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Trade Costs: A Natural Experiment in South America

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Abstract

This paper exploits a natural experiment in South America, the Pulp Mill Conflict, that introduced a time component to geographic distances to obtain accurate estimates of the elasticity of bilateral trade with respect to transport costs. Due to the construction of a pulp mill near a shared river, concerned Argentinian environmentalists blocked the main access to Uruguay as a (pacific) means of protest. As a result, the distances between Uruguay and several trading partners were temporarily extended. This distance shock presents a rare opportunity to include bilateral pair fixed effects in a gravity equation setting to account for all bilateral characteristics other than the time-varying distances. In addition, this paper exploits a unique database of both trade by land and actual land distances. The estimation results indeed show that the distance effect is much smaller (over 50% less) than the typical gravity model estimates, suggesting that the latter are overestimated and represent not just transport costs but also other country-pair characteristics.

Keywords: Distance, Trade, Natural Experiment, Gravity equation

Códigos JEL: F1, F15, O54

Trade Costs: A Natural Experiment in South America

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1 Introduction

"There is very little that we economists fully understand about global trade but there is one thing that we do know–commerce declines dramatically with the distance. It's not a small world". Leamer (2007)

It is well documented in the field of empirical international trade that distance has a negative impact on bilateral trade volumes. Ever since Jan Tinbergen's (1962) first gravity model for trade flows, increases in geographic distance were found to reduce trade significantly between country pairs. The distance effects in the literature are quite large, robust to different country samples and methodologies, and highly persistent. In their Meta-Analysis, Disdier and Head (2008) compile and examine 1467 distance effects, found in over a hundred papers, and report that the estimated distance elasticities range between -0.3 and -1.6, with a weighted mean effect of around (minus) one: a one percent increase in distance is associated to a one percent decline in trade. In addition, they show that the distance elasticity rose after 1950 and remained persistently high since then, and Leamer (1993) reports that it changed very little from 1970 to 1985 for OECD countries.

Despite this overwhelming evidence, some studies have stated concern about the accuracy of the estimates in the literature (see Grossman (1998), Hummels (1999b), and Feyrer (2009)). The gravity equation can be derived from various different trade models, from Ricardian to heterogenous firms.[1] In all of these settings geographic distance is a proxy for bilateral trade barriers, particularly transport costs. The technology of transportation, however, has improved considerably over the past century, which led to a sharp decline in transport costs. Why has the empirical distance coefficient, then, remained so stable? Chaney (2008) offers a theoretical explanation based on the need of a direct interaction between firms and clients. Since this will not be affected by transportation or communication

[1] Some of the most well-known gravity equation derivations are from Anderson (1979), Helpman and Krugman (1985), Anderson and Van Wincoop (2003), Eaton and Kortum (2002), Chaney (2008), and Arkolakis, Costinot, and Rodríguez-Clare (2012).

technology, the distance effect is expected to remain unchanged.

Grossman (1998) and Glaeser and Kohlhase (2004), among many others, argue that the typical distance effects from gravity model estimates are too large to represent just transport costs. In fact, distance is the only bilateral pair variable present in the models from which the gravity equation is derived. In any empirical exercise, this variable will be capturing all bilateral characteristics (including transport costs) that affect trade between each country pair. Several of these characteristics, like whether language, religion, border or currency are shared by the bilateral pair, have been historically included in the estimations, taking away some importance from distance. But there still exist unobservable factors, such as shared tastes, that are correlated with distance and, because they cannot be measured and (thus) accounted for, will lead to a bias in the distance estimates.

The aim of this paper is to estimate the causal relationship between distance and bilateral trade by exploiting a natural experiment, the Pulp Mill Conflict, that took place in South America. This conflict between Argentina and Uruguay arose with the construction of a pulp mill in the Uruguayan side of a river which is shared between the two countries (Uruguay River). The pulp industry is among the top soil, water, and air polluters in the world, and thus concerned Argentinian environmentalists decided to block the primary access to Uruguay as a means of protest. The conflict posed (very rare) shocks to distances: the blockade of the main bridge connecting Argentina with Uruguay from December 2006 to June 2010. Land distances between the two were extended since the bridge constitutes the shortest land route. In addition, distances between Uruguay and other MERCOSUR countries (Chile, Bolivia, Peru, and Ecuador) were also affected since their shortest land route with Uruguay is through Argentina.

The Pulp Mill conflict introduces a time component to bilateral distances, as these changed between 2005-2006 (extended) and also between 2010-2011 (reduced). This time variation in distance allows for the incorporation of bilateral pair fixed effects that will control for all of the time-constant unobservables. Note that the variation is in distances by land, which is how much of the intra-MERCOSUR trade is done due to the geography of the area, infrastructure, and relative costs. Therefore, by taking advantage of this natural experiment, the estimated distance elasticity will more accurately reflect the effect of transport costs on bilateral trade than previous estimations. In addition, this paper also takes advantage of a unique dataset of both trade by transport mode in South America as well as distances by land (calculated using real trade land trade routes). The estimation results indeed show that the distance effect is much smaller (about 40% less) than the typical gravity model estimates, suggesting that the latter represent not just transport costs but also other bilateral characteristics.

The remainder of the paper is organized as follows. Section 2 provides a short review of the extensive literature on the distance elasticity of trade. Section 3 describes in detail the paper's natural experiment: the Pulp Mill Conflict between Argentina and Uruguay, which started as a diplomatic crisis and ended with a (pacific) blockade of the main bridge connecting the two. Section 4 discusses the gravity model used to estimate the distance effects. Section 5 reports the main findings, both from the fixed effects estimation that exploits the natural experiment as well as the "counterfactual" traditional gravity estimation (for comparison purposes). Finally, Section 6 concludes.

2 Literature Review

There is strong empirical support for the gravity equation, and a particularly large literature concerned with estimating the effects of geographic distance on bilateral trade. Many of these studies, which involve different countries, time periods, and methodologies, have been summarized in the meta-analysis performed by Disdier and Head (2008). They analyze 1467 distance effects, found in 103 papers, and reveal that the estimated distance elasticities range from -0.28 to -1.55, with a weighted mean effect of 1.07 and an unweighted mean effect of -0.91. In their own words, "On average, then, a 10% increase in distance lowers bilateral trade by about 9%".[2] In addition, the authors report that the distance effect increased from

[2]Blum and Goldfarb (2006) find that this strong distance effect even holds for digital goods consumed over internet (where trade costs are presumably zero). Using data on consumption by US households over

1870 to 1950 and has remained stable since then. Since distance proxies for transport costs and these, together with freight costs associated with long distances, have declined sharply in time (see Hummels (1999a) and Frances (1997)), the persistence in the distance coefficient is known as the *distance puzzle*.

A whole new strand of the literature has emerged to try to explain this distance puzzle. On the theoretical side, Chaney (2008) develops a model, based on a stable network of importers and exporters, to explain the role of distance in a gravity equation. The idea is that firms have two ways of dealing with trade costs: creating a new foreign contact and interacting with the existing ones to learn about their own contacts. Changes in transportation or communication technology (that reduce costs) will affect the first but not the second channel. So as long as there exists direct interaction between firms and clients, the distance effect should remain unaffected since the firms that export the most are those with the largest number of contacts. Other authors point towards a composition effect[3] to explain persistence in distance. For instance, Duranton and Storper (2008) develop a model of vertically linked industries where lower transport costs can induce firms to use higher quality inputs that raise overall trade costs. Berthelon and Freund (2008), however, find no evidence of the composition of trade playing a role in how distance affects world trade.

Empirical studies can be divided into two large groups: one concerned with the estimation strategy and the other one with the distance variable itself. The first group includes Silva and Tenreyro (2006), among others, who argue that OLS estimation of the log-linear gravity equation exaggerates the role of geographical proximity in the presence of heteroskedasticity. They suggest that (constant elasticity) gravity models are estimated in their multiplicative form using a pseudo-maximum-likelihood (PML) estimation procedure. Most studies, however, agree that the distance coefficient in typical gravity model estimations reflects much more than transport costs: it captures many other components of bilateral trade costs. These include tariff and non-tariff barriers, cultural aspects like colonial ties or religion, and all types of transaction costs (regulatory barriers, different currencies for transactions,

the internet (non-US websites), they find a distance elasticity 3.25% for taste-dependent products.

[3]a change in the composition of traded goods

contract enforcement and other legal costs, etc.).

Grossman (1998) argues that because actual transport costs are very low, they can only explain a fraction of such large distance effects. He suggests that the rest is explained by (the lack of) familiarity, which includes common polity, language and culture, and thus emphasizes the need for new models "where familiarity declines rapidly with distance". Hummels (1999b) estimates the technological relationship between transport costs and distance, experimenting with different functional forms. Using data on freight rates, he finds distance effects in the (negative) 0.2 - 0.3 range and argues that distance is not only proxying for transportation costs but also many other factors such as preferences. Freund and Weinhold (2004) study the effects of technology on distance (through a decrease in transaction costs) by looking at the effect of internet on international trade. They find internet-led export growth as well as evidence that this growth decreases with distance.

Finally, there is a more recent literature that estimates these trade costs within countries. Donaldson (2018) finds that new transportation infrastructure in colonial India, the construction of a railroad network by the British government, decreased trade costs and increased trade, both at the national and subnational levels. Because of lower trading costs, some districts could start exploiting their comparative advantage and real incomes increased. Faber (2014) studies China's National Trunk Highway System, which was designed to connect large cities. The author finds that, rather than a diffusion of production from metropolitan centers to the periphery, improved transport infrastructure is associated with a reduction of output growth relative to the non-connected regions. Using a new methodology that uses spatial price gaps to estimate intra-national trade costs, Atkin and Donaldson (2015) find significantly larger effects of distance on trade costs in Africa relative to the US.

In sum, the empirical evidence suggests that the typical gravity estimates suffer from omitted variable bias and that this could be the main reason behind the large and persistent distance coefficients. Including variables that might directly or indirectly influence bilateral trade costs helps to partly reduce the elasticity of distance, but does not solve the puzzle. Feyrer (2009) addresses these endogeneity concerns by using the closing of the Suez Canal in 1967 and its reopening in 1975 as a natural experiment to examine the effect of distance on bilateral trade. He exploits the time series variation in distance posed by the Suez Canal crisis and finds a distance elasticity that is about half as large as the traditional gravity model estimates and highly significant. The closing and reopening of the canal are treated as different shocks and the author shows that they both generate an elasticity of roughly 0.5. He later uses predicted trade from the shocks to measure the the effect of trade on income.

The present paper is closely related to, and was partly inspired by, Feyrer's work. However, several differences need to be discussed. Firstly, this paper uses a pacific protest (a diplomatic conflict) as opposed to a war as a natural experiment. Though both conflicts had disruptive effects on distance, wars clearly affect trade through other (time-varying) channels like communication costs, sanctions imposed by other third-parties, temporary alliances, etc. Secondly, this study covers a group of countries within a customs union. This reduces trade-related unobservables even more. In addition, because the Pulp Mill Conflict affected land routes, both data on trade by land (rather than overall trade) and data on actual trade routes for the distances (rather than great circle distances) are used.

Furthermore, this paper includes both bilateral tariffs and the country income terms (to represent country sizes) in the gravity equation. Regarding the tariffs, Feyrer (2009) assumes that only the distances are bilateral pair and time specific.[4] As for the latter, the reason to exclude them is practical rather than theoretical; the author wants to use the predicted trade from the gravity model as an instrument to measure the effect of trade on income. However, excluding these time-varying country-specific terms will lead to omitted variable bias.[5] Finally, it is worth noting that Feyrer (2009) covers the period 1967-1975. Similar results for 2010 serve to add robustness to the idea of inflated distance coefficients in the earlier literature.

[4] It can be seen, at least for South American countries, that tariffs indeed vary across pairs and time. This will be accounted for in the estimations.

[5] Unless importer-time and exporter-time effects are used as in Baier and Bergstrand (2007).

3 The Pulp Mill Conflict

Following years of forestry development policies, mostly devoted to increasing pines and eucalyptus plantations[6], in October 2003 the government of Uruguay granted Energía y Celulosa S.A. (ENCE) permission to build a pulp mill in the city of Fray Bentos. ENCE is a Spanish firm that specializes in the production of eucalyptus pulp, a main input for paper production. The Finnish firm BOTNIA, part of Metsa-Fibre Oy and also a leader in the pulp industry, later received building permits for their one million ton plant in Fray Bentos in mid February 2005. Some facts:

- The paper and pulp mill industries are among the world's major polluters through their waste disposal (mostly chemicals) into air, water and soil. In fact, in late 2004 the Chilean pulp mill Celulosa Arauco y Constitución located in Valdivia destroyed the local black-necked swan population due to excess dumping of dioxins and heavy metals. Bordado and Gomes (2002), Haahtela, Marttila, Vilkka, Jäppinen, and Jaakkola (1992), and Helland (1998), among many others, carefully describe some of the adverse effects on the environment caused by pulp mills.

- The River Uruguay starts in Brazil and flows north to south, dividing first Argentina and Brazil and then Argentina and Uruguay. Figure 2a shows the borders between the countries, the River Uruguay, and the location of the capital cities. Since the river is shared, the governments of Argentina and Uruguay signed in 1975 the Statute of the River Uruguay which aimed to establish the rights and obligations for a joint rational utilization of the river.

- Fray Bentos city is located in the Río Negro Department, western Uruguay, on the River Uruguay. It is very close (only 35km) to Gualeguaychú, an Argentinian city in the Province of Entre Ríos on the River Uruguay as well. The two cities are connected through the Libertador General San Martín bridge, one of the three bridges connecting

[6]These warm weather species grow much faster than the Nordic ones.

Argentina with Uruguay. Figure 2b shows the location of Fray Bentos, Gualeguaychú, and the bridge.

- The Libertador General San Martín bridge (henceforth, San Martín bridge) constitutes a key part of the shortest land route between Buenos Aires to Montevideo, Argentina's and Uruguay's capital cities. It is also the main access to Montevideo used from other South American capital cities like Santiago de Chile, Sucre and Quito.

Figure 1: The conflict area

(a) Overall view (b) Zoom in

The authorizations to build mills on the banks and to utilize the river granted unilaterally by Uruguayan authorities generated a deep sense of unease in Argentina, that claimed that these were in violation of the Statute of the River Uruguay. With a 1 billion dollars investment, Botnia started the construction of the plant in mid April 2005. During the second half of the year Argentinian residents of Gualeguaychú and several NGOs, concerned about potential pollution in the river, started protesting against Botnia and the installation of pulp mills in general. The Citizen's Environmental Assembly of Gualeguaychú was created (ACAG) to represent the residents' position legally and provide support for the cause (both monetary and political), and was critical for the later developments[7]. All environmental organizations were especially worried given the recent Chilean mill's devastating effects on the local wildlife, but the ACAG felt particularly insulted that a mill construction was approved right after the incidents in Chile.

On January 3rd, 2006, Argentinian protestors (ACAG plus other groups) blocked the Libertador General San Martín bridge to boycott the building of the mill. Their (correct) reasoning was that most of the materials used for the construction were being imported by land from Argentina and Chile, whose shortest land route to Fray Bentos is through the San Martín Bridge. The boycott did not succeed as the materials were brought in from other countries and the bridge was re-opened 45 days later. Other periodic blockades took place on the other two bridges, too, between January and April.

Between February and November 2006 Néstor Kirchner and Tabaré Vázquez, the presidents of Argentina and Uruguay, met on two occasions but were not able to reach any agreements. In March the Argentinian government pressed charges against Uruguay at the International Court of Justice in The Hague. The court found Uruguay guilty of violating procedural obligations prior to authorizing the construction of the mill, but it did not ban it. On November 20th, a new pacific bridge blockade took place, but this time on a more permanent basis. It lasted for three and a half years, until June 2010.

Since Uruguay is a small country (3 million inhabitants, half of them residing in the capital city of Montevideo), most of its trade with South America departs from and arrives to Montevideo by land through the San Martín bridge. Due to the blockade of the bridge, all trade between Uruguay and Argentina, Bolivia, Chile, Ecuador and Perú suffered from a distance shock. The only alternatives to get in and out of Montevideo by land were by means of the other two other bridges, the General J. Artigas International bridge (which connects Colón city with Paysandú in Argentina) and the Represa Salto Grande International bridge (which connects Salto city with Concordia in Argentina).

Figure A.1 in the Appendix shows the location of all three bridges. Both of these al-

[7]In fact, shortly after its creation, the Argentine government filed a complaint against Botnia in OEA's Human Rights Commission.

ternatives implied a longer distance; for instance, the distance between Buenos Aires and Montevideo through Fray Bentos (using Libertador General San Martín bridge) is 547km, while through the Represa Salto Grande International bridge it is 930km. There are two more bridges to access Uruguay from the north (through Brazil), but the distances become even larger.

All in all, the diplomatic crisis between Argentina and Uruguay due to the construction of a pulp mill provides a good natural experiment to estimate the distance effects in bilateral trade as it introduces a shock to distance. The bilateral conflict resulted in the blockade of the main bridge to access Uruguay by land from several South American countries, which implied that all trade by land had to be re-routed through the other (longer) accesses. The time variation in distance can be therefore exploited to obtain well-identified distance elasticities of trade.

4 The Model

4.1 The Theoretical Model

To estimate the effects of distance on bilateral trade, this paper uses a gravity model. It is, in Leamer's words, "one of the first models estimated by economists, and possibly the only important finding that has fully withstood the scrutiny of time and the onslaught of econometric technique"[8]. The idea behind it is that bilateral trade between any two countries increases with the product of their sizes (usually measured by their GDPs) and decreases with trade barriers between them such as geographic distance. Empirically, this model has proven very successful; its simplicity, strong fit to the data, and robustness across a wide range of samples and methodologies has made it a very popular empirical tool among researchers.[9] From a theoretical standpoint, even though Tinbergen's (1962) original formulation lacks microfoundations, several studies have shown that similar gravity equations can be derived

[8]See Leamer (2007).

[9]For example, Hummels and Levinsohn (1995) show that the gravity equation seems to hold up well empirically for both developed (OECD) and developing countries.

from various trade models (such as monopolistic competition, Armington model, Ricardian model, firm heterogeneity, etc.).[10] More recent work has aimed at deepening and refining its theoretical foundations in order to interpret the estimated coefficients more accurately.[11]

This paper will use the seminal model developed by Anderson and Van Wincoop (2003), henceforth "AvW". It is a general equilibrium model where goods are differentiated by place of origin, consumers have CES preferences, and prices differ across locations due to trade costs. The gravity equation is derived by solving the representative consumer's constrained optimization problem and imposing market clearance. The authors assume that bilateral trade barriers are symmetric, which makes their gravity model simple and elegant:

$$x_{ij} = \frac{Y_i Y_j}{Y_w} \left(\frac{\tau_{ij}}{P_i P_j} \right)^{1-\sigma} \tag{1}$$

subject to

$$P_j^{1-\sigma} = \sum_j P_i^{\sigma-1} \theta \tau_{ij}^{1-\sigma} \tag{2}$$

where x_{ij} denotes nominal value of exports from i to j, Y_i, Y_j and Y_w are nominal incomes of country i, its trading partner j and the world w, $\theta \equiv Y_j/Y_w$, τ_{ij} represents the bilateral trade barriers between i and j (one plus the iceberg trade costs), either observable or unobservable; and P_i and P_j are (CES) price indexes but should be interpreted as multilateral trade resistance terms since they are a function of trade barriers with all other countries rather than consumer price indices.[12] Finally, σ is the constant elasticity of substitution between any two goods.

AvW's gravity equation (1) shows that bilateral trade flows from country i to country j depend on their sizes Y, the bilateral trade barriers τ_{ij} between them, and their multilateral trade resistance terms (MRTs) P_i and P_j. The latter are just the average barriers that

[10] See Anderson (1979), Bergstrand (1989, 1990), Deardorff (1998), Eaton and Kortum (2002), Anderson and Van Wincoop (2003), and Feenstra (2015).

[11] See Bergstrand, Egger, and Larch (2013) for the history and evolution of the gravity equation, and Anderson (2011) for an extensive review on the theoretical foundations of the gravity model.

[12] see Anderson and Van Wincoop (2003) for a discussion on this issue.

countries i and j face when trading with the rest of the world (all their other trading partners), respectively. As AvW note, the key implication of their gravity model is that, after controlling for size, bilateral trade flows are determined by *relative* trade barriers (the bilateral resistance relative to the multilateral resistances). For a given bilateral resistance τ_{ij} the higher barriers between country i and the rest of the world (P_i), or between country j and the rest of the world (P_j), will increase trade flows between i and j. This insight carries other very interesting implications regarding how countries are affected differently by increases in bilateral trade costs depending on their sizes. For a detailed description and derivation, see Anderson and Van Wincoop (2003).

Taking logs of (1) and allowing for time variation,

$$ln(x_{ijt}) = ln(Y_{it}) + ln(Y_{jt}) - ln(Y_{wt}) + (1-\sigma)[ln(\tau_{ijt}) - ln(P_{it}) - ln(P_{jt})] \qquad (3)$$

The key contribution of AvW was the empirical estimation of this general equilibrium theory-based gravity equation. Before their study, most papers estimated an equation similar to (3) but ignoring the price terms or using some remoteness variables as proxies. As stated above, the multilateral trade resistances reflect all trade barriers between i and j, respectively, with the rest of the world. They are a function of *all* bilateral trade barriers, which includes τ_{ij}. This implies that the price terms are endogenous, and AvW illustrate how a bias arises if these terms are ignored. Thus, to obtain consistent estimates of the border effects, they implicitly solve for them as a function of the observables and the model's parameters using all the market clearing conditions and their conjectured trade cost function.

Regarding the bilateral resistance term τ_{ij}, most authors (including AvW) have assumed it to be a loglinear function of observable country-pair characteristics. The most usual factors used to describe the bilateral trade costs in the literature are geographic distance, tariffs, non-tariff measures (when available), and whether the countries share a border, or a language, or a currency. Limao and Venables (2001) were among the first to include infrastructure measures to capture the quality of transport and communications in the bilateral trade costs. They show that infrastructure has a large impact on transport costs, especially for landlocked countries. Some more recent articles even include historical and institutional indicators such as whether the countries were part of the same country before or had a common colonizer.[13]

However, as Arvis and Shepherd (2013) point out, the best the literature can do is to come up with just a subset of all the factors affecting trade costs. According to the authors, the problem that this generates is quite similar to that of omitting the multilateral trade resistances discussed above: the "inclusion of some variables but not others immediately gives rise to concerns about omitted variables bias, to the extent that omitted trade costs are correlated with variables included in the model". Therefore, instead of using some loglinear function of several observable pair characteristics, I will use fixed effects (FE) to account for all the components of the bilateral trade costs τ_{ij} that are constant in time, both observable and unobservable, and will control for those that are time-varying. Next section describes the methodology in detail.

4.2 The Empirical Model

Equation (3) is AvW's theory-based gravity equation, which will be used to estimate the effects of geographic distance on bilateral trade. As noted above, the main concern when estimating gravity equations is the correct specification of both the bilateral and the multilateral trade resistance terms. Failure to do so will invariably result in omitted variable bias, which seems to be quite present in the empirical gravity literature. The most recent papers, however, have managed to correctly account for one or both terms.

Regarding the price terms, before the theory-derived gravity equation emerged most authors chose to completely ignore them. Rose and van Wincoop (2001) were among the first to empirically account for the multilateral trade resistances, through the use of country-specific FE. However, when there's a time dimension in the data (i.e. panel data) these FE no longer control for the price terms properly as these do change in time (i.e. think of

[13]Bilateral trade costs in the empirical trade literature typically look like: $ln\tau_{ij} = a * ln(dist_{ij}) + b * Sborder_{ij} + c * Sreligion_{ij} + ... + f * other\_shared\_observable + g * Stastes_{ij} + ... + m * other\_shared\_unobservable$, where S stands for "shared".

tariffs or NTBs). Baier and Bergstrand (2007) use country-and-time effects to account for time-varying multilateral trade resistances.

Dealing with bilateral trade costs is much easier than doing so with the multilateral resistances, provided the aim is just to account for these as a whole (i.e. estimating the effects of all bilateral costs combined on trade). In a cross-sectional framework (no time dimension), bilateral pair FE would do the trick. The pair FE have been much used in panel settings too, under the assumption that they represent characteristics that do not usually change in time. This is true for most of the country shared characteristics one can think of (like distance, shared border, language, etc.), with the notable exception of tariffs, and is safe to assume for other shared characteristics as long as the time period in the sample is not too large.

The challenge, however, is to control for all determinants of the bilateral resistances while isolating the effect of one variable of interest. For instance, we want to estimate the impact of distance on bilateral trade while using fixed effects to control for all other bilateral determinants of trade costs. Usually, this can't be done: the fixed effects coefficient will pick-up the distance effect too. The literature has tried to solve this by including as many determinants as possible, but this invariably leads to endogeneity bias. There doesn't seem to be a solution for this in a cross-sectional context. Feyrer (2009) solves this in a panel setting: he uses the Six Day War, which brought about the closing and later reopening of the Suez Canal, as a natural experiment that provides a time-variation component to distance.

This paper also takes advantage of a natural experiment, which took place in South America, to identify the impact of geographical distance on bilateral trade. However, unlike Feyrer (2009), it will follow Baier and Bergstrand (2007) in their treatment of the multilateral trade resistances that will help avoid implausible assumptions (like constant price terms). Therefore, it will correctly account for both the price terms by using country-and-time FE and also the bilateral trade costs by using country-pair FE. In particular, the estimating equation is:

$$ln(x_{ijt}) = \alpha + \delta_{ij} + \delta_t + \delta_{it} + \delta_{jt} + \beta ln(dist_{ijt}) + \gamma ln(t_{ijt}) + \epsilon \quad (4)$$

where x_{ij} denotes exports from country i to j at time t, α is a constant, δ_{ij} are country pair fixed effects, δ_t are time fixed effects, δ_{it} and δ_{jt} are exporter-time and importer-time fixed effects (respectively), and $dist_{ijt}$ is the shortest bilateral land route distance between countries i and j at time t. Some country pairs suffered a huge distance shock due to the blockade of the bridge, as they needed to re-route some of the goods traded, while others suffered just a mild shock or none at all. For all those country pairs affected, the shortest alternative route is calculated. Thus, these will have two travel distances: one before and after the conflict and a longer one during the conflict. For the rest of the pairs, the distance before and during the conflict will be the same one. Finally, t_{ijt} are tariff rates. Even though all countries in this analysis are Mercosur members, some are just associate members. This means that while they have the same common external tariff (CET) for trade with the rest of the world, they do not enjoy zero rates with the full members. These tariffs are usually low but have fluctuated during the sample's timeframe.

Equation (4) is the empirical analog of equation (3). The income terms Y_{it} and Y_{jt} in equation (3), as well as the price terms P_{it} and P_{jt}, are being accounted for by the country-time (importer-time and exporter-time) dummies δ_{it} and δ_{jt}. The year dummies will control for (unobserved) shocks that affect bilateral trade and are time-varying but constant across country pairs, like the world's income Y_{wt} or global inflation rate trends.[14] Finally, the bilateral pair dummies δ_{ij} will capture all (observed and unobserved) factors that are constant in time but vary across country pairs such as: common language, shared border, tastes, whether they were part of the same colony in the past, etc. We can safely assume that, in the time interval covered by the sample, all pair characteristics except for distance and tariffs (which will be controlled for) are constant in time.

The bilateral pair dummies and the country-time dummies are key to the model's correct specification, as well as to the identification of the distance effect, since both the bilateral

[14] This is developed thoroughly by Baldwin and Taglioni (2006).

trade costs (except for the distance) and the multilateral trade resistances from equation (3) have been omitted. The country pair dummies can be used to run a country pairs fixed effects estimation because there is time series variation in geographic distance provided by the natural experiment. This implies that all the variation in the bilateral trade volumes will come from the change in distance generated by the the blockade of the bridge. Thus, β will accurately reflect the incidence of a change in distance travelled (or transport costs, assuming these are a linear function of distance) on bilateral trade.

The distance elasticity will be estimated for a sample of South American countries that are part of the MERCOSUR agreement. There are clear advantages in performing the analysis for this select group of countries. There is data on trade by mode of transport for these countries. This means that data on land trade can be used instead of total trade, and the distance elasticity will more accurately reflect the true distance "costs". In addition, the protests and bridge blockade were pacific; unlike Feyrer's (2009) Suez Canal case, this conflict was not a war but rather a diplomatic crisis. Therefore, there is no need to exclude the countries involved in the conflict from the sample. Since the blockade of the Libertador General San Martín bridge was not announced (nobody, not even the protestors, knew the bridge would be blocked for more than three years)[15], this estimation will serve to identify the real effects of an extra kilometer in distance on bilateral trade volumes. The distance effects obtained will therefore reflect true transportation costs and are thus expected to be lower than the usual gravity model estimates, which rather reflect some unobserved characteristics.

5 Data

All country pair observations are annual, from 2002 to 2010, and cover all 10 MERCOSUR member countries (both full and associate members): Argentina, Brazil, Paraguay, Uruguay, Venezuela (in the process of becoming full during that time frame), Bolivia, Chile, Colombia, Ecuador and Peru. A novelty of this paper is that it uses a unique dataset that contains

[15] Both the government of Argentina and Uruguay were trying to avoid a major conflict, and if an agreement had been reached the blockade wouldn't have lasted so much time.

both distances and trade *by land*.

5.1 Trade Data

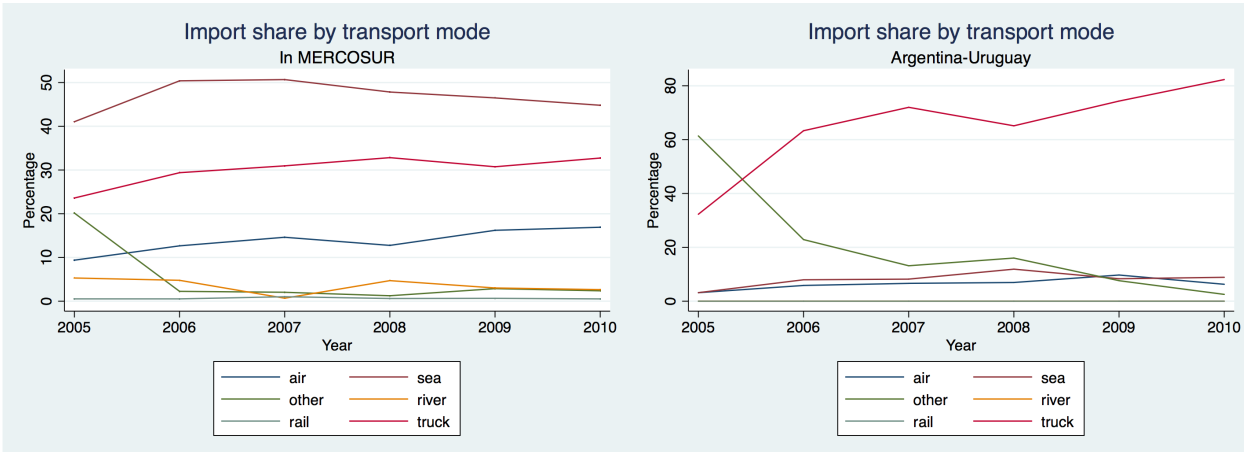
Bilateral trade data by mode of transport were obtained from UN ECLAC's International Transport Dataset, or BTI (in Spanish "Base de Datos de Transporte Internacional"). It contains bilateral imports and exports at the industry level (SITC Rev.3, 3 digits) of all South American countries disaggregated into six modes of transport: air, sea, truck, river, rail, and other (which covers rare or non-traditional modes). The source of data is BADACEL ("Banco de Datos del Comercio Exterior de América Latina y el Caribe"), which processes information of each country's national customs. Since the conflict created changes only in land distances (roads), data on bilateral trade by truck is used.

Figure 2 shows the importance of trade by land in the Mercosur countries. Panel 2a plots import shares by mode of transport for various modes for the period 2005-2010. The two main transport modes are sea and truck, which represent over 40% and 30%, respectively; far more than the other alternatives. This is due to geographic characteristics, costs, and the poor infrastructure conditions in the region; air has high marginal costs and rail requires a very large initial infrastructure investment and additional maintenance, so the network was never fully developed.[16] Panel 2b shows that the share of trade by land even dominates for some country pairs, in this case Argentina and Uruguay (where it reaches 80%). This is also the case for any pair that involves at least one landlocked country.

One concern with using only trade by land data is that there might have been a substitution in the modes of transport due to the conflict. For instance, trade by land could have been replaced by trade by sea or rail. There are several reasons why this scenario is unlikely. First, it has been documented (in newspaper articles mostly) that no one could anticipate that the conflict was going to last for so long. Moreover, as can be seen in Figure 2, the shares of trade by the different modes have remained stable in time which suggests that the

[16]See Sánchez (2003) for a detailed explanation of the infrastructure and logistic obstacles to Mercosur trade.

Figure 2



(a) (b)

conflict did not provoke a switch between them.[17]. In addition, customs data from Uruguay reveals that the switch was made at the land crossings.

Figure 3 shows the International cargo movement at each border crossing of Uruguay for the years 2003-2010. The information is from Uruguay's Transport Division, which is the only available source with data at the crossing level. As can be seen by the figures the Fray Bentos border crossing (highlighted) is the busiest in Uruguay, accounting for about a third of the total trade volumes. According to Sánchez (2003) in a study about all South American crossings by land, Fray Bentos has the best performance in terms of logistics and operations (customs times, sanitary controls, etc.) and is one of the few that can operate at full capacity. Note that the bridge was completely shut in 2007, 2008, and 2009, and the volumes for 2010 are about half the average volumes, a validation that the crossing was open for only half of that year (since June).[18] What is perhaps most striking is the abrupt increase in trade volumes for the other two alternative bridges, Salto and Paysandú during those years. The latter saw an increase of over 300% of trade volumes between 2006 and

[17]Note also that such a switch would involve considerable time and monetary costs.

[18]The 2006 volumes are also lower than previous years, which is also consistent with the fact that the blockade started in December 2006.

2007 and then a decline from 2009 to 2010.

Figure 3: International cargo movement (in tons)

Border crossing	2003	2004	2005	2006	2007	2008	2009	2010
TOTAL	2001351	2188025	2360763	2457774	2466078	2437012	2497255	2582162
Aceguá	81392	91839	33093	54029	52107	18034	0	0
Artigas	47243	49509	38513	50361	78548	48181	64590	68278
Bella Unión	114790	80385	38151	11164	14062	4183	3825	10183
Chuy	358694	427176	399824	347151	331552	238755	268876	204139
Colonia	27317	34432	42153	130803	121369	101485	98308	84450
Fray Bentos	581578	695453	826370	599473	**0**	**0**	**0**	374719
Juan Lacaze	131014	151139	182655	191612	198502	175233	180942	157888
Paysandú	37154	94496	89848	119737	512015	662705	600173	393333
Río Branco	353192	272989	366745	420960	456555	362404	468710	474963
Rivera	155283	210213	240119	263409	289513	296380	308827	274153
Salto	113694	80394	103292	269075	411855	529652	503004	540056

Source: Uruguay National Transport Division

Finally, this paper will use the well-known bilateral trade data from UN COMTRADE for robustness purposes. While the BTI total trade figures do no exactly match COMTRADE's, their correlation is very high (over .99). Note that COMTRADE's bilateral trade data is not reported by mode of transport for the time period considered in this paper.[19] For this reason, BTI data is used to construct export shares for the different modes, which are then used to re-scale COMTRADE's aggregate data. Additional adjustments relate to the units. Bilateral trade is measured in current US dollars, so data on the US CPI based to 2005 are used to scale it. These are from the World Bank's World Development Indicators (WDI) database. Baldwin and Taglioni (2006) point out that including the US aggregate price index can result in a bias as there are global inflation trends.[20] This is addressed with the inclusion of the time dummies which will capture any global trends that are year-specific.

[19]There is a 2010 addition of transport modes, but it does not cover South American countries.

[20]They name this issue the"bronze-medal mistake".

5.2 Other Data

The uniqueness of the dataset used in this paper lies not just in having bilateral trade by land but also real measures of land distances, as opposed to the usual great circle distances. Data on real land distances were collected by the author following Luraschi (2000), an official document from the Latin American Integration Association (ALADI). The publication contains very specific detail on all routes used by Mercosur country pairs, such as all stops in between origin and destination, trade volumes, state of the roads, etc. All bilateral geographic distances were calculated using Google Maps using capital cities as the points of origin and destination (since merchandise is often distributed to other cities from this point), taking the shortest existing usual land routes (measured in km).

There are a couple of advantages of using this measure of distances. First, it reflects real distances travelled both before and after the conflict better than the great circle metric, which does not exh.[21]

Note that not every distance will differ before and after the conflict. For country pairs like Argentina-Uruguay or Chile-Uruguay, the distances before and after the bridge blockade will certainly differ. For other pairs these will remain constant.

Measures of the various control variables are from different sources. For the individual income terms, data on each country's Gross Domestic Product from the WDI database are used. Again, as GDP is in current US dollars, the US CPI is used to deflate. In addition, data from CEPII's gravdata dataset is used for the traditional controls (common language and shared border). Great circle distances were also obtained to compare with the distance measure used; their correlation is .98 before the bridge blockade. Tariffs are also included in the robustness checks. As mentioned in the previous section, these have varied for those pairs that are not (both) full-members of Mercosur during the period 2002-2010. The tariff data is from UNCTAD's TRAINS, and was obtained through WITS.

[21] Though their correlation is quite high pre-conflict.

6 Empirical Results

Table 1 shows the results of estimating equation (4) for all Mercosur countries from 2002 to 2010. For comparison purposes, it goes from the most typical gravity equation estimations to this paper's (preferred) specification in the last column. The idea is to present several counterfactuals of the estimates that would have been obtained in the absence of the natural experiment, or neglecting (as usual in the literature) the time-varying multilateral trade resistances. The table starts with the usual OLS estimates, then takes advantage of the natural experiment to identify the coefficients a la Feyrer, and finally arrives to the chosen Baier and Bergstand inspired formulation.

Column (1) reports the traditional gravity specification (a pooled OLS in this case), which includes bilateral controls (shared border and language) but no time or fixed effects. Column (2) adds time dummies to the previous specification. The literature exhibits several versions of these estimations, which include a myriad of bilateral controls (usual dummies of common characteristics such as language, border, religion, colonizer, legal system, currency, FTA, etc.) and country fixed effects.[22] Estimation results are, as expected, in line with the literature. The elasticity of trade volumes with respect to distance is negative, high, and highly significant. A 10% increase in geographic distance is associated with a 10% decrease in bilateral trade. This effect is notoriously close to the mean elasticity of -0.9 reported by Disdier and Head (2008) and works as a good comparison base for the following fixed effects estimations. The income elasticities are high, positive, and highly significant. The border variable is positive and highly significant, while language is negative. This is due to all countries being Spanish-speaking except for Brazil, which is everyone's main trading partner. The problem with this specification is that it is unlikely that we are able to account for all bilateral factors that affect trade. Therefore, the distance effect will probably not just reflect transport costs but also other (unobservable) pair characteristics.

Like in Feyrer (2009), this paper takes advantage of a natural experiment that introduces a time component to geographic distances. The blockade of the bridge connecting Argentina

[22] See Disdier and Head (2008) for a survey.

Table 1: Estimation of gravity equation (4) using various specifications

	No fixed/time effects	+ time effects	+ pair FE	+ country-time FE
	(1)	(2)	(3)	(4)
$ln(dist_{ijt})$	-1.000***	-1.129***	-0.608***	-0.411**
	(0.0229)	(0.0202)	(0.159)	(0.197)
$ln(GDP_j)$	0.698***	0.753***	1.734**	
	(0.0113)	(0.0104)	(0.685)	
$ln(GDP_i)$	0.267***	0.237***	1.144*	
	(0.00939)	(0.00789)	(0.679)	
border	0.353***	0.623***		
	(0.0319)	(0.0286)		
language	-0.634***	-0.772***		
	(0.0356)	(0.0308)		
N	54837	54837	54837	54837
R^2	0.150	0.376	0.340	0.353
adj. R^2	0.150	0.373	0.337	0.348

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

to Uruguay implied increased trade distances by land, so the shock allows to identify the distance effect by including bilateral pair fixed effects to control for all time-constant characteristics. Column (3) shows the result of the panel estimation with both time and bilateral pair fixed effects. This is the same specification that Feyrer (2009) uses to exploit the time series variation in geographic distance due to the closing of the Suez Canal, except that it also includes the country income terms.[23] In line with that study, the distance coefficient is much smaller than the previous estimate (almost half), and highly significant. This result seems to suggest that the gravity model estimates inflate the distance effect by failing to account for all bilateral factors that affect trade. An important limitation of this specification, however, is it ignores the multilateral trade resistance terms. Baier and Bergstrand (2007) argue that these terms are time-varying, so the bilateral pair fixed effects will not be enough to account for them. Their omission will result in an omitted variables bias unless additional (time-varying) effects are used. This formulation is therefore not theory motivated, and is only showcased here for comparison purposes (with the Suez Canal estimates).

Finally, column (4) presents the estimation results of the preferred specification. It incorporates the *country-and-time* (it, jt) fixed effects to control for the multilateral trade resistance terms. The obtained distance elasticity is negative, significant, and much lower: over 50% less than the typical gravity estimates obtained with OLS (and also lower than the specification that ignores the trade resistances). In particular, a 10% increase in geographic distance reduces bilateral trade in less than 5%. As mentioned above, the identification of this distance effect is provided by the time series variation in distances. Note that the country income terms disappear since they are accounted for by the country-and-time effects, and the border and language controls disappear as they are accounted for by the bilateral pair fixed effects. These results support the hypothesis that the usual distance elasticities are overestimated.

Table 2 tests the robustness of these estimates, based on the last specification of Table 1. One concern with this preferred specification is that it assumes that all bilateral pair

[23]These terms belong in the gravity equation, as can be seen from its derivation, and should not be excluded since they are likely to cause an omitted variable bias.

effects, except for distance, are constant in time and will be picked up by the pair fixed effects. While it is hard to imagine many time-changing bilateral characteristics, tariffs are the obvious suspect. As was argued previously, tariffs between Mercosur full members and associate members (i.e. Argentina and Chile) as well as between associate members (i.e. Chile and Ecuador) have fluctuated in time. The first two columns of Table 2 report the results when tariffs are added. In Column (1) the estimated distance elasticity is still negative, significant, and lower than one half. The effect of tariffs appears to be positive (though small) and significant, which might just reflect that countries impose higher tariffs on their main import sources. To avoid this reverse causality effect, lagged tariffs are used in column (2). The coefficient on tariffs appears to be insignificant, showing no effect of these on bilateral trade, while the estimated distance elasticity remains unchanged.

Table 2: Robustness checks

	With tariffs		With more aggregate data		
			BTI		COMTRADE
	(1)	(2)	(3)	(4)	(5)
$ln(dist_{ij})$	-0.492**	-0.411**	-0.522**	-0.575*	-0.534*
	(0.229)	(0.199)	(0.245)	(0.309)	(0.316)
$tariffs_t$	0.0683*				
	(0.0393)				
$tariffs_{t-1}$		0.0512			
		(0.0514)			
N	43139	31462	19343	435	438
R^2	0.344	0.367	0.333	0.717	0.668
adj. R^2	0.338	0.359	0.325	0.670	0.613

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Another possible concern could be whether the results are subject to any special characteristics of the data. The last three columns of Table 2 show that results are robust to both different data sources and levels of aggregation. In column (3) the BTI data is aggregated to the 2-digit industry level, while in column (4) it is fully aggregated (so that there's one observation per pair-year). In both cases the distance elasticity does not change much from the preferred specification: the effect of a 10% increase in geographic distance reduces bilateral trade in about 5%. Finally, COMTRADE aggregate data is used for column (5). This is the most popular and reliable source of trade data, so it serves as a good counterfactual.[24] Results are very similar to those obtained with the BTI data. Again, the distance elasticity seems to be in line with the preferred estimates in terms of sign and magnitudes.

To sum up, results from both Table 1 and Table 2 suggest that the usual distance elasticities in the literature are overestimated. Traditional gravity model estimates exhibit a very large distance effect on bilateral trade, even after controlling for bilateral characteristics and time effects. The estimates identified by the exogenous shock to distances in the fixed effects regressions, on the other hand, appear to be about half as large. It is very likely that this discrepancy is due to shared characteristics that are unobservable to the econometrician and thus generate an omitted variables bias in the traditional gravity specification. Note, however, that these results do not seek to undermine the importance of distance on bilateral trade but rather understand why distance effects have so persistently large in the literature. A 5% decrease in exports due to a 10% increase in distances (ceteris paribus) seems more reasonable with declining transports costs, but the effect is still quite large. Distance certainly matters.

7 Conclusions

This paper exploits an exogenous shock to geographic distance between MERCOSUR countries generated by a conflict between Argentina and Uruguay. Due to the construction of a

[24] As discussed in the Data section, trade is not reported by transport mode so trade shares (from the BTI database) were used to estimate trade by land.

pulp mill in Fray Bentos, on the river that is shared between the two countries, concerned Argentinian environmentalists blocked the access to Uruguay as a (pacific) means of protest. As a result, the distances between Uruguay and several trading partners (Argentina, Bolivia, Chile, Ecuador and Peru) were temporarily extended. The Pulp Mill Conflict introduces a time component to bilateral distances, which provides a rare opportunity to incorporate bilateral pair fixed effects that will control for all time-constant unobservables and guarantee a proper identification of the distance effect.

The findings in this paper are in line with Feyrer's (2009), and suggest that traditional gravity equation estimates suffer from an upward omitted variable bias, and the distance elasticities represent not just transport costs but other bilateral pair characteristics that cannot be captured by the usual "gravity controls" (common language, religion, shared border, etc.). In addition, due to the detailed data (by transport mode) used in the analysis, the characteristics of the natural experiment (pacific), and the econometric specification chosen, the smaller distance elasticity obtained in this analysis might reflect better the true transportation costs.

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A Figures

Figure A.1: The three bridges connecting Argentina with Uruguay