QUANTILE EFFECTS OF NON-TARIFF MEASURES, TRADE AGREEMENTS, AND FRICTION VARIABLES ON BILATERAL DAIRY TRADE FLOWS VIA DISTRIBUTION REGRESSION

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Abstract

This study implements a quantile gravity model to examines the effects of non-tariff measures (NTMs) and trade agreements for the years 2001, 2008, and 2016 on bilateral trade flows of dairy industry. The results highlight the importance of observing distribution regression analysis, as mean regression analysis cannot fully capture the heterogeneous effects across countries. The analysis provides additional insights about the determinants of international dairy trade. The results show heterogeneity in coefficient estimates across quantiles for NTMs, trade agreements, and friction variables. For example, as the quantiles increase, the coefficient estimates for NTMs go from positive to negative, the effects of WTO joint membership, free trade agreements and distance generally increase in magnitude, and the effect of contiguity declines in magnitude.

JEL classification: F13, F14, C21, Q17, Q18

Keywords: Dairy Industry, Distribution Regression, Gravity Model, Non-Tariff Measures, Quantile Effects, Trade Agreements

1 Introduction

Poisson Pseudo Maximum Likelihood (PPML) estimator, proposed by Silva and Tenreyro (2006), is a workhorse estimation method of the empirical gravity trade literature. PPML addressed estimation issues of predecessor estimators, which include the exclusion of a large number of zeros, as well as inconsistency in the presence of heteroskedasticity for log-log regression because of the Jensen's inequality. PPML is appealing because it yields consistent estimates when heteroskedasticity is present in trade data and allows for the inclusion of zero trade flows. However, if countries are heterogeneous, the influence of policy variables and friction variables on international trade may vary along with different points on the conditional outcome distribution (Wagner, 2006).

We therefore propose to incorporate distribution regression (DR) by Chernozhukov, Fernandez-Val, and Weidner (2020) to estimate the gravity model. Relative to PPML, DR has the advantage of capturing heterogeneous effects and being robust to outlies. Furthermore, the DR model deals with zeros and any other fixed censoring points because it specifies the conditional distribution separately at the mass point, can handle a large set of fixed effects, and accommodates conditional heteroskecasticity.[1]

By using both PPML and DR, we examine the average and quantile effects of NTMs and trade agreements on bilateral trade flows of dairy products when controlling for friction variables, such as distance, common languages, colonial history and contiguity. We find that the effects of these variables are indeed heterogeneous over different quantiles of exporter countries, when comparing the average effects to the quantile effects.

We apply the DR to the gravity model to estimate the determinants of bilateral dairy trade flows. Dairy products are a commonly consumed food and beverage items globally and is also an important contributor to many countries agricultural economies, such as India (the number one milk producing country) and, to a lesser extent, the Unites States (one of the

[1]For more detailed discussion on DR, please refer to Chernozhukov, Fernandez-Val, and Weidner (2020) and Chernozhukov and Fernandez-Val (2017).

top exporters and importers of dairy products in the world). Furthermore, India consumes more than 95 percent of its own milk production (Santra, 2018), leading to low export volumes. However, over the last few decades, the US dairy industry has seen steady increase in production per cow, and, with stagnant demand, has led to an oversupply. Therefore, the US National Farmers Union supports the idea of creating a long-term supply management program to balance milk supply and demand. One outlet is exports to countries with growing demand, particularly in Southeast countries where demand for milk products outpaces supply (Cessna and Davis, 2021). Hence, trade plays an important role in international dairy industry.

Governments implement various trade policies, such as tariffs and Non-tariff Measures, which are designed to protect dairy producers and consumers and are typically part of global and regional trade agreement. NTMs are policy measures that can significantly effect international trade of goods in terms of quantity, prices or both (UNCTAD). NTMs can be challenging for policymakers, exporters, and importers. In the last decade, NTMs have become more common than tariffs. Besides, the ability to access a new market, depends on trade regulatory measures and compliance with existing standards. Therefore, NTMs can be trade enhancing or hindering depending on the measure, commodity, and country. As of 2021, the United States implemented a total of 6,063 dairy NTMs, out of which the top three measures are sanitary and phytosanitary measures, technical barriers to trade and special safeguards, at 662, 550 and 496, respectively (I-TIP).

The remainder of the paper is organized as follows: Section 2 presents the literature review. Section 3 presents the modeling strategy. Section 4 illustrates the data used. Section 5 discusses the results. Section 6 concludes.

2 Literature Review

One major avenues of the agricultural trade literature is examining the impact of trade agreements on agriculture trade. Larch, Luckstead, and Yotov (2021) find that WTO membership has a moderate impact on trade (only 1.4 percent) when they include exporter-industry-time, importer-industry-time, and country-pair-industry fixed effects. However, when domestic sales and globalization trends are added, the effect on trade becomes 36.4 percent. Sun and Reed (2010) find that FTAs effects vary over time. During the early years of trade, the effects are significant, but it disappears in later years.

Several studies examining the impacts of NTMs on agricultural trade have emerged in the past decade.[2] Recently, Santeramo and Lamonaca (2021) find that SPS measures are stimulating for developing importers for agricultural products. Santeramo, Lamonaca, Nardone, and Seccia (2019) suggest that country-specific NTMs tend to favor imports of wine. Differences emerge across market segments and types of regulations. The Technical Barriers to Trade favor bottled (bulk) wine; pre-shipment inspections enhance imports of bottled wine; the Sanitary and Phytosanitary Standards and the export-related measures are the most trade-enhancing NTMs, regardless of the market segment. However, most of these studies are estimated using the PPML estimator by Silva and Tenreyro (2006).

Given the complementary nature of mean and quantile trade effects, studies on quantile effects in trade literature are scant but evolving. Chernozhukov, Fernandez-Val, and Weidner (2020) are the first to study quantile effects with two-way fixed effects (2WFEs) in a gravity model using distribution regression. They estimate network data[3] of 157 exporting and importing countries in 1986 and construct uniform confidence bands for quantile effects. Their results show heterogeneous effects of friction variables, FTAs, legal system and currency unions across 0.55 to 0.95 percentiles.

Censored quantile regressions have also been implemented in the gravity trade litera-

[2]See Li and Beghin (2012) for a meta study on the variation in estimated trade effects of NTMs in agricultural trade.

[3]Network data refers to any dollar transaction between the exporter and importer countries

ture. Using instrumental variable censored quantile regression, Figueiredo, Lima, and Orefice (2016) find that Regional Trade Agreements (RTAs) membership and WTO membership influence international migration[4] among countries. The coefficient estimates for RTAs are statistically significant at the 1 percent significance level for upper quantiles only, while it shows no significance for lower quantiles, and have negative signs. However, for WTO membership, though all the coefficient estimates are statistically significant and positive, the magnitude decreases for upper quantiles. Comparing the censored quantile estimations to the baseline PPML estimation, the PPML estimated coefficients of RTAs are not significant, while WTO, however, has almost double coefficient estimate. These results show that heterogeneity across quantiles exists; and it remains an open question as to how trade policies affect countries on different quantiles of trade.

Our study builds on quantile effects literature by estimating the structural gravity model using distribution regression. We examine the quantile effects of Non-Tariff Measures (NTMs) and trade agreements, such as WTO, Free Trade Agreements (FTAs), and Preferential Trade Agreements (PTAs) on bilateral trade of dairy industries, while controlling for friction variables.

To the best of our knowledge, no studies in agricultural economics have examined the impact of NTMs and trade agreements on both average trade flows and the quantile of bilateral trade flow for any agricultural commodities, especially for dairy. The methodology used in this study is also novel for the agricultural economics literature.

3 Setup

We use PPML method to estimate the mean effect and use DR method to estimate the quantile effect in cross-section gravity models using 2WFEs. As of now there is no theoretical foundation of quantile analysis using 3WFEs. Therefore, we will only focus on cross-section

[4]Their dependent variable is bilateral migration stocks for every 10 years: 1960, 1970, 1980, 1990, 2000 and 2010.

gravity models using 2WFEs.

3.1 Baseline Structural Gravity Model

For the baseline structural gravity models, we use the PPML estimator with 2WFEs for cross-section data (Yotov, Piermartini, Larch et al., 2016). We allow variation in exporter and importer countries; however, the time is fixed to one year. The cross-sectional 2WFEs-PPML model is defined as

$$\begin{aligned} T_{ij} \quad = \quad & \exp\{\beta_1 \ln(1 + NTMs_{ij}) + \beta_2 WTO_{ij} + \beta_3 FTAs_{ij} + \beta_4 PTAs_{ij} + \\ & + \beta_5 \ln Distance_{ij} + \beta_6 Com\_language_{ij} + \beta_7 Contiguity_{ij} + \\ & + \beta_8 Colony_{ij} + \eta_i + \eta_j\} + \epsilon_{ij} \end{aligned} \tag{1}$$

where, $i, j = 1, \ldots, N$ are importing and exporting country indices, respectively. T_{ij} is a bilateral trade flow for country pair ij. $NTMs_{ij}$ is a count measure for the number of NTM between a country pair ij, WTO_{ijt} is an indicator variable for joint WTO membership between country pair ij, $FTAs_{ij}$ is an indicator variable for free trade membership between country pair ij, and $PTAs_{ij}$ is an indicator variable for preferential trade agreement between country pair ij. $Distance_{ij}$ is the distance between country pair ij, $Com\_language_{ij}$ is an indicator variable for common language between country pair ij, $Contiguity_{ij}$ is an indicator variable for shared border between country pair ij, $Colony_{ij}$ is an indicator variable for colonial history between country pair ij. η_i, and η_j are exporter and importer fixed effects, respectively. ϵ_{ij} is a disturbance term.

We include exporter and importer fixed effects, as the theoretical micro-foundation of gravity model calls for these fixed effects to capture the outward and inward multilateral resistance terms[5] (Anderson and Van Wincoop, 2003; Yotov et al., 2016). These fixed effects control for all measured and unmeasured country-specific factors that could affect exports

[5]Multilateral resistance terms refer to the barriers which each exporter i and importer j face in their trade with all their trading partners (including domestic or internal trade).

or imports. These fixed effects have different impacts on exporter and importer countries, and arbitrarily relate with the observed covariates. The country-pair fixed effects are not included because they are perfect collinearity with the dependent variable variables.

3.2 Distribution Regression Model

In the presence of logged dependent variable, we need to carefully consider zero trade flows, which are common in trade data and potentially arise due to rounding errors, missing observations, or no trade between the countries in a given period. Log-linear gravity models drop zero trade values because log of zero is undefined, creating sample selection bias. Prior to Silva and Tenreyro (2006), previous literature tried to incorporate zero trade values into gravity estimates by either transforming the data by adding a small constant to the zero observation, utilizing Heckman's sample selection model, or using a tobit estimator to keep the zero observation. However, Silva and Tenreyro (2006) show that dealing with the zeros in these ways leads to inconsistent coefficient estimates especially in the presence of heteroskedasticity. Also, deleting these zeros can lead to loss of an important information and bias the results as they provide an information about the probability of engaging in bilateral trade.

Except for the issue regarding zeros, a few problems have been arisen regarding the three-way fixed effects (3WFEs) PPML estimator. Weidner and Zylkin (2021) are the first to rigorously study incidental parameter problem (IPP) for the 3WFEs-PPML. They find that the 3WFEs-PPML estimates suffer from an asymptotic bias, which affects the validity of inferences. Theoretically, the bias is limited if the dimension for both country and time is large. However, they show that bias can be a concern even when the time dimension in the data is large in 3WFEs-PPML. To solve the IPP, Weidner and Zylkin (2021) suggests analytical bias correction using Taylor expansions to both point estimates and standard errors.

Therefore, for our study, we apply Chernozhukov, Fernandez-Val, and Weidner (2020)'s

Distribution Regression (DR) estimation with 2WFEs to gravity model to examine the effect on the conditional quantile of trade flows, instead of the conventional conditional mean of trade flows. Denoting $Q(\tau)$ as the left-inverse of $F(\tau)$ conditional quantile of T_{ij} given $(\mathbf{X}_{ij}, \alpha_i, \alpha_j)$, we get the following quantile (left-inverse) function:

$$Q(\tau) = F^{\leftarrow}(\tau) \coloneqq \inf\{T_{ij} \in \Upsilon \colon F(T_{ij} \mid \mathbf{X}_{ij}, v_i, w_j) \geq \tau\} \wedge \sup\{T_{ij} \in \Upsilon\} \tag{2}$$

where

$$F(T_{ij} \mid \mathbf{X}_{ij}, v_i, w_j) \;=\; \frac{1}{n} \sum_{(i,j)\in\Omega} \Lambda_{T_{ij}}\big(P(\mathbf{X}_{ij})'\boldsymbol{\beta}(T_{ij}) + \alpha(v_i, T_{ij}) + \gamma(w_j, T_{ij})\big), \tag{3}$$

$\wedge$ is a $\min\{\}$, Υ contains the T_{ij}, the set Ω includes the indexes of the pairs (i, j) that are observed, and $\Lambda_{T_{ij}}$ is a known link function such as the normal or logistic distribution, which may vary with T_{ij}. $\mathbf{X}_{ij}$ is a vector of control variables, such as indicator variables WTO, FTAs, PTAs, and friction variables, for country pair ij. $\alpha(v_i, T_{ij})$ and $\gamma(w_j, T_{ij})$ are exporter and importer fixed effects. $\boldsymbol{\beta}(T_{ij})$ is the vector of structural parameters of interest.

The assumptions on regularity conditions for consistency of the parameters are same as in Chernozhukov, Fernandez-Val, and Weidner (2020): (1) $\mathbf{X}_{ij}$ are compact to ensure the existence of extremum estimators and (2) FEs are bounded uniformly over i and j. And (3) the regressors $\mathbf{X}_{ij}$ are non-collinear after projecting out the two-way fixed effects.

4 Data Description

We collect data for dependent variable, bilateral international and intra-national trade for the dairy industry (see the list of dairy products that are aggregated into a single commodity Table 5). Cross-section data for the nominal value of bilateral trade flows in the years 2001, 2008, and 2016 on 235 exporting and 236 importing countries are obtained from International Trade and Production Database for Estimation (ITPD-E) database developed by the United States International Trade Commission (USITC). The independent trade agreement

variables, such as WTO, FTAs, PTAs, and friction variables, such as distance, common language, etc., are obtained from the Dynamic Gravity Dataset (DGD) developed by USITC. The main variable of interest, Non-Tariff Measures (NTMs) are collected from the Integrated Trade Intelligence Portal (I-TIP) by World Trade Organization (WTO). For this study, we consider the sum of the five types of NTMs: Sanitary and Phytosanitary (SPS), Technical Barriers to Trade (TBT), Special Safeguard (SSG), Safeguard (SG), and Import Licences (IL) that are in-forced by the importer countries. Definitions for each NTMs are listed in the Appendix, in Section 7.1. The NTM data are count variables and contain both nondiscriminatory (against all WTO members) and bilateral NTMs.

Table 1 provides summary statistics of these variables. Bilateral dairy trade flow range from 0 to $94,969.39 million and of the 943,495 observations, 87.66% or 827,095 are zero-trade flows. Regarding the NTMs, Special Safeguards (SSG) measures are the highest in the mean and standard deviation, while Technical Barriers to Trade (TBT), Safeguard (SG) and Import Licences (IL) have the lowest mean and standard deviation.

Table 1: Descriptive Statistics

	Mean	Std. Dev.	Minimum	Maximum	Obs
Bilateral Trade Flows	5.229	317.799	0	94,969.39	943,495
NTMs	0.408	3.627	0	129	943,495
WTO Joint	0.186	0.389	0	1	943,495
FTAs	0.052	0.223	0	1	943,495
PTAs	0.078	0.267	0	1	943,495
Distance	1,787.184	3,755.68	0	19,747.16	943,495
Common Languages	0.111	0.314	0	1	943,495
Contiguity	0.010	0.098	0	1	943,495
Colony	0.007	0.085	0	1	943,495
SPS	0.0394	0.382	0	14	943,495
TBT	0.0002	0.012	0	1	943,495
SG	0.0006	0.025	0	1	943,495
SSG	0.3662	3.591	0	128	943,495
IL	0.0011	0.033	0	1	943,495

Notes: Unit measure for trade is USD, Million. NTMs are count variables.

5 Results

This section provides results from estimating different gravity equations using both PPML (mean) and DR (quantile) approaches. In Table 2, Table 3 and Table 4, we focus on three years, in the beginning, in the middle, and at the end of our dataset, 2001, 2008, and 2016, respectively. The first column in each table provides the average (PPML) coefficient estimates, and the last five columns include DR (quantile) coefficient estimates for the 50th to 90th percentiles, respectively.[6] In Table 6, Table 7, Table 8, Table 9, Table 10, and Table 11 in the Appendix, we report SPS and SSG regression estimates separately for 70th, 80th and 90th percentiles.

For the PPML model in Table 2, column (1), all the coefficient estimates are statistically significant for all the variables, except for colonial relationship. The coefficient estimates indicate that NTMs negatively effect bilateral dairy trade. For example, a 1 percent increase in NTMs decrease bilateral trade by 0.105 percent for an average country. WTO joint membership and FTAs positively affect dairy trade, while PTAs decreases trade. For example, joining WTOs boosts trade by 2,455.93 percent $(= 100 \times (\exp(3.241) - 1))$ and FTAs by 126.14 percent $(= 100 \times (\exp(0.816) - 1))$, respectively, in 2001. However, joining PTAs decreases dairy trade by 402.79 percent $(= 100 \times (\exp(1.615) - 1))$. Given the larger magnitude of coefficient estimates for WTO, FTAs and PTAs, caution must be taken in interpreting these coefficient estimates because the reverse causality between trade flows and trade policy is not controlled for.

The negative relationship between distance and bilateral trade, and the positive relationship between common language and bilateral trade are consistent with a priori expectation. Specifically, a 1 percent increase in distance decreases the bilateral trade flows by roughly 2.4 percent. Also, if the importing and exporting countries share a common language, there are fewer trade frictions and trade expands. The results show that countries that share a common language trade dairy products, on average, 75.94 percent more than countries that

[6]The reason for not reporting lower quantiles is due to the number of zeros in our trade variable.

do not. The coefficient estimate of contiguous border is negative. A possible explanation for the negative relationship between contiguity and bilateral trade can be attributed to the territorial border conflicts that negatively effect trade between neighbors.

For the DR models in Table 2, columns (2)-(6), we observe heterogeneity across different percentiles of outcome variables. The coefficient estimates indicate that NTMs positively effect bilateral dairy trade for the countries from 50th to 70th percentiles, and the effect becomes negative for upper (80th and 90th) percentiles. The coefficient estimates are statistically significant for 50th and 60th percentiles and are not statistically significant for the upper quantiles. This could be because SSG measures are the largest share of the NTMs in the dataset. SSG measures are designed to help developing countries to strengthen their domestic dairy industry, which in return helps to boost trade. For example, a 1 percent increase in NTMs increase bilateral trade by 0.072 percent for a country on 50th percentile.

We also observe interesting results for trade agreement variables. WTO joint membership and FTAs positively affect dairy trade, while PTAs decreases dairy trade. The coeeficient estimates for WTO joint membership is not statistically significant for 50th and 60th quantiles, while it becomes significant for the upper quantiles. Besides significance, the magnitude of coefficient estimates also change and becomes larger for upper quantiles. These results could be due to the fact that in 2001 most of the developing countries, which are located on a lower quantiles, were not part of WTO. While, anticipation of trading between WTO members for developing countries, which are located on a upper quantiles, had significant and larger effects on trade. For example, if two WTO members trade with each other, it boosted trade by 43.79 percent and 95.62 percent for 70th and 90th percentiles, respectively, in 2001. The coefficient estimates for WTO joint membership are substantially smaller in magnitude for across all quantiles in the DR models than that for the PPML model.

The findings for FTAs are different from those for WTO joint membership. The coefficient estimates are positive and statistically significant for all the quantiles reported. However, compared to WTO joint membership, FTAs decrease in magnitude for upper quantiles. This

is consistent with *a priori* expectation, as developing countries benefit more from FTAs than developed countries. For example, if two countries have free trade agreement, then FTAs increase trade by 271.73 percent for the 50th percentile and by 110.22 percent for 90th percentile in 2001. The coefficient estimates are larger for FTAs and significantly smaller in magnitude for quantile models than that for PPML. PTAs negatively effect bilateral trade of dairy products and the coefficient estimates are significant only for 60th percentile.

The friction variables are all statistically significant in Table 2, for every quantiles in columns (2)-(6). The coefficient estimates for distance and common language increase in magnitude for upper quantiles; while the opposite is true for contiguity and colony which decrease in magnitude for upper quantiles. For instance, a 1 percent increase in distance decreases the bilateral trade flows by 0.88 percent and 2 percent for 50th and 90th percentiles, respectively. These coefficient estimates are smaller than PPML findings in column (1). The results show that countries that share a common languages trade dairy products between 44.34 to 139.4 percent more than countries that do not across the models. The quantile effects for common language are relatively similar to PPML compared to the other variables observed in the study. The coefficient estimates for contiguous borders and colonial history have opposite signs compared to PPML and are a significantly larger in magnitude. These coefficient estimates for both variables decrease in magnitude for upper quantiles.

Trends of the mean and quantile coefficient estimates of NTMs inTable 3 and Table 4 are similar to those in Table 2. However, for 2008, the coefficient estimates are highly significant compared to the other two years, which could be due to the 2008 financial crisis, which had a large impact on the dairy industry. The results show a large impact of WTO on the dairy trade. These very large effects could be explained by the fact that in the years of 2001 and 2008, most of the countries in the sample were not part of WTO. Therefore, the anticipation of joining to WTO results in large coefficient estimates.

In 2016, we can see that quantile effects for NTMs are not significant, and the coefficient estimates for PPML changed in magnitude compared to 2001 and 2008. By 2016, most of

Table 2: NTMs Quantile Effects for 2001

	Mean	Percentile				
	PPML	**50th**	**60th**	**70th**	**80th**	**90th**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Log NTMs	-0.105***	0.0716**	0.0750*	0.0298	-0.0283	-0.0485
	(0.002)	(0.035)	(0.041)	(0.041)	(0.036)	(0.037)
WTO Joint	3.241***	0.207	0.196	0.363*	0.453**	0.671**
	(0.000)	(0.164)	(0.181)	(0.215)	(0.222)	(0.308)
FTAs	0.816*	1.313***	1.233***	1.219***	0.932***	0.743**
	(0.051)	(0.350)	(0.315)	(0.290)	(0.299)	(0.335)
PTAs	-1.615***	-0.188	-0.297*	-0.286	-0.216	-0.161
	(0.000)	(0.115)	(0.158)	(0.180)	(0.223)	(0.255)
Log Distance	-2.353***	-0.878***	-1.410***	-1.615***	-1.808***	-1.959***
	(0.000)	(0.310)	(0.178)	(0.112)	(0.107)	(0.105)
Common Language	0.565*	0.367***	0.576***	0.673***	0.758***	0.873***
	(0.013)	(0.139)	(0.136)	(0.133)	(0.115)	(0.149)
Contiguity	-0.525*	3.122***	2.304***	2.246***	1.687***	1.050***
	(0.010)	(0.562)	(0.441)	(0.312)	(0.270)	(0.298)
Colony	-0.041	1.226***	1.363***	1.104***	0.756***	0.727***
	(0.911)	(0.359)	(0.338)	(0.205)	(0.226)	(0.252)
Exporter FEs	Yes	Yes	Yes	Yes	Yes	Yes
Importer FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,765	14,765	14,765	14,765	14,765	14,765

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: NTMs Quantile Effects for 2008

	Mean	Percentile				
	PPML	**50th**	**60th**	**70th**	**80th**	**90th**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Log NTMs	-0.223***	0.107***	0.0708	0.0424	0.00523	-0.149**
	(0.000)	(0.037)	(0.044)	(0.048)	(0.057)	(0.062)
WTO Joint	5.285***	0.640**	0.821***	0.930***	1.082***	1.273***
	(0.0000)	(0.285)	(0.284)	(0.254)	(0.348)	(0.378)
FTAs	1.561***	1.709***	1.928***	1.861***	1.493***	1.075***
	(0.000)	(0.259)	(0.271)	(0.265)	(0.257)	(0.292)
PTAs	-1.680***	-0.384**	-0.445*	-0.510**	-0.348	-0.158
	(0.000)	(0.182)	(0.233)	(0.240)	(0.232)	(0.264)
Log Distance	-1.96***	-1.511***	-1.762***	-1.919***	-2.041***	-2.176***
	(0.000)	(0.207)	(0.138)	(0.119)	(0.106)	(0.098)
Common Language	0.776***	0.857***	0.999***	0.982***	1.028***	0.830***
	(0.000)	(0.155)	(0.147)	(0.137)	(0.139)	(0.121)
Contiguity	-0.028	2.229***	1.665***	1.357***	1.003***	0.500*
	(0.893)	(0.535)	(0.364)	(0.326)	(0.285)	(0.285)
Colony	-0.41	1.170***	1.102***	1.187***	1.275***	1.138***
	(0.150)	(0.278)	(0.353)	(0.375)	(0.305)	(0.270)
Exporter FEs	Yes	Yes	Yes	Yes	Yes	Yes
Importer FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,055	15,055	15,055	15,055	15,055	15,055

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: NTMs Quantile Effects for 2016

	Mean	Percentile				
	PPML	**50th**	**60th**	**70th**	**80th**	**90th**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Log NTMs	-0.510***	-0.0296	0.0212	0.00520	0.0304	0.0108
	(0.000)	(0.044)	(0.062)	(0.054)	(0.075)	(0.156)
WTO Joint	1.018*	0.130	0.490	0.318	0.442	0.251
	(0.012)	(0.326)	(0.329)	(0.407)	(0.377)	(0.386)
FTAs	0.451**	0.997***	1.190***	1.396***	1.441***	1.253***
	(0.032)	(0.270)	(0.267)	(0.252)	(0.276)	(0.261)
PTAs	0.173	-0.320*	-0.378*	-0.382*	-0.371	-0.160
	(0.554)	(0.166)	(0.204)	(0.213)	(0.257)	(0.281)
Log Distance	-1.041***	-1.397***	-1.682***	-1.786***	-1.848***	-1.819***
	(0.098)	(0.253)	(0.159)	(0.141)	(0.136)	(0.116)
Common Language	0.628***	0.612***	0.810***	0.867***	0.885***	0.939***
	(0.000)	(0.172)	(0.157)	(0.136)	(0.136)	(0.131)
Contiguity	0.698***	2.380***	2.039***	1.873***	1.846***	1.462***
	(0.000)	(0.665)	(0.439)	(0.356)	(0.319)	(0.280)
Colony	-0.17	1.105***	0.991***	0.840**	0.913***	0.886**
	(0.211)	(0.378)	(0.298)	(0.349)	(0.306)	(0.347)
Exporter FEs	Yes	Yes	Yes	Yes	Yes	Yes
Importer FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,759	14,759	14,759	14,759	14,759	14,759

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

the countries in the sample were part of the WTO. Therefore, we see that the coefficient estimate for WTO decreased almost by 4-times. The WTO membership could be a possible explanation for insignificant coefficient estimates of NTMs. As the WTO member countries already have strict measures implemented, the effects of NTMs disappear. Hence, we expect high collinearity between WTO and NTMs, which is as expected, given that WTO is a governing body of all the non-tariff measures.

Overall, from Table 2, Table 3, and Table 4, we can see that PPML coefficient estimates are quite different compared to those from the DR quantile models. The results show that PPML coefficient estimates are larger and negative for NTMs, compared to quantile coefficient estimates. The possible explanation is that the effects of NTMs on developing countries (those on upper quantiles) are larger and negative compared to developing countries, which drives the overall average effects.

6 Conclusion

In this study, we examine the mean and quantile effects of NTMs and trade agreements via distribution regression while controling for friction variables. The gravity model is estimated using cross-sections data with over 230 unique importer and exporter countries while fixing the sample years to 2001, 2008, and 2016, respectively, in each model.

The results show heterogeneity in coefficient estimates across quantiles for NTMs, trade agreements, and friction variables. This is the first agricultural trade study to examine heterogeneity across quanties for an agricultural commodity. As the quantiles increase (from 50th to 90th), the coefficient estimates for NTMs go from positive to negative; the effects of WTO joint membership, free trade agreements and distance increase in magnitude for upper quantiles, and opposite is true for the effect of contiguity as the coefficient estimates decline in magnitude for the upper quantiles.

The findings highlight the importance of observing quantile effects, as mean regression

analysis cannot fully capture the heterogeneous effects across countries. Distribution regression analysis give us additional insights about the determinants of international dairy trade, as we observe that the countries are quite heterogeneous.

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7 Appendix

Table 5: List of Commodities Aggregated in Dairy Products

1.	Fresh liquid milk, pasteurized, sterilized, homogenized and/or ultra heat treated
2.	Milk-based drinks
3.	Cream from fresh liquid milk, pasteurized, sterilized, homogenized
4.	Dried or concentrated milk whether or not sweetened
5.	Milk or cream in solid form, Ice cream and other edible ice such as sorbet
6.	Butter
7.	Yogurt
8.	Cheese and curd
9.	Whey
10.	Casein or lactose

Source:

7.1 NTMs Definitions

- **Sanitary and Phytosanitary (SPS):** these measures are quarantine and biosecurity measures which are applied to protect human, animal or plant life or health from risks arising from the introduction, establishment and spread of pests and diseases and from risks arising from additives, toxins and contaminants in food and feed.
- **Technical Barriers to Trade (TBT):** mandatory technical regulations and voluntary standards that define specific characteristics that a product should have, such as its size, shape, design, labelling/marking/packaging, functionality or performance.
- **Safeguard (SG):** restrict imports of a product temporarily to protect a specific domestic industry from an increase in imports of any product which is causing, or which is threatening to cause, serious injury to the industry.
- **Special Safeguard (SSG):** Temporary increase in import duty to deal with import surges or price falls, under provisions that are special to the Agriculture Agreement. This is a characteristic of developing countries.
- **Import Licences (IL):** a permit to import an indicated quantity of certain goods over a period of time.

NOTE: All these measures are governed by WTO under General Agreement on Tariffs and Trade (GATT).

7.2 Heterogeneous Effects of NTMs

Table 6: SPS Quantile Effects for 2001

Percentiles	70th	80th	90th
Log SPS	0.118*	0.0988	0.0496
	(0.064)	(0.066)	(0.094)
Log Distance	-1.611***	-1.791***	-1.971***
	(0.118)	(0.105)	(0.105)
FTAs	1.266***	1.001***	0.666**
	(0.307)	(0.294)	(0.301)
PTAs	-0.274	-0.253	-0.143
	(0.175)	(0.202)	(0.247)
WTO Joint	0.391*	0.388*	0.575*
	(0.214)	(0.215)	(0.338)
Common Language	0.701***	0.780***	0.827***
	(0.142)	(0.121)	(0.134)
Contiguity	2.215***	1.680***	1.074***
	(0.346)	(0.272)	(0.271)
Colony	1.095***	0.757***	0.712***
	(0.215)	(0.221)	(0.261)
Observations	14,765	14,765	14,765

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: SPS Quantile Effects 2008

Percentiles	70th	80th	90th
Log SPS	0.0620	0.00623	0.0358
	(0.076)	(0.105)	(0.135)
Log Distance	-1.919***	-2.042***	-2.211***
	(0.121)	(0.104)	(0.107)
FTAs	1.867***	1.488***	0.981***
	(0.258)	(0.268)	(0.277)
PTAs	-0.506**	-0.343	-0.161
	(0.236)	(0.237)	(0.264)
WTO Joint	0.973***	1.104***	1.001***
	(0.221)	(0.284)	(0.367)
Common Language	0.971***	1.035***	0.846***
	(0.137)	(0.137)	(0.120)
Contiguity	1.379***	1.000***	0.561*
	(0.338)	(0.285)	(0.303)
Colony	1.176***	1.274***	1.148***
	(0.388)	(0.316)	(0.313)
Observations	15,055	15,055	15,055

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: SPS Quantile Effects for 2016

Percentiles	70th	80th	90th
Log SPS	0.00520	0.0304	0.0108
	(0.054)	(0.075)	(0.156)
Log Distance	-1.786***	-1.848***	-1.819***
	(0.141)	(0.136)	(0.116)
FTAs	1.396***	1.441***	1.253***
	(0.252)	(0.276)	(0.261)
PTAs	-0.382*	-0.371	-0.160
	(0.213)	(0.257)	(0.281)
WTO Joint	0.318	0.442	0.251
	(0.407)	(0.377)	(0.386)
Common Language	0.867***	0.885***	0.939***
	(0.136)	(0.136)	(0.131)
Contiguity	1.873***	1.846***	1.462***
	(0.356)	(0.319)	(0.280)
Colony	0.840**	0.913***	0.886**
	(0.349)	(0.306)	(0.347)
Observations	14,759	14,759	14,759

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: SSG Quantile Effects for 2001

Percentiles	70th	80th	90th
Log SSG	0.0154	-0.0522	-0.0590
	(0.049)	(0.037)	(0.044)
Log Distance	-1.609***	-1.810***	-1.959***
	(0.114)	(0.100)	(0.104)
FTAs	1.218***	0.920***	0.757**
	(0.302)	(0.287)	(0.323)
PTAs	-0.275	-0.223	-0.169
	(0.180)	(0.214)	(0.258)
WTO Joint	0.385*	0.486**	0.700**
	(0.210)	(0.221)	(0.342)
Common Language	0.673***	0.757***	0.885***
	(0.132)	(0.116)	(0.156)
Contiguity	2.252***	1.700***	1.051***
	(0.325)	(0.265)	(0.295)
Colony	1.128***	0.757***	0.722***
	(0.207)	(0.244)	(0.258)
Observations	14,765	14,765	14,765

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: SSG Quantile Effects for 2008

Percentiles	70th	80th	90th
Log SSG	0.0609	0.0399	-0.126
	(0.056)	(0.059)	(0.085)
Log Distance	-1.922***	-2.032***	-2.190***
	(0.124)	(0.107)	(0.105)
FTAs	1.852***	1.500***	1.057***
	(0.268)	(0.274)	(0.287)
PTAs	-0.503**	-0.368	-0.166
	(0.239)	(0.243)	(0.259)
WTO Joint	0.915***	1.053***	1.256***
	(0.247)	(0.317)	(0.427)
Common Language	0.983***	1.026***	0.829***
	(0.138)	(0.144)	(0.125)
Contiguity	1.349***	1.033***	0.481
	(0.333)	(0.292)	(0.294)
Colony	1.164***	1.241***	1.116***
	(0.395)	(0.308)	(0.283)
Observations	15,055	15,055	15,055

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: SSG Quantile Effects for 2016

Percentiles	70th	80th	90th
Log SSG	0	0	0
	(.)	(.)	(.)
Log Distance	-1.785***	-1.840***	-1.818***
	(0.139)	(0.134)	(0.116)
FTAs	1.397***	1.453***	1.265***
	(0.255)	(0.261)	(0.268)
PTAs	-0.381*	-0.380	-0.156
	(0.220)	(0.248)	(0.281)
WTO Joint	0.319	0.445	0.226
	(0.403)	(0.373)	(0.382)
Common Language	0.869***	0.884***	0.940***
	(0.137)	(0.135)	(0.135)
Contiguity	1.868***	1.867***	1.490***
	(0.355)	(0.300)	(0.291)
Colony	0.849**	0.910***	0.838**
	(0.377)	(0.302)	(0.338)
Observations	14,759	14,759	14,759

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$