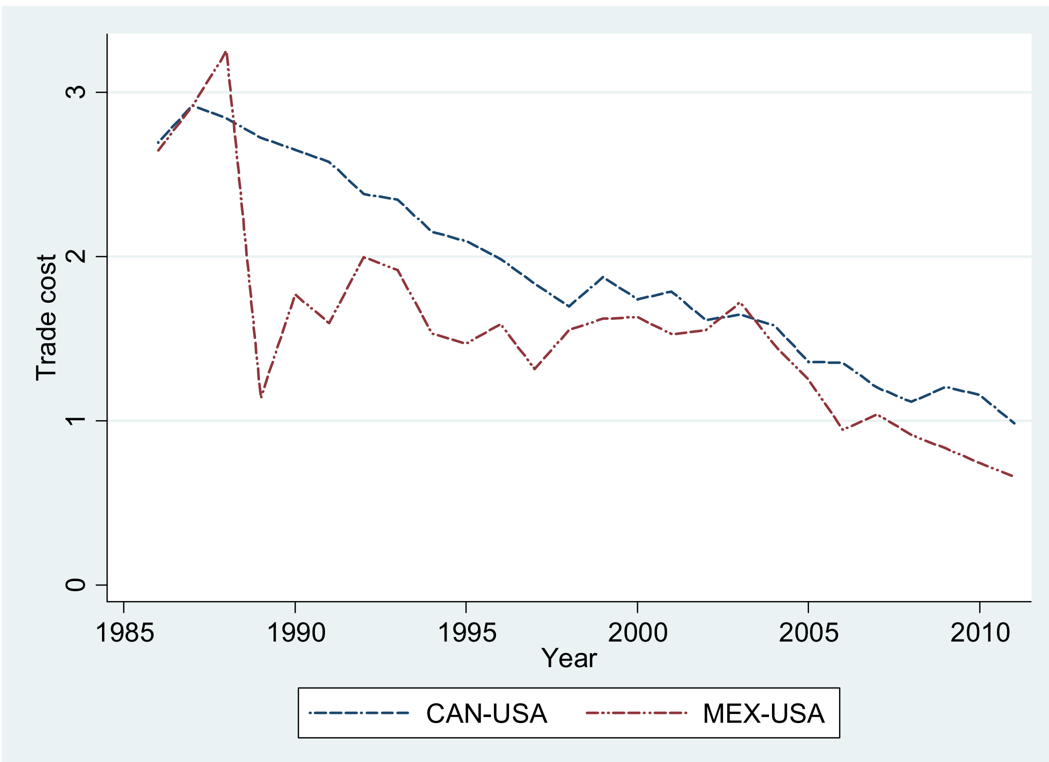
Notes: All agricultural trade cost values are reported as *ad-valorem equivalent percentage rates.*

The numbers on the diagonal line for each section in Table 5 shows within trade costs for each country group. Among the three groups, the EU has the lowest agricultural trade cost between its members, at 160 percent on average in the first thirteen-year period (1986-1998) before rising slightly to 190 percent AVE from 1999 to 2011. With a relatively larger decrease in agricultural trade cost seen from Figure 8, BRICS countries still have higher ag trade cost within themselves than with TPP and EU countries (349 percent comparing to 280 and 297 percent respectively). Among the three economic groups, TPP countries had the lowest agricultural trade cost with the U.S. at 182 percent during 1986-1998 and 198 percent between 1999 and 2011. On the other hand, agricultural trade cost for U.S. and its EU and BRICS partners are higher than with TPP countries (213 percent and 234 percent respectively). However, U.S. agricultural trade costs with TPP and BRICS are lower than the agricultural trade costs within these groups by at least 50 percent AVE. For example, BRICS countries' trade cost with U.S. is lower by 110 percent AVE than trade cost between its members (349 comparing to 233 percent AVE).

The trade cost dataset at the sector level also enables us to obtain information for smaller groups of countries such as the North American Free Trade Agreement

(NAFTA). Figure 9 below traces out agricultural trade costs between U.S. and its two NAFTA partners Canada and Mexico. Contrary to the general pattern of global trade costs, which were rising during some periods, U.S. trade costs with Canada and Mexico experienced am remarkable decrease from 1986 to 2011. Indeed, this result is very different from the global trend. Trade costs between the U.S and Canada decreased from 269 percent AVE in 1986 to 98 percent AVE in 2011, a decline of 63 percent. Trade cost between the U.S. and Mexico experienced similar decrease but with much more variability, from 264 percent AVE in 1986 down to 66 percent AVE in 2011.

Figure 9: U.S. Average Trade Cost within NAFTA partners



Notes: Trade cost is reported as *ad valorem* equivalent computed using sector-level mean of the elasticity of substitution.

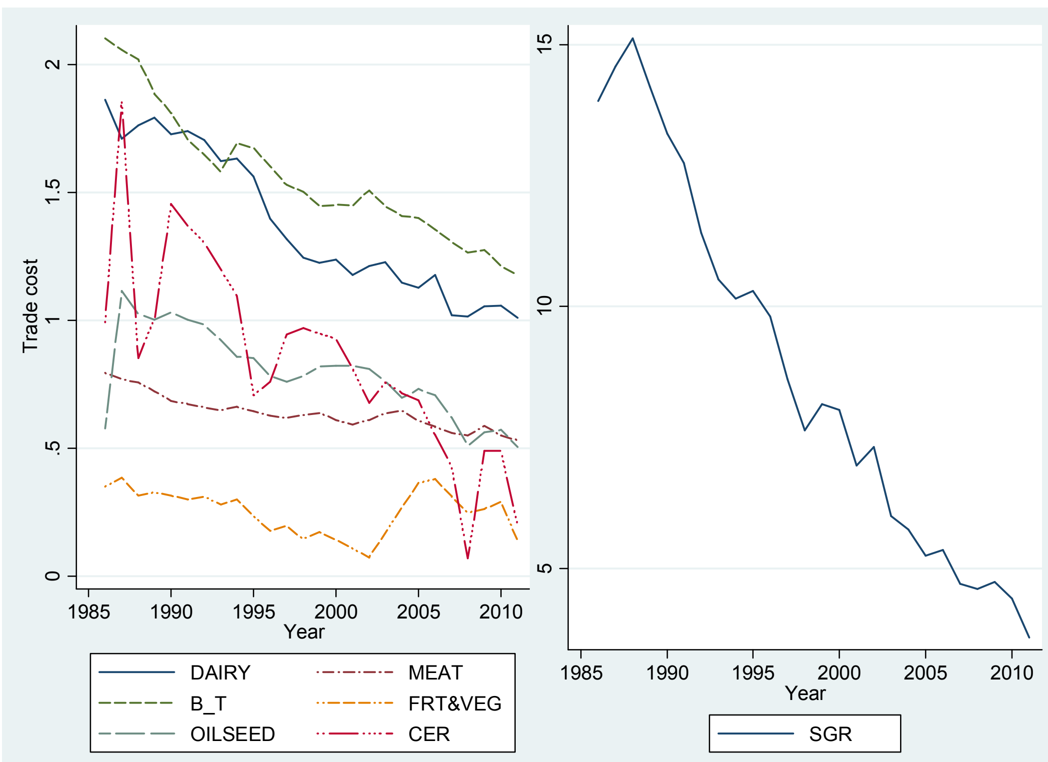
NAFTA was first implemented in 1994. The agricultural sector, however, was not negotiated trilaterally, and there were many product exclusions from NAFTA in agriculture. Even with such a big decline, agricultural trade costs are still much higher than what the empirical literature has found for U.S. total trade with its partner. Anderson and van Wincoop (2004) report a 46 percent AVE trade cost for overall trade cost between U.S. and Canada. Novy (2013) find that U.S. overall trade cost fell from 96 percent to 33 percent with Mexico and from 50 to 25 percent with Canada. Not only is it higher, U.S. agricultural trade costs with its partners also vary considerably across sectors.

We look specifically at U.S.-Canada trade costs at the sector level in Figure 10, where we utilize the sector level estimates for the elasticity of substitution. The overall decreasing trend among all sectors reflects the efforts negotiated in NAFTA to progressively dismantled trade barriers in agriculture[17]. Plotted on the left side graph are the AVE trade cost measures for Cereal (CER) Dairy, Meat, Fruit and Vegetable, Beverages and Tobacco (B_T) and Oilseed. Among these sectors, Beverages and Tobacco (B_T) and Dairy have higher trade cost throughout the sample period. This is no surprise for dairy products because they are not included in the Canadian-U.S. Free Trade Agreement (CUSTA) and both countries have a long-standing protectionist policy towards this domestic industry, especially in Canada. However, efforts have been made since the early 1990s to gradually eliminate the import quotas and lower prohibitive tariffs in dairy due to the pressure to increase market access (Doyon and Novakovic 1996). In addition, Cereal (CER) experienced the most significant decrease from 99 percent AVE to 20 percent AVE. On the right vertical axis is sugar (SGR) that began with much higher AVE trade cost than the other sectors but experienced the most dramatic decline over the sample period. It is interesting to note that all sectors show a

[17] There were a few exceptions. Canada's supply managed sectors (dairy eggs, poultry) and US tobacco, peanut and some other sectors were excluded from NAFTA negotiations in agriculture.

similar decreasing trend in the AVE trade cost measures between the U.S. and Canada. Between 1986 and 2011 the AVE trade cost in Sugar is reduced by 80 percent from 1400 percent AVE to 250 percent AVE. According to the U.S. International Trade Commission (USITC) (2011), Sugar is listed as one of the sectors with significant restraints. The major NTB that restrains U.S. sugar import are Tariff-Rate Quotas (TRQs). However, imports of sugar subject to tariff quotas have declined substantially between 2000 and 2010. The declining trend of trade cost between U.S. and Canada reflects the current trend of liberalization in the sugar sector due to the growing gap between sugar demand and regional production (Buzzanell 1997).

Figure 10: US-CAN Agricultural Trade Cost



Notes: Trade cost is reported as *ad valorem* equivalent computed using sector level mean of the elasticity of substitution.

Before moving on to an investigation of the determinants of agricultural trade cost, Table 6 reports the average agricultural trade cost and percentage change for U.S. with some major economies between 1986 and 2011. Most of the partners show a significant decrease over the sample period by more than 60 percent. However, trade costs with EU members have experienced an increasing trend starting from a 36 percent AVE in 1986 and then rising to a 199 percent AVE by 2011. This alarming result underscores the need for an ambitious trade liberalization agenda in the Trans-Atlantic Trade and Investment Partnership (TTIP) agreement. Trade costs between EU members experienced a total of 232 percent increase in AVE trade cost and majority of the increase took place after 1995. Since the beef hormones dispute, agricultural trade between EU and U.S. were subject to even more stringent restraints from higher tariff rates to newer types of NTBs, particularly SPS measures and biotechnology regulatory policies from EU. The EU has actually ban many meat products from the U.S. Even with the commitment to accept the WTO agreement on SPS measures, different interpretations and interests between the EU and U.S. have led to conflicting application of the agreements. As a result, agricultural trade between these two large economies has more than doubled since the mid-1990s.

Table 6: U.S. Bilateral Agricultural Trade Costs

Country/Region	*1986*	*1995*	*2011*	*%Change*
EU	36.04	60.83	119.79	232%
NAFTA	2.63	1.73	0.81	-69%
Brazil	13.53	5.96	4.92	-64%
China	19.37	10.43	3.59	-81%
Japan	9.52	4.39	3.16	-67%

Note: All agricultural trade cost values are reported as average *ad-valorem* equivalent rates computed using sector-level mean of the elasticity of substitution

5.5 Regression Results: Decomposing Agricultural Trade Costs

In this section, we depart from a discussion of the levels and percentage changes in agricultural trade costs over time and attempt to decompose trade costs into observable trade cost factors that may influence their level. This enables us to gain insight as to how much observable trade policies explain the variation agricultural trade costs.

Table 7 presents the main econometric results along with robust standard errors in parentheses using equation (23). Column (1) considers a very basic regression with typical gravity-like covariates. Column (2), (3) and (4) incorporate the observable tariff rate, measures for NTBs and trade facilitation indicators for years in which these variables are available. Finally, in columns (5) and (6) we investigate the robustness of the results by adding country and sector fixed effects to the specification to control for possible unobserved heterogeneity.

Table 7: Decompose Agricultural Trade Cost

	(1) Baseline	(2) Tariff	(3) NTBs	(4) Trade facilitation	(5) Ctry id FE	(6) Sector FE
ln(dist)	0.248***	0.245***	0.254***	0.307***	0.453***	0.308***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
contiguity	-0.389***	-0.379***	-0.331***	-0.397***	-0.292***	-0.478***
	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)	(0.01)
language	-0.121***	-0.143***	-0.140***	-0.198***	-0.191***	-0.195***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
year	0.014***	0.005***	-0.000	0.004	0.004	-0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ln(tariff)		0.094***	0.090***	0.108***	0.173***	-0.034***
		(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
ln(fntb)			0.184***	0.084	-0.254**	0.156***
			(0.04)	(0.06)	(0.08)	(0.03)
ln(cntb)			-0.575***	-0.433***	-0.062	-0.789***
			(0.04)	(0.06)	(0.07)	(0.03)

ln(business)				0.327***	0.565***	0.308***
				(0.03)	(0.05)	(0.02)
ln(border)				-0.111**	-0.134*	-0.209***
				(0.04)	(0.06)	(0.02)
ln(ict)				-0.640***	-0.585***	-0.386***
				(0.04)	(0.07)	(0.02)
ln(infrastru)				-0.035	-0.417***	-0.460***
				(0.04)	(0.08)	(0.02)
N	267649	137558	116175	58786	58786	58786
R-square	0.048	0.043	0.047	0.062	0.094	0.793

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable is the natural logarithm of trade cost measure computed with sector-specific sigma. Robust standard errors are in parentheses. Column (5) include country-specific fixed effects. Year is a time id. Regression where tariff rate is include only covers the sample period between 1996 and 2011. Trade facilitation indicators only covers period from 2004 to 2011.

The results are in line with expectations for most of the variables. Distance increases agricultural trade costs by a large and statistically significant amount, whereas sharing a land border and speaking the same language reduces agricultural trade costs. The distance elasticity of trade costs is 0.25 implying a 10 percent increase in distance between two countries increases trade cost by 2.5 percent. Sharing a same border and a common language often reflects cultural and preferences similarity, and thus reduces trade costs by 31 percent (exp(-0.38)-1)*100) and 11 percent respectively. The time trend coefficient (year) confirms the trend we see in the descriptive results. It is positive and statistically significant suggesting that agricultural trade costs are increasing roughly by one percent per year, on average.

Next, we expand our interest to how trade policies and specifically trade facilitation influence the level of agricultural trade costs. However, results from these sets of regression should be interpreted with caution. NTB coverage and frequency indicators might not be an accurate measurement of the actual level and stringency of these measures. Indeed, the inaccuracy and incomplete measures of observable trade cost components are two of the main reasons why we developed this AVE trade cost measure in the first place. In Column (2) and (3), we add the tariffs and NTBs to the analysis for the sample period 1996-2011. The coefficient for tariff is positive and significant. A ten percent increase in tariff rate in either country leads to a 0.9 percent increase in AVE agricultural trade costs, on average. Moreover, we also expect the coefficients for NTBs to be positive since the two variables measure the frequency and coverage ratio of the NTBs. Interestingly, the coefficient for frequency ratio is positive but not significant after we add the trade facilitation indicator in column (4) and coefficient for coverage ratio is negative and significant. This study is not alone in its failure to find a significant impact of NTBs on agricultural trade using variables that measure the frequency or coverage of NTBs. Disdier, Fontagné and Minouni (2008) find that SPS and TBTs does not have an impact on OECD agricultural exports. Besides the data quality of NTBs, the inability to separate out SPS and TBT effects may also contribute to the insignificant or negative estimates of NTBs (see Disdier, Fontagné and Minouni 2008). Finally, it could also be that the demand enhancing effect of NTBs outweighs the additional cost of complying with SPS or TBT regulations which would reduce agricultural trade costs rather than increase them as Beghin and Xiong (2013) have pointed out.

In columns (4), we add indicators of trade facilitation efficiency. Overall, we expect their coefficients to be negative. This is because the indicator is scaled from zero to one – and the more efficient is the trade facilitation indicator in reducing transactions costs at the border, the higher is the indicator. We include all four indicators in our regression: 1) information and communication technology (ICT) measures the availability of the latest ICT technology, level of technology absorption, the extent of business internet use and government prioritization of ICT; 2) Infrastructure indicator measures the quality of trade infrastructure including port, airports, roads and railroads; 3) Border and Transport efficiency indicator measures the efficiency in trade facilities in terms of the number of documents and days to export and import; 4) Business indicator measures the level of government transparency, corruptions etc.

The coefficients from these regressions indicate that those factors have a large and substantial influence on the level of agricultural trade cost measures. Estimates from column (4) suggest that ICT has the largest impact on the level of agricultural trade costs. A ten percent increase in information and communication technology (ICT) indicator in either country reduces the agricultural trade cost by 6.4 percent. Borders and infrastructure are the next important factors that influence the level of trade costs. Here, a ten percent increase in the value of the indicators would lead to a decrease of 1.1 percent and 0.3 percent respectively in agricultural trade costs. The coefficient for Business, however, is positive. Alberto and Wilson (2010) also find similar insignificant and counterintuitive estimates for the business indicator on trade volume using traditional gravity estimation.

In column (5), we employ a country fixed effects specification as a robustness check on the results. The goodness of fit statistic is still relatively low even when country fixed effects are added to the specification. The final column reports the estimates of the decomposition that includes sector fixed effects. The goodness of fit statistic rise dramatically from less than ten percent to 79 percent. This is indicates there are still many product-specific unmeasurable factors that influence the height and variation in agricultural trade costs that are not explain by our model.

To provide an alternative way to interpret the results from a policy perspective, we quantify the contribution of the variation to trade costs for all the trade cost factors using equation (24). We report the contributions using the estimates in column (3) and (4) from Table 7[18].

Table 8: Variation Contribution of Total Trade Cost Factors

	1996-2011	*2004-2011*
Total variation explained by the model	4.67%	6.42%
Distance	70.7%	65.5%
Contiguity	21.1%	19.7%
Language	4.0%	4.3%
Tariff	4.2%	3.5%
Border		0.4%
ICT		6.6%

Notes: Variation contribution is based on coefficient estimates in Column (3) and (4) in table 7, respectively. The total variation is the total percentage of variation explained by the model

Natural barriers, particularly geographical distance, are responsible for more than 90 percent of total variation in agricultural trade cost explained by the model. Tariff rates contribute 4.2 percent whereas trade facilitation accounts for 7 percent of the variation. The result from this decomposition confirms that natural barriers are responsible for a large part of the variation in trade costs. However, after adding trade facilitation indicator the contribution of geographical barriers decreases. This also indicates that there are unobservable factors whose impact on trade cost may bias the geographical barrier estimates.

Table 9 considers trade cost measure decomposition separately for nine sectors. The standard gravity coefficients are statistically significant and of the correct sign across all sectors. However, Sugar (SGR) and Cereal (CER) have slightly larger magnitude of

[18] NTB variables and the other two variable for trade facilitation (Business and Infrastructure) are not included since they are either not statistically significant or do not have the expected sign in our estimated model.

estimates. There are not significant time trends among the sectors except for an increasing trend in Cotton. The results also provides some interesting insights for tariff and trade facilitation. Tariffs seem to be more important in determining the level of trade costs in Dairy and Meat sectors, but not as much in the other sectors. Among trade facilitation indicators, border efficiency (Border) are negative and significant among six of the nine sectors. Border estimates are not significant in Sugar (SGR) sector and are positive for Beverage and Tobacco (B_T) and Oilseed sectors. Information, Communication and Technology (ICT) coefficients, on the other hand, are negative and significant for all sectors, except for Sugar (SGR). Lastly, estimates for physical infrastructure have the largest impact in Sugar (SGR) sector among all the nine sectors, but not significant for Cotton and Oilseed.

Table 9: Sector decomposition of trade cost

	(1) B_T	(2) CER	(3) COTTON	(4) C_T	(5) DAIRY	(6) FRT&VEG	(7) MEAT	(8) OILSEED	(9) SGR
Distance	0.31^{***}	0.52^{***}	0.18^{***}	0.23^{***}	0.30^{***}	0.25^{***}	0.25^{***}	0.22^{***}	0.67^{***}
	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Contiguity	-0.40^{***}	-0.72^{***}	-0.35^{***}	-0.07^{*}	-0.45^{***}	-0.51^{***}	-0.31^{***}	-0.50^{***}	-1.12^{***}
	(0.04)	(0.04)	(0.09)	(0.03)	(0.05)	(0.03)	(0.03)	(0.03)	(0.09)
Language	-0.13^{***}	-0.43^{***}	-0.02	0.07^{***}	-0.09^{***}	-0.21^{***}	-0.08^{***}	-0.13^{***}	-0.75^{***}
	(0.02)	(0.02)	(0.06)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.06)
Year	-0.00	-0.00	0.04^{***}	-0.00	-0.00	-0.00	-0.01^{*}	-0.00	-0.01
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Tariff	-0.01	0.01	-0.02	-0.01	0.03^{**}	0.01	0.06^{***}	-0.06^{***}	-0.25^{***}
	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)
Border	0.22^{***}	-0.23^{***}	-0.73^{***}	-0.34^{***}	-0.24^{**}	-0.54^{***}	-0.34^{***}	0.18^{***}	-0.11
	(0.04)	(0.05)	(0.16)	(0.07)	(0.09)	(0.04)	(0.05)	(0.04)	(0.14)
ICT	-0.15^{**}	-0.63^{***}	-0.26^{*}	-0.11^{*}	-0.31^{***}	-0.36^{***}	-0.36^{***}	-0.30^{***}	-0.14
	(0.05)	(0.05)	(0.13)	(0.05)	(0.07)	(0.03)	(0.04)	(0.04)	(0.17)
Infrastructure	-0.56^{***}	-0.56^{***}	0.03	-0.11^{*}	-0.22^{**}	-0.20^{***}	-0.24^{***}	0.04	-0.84^{***}
	(0.04)	(0.05)	(0.11)	(0.04)	(0.07)	(0.03)	(0.04)	(0.04)	(0.14)
N	7349.00	11692.00	593.00	2059.00	3634.00	12173.00	5236.00	8456.00	5231.00
R-square	0.27	0.40	0.21	0.28	0.34	0.33	0.38	0.24	0.26

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable is the natural logarithm of trade cost measure computed with sector-specific sigma. All regressions are simple OLS regression without any fixed effects. The sample period is between 2004 and 2011 when trade facilitation data is available.

Next, using the estimates from decomposition regression, we are able to take a brief comparison at how those factors have a different contribution to the variation of trade cost among the nine agricultural sectors in Table 10. This brings out a number of interesting points: For Beverage and tobacco (B_T), infrastructure contributes more than ten percent of the variation explained. For Cereal sector, Information, Communication and Technology (ICT) explains the same portion of variation as infrastructure. Border efficiency seems to play a more important role in sectors like Cotton, Fruit and Vegetable (F_V) and Meat in their variation of trade cost (14.31 percent, 12.71 percent and 7.27 percent respectively). In contrast, tariff contributes less than ten percent of variation in agricultural trade cost only in two sectors, Sugar (SGR) and Oilseed.

Table 10: Sector-specific contribution to trade cost variation

	(1) B_T	(2) CER	(3) COT	(4) C_T	(5) DAIRY	(6) FRT&VEG	(7) MEAT	(8) OILSEED	(9) SGR
Total	28.11%	40.01%	19.73%	28.52%	35.40%	33.09%	40.29%	26.10%	27.57%
Distance	68.41%	62.15%	53.11%	87.27%	69.07%	46.04%	61.93%	61.10%	60.68%
Contiguity	17.76%	13.36%	32.68%	4.62%	20.94%	16.44%	13.56%	31.85%	21.79%
Language	2.55%	5.46%	0.65%	-2.38%	1.12%	4.54%	0.92%	2.91%	8.29%
Tariff	0.22%	0.01%	0.75%	0.77%	-0.50%	0.01%	-0.87%	3.06%	6.01%
ICT	1.41%	8.21%	-1.61%	1.81%	3.34%	12.76%	9.80%	0.12%	0.20%
Border	-0.45%	1.85%	14.31%	5.86%	2.80%	12.71%	7.27%	0.88%	0.09%
Infrastruct	10.10%	8.96%	0.11%	2.04%	3.23%	7.50%	7.39%	0.08%	2.94%

Note: Sector-specific trade cost decomposition correspond to estimates in Table 9.

Overall our findings suggest that traditional gravity variables and trade facilitation together explain large part of variation in agricultural trade cost, especially at the sector level. In particular, country pairs' trade facilitation, especially the physical infrastructure and border efficiency have a significant impact on reducing agricultural trade costs across all sectors. However, there is still a large portion of unmeasurable factors that influence the level of agricultural trade costs as seen by the R-squared values less than 50 percent in all cases.

5.6 Robustness check

As a robustness check, we report several alternative specifications to check the robustness of our conclusions. In Table 11, we decompose the trade cost measure computed using a single value of the elasticity of substitution commonly found in the literature. The results show that most of our conclusions are robust to the level of sigmas used in computing our trade cost measure. However, one thing worth noting is that the goodness of fit statistic rises to 26 percent here from less than one percent in Table 7.

Table 11: Robustness check: decomposing trade cost with σ = 8

	(1) Baseline	(2) Tariff	(3) NTBs	(4) Trade facilitation	(5) Ctry id FE	(6) Sector FE
ln(dist)	0.182^{***}	0.171^{***}	0.173^{***}	0.215^{***}	0.299^{***}	0.226^{***}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
contiguity	-0.305^{***}	-0.260^{***}	-0.242^{***}	-0.340^{***}	-0.260^{***}	-0.368^{***}
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
language	-0.085^{***}	-0.098^{***}	-0.097^{***}	-0.112^{***}	-0.120^{***}	-0.126^{***}
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
year	0.009^{***}	0.003^{***}	-0.001^{***}	-0.001	-0.005^{***}	-0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ln(tariff)		-0.001	-0.007^{***}	-0.007^{**}	-0.003	-0.019^{***}
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ln(fntb)			0.292^{***}	0.087^{***}	-0.185^{***}	0.141^{***}
			(0.02)	(0.02)	(0.03)	(0.02)
ln(cntb)			-0.656^{***}	-0.478^{***}	-0.217^{***}	-0.568^{***}
			(0.01)	(0.02)	(0.02)	(0.02)
ln(business)				0.208^{***}	0.072^{***}	0.217^{***}
				(0.01)	(0.02)	(0.01)
ln(border)				-0.136^{***}	-0.136^{***}	-0.164^{***}
				(0.02)	(0.02)	(0.01)
ln(ict)				-0.288^{***}	-0.132^{***}	-0.318^{***}
				(0.02)	(0.02)	(0.01)
ln(infrastru)				-0.276^{***}	-0.355^{***}	-0.316^{***}
				(0.02)	(0.03)	(0.01)
N	267649	137558	116175	58786	58786	58786

R-square	0.180	0.158	0.189	0.257	0.335	0.337

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable is the natural logarithm of trade cost measure computed with sector-specific sigma. Robust standard errors are in parentheses. Column (5) include country-id fixed effects. Regression where tariff rate is include only covers the sample period between 1996 and 2011. Trade facilitation indicators only covers period from 2004 to 2011.

We also use an alternative specification to decompose trade cost measure. Follow Silva and Tenreyro (2009), Table 12 use the Poisson Pseudo Maximum Likelihood (PPML) estimation as an alternative specification to address possible heteroskedasticity issue. Comparing with previous results, estimates for tariff became mostly insignificant. But overall the results largely hold up for geographical trade cost factors and tariffs.

Table 12: Robustness check: PPML specification

	(1) Baseline	(2) Tariff	(4) NTB	(5) Trade facilitation	(6) Country pair and sector FE
ln(Distance)	0.499^{***}	0.497^{***}	0.581^{***}	0.582^{***}	
	(0.02)	(0.03)	(0.03)	(0.04)	
Contiguity	-0.282^{*}	-0.436^{***}	-0.326^{**}	-0.788^{***}	
	(0.13)	(0.13)	(0.12)	(0.21)	
Language	-0.351^{***}	-0.313^{***}	-0.330^{***}	-0.583^{***}	
	(0.05)	(0.08)	(0.08)	(0.13)	
yr	0.041^{***}	0.033^{***}	0.025^{**}		
	(0.00)	(0.01)	(0.01)		
ln(tariff)		-0.011	-0.003	-0.071	-0.131
		(0.03)	(0.03)	(0.06)	(0.11)
ln(fntb)			-1.636^{***}	-1.981^{**}	
			(0.39)	(0.68)	
ln(cntb)			-0.333	0.009	
			(0.30)	(0.54)	
ln(business)				-0.321	-0.541
				(0.23)	(0.60)
ln(border)				-1.031^{**}	-1.031
				(0.35)	(0.75)
ln(ict)				0.937^{*}	1.264^{**}
				(0.45)	(0.45)
ln(infrastru)				-0.172	-1.368
				(0.25)	(0.96)
No.	267649	137558	116175	58786	58605

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable is the trade cost measure computed with sector-specific sigma. Robust standard errors are in parentheses. Column (5) include country-pair and sector fixed effects. Regression where tariff rate is include only covers the sample period between 1996 and 2011. Trade facilitation indicators only covers period from 2004 to 2011.

6. Conclusion

In this paper, we examine in detail the nature and size of sector level agricultural trade costs using an indirect measure derived from the theoretically consistent version of the gravity equation suggested by AvW (2003). First we estimate the elasticity of substitution at the sector level. We find that there is substantial variation between these ten agricultural sectors and across countries for the elasticity of substitution. Notably, Coffee and Tea has the highest elasticity of substitution on average. In addition, different from Broda and Weinstein (2006)'s findings that elasticity do not change much over time for U.S. imports, our results suggest that average elasticity of substitution for agricultural products have decreased in the recent ten years. This indicates an increasing product differentiation among products imported by countries.

Using the estimated elasticity, we assemble the overall bilateral trade cost for more than five thousand country pairs using agricultural trade and production data for 10 sectors covering more than 500 agricultural products and 100 countries from 1986 to 2011. We find that agricultural trade costs in agriculture in the sample period that we study (1986-2011) remains high and have not shown significant decreasing trend on an *ad-valorem* equivalent basis. Even when we look at average trade costs for country-pairs in different income groups, we did not find a significant decreasing trend for either developed and developing countries in agricultural sectors. Trade costs between developed economies are still lower than that for developing countries and the gap continues to grow. However, for certain country pairs, i.e. NAFTA countries, we find a significant decreasing trend. In fact, NAFTA countries have the lowest agricultural trade costs of any group of countries considered in this analysis. However, the overall results suggest there is considerable scope for future liberalization, especially for developing economies.

We also studied trade costs for four major economy groups: EU, TPP, BRICS and their trade cost with U.S. as well as NAFTA members' trade cost at the sector level. Among EU, TPP and BRICS members, the EU members experienced the lowest trade cost for agriculture at around 160 percent AVE while BRICS had much higher trade cost, at 346 percent AVE. U.S. has the lowest agricultural trade cost with its TPP partners, at 157 percent AVE. A close look at NAFTA members' agricultural trade cost reveals a decreasing trend for all sectors. Among the nine sectors, Sugar experienced the most dramatic decline over the sample period, from 1,400 percent to 250 percent AVE.

Lastly, we decomposed trade costs into a sample group of measurable trade cost factors. In addition, we estimated their contribution to the overall variation in agricultural trade costs. Geographical trade cost factors such as distance, contiguity and sharing the same language together account for the majority of the total variation explained by our model. We also examined the impact of several policy factors such as tariff rates, NTBs and trade facilitation indicators. Tariffs play an important role in the level of trade costs in agriculture whereas the effect of NTB is not as clear. However, the conclusion we draw for NTBs could be due to the lack of data quality. The two trade facilitation factors that are negatively related to agricultural trade costs are indicators for border efficiency and information, communication and technology. All together the measurable trade cost factors that we examined in our study account for only 30 percent of the total variation in agricultural trade cost on average at the sector level. This indicates there still exist a significant amount of variation in trade costs that are not captured by our variables. From a policy perspective, our result suggest that efforts to promote trade integration in agricultural sectors should focus on improving information technology and border transparency especially for sectors that are sensitive to these factors such as Cotton and Cereals.

Reference

Alberto, P. and Wilson J.S. 2010. "Export Performance and Trade Facilitation Reform: Hard and Soft Infrastructure," *World Bank Policy Research Working Paper No 5361*

Anderson, J. and E. van Wincoop. 2001. “Borders, trade and welfare”. In Brookings Trade Forum 2001.

_______. 2003. “Gravity with Gravitas: A Solution to the Border Puzzle,” *American Economic Review,* 93:170-192.

_______. 2002. "Borders, Trade and Welfare," in Brookings Trade Forum 2001. Susan Collins and Dani Rodrik, eds. Washington Brookings Institution, pp. 207-44

_______. 2004. “Trade Costs,” *Journal of Economic Literature,* 42(3):691-751.

Anderson M. and S. Smith 1999. “Do National Borders Really Matter? Canada-US Regional trade Reconsidered,” *Review of International Economics*, 7(2):219-27.

Aksoy M.A. 2004. “Global Agricultural Trade Policies.” In Global Agricultural Trade and Developing Countries, ed. Aksoy M.A., Behin J.C., pp. 37-53. Dordrecht / Boston / London: Kluwer Academic Publishers.

Arkolakis C, A. Costinot and A. Rodríguez-Clare. 2012. “New Trade Models, Same Old Gains?” *American Economic Review*, 102(1): 94-130.

Arvis J.F., Y. Duval, B. Shepherd, and C. Utoktham. 2013. “Trade Costs in the Developing World: 1995-2010,” World Bank Policy Research Working Paper 6309, Washington, DC.

Baier S., J. Bergstrand. 2007. “Do free trade agreements actually increase members' international trade?” *Journal of International Economics,* 71:72-95

Baier S., J. Bergstrand. 2009. “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation,” *Journal of International Economics,* 77: 77-85

Bernard A, B. Jensen, S. Redding, P. Schott. 2009. “The margins of U.S. trade (long version).” Working Paper 14662. National Bureau of Economic Research.

Bown, C.P. and M.A. Crowley. 2007. “Trade Deflection and Trade Depression.” *Journal of International Economics,* 72:176-201

Bradford, S. 2003. “Paying the Price: Final Goods Protection in OECD Countries,” *Review of Economics and Statistics,* 85(1): 24-37

Broda C., D.E. Weinstein. 2006. “Globalization and Gains from Variety,” *Quarterly Journal of Economics,* 121(2):541-585

Bouet A., Y. Decreux, L. Fontagné, S. Jean, D. Laborde. 2008. “Assessing Applied Protection across the World,” *Review of International Economics,* 16(5): 850-863

Buzzanell, P. 1997. “The North American Sugar Market: Recent Trends and Prospects Beyond 2000.” Sugar and Beverages Group, Commodities and Trade Division, FAO.

Chen, N. 2004. Intra-national versus international trade in the European Union: why do national border matter?. *Journal of International Economics,* 63:93-118

Chen, N., Novy. D. 2011. “Gravity, trade integration, and heterogeneity across industries.” *Journal of International Economics,* 85(2):206-221

Cheng I., H. Wall. 2005. “Controlling for Heterogeneity in Gravity Models of Trade and Integration.” Federal Reserve Bank of St. Louis Review: 49-69

De Sousa J., T. Mayer and S. Zignago. 2012. "Market Access in Global and Regional Trade," *Regional Science and Urban Economics*, 42(6): 1037–1052.

Disdier A., L. Fontagné, A. Minouni. 2008. “The Impact of Regulations on Agricultural Trade: Evidence from the SPS and TBT Agreements,” *American Journal of Agricultural Economics*, 90(2):336-350

Doyon, M. A., Novakovic, A. M. 1996. “Trade liberalization and the U.S. and Canadian dairy industries”. Extension Bulletin, No. 96-14. Department of Agricultural, Resource, and Management Economics, Cornell University

Drogué, S. and L. Bartova. 2006. “A Critical Survey of Database on Tariffs and Trade Available for the Analysis of EU Agricultural Agreements.” TRADEEAG working paper 2006/16

Duval, Y. and C. Uthoktham. 2011. “Trade Costs in Asia and the Pacific: Improved and Sectoral Estimates”, Trade and Investment Division Staff Working Paper 05/11, United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), Bangkok

Evans C. 2003. “The Economic significance of National Border Effects,” *The American Economic Review*, 93:1291-1312

Feenstra R.C. 1994. “New Product Varieties and Measurement of International Prices.” *American Economic Review,* 84(1): 157-177

_____. 2003. *Advanced International Trade: Theory and Evidence.* Princeton University Press.

Fields, G.S., 2003. “Accounting for Income Inequality and Its Change: A New Method, With Application to the Distribution of Earnings in the United States.” *Research in Labor Economics,* 22:1-38

Fillat, C. and E. Pardos. 2007."Alternative Measures for Trade Restrictiveness. A Gravity Approach." Documento de Trabajo, 02.

Fontagné L., T. Mayer, S. Zignago. 2005. “Trade in the Triad: how easy is the access to large markets?” *Canadian Journal of Economics,* 90(2):336-350

Gibson P., J. Wainio, D.M. Whitley, M. Bohman. 2001. “Profiles of Tariffs in Global Agricultural Markets.” Economic Research Service, USDA, Agricultural Economic Report Number 796, January

Grant, J. H., and K. A. Boys. 2012. “Agricultural Trade and the GATT/WTO: Does Membership Make a Difference?” *American Journal of Agricultural Economics*, 94(1): 1–24.

Haveman J.D., U. Nair-Reichert, and J.G. Thursby. 2003. “How Effective are Trade Barriers? An Empirical Analysis of Trade Reduction, Diversion, and Compression,” *The Review of Economics and Statistics*, 85:480-485

Head K., J. Ries. 2001. “Increasing Returns vs. National Product Differentiation as an Explanation for the Pattern of U.S.-Canada Trade,” *Canadian Journal of Economics*, 91(4): 858-876

Head K., T. Mayer. 2000. “Non-Europe: The Magnitude and Causes of Market Fragmentation in the EU”. Weltwirtschaftliches Archiv, 136(2):285-314

Helliwell J. 1998. “How Much Do National Borders Matter?” Washington, DC: The Brookings Institution

Helliwell J., L. Schembri. 2005. “Borders, Common Currencies, Trade, and Welfare: What Can We Learn from the Evidence?” *Bank of Canada Review*, Spring 2005: 19-33

Hertel T.W., D. Hummels, M. Ivanic, and R. Keeney. 2007. “How Confident Can We Be of CGE-based Assessments of Free Trade Agreements?” *Economic Modelling*, 24(4):611-635

Hoekman B. and A. Nicita. 2011. “Trade Policy, Trade Costs, and Developing Country Trade.” *World Development,* 39(12): 2069-2079

Hummels D. 1999. “Toward a Geography of Trade Costs.” Work. Pap. 1162, Dept. of Agricultural Econ., Purdue Univ.

Imbs, J., I. Méjean. 2011. “Elasticity Optimism.” *CEPR Discussion Paper 7177.*

Jacks D.S., C.M. Meissner, D. Novy. 2010. “Trade Costs in the First Wave of Globalization.” *Explorations in Economic History*, 47(2):127-141

Josling, T., D. Roberts, and D. Orden. 2004. “*Food Regulation and Trade: Toward a safe and Open Global System.”* Washington, DC: Institute for International Economics.

Kee, H., A. Nicita, and M. Olarreaga. 2009. “Estimating Trade Restrictiveness Indices.” *The Economic Journal*, 119(534):172-199

Kee, H., A. Nicita and M. Olarreaga. 2008. "Import Demand Elasticities and Trade Distortions", *Review of Economics and Statistics*, vol. 90, no. 4, p. 666-682.

Lee, J. W. and Swagel, P. 1997. “Trade Barriers and Trade Flows across Countries and Industries.” *Review of Economics and Statistics*, 79(3), 372-382.

McCallum J. 1995. “National Borders Matter: Canada-U.S. Regional Trade Patterns.” *American Economic Review*, 85:615-623.

Melitz M. J. 2003. “The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity.” *Econometrica*, 71: 1695-1725

Meilke, K., J. Rude, M. Burfisher, and M. Bredahl. 2001. Market Access: Issues and Options in the Agricultural Negotiations. International Agricultural Trade Research Consortium Commissioned Paper No. 14625, University of Minnesota, Minneapolis.

Nicita A. and M. Olarreaga. 2007. “Trade, Production, and Protection Database, 1976-2004.” *World Bank Economic Review*, 21(1):165-171

Nitsch V. 2000. “National borders and international trade: evidence from the European Union.” *Canadian Journal of Economics*, 33(4):1091-1105

Novy D. 2013. “Gravity Redux: Measuring International Trade Costs with Panel Data.” *Economic Inquiry*, 51(1): 101-121

Olper A., V. Raimondi. 2008. “Explaining National Border Effects in the QUAD Food Trade.” *Journal of Agricultural Economics*, 59:436-462

Olper A., V. Raimondi. 2009. “Patterns and Determinants of International Trade Costs in the Food Industry.” *Journal of Agricultural Economics*, 60:273-297

Obstfeld, M. and K. Rogoff. 2000. “The Six Major Puzzles in International Macroeconomics. Is there a Common Cause?” *NBER Working Paper 7777*

OECD. 2011. “The Impact of Trade Liberalisation on Jobsand Growth: Technical Note”, OECD Trade Policy Papers, No. 107, OECD Publishing. http://dx.doi.org/10.1787/5kgj4jfj1nq2-en

Paiva, C. 2008. “Assessing protectionism and subsidies in agriculture-A gravity approach.” *Journal of International Development*, 20(5), 628-640.

Pawlak K. 2011. “The evolution of the agricultural protectionism and its measures.” Scientific Journal of Warsaw University of Life Sciences – SGGW Problems of world agriculture, Vol. 11(XXVI), No. 3. Wydawnictwo SGGW, Warszawa

Peterson, E., J.H. Grant, D. Roberts and V. Karov. 2013. “Evaluating the Trade Restrictiveness of Phytosanitary Measures on U.S. Fresh Fruit and Vegetable Imports.” *American Journal of Agricultural Economics*

Roberts, D., T. E. Josling, and D. Orden. 1999. “A Framework for Analyzing Technical Trade Barriers in Agricultural Markets.” Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture. Technical Bulletin No. 1876.

Rose A. 2002. “Estimating Protectionism through Residuals from the Gravity Model.” Background paper for the Fall 2002 World Economic Outlook, mimeo, University of California at Berkeley.

Subramanian, A. and S.J. Wei. 2007. “The WTO Promotes Trade Strongly but Unevenly.” *Journal of International Economics,* 72(1): 151-175

Trefer D. 1993. “Trade Liberalization and the Theory of Endogenous Protection: An Econometric Study of U.S. Import Policy.” *Journal of Political Economy*, 101(1):138-160.

Tinbergen J. 1962. “An Analysis of World Trade Flows,” *Shaping the World Economy,* edited by Jan Tinbergen. New York, NY: Twentieth Century Fund.

U.S. International Trade Commission. 2011. *Economic Effects of Significant U.S. Import Restraints*, Publication 3906, Seventh Update, February

Wei S. 1996. “Intra-national Versus International Trade: How Stubborn Are Nations in Global Integration?” *NBER Working Paper no. 5531.*

WTO. 2007. *World Trade Report 2007. Six Decades of Multilateral Trade Cooperation: What have we Learnt?* WTO Document WT/REG/E/37, March 2007.

Xiong, B. and Beghin J., 2013. "Aflatoxin Redux: Does European Aflatoxin Regulation Hurt Groundnut Exporters from Africa?," *European Review of Agricultural Economics*, Foundation for the European Review of Agricultural Economics, vol. 40(5): 895-895.

Appendices

Appendix A: List of Countries for Estimation of Elasticity of Substitution

Argentina	France	Norway
Australia	Greece	New Zealand
Austria	China, Hong Kong SAR	Peru
Brazil	Indonesia	Philippines
Canada	India	Portugal
Chile	Ireland	Singapore
China, mainland	Iceland	Sweden
Colombia	Italy (including Holy See and San Marino)	Swaziland
Costa Rica	Jordon	Thailand
Denmark	Japan	Turkey

Appendix B: Variables Used in the Regression

	Description	mean	sd	min	max
year		2000.80	6.97	1986.0	2011
sector1	MTN CODE	5.95	2.94	1.0	10
pairid	Country pair id	12862.03	6731.94	902.0	25643
tcmean_sigma	Trade cost computed using global mean of sigma	3.06	1.83	0.0	21
tcsmean_sigma	Trade cost computed using sector mean sigma	86.52	987.31	0.0	167253
contig	1 for contiguity	0.08	0.26	0	1
comlang_off	1 for common official language	0.16	0.37	0	1
distw	weighted distance	6149.51	4620.14	114.6	19650
mbusiness	bilateral business	0.5	0.17	0.1	1
mborder_transp	bilateral border_transparency	0.75	0.12	0	1
t	Tariff	18.13	26.26	0	1002
fntb	frequency ratio of NTBs	0.75	0.57	0	2
cntb	coverage ratio of NTBs	0.72	0.66	0	2
N	267883				

Appendix C: Product Mapping from FAO Product Categories to MTN Sectors

Beer 112.3	B_T	Yogh Conc.Or Not	DAIRY	Vegetables, fresh or dried products nes	FRT&VEG	Oil of Kapok	OILSEED
Beer of Barley	B_T	Yoghurt	DAIRY	Vegetables, frozen	FRT&VEG	Oil of Olive Residues	OILSEED
Beer of Sorghum	`	Yoghurt, concentrated or not	DAIRY	Vegetables, homogenized preparations	FRT&VEG	Oil, castor beans	OILSEED
Beer of barley	B_T	Apple juice, concentrated	FRT&VEG	Vegetables, leguminous nes	FRT&VEG	Oil, citronella	OILSEED
Beer of sorghum	B_T	Apple juice, single strength	FRT&VEG	Vegetables, preserved nes	FRT&VEG	Oil, coconut (copra)	OILSEED
Bever. Dist.Alc	B_T	Bananas and plantains	FRT&VEG	Vegetables, preserved, frozen	FRT&VEG	Oil, cottonseed	OILSEED
Beverage Non-Alc	B_T	Cassava Equivalent	FRT&VEG	Vegetables, temporarily preserved	FRT&VEG	Oil, essential nes	OILSEED
Beverages	B_T	Cassava leaves	FRT&VEG	Vetches	FRT&VEG	Oil, kapok	OILSEED
Beverages+Tobacco -1	B_T	Citrus juice, concentrated	FRT&VEG	Animal Fats -41	MEAT	Oil, linseed	OILSEED
Beverages, distilled alcoholic	B_T	Citrus juice, single strength	FRT&VEG	Animal Oil+Fat+Grs	MEAT	Oil, olive residues	OILSEED
Beverages, fermented rice	B_T	Fruit Juice Nes	FRT&VEG	Animals Live Nes	MEAT	Oil, olive, virgin	OILSEED
Beverages, non alcoholic	B_T	Grape Juice	FRT&VEG	Animals live nes	MEAT	Oil, palm	OILSEED
Cider Etc	B_T	Grapefruit juice, concentrated	FRT&VEG	Animals, live, non-food	MEAT	Oil, palm fruit	OILSEED
Cider etc	B_T	Groundnuts Tot Shd	FRT&VEG	Ass Live Weight	MEAT	Oil, palm kernel	OILSEED
Cigarettes	B_T	Juice of Grapefruit	FRT&VEG	Bovine Meat	MEAT	Oil, poppy	OILSEED
Cigars Cheroots	B_T	Juice of Pineapples	FRT&VEG	Buffalo Live Weight	MEAT	Oil, rapeseed	OILSEED
Cigars, cheroots	B_T	Juice of Tomatoes	FRT&VEG	Buffalo milk, whole, fresh	MEAT	Oil, safflower	OILSEED
Tobacco	B_T	Juice of Vegetables Nes	FRT&VEG	Camel Live Weight	MEAT	Oil, sesame	OILSEED
Tobacco Products Nes	B_T	Juice, citrus, concentrated	FRT&VEG	Camelids, other	MEAT	Oil, soybean	OILSEED
Tobacco products nes	B_T	Juice, citrus, single strength	FRT&VEG	Canned Meat nes	MEAT	Oil, stillingia	OILSEED
Tobacco, unmanufactured	B_T	Juice, fruit nes	FRT&VEG	Cattle Live Weight	MEAT	Oil, sunflower	OILSEED
Wine	B_T	Juice, grape	FRT&VEG	Chicken Live Weight	MEAT	Oilseeds nes	OILSEED
Vermouths & similar	B_T	Juice, grapefruit	FRT&VEG	Compound Feed, Cattle	MEAT	Oilseeds, Nes	OILSEED
Vermouths&Similar	B_T	Juice, grapefruit, concentrated	FRT&VEG	Duck Live Weight	MEAT	Palm kernel oil	OILSEED
Coffee Green+Roast	C_T	Juice, lemon, concentrated	FRT&VEG	Food Excl Fish	MEAT	Palm kernels	OILSEED
Coffee+Tea+Cocoa+Sp-07	C_T	Juice, orange, concentrated	FRT&VEG	Game meat	MEAT	Palm oil	OILSEED
Coffee Extracts	C_T	Juice, orange, single strength	FRT&VEG	Geese and guinea fowls	MEAT	Poppy Oil	OILSEED
Coffee Husks and Skins	C_T	Juice, pineapple	FRT&VEG	Goat Live Weight	MEAT	Poppy seed	OILSEED
Coffee Roasted	C_T	Juice, pineapple, concentrated	FRT&VEG	Goose Live Weight	MEAT	Pyrethrum Extr	OILSEED
Coffee Subst. Cont.Coffee	C_T	Juice, plum, concentrated	FRT&VEG	Horse Live Weight	MEAT	Pyrethrum, dried	OILSEED
Coffee, extracts	C_T	Juice, plum, single strength	FRT&VEG	Indigenous Ass Meat	MEAT	Pyrethrum,Dried	OILSEED
Coffee, green	C_T	Juice, tomato	FRT&VEG	Indigenous Buffalo Meat	MEAT	Rapeseed	OILSEED
Coffee, husks and skins	C_T	Kapok Fruit	FRT&VEG	Indigenous Camel Meat	MEAT	Rapeseed oil	OILSEED
Coffee, roasted	C_T	Karite Nuts (Sheanuts)	FRT&VEG	Indigenous Cattle Meat	MEAT	Safflower oil	OILSEED
Coffee, substitutes containing coffee	C_T	Kolanuts	FRT&VEG	Indigenous Chicken Meat	MEAT	Safflower seed	OILSEED
Extracts Tea, Mate, Prep	C_T	Lemon juice, concentrated	FRT&VEG	Indigenous Duck Meat	MEAT	Sesame oil	OILSEED
Tea	C_T	Lemon juice, single strength	FRT&VEG	Indigenous Geese Meat	MEAT	Sesame seed	OILSEED

Tea nes	C_T	Lupins	FRT&VEG	Indigenous Goat Meat	MEAT	Soybean oil	OILSEED
Tea, mate extracts	C_T	Mango Juice	FRT&VEG	Indigenous Horse Meat	MEAT	Sunflower Cake	OILSEED
Cocoa Butter	C_T	Mango Pulp	FRT&VEG	Indigenous Mule Meat	MEAT	Sunflower oil	OILSEED
Cocoa Paste	C_T	Onions	FRT&VEG	Indigenous Other Camel	MEAT	Sunflower seed	OILSEED
Cocoa beans	C_T	Orange juice, concentrated	FRT&VEG	Indigenous Pigmeat	MEAT	Oils, fats of animal nes	OILSEED
Cocoa, beans	C_T	Orange juice, single strength	FRT&VEG	Indigenous Rabbit Meat	MEAT	Oils,Fats of Animal Nes	OILSEED
Cocoa, butter	C_T	Oranges+Tang+Clem	FRT&VEG	Indigenous Rodents	MEAT	Oil of Tung Nuts	OILSEED
Cocoa, paste	C_T	Oth Citrus Frt	FRT&VEG	Indigenous Sheep Meat	MEAT	Oil, groundnut	OILSEED
Cocoa, powder & cake	C_T	Other Conc, Nes	FRT&VEG	Indigenous Turkey Meat	MEAT	Oil of vegetable origin, nes	OILSEED
Cocoahusks;Shell	C_T	Peanut Butter	FRT&VEG	Indigenous bird meat, nes	MEAT	Oil, vegetable origin nes	OILSEED
Cocoapowder&Cake	C_T	Peanut butter	FRT&VEG	Meat Bovine Fresh	MEAT	Olive Residues	OILSEED
Chocolate Prsnes	C_T	Pineapple Juice Conc	FRT&VEG	Meat Dried Salted Sm	MEAT	Olive oil, virgin	OILSEED
Chocolate products nes	C_T	Plum juice, concentrated	FRT&VEG	Meat Fresh+Ch+Frozen	MEAT	Olives	OILSEED
Beehives	CER	Plum juice, single strength	FRT&VEG	Meat Offals Fr nes	MEAT	Olives Preserved	OILSEED
Bran Buckwheat	CER	Pome fruit, nes	FRT&VEG	Meat Oth Camelids	MEAT	Olives preserved	OILSEED
Bran of Fonio	CER	Pulp of Fruit for Feed	FRT&VEG	Meat Poultry Fresh	MEAT	Agave Fibres Nes	OTHAG
Bran+Milling Prod	CER	Pulses	FRT&VEG	Meat Prepared Pres	MEAT	Alfalfa Meal and Pellets	OTHAG
Bulgur	CER	Soya Curd	FRT&VEG	Meat Sheep Fresh	MEAT	Alfalfa for forage and silage	OTHAG
Cereals	CER	Sweet Corn Prep or Preserved	FRT&VEG	Meat and Meat Prep -01	MEAT	Alfalfa meal and pellets	OTHAG
Cereals and Prep -04	CER	Tangerine Juice	FRT&VEG	Meat of Mules	MEAT	Beet Pulp	OTHAG
Cereals nes	CER	Tapioca of Cassava	FRT&VEG	Meat of Other Rod	MEAT	Beet pulp	OTHAG
Eggs Liquid,Dried	CER	Tapioca of Potatoes	FRT&VEG	Meat of Swine	MEAT	Beets for Fodder	OTHAG
Eggs in The Shell	CER	Taro (cocoyam)	FRT&VEG	Meat, Dried, nes	MEAT	Cattle Hides	OTHAG
Flour of Fonio	CER	Tomatojuice Concentrated	FRT&VEG	Mule Live Weight	MEAT	Clover for forage and silage	OTHAG
Germ of Maize	CER	Tung Nuts	FRT&VEG	Other Camelids	MEAT	Cmpd Feed,Oth Or Nes	OTHAG
Germ of Wheat	CER	Veg Prod for Feed	FRT&VEG	Other Camelids Live Weight	MEAT	Cmpd Feed,Pigs	OTHAG
Germ, maize	CER	Vegetable Tallow	FRT&VEG	Other Meat	MEAT	Cmpd Feed,Poultry	OTHAG
Hay (Clover, Lucerne,Etc)	CER	Vegetables Roots Fodder	FRT&VEG	Other Poultry Live Weight	MEAT	Coarse Goat Hair	OTHAG
Hay (Unspecified)	CER	Waxes Vegetable	FRT&VEG	Other Rodents	MEAT	Cocoon Unr.&Waste	OTHAG
Hay (clover, lucerne,etc)	CER	Waxes vegetable	FRT&VEG	Ovine Meat	MEAT	Cocoons, unreelable & waste	OTHAG
Hay (unspecified)	CER	Yams	FRT&VEG	Pig Butcher Fat	MEAT	Coir	OTHAG
Hay Non Legum	CER	Yautia (cocoyam)	FRT&VEG	Pig Live Weight	MEAT	Cotton waste	OTHAG
Macaroni	CER	Apples	FRT&VEG	Pig Meat	MEAT	Crude Materials	OTHAG
Milled/Husked Rice	CER	Apricots	FRT&VEG	Pigeon peas	MEAT	Crude Materials -Ex2	OTHAG
Pastry	CER	Apricots, dry	FRT&VEG	Pigeons, Other Birds	MEAT	Crude materials	OTHAG
Popcorn	CER	Avocados	FRT&VEG	Pigeons, other birds	MEAT	Degras	OTHAG
Quinoa	CER	Bananas	FRT&VEG	Poultry Meat	MEAT	Dregs From Brewing;Dist.	OTHAG
Rice	CER	Berries Nes	FRT&VEG	Rabbit - Live weight	MEAT	Dregs from brewing, distillation	OTHAG
Rice ?C total (Rice milled equivalent)	CER	Berries nes	FRT&VEG	Rabbits and hares	MEAT	Fatty Acids	OTHAG
Rice Fermented Beverages	CER	Blueberries	FRT&VEG	Res.Fatty Subs	MEAT	Fatty acids	OTHAG
Rice ¨C total (Rice milled	CER	Cherries	FRT&VEG	Rodents Live Weight	MEAT	Fatty substance residues	OTHAG

equivalent)							
Rice, broken	CER	Cherries, sour	FRT&VEG	Rodents, other	MEAT	Feed Additives	OTHAG
Rice, husked	CER	Citrus fruit, nes	FRT&VEG	Sausages	MEAT	Feed Minerals	OTHAG
Rice, milled	CER	Cranberries	FRT&VEG	Sheep Live Weight	MEAT	Feed Supplements	OTHAG
Swedes for Fodder	CER	Currants	FRT&VEG	Spermaceti	MEAT	Feed and meal, gluten	OTHAG
Turnips for Fodder	CER	Dates	FRT&VEG	Tallow	MEAT	Feed minerals	OTHAG
Wafers	CER	Dry Apricots	FRT&VEG	Turkey Live Weight	MEAT	Feed supplements	OTHAG
Wheat+Flour,Wheat Equiv.	CER	Figs	FRT&VEG	Asses	MEAT	Feed, compound, nes	OTHAG
Barley	CER	Figs Dried	FRT&VEG	Bacon and Ham	MEAT	Feed, pulp of fruit	OTHAG
Barley Flour and Grits	CER	Figs dried	FRT&VEG	Bacon and ham	MEAT	Feed, vegetable products nes	OTHAG
Barley Pearled	CER	Flour of Fruits	FRT&VEG	Bird meat, nes	MEAT	Fine Goat Hair	OTHAG
Barley, pearled	CER	Fruit Dried Nes	FRT&VEG	Buffalo meat	MEAT	Flax Fib+Tow+W	OTHAG
Bran of Barley	CER	Fruit Fresh Nes	FRT&VEG	Buffaloes	MEAT	Fodder & Feeding stuff	OTHAG
Bran of Cereals	CER	Fruit Prp Nes	FRT&VEG	Camel meat	MEAT	Food Waste,Prep. for Feed	OTHAG
Bran of Maize	CER	Fruit Tropical Dried Nes	FRT&VEG	Camels	MEAT	Food Wastes	OTHAG
Bran of Millet	CER	Fruit, citrus nes	FRT&VEG	Cattle	MEAT	Food wastes	OTHAG
Bran of Mixed Grains	CER	Fruit, cooked, homogenized preparations	FRT&VEG	Cattle meat	MEAT	Forage and silage, grasses nes	OTHAG
Bran of Oats	CER	Fruit, dried nes	FRT&VEG	Chicken meat	MEAT	Forage and silage, legumes	OTHAG
Bran of Pulses	CER	Fruit, fresh nes	FRT&VEG	Chickens	MEAT	Forage products	OTHAG
Bran of Rice	CER	Fruit, pome nes	FRT&VEG	Duck meat	MEAT	Gluten Feed&Meal	OTHAG
Bran of Rye	CER	Fruit, prepared nes	FRT&VEG	Ducks	MEAT	Grasses Nes for forage;Sil	OTHAG
Bran of Sorghum	CER	Fruit, stone nes	FRT&VEG	Goat meat	MEAT	Grease incl. Lanolin Wool	OTHAG
Bran of Wheat	CER	Fruit, tropical fresh nes	FRT&VEG	Goats	MEAT	Grease incl. lanolin wool	OTHAG
Bran, buckwheat	CER	Fruit,Nut,Peel, Sugar Prs	FRT&VEG	Goose and guinea fowl meat	MEAT	Gums Natural	OTHAG
Bran, fonio	CER	Gooseberries	FRT&VEG	Homogen.Meat Prp.	MEAT	Hair Carded/ Combed	OTHAG
Bran, maize	CER	Grapefruit (inc. pomelos)	FRT&VEG	Horse meat	MEAT	Hair Coarse Nes	OTHAG
Bran, millet	CER	Grapes	FRT&VEG	Horses	MEAT	Hair Fine	OTHAG
Bran, rice	CER	Homogen. Cooked Fruit Prp	FRT&VEG	Liver Prep.	MEAT	Hair of Horses	OTHAG
Bran, sorghum	CER	Kapok fruit	FRT&VEG	Meal Meat	MEAT	Hair, fine	OTHAG
Bran, wheat	CER	Kiwi fruit	FRT&VEG	Meal, meat	MEAT	Hair, goat, coarse	OTHAG
Bread	CER	Lemons and limes	FRT&VEG	Meat Dried Nes	MEAT	Hide nes Fr	OTHAG
Breakfast Cereals	CER	Mangoes, mangosteens, guavas	FRT&VEG	Meat Extracts	MEAT	Hides Dry Slt Horses	OTHAG
Buckwheat	CER	Marc of Grapes	FRT&VEG	Meat indigenous, ass	MEAT	Hides Dry Slt Nes	OTHAG
Cake Rice Bran	CER	Melons, other (inc.cantaloupes)	FRT&VEG	Meat indigenous, bird nes	MEAT	Hides Drysalt Buf	OTHAG
Cake of Maize	CER	Melonseed	FRT&VEG	Meat indigenous, buffalo	MEAT	Hides Nes	OTHAG
Cake, maize	CER	Must of Grapes	FRT&VEG	Meat indigenous, camel	MEAT	Hides Nes Cattle	OTHAG
Cake, rice bran	CER	Oranges	FRT&VEG	Meat indigenous, cattle	MEAT	Hides Unsp Camels	OTHAG
Canary seed	CER	Other melons (inc.cantaloupes)	FRT&VEG	Meat indigenous, chicken	MEAT	Hides Unsp Horse	OTHAG
Cereal Preparations, Nes	CER	Papayas	FRT&VEG	Meat indigenous, duck	MEAT	Hides Wet Salted Buffaloes	OTHAG
Cereal preparations, nes	CER	Paste of Tomatoes	FRT&VEG	Meat indigenous, geese	MEAT	Hides Wet Salted Camels	OTHAG
Cereals, breakfast	CER	Peaches and nectarines	FRT&VEG	Meat indigenous, goat	MEAT	Hides Wet Salted Cattle	OTHAG

Cereals, nes	CER	Pears	FRT&VEG	Meat indigenous, horse	MEAT	Hides Wet Salted Horses	OTHAG
Fibre Crops Nes	CER	Persimmons	FRT&VEG	Meat indigenous, mule	MEAT	Hides Wet Salted Nes	OTHAG
Fibre crops nes	CER	Pineapples	FRT&VEG	Meat indigenous, other camelids	MEAT	Hides and Skins -21	OTHAG
Flax Fibre Raw	CER	Pineapples Cand	FRT&VEG	Meat indigenous, pig	MEAT	Hides and skins nes, fresh	OTHAG
Flax Tow Waste	CER	Pineapples canned	FRT&VEG	Meat indigenous, rabbit	MEAT	Hides, buffalo, dry salted	OTHAG
Flax fibre and tow	CER	Plantains	FRT&VEG	Meat indigenous, rodents	MEAT	Hides, buffalo, fresh	OTHAG
Flax fibre raw	CER	Plums Dried (Prunes)	FRT&VEG	Meat indigenous, sheep	MEAT	Hides, buffalo, wet salted	OTHAG
Flax tow waste	CER	Plums and sloes	FRT&VEG	Meat indigenous, turkey	MEAT	Hides, camel, nes	OTHAG
Flour of Buckwheat	CER	Plums dried (prunes)	FRT&VEG	Meat live weight, ass	MEAT	Hides, camel, wet salted	OTHAG
Flour of Cereals	CER	Quinces	FRT&VEG	Meat live weight, buffalo	MEAT	Hides, cattle, fresh	OTHAG
Flour of Maize	CER	Raisins	FRT&VEG	Meat live weight, camel	MEAT	Hides, cattle, wet salted	OTHAG
Flour of Millet	CER	Raspberries	FRT&VEG	Meat live weight, camelids, other	MEAT	Hides, horse, dry salted	OTHAG
Flour of Mixed Grain	CER	Sour cherries	FRT&VEG	Meat live weight, cattle	MEAT	Hides, nes	OTHAG
Flour of Rye	CER	Stone fruit, nes	FRT&VEG	Meat live weight, chicken	MEAT	Hidesdry S.Cattle	OTHAG
Flour of Sorghum	CER	Strawberries	FRT&VEG	Meat live weight, duck	MEAT	Jute+Bast Fibres	OTHAG
Flour of Wheat	CER	Tangerines, mandarins, clem.	FRT&VEG	Meat live weight, goat	MEAT	Karakul Skins	OTHAG
Flour, cereals	CER	Tangerines, mandarins, clementines, satsumas	FRT&VEG	Meat live weight, goose	MEAT	Leather Use&Waste	OTHAG
Flour, fonio	CER	Watermelons	FRT&VEG	Meat live weight, horse	MEAT	Leguminous for Silage	OTHAG
Flour, maize	CER	Soya Paste	FRT&VEG	Meat live weight, mule	MEAT	Manila Fibre (Abaca)	OTHAG
Flour, mixed grain	CER	Soya Sauce	FRT&VEG	Meat live weight, pig	MEAT	Natural Rubber	OTHAG
Flour, potatoes	CER	Soya curd	FRT&VEG	Meat live weight, poultry, other	MEAT	Natural rubber	OTHAG
Flour, wheat	CER	Soya paste	FRT&VEG	Meat live weight, rabbit	MEAT	Offals Edibl Fresh	OTHAG
Fonio	CER	Soya sauce	FRT&VEG	Meat live weight, rodents	MEAT	Offals Other Camelids	OTHAG
Food Prep Nes	CER	Soybeans	FRT&VEG	Meat live weight, sheep	MEAT	Other Bastfibres	OTHAG
Food Prep,Flour,Malt Extract	CER	Almonds Shelled	FRT&VEG	Meat live weight, turkey	MEAT	Pet Food	OTHAG
Food prep nes	CER	Almonds shelled	FRT&VEG	Meat nes	MEAT	Pet food	OTHAG
Food preparations, flour, malt extract	CER	Almonds, with shell	FRT&VEG	Meat of Asses	MEAT	Pyrethrum, extraction	OTHAG
Forage and silage, maize	CER	Areca nuts	FRT&VEG	Meat of Beef,Drd, Sltd,Smkd	MEAT	Ramie	OTHAG
Forage and silage, rye grass	CER	Arecanuts	FRT&VEG	Meat of Chicken Canned	MEAT	Rubber Nat Dry	OTHAG
Forage and silage, sorghum	CER	Brazil Nuts Shelled	FRT&VEG	Meat, ass	MEAT	Rye grass for forage & silage	OTHAG
Grain, mixed	CER	Brazil nuts, shelled	FRT&VEG	Meat, beef and veal sausages	MEAT	Silk	OTHAG
Maize	CER	Brazil nuts, with shell	FRT&VEG	Meat, beef, preparations	MEAT	Silk Raw	OTHAG
Maize for forage and silage	CER	Cake of Groundnuts	FRT&VEG	Meat, bird nes	MEAT	Silk raw	OTHAG
Maize oil	CER	Cake, cottonseed	FRT&VEG	Meat, buffalo	MEAT	Sisal+Oth Agaves	OTHAG
Maize, green	CER	Cake, groundnuts	FRT&VEG	Meat, camel	MEAT	Skin Furs	OTHAG
Malt	CER	Cashew Nuts Shelled	FRT&VEG	Meat, cattle	MEAT	Skins Nes Calves	OTHAG
Malt Extract	CER	Cashew nuts, shelled	FRT&VEG	Meat, cattle, boneless (beef & veal)	MEAT	Skins Nes Goats	OTHAG
Millet	CER	Cashew nuts, with shell	FRT&VEG	Meat, chicken	MEAT	Skins Nes Pigs	OTHAG
Mixed grain	CER	Cashewapple	FRT&VEG	Meat, chicken, canned	MEAT	Skins Nes Sheep	OTHAG
Oats	CER	Chestnut	FRT&VEG	Meat, dried nes	MEAT	Skins Wet Salted Calves	OTHAG

Oats Rolled	CER	Chestnuts	FRT&VEG	Meat, duck	MEAT	Skins Wet Salted Goats	OTHAG
Oats rolled	CER	Coconuts	FRT&VEG	Meat, game	MEAT	Skins With Wool Sheep	OTHAG
Pot Barley	CER	Coconuts Desiccated	FRT&VEG	Meat, goat	MEAT	Skins of Rabbits	OTHAG
Rice Broken	CER	Coconuts, desiccated	FRT&VEG	Meat, goose and guinea fowl	MEAT	Skins, calve, wet salted	OTHAG
Rice Flour	CER	Groundnut oil	FRT&VEG	Meat, horse	MEAT	Skins, goat, fresh	OTHAG
Rice Husked	CER	Groundnuts Shelled	FRT&VEG	Meat, mule	MEAT	Skins, goat, wet salted	OTHAG
Rice Milled	CER	Groundnuts, shelled	FRT&VEG	Meat, nes	MEAT	Skins, sheep, dry salted	OTHAG
Rice bran oil	CER	Groundnuts, with shell	FRT&VEG	Meat, other camelids	MEAT	Skins, sheep, fresh	OTHAG
Rice, milled/husked	CER	Hazelnuts Shelled	FRT&VEG	Meat, other rodents	MEAT	Skins, sheep, wet salted	OTHAG
Rice, paddy	CER	Hazelnuts, shelled	FRT&VEG	Meat, pig	MEAT	Skins, sheep, with wool	OTHAG
Rye	CER	Hazelnuts, with shell	FRT&VEG	Meat, pig sausages	MEAT	Skinsdry S.Calves	OTHAG
Sorghum	CER	Karite nuts (sheanuts)	FRT&VEG	Meat, pig, preparations	MEAT	Skinsdry Slt Goat	OTHAG
Straw Husks	CER	Kola nuts	FRT&VEG	Meat, pork	MEAT	Skinsdry Sltdpigs	OTHAG
Straw husks	CER	Nuts, nes	FRT&VEG	Meat, rabbit	MEAT	Skinsdry Sltsheep	OTHAG
Sweet Corn Frozen	CER	Nuts, prepared (exc. groundnuts)	FRT&VEG	Meat, sheep	MEAT	Skinswet Salted	OTHAG
Sweet corn frozen	CER	Pistachios	FRT&VEG	Meat, turkey	MEAT	Skinswet Sltdpigs	OTHAG
Sweet corn prep or preserved	CER	Prepared Groundnuts	FRT&VEG	Meat-CattleBoneless(Beef&Veal)	MEAT	Sorghum for forage and silage	OTHAG
Triticale	CER	Prepared Nuts (Exc.Groundnuts)	FRT&VEG	Mules	MEAT	Textile Fibres	OTHAG
Wheat	CER	Tung nuts	FRT&VEG	Pig meat	MEAT	Vitamins	OTHAG
Eggs Dried	CER	Walnuts Shelled	FRT&VEG	Pigs	MEAT	Waters,Ice Etc	OTHAG
Eggs Liquid	CER	Walnuts, shelled	FRT&VEG	Pork	MEAT	Waters,ice etc	OTHAG
Eggs, dried	CER	Walnuts, with shell	FRT&VEG	Prep of Pig Meat	MEAT	Wine+Vermouth+Sim.	OTHAG
Eggs, hen, in shell	CER	Agave fibres nes	FRT&VEG	Preparations of Beef Meat	MEAT	Wool Degreased	OTHAG
Eggs, liquid	CER	Artichokes	FRT&VEG	Prepared Meat Nes	MEAT	Wool Shoddy	OTHAG
Eggs, other bird, in shell	CER	Asparagus	FRT&VEG	Rabbit meat	MEAT	Wool, degreased	OTHAG
Hen eggs, in shell	CER	Bambara beans	FRT&VEG	Sausage Beef&Veal	MEAT	Wool, hair waste	OTHAG
Honey, natural	CER	Bastfibres, other	FRT&VEG	Sausages of Pig Meat	MEAT	Wool;Hair Waste	OTHAG
Ice Cream and Edible Ice	CER	Beans, dry	FRT&VEG	Sheep	MEAT	forage Products	OTHAG
Ice cream and edible ice	CER	Beans, green	FRT&VEG	Sheep meat	MEAT	Anise, badian, fennel, corian.	OTHAG
Other bird eggs,in shell	CER	Broad beans, horse beans, dry	FRT&VEG	Turkey meat	MEAT	Anise, badian, fennel, coriander	OTHAG
Potatoes Flour	CER	Cabbages and other brassicas	FRT&VEG	Turkeys	MEAT	Chillies and peppers, dry	OTHAG
Starch, cassava	CER	Canned Mushrooms	FRT&VEG	Cake of Hempseed	OILSEED	Chillies and peppers, green	OTHAG
Seed cotton	COTTON	Carobs	FRT&VEG	Cattle Butch.Fat	OILSEED	Cinnamon (canella)	OTHAG
Cotton Carded,Combed	COTTON	Carrots and turnips	FRT&VEG	Fixed Vegetab Oils -42	OILSEED	Cloves	OTHAG
Cotton Linter	COTTON	Cassava	FRT&VEG	Kapokseed Shelled	OILSEED	Ginger	OTHAG
Cotton Waste	COTTON	Cassava Dried	FRT&VEG	Lard	OILSEED	MatÃ©	OTHAG
Cotton lint	COTTON	Cassava Starch	FRT&VEG	Lard Stearine Oil	OILSEED	Maté	OTHAG
Cotton linter	COTTON	Cassava dried	FRT&VEG	Lard+Fat,Pig+Poult	OILSEED	Nutmeg, mace and cardamoms	OTHAG
Cotton, carded, combed	COTTON	Cauliflowers and broccoli	FRT&VEG	Oil palm fruit	OILSEED	Spices, nes	OTHAG
Butter	DAIRY	Chick peas	FRT&VEG	Oil, boiled etc	OILSEED	Infant Food	OTHAG
Buttermilk, curdled, acidified milk	DAIRY	Chicory roots	FRT&VEG	Oilseed Cake Meal	OILSEED	Infant food	OTHAG
Camel milk, whole, fresh	DAIRY	Cow peas, dry	FRT&VEG	Oilseed Cake nes	OILSEED	Offals Liver Chicken	OTHAG

Cheese and Curd	DAIRY	Cucumbers and gherkins	FRT&VEG	Oilseeds -22	OILSEED	Offals Liver Duck	OTHAG
Cow milk, whole, fresh	DAIRY	Dried Mushrooms	FRT&VEG	Olive Oil,Total	OILSEED	Offals Liver Geese	OTHAG
Cream Fresh	DAIRY	Eggplants (aubergines)	FRT&VEG	Rape+Mustard Oils	OILSEED	Offals Nes	OTHAG
Cream fresh	DAIRY	Flour of Cassava	FRT&VEG	Rape+Mustard Seed	OILSEED	Offals of Cattle, Edible	OTHAG
Ghee Oil of Buf	DAIRY	Flour of Pulses	FRT&VEG	Stillingia Oil	OILSEED	Offals of Goats, Edible	OTHAG
Ghee,Butteroil of Cow Milk	DAIRY	Flour of Roots and Tubers	FRT&VEG	Oil, maize	OILSEED	Offals of Horses	OTHAG
Goat milk, whole, fresh	DAIRY	Flour, pulses	FRT&VEG	Oil, rice bran	OILSEED	Offals of Pigs, Edible	OTHAG
Margarine etc	DAIRY	Flour, roots and tubers nes	FRT&VEG	Fat Liver Prep (Foie Gras)	OILSEED	Offals of Sheep,Edible	OTHAG
Milk Cond + Evap	DAIRY	Frozen Potatoes	FRT&VEG	Fat Prep Nes	OILSEED	Offals, edible, cattle	OTHAG
Milk Cond+Dry+Fresh	DAIRY	Garlic	FRT&VEG	Fat of Camels	OILSEED	Offals, edible, goats	OTHAG
Milk Dry	DAIRY	Homogen.Veget.Prep	FRT&VEG	Fat of Cattle	OILSEED	Offals, liver chicken	OTHAG
Milk Equivalent	DAIRY	Kapok Fibre	FRT&VEG	Fat of Pigs	OILSEED	Offals, liver duck	OTHAG
Milk Fresh	DAIRY	Kapok fibre	FRT&VEG	Fat of Poultry	OILSEED	Offals, liver geese	OTHAG
Milk Skimmed Cond	DAIRY	Kapokseed in Shell	FRT&VEG	Fat of Ptry Rend	OILSEED	Offals, other camelids	OTHAG
Milk Skimmed Dry	DAIRY	Kapokseed in shell	FRT&VEG	Fat of Sheep	OILSEED	Offals, pigs, edible	OTHAG
Milk Skimmed Evp	DAIRY	Kapokseed shelled	FRT&VEG	Fat, camels	OILSEED	Offals, sheep,edible	OTHAG
Milk Skm of Cows	DAIRY	Leeks, other alliaceous veg	FRT&VEG	Fat, cattle	OILSEED	Beeswax	OTHAG
Milk Whole Cond	DAIRY	Leeks, other alliaceous vegetables	FRT&VEG	Fat, liver prepared (foie gras)	OILSEED	Gums, natural	OTHAG
Milk Whole Dried	DAIRY	Leguminous vegetables, nes	FRT&VEG	Fat, nes, prepared	OILSEED	Hemp Tow Waste	OTHAG
Milk Whole Evp	DAIRY	Lentils	FRT&VEG	Fat, pigs	OILSEED	Hemp tow waste	OTHAG
Milk, products of natural constituents nes	DAIRY	Lettuce and chicory	FRT&VEG	Cake Safflower	OILSEED	Hempseed	OTHAG
Milk, reconstituted	DAIRY	Mushrooms and truffles	FRT&VEG	Cake of Copra	OILSEED	Hops	OTHAG
Milk, skimmed cow	DAIRY	Mushrooms, canned	FRT&VEG	Cake of Cottonseed	OILSEED	Jute	OTHAG
Milk, skimmed dried	DAIRY	Okra	FRT&VEG	Cake of Kapok	OILSEED	Manila fibre (abaca)	OTHAG
Milk, whole condensed	DAIRY	Onions (inc. shallots), green	FRT&VEG	Cake of Linseed	OILSEED	Peppermint	OTHAG
Milk, whole dried	DAIRY	Onions, dry	FRT&VEG	Cake of Mustard	OILSEED	Rubber natural dry	OTHAG
Milk, whole evaporated	DAIRY	Onions, shallots, green	FRT&VEG	Cake of Oilseeds, Nes	OILSEED	Rubber, natural	OTHAG
Milkdry Buttrmilk	DAIRY	Peas, dry	FRT&VEG	Cake of Palm Kernel	OILSEED	Silk-worm cocoons, reelable	OTHAG
Prod.of Nat.Milk Constit	DAIRY	Peas, green	FRT&VEG	Cake of Rapeseed	OILSEED	Sisal	OTHAG
Reconsti.Ted Milk	DAIRY	Pepper (Piper spp.)	FRT&VEG	Cake of Sesame Seed	OILSEED	Wool, greasy	OTHAG
Sheep milk, whole, fresh	DAIRY	Pepper (piper spp.)	FRT&VEG	Cake of Soybeans	OILSEED	Vanilla	OTHAG
Whey, Pres+Concen	DAIRY	Potato Offals	FRT&VEG	Cake, copra	OILSEED	Bagasse	SGR
Butter Cow Milk	DAIRY	Potato offals	FRT&VEG	Cake, hempseed	OILSEED	Beet sugar, raw, centrifugal	SGR
Butter of Karite Nuts	DAIRY	Potatoes	FRT&VEG	Cake, kapok	OILSEED	Cane Tops	SGR
Butter of karite nuts	DAIRY	Potatoes, frozen	FRT&VEG	Cake, linseed	OILSEED	Cane sugar, raw, centrifugal	SGR
Butter, cow milk	DAIRY	Pulses, nes	FRT&VEG	Cake, mustard	OILSEED	Cane tops	SGR
Butter,Ghee of Sheep Milk	DAIRY	Pumpkins, squash and gourds	FRT&VEG	Cake, palm kernel	OILSEED	Lactose	SGR
Butterm.,Curdl,Acid.Milk	DAIRY	Roots and Tubers Dried	FRT&VEG	Cake, rapeseed	OILSEED	Sugar and Honey -06	SGR
Cheese of Goat Mlk	DAIRY	Roots and Tubers, nes	FRT&VEG	Cake, safflower	OILSEED	Sugar flavoured	SGR
Cheese of Sheep Milk	DAIRY	Roots and tubers, nes	FRT&VEG	Cake, sesame seed	OILSEED	Sugar,Total (Raw Equiv.)	SGR

Cheese of Skimmed Cow Milk	DAIRY	Spinach	FRT&VEG	Cake, soybeans	OILSEED	Fructose and syrup, other	SGR
Cheese of Whole Cow Milk	DAIRY	String beans	FRT&VEG	Cake, sunflower	OILSEED	Glucose and Dextrose	SGR
Cheese, processed	DAIRY	Sweet potatoes	FRT&VEG	Castor oil seed	OILSEED	Glucose and dextrose	SGR
Cheese, sheep milk	DAIRY	Tomato Peeled	FRT&VEG	Coconut (copra) oil	OILSEED	Isoglucose	SGR
Cheese, whole cow milk	DAIRY	Tomatoes	FRT&VEG	Copra	OILSEED	Maple Sugar and Syrups	SGR
Ghee, of buffalo milk	DAIRY	Tomatoes, paste	FRT&VEG	Cottonseed	OILSEED	Maple sugar and syrups	SGR
Liquid Margarine	DAIRY	Tomatoes, peeled	FRT&VEG	Cottonseed oil	OILSEED	Mixes and Doughs	SGR
Margarine, liquid	DAIRY	Turnips for fodder	FRT&VEG	Flour of Mustard	OILSEED	Mixes and doughs	SGR
Margarine, short	DAIRY	Veg.Prep. Or Pres.Frozen	FRT&VEG	Flour of Oilseeds	OILSEED	Molasses	SGR
Margrine Short	DAIRY	Veg.Prod.Fresh Or Dried	FRT&VEG	Flour, mustard	OILSEED	Other Fructose and Syrup	SGR
Milk, whole fresh buffalo	DAIRY	Veg.in Tem. Preservatives	FRT&VEG	Forage and silage, alfalfa	OILSEED	Sugar Confectionery	SGR
Milk, whole fresh camel	DAIRY	Vegetable Frozen	FRT&VEG	Forage and silage, clover	OILSEED	Sugar Non- Centrifugal	SGR
Milk, whole fresh cow	DAIRY	Vegetable tallow	FRT&VEG	Linseed	OILSEED	Sugar Raw Centrifugal	SGR
Milk, whole fresh goat	DAIRY	Vegetables Dehydrated	FRT&VEG	Linseed oil	OILSEED	Sugar Refined	SGR
Milk, whole fresh sheep	DAIRY	Vegetables Preserved Nes	FRT&VEG	Mustard oil	OILSEED	Sugar beet	SGR
Processed Cheese	DAIRY	Vegetables fresh nes	FRT&VEG	Mustard seed	OILSEED	Sugar cane	SGR
Whey Cheese	DAIRY	Vegetables in Vinegar	FRT&VEG	Oil Boiled Etc	OILSEED	Sugar confectionery	SGR
Whey Condensed	DAIRY	Vegetables in vinegar	FRT&VEG	Oil Citronella	OILSEED	Sugar crops, nes	SGR
Whey Dry	DAIRY	Vegetables, canned nes	FRT&VEG	Oil Essential Nes	OILSEED	Sugar non-centrifugal	SGR
Whey Fresh	DAIRY	Vegetables, dehydrated	FRT&VEG	Oil Hydrogenated	OILSEED	Sugar refined	SGR
Whey, condensed	DAIRY	Vegetables, dried nes	FRT&VEG	Oil of Castor Beans	OILSEED	Sugar, beet, raw, centrifugal	SGR
Whey, dry	DAIRY	Vegetables, fresh nes	FRT&VEG	Oil of Jojoba	OILSEED	Sugar, cane, raw, centrifugal	SGR
						Sugar, nes	SGR

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Appendix D: List of Countries by Development Status

Least Developed Countries					
Albania	Bhutan	Guinea	Kazakhstan	Moldova	Serbia
Antigua and Barbuda	Bosnia and Herzegovina	Ethiopia	Kyrgyzstan	Mongolia	Suriname
Armenia	Burkina Faso	Fiji	Laos	Mozambique	Tajikistan
Azerbaijan	Burundi	Gambia	Madagascar	Nepal	Togo
Bangladesh	Cambodia	Georgia	Malawi	Niger	Turkmenistan
Belarus	Cook Islands	Guinea	Maldives	Rwanda	Ukraine
Belize	Croatia	Iran	Mali	Senegal	Yemen
Developing Countries					
Algeria	China	Ghana	Kenya	Pakistan	Singapore
Argentina	Colombia	Guyana	Lebanon	Panama	South Africa
Barbados	Congo	Honduras	Malaysia	Paraguay	Sri Lanka
Bolivia	Costa Rica	Hong Kong	Mauritius	Peru	Thailand
Botswana	Dominican Republic	India	Mexico	Philippines	Trinidad and Tobago
Brazil	Ecuador	Indonesia	Morocco	Qatar	Tunisia
Cameroon	Egypt	Israel	Namibia	Republic of Korea	Turkey
Cape Verde	El Salvador	Jamaica	Nicaragua	Russia	Uruguay
Chile	Eritrea	Jordan	Nigeria	Saudi Arabia	Venezuela
					Viet Nam
Developed Countries					
Australia	Czech Republic	Greece	Latvia	Norway	Spain
Austria	Denmark	Hungary	Lithuania	Poland	Sweden
Belgium	Estonia	Iceland	Luxembourg	Portugal	Switzerland
Bulgaria	Finland	Ireland	Malta	Romania	United Kingdom
Canada	France	Italy	Netherlands	Slovakia	United States
Cyprus	Germany	Japan	New Zealand	Slovenia	

Chapter 2: Margins and Growth of International Agricultural Trade

Abstract: *This paper aims to dissect the growth of world and U.S. agricultural trade into intensive (expansion of existing trade flows) and extensive (expansion of trade with new countries and/or products) margins. First, we provide a graphical decomposition of the growth of world and U.S. agricultural trade along the two margins using a pre-defined base period. Second, we dissect the intensive and extensive margins of agricultural exports using a novel accounting procedure that defines one intensive and four possible extensive margin trade expansion paths. Finally, we estimate intensive and extensive margins using a theoretically founded decomposition method developed by Hummels and Klenow (2005). Finally, I discuss my empirical findings in the context of the literature on heterogeneous firms and the growth of trade along the extensive margin.*

1. Introduction

Economists often extol the virtues of more open international markets. Expanding existing markets and opening new ones allows exporters to exploit their comparative advantages and, at the same time, allows firms to increase the scale of their production. Consumers in importing countries gain not only because of the availability of cheaper foreign products but also from having access to a much wider set of product varieties throughout the year. Indeed, the growth in world trade in the post-war era has been nothing short of impressive. Celebrating its 60th anniversary on January 1, 2008, the GATT/WTO published a World Trade Report titled "Six decades of multilateral cooperation: What have we learnt?" Among its many accomplishments, the GATT/WTO notes that: "… since 1950 world trade has grown more than twenty-seven fold in volume terms and this expansion is more than three times as large as the growth in world output which expanded eight-fold during the same period" (WTO 2007, pg. 243). The impressive growth in world trade is often attributed to the GATT/WTO, largely due to its visible role in reducing barriers to trade through successive rounds of negotiation.

Theory predicts that trade liberalization, whether unilateral, bilateral or multilateral in scope, will increase trade in absolute terms. However, the theory has been virtually silent on *how* trade expands as the world economy becomes more liberalized. Until recently, little empirical evidence existed to suggest whether the growth of a country's trade is because it is simply trading more intensively with its partners in well-established product lines (higher volumes), or whether this growth was driven by the formation of new trading relationships and/or new product exports? This latter channel – the so-called extensive margin of trade – has been the topic of many recent theoretical and empirical trade studies (Melitz 2003; Broda and Weinstein 2006; Feenstra and Kee 2007; Hummels and Klenow 2005; Helpman, Melitz and Rubenstein 2008; Evenett and Veneables 2002; Bernard, Jensen, Redding and Schott 2009).

In a landmark paper, Melitz (2003) demonstrates succinctly, based on the assumption of fixed costs to enter into exporting and heterogeneous productivity among firms, that there exists a productivity threshold that firms must exceed in order to export. The implication of Melitz's model is that it results in an extensive (i.e., the number of firms) and intensive (exports per firm) margin of trade. This model contrasts to popular gravity-type models such as Anderson and van Wincoop (2003) which assumes that products are differentiated by country-of-origin, consumer love for variety, and homogeneous firms with identical productivities. As a result, there is no adjustment along the extensive margin as all policy action affects trade flows through expansion of existing volumes of trade. Chaney (2008) extends the Melitz model by assuming a Pareto distribution of productivity for heterogeneous firms and proved that the degree of impact that trade barriers have on the extensive and intensive margins also depends on the elasticity of substitution between product varieties. That is, for differentiated products where demand is less affected by changes in trade barriers, trade growth along the extensive margin is more sensitive to trade barriers whereas intensive margins are less affected by trade barriers. This is because when the elasticity of substitution is low, products are less substitutable and thus firms are sheltered from competition. When trade barriers lower, less productive firms can enter the market and capture a relatively large and stable market share.

Growth of a country's trade profile can occur through increasing the volume of products traded, increases in the price (unit value) charged for those products, or by exporting new products and/or transacting with new trading partners. These channels, often referred to as the intensive or extensive margins of trade, have shed new light on key economic variables such as productivity, economic growth, export duration, and the gains from trade (see for e.g., Besedeš and Prusa 2006; Hillberry and McDaniel, 2002; Broda and Weinstein 2006). Expanding exports through higher volumes along the intensive margin is often viewed as an indication that countries are making the most of their comparative advantage and firms in those industries are exploiting their economies of scale. However, one of the drawbacks of relying on a fixed set of goods and partner countries is that it may lead to declining export prices as supply expands and the potential for demand-side shocks in destination regions that may disrupt export flows (Liapis 2006).

Thus, there are economic benefits to diversifying a country's destination and product set. A diversified export basket mitigates variability in export earnings, particularly during prolonged global economic events, and also reduces the potential for declining terms of trade changes. Further, creating new or higher quality products and developing new trading partners, can spur productivity and economic growth, particularly in developing economies where export led growth features prominently as a development goal. However, even the most recent theories of international trade that include firm level productivity and fixed cost thresholds for exporting say very little about the way in which new markets are penetrated. Melitz's (2003) model introduces uncertainty in the productivity draws of firms but once firms know their productivity and the sunk cost they must incur to export, there is no uncertainty in destination markets. Melitz and Ottaviano (2008) introduce endogenous markups so that larger economies have higher productivity firms which produces some differentiation in the destination markets that can be profitably served (i.e., larger economies can reach smaller and more distant markets). Broda and Weinstein (2006) find that roughly half of the US import variety growth is due to an increase in the number of goods and the other half resulting from more trading partners. Hummels and Klenow (HK) (2005) remove the temporal dimension implicit in much of this literature and develop intensive and extensive margin indices relative to a reference country (i.e., the rest of the world) *at a single point in time*. Liapis (2009) evaluates HK intensive and extensive margins for agricultural trade. Finally, while destination markets feature prominently in Bernard, Jensen, Redding, and Schott (BJRS 2009), their analyses decompose firm level exports into the number of products exported and exports per product.

Clearly this evolving literature has shed new light on the factors affecting the decision to export and the growth of exports. However, much more remains to be done. In particular, do we really know how important is the new destination or new product dimension of export growth? Do we know the relative importance of the extensive margin channels for agricultural trade? Do these channels of export growth depend on the familiarity of destinations – markets already being served by other products versus markets that have never been served by any product - so as to reduce uncertainty in international transactions? Does familiarity influence export growth along the product dimension? And do developed countries exhibit a different pattern of export growth compared to their developing country counterparts? The work by Evenett and Veneables (2002) is the closest paper in methodology to this one because it analyzes separately the product and destination dimensions of export growth whereas this essay focuses on destination-product pairs as individual varieties.

I fill in the gap in the literature by looking at detailed agricultural trade growth and its margins over a long time series for the world as well as the U.S. This study examines the contributions that each margin has for agricultural exports using very detailed product lines over the period from 1989 to 2010. With the negotiation of the largest free trade agreement with Europe, and the Trans-Pacific Partnership (TPP), U.S. trade is facing many opportunities for export growth. Studying trade growth through various margins will provide interesting insights on how trade liberalization has impacted U.S. trade and will provide new insights for the theory.

2. Research objective

There seems to be important fixed and sunk costs of exporting and, in particular, of exporting to specific destinations. These costs inhibit firms' product expansion into foreign markets. While the theory has underscored the importance of the extensive margin, little is known about how exports increase along various channels of the extensive margin. In the widely cited paper by Hummels and Klenow (2005), their definition of the extensive margin is based on how many "more" products an exporter ships relative to the rest of the world. In this essay I focus more on how many "new" products an exporter ships for a given country and through what margins are these varieties exported?

This paper proposes to lay out a novel framework for decomposing trade growth along the intensive margin and four different channels within the extensive margin. Rather than focusing on a particular theory or gravity-type econometric framework this paper investigates these questions from a measurement and index number perspective. Our interest here is not to sketch out a new theoretical model but rather to reveal empirical facts about export growth within countries to inform new trade theories. We do not aim to test each growth channel formally. Rather the goal instead is to identify the ingredients of export growth that may inform a more nuanced theory.

Specifically, there are three main objectives of this essay.

1. *Accounting Exercise*: to dissect the growth of world and US agricultural and nonagricultural exports into one intensive margin channel and four potential extensive margin channels using detailed market expansion grids

2. *HK Margins*: to introduce the Hummels and Klenow (HK, 2005) intensive and extensive margin indices to agricultural trade and further decompose the relative contributions of each margin to countries' overall export elasticity
3. *Evidence for Theory*: to synthesize the findings from objectives 1 and 2 to help inform the theory relating to the heterogeneous firms and the extensive margin of trade

I apply this measurement framework to study detailed U.S. as well as several other major economies' agricultural export growth along several margins using different definitions of the trade codes such as the Standard Industrial Classification (SITC) and the Harmonized System (HS) from six to ten digits. It should be noted that many of the methods used to quantify the extensive margin require a choice about the base period of comparison, the level of product disaggregation from which to conduct the analysis, and the types of factors that may affect the relative contribution of the extensive and intensive margins of trade. I intend to provide several different reference points (i.e., base years) and product aggregations (i.e., Standard Industrial Trade Classification (SITC) and six-digit Harmonized System (HS) codes) for comparison. While many of the preliminary results appear to be robust to alternative timeframes and product aggregations, this study is not entirely exhaustive in this respect, nor does it attempt to investigate possible factors such as tariffs, barriers to entry, firm level trade, etc., that may influence the decision to export or the relative magnitude of the extensive margin. I save these important topics for future research.

The remainder of this paper is organized as follows. Section 3 reviews the trade margins literature and introduces the methodological framework to compute the intensive and extensive margins of world and U.S. agricultural trade. Section 4 discusses the data used in the paper and various summary statistics. Section 5 presents the results and discussion and section 6 concludes.

3. Methodologies

There are several perspectives to the decomposition of trade growth into extensive and intensive margins. In what follows, I group them into four categories: the first approach focuses on a firm or country's decision to export (Melitz 2003; Helpman, Melitz and Yeaple 2003; Baldwin and Di Nino 2006; Felbermayr and Kohler 2006; Flam and Nordström 2007; Sun and Reed 2010; Eaton, Kortum and Kramarz 2011). Modified gravity estimation that incorporates zero trade flows enables researchers to examine the impact of various trade policies, such as tariff rates (Debaere and Mostashari 2010) or joining a trade agreement (Felbermayr and Kohler 2006). Using bilateral trade flows for the U.S. at the 10-digit Harmonized Tariff Schedule (HTS) level for two ten-year periods, Debaere and Mostashari (2010) finds that the contribution of tariff changes to the extensive margin is significant but not too large, about 12 percent of newly traded goods can be attributed to tariff liberalization. Felbermayr and Kohler (2006) use a similar framework and find WTO membership has a positive impact on countries' probability to trade with each other. Importantly, this branch of research studies the probability, or likelihood, of exporting as opposed to the growth of exports itself.

The second approach decomposes trade flows into the number of varieties and average value of exports per variety (see Berthou and Fontagné 2008; Bernard *et al.* 2009; Dutt, Mihov and Van Zandt 2013). The number of varieties exported to each importer is defined as the extensive margin in this framework, or what could better be called the diversification margin of exports, while the average export value per variety is defined as the intensive margin. Estimating a gravity-like equation using the log of each margin as dependent variable allows for an evaluation of the impact of different trade policies on the two margins, respectively. Compared to previous definitions of the extensive and intensive margins, this framework focuses more on the variety rather than decision to export. Berthou and Fontagné (2008) uses firm-level export data for French firms to study the micro effect of the Euro, and find that the Euro had a positive effect on the extensive margin (number of varieties). Using HS6-digit bilateral trade data, Dutt, Mihov and Van Zandt (2013) shows that the impact of the WTO is almost exclusively on the extensive product margin of trade: WTO membership increases the extensive margin of export by 31%.

The third approach, pioneered by Feenstra (1994), constructs price indices that measure countries' export variety based on the familiar monopolistic competition model and Constant Elasticity of Substitution (CES) preferences. Several extension of the price indices has been developed to study trade growth and welfare (Feenstra and Kee 2004; Hummels and Klenow 2005; Amiti and Freund 2010; Baier, Bergstrand and Feng 2011). Feenstra and Kee (2004) use the ratio of cost functions and derives a ratio which reflects the changes in product variety. With U.S. as the comparison country, they study the relative product variety and productivity of 34 countries that export to U.S. and find a close link between export variety and productivity both cross-sectionally and chronologically. They also find an annual growth of 1.5 percent in agriculture product variety from Mexico to U.S. over the period 1991 to 2001. HK develop an across exporter analogue of Feenstra's (1994) price indices to decompose trade flow into extensive and intensive margins. HK use these indices to study trade pattern from 126 exporters to 59 importers in 1995. They find the extensive margin makes up 60 percent of the larger exports for industrial economies. Liapis (2009) uses HK's framework for agricultural sectors in OECD countries and similarly find that richer exporters have a more diversified export basket.

Finally, the fourth approach is the descriptive method which simply counts the number of newly established product-destination relationships over a specified period or at a point in time. Using this method, Hillberry and Daniel (2002) decompose trade growth into the growth in product quantity, product value, and product variety. Their empirical results for U.S. trade with its NAFTA partners suggest that the positive effect of free trade agreements comes from the extensive margins. Evenett and Venables (2002) compares the export product categories and export destinations at two points in time as a descriptive method for 23 developing economies and find that one third of their export growth is due to growth along the extensive margin (export to new destination markets).

Any study of the growth of international trade along the intensive and extensive margins (henceforth IM and EM) encounters a number of data-related obstacles. First, the purest measure of the EM as advocated by Melitz (2003) is at the firm level where one could observe the behavioral dynamics of firms entering into and exiting out of destination markets for each of the products they sell over a certain time period. However, as is widely known (see Bernard, Redding, Jensen and Schott 2009), such data is difficult to obtain (at least as of this writing). Moreover, one might underestimate the number of varieties by treating all imports from a firm as a single variety. Thus, although we do not observe important dynamics at the firm level, the results of this study, which are at the country level, reflect the underlying behavior of firms interacting in the global marketplace. Second, the EM can be measured at different levels of aggregation in the product-destination variety space. Helpman, Melitz, and Rubinstein (2008) define it at the country level for various single year cross-sections, whereas Hummels and Klenow (2005) and Baldwin and Di Nino (2006) work at the country and HS6-digit product level. Furthermore, Hillberry and Hummels (2008) investigate shipment level data and Berthou and Fontagné (2008) evaluate firm level EMs using French firm-level data.

In this study, we focus on decomposing the growth of U.S. and global agricultural trade into the relative contributions of the extensive and intensive margins at the country and product level. We develop two approaches and various extensions within each to systematically dissect the growth of agricultural trade. Below I describe in more detail each of these methods.

3.1 Accounting Exercise

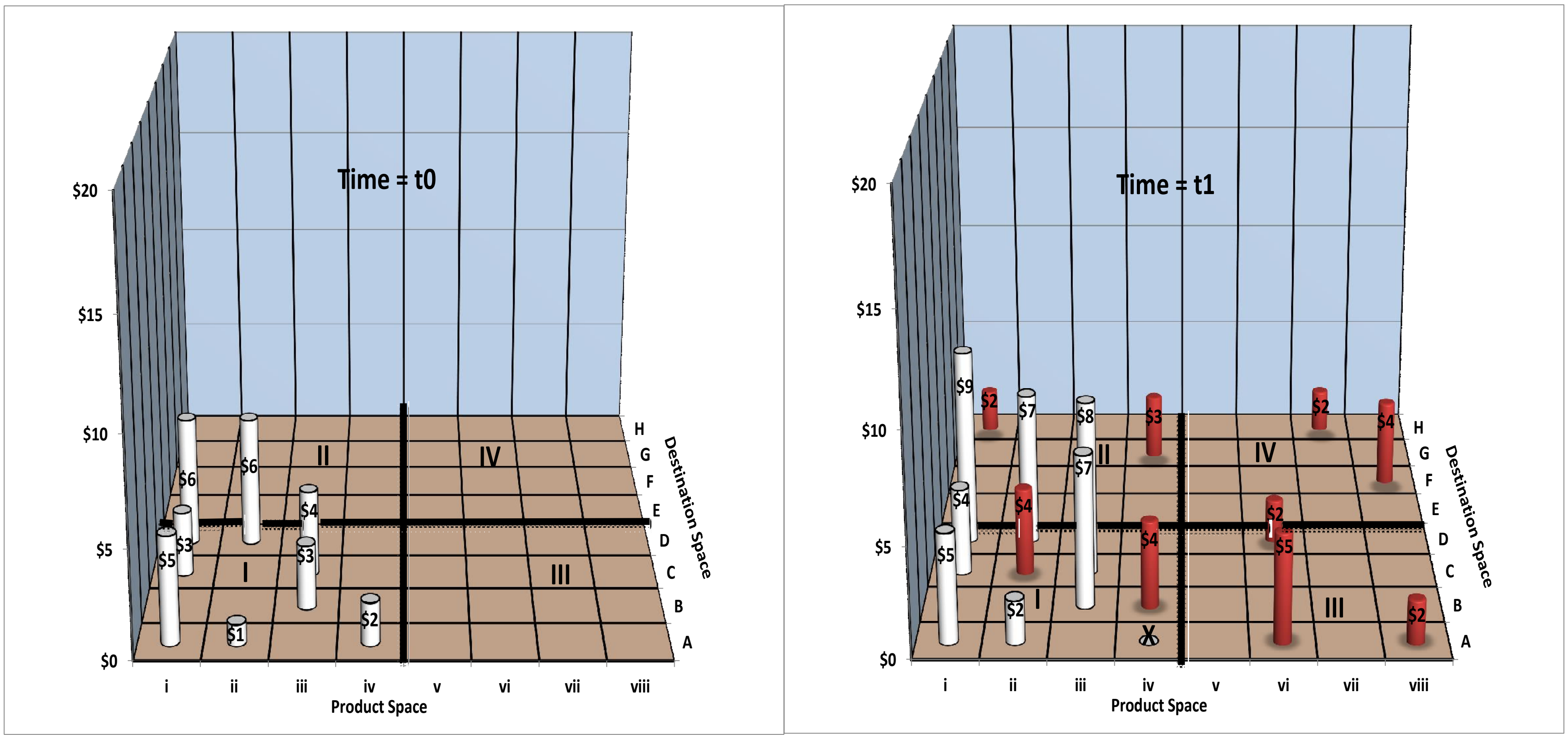
The accounting decomposition provides a rich analysis of US and world export growth because of the partition of trade into one intensive margin (IM) channel and four potential extensive margin (EM) expansion grids. This is best illustrated using a hypothetical example depicted in Figure 11 below, which contains two three-dimensional graphs for the reference period (t_0) and a later counterfactual year (t_1).

Using US exports as an example, the potential product space for US exports is comprised of eight products numbered i, … ,through viii, which can be shipped to eight destination countries, labeled A through H. Together these combinations comprise the maximum potential destination-product market space. Thus, the floor of the 3-dimensional diagram contains the maximum potential destination-product variety space.

The height of the graph represents the intensity of trade, measured in value terms, for each destination-product variety. A critical assumption in this analysis is that products are differentiated based on the destination to which they are shipped. Thus, for a given product such as apples, we assume that apples exported to Canada are differentiated from apples exported to the European Union, even if the variety (say Red Delicious) was materially the same from the consumers' perspectives and produced in the same region within the US. This is because there are likely different production processes and entry barriers (i.e., SPS regulations, product standards, and TBTs) to bring a product into compliance in the Canadian market compared to the European market that represent an important source of product differentiation.

In time period t_0 of Figure 11, the US could potentially export all eight products to each of the eight destination countries such that the maximum potential product-destination variety space is 64 (8*8). However, as is well documented in the trade data and remains one of the shortcomings of Krugman-style (1980) models, countries and particularly firms do not export every product to every destination. In our example, the US exports four products to four destination markets but not every product line is shipped to these markets in t_0. In the example, the US exports eight of the 64 potential destination-product varieties in the reference period and the value of this export profile is $30 (i.e., billion).

Figure 11: Hypothetical Example of Export Market Expansion Paths



Note: the vertical axis measures the dollar value of trade; the horizontal axis measures the potential product space that can be traded and the depth axis measures the potential destination space to which products can be exported.

The dark bolded lines on the floor of the three-dimensional graph allow us to partition the destination-product space into four possible EM expansion paths by which US exports can grow. These are labeled as quadrants I through IV in Figure 11. The red shaded cylinder bars in time period t_1 represent new US export varieties that did not exist in t_0. Summing the value of new and base-period trade in time period t_1 shows that US exports have grown from $30 to $70, a 133 percent increase. Many of the base-year varieties continue to be exported at higher values but one variety has disappeared (variety vi previously exported to market A). Thus, some of the increase in US exports is due to the net growth in the base year variety. We refer to this net growth as an increase in the IM of US exports. In Figure 11, net growth of the surviving base-year varieties increased by $14, from $28 ($30-$2) to $42, which represents a 50 percent increase. The number of surviving destination-product varieties shrunk from eight to seven.

Exports can also grow because of the creation of new destination-product trade relationships. The introduction of new varieties is referred to as the EM of US exports and represents the value of new export varieties that did not exist in the reference period. In Figure 11, the value of the overall EM is found by summing the value of all red (dark) shaded bars. This total is $28. However, a more policy-relevant question in this example is not by how much the EM has increased, but how has the EM increased? Together with the assumption that each destination-product combination represents a differentiated variety the four quadrants depicted in Figure 11 allow us to effectively decompose the US EM into four distinct expansion paths:

1) Familiar product and destination (Newly occurred bars in quadrant I)

2) Unfamiliar products and familiar destinations (quadrant II)

3) Familiar product and unfamiliar destination (quadrant III)

4) Unfamiliar product and destination (quadrant IV)

Under the first EM channel, countries will populate new destination-product variety combinations in quadrant I during time period t_1. Products *ii* and *iv* exported to destinations B and C totaling $8 illustrate this channel of export growth. Quadrant I is called the “Known product and destination” quadrant because products *ii* and *iv* were being exported in the base period but not to markets B & C and therefore they are termed “familiar” varieties. Similarly, markets B and C were being served in the base period but not with products *ii* and *iv*. Thus, quadrant I can be thought of as the most “familiar” market expansion path. One thing to note here is that this quadrant is the only quadrant that not only includes growth in EM but also has growth along IM as well. The difference between a growth in EM and IM is whether or not these product-destination varieties have positive trade flows in the base period t_0.

Second, US exports of known products can expand into unknown destination markets. This destination-product space is illustrated in quadrant II (Figure 11). In our example, US trade expanded by two new varieties totaling $5 to new destinations in quadrant II. Together, we refer to quadrants I and II – the leftward rectangular portion of the floor - as new destinations since they represent the expansion of familiar products into new export markets for the product, whether they are familiar or unfamiliar destinations for US trade. In Figure 11, new destinations (quadrants I and II) represent $9 of EM export growth.

In quadrant III, exports expand into unknown product areas but known destination markets already served by other products in relation to the base period. This is a movement to the lower right in Figure 11, where products *v* through *viii* are now profitable to export. Here, the US exports two new products (*vi* and *viii*) corresponding to three new varieties since product *vi* is shipped to two different destination-differentiated markets. In Figure 11, the value of US exports of new products to known destinations is $9.

Finally, US exports can expand into unknown products and destinations. This is shown as movement to quadrant IV in Figure 11, worth $6. Combined, quadrants III and IV are called the new products expansion path and represent $15 of new exports in Figure 11. Although there is a new destination component to the new products space in quadrants III and IV (more specifically, quadrant IV), we refer to it as new products because the introduction of new products is a common feature to both quadrants.

To summarize our hypothetical example, between time periods t_0 and t_1, US exports expanded from $30 in the base year to $70 in t_1. The net growth of US exports which considers only surviving base year varieties plus new EM trade was higher at $42 (70-28). The IM increased $14, or one-third of the total net growth. The EM growth was $28 or two-thirds of total net growth. The most illuminating concept of this exercise is the way in which we can dissect the various channels of EM growth. The EM breakdown is as follows: known products and destinations (quadrant I) contributed 28.6 percent of the extensive margin (19% of total net growth), known products and unknown destinations (quadrant II) contributed almost 18 percent (12% of total net growth), unknown products and known destinations contributed 32 percent (21% of total net growth), while unknown products and destinations contributed 21 percent (14 percent of total net growth).

3.2 The Hummels-Klenow Margin Decomposition

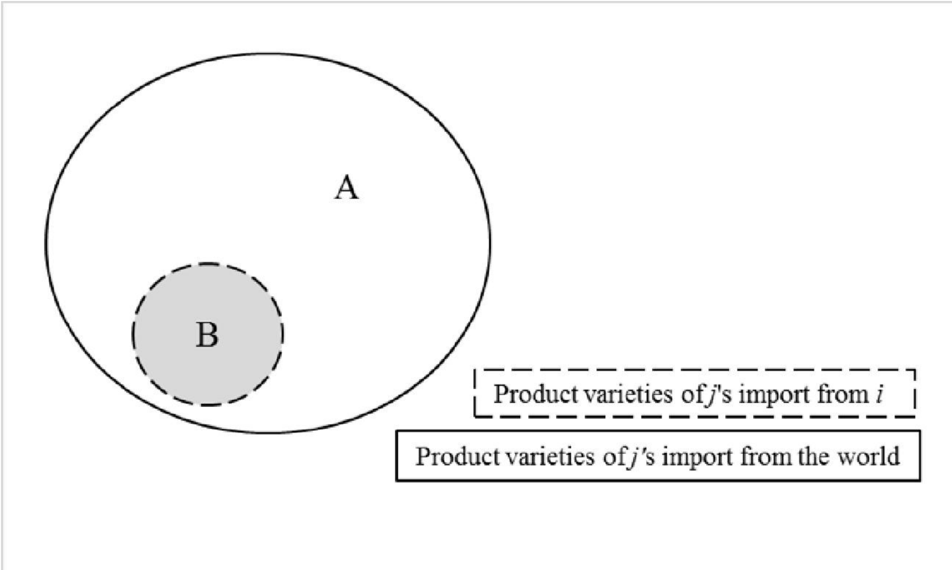
While instructive, the previous decomposition hinged on a comparison of products and trade values in a counterfactual year relative to a benchmark time period. However, because the growth of trade and the decomposition of product varieties into the intensive and extensive margins are judged relative to a fixed reference period, the choice of the appropriate base period may be a point of contention.

To address this concern, we introduce the Hummels and Klenow (2005) to decompose trade growth relative to a reference group of countries at a single point in time. In addition, these indices also enable us to consider trade growth along the margins in a dynamic setting. Guided by recent theory (see Feenstra 1994; Feenstra and Kee 2004; Hummels and Klenow 2005; Feenstra and Kee 2007), we can decompose a country's agricultural trade into two indices that measure the extensive and intensive margins (see also Liapis 2006). Following Hummels and Klenow (2005), the extensive and intensive margins are defined as:

$$(1) \qquad EM_{ijt} = \frac{\sum_{k \in K_{ij}} x_{mjkt}}{\sum_{k \in K} x_{mjkt}}, \quad IM_{ijt} = \frac{\sum_{k \in K_{ij}} x_{ijkt}}{\sum_{k \in K_{ij}} x_{mjkt}};$$

where x is the trade value, i is the exporter, j is the importing country, K_{ij} is the set of product categories in which positive exports from i to j are observed, and m is the reference country, which in our case is Rest Of the World (ROW). A simple Venn diagram helps explain how this index is computed (Figure 12).

Figure 12: Illustration of the Hummels and Klenow index



The Venn diagram in Figure 12 represents the sets of product varieties that is imported from the world by country *j*. The solid line circle represents the product varieties that are exported to *j* from all over the world and the dashed line circle represents the group of product varieties that are exported to country *j* from *i*, which is labeled as area B. The area labeled A represents the product varieties that are exported to *j* from ROW. The Hummels and Klenow margin indices are constructed using the following three summations of trade:

a. Summation of trade from ROW to *j* of product varieties in area A;
b. Summation of trade from *i* to *j* of product varieties in area B;
c. Summation of trade from ROW to *j* of product varieties in area B.

Having computed all three summations, the Hummels and Klenow margin index is defined as follows:

(2) $EM_{ijt} = a / c;$

(3) $IM_{ijt} = b / a$

Thus, the extensive margin is a weighted metric of exporter's exportable categories relative to the ROW's categories. It measures the diversification of the exporter *i's* exports in terms of the number of products it sells relative to the number of products sold by the rest of the world. The intensive margin is a relative measure of the intensity of exporter *i*'s export to *j* weighted by the ROW's exports to *j* in *i*'s goods categories ($k \in K_{ijt}$). Put differently, exporters' EM can be thought of as a weighted metric of its exportable categories relative to ROW categories. For the margins of one particular exporter, we can also summarize them across all markets using a geometric average with weights α_{ij}, which are the logarithmic mean of the share of *i* in the overall exports of *j* and ROW. This decomposition enables us to decompose the ratio of export from country *i* relative to export from the ROW into the two margins:

(4) $$\frac{x_{ijt}}{x_{mjt}} = EM_{ijt} \cdot IM_{ijt}$$

Taking the log of both sizes of the equation yields:

(5) $$\ln \frac{x_{ijt}}{x_{mjt}} = \ln EM_{ijt} + \ln IM_{ijt}$$

The decomposition in equation (5) enables us to estimate the corresponding contribution of the two margins to relative trade growth. That is, because Ordinary Least Squares (OLS) is a linear operator, and the product of the two margins yields the exporting country's overall share, we can decompose *i's* exports into the relative contributions of the intensive and extensive margins additively in logarithmic form. Following HK (2005) and Liapis (2009), we specify a single variable regression equation for the IM and EM to study the impact of country's economy size on trade margins. While HK (2005) and Liapis (2009) use exporters' GDP and labor force to proxy countries economy size and productivity, we use exporters' agricultural productions, arable land base and country's remoteness to the rest of the world since we are focusing on agricultural trade flows. This is because agricultural production and arable land are better proxies to capture the diversity and productivity in agricultural sectors as opposed to GDP where in developed countries, agriculture often contributes less than two percent to overall gross domestic product. These sets of single variable regression on trade margins allow us to evaluate the contribution of each margin to the overall export elasticity with respect to each independent variable. This econometric exercise is just an attempt to peak into the relationship between agricultural productivity and trade growth along the intensive and extensive margins. We leave a gravity-type estimation for the two margins for future work.

4. Data

One of the key ingredients in this analysis is how to define products because the choice of product classification can have a significant impact on the resulting number of products. As a result we consider three data sets with different levels of product classifications. The first dataset we use has 4-digit level trade flows at the Standard International Trade Classification (SITC) revision 2 and is from United Nations Commodity Trade Statistics database. It covers 147 agricultural product categories for

101[19] countries from 1976 to 2010. As a robustness check on the results, we also consider bilateral trade data at the 6-digit level of the Harmonized System(HS) for 100 countries that account for more than 90% of world trade between 1996 and 2010 from the BACI (Base pour l'Analyse du Commerce International) website (www.cepii.fr). It is a finer level of product classification that covers 5018 products, over 611 of which are agricultural and food trade. The advantage of the SITC data is that we can cover a much longer time series. However, the disadvantage is that it is more aggregated and thus may underestimate the true extensive margin of products. Finally, for U.S. trade, we downloaded agricultural export and import data at the HS8-digit level from the United States International Trade Commission (USITC)[20]. The complete date set showcases U.S. agricultural exports and imports to 223 countries in 2548 HS8-digit product categories from 1989 to 2010.

In the HK (2005) decomposition of the extensive and intensive margins, we use data on agricultural production, the arable land base, and a remoteness index (computed using GDP and distance data). Production data are taken from the Food and Agricultural Organization's (FAO) production statistics (PRODSTAT) database, whereas variables such as GDP, geographical distance are from CEPII (Centre d'Etudes Prospectives et d'Informations Internationale). Arable land base data are taken from the World Bank Development Indicators[21]. The remoteness index is a measure of how remote a country is relative to the rest of the world and is constructed as a GDP weighted distance measure of a country with all of its trading partners. Following Liu (2009), we compute the remoteness index (rem_{it}) for country *i* at time t as follows:

[19] See Appendix E for the list of countries that is included in the study
[20] http://dataweb.usitc.gov/
[21] http://data.worldbank.org/indicator

$$(6)\ \ rem_{it} \equiv \left(\frac{\sum_{m \neq i} \text{distance}_{\text{mi}} GDP_{mt}}{\sum_{m \neq i} GDP_{mt}} \right)$$

where $\text{distance}_{\text{mi}}$ is the geographical distance between country *m* and *i* and GDP_{mt} is the GDP for country *m* in year *t*. For each dataset, we create two databases for this study: one for the descriptive analysis and another one for computing the HK indices. For the descriptive analysis, we categorize all trade observations at the product level into intensive margin and four extensive margin groups based on a five-year reference period (1980-1984). We use a multiple year reference period instead of one year to smooth out production shocks that may influence agricultural exports. Based on the reference period, a country-pair's trade in one particular product is classified into the existing trade group if it had nonzero trade in the reference period and continued to trade (either continuously or with gaps). Trade product or partners is defined as new if they had zero trade in the reference period but later became nonzero. The first resulting database includes trade between 100 countries in 147 agricultural products at the SITC 4-digit codes over a longer period 1980-2010, of which 45 percent are in the extensive margin group. The second database has 611 agricultural products at the HS 6-digit level for 100 countries and a shorter time period spanning 1996-2010. Here, 27 percent of observations are classified as the extensive margin group. The third database includes U.S. exports to more than 200 partners covering 1,128 agricultural products at the HTS 8-digit level where 37 percent of product-destinations are classified as extensive margin.

The HK database using SITC 4-digit trade flow data showcase bilateral extensive and intensive margins indices for 35 years, with the mean of extensive margins at 0.16 and the mean of intensive margin at 0.08. After taking the geometric average of the margins for the exporters, we have exporters' extensive and intensive margins for all 101 exporters over the period 1976-2010. The mean of the overall extensive margin for exporters is at 0.35 and the mean of overall intensive margin is 0.08. Similarly, we also have the HK margin indices dataset computed using HS 6-digit trade data for shorter period (1995-2010) and 100 countries. The mean of bilateral extensive and intensive margins are 0.19 and 0.20 respectively and the overall exporters' extensive and intensive margins have mean of 0.30 and 0.03 respectively. What do the levels of extensive and intensive margins imply? To see a simple example of the indication of the two margins, consider the intensive and extensive margins for U.S. exporting to China. Extensive margin is 0.86 for U.S exporting to China in 2000. That is, U.S. export 86 percent of weighted account of the varieties that the rest of the world export to China. Similarly, the intensive margin is 0.31 meaning the U.S. takes up 31 percent of the total shipment value of China's total import from the rest of the world in U.S. export basket.

5. Result

The results are organized into four sections. Section 1 discusses the graphical approach to the extensive margin using a reference period (1980-1984) (Figure 13). Section 2 presents the results of the accounting decomposition for the extensive margin for the export and import of U.S. and several growing economies (Table 13 to Table 15). In addition, section 3 discusses the HK (2005) IM and EM results for agricultural trade (Table 16). Finally, section 4 discusses the empirical findings in the context of the literature on heterogeneous firms and the growth of trade along the extensive margin.

5.1 Graphical Approach

Figure 13: World Merchandise and Agricultural Trade Growth, Base=1980-1984

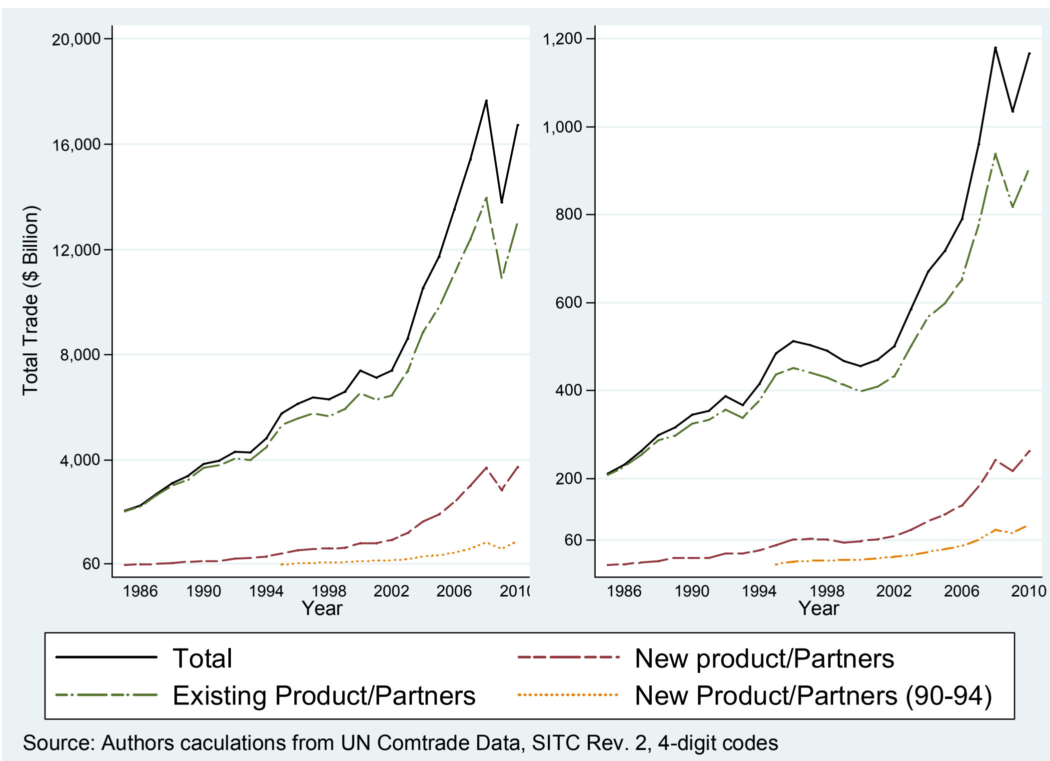


Figure 13 illustrates the growth in the value of global trade for total merchandise products and the subset of agricultural products starting in the reference period 1980-

1984. In both panels of Figure 13, the growth of world and agricultural trade is decomposed into the existing partner and/or product trade and new partner or product trade. For comparison, and to illustrate that the EM is sensitive to the choice of reference period, we also plot the growth of new trade starting from a 1990-1994 reference period. Finally, also plotted in Figure 13 are the shares of new partner/product trade in world trade.

In 2010, total merchandise trade topped $16 trillion and agricultural trade exceeded $1.1 trillion. Dissecting the growth of total merchandise and agricultural trade showcases some important findings (Figure 13). First, the IM accounts for the majority of world trade growth. In 2000, for example, 90 (86) percent of the increase in total merchandise (agricultural) trade occurred between partners and products that traded in the reference period. Second, an increasing share of world trade is occurring at the EM, in new markets either through establishing new partners or the introduction of new products. Which one of these is the source of the growth along the extensive margin is discussed shortly when we present the results of the extensive margin expansion paths. In 2000, the EM accounted for 11 percent ($800 billion) of total merchandise trade and 13 percent ($57 billion) of agricultural trade. By 2010, the share of world trade that was due to the formation of new partners and/or products was 22 percent, or $3.7 trillion, and 22 percent of the total, or $262 billion in agriculture.

Finally, the dotted line beginning in 1995 traces out the growth of the EM using 1990-1994 as the reference period, and clearly illustrates that this margin is a much smaller share of the growth of world trade compared to the reference year 10 years earlier

(1980-1984). That is, the shorter the time period between the reference year and the end year is, the lower the contribution of the EM to overall trade growth will be.

5.2 Accounting Decomposition for U.S., BRICS, EU, TPP, OECD

Before presenting the results of the detailed market expansion paths using actual U.S. export data, Table 13 evaluates the EM of U.S. agricultural exports and imports from a slightly different perspective. First, for a given partner country we investigate the product mix exported and imported along both margins. Second, because changes in the extensive and intensive margins can only take place along the product margin (for a given partner), we work at the HTS8-digit level, which contains a much larger set of products and compares and contrasts the two three-year periods (1989-1991 and 2008-2010). The results of this analysis are presented in Table 13.

The second column of Table 13 reports the total number of product varieties ever traded in the sample period (average number of product varieties for country groups: BRICS, TPP, EU and ROW) that are exported or imported by U.S. at HTS 8-digit level. In addition, the total number of varieties is divided into numbers of products that are newly traded, continued to trade and disappeared after the base period in the subsequent three columns. Furthermore, the respective trade shares of each group of product varieties are also calculated in the last three columns.

Table 13: Dissecting U.S. Agricultural Exports & Imports, HTS8 Digit Products, 1989-2010

Partner	No. of goods	No. of new products	No. of existing products	No. of disappearing products	2010 Trade share of new products	1989 Trade share of disappearing products	2010 Trade share of existing products
U.S. Agricultural Exports (1128 HTS8-digit Categories)							
Canada	1068	213	612	243	18.1%	18.7%	81.9%
Mexico	1102	276	613	213	11.9%	12.6%	88.1%
China	993	500	417	76	76.8%	0.7%	23.2%
Japan	1082	226	591	265	5.5%	16.9%	94.5%
BRICS[a](avg)	813	308	404	101	36.4%	26.8%	63.6%
TPP-8 [b](avg)	755	266	376	113	41.7%	20.9%	58.3%
EU-15 (avg)	485	130	255	99	17.9%	16.4%	82.1%
ROW [c] (avg)	288	92	148	48	26.3%	21.5%	73.7%
U.S. Agricultural Imports (2243 HTS8-digit Categories)							
Canada	1867	490	992	385	39.3%	24.6%	60.7%
Mexico	1485	483	760	242	31.7%	21.5%	68.3%
China	1297	463	634	200	54.1%	44.1%	45.9%
Japan	1014	196	485	333	37.4%	35.5%	62.6%
BRICS[a](avg)	792	271	408	113	46.8%	40.2%	53.2%
TPP [b](avg)	608	198	294	115	45.3%	56.3%	54.7%
EU (avg)	513	135	267	111	44.6%	37.5%	55.4%
ROW [c](avg)	152	42	79	31	31.8%	39.2%	68.2%

Note: with the exception of the last three columns, all values are counts of the number of HTS8-digit agricultural products

[a]BRICSS includes Brazil, Russia, South Africa and India since China is listed individually

[b] TPP-8 includes Australia, Brunei, Chile, Malaysia, New Zealand, Peru, Singapore, and Vietnam. Excludes Canada, Mexico, Japan, since they are listed individually, and countries that have not confirmed its accession to the TPP talks.

[c] 195 destination countries and 192 source countries included in these groups.

Not surprising, the U.S. exports the most agricultural products to Canada and Mexico, at 1,068 and 1,102, respectively, and purchase the most from these two countries, at 1,867 and 1,485 goods, respectively. Japan and China are a distant third and fourth in terms of U.S. exports and imports. However, this ranking is almost reversed when we consider the next column in Table 13, which is the number of new HTS8-digit products shipped in the period between 1989 and 1991 compared to 2009-2010. In 1989-1991, the U.S. exported just 213 and 276 new products to Canada and Mexico, respectively, and as a share of 2010 trade these products accounted for less than 20 percent (18.1 and 11.9 percent). However, for countries like China, the BRICS and TPP countries (Excluding Japan, Canada and Mexico) the number of new products exported was substantially larger. The share of new product exported by the U.S. in 2010 to China, BRICS and TPP countries was 76.8, 36.6 and 41.7 percent, respectively. Although the growth of new trade to these markets has been met with a simultaneously high share of disappearing products (except for China), it is likely that these regions represent an important source of U.S. agricultural export growth along the EM.

The next section in Table 13 summarizes U.S. agricultural imports varieties, which is more than twice the size of U.S. export varieties (2,243 HTS8-digit categories compared to 1,128). Canada and Mexico export more new agricultural products to U.S. than China and Japan, at 490 and 483 comparing to 463 and 196. However, the trade share of new varieties in 2010 is higher for imports from China, at 54 percent. In addition, U.S. agricultural imports have a much higher share of disappearing product than U.S. exports.

Table 14 provides a much richer decomposition of U.S. exports along the IM and four EM expansion paths. In these scenarios we focus on the aggregate growth of the U.S. agricultural exports based on the HTS8-digit classification with a 1989-1991 reference period. Notice this table's result is not comparable with the previous table because here we are counting the product-destination varieties whereas the previous table only counted product varieties for a given partner country.

Table 14: Decomposition of U.S. Exports, 1989 vs. 2010, HTS8-digit Products

		(1)Total Agriculture	(2)Processed Agricultural Products	(3)Primary Agricultural Products
(a)	**Total Trade Growth ($Bil. or % Change)**			
	(i) 1989 U.S. Export	$42.90	$16.70	$26.20
	(ii) 2010 U.S. Export	$118.50	$55.60	$62.90
	(iii) Growth	176%	233%	140%
	(iv) Disappearing Trade	$7.36	$4.58	$2.78
	(v) Net Growth	233%	359%	169%
(b)	**Extensive Margin Growth ($ Bil.)**			
	Known Destination & Product	$18.67	$4.17	$14.50
	Known Destination & Unknown Product	$14.38	$12.00	$2.38
	Unknown Destination & Known product	$0.48	$0.23	$0.25
	Unknown Destination & Product	$0.47	$0.47	$0.00
(c)	**Total Export Growth Relative to 1989 ($Bil.)**	$75.60	$38.90	$36.70
	Overall Extensive Margin Share	45%	43%	47%
	Known Destination & Product	25%	11%	40%
	Known Destination &Unknown Product	19%	31%	6%
	Unknown Destination & Known Product	1%	1%	1%
	Unknown Destination & Product	1%	1%	0%
(d)	**Destination-Product Variety Growth (No. of Product-Destination or % Change)**			
	(i) 1989 Varieties	19,233	12,517	6,716
	(ii) 2010 Varieties	29,483	20,435	9,048
	(iii) Variety Growth (%)	53%	63%	35%
	(iv) Disappearing Varieties	6,076	3605	2,471
	(v) Net Variety Growth (%)	124%	129%	113%
	(vi) New Varieties	16,326	11,523	4,803
	(vii) Share of New Varieties in 2008-10 Varieties	55%	56%	53%

Notes: Net Growth and Net Variety Growth (v) is equal to {(ii)/((i)-(iv))-1}*100. See *Figure 11* for definition of the four expansion path of the extensive margin.

The growth of U.S. total agricultural exports is notable. Between 1989 and 2010, U.S. agricultural exports expanded by 176 percent in gross terms reaching 118 million in 2010. Growth rates for agriculture which is further broken down into processed and primary products are also shown in columns (2) and (3), Table 14. Processed food trade witnessed the largest increase at 233 percent, whereas primary agricultural products expanded by 140 percent. However, not all partner/product combinations survived this period as illustrated by the 4.58 billion and 2.78 billion totals of disappearing processed and primary agricultural trade, respectively. Thus, on net, the base year variety set of U.S. agricultural exports expanded 359 percent and 169 percent for processed and primary agri-food products, respectively.

As discussed in Figure 11, the EM growth can be decomposed into four market expansion paths (known destination and product, unknown destination but known product, known destination but unknown product, and unknown destination and product). The results in Table 14 provide several interesting insights into the evolution of U.S. export growth. First, the growth in U.S. agricultural exports along the EM is concentrated almost entirely in familiar market segments (quadrants I and III of Figure 11). These two expansion paths accounted for 98 percent of the EM growth of U.S. agricultural exports (Table 14, section (c), column (1)). The U.S. did not have a large shipment in exporting new products to either familiar or unknown markets (quadrant II& quadrant IV). In the case of primary agricultural products, the U.S. did not ship a single dollar worth of exports in unknown primary products to unknown destinations. Thus, in terms of recent theoretical contributions where the decision to export features prominently, it appears that even if U.S. firms are successful in entering into export markets, they likely face additional uncertainties in serving unfamiliar markets because firms are more likely to ship products to existing destinations as opposed to shipping agricultural products to new markets.

Second, while the contribution of the overall EM to U.S. export growth is almost identical for processed and primary trade, the expansion paths are different. Primary agricultural exports grew by $36.7 billion since 1989 and 47 percent of this growth ($17.2 billion) was due to the expansion of trade along the EM. The majority of EM growth for primary agricultural products was from shipping familiar products to familiar destinations. However, EM growth in processed agricultural products is dominated by shipping to known destinations and in (initially) unknown products varieties. Thus, the familiarity of destinations and products appears to be an important determinant in the decision to export agricultural goods.

The final section in Table 14 removes the dollar value of U.S. export growth and focuses on tabulating the number of destination-product varieties exported. In 1989 the U.S. exported 19,233 agricultural destination-product varieties. This number is much larger than product varieties in Table 13 because there is one more dimension in counting varieties: we are assuming product is not only differentiated by their HTS 8-digit classification but also the destination to which they are shipped. In 2010, the destination-product space grew by 53 percent, the processed food trade grew by 63 percent and bulk products grew by 35 percent. Subtracting disappearing products from the variety set, the net growth rates are 113 and 129 percent for primary and processed agricultural goods, respectively. This important result suggests that, even though the number of disappearing varieties in the base-year variety set was larger for the processed products compared to the primary products, disappearing varieties were replaced by a much larger set of new varieties in the former. Thus, the variety growth of exports has, and will continue to be an important part of U.S. agricultural trade growth.

Table 15 repeats the accounting exercise using SITC4-digit data for three groups of countries: EU, BRCIS and TPP (excluding the U.S.) as well as U.S. For each group of countries and U.S., their total agricultural export growth is presented in the first row and the subsequent four rows are the share of each expansion path to the total growth. On average, BRICS countries have the largest share of growth in the extensive margin - an impressive 27 percent of export growth – with the majority of this growth due to shipping familiar product to known destinations. Surprisingly, EU countries have the highest share of EM growth from shipping new products to new destinations, at 2.8 percent compared to less than one percent for the rest of the country groups.

In addition, we divide products into three groups according to Rauch's (1999) classification scheme[22]: Homogeneous, reference priced and differentiated products[23]. Differences in the pattern of trade for homogeneous and differentiated products are explored since the work of Krugman (1980) and Helpman and Krugman (1985). Trade growth at the extensive margin for differentiated products are much more sensitive to trade barriers since these products typically face larger sunk costs when trade relationships first start (see Rauch 1999; Besedeš and Prusa 2006; Chaney 2008). Indeed, our results in Table 15 support this. Homogeneous products experience a higher share of

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[22] SITC4-digit product code is categorized into three types using mapping available at: http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeData.html#Rauch

[23] This classification divide goods into these three categories based on the substitutability of goods. Homogeneous goods are defined as goods that are traded on organized exchanges. Reference priced goods are less substitutable but has a reference price. All the other products are classified into differentiated products.

growth at the extensive margin than differentiated and reference priced products. However, the growth in homogeneous products is dominated by shipping familiar products to familiar destinations. This result is robust for all three groups of countries[24].

Table 15: Export Decomposition for EU, BRICS and TPP, 1980 vs. 2010, SITC4-digit

	$Bil or % share	Total Agriculture	Differentiated Products	Reference Price Products	Homogeneous Products
EU	**Total Growth ($Bil.)**	$396.00	$113.00	$192.70	$90.30
	Known Destination & Product	11.0%	8.2%	9.5%	17.7%
	Known Destination & Unknown Product	0.5%	0.2%	0.5%	0.8%
	Unknown Destination & Known product	4.2%	4.1%	3.9%	4.8%
	Unknown Destination & Product	2.8%	1.8%	2.9%	3.7%
BRICS	**Total Growth ($Bil.)**	$126.80	$17.78	$37.52	$71.50
	Known Destination & Product	27.3%	10.0%	15.9%	37.6%
	Known Destination & Unknown Product	2.0%	0.0%	0.1%	3.5%
	Unknown Destination & Known product	10.7%	22.0%	16.3%	5.0%
	Unknown Destination & Product	0.6%	0.5%	0.0%	0.9%
TPP[a]	**Total Growth ($Bil.)**	$135.70	$24.25	$64.95	$46.50
	Known Destination & Product	16.4%	17.2%	13.4%	20.1%
	Known Destination & Unknown Product	0.5%	0.4%	0.4%	0.8%
	Unknown Destination & Known product	3.3%	3.0%	2.4%	4.6%
	Unknown Destination & Product	0.1%	0.2%	0.1%	0.1%
U.S.	**Total Growth ($Bil.)**	$80.07	$15.79	$28.78	$35.50
	Known Destination & Product	12.5%	1.6%	2.9%	16.7%
	Known Destination & Unknown Product	0.0%	0.0%	0.0%	0.0%
	Unknown Destination & Known product	0.9%	0.4%	0.7%	0.5%
	Unknown Destination & Product	0.0%	0.0%	0.0%	0.0%

Notes: [a] TPP includes Australia, Brunei, Canada, Chile, Malaysia, Mexico, New Zealand, Peru, Singapore, Vietnam and Japan, excluding United States and countries that have not confirmed its accession to the TPP talks. Percentage is the share of contribution of the expansion path to total export growth. See Figure 11 for definition of the four expansion path of the extensive margin.

However, the results for U.S. exports based on the HTS 8-digit classification in Table 14 is not comparable with results based on SITC 4-digit classification in Table 15. The reasons are the following: First, these two datasets contain different sets of export destinations. The SITC 4-digit dataset only includes 101 destination markets whereas the HTS 8-digit includes more than 200 partners for U.S. Second, time frame issues also

[24] We also run the same exercise on the Baci trade data from 1995 to 2010 (see Appendix F). EM margin growth in agricultural products are compared with non-agricultural goods, where we find similar pattern for the same country groups.

makes comparing results between the two tables difficult. Third, the level of product aggregation is another contributor to the differences in EM expansion results. A lot of HTS 8-digit level products would fall into a same SITC 4-digit group hence there is more action in the EM when using the HTS 8-digit classification.

5.3 Hummels and Klenow (2005) Extensive Margins

In the previous sets of analysis, we picked a reference year and a counterfactual year and used different methods to decompose the growth of world and U.S. exports. Thus, the forgoing analysis contained an explicit temporal dimension. An alternative way to define the EM is to fix the time period and compare a country's export bundle to a reference set of countries. This is the strategy behind the IM and EM margins developed by Hummels and Klenow (2005). Table 16 presents the single variable regression results for the IM and EM equations (equation (1)) with time dummies to capture the global time trend. All margins are computed using SITC4-digit data for 101 exporters[25] for 35 years (1976-2012), with a total of 3,535 observations[26]. Our results shed empirical light on theoretical conjectures for the relative effects of variable trade costs on intensive and extensive margins in a Melitz (2003) heterogeneous firm model. Using the HK index, we incorporate some of the factors that are related to different patterns of agricultural trade expansion.

Table 16: Hummels and Klenow (2005) Margin Regressions on SITC4-Digit Bilateral Trade Data

Independent variable →	Ag	N	Arable land	N	Remoteness	N

[25] We also conduct the same analysis using HS6-digit trade data, the results are very similar.
[26] See Appendix G for list of countries and their margin values in two sample years.

Dependent variable ↓	production	R^2	(per person)	R^2		R^2
			1976-1986			
Overall exports	0.693***	748	0.449***	913	-2.696***	1089
	(0.03)	0.573	(0.05)	0.210	(0.27)	0.081
Intensive margin	0.382***	748	0.330***	913	-1.482***	1089
	(0.02)	0.399	(0.03)	0.187	(0.18)	0.084
Extensive margin	0.311***	748	0.119***	913	-1.214***	1089
	(0.01)	0.396	(0.02)	0.041	(0.12)	0.100
IM contribution	55%		73%		55%	
EM contribution	45%		27%		45%	
			1987-2006			
Overall exports	0.687***	1858	0.326***	2196	-1.148***	1980
	(0.02)	0.520	(0.03)	0.108	(0.20)	0.261
Intensive margin	0.451***	1858	0.239***	2196	-0.231***	1980
	(0.01)	0.465	(0.02)	0.097	(0.13)	0.196
Extensive margin	0.236***	1858	0.087***	2196	-0.917***	1980
	(0.01)	0.370	(0.01)	0.050	(0.08)	0.075
IM contribution	66%		73%		58%	
EM contribution	34%		27%		42%	

Note: Three single variable OLS regressions with time-dummies are reported for each of the independent variables listed in the columns (Ag production value, Arable land and remoteness index, respectively), first for overall exports, second for intensive margin, and third for extensive margin. All variables are in natural logarithms. Robust standard errors are in parentheses. One, two, and three asterisks denote statistical significance at ten, five, and one percent levels, respectively. Intensive and extensive margin contributions reflect the contribution of each to the overall trade elasticity with respect to each independent variable. Ag land is the arable land per person in the exporting country. Remoteness indices for exporters is computed using equation (6). Ag production is in dollar value.

Table 16 presents the results of the regression of the logarithm of total export share, the computed HK (2005) IM and EM indices separately on the logarithmic value of agricultural production, the agricultural land base and an exporter remoteness index.[27] In this table, we conduct our analysis for two periods: 1976-1986 and 1987-2006[28]. The first row in each section contains the coefficients on the logarithmic of overall export share, followed by the coefficients on logarithmic of IM and EM. At the bottom of each section we report the relative contributions of the IM and EM to the overall export

[27] The regressions are deliberately kept simple to isolate the contributions of the EM and IM to the overall export elasticity.
[28] Land and production data is only available for the period between 1976 and 2006.

elasticity[29]. All variables are statistically significant. Furthermore, despite the single variable nature of the regression equations, agricultural production explains a large portion of the variation in overall exports and along each margin (57.3, 39.9 and 39.6 percent), whereas arable land and remoteness variables explains relatively lower variation (21, 18.7 and 4.1 percent for arable land; 22.5, 21 and 17 percent for remoteness index).

The Hummels and Klenow indices are essentially a weighted price and quantity index that measures a country's variety bundle with a particular partner relative to the reference country (rest of the world in our case). The single variable regression on these price elasticities informs us about how a country's agricultural productivity, arable land and remoteness to the rest of the world influence countries' agricultural exports through the extensive and intensive margins. The coefficient, 0.693, on agricultural production in the Overall equation implies that an export with twice the value of agricultural production is associated with 69.3 percent higher trade share across its partner markets. Fifty-five percent of this is due to exporters trading more intensively with its partner countries in a common set of goods and 45 percent is due to exporters trading a greater variety of SITC4-digit products relative to the rest of the world. The arable land per person contributes less to the Overall export elasticity compared to agricultural production (0.449 versus 0.693) and the IM, at 73 percent, accounts for a much larger contribution to the overall export elasticity compared to the EM (27 percent). Finally, an exporter's remoteness relative to the rest of the world has a significant negative effect on overall exports and the margins. A one percent increase in the remoteness index is associated with 2.70 percent decrease in the overall trade share. The remoteness affects the two

[29] Recall, because the regressions are in double logarithmic form and the product of the IM and EM margins equals to an exporter's overall share, the coefficients on each margin allows for a decomposition of the IM and EM in the overall export elasticity.

margins almost equally, with 55 percent accounted on the IM and 45 percent on the EM. The results suggest an exporter's remoteness to the rest of the world has an equal impact on its intensity of trade as well as the diversity of its product mix. Comparing to HK (2005) and Liapis (2009) who find that trade for richer countries is at the EM, we find that the IM accounts for a slightly larger part of higher exports for countries that have larger agricultural production and more arable land. Furthermore, a comparison between the two periods (1976-1986 and 1987-2006) shows that there is a striking decrease in the effect of arable lands and remoteness on overall exports and its margins. The elasticity for arable land went from 0.449 to 0.326, 0.119 to 0.087 for the extensive margin. For the remoteness index, the decrease is even larger. The estimates went from -2.696 to -1.148 for overall exports, a 57 percent decrease in magnitude. Interestingly, a majority of the decrease takes place at the IM (from -1.482 to -0.231). This indicates agricultural export growth relies less on the agricultural land and remoteness more recently, especially for trade growth through the IM.

5.4 Evidence for Theory

In this section, we provide a review of the theory that motivated our analysis and how our empirical exercise provides evidence to the theory. The heterogeneous firms model was first introduced by Melitz (2003) and augmented by Chaney (2008). Unlike the traditional trade model that assumes comparative advantage at the country level (a representative firm that has the same productivity), the heterogeneous firms model highlights the important role of firm heterogeneity. Based on Krugman's (1980) Monopolistic Competition model that assumes increasing returns to scale, Melitz (2003) adds marginal productivity heterogeneity across firms. Differences in firms' productivity impacts firms' decision to export to a foreign country. In particular, firms face a sunk fixed cost of market entry and variable cost after entering the market. Melitz's model predicts that only firms that are above a certain cutoff productivity threshold will export to foreign markets, leaving the less productive firms serving only their domestic market. In addition, higher productivity is systematically correlated with exports because the opening of trade forces less productive firms out of the market. This result comes from two channels: entering of more productive firms in foreign markets takes up market share and thus drives down profits for all firms; second, with the high productivity firms expanding to new markets, they need more labor (the only factor of production in the mode) to increase their scale of production. This leads to higher real wages and thus again forces the least productive firms out of the market.

Based on Melitz's model, Chaney (2008) expands the model and highlights the role of the extensive margin in the elasticity of trade flows with respect to trade barriers. He points out that unlike Krugman's model where firms increase the volume of goods exported as trade barriers are reduced, the variety of goods firms export also changes in the heterogeneous firms model. This is because when trade barriers go down, it is now profitable for less productive firms to export. Their contribution to trade growth is what Chaney (2008) defined as the extensive margin which is not considered in Krugman's model. In addition, Chaney's model predicts that the trade barriers' impact on trade through its margins also depends on the elasticity of substitution: when goods are homogeneous, intensive margins are more sensitive to changes in trade barriers. This is because even when less productive firms enter the market when trade barriers are lower, the market share they can capture is usually low. On the other hand, when goods are highly differentiated, the extensive margin is highly affected by trade barriers. This is because the demand for each individual variety is relatively insensitive to changes in trade costs, thus less productive firms are able to capture a relatively larger market share than for firms that produce homogeneous goods.

Our empirical results are supportive to the Melitz-Chaney model in the following three aspects. First, our empirical results suggest that at the product-destination level the extensive margin is an important part of agricultural trade growth. Second, products with a higher elasticity of substitution (homogeneous products) dominate the growth in extensive margins since they are more sensitive to trade barriers; third, the HK regression provides us with supportive but not conclusive empirical evidence that higher agricultural productivity is positively correlated with countries' extensive and intensive margins.

One of the key assumptions in Melitz's model is that after passing a certain universal productivity threshold, firms can serve all possible markets. In other words, the major hurdle in Melitz's model is getting out of the home market. However, our results suggest even after passing the productivity threshold, firms still faces considerable uncertainty when products or destinations are not familiar. Thus, there must be certain product and destination specific costs that further prevent firms from exporting to all potential destination markets. In particular, our results show that almost all of the growth in the extensive margin occurs by shipping products to familiar destinations even if the product is unfamiliar. These are the features of product level data that to date are not well explained by the existing theories of international trade.

6. Conclusion

Understanding the role of new products and partnership in international trade has been one of the important questions in the emerging new trade theory literature. Until recently, the literature has focused more on the volume growth of trade. This study provided one of the first systematic decompositions of the world and U.S. agricultural trade flow into the familiar intensive and extensive margins as well as several new margins that have previously not received a lot of attention in the literature. Summarizing the results of this analysis can be difficult because different timeframes, levels of product disaggregation and product variety definitions were used. However, several new insights for agricultural and food trade have emerged.

First, from a graphical perspective world agri-food trade has expanded from an average of $262 billion in 1980-1985 to $1.14 trillion in 2010. We found that 78 percent of world agri-food trade growth is due to the expansion along the IM and 22 percent along the EM. Furthermore, the relative importance of the EM increases as the time period between the reference year and end year increases.

Second, we took a close look at U.S. agricultural trade growth. For a given partner we evaluated the intensive and extensive product margins of U.S. agricultural exports and imports. The results confirmed that the importance of the extensive product margin for future U.S. agricultural trade growth hinges on whether the partner country is an emerging market (i.e., China, BRICs and TPP) or a long-standing traditional market such as Canada and Mexico. For more traditional partner countries, the intensive product margin explains a large part of U.S. agri-food export growth, whereas the extensive product margin is a bigger factor in emerging markets.

Third, we illustrated a novel decomposition of the extensive margin of agricultural exports for U.S. as well as several major economies into four additional destination-product extensive margins. In addition, we studied differences between processed and primary product groups as they represent differentiated and homogeneous good, respectively. The decomposition produced several important findings. First, for U.S. agricultural exports over the period 1989-2010, growth along the EM accounts for roughly 45 percent of total agricultural trade growth. Moreover, this result was robust to the trade classification used. Second, most of the growth of U.S. agricultural exports along the EM is concentrated in shipping familiar goods to known destinations. Of the 45 percent overall share of the EM, 44 percentage points were due to exporting new varieties to known destinations. Third, the U.S. agricultural export profile has experienced tremendous growth in the number of new-destination-product varieties. In 2010, new agri-food varieties accounted for over half of the total number of varieties exported.

Fourth, our results provide empirical support for the existing theoretical hypothesis that firm level exports are subject to a one-time sunk and fixed cost. Thus, firms are more likely to expand their trade to familiar destinations. Among the four major economies that we studied, a major part of trade growth along the extensive margin is by exporting familiar products to known destinations. Furthermore, trade growth along the margins also varies for differentiated and homogeneous products. Chaney (2008)'s heterogeneous firms model with a Pareto distribution productivity predicts that for differentiated goods, extensive margins are strongly affected by trade barriers whereas intensive margins are relatively insensitive to trade barriers. The reverse holds for homogeneous goods. Indeed, by dividing products into differentiated, reference priced and homogeneous groups for three major economies, we find that the majority of growth along the extensive margin is in the homogeneous product category and the results are robust as we look at different base year periods and different levels of aggregation.

Fifth, we introduced the Hummels and Klenow (2005) IM and EM indices to global agricultural trade (and extended their framework from cross-section to panel analysis). The advantage of these margins is that they are constructed relative to a control group (the rest of the world) at a single point in time. Thus, these margins avoid having to choose a beginning and end year, although one still has to decide the level of product aggregation on which to conduct the analysis. Contrary to HK (2005), we find that the intensive margin tends to explain a larger portion of the greater exports for economies that have larger agricultural productions and a greater arable land base.

Reference

Amiti, M., & Freund, C. 2010. The anatomy of China's export growth. *In China's growing role in world trade* (pp. 35-56). University of Chicago Press.

Anderson J. and E. van Wincoop. 2003. “Gravity with Gravitas: A Solution to the Border Puzzle,” *American Economic Review,* 93:170-192.

Baier, S. L., Bergstrand, J. H., & Feng, M. 2014. “Economic integration agreements and the margins of international trade”. *Journal of International Economics,* 93(2): 339-350

Baldwin, R. and V. Di Nino. 2006. "Euros and Zeros: The Common Currency Effect on Trade in New Goods," CEPR Discussion Papers 5973.

Bernard, A.B., J.B. Jensen, S.J. Redding, and P.K. Schott. 2009. “The margins of U.S. trade.” *American Economic Review*, 21:105-130.

Berthou, A. and L. Fontagné, 2008. "The Euro Effects on the Firm and Product-Level Trade Margins: Evidence from France," Working Papers 2008-21, CEPII research center.

Besedeš, T. and T. Prusa. 2006. “Ins, outs, and the duration of trade," *Canadian Journal of Economics*, Canadian Economics Association, 39(1): 266-295

Broda C. and D. Weinstein. 2006. “Globalization and the Gains from Variety.” *Quarterly Journal of Economics*, 121(2):541-585

Chaney T. 2008. “Distorted Gravity: The Intensive and Extensive Margins of International Trade.” *The American Economic Review,* 98(4):1707-1721

Debaere, P. and S. Mostashari. 2010. "Do tariffs matter for the extensive margin of international trade? An empirical analysis." *Journal of International Economics,* 81(2): 163-169.

Dutt, P., Mihov, I., and Van Zandt, T. 2013. “The Effect of WTO on the Extensive and the Intensive Margins of Trade”. *Journal of International Economics,* 91(2): 204-219.

Eaton, J., Kortum, S., & Kramarz, F. 2011. “An anatomy of international trade: Evidence from French firms”. *Econometrica*, 79(5), 1453-1498.

Evenett S. J. and A.J. Venables. 2002. “Export Growth in Developing Countries: Market Entry and Bilateral Trade Flows.” University of Bern working paper, mimeo.

Feenstra R. 1994. “New product varieties and the measurement of international prices,” *American Economic Review*, 84(1): 157-177.

Feenstra R.C., H. Kee. 2004. “On the measurement of product variety in trade,” *American Economic Review*, 94(2): 145-149.

_______. 2007. “Trade liberalization and export variety: a comparison of China and Mexico,” *World Economy*, 30(1): 5-21.

Felbermayr, G. J. and W. Kohler. 2006. "Exploring the Intensive and Extensive Margins of World Trade." *Review of World Economics,* 142(4): 642-674.

Flam, H., & Nordström, H. (2007). “Explaining large euro effects on trade: the extensive margin and vertical specialization.” Manuscript, Institute for International Economic Studies, Stockholm University.

Helpman, E., M. Melitz, and Y. Rubinstein. 2008. “Estimating trade Flows: Trading Partners and Trading Volumes,” *Quarterly Journal of Economics*, 123(2): 441-487.

Hillberry R. and C. McDaniel. 2002. “A Decomposition of North American Trade Growth since NAFTA.” ITC Working paper.

Hillberry, R. and D. Hummels. 2008. “Trade Responses to Geographic Frictions: A Decomposition Using Micro-Data." *European Economic Review*, 52: 527-550.

Hummels, D. and P.T. Klenow. (2005). “The Variety and Quality of a Nation’s Exports,” *American Economics Review*, 95(3): 704-723.

Krugman, P.R. 1980. “Scale Economies, Product Differentiation, and the Patterns of Trade,” *American Economic Review,* 70:950-959

Helpman, E and P. Krugman. 1985. *Market Structure and International Trade.* MIT Press.

Helpman, E., Melitz, M. J., & Yeaple, S. R. 2003. Export versus FDI (No. w9439). National Bureau of Economic Research.

Liu X. 2009. “GATT/WTO Promotes Trade Strongly: Sample Selection and Model Specification,” *Review of International Economics*, 17(3): 428-446.

Liapis P. 2009. “Extensive margins in agriculture. OECD Food, Agriculture and Fisheries,” Working papers. No. 17, OECD Publishing. doi: 10.1787/224422031753.

Melitz M.J. 2003. “The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity,” *Econometrica*, 71(6): 1695-1725

Melitz, M.J. and G. I. P. Ottaviano. 2008. "Market Size, Trade, and Productivity," *Review of Economic Studies*, Oxford University Press, 75(1): 295-316.

Prehn, S. and B. Brümmer. 2012. “A Critical Judgement of the Applicability of “New New Trade Theory to agriculture: Stuctural Change, Productivity, and Trade, Diskussionspapiere, Department Für Agrarökonomie und Rurale Entwicklung, No. 1206, http://hdl.handle.net/10419/57649

Rauch, J.E. 1999. “Networks Versus Market in International Trade,” *Journal of International Economics,* 48(1): 7-35

Sun L. and M.R. Reed. 2010. “Impacts of Free Trade Agreements on Agricultural Trade Creation and Trade Diversion,” *American Journal of Agricultural Economics*, 92 (5): 1351-1363.

WTO. 2007. World Trade Report 2007. Six Decades of Multilateral Trade Cooperation: What have we Learnt? WTO Document WT/REG/E/37, March 2007.

Appendices

Appendix E: List of Countries

Angola	Estonia	Nicaragua
Belgium and Luxemburg	Finland	Netherlands
Iraq	France	Norway
Libya	Gabon	New Zealand
Romania	United Kingdom	Oman
Taiwan	Ghana	Pakistan
South Africa	Greece	Panama
United Arab Emirates	Guatemala	Peru
Argentina	Hong Kong	Philippines
Australia	Honduras	Poland
Austria	Croatia	Portugal
Bangladesh	Hungary	Paraguay
Bulgaria	Indonesia	Qatar
Bahrain	India	Russia
Belarus	Ireland	Saudi Arabia
Brazil	Iran	Sudan
Brunei	Israel	Senegal
Canada	Italy	Singapore
Switzerland	Jamaica	El Salvador
Chile	Jordan	Slovakia
China	Japan	Slovenia
Cote d'Ivoire	Kazakhstan	Sweden
Cameroon	Kenya	Syria
Colombia	Korea, South	Thailand
Costa Rica	Kuwait	Trinidad and Tobago
Czech Republic	Sri Lanka	Tunisia
Germany	Lithuania	Turkey
Denmark	Latvia	Ukraine
Dominican Republic	Morocco	Uruguay
Algeria	Mexico	United States
Ecuador	Malta	Venezuela
Egypt	Malaysia	Vietnam
Spain	Nigeria	Yemen
		Zambia

Appendix F: Decomposition of Agricultural exports, 1995 vs. 2010, HS6-Digit Products (HS 1996 Classification)

	$Bil or % share	Non-Agriculture	Agriculture
EU	**Total Growth ($Bil.)**	$2,480	$231
	Known Destination & Product	7.5%	9.4%
	Known Destination & Unknown Product	0.1%	0.2%
	Unknown Destination & Known product	0.0%	0.0%
	Unknown Destination & Product	0.0%	0.0%
BRICS	**Total Growth ($Bil.)**	$2,127	$93
	Known Destination & Product	8.7%	19.0%
	Known Destination & Unknown Product	0.0%	0.1%
	Unknown Destination & Known product	0.0%	0.0%
	Unknown Destination & Product	0.0%	0.0%
TPP[a]	**Total Growth ($Bil.)**	$1,253	$94
	Known Destination & Product	7.5%	10.3%
	Known Destination & Unknown Product	0.4%	0.2%
	Unknown Destination & Known product	0.0%	0.1%
	Unknown Destination & Product	0.0%	0.0%
US	**Total Growth ($Bil.)**	$503	$51
	Known Destination & Product	1.7%	4.1%
	Known Destination & Unknown Product	0.0%	0.0%
	Unknown Destination & Known product	0.1%	0.2%
	Unknown Destination & Product	0.0%	0.0%

Appendix G: List of Countries and Their Margin Values

Country	1995		2006	
	EM	IM	EM	IM
Angola	0.044	0.002	0.019	0.001
United Arab Emirates	0.255	0.007	0.469	0.010
Argentina	0.482	0.055	0.558	0.054
Australia	0.651	0.037	0.704	0.040
Austria	0.664	0.009	0.703	0.017
Bangladesh	0.065	0.002	0.169	0.002
Bulgaria	0.253	0.006	0.451	0.004
Bahrain	0.131	0.002	0.122	0.001
Belarus	0.072	0.003	0.276	0.009
Belgium-Luxembourg	0.815	0.052	0.840	0.050
Brazil	0.489	0.074	0.656	0.084
Brunei	0.028	0.000	0.062	0.000
Canada	0.686	0.050	0.697	0.052
Switzerland	0.611	0.011	0.608	0.012
Chile	0.347	0.023	0.472	0.022
China	0.658	0.043	0.725	0.046
Cote d'Ivoire	0.207	0.029	0.170	0.031
Cameroon	0.135	0.013	0.163	0.007
Colombia	0.274	0.037	0.381	0.020
Costa Rica	0.249	0.022	0.317	0.016
Czech Republic	0.428	0.007	0.575	0.008
Germany	0.877	0.087	0.903	0.092
Denmark	0.668	0.036	0.709	0.030
Dominican Republic	0.266	0.007	0.304	0.005
Algeria	0.099	0.004	0.142	0.001
Ecuador	0.180	0.029	0.288	0.019
Egypt	0.258	0.007	0.358	0.008
Spain	0.733	0.044	0.819	0.050
Estonia	0.212	0.003	0.325	0.003
Finland	0.361	0.008	0.440	0.006
France	0.875	0.118	0.887	0.090
Gabon	0.023	0.001	0.037	0.001
United Kingdom	0.832	0.053	0.815	0.039
Ghana	0.124	0.012	0.199	0.013
Greece	0.514	0.015	0.567	0.011
Guatemala	0.185	0.023	0.243	0.014
Hong Kong	0.541	0.022	0.550	0.009
Honduras	0.193	0.011	0.194	0.009
Croatia	0.308	0.003	0.390	0.003
Hungary	0.537	0.012	0.599	0.011
Indonesia	0.413	0.025	0.455	0.036
India	0.497	0.027	0.632	0.025
Ireland	0.513	0.039	0.556	0.033
Iran	0.165	0.013	0.296	0.012
Iraq	0.034	0.000	0.046	0.007
Israel	0.452	0.008	0.474	0.006
Italy	0.795	0.047	0.864	0.047
Jamaica	0.240	0.004	0.260	0.002

Jordan	0.189	0.005	0.275	0.004
Japan	0.561	0.009	0.586	0.006
Kazakhstan	0.135	0.012	0.089	0.018
Kenya	0.214	0.012	0.252	0.010
Korea, South	0.514	0.008	0.520	0.007
Kuwait	0.102	0.001	0.216	0.002
Libya	0.035	0.006	0.028	0.003
Sri Lanka	0.166	0.007	0.228	0.009
Lithuania	0.229	0.006	0.478	0.006
Latvia	0.164	0.003	0.361	0.003
Macau	0.219	0.001	0.102	0.002
Morocco	0.247	0.010	0.288	0.009
Mexico	0.536	0.027	0.590	0.034
Malaysia	0.410	0.042	0.516	0.032
Nigeria	0.129	0.006	0.131	0.008
Nicaragua	0.166	0.005	0.176	0.006
Netherlands	0.861	0.123	0.882	0.102
Norway	0.325	0.004	0.408	0.003
New Zealand	0.417	0.032	0.455	0.034
Oman	0.081	0.014	0.152	0.004
Pakistan	0.226	0.012	0.294	0.008
Panama	0.125	0.014	0.179	0.008
Peru	0.173	0.022	0.376	0.013
Philippines	0.364	0.016	0.432	0.011
Papua New Guinea	0.083	0.018	0.056	0.013
Poland	0.459	0.012	0.704	0.020
Portugal	0.458	0.007	0.595	0.008
Paraguay	0.149	0.017	0.141	0.019
Qatar	0.065	0.002	0.079	0.001
Romania	0.276	0.005	0.399	0.004
Russia	0.251	0.015	0.363	0.018
Saudi Arabia	0.212	0.007	0.387	0.006
Serbia	0.077	0.001	0.309	0.004
Senegal	0.105	0.005	0.147	0.002
Singapore	0.474	0.019	0.512	0.011
El Salvador	0.142	0.013	0.137	0.007
Slovakia	0.372	0.004	0.514	0.005
Slovenia	0.322	0.002	0.416	0.002
Sweden	0.552	0.007	0.604	0.009
Syria	0.143	0.013	0.282	0.010
Thailand	0.501	0.031	0.602	0.023
Trinidad and Tobago	0.168	0.003	0.172	0.002
Tunisia	0.179	0.008	0.264	0.007
Turkey	0.502	0.020	0.566	0.020
Taiwan	0.439	0.016	0.447	0.003
Ukraine	0.187	0.008	0.344	0.019
Uruguay	0.233	0.011	0.301	0.010
United States	0.909	0.224	0.901	0.157
Venezuela	0.261	0.005	0.173	0.003
Vietnam	0.261	0.013	0.394	0.015
South Africa	0.455	0.013	0.526	0.011
Zambia	0.097	0.001	0.085	0.006