How Do Transport Costs Affect Firms' Exports? Evidence from a Vanishing Bridge[♦]

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Abstract

In this paper we provide estimates of the effects of international transport costs on firms' exports and disentangle the channels of these effects. In so doing, we use a unique dataset consisting of highly disaggregated transaction-level trade and transport cost data and, in order to account for endogeneity, we exploit the exogenous variation in these costs associated with the non-trade related closure of the main bridge connecting two countries.

Keywords: Transport Costs, Trade, Firms, Argentina, Uruguay
JEL-Code: F10, F13, F14, H54, L25, C26

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Evidence from a Vanishing Bridge

1 Introduction

A series of papers have shown that international transport costs are an important determinant of trade.[1] The extent to which these costs matter is, however, far less well-established. The reason is twofold. First, accurate product-level data on transport costs are only available for a handful of countries (Hummels, 2007). Second, transport costs are likely to be endogenous to trade (Hummels, 2010). Possible explanations for costs to vary endogenously with trade include the existence of economies of scale in the adoption of transport technologies better matched to specific products and the market structure of the shipping industry (Hummels and Skiba, 2004; and Hummels et al., 2009). While insightful, most existing studies do not tackle both issues together. Further, for similar reasons, evidence on how international transport costs affect firms' exports is even scarcer. Thus, firm-level data on transport costs are virtually inexistent (e.g., Bernard et al., 2006). And, again, endogeneity problems are predictably severe. For instance, anecdotal evidence suggests that larger exporters can negotiate better fares.

In this paper, for the first time to our knowledge, we assess the impact of transport costs on firms' exports while simultaneously overcoming those data and methodological limitations. We use a unique dataset that consists of firm-level import and actual transport cost data covering all manufacturing trade transactions between Argentina and Uruguay over the period 2004-2007. In order to address endogeneity concerns, we exploit the exogenous variation in transport costs associated with the closure of the main bridge connecting these countries due to social protests on environmental matters during this period.[2] According to our estimates, firms' exports decline 6.5% when transport costs increase 1%.

Our paper contributes to an emerging literature that makes use of "natural experiments" to assess the effects of transport costs on trade. Using the gravity model on country-level data, Feyrer (2009) examines how the shock to sea distances induced by the closing of the Suez Canal between 1967 and 1975 affected trade and thereby income. Akerman (2009) investigates the impact of the construction of the bridge linking Copenhagen and Malmö in 2000 on Swedish firms' export outcomes and productivity.[3] Unlike ours, these studies do not use actual transport cost data.

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[1] See, e.g., Harrigan (1993), Hummels (2001), Limao and Venables (2001), Clark et al. (2004), Blonigen and Wilson (2008), and Moreira et al. (2008).

[2] We believe that trade between Argentina and Uruguay is an interesting case study. This trade has been virtually free from tariffs now over several years thanks to MERCOSUR. This allows for a cleaner identification of the effects of transport costs relative to a situation in which both tariffs and transport costs are not negligible and have to be bundled together for estimation purposes (e.g., Hummels, 2001; Bernard et al., 2006). In addition, our findings are relevant for a substantial portion of the trading relationships as trade between countries that share a land border such Argentina and Uruguay accounts for approximately 25% of the world total.

[3] A number of papers examine the impact of domestic transport infrastructure on several economic outcomes (e.g., Baum-Snow, 2007; Michaels, 2008; Banerjee et al., 2012; Donaldson, 2013; and Volpe Martincus and Blyde, 2013).

2 The "Natural Experiment"

In addition to air and fluvial transport, Argentina and Uruguay are connected by three bridges on the Uruguay River. The San Martín International Bridge (SMIB hereafter) connecting Gualeguaychú in Argentina and Fray Bentos in Uruguay is by far the most important from the point of view of bilateral trade. In 2004 more than 50% of total Argentine exports to Uruguay were channeled through this bridge.

Starting in mid-2005, the SMIB began to be blocked as a result of the protests by organized groups concerned with the environmental consequences of the establishment of paper and pulp processing plants on the Uruguayan coast of the Uruguay River. In particular, as consequence of these clearly non-trade related events, the SMIB was inaccessible for several days between November 2005 and April 2006; and, after an impasse in the protest actions during a period of diplomatic negotiations between the countries, it became completely closed to traffic on November 20, 2006 remaining so until June 20, 2010.[4] This had important effects on transport decisions of economic agents. The share of Argentine exports to Uruguay through the SMIB fell to zero after the persistent blockade. Shipments were rerouted from the SMIB to the other two bridges -primarily to that linking Argentina's Concordia and Uruguay's Salto-, which implied an increase in the road distance traveled, or there was directly a switch in transportation mode to ship or airplane also with the consequence of higher transport costs (Figure 1).[5]

3 Data and Descriptive Statistics

Our main dataset consists of dated transactional data on Uruguay's import values and weights and actual transport costs (freight plus insurance) from Argentina, disaggregated by firm, product (10 digit HS), port of entry, and crucially exporter over the period 2004-2007 from the Uruguayan customs DNA. In addition, we have access to data on Argentine exporters' location (zip code) from the Argentine customs DGA. These data cover all manufacturing trade transactions in this period.

Table 1 characterizes the average Argentine firm exporting manufactures to Uruguay. On average, this firm sells 5 products to 1.5 buyers for approximately USD 150,000. The average share of either export value or shipments across companies that was initially channeled through the SMIB was as high as 60%. After the traffic interruptions, this share declined virtually to zero in 2007. Not surprisingly, average transport costs increased over the period.

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[4] See, e.g., MERCOSUR Secretariat (2006), Di Martino (2007), Merlinsky (2008), and Toller (2009).

[5] Cross-border transit disruptions were significantly smaller in the Artigas International Bridge between Colón and Paysandú and especially the Bridge on the Salto Grande Dam between Concordia and Salto (MERCOSUR Secretariat, 2006).

4 Empirical Approach

Our empirical model of exports is as follows:

$$lnX_{fpt} = \alpha lnTC_{fpt} + \lambda_{fp} + \delta_{ft} + \rho_{pt} + \varepsilon_{fpt} \quad (1)$$

where f denotes (Argentine) firm, p product, and t year (i.e., transactional data are aggregated by year). The main variables are X and TC, which represent the f.o.b. export value to Uruguay and the respective transport cost as measured by the ratio between the c.i.f. and f.o.b. export values.[6] The remaining terms of Equation (1) correspond to control variables: λ_{fp} is a set of firm-product fixed effects that captures, for instance, the firms' knowledge of the market for a given product in Uruguay; δ_{ft} is a set of firm-year fixed effects that accounts for firm-level production shocks, time-varying firm characteristics, and firm-level public policies; ρ_{pt} is a set of product-year fixed effects that controls for product shocks such as fluctuations in demand; and ε is the error term. In estimating Equation (1), we use differencing relative to the initial, blockade-free year -2004- to eliminate the firm-product fixed effects. We therefore estimate the following main equation:

$$\Delta lnX_{fpt,2004} = \alpha \Delta lnTC_{fpt,2004} + \delta'_f + \rho'_p + \varepsilon'_{fpt} \quad (2)$$

where $\delta'_f = \delta_{ft} - \delta_{f2004}$; $\rho'_p = \rho_{pt} - \rho_{p2004}$; and $\varepsilon'_{fpt} = \varepsilon_{fpt} - \varepsilon_{fp2004}$.

Given that transport costs can be endogenous to exports, we use the exogenous variation in these costs derived from the event described in Section 2 to properly identify the effect of interest. In particular, the closing of the SMIB due to social protests can be viewed as an exogenous restriction imposed on the transportation network, whereby simultaneous determination of transport costs and trade can be broken. This induced firms that heavily used the disabled bridge to re-optimize their transport strategies under a constrained system and accordingly to modify their shipping plans for reasons beyond their control and entirely unrelated to trade.[7] As a consequence of such deviations from the optimal unconstrained strategies, transport costs increased (Figure 2).[8]

More precisely, we use the share of exports originally channeled through the SMIB as an instrument for the change in transport costs. Formally, we estimate the following first equation:

$$\Delta lnTC_{fpt,2004} = \alpha lnSMIB_{fp2004} + \gamma_f + \phi_p + \mu_{fp} \quad (3)$$

where *SMIB* is the share of shipments going through the bridge in question in 2004; γ_f and ϕ_p are sets of firm and product fixed effects, respectively; and μ is the error term.

[6] We use mirror values for exports (i.e., Uruguayan imports from Argentine exporting firms).
[7] Transport costs for firms using other routes can be safely assumed to have remained virtually unaffected. There is no evidence of congestion effects. A set of illustrative graphs and tables are available from the authors upon request.
[8] The Kolmogorov-Smirnov test-based procedure proposed by Delgado et al. (2002) indicates that the distribution of freight rates for 2007 statistically dominates that prevailing in 2004, whereas distribution of freight rates in 2004 and 2005 seem to be similar. A table containing the results of the tests is available from the authors upon request.

To be a valid instrument, the share of the SMIB in 2004 should predict the change in transport costs, but it should be otherwise uncorrelated with the change in exports. This involves two conditions. First, this share must be correlated with the variation in transport costs once other relevant variables have been netted out. This can be expected to be the case, as firm-product exports that initially relied more on the SMIB had be redirected and henceforth experienced larger increases in transport costs (Figure 3). Second, the share of the SMIB in 2004 must be uncorrelated with the error term, which requires properly controlling for factors that influence exports and are correlated with usage of this bridge. This is precisely what the firm and product fixed effects do. The exclusion restriction cannot be formally tested because there is only one instrument for the endogenous variable. However, after conditioning by these fixed effects, there is no obvious reason why share of the SMIB could affect foreign sales through channels other than transport costs.

5 Estimation Results

Table 2 present ordinary least squares (OLS) and instrumental variable (IV) estimates of Equation (2) along with the respective estimates of Equation (3) for the latter, for three alternative periods 2004-2005, 2004-2006, and 2004-2007. As for the IV estimations, note that, as expected from the timing of the blockades to the SMIB, the F-test statistics is well above 10 (Staiger and Stock, 1997) for 2004-2007, thus indicating that in this period the initial share of this bridge is strongly correlated with the change in transport costs. Hence, this will be our baseline estimation period. According to the IV estimates for this period, the transport cost elasticity of exports is roughly 6.5%, i.e., a 1% increase in transport costs is associated with a 6.5% reduction in firms' exports. This is above the respective OLS estimates, which suggests that the elasticity is 3.3.[9] A possible explanation of this gap could be that the OLS estimated coefficient is downward biased because of omitted variables that are positively correlated with both transport costs and exports.[10] While admittedly it is difficult to establish what the sources of endogeneity are, this could be for instance the case of public sector support to firm-product exports facing increased transport costs.[11] On the other hand, our elasticity is below those estimated by IV at higher aggregation levels (Harrigan, 1993).[12]

[9] Estimates are comparable when we impose a common sample across periods by including only those firm-product observations that are in all three periods. These estimation results are available from the authors upon request.
[10] Measurement error in transport costs could be an alternative potential explanation. Given the use of accurate customs-based data this is unlikely to be the case.
[11] More specifically, the public sector could have provided support to firm-product exports confronted with increased transport costs. Thus, according to data from Volpe Martincus et al. (2012), 9% of the manufacturing firms that had to ship their goods over longer distances or switch their transport modes received assistance from Argentina's national trade promotion organization, ExportAR, and this share is slightly larger than that for their counterparts not using the bridge in question.
[12] Our elasticity is comparable to the average elasticity across SITC-2 digit manufacturing goods as estimated by Hummels (2001).

In making inferences, we use standard errors clustered by province-sector (2-digit HS) to account for potential correlation of exports stemming from the same region, particularly from firms selling similar products. Results are robust to using alternative clusterings, including by firm, zip code, and sector as well as their combinations.[13]

A simple back-of-the-envelope calculation based on our IV estimates reveals that Argentine manufacturing exports to Uruguay would have been USD 117 million larger in 2007, which amounts to approximately three quarters of the 2007 value of the costs incurred in constructing the SMIB in 1972.

We next explore the channels through which this effect arises. In particular, we estimate the impact of international transport costs on the weight shipped, the unit values, the number of shipments, the average value and weight per shipment, the number of buyers, and average number of shipments, value and weight per buyer, based on Equation (2). OLS and IV estimates are presented in Table 3. These estimates reveal that increased transport costs have primarily affected the average size of the shipments in general and per buyer and both in terms of value and quantity and, to a lesser extent, the number of shipments. No significant effects on the number of buyers are observed. Noteworthy, according to the IV estimates, unit values seem to have increased as a consequence of the larger freight costs.[14]

Increased transport costs may have also caused some exports to disappear. Hence, we have also explored their effect on the extensive margin. In this case, the dependent variable is a binary indicator that takes the value of one if an export continues from the first to the final year of the relevant period and 0 otherwise and the main explanatory variable is the change in transport costs between the first and the previous to last year of this period. Consistent with the results on the number of buyers, estimates of this modified version of Equation (2) on the sample consisting on all positive exports in the initial year indicate that transport costs did not significantly affect export probabilities. *A priori*, this is not surprising. Firms may have preferred to keep exporting despite increased variable transport costs in order to avoid paying a reentry fixed cost.

[13] We do not report standard errors clustered by province or ports because their number are relatively small (18 and 8, respectively). However, estimates and tests statistics are similar to those shown here. These alternative estimates are available from the authors upon request.

[14] These results are consistent with findings reported in Martin (2012) according to which firms charge higher f.o.b. unit values on exports to more distant destinations. Bastos and Silva (2010), Görg et al. (2010), and Manova and Zhang (2012) also find a positive impact of distance on f.o.b. unit values. There are several mechanisms that may explain why this would be the case (Martin, 2012). A possible explanation consistent with modeling transport costs as *ad valorem* –as we do here- would be the existence of supply-driven within-firm selection of higher quality varieties of given products to markets that are more difficult to reach. Such a selection effect could be traced back to the presence of product-specific fixed costs that are paid by multiproduct exporters. Most alternative explanations (i.e., higher markups to more distant markets, quality upgrading and additional shipping costs) are based on demand-driven mechanisms that require per unit transport costs (e.g., Hummels and Skiba, 2004). Note, however, that, unless there is additional omitted variable operating in a different direction, our OLS and IV estimates would not be a priori consistent with quality upgrading.

6 Concluding Remarks

This paper provides rigorous estimates of the impact of transport costs on firms' exports. These estimates are based on highly disaggregated firm-level data on trade and transport costs and an IV estimation procedure whereby identification relies upon the exogenous variation in these costs associated with rerouting and switching in transport modes generated by the persistent closing of the main bridge connecting Argentina and Uruguay due to social demonstrations against the establishment of paper and pulp processing mills on the Uruguay River. Our estimations suggest a 1% increase in transport costs results in a 6.5% reduction in firms' exports. This negative effect can be traced back to a reduction in the size and the number of shipments.

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Table 1

Average Argentine Manufacturing Exporter to Uruguay				
Variable	**2004**	**2005**	**2006**	**2007**
Total Exports	121.288	140.286	149.091	177.969
Number of Products	5.116	5.372	5.438	5.470
Number of Buyers	1.553	1.597	1.607	1.596
Number of Buyers per Product	1.164	1.180	1.180	1.169
Average Exports per Product	31.235	35.685	43.537	57.492
Average Exports per Buyer	59.259	67.614	77.743	95.668
Average Exports per Product and Buyer	23.020	27.368	30.826	44.676
Average Share of Exports through the SMIB	0.589	0.583	0.194	0.001
Average Share of Shipments through the SMIB	0.590	0.584	0.194	0.001
Average Transport Cost	0.062	0.063	0.064	0.065

Source: Authors' calculations based on data from DNA.

Table 2

The Impact of Transport Costs on Firms' Exports: Baseline Estimates						
	2007-2004		**2006-2004**		**2005-2004**	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**
Transport Costs	-3.298	-6.498	-2.363	-1.801	-3.725	-0.710
	(0.930)***	(2.043)***	(0.679)***	(2.595)	(0.429)***	(4.121)
Share of the SMIB in 2004 (First Stage)		0.060		0.045		0.024
		(0.014)***		(0.014)***		(0.009)***
F (First Stage)		17.7		10.2		8.1
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Product Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.558		0.539		0.494	
Observations	7,306	7,306	8,878	8,878	10,241	10,241

Source: Authors' calculations based on data from DNA and DGA.

The table reports OLS and IV estimates of Equation (2) along with the first stage estimates and the F test statistics for the latter, for all manufacturing products. The dependent variable is the change in the natural logarithm export value (to Uruguay) at the firm-product level between 2004 and 2005, 2006, and 2007. The main explanatory variable is change in the natural logarithm of transport costs at the same level. In the instrumental variables estimation, the latter is instrumented with the share of the firm-product transactions channeled through the San Martín International Bridge (SMIB). Firms and product fixed effects included (but not reported). Standard errors clustered by province-sector (2 digit HS products) are reported in parentheses below the estimated coefficients. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

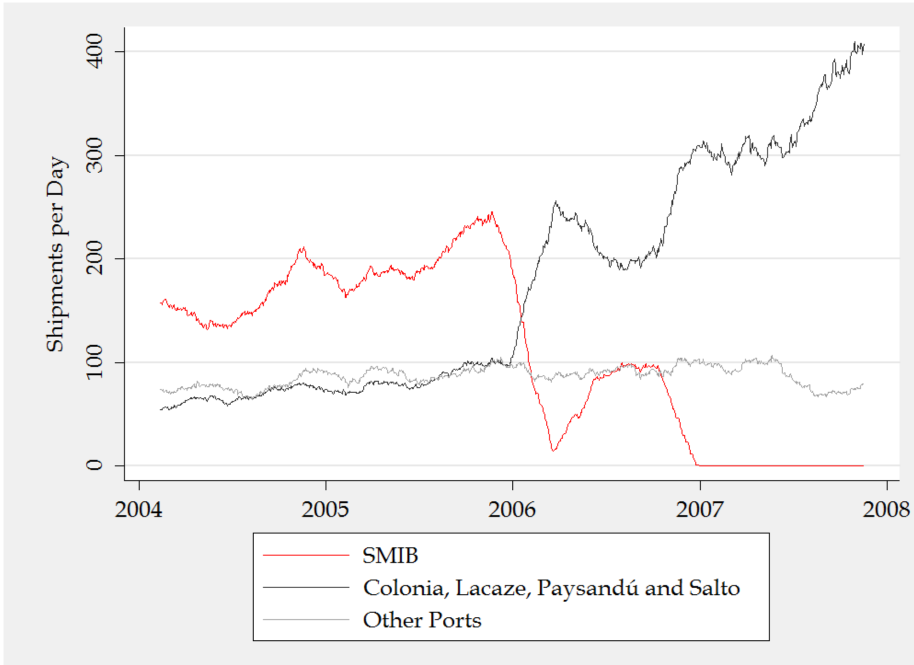
Table 3

The Impact of Transport Costs on Firms' Exports: Channels		
	OLS	**IV**
Export Value	-3.298***	-6.498***
	(0.930)	(2.043)
Export Weight	-2.780***	-8.666***
	(0.784)	(2.435)
Unit Value	-0.519	2.168*
	(0.427)	(1.269)
Number of Shipments	-0.638**	-2.685**
	(0.296)	(1.275)
Export Value per Shipment	-2.660***	-3.813***
	(0.762)	(1.461)
Export Weight per Shipment	-2.142***	-5.981***
	(0.653)	(1.878)
Number of Buyers	-0.038	0.082
	(0.076)	(0.556)
Number of Shipments per Buyer	-0.600**	-2.767**
	(0.282)	(1.203)
Export Value per Buyer	-3.260***	-6.580***
	(0.916)	(2.033)
Export Weight per Buyer	-2.742***	-8.748***
	(0.767)	(2.402)
Firm Fixed Effect	Yes	Yes
Product Fixed Effect	Yes	Yes
Observations	7,306	7,306

Source: Authors' calculations based on data from DNA.

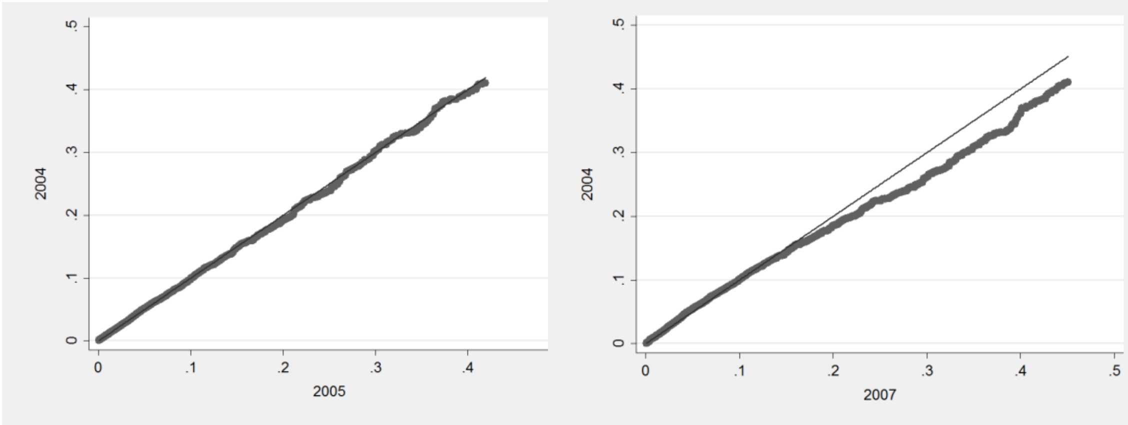
The table reports OLS and IV estimates of Equation (2) for all manufacturing products. The first stage estimates and the F test statistics for the latter are the same as in Table 2. The dependent variables are the change in the natural logarithm of export value, export weight, unit value, number of shipments, average export value per shipment, and average export weight per shipment, number of buyers, number of shipment per buyer, average export value per buyer, and average export weight per buyer (to Uruguay) at the firm-product level between 2004 and 2005, 2006, and 2007. The main explanatory variable is change in the natural logarithm of transport costs at the same level. In the instrumental variables estimation, the latter is instrumented with the share of the firm-product transactions channeled through the San Martín International Bridge (SMIB). Firms and product fixed effects included (but not reported). Standard errors clustered by province-sector (2 digit HS products) are reported in parentheses below the estimated coefficients. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Figure 1
Evolution of the Number of Shipments from Argentina to Uruguay: SMIB and Other Ports



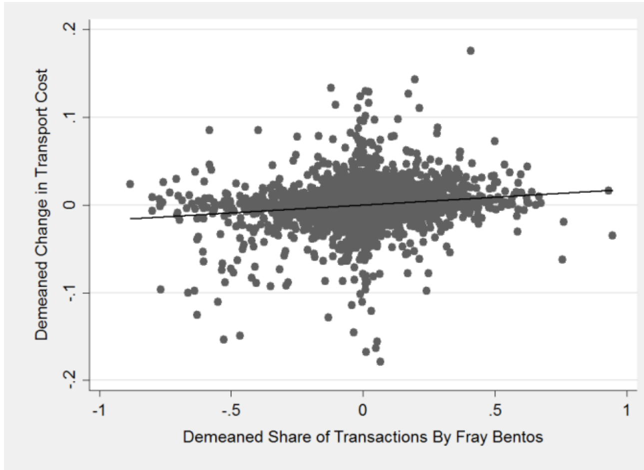
Source: Authors' calculations based on data from DNA.
The figures shows a 30-days moving average of the number of shipments from Argentina to Uruguay through the San Martín International Bridge (SMIB) and other entry ports.

Figure 2
Transport Costs, 2004 vs. 2005 and 2004 vs. 2007



Source: Authors' calculations based on data from DNA.
The figures are quantile-quantile graphs that plot the quantiles of the firm-product level transport costs prevailing in 2004 (i.e., before the blockade to the San Martín International Bridge -SMIB) (x-axis) against those prevailing in 2005 and 2007 (i.e., after the blockades of the SMIB) (y-axis). These figures exclude the top 1% of the distribution of transport costs.

Figure 3
Share of the SMIB and Changes in Transport Costs, 2004-2007



Source: Authors´ calculations based on data from DNA.
The figure is a scatterplot showing the relationship between the share of shipments channeled through the San Martín International Bridge (SMIB) in 2004 and the change in transport costs between 2004 and 2007 after netting out firm and product fixed effects. The straight line is the OLS-estimated relationship.