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Abstract

This paper explores the role that quality of infrastructure has on a country's trade performance, estimating a gravity model that incorporates bilateral tariffs and a number of indicators for the quality of infrastructure. The paper looks at the impact of the quality of infrastructure (road, airport, port and telecommunication, and the time required for customs clearance) on total bilateral trade and on trade in the automotive, clothing and textile sectors. In order to obtain unbiased estimators, multilateral resistances for tariffs and remoteness are introduced in the gravity equation. Moreover, the robustness of the results is tested by estimating a fixed-effect model, where bilateral indexes of the quality of infrastructure are included. The results can be summarised in four main findings: (i) bilateral tariffs, generally neglected in gravity regression of bilateral flows, have a significant negative impact on trade; (ii) quality of infrastructure is an important determinant of trade performance; (iii) port efficiency appears to have the largest impact on trade among all indicators of infrastructure; (iv) timeliness and access to telecommunication are relatively more important for export competitiveness in the clothing and automotive sector respectively.

JEL classification: F13, F17

Keywords: trade, infrastructure, gravity model, resistance terms, tariffs.

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I. INTRODUCTION

Average applied tariffs on industrial products have declined from 15.5 per cent in 1990 to 7.9 per cent in 2003.[2] Yet, the volume of international trade is still less than one would expect from observed differences in factor endowments, tastes and technology between countries (Trefler, 1995). A possible explanation of the missing trade is non-tariff barriers to trade, including transport costs and other costs related to searching for international suppliers or customers, entering into contracts and shipping the goods or services from the domestic producer to the foreign customer. These transaction costs have several dimensions. First, there are the direct monetary outlays on communication, business travel, freight, insurance and legal advice. These are partly determined by the physical and cultural distance between the trading partners, but also the quality of infrastructure and the cost and quality of related services. A British telecommunication services company, for example, offers a 3 minute telephone conversation from Switzerland to the US at a cost $0.18, while the same length of telephone conversation from Switzerland to Albania costs $0.81. The distance between Switzerland and Albania is much less than the distance between Switzerland and the US, but Albania has a poorer telecommunications infrastructure and a less competitive telecommunications sector than the US, which probably explains the difference.[3] Recent empirical evidence on a linkage between the quality of infrastructure and trade costs are two studies by Clark et al. (2004) and Limão and Venables (2001). The former finds that port efficiency is an important determinant of ocean freight costs.[4] For example, they estimate that maritime transport costs in Brazil or India would fall by over 15 per cent if their port efficiency was at the level of France or Sweden. The latter finds that own infrastructure explains 40 per cent of transport costs for coastal countries while own and transit country infrastructure explains 60 per cent of transport costs for landlocked countries.

A second dimension of transaction costs is time. The proverbial "time is money" suggests a linkage between monetary outlays and the time dimension, but time also plays a role in its own right. This is particularly the case in industries that have adopted just-in-time business practices and have an international supply network. Just-in-time business practices imply that producers have small inventories of intermediate goods and the entire production process would come to a halt if one input was missing. Under such circumstances delays in delivery of intermediate inputs would have a disproportionate impact on the importing firms' total costs.[5] In fact, if the production plant has to stop production due to a missing part, emergency transport at a cost that by far exceeds the price of the good transported is not uncommon.[6] As with transport costs, delivery time is partly determined by distance between the trading partners. However, geography and the quality of infrastructure probably matter even more for timeliness than for freight rates. Gravel roads, for example become impassable after rain storms. Poor port infrastructure or inadequate port handling capacity may cause long delays that are not necessarily reflected in the monetary outlays on transport services. The same goes for red tape at customs.

Uncertainty about delivery time is an important determinant of total transaction costs. The more uncertain is delivery, the more inventory is needed as a buffer stock if demand fluctuations are unrelated to fluctuations in delivery time. Inventories are expensive both because they bind up capital

[2] Source: TRAINS database. Data refer to the WTO HS aggregation as calculated in WITS, using effectively applied rates.

[3] The rates quoted are from EasyVoice, a British telecommunication services firm providing virtual communication services; i.e. services provided through the purchase of access to other firms' networks or the internet (http://www.comxo.com/easyvoice.cfm; website accessed 17.05.04).

[4] Note that in Clark et al. (2004) port efficiency is also approximated by a general measure of infrastructure (based on information on paved roads, paved airports, railways and telephone lines) and an index of sea port infrastructure. This index is calculated as the total square number of large seaports (i.e. lifts with a leverage capacity of 50 tons and above) by country, normalised by the product between foreign country's population and area.

[5] See Harrigan and Venables (2004) for a recent discussion.

[6] In the offshore oil industry, for example, emergency transport of parts by helicopter is not uncommon.

and because the value of the stored goods may depreciate over time.[7] Fashion clothing and electronic components, for example, depreciate rapidly and firms typically aim at keeping inventories to a minimum. Again we argue that uncertainty of delivery time is related to the quality of infrastructure. Weather conditions can wreck havoc on infrastructure and delay delivery in unpredictable ways when infrastructure is poor. In addition poor infrastructure combined with poor quality transport equipment often result in vehicle break down and further delays.

Uncertainty is an important dimension of trade cost not only in terms of uncertainty about when a shipment is delivered but also in what conditions it arrives at its destination. The uncertainty about to which extent the quality and the quantity of the shipment upon arrival correspond to the one loaded at departure is part of the cost of transport and depends on the quality of infrastructure. A poor quality of infrastructure is likely to be associated to a higher risk of damaging the cargo and therefore higher losses and insurance costs.

A forth dimension of transaction costs is the opportunity cost of lack of access to a good transport or telecommunication service. For example, large trucks would bypass villages whose roads cannot carry them. Large ships would bypass harbours with inadequate facilities. Similarly, anecdotal evidence suggests that lack of access to a good telecommunication network can create barriers between those connected and those not connected. For example, traders in Ghana regularly travel to visit suppliers of agricultural products in order to purchase their produce. Some of the traders have recently acquired mobile phones and started to contact suppliers beforehand to check what they have on offer. In some cases they have stopped visiting those suppliers who could not be contacted over the telephone (Overå, 2004).

As these examples have shown, time to market and delivery reliability depends as much on the infrastructure behind the borders as the transport services between the borders. This is a dimension that is not captured in standard gravity equations which establish the relation between relative market size and distance between trading partners. It is to some extent picked up in estimates that use country fixed effects, but in these estimates it is of course not possible to distinguish the impact of infrastructure from other country-specific factors. The quality of infrastructure is also highly correlated with GDP per capita. Thus, gravity models that incorporate GDP per capita and find a positive and significant coefficient may well pick up the quality of infrastructure.[8] But again these estimates do not provide explicit information about the link between trade flows and the quality of infrastructure.

Previous studies that looked at the relationship between trade and infrastructure have found a positive and significant impact of quality of infrastructure on trade (Clark et al., 2004; Wilson et al., 2003; Limão and Venables, 2001).[9] For example, Clark et al. (2004) estimate that if a country like Peru or Turkey improved sea port efficiency to the level similar to Iceland or Australia, it would be able to

[7] For example, Gaush and Kogan (2001) estimated that developing countries could reduce the unit cost of production by as much as 20 per cent by reducing inventory holdings by half.

[8] There is otherwise little reason why GDP per capita per se should affect bilateral trade flows when distance, market size and the average trade barrier facing all trading partners are controlled for (see Anderson and van Wincoop, 2003a).

[9] Clark et al. (2004) estimate a gravity model augmented for an index of sea-transport costs, based on information on level of containerization, seaport infrastructure, regulatory environment, organized crime and level of development for 43 countries. They estimate that moving from the 25th to the 75th percentile in the distribution of port efficiency, increases trade by 22 per cent. Limão and Venables (2001) find that improving infrastructure so as to move from the median country to the top 25th percentile in the distribution of infrastructure enhances trade by 68 per cent, moving down to the bottom 75th percentile reduces trade by nearly 30 per cent. Their index of infrastructure includes information on paved and unpaved roads, railways and telephone main lines. Focussing on the Asia-Pacific region, Wilson et al. (2003) find that increasing port and airport efficiency has a significant and large positive impact on intra-APEC trade.

increase trade by roughly 25 per cent. However, these studies have focused either on an overall measure of infrastructure quality or on maritime transport infrastructure.

This paper aims at shedding more light on the role of behind the border infrastructure for bilateral trade flows, using an augmented gravity model. The main contributions of the paper is first to develop indicators of the quality of infrastructure. We develop three types of indicators. First we construct an index for each type of infrastructure (rail, roads, telecommunications, ports, airports and time for customs clearance) that positions each country relative to the sample average. The individual indicators are next aggregated into one measure of overall quality of infrastructure. The methodology adopted is the same as in Limão and Venables (2001), but we add more individual indicators. Both the individual and the aggregate indicators are used in the regressions. Therefore, our approach allows us to disentangle and estimate the role of the different modes of transport in supporting trade. Finally, we construct two bilateral quality of infrastructure dummy variables for each category and for the aggregate. The first of these variables is a dummy that takes the value of one if both trading partners have above average quality and zero otherwise. The rationale for this variable is that countries that have similar behind the border infrastructure may also be more likely to have similar transport services. Countries with good infrastructure are, for example, more likely to use containers and seamless multi-modal transport than countries with poor infrastructure. The second bilateral dummy takes the value of one if the country pair has a quality of infrastructure above the average of all pairs and zero otherwise. This dummy indicates whether there is a threshold combined quality of infrastructure.

The second contribution of the paper is to correct for what we argue is an omitted variable bias in existing literature where tariff rates are typically not included.[10] Tariffs are a policy measure introduced in order to curb imports and as will be shown in Section III below, simple average applied tariff rates vary significantly between countries. The variation of an importer's tariffs relative to its trading partners partly reflects preferences due to free trade agreements or preference schemes on the part of OECD countries relative to developing countries. In addition such variation reflects differences in trade patterns. A country which is specialized in agriculture or textiles and clothing, for example, will face higher average tariffs in the European Union and the US than a country specialized in electronics. In order to capture the impact of tariffs on bilateral trade flows, we introduce bilateral tariffs in our gravity estimates. These are found to be negative and significant and the economic significance is also high; a 10 per cent increase in the bilateral tariff factor (one plus the tariff rate) relative to the average tariff rates of the importer and the average tariff rates facing the exporter would reduce bilateral trade by more than 20 per cent. This estimate is similar to Limão and Venables' (2001) estimate of the elasticity of bilateral trade flows relative to transport costs.

Our third contribution is to analyze differences among sectors as far as the importance of infrastructure is concerned. As indicated in the discussion above, sectors in which just-in-time production practices are commonly used are more sensitive to delays in delivery of intermediate inputs than other sectors. The automotive industry, for example, has been a leading sector in terms of organizational innovations and was the pioneer as far as just-in-time practices are concerned. Just-in-time at the retail level is also important in some sectors. An example is the clothing industry where the number of seasons has increased and even the low-price market is characterized by rapidly changing fashions. According to an in depth study of the sector, the dominant retailers require their suppliers to replenish the stocks frequently and without delay (Abernaty et al., 1999). We therefore include estimates for the automotive sector and textiles and clothing in our study. We find that among the individual indicators for the quality of infrastructure, port efficiency has in general the largest impact. The quality of roads appears to be a significant factor of export performance across the three sectors. Time for customs clearance appears to be particularly important in the clothing sector, where accordingly also airport density has a significant and large impact. Finally, telephone density plays the most important role in determining bilateral trade in the automotive sector.

[10] One exception is Fink et al. (2002).

The rest of the paper is organized as follows: The next section relates our work to previous studies and discusses the relation between infrastructure and bilateral trade flows in some more detail. Section III presents the data, Section IV describes the modelling approach and presents and discusses the results, while Section V concludes.

II. TRADE COSTS AND BILATERAL TRADE

Trade costs can be broadly divided into search costs, the cost of entering into and enforcing contracts, transport costs, tariffs and the cost of delays and uncertainties of delivery. Starting with search costs, they are probably the lowest in trade between countries whose business practices, competitiveness and delivery reliability are well known to the trading partner. Firms in adjacent countries, countries with common language or other relevant cultural features are likely to know more about each other and understand each others' business practices better than firms operating in less similar environments. For this reason firms are more likely to search for suppliers or customers in countries where the business environment is familiar to them. Therefore, common border, common language, common colonial history and other variables that may capture commonalities in business practices and perceptions are routinely included in gravity models of international trade flows.[11] These variables are indeed found to have a positive effect on bilateral trade flows as expected.[12] In addition, availability of information and the ease at which information can be accessed and exchanged are important determinants of search costs. Rauch and Trinidade (2003a) argue that the proliferation of the information economy has reduced search costs substantially. As a result, the first cut at matching trading partners is better and subsequent contract negotiations less time consuming. The implication of this, they find, is a higher elasticity of substitution between domestic and imported goods (using the Armington assumption in a general equilibrium model of international trade).

Transnational networks and the movement of people across borders can facilitate the flow of information across countries by, for example, helping suppliers in adapting the characteristics of a product to consumers' preferences in a country, thus enhancing trade. Rauch and Trindade (2003b) estimate the impact of the overseas Chinese network on bilateral trade in differentiated commodities and in homogeneous commodities. They find that the increase in bilateral trade attributable to the overseas Chinese network is larger for differentiated goods, where information costs are likely to be more relevant. Similarly, Gould (1994) and Head and Ries (1998) find a positive effect of migration flows on the US and Canada bilateral trade respectively.

Fink et al. (2002) include the bilateral cost of making a telephone call in a gravity regression and find that the cost has a significant and negative impact on bilateral trade flows. Furthermore, they find that the bilateral cost of telecommunications have a larger effect on trade flows for differentiated than for homogenous products, supporting the idea that the cost of telecommunications indeed affect search costs. The regression also includes bilateral tariffs and country fixed effects, thus implicitly taking into account the impact of infrastructure. We argue that the cost of not being able to place a telephone call or access the internet may be just as important as the cost of making the call. The former cost is more related to the penetration rate of telephone lines and we include this in our regression in order to analyze its impact on bilateral trade flows. In addition to including the penetration rate for each importer and exporter, we also construct a bilateral dummy which is one if both importer and exporter have a telephone penetration rate that is higher than the average. Since electronic communication does not flow easily unless both partners have good access to telecommunication infrastructure, we argue that this variable could capture the effect explored theoretically in Rauch and Trindade (2003a).

[11] See for example Anderson and van Wincoop (2003b) for an overview.

[12] See Grossman and Helpman (2002) for a discussion on the role of search costs in international outsourcing.

The cost of entering into and enforcing contracts are probably also related to having a common business environment and good communication infrastructure.

Turning to transport costs and the cost of time in transit, we argue that the latter is by far more important than the former. Time as a trade barrier has been extensively studied by Hummels (2001). He first observes that air freight has increased substantially relative to sea freight over the past decades and attributes this change partly to a sharp decline in the relative price of air freight and partly to traders' valuation of time. On the basis of data on US trade by commodity category, source of imports, mode of transport, freight rates and time in transit, he estimates the time cost of one day in transit. It is found to be the equivalent of an *ad valorem* tariff rate of 0.8 per cent, which in turn is equivalent to a 16 per cent tariff rate for an average length ocean shipment. This is much higher than both the US average tariff rate and average freight rates. Furthermore, he finds that each day in transit reduces the probability that a country will export to the US by one per cent for all goods and 1.5 per cent for manufactures. Finally, he argues that time costs are magnified several times in sectors where production is fragmented into vertical production stages. We argue that time in transit probably has a non-linear impact on trade costs. Perishable goods, for instance, have no value upon arrival at the retailer if time in transit exceeds a certain number of days.

Unfortunately, detailed data on time in transit is only available for the US and possibly a few other OECD countries. However, Hummels (2001) argues that time in transit is closely related to the quality of ports and port services, customs procedures, etc., and we would argue that time in transit also depends on the quality of infrastructure in general. Our constructed indicators for the quality of infrastructure and the constructed bilateral indicators are designed to capture the impact of time on bilateral trade in a much larger sample of countries, although our ability to analyze time in transit explicitly is limited by the availability of data.

Mode of transport is important for time in transit, and traders trade off time costs and freight costs when they choose mode of transport. An industry where the trade-off between monetary outlays and timeliness is particularly interesting is the clothing industry, where both timeliness and costs are important, particularly in the market segments characterized by rapidly changing styles. On the one hand, clothing is a labour-intensive industry for which labour-abundant developing countries have a comparative advantage. On the other hand, labour-rich developing countries are typically located far from the major markets and have relatively poor infrastructure. Evans and Harrigan (2003; 2004) have studied this trade-off in the US's sourcing of clothing and find that Mexico and the Caribbean have gained market shares in the fashion market during the 1990s in the US in spite of the emergence of China as a major exporter, due to their proximity to the US market.[13] In other words, sectors where timeliness is important tend to be located near the source of final demand.

So-called multimodal transport services including packaging, warehousing and transport from the premises of the exporter to the premises of the importer have become increasingly important (see UNCTAD, 2003a). Such multimodal transport services often include containerization, which in turn requires a minimum quantity of the goods in question. The choice of mode of transport is also limited by geography. Obviously, island countries are prevented from using rail and road transport for their exports while landlocked countries are prevented from using ocean freight for the first leg of transportation to the final destination. In order to capture the limited choice of mode of transport facing exporters in landlocked and island countries, we introduce dummies for island and landlocked respectively. This is also done in other studies, but they apparently have a somewhat different definition of island than we have. For the purpose of our study being landlocked or an island is relevant because of the range of modes of transport available and we therefore define an island as a country that has no land border with other countries, including for example Japan and Taiwan, which are not considered islands in previous studies.

[13] As shown in Nordås (2004), China has, however, recaptured market shares during the period after 1998, the final year of the Evans and Harrigan studies.

We finally note that there is a dynamic relationship between developments in transportation costs and transportation technology on the one side and the composition of trade on the other. As pointed out by Yi (2003), lower trade costs have made fragmentation of the production process possible. The resulting increased trade in intermediate products has in turn driven demand for timely and effective transport and logistics services. On the other hand, Hummels (2001) identifies the decline in air transport costs *relative* to sea transport and the development of fast transport (such as faster ocean vessels) as responsible for the increase of trade in time-sensitive goods.[14] Therefore, since timeliness seems to have become very important, we argue that the quality of transport infrastructure might have become a more important determinant of trade than in the past.

The quality of infrastructure can also create or reinforce comparative advantage. A study by Yeaple and Golub (2002) finds that differences in the quality of public infrastructure between countries can explain differences in total factor productivity. Furthermore, since sectors differ in how intensively they use services related to infrastructure and how dependent they are on good infrastructure, the impact of quality of infrastructure on total factor productivity differs between sectors. For example, Yeaple and Golup (2002) find that the quality of road infrastructure appears to be particularly important for productivity growth in the transportation equipment sector and for specializing in the production of textile and apparels. Hence, the quality of infrastructure has an impact on patterns of specialization and international trade.

Turning to the size and variability of transport costs, the effective rate of protection provided by transport costs is in many cases higher than that provided by tariffs. A recent study of the World Bank (2001) shows that for 168 out of 216 US trading partners, transport costs barriers outweighed tariff barriers. For the majority of Sub-Saharan African countries, transport cost incidence for exports (the share of international shipping costs in the value of trade) is 5 times higher than tariff cost incidence (the trade weighted *ad valorem* duty actually paid). Similarly, in many countries in Latin America and the Caribbean, transport costs account for a larger share than tariffs in the import price. Moreover, transport costs vary across regions and products. Freight costs in developing countries are on average 70 per cent higher than in developed countries, and they are highest in Africa, where they are twice the world average (UNCTAD, 2003b). At the industry level, freight costs are highest among industries producing goods with a low value-to-weight ratio. In general agricultural and mining products are more expensively shipped than manufactured goods (see Hummels, 1999). Data on the cost of making a phone call show that telecommunication costs have fallen in the 1990s both for developing and developed countries, and it has declined more for developing countries. However, large differentials between the two groups persist. Phone calls are most expensive in developing countries and cheapest in developed countries, particularly in Scandinavian countries (ITU, 2003).

To summarize the evidence on the impact of transaction costs, there is strong empirical evidence that search costs, the costs of entering and monitoring contracts with suppliers and the cost related to the time lapsed from demand patterns are observed to the product arrives at the retailer (or is offered for sale on the internet) are important for international trade patterns. Indeed, as product differentiation, vertical specialization and international outsourcing have become more prominent in world trade, the relative importance of these costs as a determinant of world trade has probably increased over time.[15] We argue that these costs are strongly correlated with the quality of infrastructure, and explore the relationship between the quality of infrastructure and trade patterns by means of an augmented gravity model.

[14] Hummels (2001) has estimated that the development of fast transport (air shipping and faster ocean vessels) was equivalent to reducing tariffs from 20 per cent to 5.5 per cent between 1950 and 1998, thus explaining part of world trade growth over the post-World War II period.

[15] Redding and Schott (2003) find that the importance of distance (i.e. the absolute value of the parameter on distance in a country fixed effects gravity model) has increased over time during the period 1970 to 1995.

III. THE DATA IN THIS STUDY

A. DATA ON TRADE COSTS

This study focuses on three types of trade costs: tariff barriers, transport costs and the cost of information. This section discusses the data used in this paper to measure each type of cost.

1. Tariffs

Three measures of tariff barriers are used:

(i) Bilateral tariffs represent the simple average tariff rate country *i* applies on imports from country *j*.

(ii) Import resistance represents a country's average import tariff. We calculated this as the average across all trading partners.

(iii) Export resistance represents the average tariff faced by a country's exports. We calculated it as the weighted average import tariff that trading partners of country *j* (the exporter) impose on imports from *j*. Weights are given by country *i*'s share in country *j*'s total exports.

Tariff data used are derived from TRAINS (the Trade Analysis and Information System) and aggregated using WITS (World Integrated Trade Solution). Bilateral trade flows values are extracted from COMTRADE (the Commodity and Trade Database).

Table 1 shows country pairs with the highest bilateral tariffs and indicates the median country pair in the distribution of bilateral tariffs. The table also reports the highest and the median tariff that a country levies on imports and faces when it exports. This information is reported for the whole manufacturing sector, and for the three sectors studied in this paper (automotive, clothing and textile). It is worth noticing that the average value for export resistances is consistently lower than average bilateral tariffs and average import resistances. The reason is that export resistances are calculated as trade-weighted averages. Very high tariff rates are generally associated with lower volumes of trade and *vice versa*. Therefore, trade-weighted averages smooth out tariff peaks and increase the weight of low tariff lines. In contrast, import resistances are calculated as simple averages, therefore they are more affected by extreme values. The advantage of using simple averages for import resistances is that they are more likely to be a measure of tariff barriers exogenous to bilateral trade flows than weighted average, therefore they will not generate endogeneity problems in the gravity regressions. However, simple averages cannot be used when calculating export resistances because they would not lead to enough cross country variation in the resulting variable, hence their impact on trade could not be estimated in the gravity regression.[16] Note that for all measures of tariffs the minimum value is zero. As shown in Table 1, international applied average tariff rates vary greatly across countries and across sectors.

[16] Given a country *i*, its simple average of import tariffs of all other countries in the world is not likely to differ greatly from that of country *j*, as *i* and *j* are only one out of 138 countries in the world in our data set.

Table 1: Tariff barriers

	Median		Maximum	
Manufacturing				
Bilateral tariff	8.8	United States-Myanmar	180.0	Jordan-Bolivia
Import Resistance	12.8	Colombia	32.5	India
Export Resistance	3.5	Zambia	44.6	Marshall Islands
Automotive				
Bilateral tariff	6.6	Costa Rica-Singapore	170.0	Pakistan-Kenya
Import Resistance	8.6	FYR Macedonia	57.0	Malaysia
Export Resistance	5.0	Lao PDR	33.7	Ecuador
Clothing				
Bilateral tariff	13.0	Hungary-Honduras	80.0	Mauritius-Brazil
Import Resistance	14.9	Azerbaijan	72.3	Mauritius
Export Resistance	9.9	Kenya	35.4	Gabon
Textile				
Bilateral tariff	8.7	US-Korea	112.5	Maldives-Finland
Import Resistance	9.6	Jordan	51.8	Nigeria
Export Resistance	7.2	Vietnam	29.6	Grenada

Note: When more than one country pair have the same tariff rate, only one example is reported.
Source: TRAINS database.

2. Infrastructure

Direct transport costs include freight charges and insurance on shipments (customary added to freight charges data), holding costs for the goods in transit, the opportunity cost of time spent for moving goods across the border, vehicle renewal costs and other general charges. Data on the direct fees of transport exist, but their availability is limited by product and country coverage, time horizon or by their private nature.[17] A measure of transport costs sometimes used in the economic literature is the c.i.f./f.o.b. ratio.[18] However, this is a very imprecise measure of transport costs. First, c.i.f./f.o.b. ratios are not available for Europe and Japan, for example, and they are usually not available at

[17] For example, disaggregated freight rates for ocean, air and land transportation exist for imports in the US, New Zealand and a few Latin American countries. Indexes of *ad valorem* shipping liner rates have been collected by the Royal Netherlands Shipowners Associations, and the Norwegian Shipping News, but they are limited only to a certain number of commodities and routes. An index on liner shipping costs is also calculated by the German Ministry of Transport, but it only includes liners loading and unloading in Germany and the Netherlands. As regards air transport, the World Air Transport Statistics reports worldwide air freight revenue and ton-kilometres over the period 1955-1997. The International Civil Aviation Organisation surveyed air cargo transport rates (price per kilometres between two cities) worldwide for the period 1973 and 1993. As concerns land freight rates, the US Transborder Surface Freight supplies data on overland imports from Canada, by city of origin and destination and transport mode (rail or truck).

[18] The f.o.b. price measures the cost of an imported item at the point of shipment by the exporter as it is loaded onto a carrier for transport. The c.i.f. price measures the cost of the imported item at the point of entry into the importing country, inclusive of the costs of transport, including insurance, handling, and shipment costs, but not including customs charges. The higher the value of the ratio, the higher is the share of transport cost in the value of traded goods.

disaggregated level. Second, the quality of the data is poor. Third, it is a measure subject to variations do to changes in the commodity composition of trade flows and in shift of the demand between modes of transport.

Since data on direct transport costs are either unavailable or of poor quality, transportation costs are in general approximated on the basis of information on distance, geography and quality of infrastructure in gravity equation regressions.[19] It is expected that transport costs between trading partners increase with distance, and decrease with adjacency (as transportation networks between neighbouring countries may be more integrated). It is also assumed that transport costs increase if a country is landlocked or is an island, due to the more limited choice between alternative modes of transport. In this paper we take this approach and we measure transport costs using distance, a border dummy and a dummy to identify whether one of the two trading partners is a landlocked country or an island.

In addition, we construct one indicator of the quality of infrastructure for each of the three modes of transport (land, sea and air) in an attempt to capture not only variations in the efficiency of the transport service and direct transport costs, but also other dimensions of transport costs as discussed in the previous section.

Table 2 reports the median, minimum and maximum values in the cross country distribution of the major indicators that we use. All data are from 2000. Data on infrastructure density used in the regressions (railroads, roads and airports per sq-km and telephones per 1000 inhabitants) are taken from the Wold Bank's World Development Indicators. Port efficiency is measured by an index that ranges between one and seven. It is based on surveys conducted on representative firms of each country by the World Economic Forum (WEF, various years 1996-2000, Global Competitiveness Report, as reported in Clark et al. 2004). The question asked is: "Port facilities and inland waterways are extensive and efficient? (1 if strongly disagree, 7 if strongly agree)". Data for median port clearance time are based on surveys conducted by the World Bank on importers of each country. The specific question asked is "if you import, how long does it typically take from the time your goods arrive at their port of entry until the time you can claim them from customs?" The data show large differentials in the quality of infrastructure across countries and a large gap between poor and rich countries. To take an example, the United States has over 5,131 times more airports than Benin, but has only 86 times larger area and is 44 times larger in terms of population. And in Luxemburg over 92 per cent of the population is connected to the mobile telephone network, in Guatemala only 10 per cent of the population is connected, while in Niger mobile phone connections are almost non-existent.

[19] There is also an econometric reason for not using direct transport fees in gravity models of trade. Bilateral transportation costs are in part endogenous to bilateral trade, and could bias the results. In fact, high transport costs may be the result of intense traffic on a specific route rather than the cause of low bilateral trade flows. For example, China's rising import demand for raw materials not accompanied by adequate improvement in port infrastructure has caused port queues. Freight rates for dry cargo have doubled in the last six months and bulk carriers are waiting up to a month at the dock (A. Wheatley, 2004).

Table 2: Quality of Infrastructure

	Median		Minimum		Maximum	
Number of paved airports per 1000 square km	0.11	Lesotho/Belarus	0.0	Myanmar	17	Bermuda
Percentage of paved roads	44.6	Hungary/India	0.8	Chad	100	Austria
Main telephone lines per 1,000 people	110.5	Trinidad and Tobago	0.0	Congo, Dem. Rep	869	Bermuda
Port efficiency index (1-7)	3.8	Portugal	1.6	Bolivia	7	Singapore
Median clearance time (days)	5.0	Germany	1.0	Lithuania	30	Ethiopia
Aggregate indicator	1.2	Venezuela	4.9	Niger	0.5	Antigua and Barbuda

Source: World Bank, WDI, 2003; CIA, World Factbook, 2003; Global Competitiveness Indicator, various years, as reported in Clark et al., 2004.

Note: aggregate indicator is lower the better the infrastructure

We use these six indicators separately in the regression. The aggregate indicator represents the overall quality of infrastructure. It is constructed as an average over the five individual indicators presented in Table 2, plus the density of railroads and paved roads (number of kilometres per 100 sq-km), the density of mobile telephones (mobile lines per 100 inhabitants) and the number of international departure of aircraft per sq-km. All infrastructural variables are normalized by the mean before the average is being calculated. Following Limão and Venables (2001), this average is then raised to the power -0.3, hence the index of overall quality of infrastructure is higher when the quality is worse.

IV. THE ECONOMETRIC MODEL AND THE RESULTS

Following the approach commonly used in the empirical literature of international trade flows, we evaluate the impact of the quality of infrastructure on trade using a gravity model. We estimate three sets of gravity equations for total bilateral merchandise trade and for bilateral trade in the automotive, textile and clothing sectors. The next subsection describes the model and the estimated equations, while subsection B provides and discusses the results of the regressions.

A. THE GRAVITY MODEL ANALYSIS

In its standard form, the gravity model explains bilateral trade flows as a function of the trading partners' market sizes and their bilateral barriers to trade. Market size is commonly measured by GDP. A number of variables are standard in the empirical literature to capture trade barriers: (i) Transport costs are generally captured by distance and island, landlocked and border dummies to reflect that transport costs increase with distance, they are higher for landlocked countries and islands and are lower for neighbouring countries; (ii) Information costs are generally captured by a dummy for common language; (iii) Tariff barriers are generally neglected. However, data on tariff barriers show that there is a high degree of variability in cross-country bilateral applied tariffs. Neglecting tariffs may be a source of an omitted variable bias. Therefore, we include tariffs in our estimations. The first equation that we estimate is the following:

$$(1) \quad \ln M_{ij} = a_0 + a_1 \ln y_i + a_2 \ln y_j + a_3 \ln d_{ij} + a_4\, border_{ij} + a_5\, lang_{ij} + a_6\, island_{ij} + a_7\, landlock_{ij} + a_8 \ln(1+t_{ij}) + a_9 \ln infr_i + a_{10} \ln infr_j$$

where M_{ij} denotes country i imports from country j, y denotes GDP in PPP, d distance, *border* and *lang* are dummy variables that assume value of one if trading countries i and j share a border and speak a common language respectively and zero otherwise, *island* and *landlocked* also represent dummy variables. They are equal to one if either country i or country j is an island or is a landlocked country respectively, and zero otherwise. Finally, t is the applied bilateral tariff rate and *infr* denote the quality of infrastructure. Each of the six indicators presented in Table 2 is added one at time in the regression.

Recent literature on gravity models of international trade has highlighted that in a theoretically founded gravity model bilateral trade is determined by *relative* trade barriers. In other words, the propensity of country i to import from country j is determined by country i's trade barrier toward j relative to its overall resistance to import and to the average resistance facing exporters to country j, and not simply by the absolute trade barriers between country i and j (Anderson and van Wincoop, 2003a).

We therefore include multilateral resistance terms in our gravity model. Bilateral tariffs are related to the average import tariff of the importer country and the average tariff the exporter face in other markets. Likewise the distance between trading partners is measured relative to an index of the overall remoteness of the two countries. The second equation that we estimate is:

$$(2) \quad \ln M_{ij} = a_0 + a_1 \ln y_i + a_2 \ln y_j + a_3 \ln d_{ij} + a_4\, border_{ij} + a_5\, lang_{ij} + a_6\, island_{ij} + a_7\, landlock_{ij} + a_8 \ln(1+t_{ij}) + a_9 \ln infr_i + a_{10} \ln infr_j + a_{11} T_i + a_{12} T^*_j + a_{13} \ln lat_i + a_{14} \ln lat_j.$$

where T_i is the average tariff levied by the importer, T^*_j is the weighted average tariff faced by the exporter (where weights are given by the share of each trading partner in country j's total exports), and *lat* denotes latitude and it is chosen as a proxy for the remoteness from the major markets.

An alternative method to obtain unbiased estimates of the impact of distance and other bilateral variables on bilateral trade flows is to replace the multilateral resistance indexes with importer and exporter dummies (Anderson and van Wincoop, 2003b). We therefore estimate a third gravity equation including country specific fixed effects. In order to further explore the impact of infrastructure on bilateral trade flows within the fixed effect model, we develop two bilateral variables for the quality of infrastructure. One variable is intended to capture the positive effect of low transport costs on trade. The other is intended to capture the positive effect that the use of similar transport system might have on trade. For example, an exporter can use technologically advanced multimodal transport system only if the importer country has similar facilities. The estimated equation is:

$$(3) \quad \ln M_{ij} = a_0 + a_3 \ln d_{ij} + a_4\, border_{ij} + a_5\, lang_{ij} + a_6\, a_6\, island_{ij} + a_7\, landlock_{ij} + a_8 \ln(1+t_{ij}) + a_9\, \text{good\_av}infr_{ij} + a_{10}\, \text{good\_}infr_{ij} + a_{11i} \sum D_{\text{i}} + a_{12j} \sum D_{\text{j}}.$$

where D_i and D_j denote fixed effects for the importing and the exporting country, respectively; good_av$infr_{ij}$, is a dummy that takes the value of one if the average quality of the infrastructure index (be it road, port, airport, telecommunications or the overall infrastructure index) over the two trading partners is greater than the average across all countries, and zero otherwise; and good_$infr_{ij}$ is a dummy that takes the value one if both trading partners have above average quality of infrastructure and zero otherwise.

B. RESULTS

This subsection reports the results of the OLS regressions for the three sets of estimated gravity equations. For each specification of the gravity equation we perform six regressions, one for each index of quality of infrastructure (road, port, airport, telecommunication, time and the overall infrastructural index). These regressions are performed both on total bilateral trade and on sectoral bilateral trade for the automotive, textile and clothing sectors.

The results of the estimation of equation (1) for total bilateral imports are reported in Table 3a. The first column shows the results for the traditional gravity regression, where in addition we control for bilateral simple average tariffs. The results are similar to that of other studies (McCallum, 1995, for example). We notice that bilateral tariffs are highly significant. A reduction in the tariff factor (1 + t_{ij}) of 10 per cent would increase bilateral trade by about 12.5 per cent. Columns 1- 6 introduce various measures of the quality of infrastructure. It appears that port efficiency has the largest impact on bilateral trade flows, although the results are not entirely comparable since that regression drops all observations of land-locked countries and the countries for which data on port efficiency exist are a relative small sample. Nevertheless we notice that a ten per cent improvement in port efficiency in either exporter or importer increases bilateral trade by over 6 per cent. Furthermore, controlling for port efficiency reduces the economic significance of distance, common border and common language and increases the explanatory power of the model in spite of the much lower number of observations. This suggests that port efficiency is indeed an important determinant of bilateral trade flows. The robustness of the distance parameter when we control for the quality of infrastructure except in the case of port efficiency is somewhat surprising. It suggests that the improvement of infrastructure will not result in bilateral trade falling less off with distance. In other words, distance is unlikely to die with the improvement of transport and communication infrastructure.

Table 3a: Importance of infrastructure in bilateral trade for the importer and the exporter

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
GDP importer	0.96***	.94***	.95***	.80***	.97***	.97***	1.00***
GDP exporter	1.17***	1.12***	1.14***	.91***	1.14***	1.13***	1.17***
distance	-1.31***	-1.22***	-1.22***	-.71***	-1.24***	-1.24***	-1.34***
common border	.58***	.66***	.70***	.02	.67***	.64***	.66***
common language	1.10***	1.09***	1.07***	.92***	1.06***	1.07***	1.27***
island	.23***	-.08	.04	-.39***	-.04	.16***	.35**
landlocked	-.58***	-.58***	-.58***	..	-.51***	-.53***	-.26***
bilateral tariffs	-1.25***	-.74***	-.59*	-.94	-.38	-1.39***	-2.22***
infr. importer		-.46***					
exporter		-.63***					
roads importer			.12***				
exporter			.10***				
port importer				.68***			
exporter				.61***			
airport importer					.11***		
exporter					.11***		
telecom importer						-.01	
exporter						.09***	
time importer							-.30***
exporter							.02
Number of obs.	13915	11901	11327	1710	11361	11428	3411
Adjusted R sq	0.67	0.68	0.68	0.75	0.68	0.68	0.71

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively

We next include resistance terms that take into account that the trade impact of bilateral tariffs is affected by how the level of these tariffs compare to the tariffs other countries face in the importer's market and the average tariff the exporter faces in other markets. Likewise we introduce a resistance parameter that take into account that the impact the distance between the two trading partners has on their bilateral trade depends on how close they are to other markets. For this we use the absolute latitude of the two trading partners. The results are presented in Table 3b. Comparing Tables 3a and 3b it appears that the resistance parameters indeed do increase the parameters on distance, bilateral tariffs and infrastructure as one would expect. However, the results do otherwise not differ very much from those presented in Table 3a, and the explanatory power of the model does not change much either. The regression with port efficiency as the infrastructure variable again sticks out, but it appears to be a problem with this sample as one of the resistance parameters take the wrong sign and is significant.

Table 3b: Importance of infrastructure in bilateral trade for the importer and the exporter Adding Multilateral Resistance Terms in the gravity equation

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
GDP importer	.98***	.97***	.97***	.82***	.99***	.98***	1.03***
GDP exporter	1.21***	1.16***	1.19***	.95***	1.19***	1.16***	1.17***
distance	-1.38***	-1.28***	-1.30***	-.77**	-1.30***	-1.30***	-1.41***
common border	.37**	.46***	.46***	-.32	.47***	.48***	.48**
common language	.93***	.88***	.88***	.86***	.85***	.86***	1.19***
island	.21***	-.03	.75	-.30***	-.00	.13**	.40***
landlocked	-.59***	-.58***	-.59***	...	-.50***	-.47***	-.33***
bilateral tariffs	-1.41***	-1.87***	-1.95***	-2.79*	-2.01***	-1.63***	-5.44***
latitude importer	-.07***	-.07***	-.08***	-.14***	-.08***	-.11***	-.14***
latitude exporter	-.15***	-.21***	-.18***	-.35***	-.20***	-.29***	-.22***
importer tariffs	-.13	1.46**	1.82***	1.66	2.47***	.76	4.53***
tariffs facing exporter	4.14***	2.62***	2.19***	-6.02***	2.30***	2.82***	-.37
infr. importer		-.45***					
exporter		-.74***					
roads importer			.12***				
exporter			.11***				
port importer				.67***			
exporter				.92***			
airport importer					.14***		
exporter					.14***		
telecom importer						.07***	
exporter						.19***	
time importer							-.53***
exporter							-.22***
Number of obs.	11660	10044	9721	1587	9553	9637	2955
Adjusted R sq	0.68	.70	.69	.77	.69	.70	.71

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively

Third, we estimated equation (3). We applied a fixed effects model where all the country-specific characteristics are obviously captured by the fixed effects. This gives us an unbiased estimate of the impact of distance and other bilateral variables on bilateral trade flows. In order to further explore the impact of infrastructure on bilateral trade flows within the fixed effect model, we develop bilateral variables for the quality of infrastructure, as explained above. The results are presented in Table 3c. We notice that the results for the bilateral variables other than infrastructure is similar to those observed in the OLS regression with resistance terms, although the parameters on distance is slightly higher in all regressions while the parameter on common border is slightly lower. Also the island and landlocked dummies are consistently negative in these regressions. In general, being a landlocked country appears to be more disadvantageous for trade than being an island. A comparison between transport costs by land and by sea suggests a similar conclusion. Using data on the cost of transporting a standard container from Baltimore to selected destinations, Limão and Venables (2001) estimate that land transport is about 7 times more costly than sea transport. An extra 1000 kilometres by sea adds on average 190 dollars whereas by land it adds on average 1,380 dollars to the transport cost.

Table 3c: Gravity model with fixed effects: Total Bilateral Trade

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
distance	-1.45***	-1.46***	-1.49***	-.88***	-1.48***	-1.46***	-1.47***
common border	0.39***	0.24*	.21	-.37**	.18	.26*	.26
common language	1.00***	1.04***	1.03***	.98***	1.03***	1.01***	1.54***
island	-0.84***	-0.99***	-.94***	-.04	-.77***	-.89***	.80
landlocked	-0.81***	-0.91***	-.91***	..	-.92***	-.80***	-.97***
bilateral tariffs	-1.78***	-2.69***	-2.84***	-1.39	-2.63***	-2.40***	-5.07***
good_avinfrastructures		.31***					
good_infrastructures		-.18**					
good_avroads			.05				
good_roads			-.41***				
good_avport				.26***			
good_port				.15			
good_avairport					-.08		
good_airport					.86***		
good_avtelecom						.17**	
good_telecom						-.10	
good_avtime							-.09
good_time							-.37
Number of obs.	15730	11901	11327	1710	11361	11428	3411
Adjusted R sq	0.72	0.74	.74	.83	.74	.74	.77

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively

Comparing Tables 3b and 3c nevertheless suggests that the resistance variables that we use yields close to unbiased parameter estimates. The total average infrastructure bilateral variable has a significant impact on bilateral trade. Country pairs that have combined quality of infrastructure above average trade 1.36 times more than country pairs that have combined quality of infrastructure below average.[20] For the individual infrastructure indicators, it appears that ports and airports have the largest effect. Good average for ports and similarly good quality for airports have a positive impact on bilateral trade (1.30 and 2.36 times higher trade respectively). One puzzling result is that trade is significantly *lower* if both countries have better than average quality of roads. Since all country-specific effects are captured in the model, it is unlikely that this is caused by some spurious correlation, but it can not be ruled out.

The fourth to sixth set of regressions are OLS estimates with and without resistance terms and fixed effects estimations for the textiles, clothing, and automotive industries.[21] The summary of the results are presented in Table 4 below, while the details are found in the Appendix Tables 1 to 3.

[20] The combined infrastructure is a dummy, thus the impact is exp(0.31) = 1.36.

[21] For clothing and textiles we introduce a dummy that is one if the exporter faces quota restrictions on its trade with the importer (EU members, USA and Canada) under the Agreement of Textiles and Clothing) and zero otherwise.

Table 4: The role of infrastructure and timeliness in determining comparative advantage

	Auto		Textile		Clothing	
	(1)	(2)	(1)	(2)	(1)	(2)
Infrastructure	0.36**	-.09	.12	.02	-1.18***	-.88***
	-0.65***	-.78***	.02	-.29**	-.21	-.57***
Roads	-0.6**	-.01	.03	.03	.12***	.05*
	.24***	.26***	.23***	.28***	.15***	.23***
Ports	0.59**	1.27***	.48**	1.11***	2.14***	1.69***
	1.23***	1.37***	.02	.67***	-.00	1.08***
Airports	-0.1***	-.05	.034	.06**	.15***	.11***
	0.2***	.21***	.05**	.08***	.07**	.12***
Telecom	-0.21***	-.07	.03	.19***	.35***	.29***
	0.11***	.20***	-.22***	-.17***	-.18***	-.05
Time	0.08	-.18	-.14	-.37***	-.60***	-.42***
	-0.56***	-.55***	-.21**	-.71***	-.12	-.91***

Note: (1) core equation, (2) regression with resistances. ***,**,* denote 1, 5, 10 per cent significance level, respectively. For each infrastructural index, the first row refer to the importer's infrastructure, the second to the exporter's.

We first notice that it appears that the exporters' infrastructure is more important than the importers'. Second, among the individual indicators for the quality of infrastructure, it appears that port efficiency again has the largest impact. It is also worth noticing the importance of time for customs clearance, particularly in the case of exporters in the clothing sector. This suggests that own red-tape can be an equally big problem as are importers' trade barriers towards clothing exporters from developing countries, a result that is relevant to the study of the impact of quota elimination under the Agreement on Textiles and Clothing (ATC). The significant and negative impact of telecommunications may reflect that countries with poor telecommunication infrastructure may have comparative advantage in the clothing and textiles sector. In fact, the impact of the bilateral telecommunication quality variables included in the fixed effects regressions is positive and significant in all but one case (both good infrastructure in clothing, where it is positive, but insignificant). It appears also that the time factor is particularly important in the clothing industry. If both trading partners have good airports, trade is twice as high as otherwise, while if both has lower than average time through customs trade is about 1.4 times higher. In the textiles sector, having a common language appears to matter less than in the other sectors, while tariffs have a large negative impact on bilateral trade flows (see Appendix Table 2c). Among the infrastructure variables it is telecommunications that have the largest effect on bilateral trade flows in the fixed effects regressions. Finally, in the automotive sector port efficiency has the largest impact on bilateral trade, followed by telecommunications.

V. SUMMARY AND CONCLUSIONS

This paper has provided additional measures of bilateral trade restrictions in empirical estimates using the gravity model. First, we introduce a number of indicators of behind-the-border infrastructure that we believe have an impact on transaction costs in international trade. Second, we introduce bilateral tariffs, which are largely ignored in the empirical gravity literature. Third, in order to ensure unbiased estimates, we introduce resistance parameters related to both tariffs and remoteness. Fourth, we develop bilateral indicators for the quality of infrastructure, assuming that the combined quality of infrastructure in pairs of trading partners matter for bilateral trading costs. This also allows us test to what extent our resistance parameters yield unbiased estimates, using a fixed effects model where all the country-specific characteristics, including the quality of infrastructure, are captured by the fixed effects.

We find that the quality of infrastructure has a significant and relatively large impact on bilateral flows. Among the individual infrastructure indicators, port efficiency has the largest impact on bilateral trade, but there is possibly a selection bias in the sample here, since data are available only for a subsection of coastal countries on this variable. Further, we find that bilateral tariffs have a relatively large and negative impact on bilateral trade, a factor that in most cases are not included in gravity regressions of bilateral trade flows. Among the individual sectors, clothing appears to be the most time-sensitive, while the automotive sector appears to be the most information-sensitive. These findings support recent research on these sectors suggesting that clothing is largely a "replenishment good" or even a perishable good where changes in fashion are rapid and sales seasons short followed by large discounts as the season runs late. The automotive sector in turn is characterized by just-in-time production technology, differentiated products and intra-industry trade both in components and finished cars. Just-in-time production requires coordination, which in turn is information-intensive. Finally, textiles are the sector most sensitive to distance and tariffs.

Interestingly, we find that the importance of distance is not diminished when the quality of infrastructure is included. Since distance is a proxy for trade costs and trade costs according to several studies quoted in this paper are largely determined by the quality of infrastructure, this is somewhat surprising. It is, however, likely that better infrastructure and lower transport costs first and foremost increase the total volume of trade, while the distance is as important as before for the distribution of (a larger volume) of trade on individual trading partners.

These findings have important policy implications for least developed countries. If improvements in the quality of infrastructure in these countries lag behind the development in more developed countries, their share of world trade is likely to continue to decline. Worse, it appears that time to market and hence the quality of infrastructure matter more than before in sectors such as textiles and clothing; a development that threaten to undermine least developed countries' comparative advantage in important segments of these sectors. Improvements in the quality of infrastructure can, however be costly and in the short term beyond the means of the governments of least developed countries. Nevertheless, there are areas where large improvements could be obtained at modest cost. This study suggests that port efficiency is the single most important infrastructure variable. Other studies have shown that liberalization of the port services sector has improved efficiency substantially in many countries. This is a policy option that has modest costs and, if well designed, would improve trade performance significantly. Internal and external liberalization of other key infrastructural services has also improved efficiency in other key infrastructural services sectors, most notably telecommunications. In addition, developing industrial areas close to major harbours or airports could be a starting point in countries that cannot afford universal infrastructure services in the short to medium term. By this we do not advocate the establishment of export processing zones or special economic zones. What we have in mind is rather to develop fully serviced areas where exporting, import-competing and non-traded sector companies alike have access to and are charged the full cost of the infrastructure services.

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Appendix Table 1a

The role of infrastructure in determining comparative advantages: the Automotive Sector

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
GDP importer	.67***	0.71***	.70***	.79***	0.69***	.76***	.80***
GDP exporter	1.31***	1.28***	1.28***	1.64***	1.29***	1.29***	1.4***
distance	-1.23***	-1.27***	-1.22***	-1.40***	-1.25***	-1.33***	-1.56***
common border	.90***	.90***	.99***	.30	0.9***	.78***	.71***
common language	1.11***	1.16***	1.25***	.83***	1.2***	1.12***	.89***
island	.43***	.28**	.16	-.10	0.28**	.44***	.21
landlocked	.20***	.21**	.18**	...	0.26***	.19**	.47***
bilateral tariffs	-1.02***	-1.77***	-1.60***	-1.79***	-1.8***	-2.5***	1.22
infrastructure		0.36**					
		-0.65***					
roads			-0.6**				
			.24***				
ports				0.59**			
				1.23***			
airports					-0.1***		
					0.2***		
telecommunications						-0.21***	
						0.11***	
time							0.08
							-0.56****
N. obs	5468	4782	4623	1284	4527	4707	1729
Adj-R sq	0.5	0.52	0.53	0.61	0.52	0.52	0.57

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively

Appendix Table 2a

The role of infrastructure in determining comparative advantages: the Textile Sector

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
GDP importer	.75***	.75***	.75***	.68***	.74***	.75***	.79***
GDP exporter	1.07***	1.06***	1.00***	1.12***	1.05***	1.31***	1.11***
distance	-1.21***	-1.27***	-1.20***	-1.39***	-1.27***	-1.35***	-1.47***
common border	1.04***	1.06***	1.25***	.38	1.11***	.93***	.94***
common language	.66***	.71***	0.75***	1.04***	.62***	.72***	.55***
island	0.02	.01	-.22**	-.21	-.05	.06	.35
landlocked	-.34***	-.32***	-.31***	...	-.27***	-.32***	.03
bilateral tariffs	-2.24***	-2.51***	-2.26***	-.37	-1.86***	-1.86	-2.93***
quota	1.01***	.88***	.96***	.66***	1.03***		.95***
infrastructure		.12					
		.02					
roads			.03				
			.23***				
ports				.48**			
				.02			
airports					.034		
					.05**		
telecommunications						.03	
						-.22***	
time							-.14
							-.21**
Number of obs	6595	5734	5486	1402	5405	5634	1983
Adj R-squared	0.5	0.5	0.51	0.56	0.51	0.51	0.57

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively

Appendix Table 3a

The role of infrastructure in determining comparative advantages: the Clothing Sector

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
GDP importer	.74***	.74***	.79***	.66***	.80***	.71***	.87***
GDP exporter	.74***	.75***	.75***	.69***	.78***	.83***	.87***
distance	-1.08***	-1.09***	-1.14***	-1.33***	-1.16***	-1.16***	-1.26***
common border	.64***	.78***	.76***	.08	.69***	.67***	.57**
common language	1.04***	1.12***	1.07***	1.18***	1.02***	1.06***	1.10***
island	.55***	.27***	.42***	.27	.44***	.44***	.80***
landlocked	-.38***	-.54***	-.48***		-.40***	-.45***	-.02
bilateral tariffs	-5.0***	-3.80***	-4.52***	-3.44***	-4.04***	-2.82***	-2.88***
quota	2.41***	2.10***	1.28***	1.70***	2.10***	2.06***	1.64***
infrastructure		-1.18***					
		-.21					
roads			.12***				
			.15***				
ports				2.14***			
				-.00			
airports					.15***		
					.07**		
telecommunications						.35***	
						-.18***	
time							-.60***
							-.12
Number of obs	6917	6029	5733	1391	5682	5884	1990
Adj R-squared	0.43	0.45	0.46	0.47	0.46	0.45	0.5

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively

Appendix Table 1b:

The role of infrastructure in determining comparative advantages: The Automotive Sector Adding Multilateral Resistance Terms in the gravity equation

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
GDP importer	.71***	0.75***	.74***	.80***	.73***	.77***	.84***
GDP exporter	1.36***	1.34***	1.33***	1.69***	1.34***	1.34***	1.43***
distance	-1.32***	-1.36***	-1.31***	-1.42***	-1.33***	-1.37***	-1.61***
common border	.70***	.70***	.81***	-.10	.70***	.69***	.77*
common language	.94***	.96***	1.03***	.70***	1.00***	.94***	.68***
island	.40***	.33**	.23*	-.07	.34***	.42**	.24
landlocked	.09	.06	.04	...	.14	.06	.36**
bilateral tariffs	-1.95***	-2.83***	-2.70***	-3.53***	-2.55***	-2.62***	.04
latitude importer	-.20***	-.19***	-.17***	-.23***	-.17***	-.11**	-.20***
latitude exporter	-.04	-.10**	-.11**	-.16**	-.08*	-.17***	-.05
importer tariffs	.78	.86	1.06	2.60	.52	-.19	.92
tariffs facing exporter	-1.51	-3.59**	-2.68**	-6.83**	-2.94*	-3.63**	-.18
infr. importer		.28					
exporter		-.75***					
roads importer			-.05				
exporter			.25***				
port importer				.69**			
exporter				1.29***			
airport importer					-.08**		
exporter					.21***		
telecom importer						-.16***	
exporter						.19***	
time importer							.00
exporter							-.66***
Number of obs.	4717	4146	4027	1186	3911	4081	1509
Adjusted R sq	0.51	.54	.54	.62	.54	.54	.58

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively

Appendix Table 2b:

The role of infrastructure in determining comparative advantages: The Textile Sector Adding Multilateral Resistance Terms in the gravity equation

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
GDP importer	.80***	.79***	.80***	.78***	.80***	.78***	.87***
GDP exporter	1.08***	1.07***	1.02***	1.18***	1.07***	1.13***	1.17***
distance	-1.31***	-1.35***	-1.29***	-1.47***	-1.35***	-1.40***	-1.63***
common border	.91***	.96***	1.16***	-.15	1.02***	.83***	.77**
common language	.53***	.58***	0.59***	.95***	.48***	.61***	.42***
island	-.16*	-.08	-.26***	-.17	-.08	.01	.30
landlocked	-.36***	-.34***	-.35***	...	-.29***	-.35***	.11
bilateral tariffs	-4.64***	-5.05***	-4.89***	-4.87***	-4.49***	-4.33***	-5.42***
quota restrictions	.99***	.94***	1.09***	.62***	1.17***	.95***	1.09***
latitude importer	-.02	-.02	-.00	-.32***	-.02	-.08*	-.08
latitude exporter	-.07*	-.09**	-.13***	-.40***	-.09**	-.03	-.39***
importer tariffs	4.09***	5.06***	5.24***	6.45***	5.32***	5.38***	5.86***
tariffs facing exporter	9.91***	8.23***	7.12***	-2.79	6.90***	7.68***	4.63**
infr. importer		-.10					
exporter		-.16					
roads importer			.04				
exporter			.25**				
port importer				.87***			
exporter				.20			
airport importer					.06**		
exporter					.07***		
telecom importer						.12***	
exporter						-.19***	
time importer							-.29**
exporter							-.55***
Number of obs.	5678	4966	4778	1304	4661	4877	1725
Adjusted R sq	.51	.51	.52	.58	.52	.52	.58

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively

Appendix Table 3b:

The role of infrastructure in determining comparative advantages: The Clothing Sector
Adding Multilateral Resistance Terms in the gravity equation

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
GDP importer	.74***	.74***	.77***	.65***	.78***	.72***	.92***
GDP exporter	.79***	.79***	.77***	.80***	.81***	.84***	.90***
distance	-1.24***	-1.22***	-1.26***	-1.43***	-1.28***	-1.30***	-1.49***
common border	.49**	.60***	.59***	-.47	.53**	.49**	.24
common language	.94***	.99***	.97***	1.12***	.90***	.93***	.84***
island	.50***	.28**	.44***	.29*	.44***	.43***	1.03***
landlocked	-.45***	-.53***	-.50***	...	-.46***	-.46***	.11
bilateral tariffs	-3.21***	-2.74***	-2.79***	-2.46**	-2.40***	-1.53**	-2.07**
quota restrictions	2.09***	1.87***	1.79***	1.25***	1.93***	1.85***	1.60***
latitude importer	.12***	.11***	.13***	.14*	.12***	.04	-.11
latitude exporter	-.14***	-.19***	-.24***	-.73***	-.22***	-.12**	-.44***
importer tariffs	-3.35***	-2.51**	-4.35***	-2.47	-371***	-3.19***	-.73
tariffs facing exporter	17.49***	14.41***	9.70***	-2.16	9.82***	14.28***	11.60***
infr. importer		-.91***					
exporter		-.33**					
roads importer			.02				
exporter			.18***				
port importer				1.79***			
exporter				.41*			
airport importer					.10***		
exporter					.09***		
telecom importer						.35***	
exporter						-.12***	
time importer							-.74***
exporter							-.60***
Number of obs.	5915	5212	5009	1293	4892	5082	1731
Adjusted R sq	.45	.46	.47	.50	.47	.47	.52

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively

Appendix Table 1c:

The role of infrastructure in determining comparative advantages: The Automotive Sector
Gravity model with fixed effects

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
distance	-1.54***	-1.63***	-1.67***	-1.77***	-1.65***	-1.62***	-1.94***
common border	.71***	.56***	.52***	.33	.54***	.49***	.39
common language	1.15***	1.24***	1.24***	1.03***	1.26***	1.31***	1.44***
island	-.62**	-.79**	-.77**	-.64	-.72**	-.85***	-.99
landlocked	-.85***	-.94***	-.92***	..	-.90***	-.94***	-.95**
bilateral tariffs	.72	-.03	.11	-2.54*	.37	.10	2.73*
good_avinfrastructures		.03					
good_infrastructures		.52***					
good_avroads			.29**				
good_roads			.38***				
good_avport				.38**			
good_port				.99***			
good_avairport					.21*		
good_airport					.50		
good_avtelecom						.39***	
good_telecom						.64***	
good_avtime							.94***
good_time							.21
Number of obs.	5877	4782	4623	1284	4527	4707	1729
Adjusted R sq	0.68	.67	.70	.77	.679	.67	.70

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively

Appendix Table 2c:

The role of infrastructure in determining comparative advantages: The Textile Sector
Gravity model with fixed effects

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
distance	-1.63***	-1.72***	-1.76***	-1.77***	-1.75***	-1.71***	-1.88***
common border	.56***	.56***	.565***	-.05	.52***	0.54***	.39*
common language	.92***	.92***	.92***	.87***	.93***	0.97***	.76***
island	-.67***	-.57**	-.62**	-.13	-.56**	-.61**	-.20
landlocked	-.41**	-.43**	-.39**	..	-.41**	-.44**	-.16
bilateral tariffs	-5.30***	-6.30***	-5.87***	-1.32	-5.86***	-6.10***	-6.9***
quotas	.45***	.37***	.49***	.40**	.38**	.36**	.61***
good_avinfrastructures		.26**					
good_infrastructures		.44***					
good_avroads			.06				
good_roads			.19				
good_avport				.36***			
good_port				.37**			
good_avairport					.07		
good_airport					.33		
good_avtelecom						.26**	
good_telecom						.54***	
good_avtime							.22
good_time							.13
Number of obs.	7058	5734	5486	1402	5405	5634	1983
Adjusted R sq	0.67	.70	.70	.78	.68	.69	.70

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively

Appendix Table 3c:

The role of infrastructure in determining comparative advantages: The Clothing Sector
Gravity model with fixed effects

	(core)	(1)	(2)	(3)	(4)	(5)	(6)
distance	-1.51***	-1.53***	-1.6***	-1.63***	-1.58***	-1.55***	-1.65***
common border	0.43***	.51***	.44***	-.06	.36**	.50***	.28
common language	1.24***	1.33***	1.32***	1.06***	1.36***	1.31***	1.44***
island	-0.51***	-.23	-.30	1.25***	-.13	-.22	1.25
landlocked	0.08	.14	.12	..	.13	.20	-.02
bilateral tariffs	-1.42**	-1.15	-.89	.03	-.87	-1.24*	.01
quotas	.74***	.59***	.55***	.27	.56***	.52***	.39*
good_avinfrastructures		0.05					
good_infrastructures		.29**					
good_avroads			.01				
good_roads			.16				
good_avport				.44***			
good_port				.24			
good_avairport					.07		
good_airport					.66**		
good_avtelecom						.21*	
good_telecom						.06	
good_avtime							.26
good_time							.34*
Number of obs.	7475	6029	5733	1391	5682	5884	1990
Adjusted R sq	0.68	.70	.71	.74	.70	.71	.71

Note: ***,**,* denote 1, 5, 10 per cent significance level respectively