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Heterogeneous time zone effects and exports

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Abstract

The negative effect of time zone differences on trade flows due to an increase in trade costs across country-pairs has been well established in the literature. Recent studies also find trade cost elasticity to be heterogeneous across country-pairs and across the distribution of trade flows. We use a quantile estimation to examine whether time zone differences have heterogeneous effects along the conditional distribution of exports. This estimation enables us to identify the log-linear gravity model with zero trade flows. We find that the negative between time zone differences and trade is driven mainly by country-pairs that trade the least. Specifically, we find that while time zone differences negatively impact trade in general, these differences affect countries at the low end of the trade distribution (10th percentile) more compared to higher end of the trade distribution (90th percentile). Our results further demonstrate the potentially large fixed costs associated with trade, especially for country-pairs that trade the least.

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1 Introduction

The negative effect of distance on trade is well established (Anderson and van Wincoop 2003; Eaton and Kortum 2002). It is less clear what distance may proxy for, though. Transportation costs are a strong contender, but this does not fully explain the negative distance effect (Obstfeld and Rogoff 2000). Despite the absence of transportation costs, the negative distance effect is still present in services and financial capital trade (Portes et al. 2001). Huang (2007) suggests that the distance measure proxies for unfamiliarity between countries that increases with physical distance. To reconcile this discussion in the distance literature, Stein and Daude (2007) introduce a time zone difference measure to capture the increased communication costs associated with longitudinal distance because they argue that a failure to account for this increased cost leads to overestimation of the negative distance effect. Stein and Daude (2007), along with Hattari and Rajan (2012), find a negative relationship between time zone differences and trade.

Time zone differences deter trade due to increased communication costs resulting from offices in different locations where workers may have to work unusual hours due to the lack of overlapping traditional working hours. This results in additional compensation for these workers, raising the corporate labor costs of doing business in locations that are far apart in terms of time zone differences (Stein and Daude 2007). Egger and Larch (2013) suggest that large time zone differences decrease opportunities of direct personal interaction while Anderson (2014) suggests that time differences raise the non-pecuniary costs of travel and communication, which affects the establishment and maintenance of trading opportunities or networking. Therefore, the literature argues that increases in time zone differences represent increases in trade costs for country-pairs. Theoretical trade models argue that countries must reach a threshold productivity level before exporting makes sense, which depends on country-pair specific trade costs (Bernard et al. 2003; Melitz 2003).

We extend the time-zone literature by examining whether increases in time zone differences affects trade differently for country-pairs that have high levels of exports compared to country-pairs with low levels of exports. As time zone differences represent an increase in the cost of doing business, we argue that the impact of time zone differences should be more relevant for country-pairs that trade at the lower end of the export distribution. Our hypothesis is based on studies that find substantial differences in country-pair specific trade cost elasticities (Bas et al. 2017; Novy 2013) and, more importantly, that these elasticities depend on the level of trade itself (Bas et al. 2017; Spearot 2013). Spearot (2013) shows that the elasticity of trade with respect to a reduction in tariffs is a function of the level of trade while Bas et al. (2017), in the context of trade liberalization, find the trade cost elasticity to be larger (in absolute value) for country-pairs with a low volume of bilateral trade flows. Novy (2013) shows that the intensity of trade between country-pairs has a large impact on how much trade costs matter, while Baltagi and Egger (2016) find that trade costs differ in a statistically meaningful way across the quantiles of the conditional distribution of bilateral exports. Therefore, we expect the negative impact of time zone differences on trade to be larger for country pairs that have low levels of exports.

We use a quantile regression estimation technique to examine the effect of time zone differences on the distribution of trade flows. We find that an increase in time zone differences impacts country pairs with low trade flows much more compared to countries with high trade flows. These findings are consistent with studies that suggest heterogeneity in trade costs across country-pairs and across the trade distribution. Although country-pairs do not have any control over the physical distance between them, they can possibly adjust their time zones. Further, our findings demonstrate that distance remain a formidable fixed cost, particularly for country-pairs that trade the least.

2 Econometric Model and Data

2.1 Censored Quantile Model

In general notation, the gravity model of trade can be represented by a simple exponential model:

$$X_{ijt} = \exp\left(z_{ijt}\beta\right)\eta_{ijt}, \tag{1}$$

where X_{ijt} is total positive trade flows, z_{ijt} is the set of covariates widely used in the trade literature and η_{ijt} is a non-negative random variable such that $E\left(\eta_{ijt}|z\right) = 1$. The gravity equation is usually transformed into a linear model by taking logarithms, which yields the following log specification:

$$\ln X_{ijt} = \beta z_{ijt} + \ln \eta_{ijt}, \tag{2}$$

In the absence of heteroskedasticity, we can obtain unbiased and consistent coefficients by considering an OLS estimation of the log-linear model (2). However, as shown in Santos Silva and Tenreyro (2006), the OLS estimator of log-linear gravity equations will be severely biased in the presence of heteroskedasticity. However, the log-linear model is robust to heteroskedasticity issues when estimated by a quantile regression (QR) (Baltagi and Egger 2016), as the QR model is able to identify both exponential (1) and log-linear (2) models (Figueiredo et al. 2016).

In addition to being robust under heteroskedasticity and outliers, the QR model has the ability to capture the parameter heterogeneity across quantiles (Baltagi and Egger 2016). Hence, we have the following QR specification:

$$Q_\tau\left[\ln X_{ijt}|z_{ijt}, \alpha_{it}, \alpha_{jt}\right] = \alpha_{it}(\tau) + \alpha_{jt}(\tau) + z_{ijt}\beta\left(\tau\right). \tag{3}$$

where $\beta(\tau)$ is a vector of coefficients which now measures the impact of z_{ijt} on the τ^{th} conditional quantile of $\ln X_{ijt}$. $\alpha_{it}(\tau)$ and $\alpha_{jt}(\tau)$ represents the quantile coefficients on the time varying exporter and importer fixed effects intended to capture the multilateral resistance terms.

However, equation (3) assumes that observed trade flows (X_{ijt}) are strictly positive. This feature is a problem for log-linear models such as (2) and (3), because the log of zero is not defined. We assume the presence of zeros is due to data rounding (Dutt et al. 2013; Head et al. 2010) and build upon the literature of lognormal Tobit models (Cameron and Trivedi 2009). In this framework, a non-negative latent variable X is defined by an exponential model like (1) but we only observed

$$X^*_{ijt} = \begin{cases} X_{ijt} & \text{if} \quad \ln X_{ijt} > \gamma \\ 0 & \text{if} \quad \ln X_{ijt} \leq \gamma \end{cases} \tag{4}$$

Thus, X_{ijt} equals zero whenever $\ln X_{ijt} \leq \gamma$(or $f_{ijt} < \exp(\gamma)$). Therefore, the observed data of $\ln X_{ijt}$ are

$$\ln w_{ijt} = \begin{cases} \ln X_{ijt} & \text{if} \quad X_{ijt} > \exp(\gamma) \quad \text{or} \quad (\ln X_{ijt} > \gamma) \\ \gamma & \text{if} \quad X_{ijt} \leq \exp(\gamma) \quad \text{or} \quad (\ln X_{ijt} \leq \gamma) \end{cases} \tag{5}$$

The parameters of the latent model are estimated by using the observed data $\ln(w_{ijt}) = \max(\gamma, \ln X_{ijt})$ which contains observations of the dependent variable above and at γ. Therefore, based on the equivariance property of the quantile function, our censored quantile regression model for the latent variable is given as :

$$\begin{aligned} Q_\tau \left[\ln(w_{ijt}) \,|z_{ijt}\right] &= \max\left(\gamma, Q_\tau \left[\ln X_{ijt}|z_{ijt}\right]\right) \\ &= \max\left(\gamma, z_{ijt}\beta(\tau)\right). \end{aligned} \tag{6}$$

Following Galvao et al. (2013), equation (6) is estimated by a three-step procedure. In the first step, we estimate a probability function that predicts the probability of an observation being censored. We then collect a sub-sample of observations for which the probability of censoring is low. This process allows us, in the second step, to estimate a linear – rather than censored linear – model of the conditional quantile function on the sub-sample that includes both censored and uncensored selected observations. In the third step, we repeat the steps above to gain parameter efficiency.

2.2 Data

We use an unbalanced panel with 149 countries for the time period 1965-2010 at 5-year intervals.[1] The data for trade flows are retrieved from Feenstra et al. (2005). Our dependent variable has 42% of flows equal to zero (391,213 observations with 167,028 of trade flows equal to zero). The common gravity control variables such as distance, common border, language, and colonial ties are collected from the The Center for Prospective Studies and International Information (CEPII).[2] Our main variable of interest is the time zone differences between country-pairs which are measured by the absolute difference in time zones between capital cities of countries i and j. We consider the absolute time zone difference based on theoretical implications that the time of day between two countries is important, not the overall time zone difference. For example, in standard time, Australia (UTC + 11) is 15

[1] The implementation of exporter-by-year and importer-by-year fixed effects to proxy for the multilateral resistance terms results in an extremely large number of interaction terms in the regression. Therefore, we opted to use 5-year intervals instead of annual data.

[2] Available here: http://www.cepii.fr/CEPII/fr/bdd_modele/presentation.asp?id=6.

Table I: Baseline Model

	$\tau = 0.10$	$\tau = 0.25$	$\tau = 0.50$	$\tau = 0.75$	$\tau = 0.90$
Absolute Time Zone Difference	-0.111***	-0.093***	-0.051***	-0.031***	-0.023***
	(0.028)	(0.015)	(0.005)	(0.011)	(0.009)
log of Distance	-1.212***	-1.057***	-1.034***	-0.801***	-0.702***
	(0.021)	(0.041)	(0.005)	(0.031)	(0.110)
Border	0.362***	0.406***	0.531***	0.502***	0.525***
	(0.012)	(0.010)	(0.022)	(0.013)	(0.103)
Language	0.662***	0.657***	1.08***	0.548***	0.5068***
	(0.181)	(0.101)	(0.023)	(0.112)	(0.128)
Colony	0.911***	0.993***	1.071***	1.102***	1.112***
	(0.163)	(0.102)	(0.145)	(0.177)	(0.201)
RTA	0.562***	0.551***	0.457***	0.387***	0.324***
	(0.112)	(0.015)	(0.027)	(0.055)	(0.078)
Observations	391,213	391,213	391,213	391,213	391,213
Importer-by-year fixed effects	yes	yes	yes	yes	yes
Exporter-by-year fixed effects	yes	yes	yes	yes	yes

Note: *** indicates p-value less than 0.01, ** less than 0.05 and * less than 0.10.

hours ahead of Canada (UTC -4) but this is equivalent to a 9 hour daily time zone difference; if it is at 8:30 AM on Tuesday in Canada, then it is 11:30 PM on Tuesday in Australia.[3]

3 Results

The average relationship estimated by the OLS can mask the heterogeneous effect between time zone differences and various levels of the trade flows distribution. One of the reasons that countries may trade at the lower end of the distribution could be due to the relatively higher trade costs they face. Novy (2013) shows that the level or volume of trade flows between two countries can significantly impact if and by how much trade costs matter. Therefore, an increase in country-pair specific costs, such as time zone differences, can make these countries more responsive to changes in trade costs. Our approach allows us to capture the potential asymmetric effect of time zone differences across quantiles of the trade flows distribution.

Table I reports the results for the impact of time zone differences on the distribution of trade, inclusive of zero trade flows. The results show that the impact of time zone differences

[3] UTC stands for "coordinated universal time." The standard time zone measure ranges from -12 to +14. We derive time zone differences by subtracting one UTC from the other. For example, 11 - (-4) yields the 15-hour time zone difference between Australia and Canada. Absolute time zone difference is measured on a 12 hour scale. We derive the absolute time zone difference by subtracting the time zone difference from 24. In our example, 24 - 15 = 9 hours of absolute time zone difference.

Table II: Robustness Check: Alternative Distance Measures

	$\tau = 0.10$	$\tau = 0.25$	$\tau = 0.50$	$\tau = 0.75$	$\tau = 0.90$
Absolute Solar Time Difference	-0.092***	-0.075***	-0.043***	-0.029***	-0.019***
	(0.014)	(0.011)	(0.005)	(0.005)	(0.003)
log of Cargo Distance	-0.690***	-0.672***	-0.501***	-0.456***	-0.401***
	(0.010)	(0.017)	(0.010)	(0.011)	(0.025)
log of Absolute Difference in Latitude	-0.033***	-0.026	-0.022***	-0.045***	-0.046***
	(0.010)	(0.019)	(0.002)	(0.010)	(0.011)
log of North-South Distance	0.031	0.056***	0.172***	0.154***	0.159***
	(0.029)	(0.023)	(0.014)	(0.022)	(0.033)
log of Distance	-1.190***	-1.202***	-0.964***	-0.744***	-0.611***
	(0.124)	(0.114)	(0.120)	(0.127)	(0.181)
Border	0.501***	0.539***	0.583***	0.604***	0.652***
	(0.034)	(0.023)	(0.020)	(0.033)	(0.031)
Language	0.453***	0.580***	0.657***	0.702***	0.703***
	(0.192)	(0.111)	(0.152)	(0.203)	(0.218)
Colony	0.992***	1.001***	1.236***	1.255***	1.373***
	(0.255)	(0.234)	(0.203)	(0.205)	(0.200)
RTA	0.452***	0.300***	0.277***	0.256***	0.138***
	(0.154)	(0.102)	(0.090)	(0.143)	(0.163)
Observations	391,213	391,213	391,213	391,213	391,213
Importer-by-year fixed effects	yes	yes	yes	yes	yes
Exporter-by-year fixed effects	yes	yes	yes	yes	yes

Note: *** indicates p-value less than 0.01, ** less than 0.05 and * less than 0.10.

is more pronounced at the lower end of the trade distribution relative to the upper end. The coefficients along the trade distribution are both statistically significant and statistically different from each other. Our estimates show that a one hour increase in the time zone difference between countries lowers trade by approximately 10.5% for country-pairs at the lowest end of the trade distribution compared to only 2.3% for those at the high end of the trade distribution. These numbers are consistent with what other studies find for the average effect, with the difference being that our estimates consider the impact along the distribution of trade (Anderson 2014; Bista and Tomasik 2017; Egger and Larch 2013). These results indicate that the impact of increases in trade costs such as time zone differences are heterogeneous across the distribution of total trade flows. Our results are consistent with past studies that suggest that trade cost elasticity varies across countries and depends on the level of trade between country-pairs.

In Table II, we examine the robustness of our estimates. First, we use solar time differences as an alternative to absolute time zone differences. Anderson (2014) explains that the latter may be sensitive to reverse causality, as governments establishing time zones within their country likely consider the business implications prior to doing so. Second, we use cargo distance, absolute latitude distance, and North-South distance as alternatives to great-circle distance to mitigate potential omitted variable bias issues discussed in Anderson (2014). We gather cargo distance data from Bertoli et al. (2016) and generate the other distance measures and solar time difference using Anderson (2014). Our results are qualitatively robust to these alternative variable choices. We still see that a one hour increase in time zone differences decreases trade more for countries at the low end of the trade distribution (8.8%) relative to the high end (1.9%).

4 Conclusion

Several studies find a negative impact of time zone differences on trade. We contribute to the existing literature by examining the impact of time zone differences across the distribution of trade flows. We hypothesize that the negative impact of time zone differences should be more pronounced for country-pairs with low levels of trade flows. We use quantile regression to examine this possibility and find substantial heterogeneity in the response of trade flows to increases in time zone differences. We find that an increase in time zone differences affect country-pairs at the low end of the trade distribution more compared to higher end of the trade distribution. Our results are robust to the inclusion of zero trade flows, as well as alternative measures of time zones and distance. Our results highlight the persistent impact of fixed costs as a barrier to trade, especially for country-pairs that trade the least.

References

Anderson, E. (2014). Time differences, communication and trade: longitude matters ii. *Review of World Economics 150*(2), 337–369.

Anderson, J. E. and E. van Wincoop (2003, March). Gravity with gravitas: A solution to the border puzzle. *American Economic Review 93*(1), 170–192.

Baltagi, B. H. and P. Egger (2016, Feb). Estimation of structural gravity quantile regression models. *Empirical Economics 50*(1), 5–15.

Bas, M., T. Mayer, and M. Thoenig (2017). From micro to macro: Demand, supply, and heterogeneity in the trade elasticity. *Journal of International Economics 108*, 1 – 19.

Bernard, A. B., J. B. Jensen, and P. K. Schott (2003, April). Falling trade costs, heterogeneous firms, and industry dynamics. Working Paper 9639, National Bureau of Economic Research.

Bertoli, S., M. Goujon, and O. Santoni (2016). The cerdi-seadistance database.

Bista, R. and R. Tomasik (2017). Time zone effect and the margins of exports. *The World Economy 40*(6), 1053–1067.

Cameron, A. and P. Trivedi (2009). Tobit and selection models.

Dutt, P., I. Mihov, and T. V. Zandt (2013). The effect of wto on the extensive and the intensive margins of trade. *Journal of International Economics 91*(2), 204 – 219.

Eaton, J. and S. Kortum (2002). Technology, geography, and trade. *Econometrica 70*(5), 1741–1779.

Egger, P. H. and M. Larch (2013). Time zone differences as trade barriers. *Economics Letters 119*(2), 172 – 175.

Feenstra, R. C., R. E. Lipsey, H. Deng, A. C. Ma, and H. Mo (2005, January). World trade flows: 1962-2000. Working Paper 11040, National Bureau of Economic Research.

Figueiredo, E., L. R. Lima, and G. Schaur (2016). The effect of the euro on the bilateral trade distribution. *Empirical Economics 50*(1), 17–29.

Galvao, A. F., C. Lamarche, and L. R. Lima (2013). Estimation of censored quantile regression for panel data with fixed effects. *Journal of the American Statistical Association 108*(503), 1075–1089.

Hattari, R. and R. S. Rajan (2012). Sources of foreign direct investment flows to developing asia: The importance of time zone. *China Economic Policy Review (CEPR) 01*(02).

Head, K., T. Mayer, and J. Ries (2010). The erosion of colonial trade linkages after independence. *Journal of international Economics 81*(1), 1–14.

Huang, R. R. (2007). Distance and trade: Disentangling unfamiliarity effects and transport cost effects. *European Economic Review 51*(1), 161 – 181.

Melitz, M. (2003). The impact of trade on intra-industry reallocations and aggregrate industry productivity. *Econometrica 71*, 1695–1725.

Novy, D. (2013). International trade without ces: Estimating translog gravity. *Journal of International Economics 89*(2), 271–282.

Obstfeld, M. and K. Rogoff (2000). [the six major puzzles in international macroeconomics: Is there a common cause?]: Discussion. *NBER Macroeconomics Annual 15*, 411–412.

Portes, R., H. Rey, and Y. Oh (2001). Information and capital flows: The determinants of transactions in financial assets. *European Economic Review 45*(4), 783 – 796. 15th Annual Congress of the European Economic Association.

Santos Silva, J. and S. Tenreyro (2006, 09). The log of gravity. *The Review of Economics and Statistics 88*(4), 641–658.

Spearot, A. C. (2013). Variable demand elasticities and tariff liberalization. *Journal of International Economics 89*(1), 26 – 41.

Stein, E. and C. Daude (2007, March). Longitude matters: Time zones and the location of foreign direct investment. *Journal of International Economics 71*(1), 96–112.