Agricultural Trade Costs: 1965-2010

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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 plausible values of the elasticity of substitution, we find that median global agricultural trade costs were 285 percent in 1965, on an ad-valorem equivalent basis, before declining dramatically to a 118 percent ad-valorem equivalent in 2010. There is considerable variation in agricultural trade costs, bilaterally, and within various policy arrangements such as regional integration and the GATT/WTO. Statistical analysis of the determinants of agricultural trade costs largely confirms this variation: bilateral and regional free trade initiatives lower international trade costs by 36 percent on average, whereas GATT/WTO membership lowers trade costs by nearly 20 percent.

Keywords: *trade costs, agriculture, gravity, regional trade agreements, GATT/WTO.*

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 and globalization is the reduction in international trade costs, particularly transportation costs and tariffs (Grant and Boys 2012).

However, impediments to the free flow of goods across national borders continue to exist and are known to be large but difficult to measure (Novy 2011b). 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; Helliwell 1998; Wei 1996; Hummels 1999; Anderson and Smith 1999; Head and Ries 2001; Anderson and van Wincoop 2003, 2004). 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) given the myriad of policies that can affect commercial exchange such as transportation costs, tariffs, non-tariff measures, product standards, informational barriers, cultural asymmetries, institutional rigidities, and currency movements. 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 direct measures of trade costs and market access impediments, the purpose of this articles is to develop an indirect assessment - one that compares a nation's international trade to trade taking place within its border - the latter of which serves as the appropriate benchmark to define a seemingly well integrated zone.

Our analysis extends previous research examining the "border effect" in international trade patterns using the gravity equation augmented to include a dummy variable indicating a nation's trade with itself (c.f., MacCallum 1995; Wei 1996; Olper & Raimondi 2008; Fontagne et al. 2008; Nitsch 2000, Head & Mayer 2000; Evans 2003). McCallum (1995) found that Canadian provinces were 22 times more likely to trade with themselves than with a comparable U.S. State. Extending the analysis to OECD countries, Wei (1996) finds that the average country imports two and a half times as much from itself as from an otherwise identical foreign country. Fontagne et al. (2008) focus on market access between United States, the EU and Japan and find

that EU members have 13 times more intra-national trade compared to their trade with another EU country, on average. The ratio raises to 32.5 for U.S. imports from the EU. Olper and Raimondi (2008) find that even for comparatively well-integrated European Union countries, intra-country trade is an alarming 66 times greater on average than crossing border in agri-food industries.

Focusing on tradable goods categories in agriculture, this study extends this branch of literature deriving a theoretically consistent measure of international trade costs that includes a bilateral dimension. Based on the framework in Novy (2011), we modify the theoretical gravity equation developed by Anderson & van Wincoop (2004) to solve for an indirect measure of the international trade costs that is parsimonious in data requirements and relatively easy to implement empirically. The model is appealing because it makes no assumptions about the symmetry of bilateral trade costs (AvW 2004). Moreover, there are no additional assumptions needed to derive the trade cost function - that is, international trade costs are not tied to one particular theoretical model.

Novy (2011) finds that U.S. trade costs with partner countries declined by 40% on average from 1970 to 2000. In addition, the average Canadian relative trade cost measure declined by 30% from 1970 to 2000. However, Novy (2011) focused on total merchandise trade. Much less is known about the height of international trade costs impacting agricultural trade and the extent to which international agreements improve market access conditions.

2. Model Description

The popular Anderson and van Wincoop (2003) gravity equation is as follows:

$$x_{ij} = \frac{y_i y_j}{y^W}\left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma} \tag{1}$$

where x_{ij} is the bilateral trade form i to j, y_i & y_j are nominal income of country i and j, y^W is the world income, Π_i is the outward multilateral resistance of country i, P_j is the outward multilateral resistance of country j, and t_{ij} is the bilateral trade cost measure. The main innovation in AvW's (2003) model is to incorporate exporter and importer price indices(Π_i and P_j) such that trade not only depends on bilateral trade costs t_{ij} between the two countries but also on the trade ``resistance" they face with all of their trading partners in the rest of the world. That is, country i is more likely to trade with country j if Π_i is higher, meaning the multilateral resistance of country i to all other partners is higher.

Using equation (1), consider the intra-national trade of country i as:

$$x_{ii} = \frac{y_i y_j}{y^W}\left(\frac{t}{\Pi_i P_i}\right)^{1-\sigma} \tag{2}$$

and rewrite it as:

$$\Pi_i P_i = \left(\frac{x_{ii}/y_i}{y_i/y^W}\right)^{\frac{1}{\sigma-1}} t_{ii} \tag{3}$$

which solve for country i's multilateral resistance. Multiplying by x_{ij} and x_{ji}, we obtain:

$$x_{ij}x_{ji} = \left(\frac{y_i y_j}{y^W}\right)^2\left(\frac{t_{ij}t_{ji}}{\Pi_i P_i \Pi_j P_j}\right)^{1-\sigma} \tag{4}$$

and substitute (3) for country i and j into (2), we can derive the bilateral trade costs relative to domestic trade costs τ_{ij}:

$$\tau_{ij} = \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{\frac{1}{2}} - 1 = \left(\frac{x_{ii}x_{jj}}{x_{ij}x_{ji}}\right)^{\frac{1}{2(\sigma-1)}} - 1 \tag{5}$$

where, τ_{ij} is defined as the indirect measure of relative bilateral trade costs, expressed as an *ad-valorem* equivalent (by subtracting one), and σ is the elasticity of substitution between domestic and foreign goods. This border effect measure is a scaled ratio of trade cost across national border relative to trade cost within national border weighted by the elasticity of substitution. One thing worth noting is that τ_{ij} is not directional. That is, τ_{ij} 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_{ij} 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). An additional advantage is that it allows time-varying measurement of bilateral trade barriers. With readily available trade and production data in tradable goods categories, we are able to measure and explain the determinants of bilateral border effects.

As is common in empirical trade models with national product differentiation, the degree of substitutability, σ, plays a fundamental role since international trade costs are decreasing in the degree of substitutability. Chen & Novy (2011) estimate σ at the industry level and confirm that the elasticity of substitution is heterogeneous across industries. Similar evidence is presented in Hertel et al. (2007); Head and Ries (2001), Haveman et al. (2003) and Chen & Novy (2011). In this paper, we assume $\sigma = 10$ for agricultural trade, but also report ad-valorem trade costs when sigma is assumed to take on a lower value of eight.

Finally, we investigate the determinants of international trade costs (τ_{ij}). We begin by experimenting with several gravity-type variables to examine how international trade costs are affected by geographic distance, contiguous borders, common languages, as well as policy type influences related to regional and multilateral agreements. The baseline model is as follows:

$$\ln \tau_{ijt} = \alpha_1 TT_t + \beta_1 Dist_{ij} + \beta_2 Cont_{ij} + \beta_3 Lang_{ij} + \beta_4 LL_{ij} + \lambda^k RTA\_WTO_{ijt}^k + \varepsilon_{ijt} \quad (6)$$

Where TT_t is a time trend, $Dist_{ij}$ is the distance between two countries, $Lang_{ij}$ is a dummy equal to one if a country pairs speaks the same language, and zero otherwise, $Cont_{ij}$ is a dummy variable equal to one if I and j share a contiguous border, and zero otherwise, LL is a dummy variable indicating the number of landlocked countries in each country pair, and ε_{ijt} is a log-normal error term. The parameters of specific interest are in the vector λ^k which measures the extent to which international and regional trade agreements reduce agricultural trade costs. More specifically, RTA-WTO_{ijt} is a vector of two policy-related variables indicating joint membership in a regional trade agreement (RTA) or the WTO in time t.

3. Data Description

The difficulty in estimating equation (5) is how do we define a nation's trade with itself (x_{ii} and x_{jj})? The intra-national trade x_{ii} needed in equation (5) for calculating border effect measure is constructed using the approach by Novy (2011) and Shang-Jin Wei(1996). Both sets of authors assume intra-national trade can be expressed as total production minus total exports in tradable goods categories:

(7) $$x_{iit} = y_{it} - X_{it}$$

where, x_{iit} is the value of country i's trade with itself, y_{it} is the value of country i's production, and X_{it} is the value of country i's exports. Novy (2011) and Wei (1996) undertake a complicated process of constructing a GDP-corrected measure of country i's total production to remove non-traded value-added services and other components that make up GDP.

In this study, we focus on agricultural trade costs with readily available agricultural production and export values for the Food and Agricultural Organization (FAO). The FAO tabulates statistics on agricultural production quantities and values, in real and nominal terms, for many countries over a long time period extending back to 1960 in many cases. Two production values are reported with differing sample periods: (i) nominal gross values of agricultural production (1990 onwards), and (ii) constant (2004-2006) values of agricultural production (1960-2010). FAO export values are reported in nominal values and cover the period 1960-2010. We use constant production values which offer a much longer time series. Export values are then converted to real values using exporters' GDP deflator. With real production and export values in constant values, we then estimated each countries' trade with itself using equation (7).

The final component of equation (5) is countries' bilateral trade (x_{ij} and x_{ji}). We assemble a bilateral dataset of the value of total agricultural trade flows covering 45 years of data (1965-2010) and 121 countries to match the countries with reported production and export values from the FAO dataset. The trade data are based on countries' reported import notifications to the United Nation's Commodity Trade Statistics (Comtrade) using the Standard Industrial Trade Classification (SITC, revision 1). Following Feenstra et al. (2005), mirrored trade flows, defined as the exporters' reported exports, are employed when the reporting countries' imports are missing. The WTO's Multilateral Trade Negotiation (MTN) categories are used to classify

agricultural goods. Note that Comtrade's bilateral import and export statistics are reported in nominal values. Thus, we use the exporters' (2004-2006) GDP deflator to convert buialteral agricultural trade to real values. A comprehensive list of GDP deflators can be obtained form the Economic Research Service's (ERS) international macroeconomics database (available at: http://www.ers.usda.gov/Data/Macroeconomics/).

Distance, common borders and language, landlocked countries, and colonial linkages are taken from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) geo-distance dataset developed by Mayer and Zignago (2006) (www.cepii.com). Information on regional trade agreements is taken from the WTO's newly enhanced Regional Trade Agreements Information System (RTA-IS), whereas WTO membership is taken from the WTO's website and list of accessions. Given our sample 1965-2010 and 121 countries with available production and export data, we evaluate 110 RTAs.

The completed (unbalanced) panel spans the period 1965-2010 at five year intervals to smooth year-over-year fluctuations and disruptions in production and trade flows. The dataset contains a total 32,890 country-pair and year observations. Of this total, 48 (52) percent are zero (positive) trade flows. Eleven percent (16,514) of the bilateral

4. Agricultural Trade Costs

The results are organized as follows. In section 4.1 (*Patterns of Agricultural Trade Costs*) we provide a graphical analysis of the evolution of agricultural trade costs over the period 1965-2010 using various slices of the data. Section 4.2 proceeds to a set of empirical specifications to

identify observable trade policies that are responsible for the variation in the computed trade cost measures.

4.1. Patterns in Agricultural Trade Costs

Figure 1 traces out multilateral agricultural trade costs over the sample period 1965-2010, for elasticity of substitution values of eight ($\sigma = 8$) and ten ($\sigma = 10$). Plotted are the mean (solid line) and median (dashed line) *ad-valorem* equivalent trade cost values covering 121 countries after estimating equation (5). The reduction of global agricultural trade costs through globalization, lower transportation costs, regional trade agreements and successive rounds of multilateral negotiations is evident. In 1965, the height of agricultural trade costs was 304 percent on an *ad-valorem* equivalent (AVE) basis ($\sigma = 10$). After 1970, trade costs have fallen remarkably to their current level of 125 percent AVE which translates to a reduction of nearly 60 percent. Also plotted in figure 1 are the AVE trade costs for an elasticity of substitution of eight. Clearly, agricultural trade costs are quite sensitive to changes in the degree of substitutability. However, the declining trend in trade costs is not sensitive to this parameter choice. When $\sigma = 8$ agricultural trade costs averaged 740 percent AVE in 1965 before falling to 248 percent AVE in 2010, a 67 percent decline which is even larger than the percentage change when $\sigma = 10$, over the same time period.

While figure 1 focused on multilateral trade costs for 121 countries, figure 2 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. Again there is a clear downward trend in agricultural trade costs. When both countries are OECD members, trade costs declined from 224

percent AVE in 1965 to a level of 60 percent in 2010. Comparatively, non-OECD member trade costs peaked at 350 percent in 1970 before falling to 144 percent AVE in 2010 - more than twice the level of OECD countries. In practice, trade costs can vary considerably across goods and readers may recall some specific product lines where the import tax exceeds the average reported in 2010 of nearly 60 percent AVE for OECD countries. However, it is important to remember that this analysis represents average trade costs for all agricultural trade and all international frictions that affect the production and shipment of agricultural 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.

The proliferation of regional trade agreements and the increasing size of WTO membership has been one of the great international economic developments since the post-war era. Multilateral and regional integration share at least one thing in common – the reduction of trade barriers among member nations. In figure 3 we contrast agricultural trade costs between four groups of countries: (i) country-pairs that are both members of the WTO; (ii) country-pairs that are both members of a mutual RTA; (iii) country-pairs that are members of both the WTO and a mutual RTA; and (iv) country-pairs that are members of neither. At first glance, regional integration clearly dominates multilateral efforts. The average *ad-valorem* trade costs within RTAs were 84 percent in 2010, compared to an average of 121 percent for all WTO members. However, it is difficult to sort out causality here since many countries were members of the WTO before joining an RTA and vice versa. Moreover, trade costs are everywhere lower for country-pairs that participate in RTAs but show a much weaker downward trend compared to country-pairs belonging to the WTO. To gain some insight, figure 3 also traces out the level of

agricultural trade costs for country-pairs that are members of both RTAs and the WTO. Being party to both types of agreements has little effect in the early years but the two lines separate marginally after 1980, implying that country-pairs are somewhat more open if they participate in regional and multilateral initiatives.

Before moving on to an investigation of the determinants of agricultural trade costs and the role of RTAs and the WTO, figure 4 considers the relationship between trade costs and one prominent explanatory factor in typical gravity-type analyses: the log of geographic distance. Economic distance is clearly one factor in explaining the height of international agricultural trade costs (figure 4). One potential problem with using distance between countries is that it ignores differential shipping costs across products (i.e., perishable versus non-perishable). If a country's production and export profile consists largely of perishable or bulky products then agricultural trade costs would tend to be higher. A better indicator of shipping costs might be to considerable the types of products countries' export. While this is beyond the scope of the current paper, we view this as a fruitful area of further research.

4.2. Regression Results: Explaining Agricultural Trade Costs

Table 1 presents the econometric results along with robust standard errors in parentheses. Column (1) considers a basic regression with typical gravity-like covariates. Column (2) adds historical colonial ties as a determinant of agricultural trade costs. Columns (3) and (4) incorporate dummy variables for mutual RTA membership and joint GATT/WTO membership, respectively. Finally, in columns (5) and (6) we investigate the robustness of the results by adding country-time and country-pair fixed effects to the specification to control for unobserved heterogeneity in agricultural trade costs.

The results are in line with expectations. The time trend coefficient is negative and statistically significant throughout suggesting that agricultural trade costs are falling by ten to 13 percent every five years, or roughly two percent per year, on average. Distance increases the agricultural border effect by a large and statistically significant amount whereas sharing a land border and speaking the same language reduce agricultural trade costs. For example, common borders reduce agricultural trade costs by 24 percent (exp(-0.28)-1)*100), on average. Finally, trade costs are larger for landlocked countries (column (1)).

Column (2) adds colonial ties as a possible factor affecting agricultural trade costs. In many cases, former dependent colonies of developed countries (i.e., Britain) enjoy preferential treatment with respect to tariffs. The results confirm this and suggest that colonial beneficiaries or colonizing nations have trade costs that are 37 percent lower than the average country-pair with no colonial link.

Columns (3) and (4) add dummy variables for regional trade agreements and GATT/WTO membership. The results are impressive. The effect of regional integration is to reduce agricultural trade costs by 37 percent on average. To put this into perspective, agricultural trade costs averaged 125 percent in 2010 across all countries (figure 1). The results suggest that countries that enjoy preferential access to markets in RTA partner countries face an AVE trade cost factor of 79 percent. Column (4) considers the effect of joint membership in the GATT/WTO. Membership in the multilateral organization results in a reduction in agricultural trade costs of 17 percent, on average, compared to similar non-member countries. Interestingly, the trade cost reducing effect of the GATT/WTO effect is less than half that of RTAs. This is also confirmed by testing the equality of the coefficients (H_1, table 2). This result is likely due to

the fact that agriculture has only recently been brought under the auspices of the WTO during the Uruguay Round agreement in 1995, commemorating the official creation of the WTO.

The final two columns in table 2 (columns (5) and (6)) employs a fixed effects specification as a robustness check on the results. The results continue to hold and are highly significant, although the effects of RTAs and membership in the GATT/WTO on agricultural trade costs are lower in magnitude. It is also important to note the large increase in the goodness of fit (R^2) statistic when the fixed effects are added to the specification. While not uncommon in gravity-type regressions, it does point to the fact that there must be other important factors explaining the height and variation in agricultural trade costs not accounted for by the right-hand side variables in table 2.

6. Conclusion

In this paper, we examined the nature and size of agricultural trade costs using an indirect measure derived from the theoretically consistent version of the gravity equation suggested by AvW (2003). We find that agricultural trade costs have decreased dramatically since 1965. However, the mean (median) level of trade costs in agriculture in the latest year in our sample period (2010) is still 125 (118) percent on an *ad-valorem* equivalent basis. Because tariffs remain high on many agricultural goods and non-tariff measures are pervasive in the food sector, the results suggest there is considerable scope for future liberalization. Unlike previous studies (Novy 2011), we find that membership in regional and multilateral trade agreements effectively enhance agricultural market access conditions.

Finally, while the conclusions that we draw from this analysis are robust to differing empirical specifications, the level of agricultural trade costs is quite sensitive to our maintained assumption that σ, the elasticity of substitution between home and foreign goods, is in the neighborhood of ten. The use of a uniform elasticity of substitution for agricultural products likely needs further consideration and estimation. Indeed there is no consensus in the literature on the exact value of σ, but there seems to be some support for σ in the range of five to ten (Hertel et al, 2007). Refining this parameter value is the subject of future work for this study despite the fact that the trend and declining rate of agricultural trade costs is little impacted by the chosen value of σ.

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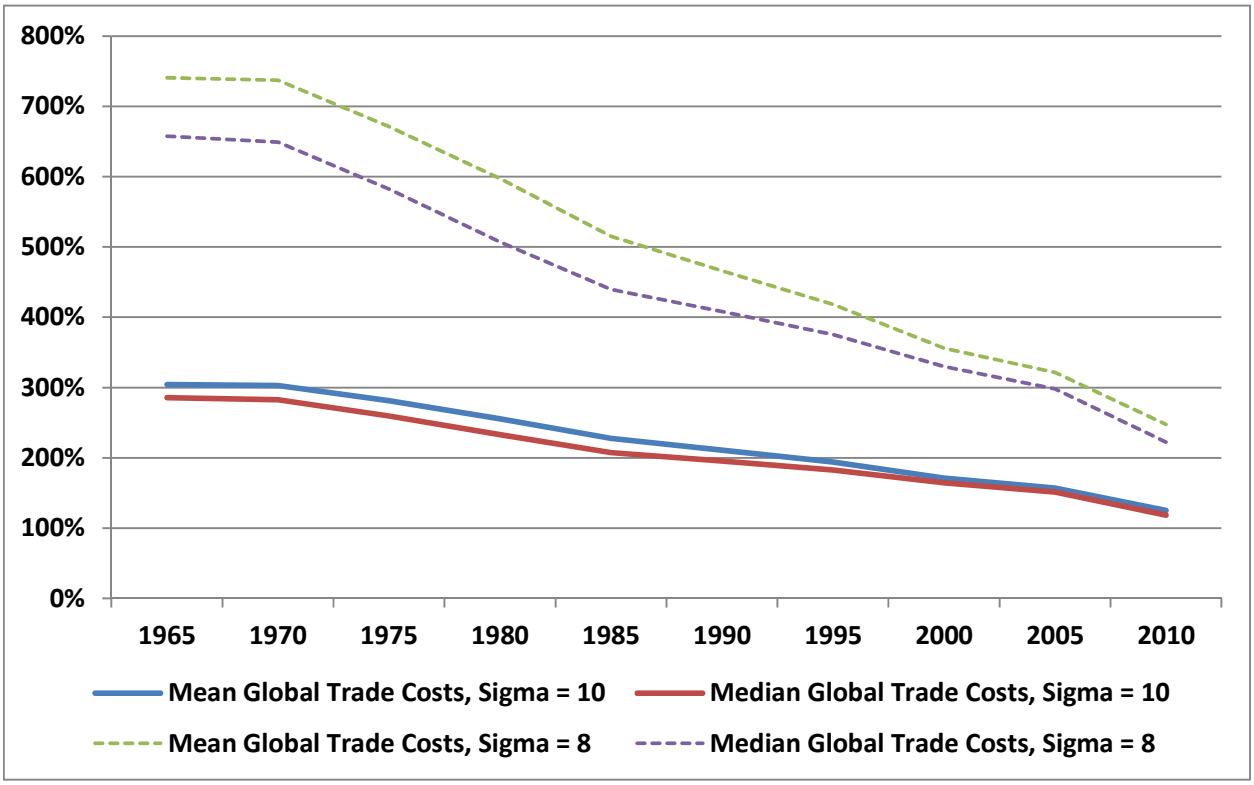

Figure 1. International Agricultural Trade Costs, 1965-2010

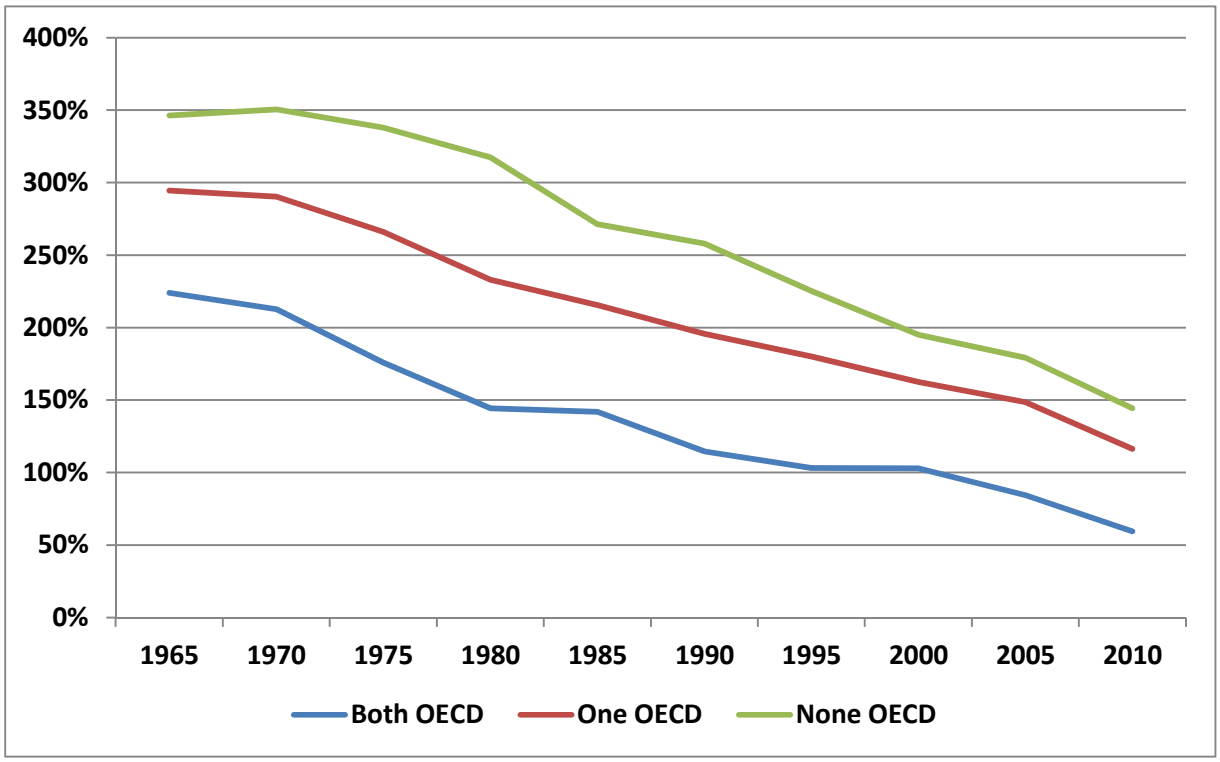

Figure 2. Agricultural Trade Costs of OECD and Non-OECD Members

Table 1. NAFTA, EU, and U.S. Bilateral Agricultural Trade Costs

Country/Region	Partner	1965	2005	% Change
NAFTA	NAFTA	1.57	0.21	-0.86
EU-15	EU-15	2.07	0.45	-0.78
---------- U.S. Bilateral Trade Costs----------				
U.S.	Canada	0.98	0.16	-0.84
U.S.	Australia	1.38	0.53	-0.62
U.S.	Germany	1.28	0.50	-0.61
U.S.	China	1.78	0.71	-0.60
U.S.	Japan	1.37	0.57	-0.59
U.S.	Chile	1.29	0.54	-0.58
U.S.	Brazil	0.91	0.77	-0.16
Mean of U.S. Bilateral Trade Costs		*1.28*	*0.54*	*-0.57*

Note: All agricultural trade cost values are reported as *ad-valorem* equivalent rates. Trade data are not available for China prior to 1970. Thus, the trade cost measure for China in 1965 is representative of 1975.

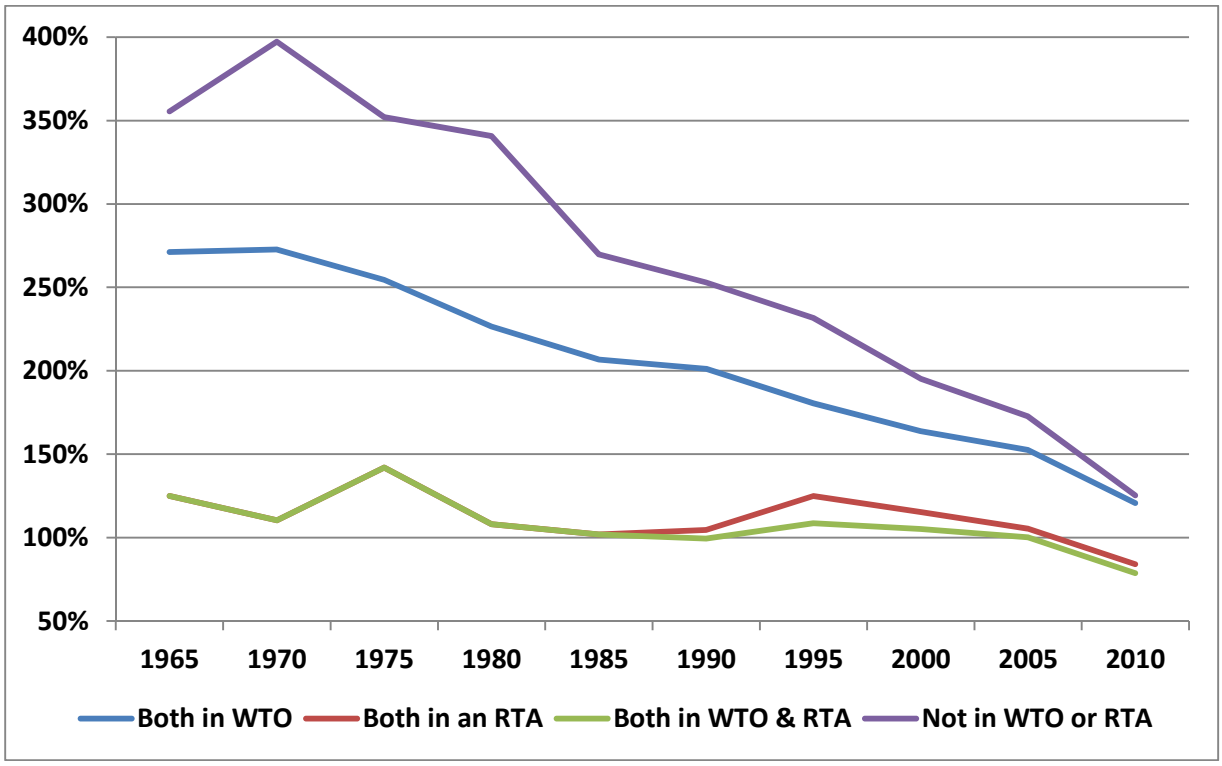

Figure 3. Agricultural Trade Costs Inside RTAs and the WTO

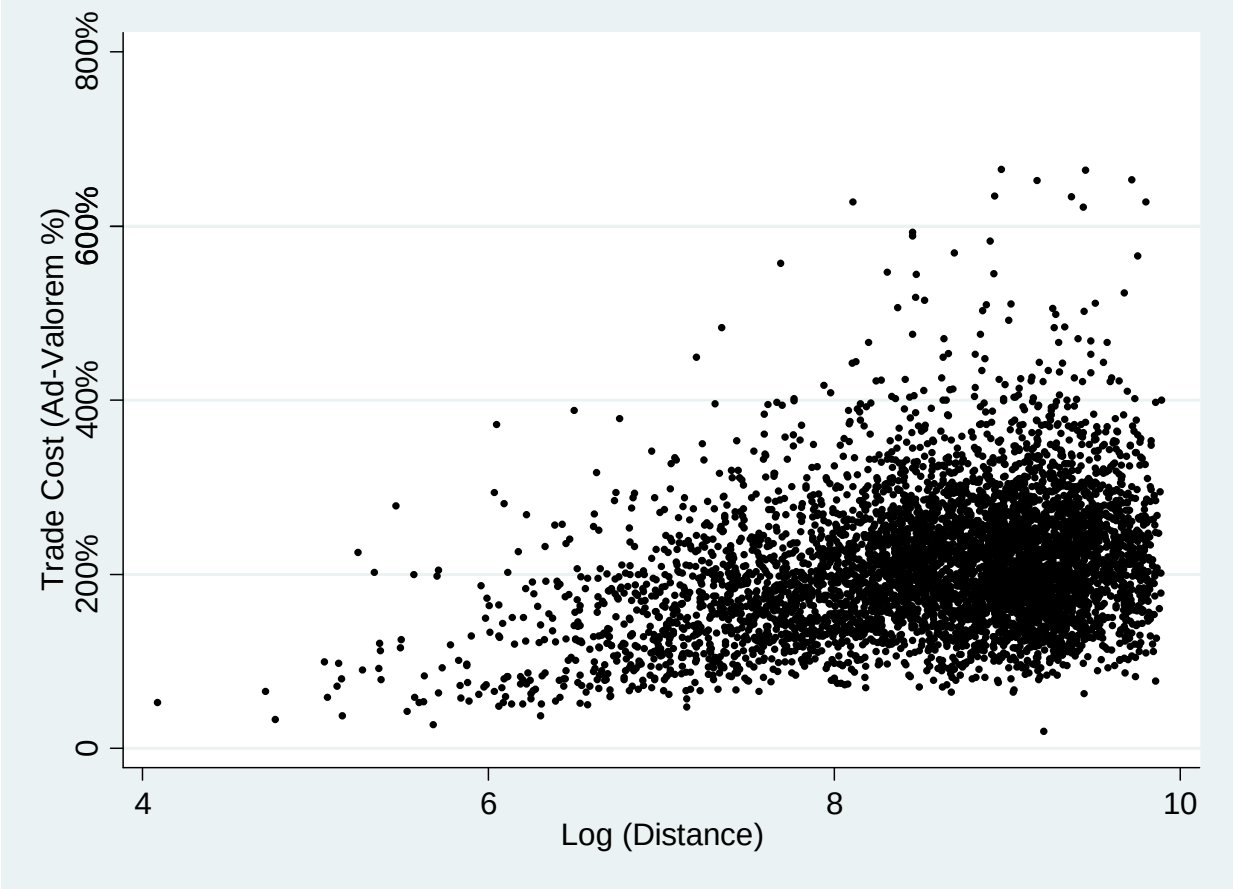

Figure 4. Agricultural Trade Costs versus Log of Geographic Distance

Table 2: Factors Explaining Agricultural Trade Costs, 1965-2010

	(1) Baseline	(2) Colonial Ties	(3) RTA	(4) GATT/WTO	(5) Country-Time Fixed Effects	(6) Country-Pair Fixed Effects
Time Trend	-0.11***	-0.11***	-0.10***	-0.10***		-0.13***
	(0.00)	(0.00)	(0.00)	(0.00)		(0.00)
Log Distance	0.14***	0.15***	0.09***	0.11***	0.19***	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	
Contiguity	-0.28***	-0.26***	-0.24***	-0.24***	-0.20***	
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	
Common Language	-0.10***	-0.05***	-0.06***	-0.05***	-0.11***	
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	
Landlocked	0.13***	0.12***	0.11***	0.09***		
	(0.01)	(0.01)	(0.01)	(0.01)		
Colonial Ties		-0.46***	-0.44***	-0.44***	-0.24***	
		(0.02)	(0.02)	(0.02)	(0.01)	
RTA			-0.46***	-0.42***	-0.20***	-0.25***
			(0.01)	(0.01)	(0.01)	(0.01)
Both in GATT/WTO				-0.19***	-0.05***	-0.04***
					(0.01)	(0.01)
H_1: RTA = GATT/WTO				286.45***	147.92***	198.09***
Prob. > F				(0.00)	(0.00)	(0.00)
N	31,837	31,837	31,837	31,837	31,837	31,837
R^2	0.36	0.38	0.42	0.43	0.81	0.84
RMSE	0.46	0.45	0.43	0.43	0.25	0.25

Note: The dependent variable is log bilateral trade costs ($\sigma = 10$). Standard errors are in parenthesis. Fixed effects coefficients are not reported to save space. One, two and three asterisks denote statistical significance at the ten, five, and one percent levels, respectively.