THESIS

POTENTIAL IMPACTS OF HARD INFRASTRUCTURE DEVELOPMENT ON AGRICULTURAL TRADE

Submitted by

Aaisha Al-Maamari

Department of Agricultural and Resource Economics

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Master's Committee:

Advisor: Amanda Countryman

Dawn Thilmany
Anita Pena

ABSTRACT

POTENTIAL IMPACTS OF HARD INFRASTRUCTURE DEVELOPMENT ON AGRICULTURAL TRADE

The development of hard infrastructure has the potential to enhance agricultural production and international agricultural trade. Good quality physical networks could reduce the transport costs for producers and suppliers, thereby increasing the volume of agricultural bilateral trade. For most countries, tariff rates, transport costs, geographic drawbacks, and other nontariff barriers are considered to be the most significant potential impediments to trade. This study estimates the role of hard infrastructure on agricultural bilateral trade among North and Latin American countries, as one determinant of transport costs. By using panel data for agricultural imports from 2006 to 2014, we measure the potential impact of the quality of overall hard infrastructure as well as specific modes of transport networks such as roads, railroads, ports and airports infrastructure on the prevalence and patterns of agricultural trade. A modified gravity model of trade has been used to measure the impact of different trade barriers on the trade of food, animal, vegetable and aggregated agricultural products. Results show that the distance between countries and hard infrastructure are statistically significant and play an important role in determining transport costs as well as the variation in agricultural bilateral trade. For both aggregated and disaggregated agricultural trade, the estimated coefficients show that exporters' infrastructure has a larger impact on trade than importers' infrastructure. Results show that a 10 percent improvement in the quality of an exporters' hard infrastructure may

increase total agricultural import volume by 8.6 percent, while a 10 percent improvement in importers' hard infrastructure may increase aggregated agricultural imports by 6.0 percent.

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CHAPTER 1/INTRODUCTION

The agricultural sector receives special emphasis across the world given its potential role to enhance food production and distribution specifically for low-income countries. Most agricultural activities are concentrated in rural areas where labor and natural resources are concentrated. However, the production and supply of agricultural products are unstable since the production of any commodity is impacted highly by changes in climate, seasonality of production, availability of natural and capital resources, and the cost of production. On the other hand, demand and consumption of agricultural goods are assumed to be stable given that agricultural commodities are primary and necessary products for consumers. Large demand quantities for agricultural products can be observed in countries that have large populations such as Canada and the U.S. However, there are different goals that importing and exporting countries may want to achieve with imports and exports of agricultural commodities. For exporters, excess supply of agricultural commodities can be sold on the world market, which represents a source of income for the country. Importers buy agricultural products because countries cannot grow or produce all types of agricultural commodities due to climate, natural resource availability, and production season and costs. Also, some countries work on processing food products, and may need to purchase raw materials from other countries. In addition, many countries import to meet food security needs, to facilitate consumer access to primary agricultural products. Although there has been an increase in agricultural production in most of the developing world, the cost to access the market, or transport costs, may reduce rural farmers' return. A major determinant of transport costs is the inefficient network of rural infrastructure (Andersen and Shimokawa, 2006). The deficiency in the quality of rural infrastructure may result in high processing and transportation rates for producers. Rural infrastructure is essential as it provides a means of accessing both local and global markets. Many researchers address the topic of improving rural infrastructure and development in developing countries to help agricultural producers better connect to markets (Andersen and Shimokawa, 2006, Wanmali and Islam, 1997).

Infrastructure including roads, railroads, ports, airports, telecommunication, and so on, is a requirement for economic growth and world integration. Infrastructure can be categorized as soft or hard infrastructure. Soft infrastructure includes institutions such as government, communication system, education and the health system, which influence one aspect of the economy. However, this paper investigates focuses on hard infrastructure which comprises all types of physical networks such as roads, railroads, ports and airports. This is known as the hard network system that enables physical connections within the country and across international borders. Hard infrastructure has a salient role in determining the cost of transportation that producers incur to move commodities to local or international markets. Generally, the impact of poor quality infrastructure has not been observed solely among rural producers while transporting commodities to the center of the market, but also by other traders, or intermediaries, when selling products in international markets.

1.1 Agricultural trade and transport costs

Continued emphasis has been placed on international trade of agricultural and food products by both developed and developing countries. Although some countries have shown large growth in agricultural trade over the last twenty years, large portions of the developing world are still behind. These countries are unable to realize the full benefits of trade as a result of either tariff or non-tariff trade barriers which often restrict international trade. The reduction of trade costs becomes one major objective for most countries. Trade barriers include policy variables, information costs, geographic factors, transport costs, time, and transaction costs (Anderson and van Wincoop, 2004; Hummels, 2001).

Policy variables such as applied tariffs, especially for agricultural products, have been reduced or eliminated over the past twenty years as a result of recommendations by the World Trade Organization (WTO). The WTO gives emphasis to the negotiation of agricultural trade barriers including high tariff rates and subsidies. The Agricultural Agreement held in the Uruguay Round from 1986-1994 covered the main agricultural trade issues comprised of market access, domestic support and export competition (World Trade Organization, 2017). After the agreement was fully implemented in 1995, countries started to reduce or eliminate tariff rates and subsidies on agricultural trade, especially for partners within the same regional or preferential trade agreements. However, given the noticeable reduction in tariff rates, the volume of agricultural trade is still relatively low in some low-income countries. For instance, the percentage of agricultural imports compared to total imports for Barbados was 15.42 percent in 2000 and it increased gradually by approximately 4 percent in 2014, which indicates slower growth in the value of imports. Relative to non-agricultural products, there is also a decrease in the rate of exports of agricultural products for selected North and Latin American countries as shown in Table 1. For example, the percentage of agricultural exports compared to total export by Bolivia, Honduras and Nicaragua were 30.25 percent, 71.65 percent and 87.97 percent in 2000, respectively. However, the percentage of agricultural exports decreased to 15.94 percent for Bolivia, 54.91 percent for Honduras and 51.47 percent for Nicaragua in 2014.

Transport costs have a major impact on trade flows (Limao and Venables, 2001; Clark, Dollare and Micco, 2004; Behar and Venables, 2010; Bougheas, Demetriades and Morgenroth, 1999). Transport costs are determined by transaction and shipment costs, quality of infrastructure and geographic variables such as distance, common border, and whether a country is an island, or landlocked. Geographic factors, infrastructure, and distance between countries are important in determining transport costs and trade patterns as they implicitly represent shipment and travel costs (Limao and Venables, 2001; Behar and Venables, 2010). One potential geographic disadvantage for a country is if its place increases the transport costs to move goods within or across the borders of countries. Agricultural commodities are particularly impacted by the effects of transport costs as they are often bulky, perishable and quality maintenance requires delivery to be time sensitive. This study investigates how changes in particular transport costs of agricultural goods affect trade flows. Transport costs have been used indirectly in trade models by including variables such as hard infrastructure, distance and presence of a common border. Finally, information costs are another non-tariff barrier to trade which represent the impact on trade volume of sharing a common language, colonial history, and having well developed telecommunication technology.

The recent developments in infrastructure, both soft and hard, have led to global economic integration among many countries around the world. Hard infrastructure development is especially important for the trade of agricultural products as many are perishable, and thus, quality may diminish once moved over a long distance. Well-developed hard and soft infrastructure systems enable the delivery of agricultural products in a shorter time and reduce shipment expenses and higher returns to producers. Thus, improving the quality of physical networks across the country and at the border may be one effective strategy to overcome distance and other geographic disadvantages, and reduce international trade costs. Accordingly, infrastructure developments are expected to reduce transport costs and provide welfare benefits to trading partners. For instance, if importers invest in roads, railroads, airports or ports improvement, then the country may increase the volume of imports by lowering costs. On the other hand, exporters also benefit from infrastructure improvements. This supports the view that good, quality physical infrastructure is expected to reduce trade costs. Therefore, the aim of this study is to investigate the effects of infrastructure on agricultural trade.

1.2 Objectives

The main objective of this study is to estimate the relationship between hard infrastructure development and bilateral trade flows. Specifically, the study estimates the effect of the quality of hard infrastructure on agricultural trade volume given other factors influencing the quantity traded, such as different tariff rates imposed by importing countries, distance and contiguity between the two countries, and the noticeable difference in the income level of each country. A modified gravity model of trade is used to address the impact among selected North and Latin American countries for a time period of nine years. The sub-objectives of the study are:

1. To address the effects of transportation infrastructure quality on agricultural trade from 2006 to 2014.
2. To compare the impact of hard infrastructure development on agricultural trade flows including aggregated agricultural products and agriculture sub-sectors including food, animal and vegetable products.
3. To estimate the unique contribution of each mode of transport infrastructure including roads, railroads, ports and airports on agricultural trade volume.

While previous research estimates the impact of infrastructure development on total product trade or compares trade flows of aggregated agricultural and non-agricultural products, this study focuses on estimating the impact of physical infrastructure on trade of agricultural products targeting the analysis to particularly focus on the main subsectors; food, animal and vegetable products. A modified gravity model of trade is used to estimate the impact of hard infrastructure development on agricultural trade. Where zero trade flows have been omitted by many past studies, this research accounts for zero trade flows in the analysis using Tobit and Poisson Pseudo Maximum Likelihood estimation methods.

1.3 Agricultural trade in North and Latin America

The United States, Canada, Argentina and Brazil are considered as key exporters and importers of agricultural products. The main forces that influence agricultural trade, in general, are changes in global food supply and demand, changes in agricultural commodity prices, countries' specific government regulations to protect agricultural trade, and direct or indirect domestic support to enhance agricultural domestic production (U.S. Department of Agriculture, 2017). The demand for food products derived by the increase in global population and income growth has resulted in the increase of U.S. food export volume by more than 30 billion U.S. dollars from 1991 to 2015 (World Integrated Trade Solution, 2017). Conversely, agricultural imports are affected by the domestic consumption of a nation and the cost of food production. The percentage of food exports was higher than the increase in food imports for the sample selected countries, which could be attributed to the increase in agricultural production by these countries.

Trade values of agricultural products in the selected sample countries are presented in Table 1 as the percentage of total imports and exports for 2000 and 2014. There have been some variations in agricultural trade values over the last ten years. The data shows that some countries experience a noticeable decline in the percentage of agricultural imports and exports including Bolivia, Colombia, Honduras and Peru by comparing 2000 to 2014. On the other hand

Argentina, Canada and Guyana experienced a rise in both the percent of imports and exports in 2014 compared to 2000. Exports from Brazil increased by a rate of 12 percent in 2014 while the percent of imports decreased by nearly 2 percent during the same time. Mexico has similar percentage changes in the rate of agricultural imports and exports (they increased from 4 percent in 2000 to 6 percent in 2014). These changes could be due not only to changes in production but also due to variation in geography of a country, travel routes available to export or import products and the efficiency level of infrastructure in the country.

Agricultural trade among North America and Latin America[1] countries from 2010-2015 are compared in Figure 1. The total agricultural import value for North America from Latin America increased significantly from 2010 to 2015. Meanwhile, the export levels for North America from Latin America and the imports of Latin America from North America have fluctuated over the six years with a decline of roughly 3 billion from 2014 to 2015.

Agricultural trade patterns of selected countries from North and Latin America are represented in Figure 2. Countries are presented to show the difference in agricultural trade levels between developed and developing countries. In addition, the trade direction captures the effects of some trade determinants on the level of imports such as policy effects, including tariff rates or being a member of the same trade agreement, as well as geographic variables. The level of agricultural imports to the U.S. from Canada is the highest in volume as it gradually increased from about 19 trillion U.S. dollars in 2010 to 26 trillion U.S. dollars in 2014. This could be due to the noticeable reduction in import tariff rates by the U.S. during the last decade, another reason is the high quality of infrastructure within the two countries and their proximity, all of

[1] North America includes the United States, Canada and Mexico. The Latin America region includes South America (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela), Central America (Belize, Costa Rica, El Salvador, Guatemala, Nicaragua, and Panama) and the Caribbean (Antigua and Barbuda, Bahamas, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and Grenadines, and Trinidad and Tobago).

which overcome geographic drawbacks. Compared to Canada and the U.S., Argentina imports from Brazil are relatively low even though they also share a common border and are members of the same regional trade agreement. In contrast, agricultural trade between Mexico and the U.S. has increased during the period 2010 to 2015. The volume of agricultural imports to the U.S. from Mexico was more than 20 billion U.S. dollars in 2015 compared to 15 billion in 2010. This increasing pattern of bilateral trade between Mexico and the U.S. could be due to the improved quality of trade facilitation over time, given that the two countries are sharing a common border.

In summary, the current trends and patterns for agricultural trade indicate that the dependency on international trade of any one country is highly influenced by time and cost efficiency of transporting agricultural products across land borders or water, especially among developing countries.

1.4 Quality of physical infrastructure

The trends illustrating the quality of overall infrastructure between Argentina, Brazil, Mexico, Paraguay, the U.S. and Canada over the ten year period are presented in Figure 3. In the figure, the quality of infrastructure is represented in term of indices from 2006-2015. Infrastructure indices data are provided by the World Economic Forum through a yearly published report called the Global Competitiveness Report. The data collected from the Executive Opinion Survey, which are based on the informed judgments of the actual participants from the selected economic institutions of each country. Then the World Economic Forum provides a competitiveness analysis using a Global Competitiveness Index (GCI), which provides a method for measuring the microeconomic and macroeconomic activities of each country (Porter and Schwab, 2007). The infrastructure indices take values from 1 to 7, where the lowest quality takes the value of 1 and the best quality takes the value of 7, and as index value increases from 1 to 7, this means that the infrastructure quality has improved. Trends clearly show that infrastructure in the United States and Canada is much better than in Argentina, Brazil, Mexico and Paraguay. The quality of infrastructure is similar between the U.S. and Canada with index values equal to approximately 6 for both countries. This is also the case for Brazil, Argentina and Mexico, where infrastructure quality improved over time and reached index values of approximately 4 in 2015. This reflects the difference in the quality of infrastructure between developed and developing countries. Also, it clearly demonstrates how developing countries may start realizing the benefit of developing infrastructure over time, as trends do show some slow growth in the quality of infrastructure. However, Paraguay has the lowest infrastructure index among the given countries for the timeframe considered. In general, Figure 3 indicates that there is a gap between the quality of infrastructure of the developed and developing world. Nevertheless, the trends show slight improvements in the quality of the overall infrastructure from 2012 and onward among all countries. These improvements are expected to positively impact bilateral trade. This assumption will be investigated in this paper using the gravity model of trade focused on agricultural products in North and Latin American countries.

1.5 High and low quality hard infrastructure

1.5.1 Roads

Roads are considered as the primary transportation system for both passengers and goods transport. Goods and cargo are shipped via trucks while using road networks. The lowest quality roads, with index values of 1, refers to routes which are normally without any construction and maintenance and are unpaved or gravel roads. Low quality roads are common in most of developing countries and oftentimes in rural areas of developed nations. These old roads and highways would require substantial funding projects to invest in remodeling to create higher quality transportation networks. All sample countries have values for the roads index of more than 2, suggesting low to medium weighted average quality of roads at a minimum within the sample. High quality roads, represented by an index value of 7, have features of paved and smooth roads that connect cities and rural areas in the country, with no vehicle congestion or traffic. Also, they are comprised of large and new highways around all the regions of a country. Canada and the U.S. have the highest weighted average quality index values for roads, relative to other countries in the sample, with index values of approximately 5.7 in recent years. This means that the road networks in these two countries are well constructed to provide industries and consumers easy access to markets.

1.5.2 Railroads

Railroads are considered a significant part of the hard infrastructure transportation system in North American countries (Canada, U.S. and Mexico). North American countries use rail networks to move cargo and large product shipments between cities using trains. In general, railroad industries are classified based on the weight over the line-length. Short-line railroads usually connect companies or firms to supply sources, while large-line railroads connect far away companies and cities (Simpson, 2017). Low quality railroads have a traditional track structure which consists of flat-bottom steel rail lines supported by wood and placed on ballasted stone (American-Rails.com, 2017). This old rail system structure requires more maintenance and repair given the intensive use for transportation. Suriname, Paraguay, Honduras, Guatemala, Costa Rica and Brazil have low quality railroads index values of 1 to 2 for 2006-2014, relative to the other countries in the sample. Barbados and Trinidad and Tobago have no railroad transportation system. High quality railroads have iron strap rail and ballastless track, which is based on a continuous reinforced concrete slab (similar to a highway structure) (American-Rails.com, 2017). This structure remains in a good condition for longer periods of time and requires less maintenance over time, compared to the low quality rails network. Canada has the highest quality index among North and Latin American countries, with an index value of about 5 for 2006-2014.

1.5.3 Ports

More than 80 percent of world trade is carried through waterways (The Global Facilitation Partnership for Transportation and Trade, 2013). The physical infrastructure of ports includes all facilities, vessels, and institutions at the border of a country that are essential to facilitate cargo shipment through waterways easily. Low quality ports are small in size with old and degraded facilities and small size vessels. They have higher turnaround times for ships, ship to nearby countries and serve a relatively low number of customers around the world. Brazil and Venezuela are examples of low quality ports with indices of 2.4 to 2.9, as assigned by the Global Competitiveness Report (GCR), compared to other countries in the sample. High quality ports can support large vessels that can carry large, heavy weight cargo, increasing their ability to earn higher profits by handling larger shipments. In addition, these ports are located in an accessible coastal border of a country. They have good and new storage facilities, less congestion, and they provide quicker services to customers with less cost to all parties. They also provide easier access to railroads, roads and highways to move cargo on the interstates or to inland cities. Also, more projects and increased investment in high quality ports is occurring to expand the industry to meet the future needs and market demand of different counties around the world. Panama has the best quality ports, based on physical infrastructure, among the sample countries with an index value of 6.3 in recent years.

1.5.4 Airports

Usually airports are used less for both freight transport and shipments of agricultural products. Low quality airports are of a small size and have fewer connecting flights to a smaller number of countries around the world. They are old and would require relatively large investment projects to rebuild and expand their capacities. In contrast, high quality airports are of a large size, have newer facilities and include further transportation services on the airport site (rail networks, public buses, taxi, shuttle services). High quality airports can facilitate customs and immigration quickly and have specific high technical standards to ensure safety and security of moving products across air ways. Among the sampled countries, Canada, Panama and the U.S. have the best quality of airports with weighted average quality index values of about 6; and Paraguay has the lowest quality with index values ranging from 2 to 3 in 2006-2014 assigned by GCR.

1.5.5 Hard infrastructure in Brazil

Brazil is an example of an important agricultural exporter and importer with low to medium overall hard infrastructure quality. Roads are the primary mode of transportation across Brazil. However, they are insufficient in terms of both quantity and quality because of Brazil's increasing population, which impacts passengers and freight transportation. Brazil has a less developed road system with many unpaved roads, especially in rural areas. The country has some investment projects to expand and reform roads in less developed areas of Brazil, specifically roads that are used more by the industrial sector. The Global Competitiveness Report of 2014 assigned an index value of 2.8 to Brazilian roads, which indicates the poor condition of the road system. Railroads were used in Brazil for transportation in the 1800's for the first time (Meyer, 2010). An index value of 1.7 was assigned by GCR to railroads in Brazil in 2014. Both the road and railroad networks lack the sufficient capacity to connect all the regions around the country. The current ground networks require investment projects to upgrade the old system and build new paved roads and good quality railroads.

Brazil has a well-developed air transport system with an assigned index value of 3.4 in 2014 by GCR, suggesting a medium to good average quality of airports in the country. Ports are an essential part of the Brazilian transportation system, especially for foreign trade. Ports in Brazil are of medium to low quality. There are some small ports which slow the movement of large ships and so delay the transportation of freights. An index value of 2.7 was assigned to Brazilian ports in 2014 by GCR.

1.5.6 Hard infrastructure in United States

The U.S. is an example of a highly developed country with good overall hard infrastructure. The roads in the U.S. are of a good condition with a weighted average quality index value of 5.7 in 2014. The roads in urban cities are of a relatively high quality but they are crowded and congested. However, the quality of roads in rural areas is poorer, given insufficient pavement of roads, which requires more maintenance and repair (Infrastructure Report Card, 2017). Railroads are important for the movement of goods around the U.S. The U.S. rail system includes about 140,000 miles of rail track and about 100,000 bridges (Infrastructure Report Card, 2017). Private freight railroads are responsible for the shipment of goods around the country. U.S. railroads are of a good condition with an index value of 4.9, but the rail networks face some problems regarding maintenance and expansion, given insufficient funding for repairing.

In the United States, there are more than 100 ports which play an important role in international trade, given that about 99% of foreign trade to the U.S. takes place through waterways (Infrastructure Report Card, 2017). U.S. ports are ranked to have an excellent quality with an index value of 5.7 in 2014. This index value refers to the large ports with capacity for large ships as well as to the modernized international airport infrastructure around the country. These ports have a large capacity for processing vessels, with more than 82,000 vessels handled in U.S. ports in 2015 (Infrastructure Report Card, 2017). The U.S. has well-constructed airports with a weighted average quality index value of 6.1, which is nearly classified as high quality. Large and new airports, efficient customs and immigrations processes and good facilities and transportation systems are features of U.S. airports.

Table 1: Trade performance in North and Latin American countries in 2000 and 2014, (% of total imports and exports).

	2000		2014	
Country Name	Agricultural exports (% of exports)	Agricultural imports (% of imports)	Agricultural exports (% of exports)	Agricultural imports (% of imports)
Argentina	43.78	5.01	55.81	2.42
Bolivia	30.25	13.53	15.94	7.64
Brazil	23.39	6.57	35.39	4.89
Barbados	37.16	15.42	33.44	19.74
Canada	6.75	5.10	10.80	7.85
Chile	24.68	7.38	22.45	8.43
Colombia	19.02	11.93	10.92	9.50
Ecuador	36.51	9.00	35.17	7.72
Guatemala	56.23	12.13	42.40	13.56
Guyana	59.24	13.95	69.11	14.66
Honduras	71.62	22.16	54.91	18.07
Jamaica	22.64	15.46	18.28	16.68
Mexico	4.84	4.74	6.40	6.44
Nicaragua	87.97	15.86	51.47	16.66
Panama	76.50	11.60	67.52	11.90
Peru	30.33	11.65	23.60	10.51
Paraguay	64.88	16.67	65.35	8.19
El Salvador	19.20	12.36	19.14	16.32
Suriname	2.41	14.04	3.32	13.69
Uruguay	46.68	11.49	65.29	11.07
United States	7.44	4.07	10.45	5.55

Source: World Integrated Trade Solution (WITS), 2000 and 2014.

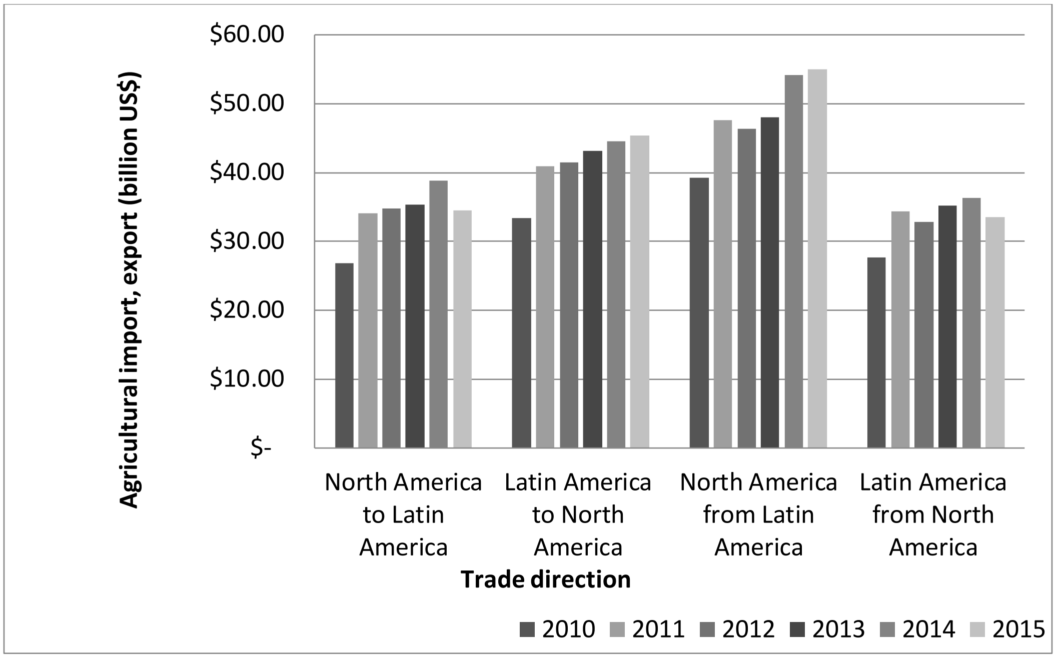

Figure 1: Agricultural trade pattterns in North and Latin America 2010-2014
Source: World Integrated Trade Solution (WITS), 2010-2015.

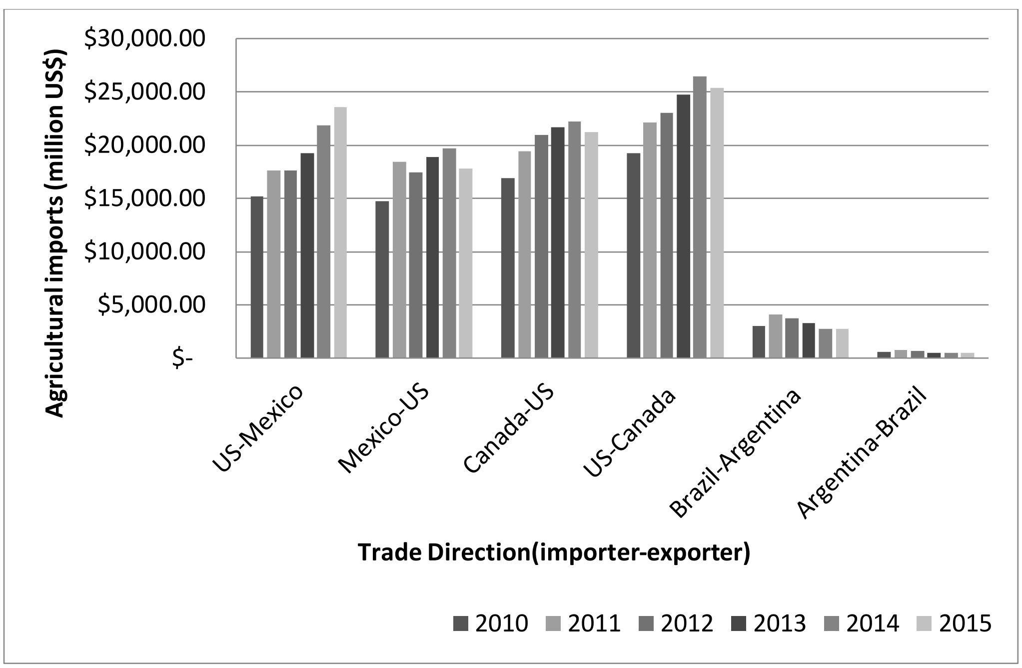

Figure 2: Total agricultural imports 2010-2015
Source: World Integrated Trade Solution (WITS), 2010-2015.

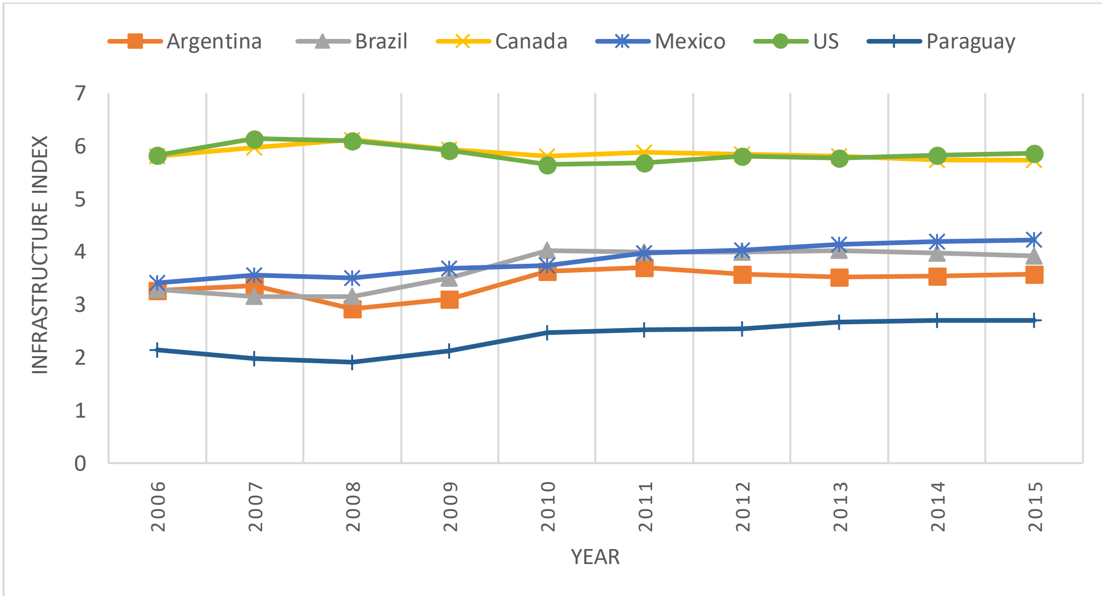

Figure 3: The quality of hard infrastructure, index ranging from 1 to 7, with 7 being the highest quality.

Source: World Economic Forum, Global Competitiveness Report, 2006-2015.

CHAPTER 2/LITERATURE REVIEW

2.1 Transport costs as barrier to international trade

The impact of transport costs on international trade has been classified as either direct or indirect transport costs. Direct transport cost is the cost associated with shipment and insurance charges and indirect costs include the opportunity costs related to inventory and delay of shipment across borders (Anderson and van Wincoop, 2004). Generally, transport costs include all the commodity related expenses that traders incur from shipping point to the destination point (Kurmanalieva, 2006). However, it is not easy to quantify the value of transport costs, especially for maritime transport costs. The difficulty in estimating transport costs value with unavailability of such data, recent studies use the determinants of transport costs in gravity model of trade, which gives an approximation to transport costs (Behar and Venables, 2010; Clarck, Dollare and Micco, 2004; Limao and Venables, 2001; Nordas and Piermartini, 2004). Distance, other geographic variables and quality of infrastructure can determine the cost of moving products indirectly and can restrict bilateral trade flows.

Limao and Venables (2001) use three ways to measure transport cost values including shipping costs data, CIF/FOB ratio[2] and gravity model of trade. They use data for 103 economies to assess the influence of infrastructure and transport costs on bilateral trade. Findings indicate that being a landlocked country increases shipping and transport expenses by about 55 percent higher than a coastal country, at the median. They include own country infrastructure, partner and transit country infrastructure with other geographic factors to analyze the impact of transport

[2] CIF/FOB represents Cost, Insurance and Freight (CIF) and Free on Board (FOB) which give an estimate of border prices of importing and exporting countries. CIF prices are reported by importing country, which estimate the cost of imports. FOB prices are reported by exporting country and they refer to costs of shipping the products abroad from exporting borders (see Limao and Venables, 2001). CIF/FOB data are provided by IMF's Direction of Trade Statistics.

costs on trade volume. They conclude that own country infrastructure, partner infrastructure and transit country infrastructure are significantly affecting trade volume with an elasticity of 1.32, 1.11 and 0.60, respectively. This means that a 1 percent improvement in own country infrastructure, partner infrastructure and transit country infrastructure, would increase trade volume by 1.32 percent, 1.11 percent and 0.60 percent, respectively.

Behar and Venables (2010) explore the determinants of transport costs consisting of distance, geography, trade facilitation and infrastructure. They argue that improving soft and hard infrastructure can reduce the impact of geographic drawbacks of some trading countries. Kurmanalieva (2006) uses transport density[3] to measure transport costs. He approximated transport density by using minimum distance or path between the two countries, where the shortest travel route is assumed to be used more by traders. The transportation cost function is used to measure the impact of different factors on transport cost and it is concluded that distance is positively and significantly related to transport costs, while poor infrastructure has negative effects on transport costs.

2.2 The role of infrastructure in agricultural development, economic growth and international trade

Trade facilitation is a broad category that consists of hard and soft infrastructure aspects, which largely impact trade volume. A study by Wilson, Mann, and Otsuki (2004) investigates the effects on trade from four indicators of trade facilitation: port efficiency, customs, regulations and service infrastructure on trade flows of manufacturing products. They show that trade volumes are positively influenced by the four measures of trade facilitation with the largest impact being port efficiency. Another study by Mirza (2009) confirms that the gains to trading

[3] Kurmanalieva (2006) estimates transport density using the difference between the potential density and actual density measure. The potential density measure refers to the minimum travel path between countries and actual density measure gives the minimum value of the actual transport cost.

countries exceeds the capital costs of investing at border infrastructure reforms in Sub-Saharan Africa with a benefit-cost ratio of 3.9%. Mirza (2009) found that infrastructure development projects require a substantial amount of capital and resources. However, such investments may be necessary, as improving physical infrastructure by investing in new projects, or renewing the old network system, results in comparative advantages for trading countries through the reduction of transportation costs, which would allow for shorter travel time.

On the side of agricultural growth, studies have argued that considering the investment in rural infrastructure is necessary for low-income developing countries, as it is one requirement for agricultural development and poverty alleviation (Andersen and Shimokawa, 2006; Wanmali and Islam, 1997). Thus, improving rural transport infrastructure is important for enhancing agricultural productivity by facilitating the physical connections for agricultural producers to the market.

Felloni et al. (2001) assess the impact of transport infrastructure on agricultural production in China. By using data for 83 countries and 30 provinces in China, they conclude that roads and electricity are significantly important to enhance land productivity. In addition, density of roads and better access to electricity are found to be essential for increasing labor productivity and agricultural production. Thus, good rural infrastructure, including hard network systems, institutions, and telecommunications, enable producers to better access technology and information and subsequently results in domestic agricultural growth.

The role of infrastructure on economic growth has not been neglected; Calderon and Serven (2008) address the impact of infrastructure development on economic growth and inequality for more than 100 African countries. They conclude that both better quality and quantity of infrastructure reduces income inequality and positively affects income growth.

Similarly, Ismail and Mahyideen (2015) analyze the impact of the quantity and quality of infrastructure on economic growth and trade of manufacturing and agricultural products for specific Asian countries from 2003 to 2013. Their findings support the view that quantity, along with the quality of infrastructure, is essential to foster economic growth and raise trade volume. Thus, such studies provide evidence that well-constructed infrastructure is one of the primary necessities that speeds up economic growth and reduces poverty.

Physical infrastructure has been found to influence trade flows positively by its negative impact on transport costs (Edmonds and Fujimura, 2006; Limao and Venables, 2001; Nordas and Piermartini, 2004; Francois and Manchin, 2007). This suggests that investment in both hard and soft infrastructure is required to enhance bilateral trade, by providing rural agricultural producers access to input and output markets thereby reducing transport and freight costs. Agricultural commodities are more commonly shipped by railroads and roads within the country, as this is known to have a cost advantage compared to air and sea transport. However, shipments to the global market are affected heavily by transaction costs at borders and the distance between countries. Sharing a common border increases trade volume, while long travel distance inversely affects bilateral trade (Magerman, Studnicka and Van Hove, 2015). For example, Brazil and Colombia have a common land border which means that they depend on either roads or railroads for bilateral trade. Conversely, since Brazil and the U.S. do not share a common border, ports or sea shipments are used to trade agricultural products between their borders.

Port efficiency has a large role in determining maritime transport costs and trade flows for island and coastal countries. Clark, Dollar and Micco (2004) were the first to estimate port efficiency indices for most of the world’s countries in their study to analyze the effects of port efficiency and maritime transport costs on bilateral trade. They found that enhancing port efficiency from the 25th to the 75th percentiles is expected to reduce shipment costs by over 12% and raise global trade flows by about 25%.

Nordas and Piermartini (2004) have used a gravity model of trade to estimate the impact of infrastructure on bilateral trade of the automotive, clothing and textile sectors. They investigate the effects of roads, rail, airport, port, telecommunication and time along with the overall infrastructure on bilateral trade. The port infrastructure index among all modes of infrastructure is found to have the largest significant effects on the trade flows of both importers and exporters with an elasticity of 0.68 and 0.61, respectively. This means that a 10 percent improvement in port infrastructure would increase trade volume by 6.8 percent for importing counties and 6.1 percent for exporting countries. Findings show that in addition to bilateral tariff rates, the quality of aggregated and individual indicators of infrastructure are essential in facilitating trade flows.

Francois and Manchin (2007) demonstrated that both institutional and infrastructure quality are important variables in explaining the variation of trade performance. The results show that better institutional quality and well developed infrastructure positively impact export volume. The extended work by Francois and Manchin (2013) to address the impact of infrastructure and institutional quality on the pattern of bilateral trade among selected low and high income countries (North and South trade), has confirmed the importance of institutional and infrastructure quality on export flows. By highlighting the export flows of developing countries, they found that poor infrastructure and institutional quality inversely affect trade volume, particularly among low-income countries. Their analysis shows that trade flows within low income countries are about 74% lower than trade values between high-income countries based on the difference in the infrastructure and institutional quality between them.

Although various studies assess the impacts of infrastructure and transport costs on trade, they estimate the effects on trade in terms of either all traded goods or manufacturing goods. Most previous studies analyze the effects of trading goods by sector such as agriculture, textile, manufacturing and services, while other studies used an aggregation of agricultural and non-agricultural products. Park (2005) estimated the impact of recent developments in telecommunication infrastructure on agricultural and non-agricultural trade. The study found that improved telecommunication has much stronger impacts on trade of non-agricultural products than trade of agricultural products. However, there were few studies focusing on the impact of physical infrastructure development on trading agricultural commodities. Accordingly, the estimation of the effects of transportation infrastructure development on agricultural bilateral trade will add to the knowledge of market participants and policy makers by providing insight on economic impacts of investing in the improvement of transportation infrastructure.

CHAPTER 3/THEORETICAL WELFARE EFFECTS OF INFRASTRUCTURE DEVELOPMENT

Insufficient physical networks are one impediment to international trade. The economic costs of poor quality roads and highways to producers are represented by the delay of shipments to the destination and so increasing variable costs. Thus, the investments in physical infrastructure are required to reduce marketing and trading costs. However, in recent decades, richer countries have better quality transportation infrastructure than poorer countries. At the local level, the problem of inadequate transportation infrastructure can be seen often in rural agricultural areas within most countries. The agricultural sector depends heavily on trucks to deliver farm products to market destinations either to the urban local centers or the export borders. Generally, agricultural products (especially high value crops), unlike manufacturing goods, are considered perishable products. Therefore, an efficient transportation system will facilitate the delivery of these commodities on time and without significant degradation. Another issue with inadequate transportation networks is the congestion of trucks where congestion increases travel shipment time and costs (Sage, 2015). This problem can often be seen in developing countries which entails increasing the number of trucks and laborers required to deliver products to the markets.

Agricultural commodities, such as fruits as vegetables, are necessary products that have inelastic demand, where a change in the prices of agricultural products result in a small change in the quantity demanded (Hofstrand, 2007). However, the demand for animal products tends to be elastic, because there are close substitutes for some types of animal sub-products, specifically for meat products. For example, if the price of beef increases, the quantity of beef purchased will decrease, as consumers switch to buy poultry or pork products. Generally, the prices of agricultural products are unstable over time, which are impacted by changes in demand and supply (Business Marketing, 2017). At the macroeconomic level, importers search for lower import prices and exporters search for higher selling prices than would prevail in the domestic market without trade. However, agricultural products prices are unstable because of different factors that affect production and trade volume such as supply shocks (e.g. diseases, drought, floods, etc.), seasonal products, cost of production, and domestic support by government to help food producers. Even though bilateral trade takes place at the equilibrium price or world price for the agricultural product, importers can determine the pattern of bilateral trade targeting countries that have comparative advantages in specific agricultural production activities, as well as having low trade barriers.

The elasticity of supply differs in the short run versus long run [4] for agricultural commodities, which tends to be inelastic in short run given a specific season of production and employing natural and capital resource for production in a short time period (Hudson, 2007). This means that if the price of a specific food or vegetable product increases, the quantity supplied will increase by a percentage that is lower than the change in the price. However, in the long run, the elasticity of supply tends to be more elastic, because producers have time to adjust production in response to market forces. Therefore, a decrease in the price of an agricultural commodity will result in a larger decrease in supplied quantity in the long run (Hudson, 2007).

The development of physical network systems is expected to benefit both developing as well as developed countries by increasing bilateral trade and positively affecting production and

[4] Short run has at least one fixed input and output level depends on the level of variable input utilized in production. It is usually a time period of less than one year, specifically for food and vegetable products. In the long run, all factors of production are variable. The production process in the long run takes more than one year. For example animal products such as beef, where cows go through breeding process and take time to grow and to process final products. Similarly, even though food and vegetables have short run production process, in general, some raw material from the farm gate takes a longer time to get converted to final products or processed food and vegetables.

consumption levels. Exporting countries will gain from potential increases in GDP levels as well as increases in agricultural production due to lower transportation costs. For an importing country, physical infrastructure reforms can increase import levels at lower trade costs and so consumption of foreign goods is expected to increase.

Another gain form such development is the effects on the price level of agricultural commodities. The quality of physical infrastructure does not influence the price of agricultural commodities directly, but rather indirectly through upward pressure on transportation costs. However, the volume of agricultural trade is expected to increase as a result of the development in transportation infrastructure. Consequently, the gain from increased supply to local and global markets has the potential effects of reducing the price level of agricultural commodities. At the global level, the impact of trade enhancement due to lowering transportation costs by infrastructure development can be described by a simple partial equilibrium model of one large export country and one large import country that represents the total world market for an agricultural commodity in Figure 4.

Figure 4 shows the domestic demand and supply curves for both exporting and importing countries and the aggregation of demand curves (ED) and supply curves (ES) in the international market. The figure demonstrates the impacts of reducing transport costs on bilateral trade volume graphically, where infrastructure improvements are made in a large export country. We assume that the impact of infrastructure investments can be seen through the decline in transport costs. In the case of no transport costs and no market distortions, the two countries are assumed to trade at world price P_{w1}. However, when transport costs are included in the model, exporting and importing countries are assumed to share the transport costs equally, in this example, exports by country 1 are assumed to be equal to the amount imported by country 2. This assumption are hold as the price elasticity of imports is assumed to equal price elasticity of supply. In the graph, P_e is the price faced by exporting country; P_m is the price faced by importing country; Q is the quantity level; TC refers to the level of transport costs; S is the domestic supply curve; D is the domestic demand curve; ES is the excess supply curve and ED is the excess demand curve.

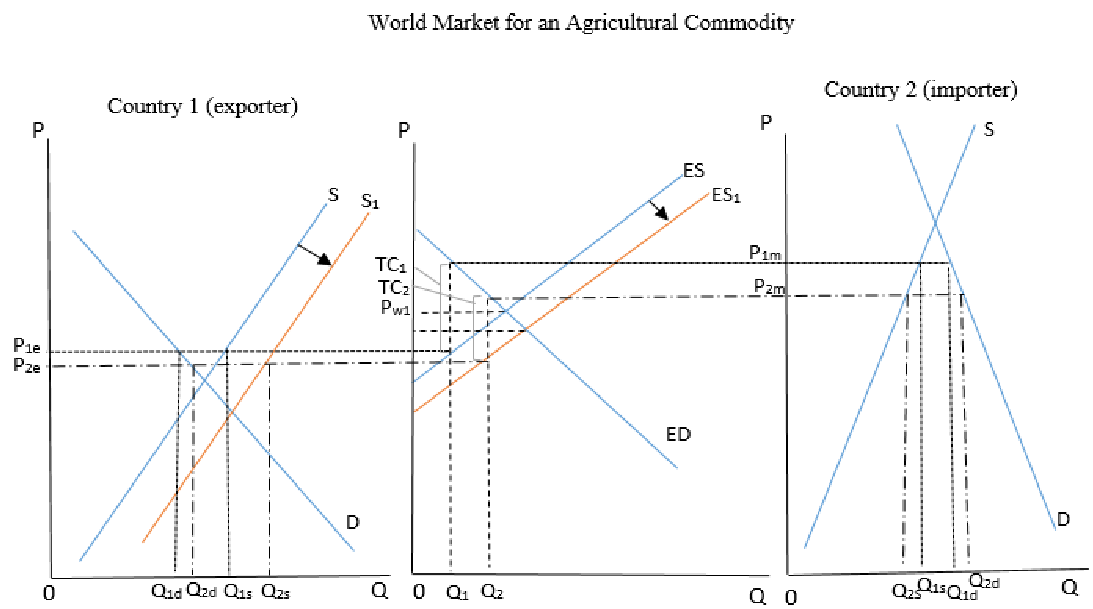

Figure 4: Bilateral trade with the reduction in transport costs in the exporting country

Before improving the hard network system, the traded quantity is equal to the difference between Q_{1s} and Q_{1d} (domestic production minus consumption level) which is equivalent to Q_1 in the world market. The exporting country pays P_{1e} in addition to the value of transport costs, which is equal to 1/2 TC_1. The importing country would buy the exported quantity at P_{1m} in addition to the other half of transport costs (1/2TC_1).

After investments in building new hard infrastructure networks or reforming the old one, transport costs decrease to TC_2. Producers pay less to transport goods to be traded, compared to the case of using poor quality transport systems for shipments. These effects are reflected by an increase in export volume; in the figure, the domestic supply curve S in the export market shifts outward to S1. Then the excess supply curve ES shifts to ES1, in the world market. As a result, the export price decreases from P_{1e} to P_{2e}. Consequently, the quantity exported increases from Q_1 (Q_{1s}-Q_{1d}) to Q_2 (Q_{2s}-Q_{2d}) due to the shift in the supply curve in the export market, which represents the production level. In this case, the transport costs paid by the exporter is equivalent to 1/2 TC_2, which is lower than the transport costs paid before improving physical networks. Domestically, production and consumption levels in the exporting country increase, and the figure shows the changes in quantities supplied and demanded resulting from the shift in the exporter supply curve.

As a consequence of the decrease in transport costs and the increase in export level, the demanded quantity by the importing country increases from Q_{1d} to Q_{2d} as a result of the decrease in importing price from P_{1m} to P_{2m}. These changes lead to an increase in the domestic consumption level and a decrease in local production in the importing country from Q_{1s} to Q_{2s}. In the import country, consumers gain from the reduction in price and the increase in import supply and producers lose, because consumers turn to buy imported products. Similar to the exporter, the importer pays transport costs equal to 1/2 TC_2 in addition to P_{2m}. Accordingly, with data on transport costs, prices and quantity traded, one could calculate consumer and producer welfare impacts caused by a reduction in transport costs and estimate the change in total welfare of both countries.

CHAPTER 4/METHODOLOGY

4. Empirical model: Specification of the gravity model

4.1.1 General gravity model of trade

The gravity model of trade is similar to Newton's law of Gravitation in Physics. It was used for the first time by Jan Tinbergen in 1962**.** The basic gravity model of trade assumes that the bilateral trade between two countries or regions is positively related to the economic size of each one and negatively related to the distance between them. The form of the basic gravity model of trade as specified by Tinbergen (1962); Anderson (1979); Anderson and van Wincoop, (2003) is as follows:

$$T_{ij} = \propto \frac{Y_i Y_j}{D_{ij}} \tag{1}$$

Or it can be written as:

$$T_{ij} = \alpha \, Y_i{}^{\beta} \, Y_j{}^{\gamma} \, D_{ij}{}^{\delta} \, \varepsilon_{ij} \tag{2}$$

Where i and j stand for importing and exporting countries, respectively, T_{ij} stands for trade flows between two countries, α refers to the constant term, Y_i (Y_j) stands for income of origin (destination) country, and D_{ij} is the distance between the two trading countries. Equation 2 is the gravity model specified in the form of the Cobb-Douglas expenditure function. The model has been applied to different sets of goods and factors traded across countries. It states that trade volume is a function of economic factors in the importing and exporting countries and other bilateral trade barriers or incentives, which determine trade flows between the two countries. The model was used for the first time by Tinbergen (1962) to explain the pattern of trade flows. The basic, traditional model includes variables such as the country’s income level, distance, and other dummy variables (e.g. contiguity, common language, colonial history, free trade agreement).

Later on, the model developed to explain the variation in bilateral trade by adding other determinants of trade such as trade facilitation (Anderson and Wincoop, 2007; Behar and Venables, 2010; Clarck, Dollare and Micco, 2004; Francois and Manchin, 2007; Limao and Venables, 2001; Nordas and Piermartini, 2004). Given the widespread use of this framework in the literature, we use this as the foundation to investigate the effects of infrastructure quality on agricultural trade.

4.1.2 Modified gravity model of trade:

The gravity model of trade has been modified to include different possible economic forces that may influence trade flows, either through enhancement or restriction of bilateral trade. Tariff rates, geographic factors, and regional trade agreements are examples of determinants of bilateral trade flows. The estimated coefficients of these determinants are used as elasticities to explain the variation in bilateral trade flows. The following conceptual model has been used to represent the barriers to trade flows:

$Q_{trade\ ij} = f\ (i.e.: PV, IV, D, ADJ, LD, ID, CL, CH, CR, FTA, TC, TF, etc)$

Where *PV* refers to policy variables, *IV* represents income variables, *D* represents distance between countries, *ADJ* represents the adjacency between countries, *LD* refers to landlocked countries, *ID* refers to island countries, *CL* represents a dummy variable to account for sharing a common language, *CH* is the colonial history, *CR* refers to common religion, *FTA* is whether or not there is free trade agreement between the two partners, *TC* represents transport costs, and *TF* refers to trade facilitation.

Policy variables, such as applied tariff rates, are considered as one of the most important variables that effect trade volume directly (Nordas and Piermartini, 2004). The reduction in tariff rates is found as an incentive for countries to trade more at lower costs, which suggests a negative relationship between tariff rates and trade volume. The income level of each country is included in the gravity model to capture the effects of a country's economy, or the country's relative market size on trade patterns. Usually countries with high GDP (Gross Domestic Product) are assumed to trade more than countries with low GDP, which suggests a positive relationship and coefficient close to 1 (see Anderson, 1979). Also, the inclusion of dummy variables such as language, colony and geography variables helps to capture some trade related costs within the model, such as information and travel costs. Transport costs, as one barrier to international trade, has been reflected in the gravity model by including different variables that indirectly represent transport costs (Behar and Venables, 2010; Clarck, Dollare and Micco, 2004; Limao and Venables, 2001; Nordas and Piermartini, 2004). These variables are listed in the following equation:

Transport costs = {GF (LD, ID, ADJ), D, INF, INS, TF, etc}[5]

Where *GF* refers to geographic factors, *LD* refers to landlocked countries, *ID* refers to island countries, *ADJ* refers to the adjacency between countries, *D* is the distance between countries, *INF* refers to the quality of infrastructure, *INS* refers to the quality of institutions, and *TF* refers to trade facilitation.

These variables have been included in the gravity model to assess the impact of transport costs on bilateral trade flows. Recent literature found that being a landlocked or island country, traveling over long distance, and having inadequate quality of infrastructure and institutions increases transport costs among trading countries (Behar and Venables, 2010; Clarck, Dollare, and Micco, 2004; Kurmanalieva, 2006; Limao and Venables, 2001; Nordas and Piermartini, 2004).

[5] Behar and Venables (2010) explain the relationship between transport costs and the determinants listed in the equation.

Following past literature, we use the following basic traditional trade gravity equation to examine the impact of hard infrastructure quality on agricultural trade flows:

$$M_{ijt} = \frac{GDP_{it}GDP_{jt}}{GDP_{wt}D_{ijt}}Z_{ijt} \qquad (3)$$

Where M_{ijt} is the import volume from country *i* to country *j* at time *t*; GDP_{it} (GDP_{jt}) is the income level of importing (exporting) country at time *t*; GDP_{wt} is the world income level at time *t*, D_{ijt} is the geographical distance between trading countries and Z_{ijt} is the vector of other bilateral trade variables, including common language, common border, free trade agreement dummies and applied tariff rates. In addition, we add new variables to the model which are hard infrastructure indices for importing and exporting countries as one barrier to bilateral trade and one determinant of transport costs. The model specification in terms of the Cobb-Douglas expenditure system is the following:

$$M_{ijt} = \alpha_0\, GDP_{it}^{\beta_1}\, GDP_{jt}^{\beta_2}\, D_{ijt}^{\beta_3} CB_{ijt}^{\beta_4} lang_{ijt}^{\beta_5} PTA_{ijt}^{\beta_6} (1+\tau_{ijt})^{\beta_7} INF_{it}^{\beta_8}\, INF_{jt}^{\beta_9}\, \mathcal{E}_{ijt} \qquad (4)$$

Taking the logarithm of the equation results into the following model that is log-log in some variables and log-linear in others:

$$ln\, M_{ijt} = \beta_0 + \beta_1\, ln\, GDP_{it} + \beta_2\, ln\, GDP_{jt} + \beta_3\, ln\, D_{ijt} + \beta_4 CB_{ijt} + \beta_5 lang_{ijt} + \beta_6 PTA_{ijt}$$
$$+ \beta_7\, ln(1+\tau_{ijt}) + \beta_8\, ln\, INF_{it} + \beta_9\, ln\, INF_{jt} + \mu_{ijt} \qquad (5)$$

In this model, β_0 = (-$lnGDP_{wt}$), which represents the constant term, *i* and *j* denote importing and exporting countries, respectively, M_{ijt} represents the value of agricultural imports from country *i* to country *j* in thousands of US dollars, *GDP* represents gross domestic product in millions of US dollars (constant for 2010). D_{ijt} is the distance between importing and exporting countries measured in kilometers, and τ_{ijt} is the effectively applied bilateral tariff rate (weighted average tariff rate). *CB*, *lang*, and *PTA* are dummy variables for common border, common language, and preferential (free) trade agreement, respectively. The dummy variables take the value of one if the two countries share a common border, speak common language, or have a preferential (or free) trade agreement, and zero otherwise. *INF* measures importer and exporter infrastructure quality measured by 5 different indices including overall hard infrastructure, roads, railroads, ports and airports. The values of the indices correspond to the quality of infrastructure ranging from 1-7; 7 representing the best, and 1 the worst quality. Finally, u_{ijt} represents the random error term.

4.2 Data

4.2.1 Data sources

We have used a panel data of agricultural bilateral trade for 25 selected North and Latin American countries[6] from 2006 to 2014. This countries has been selected based on the availability of infrastructure indices data, where the first sample data includes 35 North and Latin American countries and 10 countries[7] were excluded from the analysis due to unavailability of infrastructure indices. The gravity model used to assess the impact of development in hard infrastructure on trade flows of aggregated and disaggregated (food, animal and vegetable) agricultural products. We limit the panel data to nine years (2006-2014) given that the import values have not been reported for 2015 for most countries, and there are many zero trade flows for most country pairs for years before 2006. The data on import values and tariff rates were obtained from the World Integrated Trade Solution (WITS), which is provided by the United Nations Conference on Trade and Development (UNCTAD) Trade Analysis Information System (TRAINS), the United National Statistical Division (UNSD) Commodity Trade Data Base

[6] In this analysis, we include Central American, Caribbean, and South American countries in Latin American category. North America includes Canada, Mexico and the United States. Countries are listed in Table 11 in the Appendix.

[7] The excluded countries are Antigua and Barbuda, Bahamas, Belize, Cuba, Dominica, Grenada, Haiti, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines.

(COMTRADE system) and the World Trade Organization's (WTO) integrated tariff database (IDB). We use import data to estimate the model because they are reported with the relevant applied weighted average tariff rates. Data on imports for food, animal and vegetable sectors has been collected for all possible pairs of the 25 countries. Then, the aggregation of these three sectors is used to represent the total aggregated agricultural import volume.

GDP, as a proxy for income, is taken from the World Development Indicators Database. Data on distance, common language and common border dummy variables are taken from the CEPII[8] Database. Distance has been calculated using the Great Circle Formula, which depends on the latitude and longitudes between major cities. Specifically, distance between countries is measured using city level data while accounting for geographic distribution of population of each country (Mayer and Zignago, 2011). Distance data are represented in terms of capital-to-capital distance. Data on preferential (or free) trade agreements are collected from the Foreign Trade Information System (SICE) and World Trade Organization (WTO).

Because we are interested in the impact of hard infrastructure quality on agricultural trade, we used infrastructure indices to represent the quality of transportation infrastructure in the model. Data on transportation infrastructures are taken from the Global Competitiveness Report 2006-2014, which were provided by the World Economic Forum (WEF)[9]. The data on infrastructure are represented in term of weighted average quality, indices valued at 1-7, where 1 refers to an extremely underdeveloped country and 7 refers to a well-developed country that is considered efficient by international standards. These indices have been collected through the

[8] CEPII is a research center which conducts different research programs related to international economics. It has different fields of expertise (e.g. competitiveness and growth, economic policy, environment and natural resources, migrations, trade and globalization, etc). Data on distance, language and adjacency are provided by CEPII as geography data.

[9] WEF is an international organization for public-private cooperation, established in 1971 and its main activity is to model world-class corporate governance.

World Economic Forum's Executive Opinion Survey (EOS). The data for EOS has been collected from 150 institutions around the world that have a partnership with the World Economic Forum. The survey generated data for 131 counties in 2007, 133 countries in 2009 and 140 countries in 2015. In general, the index values have been collected and then the averages per year for each survey question have been calculated, in order to increase the robustness of data and to avoid year to year variations in index values. The variation exists because the responses of the participants in each country are influenced by firm size and the degree of foreign ownership, which is represented by eight questions in the survey. Therefore, given different ranking levels in the survey responses by different firms and institutions in a country, the average response per question is calculated and then aggregated to a national average level using fixed weights, which are the share of each question in a specific year over the last five years. The weight is based on specific criteria, for example, year 2006 receives a weight of 40 percent and year 2007 receives a weight of 60 percent, relative to the number of survey responses per year (Porter and Schwab, 2007).

The report specifies infrastructure as one of the basic requirements that foster productivity and enhance economic growth. The data gives specific indices and measures to assess countries' economic performance and global competitiveness. Accordingly, using the indices provided by the Global Competitiveness Report, the overall hard infrastructure variable has been included in the model with four modes of transport infrastructure comprised of the quality of roads, railroads, ports and airports.

4.2.2 Estimation of missing data

There are several country pairs in which import values have not been reported or there have been zero trade flows. We assume that the observations with missing import values are zero bilateral trade following the literature (Baldwin and Harrigan, 2011; Francois and Manchin, 2013; Helpman, Melitz, and Rubinstein, 2008; Santos Silva and Tenreyro, 2006). On the other hand, data on applied bilateral tariff rates have not been consistently reported for some pairings. Therefore, we calculated missing values for applied tariff rates using a weighted average tariff rate formula[10.] Also, there were a few infrastructure indices and data points that are not reported by the Global Competitiveness Report[11]. We calculated the missing data using interpolation by considering the indices' trends over the past two years. Interpolation is a method of estimating new points (usually missing observations) within the discrete set of given points which usually have a specific trend (e.g. linear, polynomial, spline and so on). In our data, we assessed the trend of the past data sets and then used trend analysis to construct the missing indices values[12].

4.2.3 Summary of data

We collected a sample of 5400 observations, which consists of all possible trade combinations between all countries in the sample to capture the role of infrastructure on bilateral trade patterns. We have both unreported import values and zero trade flows at the same time. Therefore, following the literature, we set the unreported import values to zero. However, in order to avoid high correlation between the GDP variables and infrastructure indices, we drop bilateral trade pairs that do not trade at all for all years, 2006-2014. This leaves 4950, 4375 and

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[10] Weighted average tariff rate for year t =((tariff rate of year(t-1)*import value of year(t-1))+(tariff rate of year(t-2)*import value of year(t-2))/(import value of year(t-1)+ import value of year(t-2)).

[11] Missing infrastructure indices, import value and tariff data are reported in the Appendix.

[12] Excel software has been used to generate the missing values.

4625 observations for food, animal and vegetable products, respectively. The data show that about 11 percent of the food sector has zero trade flows. Approximately 23 percent of the animal sector import values represent zero trade. For vegetables, nearly 16 percent of bilateral trade flows represent zero trade. For total agricultural products, 9 percent of trade partners have zero trade flows at some years in the sample.

The summary of the variables' mean, standard deviation, minimum and maximum values and the number of observations is provided in Tables 12, 13, 14 and 15 in the Appendix for total agricultural, food, animal and vegetable products. The summary shows that each sector has 25 groups of importers, which represents the number of importing countries. There are 198 trade pairs[13] for the total, aggregated agriculture data, 198 trade pairs for food, 175 trade pairs for animal and 185 trade pairs for the vegetable sector. Zero flows is the minimum value for all sectors, where there is no bilateral trade that took place during the given year. For the maximum trade flows, the US and Canada partnership has the highest trade value among the sample. For aggregated agricultural trade, the highest bilateral trade was U.S. imports from Canada in 2014 with an import value of 26.47 billion US dollars. The maximum value of food imports was Canadian imports from the US in 2014 with an import value of 12.20 billion US dollars. For the animal sector, the US has the largest value of imports from Canada in 2014 with import flows of 76.56 billion US dollars. Also, for vegetable products, US import from Mexico was the highest among the sample, equaling 10.91 billion US dollars.

The mean values of weighted average tariff rates range from 8 to 11 percent, while the median values range from 3.75 to 9.35 percent, for all sectors. The values of mean and median tariff rates clearly demonstrate the reduction in applied tariff rates in recent years. The minimum tariff rates are zero in many cases, in recent years, and it is mostly common in pairs that are

[13] Trade pair refers to the trade between two countries for a given time period, nine years in our data set.

members of the same regional or preferential trade agreements. The maximum applied tariff rates on total agricultural products, and food products, were the rates imposed by Trinidad and Tobago on imports from Brazil in 2007 (tariff rates of 189.11 percent and 517.23 percent, respectively). The highest applied tariff rate on animal products was the rate imposed on imports onto Mexico from Brazil in 2013, with a tariff rate of 142.34 percent. For vegetable products, the maximum applied tariff rate was 160.31 percent, which was imposed by Barbados on imports from Honduras in 2007.

The summaries of infrastructure indices are reported in Tables 12, 13, 14 and 15 in the Appendix for total agricultural, food, animal and vegetable products. The tables provide the mean, standard deviation, minimum and maximum values. However, the comparison of transport infrastructure indices for year 2014, the most recent data we include in this analysis, are shown in Table 2 for representative countries that have either the high, low or maximum index value in each index category. The data in the table are from the Global Competitiveness Report, which is one of the various reports published by the World Economic Forum. Quality of infrastructure has been provided in terms of an index, which takes values of 1 to 7 where 1 represents the lowest quality (extremely underdeveloped country) and 7 refers to the best quality (well-developed country), as an average level of infrastructure in the country. The comparison of hard infrastructure quality is included for the selected sample countries. The United States transport infrastructure quality represents the best among North and Latin America for 2014, with index value equal to 5.82 for overall infrastructure, 6.1 for airports, 5.7 for roads and 4.9 for railroads. Panama has the highest quality of ports infrastructure among the sample countries for the year 2014. The minimum quality of overall transport infrastructure is for Venezuela. For railroads, countries with no railroads had quality index values equals to zero.

Table 2: Comparison of hard infrastructure indices among selected North and Latin American countries in 2014

	Median	Minimum	Maximum
Transport infrastructure index (1-7)	3.98 Brazil	2.65 Venezuela	5.82 United States
Roads index (1-7)	3.7 Guatemala and Jamaica	2.5 Paraguay	5.7 United States
Railroads index (1-7)	1.9 Costa Rica and Suriname	0.00 Trinidad and Tobago and Barbados	4.9 United States
Port index (1-7)	4.2 Trinidad and Tobago	2 Bolivia	6.3 Panama
Airport index (1-7)	4.1 Colombia and Guatemala	2.6 Paraguay	6.1 United States

Data source: World Economic Forum, Global Competitiveness Report, 2014.

Correlation between the variables is shown in Tables 16, 17, 18 and 19 in the Appendix for total agricultural, food, animal and vegetable products. In general, correlation coefficients measure the linear relationship between the variables, taking values from -1 to +1, where the sign of the coefficient shows whether the relationship between two variables is negative or positive and the magnitude of the coefficient measures the strength of the relationship. The values of correlation coefficients between variables show a moderate to low strength of relationships between variables. The dependent variable, aggregated agricultural imports, has a positive but low to moderate strength of relationship with all variables except tariff rates, distance, common border and railroads infrastructure. Surprisingly, common border and railroads index are negatively correlated, and accordingly, do not have the expected direction of relationship with aggregated agricultural imports, where they are expected to move in the same direction with import volumes. For vegetable imports, all variables have the expected sign of relationship with vegetable imports, except the common border variable. For food and animal products, import values of both food and animal products move in the same direction with all variables except tariff rates, distance, common border and GDP of importers. This means that tariff rates and distance are negatively related to trade and a reduction of tariff rates and distance would increase trade volume. Infrastructure indices have positive correlation with aggregated agricultural, food, animal and vegetable import values.

4.3 Estimating the gravity model of trade

When dealing with international trade, countries do not trade with every other country in the world. There are country-pairs that do not trade at all and other pairs that trade for some years, but have zero trade for others. In general, zero import values in bilateral trade can be observed in products at highly disaggregated levels or even at the more aggregated product level. Zero trade observations become a problem when estimating a gravity model of trade using an Ordinary Least Squares (OLS) estimator since the log of zero is undefined for the log-log or log-linear models. The estimation of the model, while omitting zero trade flows, leads to biased estimates and a loss of information by dropping the zeros (Gómez-Herrera, 2013; Linders and de Groot, 2006; Martin and Pham, 2015). Many studies argue that zero trade observations should be included in the model to solve empirical estimation problems (see Helpman, Melitz, and Rubinstein, 2008; Gómez-Herrera, 2013; Linders and de Groot, 2006; Martin and Pham, 2015). Zeros should not be dropped because they contain information to explain the effects of trade determinants on the pattern of trade flows. The Heckman estimator, Tobit estimator and Poisson Pseudo Maximum Likelihood (PPML) are examples of estimation methods that have been widely used to deal with zero trade flows which yield unbiased estimators. Gómez-Herrera (2013) compares alternative methods of estimating the gravity model of trade in the existence of zero trade flows and found that among these methods, the Heckman sample selection performs better. Francois and Manchin (2013) used a PPML estimator while accounting for multilateral trade resistance terms[14] and firm heterogeneity to estimate the impact of infrastructure and institutions on import volume. Multilateral trade resistance is viewed to be a problem in the trade gravity equation due to the inclusion of different political variables that might change over time and due to the change in trade costs and prices over time (Behar and Nelson, 2012). This affects estimation results given changes in trade patterns. Multilateral trade resistance also occurs if such political variables are not observed in the model. Most previous studies that employed a gravity model of trade framework argue that not controlling for multilateral resistance terms may yield biased estimators. To control for multilateral resistance terms, we added country-specific dummy variables to the model to account for unobserved variables such as exporter and importer fixed effects (see Feenstra, 2002). Accordingly, importer and exporter fixed effects should control for country-specific multilateral resistance terms.

Generally, given that each estimation method has its own advantages and disadvantages, many studies use more than one estimation method for the same data to compare results (Gómez-Herrera, 2013). For instance, the Heckman estimator works well when there is multicollinearity and gives a better sense for zero trade flows while separating censored and uncensored observations[15] (Gómez-Herrera, 2013). Similarly, the Tobit estimator is another example of a method used to deal with limited dependent variables, which is considered a simple method for censored regression. On the other hand, the PPML estimator is known to work better in the

[14] Multilateral trade resistance refers to the impact of the elasticities of trade flows as a result of change in trade costs and prices by specific country which might change bilateral trade pattern, where smaller importers are more effected by this changes compared to larger importers, which in turn will change trade directions and exporters will export to larger importers instead of smaller importers (Behar and Nelson, 2012).

[15] Censored observations are the values or points in the sample that are below or above a specific value (e.g. <1, because the log of the observations lower than one equals negative values). Uncensored observations are the values that we are using to estimate the model (non-zero or positive values in our data set).

presence of heteroskedasticity and results in unbiased as well as consistent estimators (Francois and Manchin, 2013; Gómez-Herrera, 2013; Santos Silva and Tenreyro, 2006) .

One of the common issues when collecting data is that some trade partners do not report trade values, which could be systematic or zero trade flows. However, past research assumes that unreported trade values mean zero trade flows (see: Helpman, Melitz, and Rubinstein, 2008; Francois and Manchin, 2013; Santos Silva and Tenreyro, 2006). Such missing observations are similar to the importance of zero trade flows, as dropping them leads to reduced sample size and loss of important information that may have a role in bilateral trade performance.

This research employs both Tobit and PPML estimation methods, to estimate the impact of the quality of hard infrastructure on the import volume of subsectors of agriculture (food, animal and vegetable) along with aggregated agricultural products, while appropriately accounting for zero trade values.

4.3.1 Tobit estimation

The Tobit model was developed by James Tobin (1958) to be used for censored sample data where the dependent variable is constrained. The basic Tobit model as specified by Tobin (1958) with the latent variable (y*) [16] is applied to the gravity model of trade as the following:

$$y_{ijt}^{*} = \beta x_{ijt} + u_{ijt} \qquad where\ u_{ijt} \sim N(0, \sigma^2) \tag{6}$$

Where y_{ijt}^{*} is the latent dependent variable that represents import value in our model; x_{ijt} is the vector of independent variables including GDP, D_{ijt}, τ_{ijt}, CB, lang, PTA, and INF, and u_{ijt} is random error term which is normally distributed with zero mean and constant variance σ^2. For the censored sample:

[16] The latent variable is unobserved dependent variable y* which is determined by the independent variables. In our gravity model of trade it is determined by the income level and other trade costs. However, the larger the value of y*, the greater the probability that trade is to occur (ie: positive trade).

$y_{ijt} = y^*_{ijt} \; if \; y^*_{ijt} > 0$

$y_{ijt} = 0 \; if \; y^*_{ijt} \leq 0$

The model is normally distributed $u_{ijt} \sim N(0, \sigma^2)$ and the probability of distribution is as follows:

$$pr\left(y_{ijt} > 0\right) = pr\left(y^*_{ijt} > 0\right) = \phi\left(\frac{\beta x_{ijt}}{\sigma}\right)$$

$$pr\left(y_{ijt} = 0\right) = pr\left(y^*_{ijt} \leq 0\right) = 1 - \phi\left(\frac{\beta x_{ijt}}{\sigma}\right)$$

Where ϕ is the standard normal cumulative distribution function. Gómez-Herrera (2013), Martin and Pham (2015) and Santos Silva and Tenreyro (2006) estimate the gravity model of trade using the ET-Tobit[17] estimator. Following the aforementioned authors, we estimate the model including all variables specified with the addition of country and time fixed effects.

In our study we estimate six models, model 0 to model 5, using the ET-Tobit estimator which are listed as follows:

Model 0:

$$ln(1 + M_{ijt}) = \beta_0 + \beta_1 \, ln \, GDP_{it} + \beta_2 \, ln \, GDP_{jt} + \beta_3 \, ln \, D_{ijt} + \beta_4 CB_{ijt} + \beta_5 lang_{ijt} + \beta_6 PTA_{ijt} + \beta_7 \, ln\left(1 + \tau_{ijt}\right) + \beta_8 \sum Dum_i + \beta_9 \sum Dum_j + \beta_{10} \sum \gamma_{ijt} + \mu_{ijt} \quad (7)$$

Model 0 represents the basic model before adding infrastructure indices to the equation. In the model, M_{ijt} represents the value of agricultural imports from country *i* to country *j* in thousands of US dollars, and *GDP* represents gross domestic product in millions of US dollars (constant for 2010) . D_{ijt} is the distance between importing and exporting countries measured in

[17] ET-Tobit estimates the model and adds a fraction or value (usually 1) to dependent variable so that the model is estimated with log of dependent variable ln $(a+M_{ijt})$ instead of level of imports (M_{ijt}) and then the model is estimated while censoring the log of the dependent variable of zero values instead of undefined values.

kilometers, and τ_{ijt} is the effectively applied bilateral tariff rate (weighted average tariff rate). *CB*, *lang*, and *PTA* are dummy variables for common border, common language, and preferential (free) trade agreement, respectively. Dum_i (Dum_j) is the dummy variables of importing (exporting) countries, γ_{ijt} is the time fixed effects or time dummy variables for a given trade pair in year t and μ_{ijt} is the random error term.

Model 1:

$$ln(1 + M_{ijt}) = \beta_0 + \beta_1 \, ln\, GDP_{it} + \beta_2 \, ln\, GDP_{jt} + \beta_3 \, ln\, D_{ijt} + \beta_4 CB_{ijt} + \beta_5 lang_{ijt} + \beta_6 PTA_{ijt} + \beta_7 \, ln\big(1 + \tau_{ijt}\big) + \beta_8 \, ln\, infrastructur_{it} + \beta_9 \, ln\, infrastructure_{jt} + \beta_{10} \sum Dum_i + \beta_{11} \sum Dum_j + \beta_{12} \sum \gamma_{ijt} + \mu_{ijt} \tag{8}$$

In model 1, all variables are as defined in model 0, the only difference is the addition of infrastructure variable, $infrastructure_{it}$ ($infrastructure_{jt}$), which represents the overall infrastructure index in importing (exporting) countries.

Model 2:

$$ln(1 + M_{ijt}) = \beta_0 + \beta_1 \, ln\, GDP_{it} + \beta_2 \, ln\, GDP_{jt} + \beta_3 \, ln\, D_{ijt} + \beta_4 CB_{ijt} + \beta_5 lang_{ijt} + \beta_6 PTA_{ijt} + \beta_7 \, ln\big(1 + \tau_{ijt}\big) + \beta_8 \, ln\, roads_{it} + \beta_9 \, ln\, roads_{jt} + \beta_{10} \sum Dum_i + \beta_{11} \sum Dum_j + \beta_{12} \sum \gamma_{ijt} + \mu_{ijt} \tag{9}$$

In model 2, all variables are as defined in model 0, the only difference is the addition of a roads variable, $roads_{it}$ ($roads_{jt}$), which represents the roads index in importing (exporting) countries.

Model 3:

$$ln(1+M_{ijt}) = \beta_0 + \beta_1 \, ln\, GDP_{it} + \beta_2 \, ln\, GDP_{jt} + \beta_3 \, ln\, D_{ijt} + \beta_4 CB_{ijt} + \beta_5 lang_{ijt}$$

$$+ \beta_6 PTA_{ijt} \; + \beta_7 \, ln\big(1+\tau_{ijt}\big) + \beta_8 \, ln\, railroads_{it} + \beta_9 \, ln\, railroads_{jt}$$

$$+ \beta_{10} \sum Dum_i + \beta_{11} \sum Dum_j + \beta_{12} \sum \gamma_{ijt} + \mu_{ijt} \qquad (10)$$

In model 3, all variables are as defined in model 0, the only difference is the addition of a railroads variable, *railroads*$_{it}$ (*railroads*$_{jt}$), which represents the railroads index in importing (exporting) countries.

Model 4:

$$ln(1+M_{ijt}) = \beta_0 + \beta_1 \, ln\, GDP_{it} + \beta_2 \, ln\, GDP_{jt} + \beta_3 \, ln\, D_{ijt} + \beta_4 CB_{ijt} + \beta_5 lang_{ijt}$$

$$+ \beta_6 PTA_{ijt} \; + \beta_7 \, ln\big(1+\tau_{ijt}\big) + \beta_8 \, ln\, ports_{it} + \beta_9 \, ln\, ports_{jt} + \beta_{10} \sum Dum_i$$

$$+ \beta_{11} \sum Dum_j + \beta_{12} \sum \gamma_{ijt} + \mu_{ijt} \qquad (11)$$

In model 4, all variables are as defined in model 0, the only difference is the addition of a ports variable, *ports*$_{it}$ (*ports*$_{jt}$), which represents the ports index in importing (exporting) countries.

Model 5:

$$ln(1+M_{ijt}) = \beta_0 + \beta_1 \, ln\, GDP_{it} + \beta_2 \, ln\, GDP_{jt} + \beta_3 \, ln\, D_{ijt} + \beta_4 CB_{ijt} + \beta_5 lang_{ijt}$$

$$+ \beta_6 PTA_{ijt} \; + \beta_7 \, ln\big(1+\tau_{ijt}\big) + \beta_8 \, ln\, airports_{it} + \beta_9 \, ln\, airports_{jt}$$

$$+ \beta_{10} \sum Dum_i + \beta_{11} \sum Dum_j + \beta_{12} \sum \gamma_{ijt} + \mu_{ijt} \qquad (12)$$

In model 5, all variables are as defined in model 0, the only difference is the addition of airports variable, *airports*$_{it}$ (*airports*$_{jt}$), which represents the airports index in importing (exporting) countries.

4.3.2 Poisson Pseudo-Maximum Likelihood estimator

The Poisson Pseudo-Maximum Likelihood estimator has been found to be a good way to work with heteroskedasticity problems and gives equal weight to the observations of import values. Santos Silva and Tenreyro (2006) find that the PPML estimator performs better in the presence of heteroskedasticity and results in consistent estimators and is an appropriate method to deal with zero trade values. However, it relates the level of bilateral trade (import or export level) to the explanatory variables rather than the log of trade. However, the interpretation of the resulting variables is similar to OLS estimation, where coefficients of log variables can represent simple elasticities. The PPML model has been specified by Santos Silva and Tenreyro (2006) in terms of a constant elasticity of substitution (CES) model which take the following form:

$$y_{ijt} = exp(x_{ijt}\beta)\,\varepsilon_{ijt} \tag{13}$$

Where y_{ijt} is the import value; x_{ijt} is a vector of explanatory variables, which is the same as described in equation 6, including *GDP*, D_{ijt}, τ_{ijt}, *CB*, *lang*, *PTA*, and *INF*, β is the coefficient of explanatory variables and ε_{ijt} is the error term, where $(\varepsilon_{ijt}|x) = 1$. Taking the first order condition of equation 13 and solving for β yields the following form:

$$\sum_{i=1}^{N}[y_{ijt} - exp(x_{ijt}\beta)]x_{ijt} = 0 \tag{14}$$

Where N is the number of observations and y_{ijt} and x_{ijt} are as specified in equation 7. Under this specification, the function results in consistent estimators and satisfies the condition that conditional variance is proportional to the conditional mean[18] as explained by Santos Silva and Tenreyro (2006). Our gravity model of trade takes the following form while estimated using the PPML method:

[18] This hypothesis says that $E(y_{ijt}|x) = \exp(x_{ijt}\beta) \propto V(y_{ijt}|x)$ (see Santos Silva and Tenreyro, 2006; pa.645)

PPML Model 1:

$$M_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln D_{ijt} + \beta_4 CB_{ijt} + \beta_5 lang_{ijt} + \beta_6 PTA_{ijt} + \beta_7 \ln(1 + \tau_{ijt}) + \beta_8 \ln INF_{it} + \beta_9 \ln INF_{jt} + \beta_{10} \sum Dum_i + \beta_{11} \sum Dum_j + \beta_{12} \sum \gamma_{ijt} + \mu_{ijt} \quad (15)$$

Where M_{ij} is the level of imports from country *i* to country *j* in thousands of US dollars, and *GDP* represents gross domestic product in millions of US dollars (constant for 2010). D_{ijt} is the distance between importing and exporting countries measured in kilometers, and τ_{ijt} is the effectively applied bilateral tariff rate (weighted average tariff rate). *CB*, *lang*, and *PTA* are dummy variables for common border, common language, and preferential (free) trade agreement, respectively. Dum_i (Dum_j) is the dummy variables of importing (exporting) countries, γ_{ijt} is the time fixed effects or time dummy variables for a given trade pair in year t and μ_{ijt} is the random error term. *INF* represents importer and exporter infrastructure quality measured, by 5 indices including overall hard infrastructure, roads, railroads, ports and airports.

We estimated the PPML equation following the same strategy used in Tobit models by estimating six models; basic model, and then five models each including the basic model variables with the separate addition of infrastructure indices to the basic model (overall infrastructure, roads, railroads, ports and airports). The only difference between the models is that the dependent variable in the PPML estimation represents the level of imports M_{ij}.

CHAPTER 5/EMPIRICAL RESULTS AND DISCUSSION

This chapter presents the results of the estimated coefficients for the gravity model of trade for selected North and Latin American countries. For each of the estimated gravity equations, we report six regressions, one for the basic model, one for the overall hard infrastructure index, and regression results for each mode of transport infrastructure (roads, railroads, ports and airports) in each subsection below. The first section provides Tobit estimates for agricultural bilateral trade. The second section presents a comparison of the estimates of aggregated agricultural products against disaggregated agricultural products comprised of food, animal and vegetable products. The third section compares the results of Tobit and PPML estimators.

5.1 Bilateral trade of aggregated agricultural products

The Tobit estimates of the agricultural bilateral gravity model of trade are shown in Table 3. The results represent the marginal effects of trade determinants on agricultural trade flows in North and Latin America with panel data for the period of 2006-2014. The robustness check, including standard errors, is shown in parentheses for all the independent variables.

The total number of observations used in all models, except for model 3, which account for railroads, is 4,950 observations. The regression with the railroads index has 765 observations with zero values for the railroads index, which reduces the sample to 4,185 observations. The level of significance for all Models shows that the models perform well with a p-value of 0.0001. The value of the pseudo R^2 is 0.26 for all models, indicating that the models predicted the outcome better than the null model (the model with intercept only) since the value of pseudo R^2 is larger than 0.1 or not close to zero. Result tables show six estimated models for aggregated and for each disaggregated agricultural products, one model for the basic variables excluding infrastructure indices, and other five models estimated including infrastructure indices; overall infrastructure, roads, railroads, ports and airports.

First, we describe the results from model 0 for agricultural commodities aggregated together, which represents the basic model in Table 3. The GDP variables have the largest statistically significant and positive impact on agricultural trade volume with an elasticity of approximately 2.2 for importers and 1.3 for exporters. This suggests that with a one percent increase in a country's income level, total agricultural trade would increase by 2.2 percent for importing countries and 1.3 for exporting countries. These results confirm theory, where countries with greater market size are expected to trade more. For importing countries, income level represents the demand or purchasing power of the country; with higher income levels, importers are expected to increase the level of imports. In exporting countries with high income levels, producers are able to increase production and export volume.

The bilateral applied tariff rate estimated coefficient has significantly negative impacts on agricultural imports, which supports the theory that says the reduction in tariff rates are expected to increase import volumes. The result indicates that agricultural imports would increase by roughly 3.6 percent given a ten percent reduction in the tariff rates factor $(1+\tau_{ijt})$. The impact of the decline in applied tariff rates on the exporting country is represented in terms of increasing the supply as a response to the increased demand by the importing country.

The coefficient of the distance variable is statistically significant and negatively influences agricultural import volume, indicating that distance is negatively correlated with trade flows. Distance is one determinant of transport costs in the model which reflect the proximity between countries. The estimated coefficient has a negative sign, denoting that a shorter travel route is expected to increase bilateral trade flows. The results of the model suggest that, with a one percent decrease in the distance traveled, agricultural imports would increase by more than 1.4 percent.

PTA and common language variables have highly significant and positive elasticities of more than one. Most of the sample countries are members of either the same regional trade agreement or have bilateral preferential trade agreements which results in marginal effects that move in the same direction as agricultural trade volumes. The coefficient of the common language dummy variable also has the expected sign. Sharing a common language is a benefit that facilitates the communication and exchange of trade related information between pairs of countries. The common border estimated coefficient has the lowest influence on agricultural trade with an elasticity of approximately 0.18, and is positively related to bilateral trade flows of agricultural commodities and statistically significant at the 10 percent level. The contiguity variable is another determinate of transport costs alongside distance. Contiguity results in many advantages for trading countries, where sharing a common border with trading partners reduces the cost of long distance travel and the costs related to shipments through transit countries.

Second, we describe results from Model 1 with overall hard infrastructure indices as the measurement of the impact of infrastructure on total agricultural trade. The quality of hard infrastructure has a strong positive impact on agricultural bilateral trade volume for both exporters and importers. Nevertheless, the estimated coefficient of exporters' transport infrastructure has a larger impact on trade flows than importers' transport infrastructure. This could be due to the higher costs that are incurred by producers in exporting countries while moving agricultural commodities from farm gates or processing factories to exporting borders, while for importers, they ship the commodities from importing borders to domestic market centers. Hard infrastructure is assumed to be of higher quality in market centers compared to rural and agricultural areas. The importer infrastructure coefficient is statistically significant at the 10 percent level and the exporter infrastructure coefficient is statistically significant at the 5 percent level. The signs of coefficients are as expected, where improving the quality of exporter and importer physical infrastructure by 10 percent is expected to raise agricultural trade flows by 8.6 percent and 6.0 percent, respectively. This means that investments in all physical infrastructure networks including roads, railroads, ports and airports, by reforming existing facilities and constructing a new physical network system are expected to lead to increased trade. Even though the results show that improving hard infrastructures positively influences agricultural bilateral trade, the advantages from such developments may differ from country to country based on the volume of agricultural trade, direction of bilateral trade and the influence of other incentives on agricultural trade flows (e.g. GDP level, low tariff rate, etc.).

Also, we describe results from models 2, 3, 4 and 5 with roads, railroads, ports and airports indices, respectively, for aggregated agricultural commodities in Table 3. Among the four indicators of hard infrastructure, the importers' airports index and the exporters' ports index have the largest marginal effects. This result is consistent with the finding by Nordas and Piermartini (2004), where they conclude that port infrastructure has the largest impact on bilateral trade, among all indicators of infrastructure. Also, it appears that roads and ports infrastructure indices have high and similar effects in magnitude for both exporters and importers. For roads infrastructure, the results suggest that improving importers and exporters roads by 10 percent in North and Latin America are expected to increase agricultural bilateral trade flows by 7.2 percent and 6.0 percent, respectively. These results indicate that most of the sample countries, especially among Latin American countries, depend heavily on road networks for agricultural bilateral trade because they share a common land border. The port infrastructure index has similar effects as the road index. The quality of importers' ports is highly significant and positively related to trade volume with an elasticity of 0.74, suggesting that a 10 percent improvement in the quality of importers' ports, would increase agricultural trade by 7.4 percent. The index of exporters' ports shows a marginal effect of 0.61, which is statistically significant at the 10 percent level. These large marginal effects explain the importance of improving ports for countries that depend on sea transportation of agricultural commodities, especially for countries that do not share common land borders and use sea shipments for trading goods. The investments in port infrastructure improvement are assumed to have a large impact on trade of agricultural commodities in the sample given that all of North and Latin American countries are coastal countries except Bolivia and Paraguay.

Railroads indices have the smallest impacts on agricultural imports. The estimated coefficient for model 3 implies that improving the quality of exporters' railroads by 10 percent would enhance trade flows by 3.2 percent. This low impact could be due to the low quality of railroads in developing countries included in the sample, and Barbados and Trinidad and Tobago have no railroad infrastructure, which mean that these countries depend heavily on other transport networks to trade such as ports and roads rather than railroads. However, while exporter and importer estimated coefficients are statistically significant at the 10 percent level, the estimated coefficient of importers' railroads index has an unexpected sign. This could be due to the observations or countries with zero values for the index in the sample, which have no railroad infrastructure within the country. Similar to roads infrastructure, railroads are commonly used to trade among countries that share a common land border and for the shipment of agricultural commodities across the country. Finally, the importers' airports infrastructure index has the largest impact on agricultural trade, relative to other modes of hard infrastructure. The enhancement of importers' airports infrastructure is expected to significantly and positively influence bilateral trade flows with an elasticity of 0.89, which suggests that improving importers' airports infrastructure by 10 percent would increase aggregated agricultural trade by 8.9 percent. The estimated coefficient of the exporters' airports index is statistically insignificant, even though it has the expected sign for the effects on agricultural trade flows. This suggest that the quality of airports for exporting counties has no effects on agricultural imports.

5.2 Bilateral trade of food, animal and vegetable

This section presents the difference between trade of food, animal and vegetable products versus aggregated agricultural trade. Tables 4, 5 and 6 show Tobit estimates for the food, animal and vegetable gravity models of trade, respectively. The pseudo R^2 values range from 0.19 to 0.26; the lowest R^2 is 0.19 for animal bilateral trade and the highest R^2 is 0.26 for aggregated agricultural trade. Food and vegetable trade estimations both have a pseudo R^2 of 0.24. The level of significance for all six models for food, animal and vegetable products shows that the models perform well with a p-value of 0.0001.

First, we provide a description for the results from model 0, the basic model for food, animal and vegetable sectors. The estimated coefficient for the bilateral tariff rate is statistically significant and negatively influences bilateral trade flows of food, animal and vegetable products. The values of the estimated coefficients suggest that a one percent decrease in the tariff rates applied by importing countries, would increase bilateral trade by approximately 0.49, 0.27 and 0.39 percent for food, animal and vegetable products, respectively. These results are similar to the estimated effects of the aggregated agricultural trade estimates. The results clearly show that food imports are more sensitive to the change in applied tariff rates than animal and vegetable imports. This pattern of trade could be due to the higher volume of trade in food products than animal products, which can be observed within the majority of North and Latin America.

The coefficients of GDP variables are statistically significant and positively related to the import values for all agricultural subsectors of both exporting and importing countries. It appears that GDP has the highest impact on aggregated agricultural products as well as on disaggregated agricultural products. The magnitude of the estimated coefficients of importers' and exporters' GDP for all the basic models estimated ranges from -0.2 to 3.0. However, for animal products, the negative sign of exporters' GDP indicates that this variable is negatively correlated with trade volume. This could be a result of the large set of zero imports in the sample of animal products.

The estimated coefficient for distance is statistically significant, negative in sign and has a magnitude of more than one for food, animal, vegetable and total agricultural imports. The imports of animal products is impacted largely by distance, compared to the imports of aggregated agricultural and food products, with an elasticity of 1.6. This means that a reduction in the distance traveled by one percent is expected to increase animal products import by 1.6 percent.

The dummy variables that account for common border, common language, and PTA have significantly positive impacts on bilateral trade volume of both aggregated and disaggregated agricultural trade flows. The coefficient of the common border variable in the animal trade equation is larger than the aggregated agricultural trade value with an elasticity of 0.92. On the other hand, the common language dummy variable appears to have the largest impact on the trade of food and aggregated agricultural products. The preferential trade agreement coefficient in the vegetable trade equation is higher than that in the total agricultural trade equation.

Second, we describe the estimated results from model 1 with overall infrastructure indices for food, animal and vegetable products. Good quality hard infrastructure can stimulate agricultural bilateral trade. The estimated coefficients of hard infrastructure show large positive effects on food, animal and vegetable trade volumes. The estimated marginal effects of exporters' hard infrastructure are larger in magnitude than the estimated marginal effects of importers' hard infrastructure for food, animal and vegetable estimates, indicating that improving hard infrastructure has a much larger impact on trade of exporting countries than importing countries, which is consistent with the finding of aggregated agricultural products estimates. The elasticities of the impact of the transport infrastructure quality on food, animal and vegetable trade range from 0.65 to 0.89 for the importing countries and range from 0.98 to 1.33 for the exporting countries. Overall hard infrastructure has the largest impact on exports of food products, while the imports of vegetables are largely influenced by the quality of overall infrastructure of the importer country. This could be due to inelastic demand of food and vegetables, where the increase in the price of food and vegetable commodities, is not expected to decrease the quantity imported or exported because they are necessary products and have no close substitutes. This means that the bilateral trade of food and vegetables are important and highly determined by trade barriers such as transport costs. While in the animal sector, if importing counties face high prices for poultry products, they can switch to increase imports of beef or pork products, as an example. Thus, the magnitude of the impact of a specific agricultural product traded is heavily influenced by the volume or the value per unit of the commodity.

Finally, we describe the estimated results from models 2, 3, 4 and 5 with roads, railroads, ports and airports indices for food, animal and vegetable products. Comparing the influence of the four indicators of transport infrastructure on food, animal and vegetable trade flows, the quality of the importers' ports and the exporters' airports have the largest impact on bilateral trade. These results suggest that investments in port and airport reforms are positively related to agricultural trade flows, for both aggregated and disaggregated agricultural commodities. Therefore, a good quality port and airport system is sufficient to reduce the time and costs of trading a shipment of products.

For food products, port efficiency may play an essential role in enhancing bilateral trade. The estimated coefficient of the ports index shows that improving the quality of ports by ten percent is expected to raise bilateral trade of importers and exporters by 8.9 percent and 8.3 percent, respectively. These results indicate that food products are more highly impacted by sea shipments than total agricultural products. This could be attributed to the variation in the percentage of food, animal and vegetable import values in the total for agricultural trade of each shipment. In addition, as mentioned in chapter three, food products are characterized by less sensitivity to changes in prices, which implies that the changes in prices of food products may reduce the imported quantity by relatively small values. Therefore, the quality of ports is important for sea shipments of food products between North and Latin American countries, specifically for the trade of raw material food commodities. Because in some cases, processed food products may be easier to be shipped and to finish customs clearance more quickly, compared to raw material food products, given packaging and other features of processing. Similarly, the roads infrastructure index has highly significant and positive effects on import volumes of both importing and exporting countries, with an elasticity of 0.73 and 0.68, respectively. These estimated results are similar to the marginal effect for the roads index from the total agricultural trade equation. This indicates that roads shipments have similar impacts on aggregated and disaggregated agricultural products. The quality of railroads has the lowest impact on food bilateral trade flows. This implies that railroads are used less than the other modes of transport infrastructure for international trade across borders. Railroads may be used to ship food products domestically. For example, the U.S. and Mexico use railroads infrastructure to ship products locally around the country and use ports infrastructure to import and export with South American countries.

For animal products, the roads and ports indices have relatively large impacts on animal trade, which are consistent with the aggregated agricultural trade results. The estimated coefficients for the ports index show that the trade of animal products has the lowest impact by the quality of ports compared to food and vegetable products. This could be due to the low value of animal imports between North and Latin American countries, as the collected data show. The quality of roads is significantly and positively related to animal trade flows, indicating that the investment in roads can stimulate animal bilateral trade flows. Railroads infrastructure appears to have a larger impact on animal trade, compared to food, vegetable and total agricultural products. This means that railroads are more important for animal than food and vegetable trade because food and vegetables may be processed products at the border, which is easier to ship, compared to the case of unprocessed animal products that are impacted heavily by the quality of railroads infrastructure. The results suggest that a one percent improvement in the quality of railroads infrastructure is expected to increase bilateral trade by nearly 0.6 percent and 0.7 percent for importing and exporting countries, respectively. These elasticities show that the railroad infrastructure requires a substantial investment to construct new railroads networks as they are essential for agricultural products shipments, specifically across the country. The estimated coefficients of the overall hard infrastructure and the exporters' ports infrastructure are statistically insignificant even though their impacts are positively correlated with trade volume.

This could be due to imperfect data, since the highest number of zero trade flows is found in animal imports, compared to food and vegetable imports, which may eliminate the impact for country pairs with zero trade and good quality ports infrastructure.

For vegetable products, the overall influence of the quality of hard infrastructure indicators on vegetable trade are similar in direction and magnitude to that of food, animal and total agricultural trade. The exporters' air transport infrastructure is significantly and positively related to vegetable trade volumes with an elasticity of 0.88, which means that improving exporters' airports by 10 percent would increase vegetable trade flows by 8.8 percent. However, the importers' airport infrastructure has an unexpected sign but is statistically significant at the 10 percent level. The unexpected sign could be a result of imperfect data, specifically there is no large variation between the airports indices of the developing countries included in the sample, while there is a significant difference in the vegetable import values for these countries. The estimated coefficients of ports infrastructure significantly and positively impact vegetable trade flows, suggesting that a ten percent improvement in the quality of ports infrastructure is expected to enhance vegetable bilateral trade flows by approximately 7.7 percent and 6.6 percent for exporters and importers, respectively. Similar to food and total agricultural products, trade in vegetable products are highly influenced by road transportation. Results show that a 10 percent improvement in the quality of importers' roads, results in about 6.3 percent increase in vegetable bilateral trade. Similarly, exporters’ roads have a statistically significant impact, but it appears to be negatively correlated with vegetable imports. The marginal effect of the railroads index has the lowest impact on vegetable trade, which is consistent with the results for food, animal and total agricultural trade.

5.3 Poisson Pseudo Maximum Likelihood estimates

This section presents the estimated results of Poisson Pseudo Maximum Likelihood (PPML) estimators and provides a discussion of the main differences and similarities between Tobit and PPML results of the gravity model of trade. The estimated coefficients using the PPML estimator are provided in Tables 8, 9, 10 and 11 for aggregated agricultural, food, animal and vegetable bilateral trade, respectively. The value of pseudo R^2 ranges from 0.93 to 0.95 for all models, which indicates that the PPML gravity models of trade predict the explanatory variables relatively well. All PPML regressions have a p-value of 0.0001 which reflects the high level of significance among the models. The overall differences between the estimated coefficients using Tobit and PPML estimators are the differences in magnitudes and few differences in the sign of the estimated coefficients for the basic model. Infrastructure indices have relatively similar values for both estimation methods, with lower magnitudes for PPML estimates; however, the level of statistical significance of the estimated coefficients for most indices has improved using the PPML estimator.

For the basic model (model 0), the estimated coefficients for the applied tariff rate variable, exporters’ GDP variable, distance variable, common language variable and preferential trade agreement variable appear to have lower magnitudes in the PPML results for food, animal, vegetable and total agricultural trade, compared to the Tobit estimates. However, the estimated coefficient for importers' GDP is higher in the Tobit estimates than in the PPML estimates for food and animal products. In contrast, PPML estimated coefficients for the common border variables are higher in magnitude than Tobit estimates for all models.

Surprisingly, the coefficients for the common language variable have an unexpected sign for all the PPML estimated equations except for the food products model results. This may be due to the large number of zeros between trade pairs that do not share a common language, in which the impact of those pairs would be neglected. On the other hand, some trade pairs have positive trade values but they do not share a common language (e.g. the U.S. (English) and Brazil (Portuguese)) which could negatively relate the estimated coefficient to the import values.

The estimated coefficient for exporters' GDP is insignificant in the agricultural and animal trade equations, where it is statistically significant at the 10 percent level in the food trade equation and at the 5 percent and 10 percent levels in vegetable equations, relative to the Tobit estimates. For animal bilateral trade estimates, the exporters' GDP coefficient is insignificant for both Tobit and PPML estimates. For the food trade model, the coefficient for exporters' GDP appears to be negatively related to trade at the 10 percent level of significance. In addition, the estimated coefficient for the presence of a preferential trade agreement is insignificant in the PPML estimates where it is highly significant using the Tobit estimation method.

The estimated coefficients for hard infrastructure indices in model 1 are lower in magnitude for all PPML estimated equations, compared to Tobit estimates. However, the importer versus exporter effects are the same for both estimators for animal and aggregated agricultural products, where exporters' infrastructure has a larger impact on animal and aggregated agricultural trade than importers' infrastructure. However, for food products, the PPML estimates show that importers' infrastructure has a larger impact on trade volumes than exporters' infrastructure. While for vegetable products, the estimated coefficient for importers' infrastructure has an unexpected sign using the PPML estimator. This unexpected sign of importers' infrastructure in vegetable products could be a result of the different estimation method, because the PPML method estimates the relationship between the level of imports with the log of infrastructure index (linear-log), while in Tobit estimation, the model takes the form of log-log.

We described the results from model 2, 3, 4 and 5 with roads, railroads, ports and airports for aggregated agricultural, food, animal and vegetable products trade using the PPML estimator. For aggregated agricultural trade, all four modes of transport infrastructure appear to be highly statistically significant at the 1 percent or 5 percent level. Almost all infrastructure indices have lower estimated coefficients in magnitude, compared to the Tobit estimates. PPML estimates for all infrastructure indices result in coefficients with expected signs, which suggest that the quality of hard infrastructure indicators is positively related to agricultural trade. Among the four indicators of hard infrastructure, the quality of importers' and exporters' ports has the largest impact on agricultural trade using the PPML estimator.

For food products trade, all infrastructure indices are positively related to bilateral trade. The significance of the estimated coefficients for most of the infrastructure indices has improved from the 5 percent level using Tobit estimators to the 1 percent level using the PPML estimators. However, the coefficient of exporters' airports is statistically insignificant using the PPML estimation method, where it is highly significant using Tobit estimates. Similar to agricultural estimates, the estimated coefficients in all models for the food sector have lower values compared to the estimated coefficients using a Tobit estimator. The importers' roads index and the exporters' ports index have the highest impact on food trade, relative to other indices.

For animal products trade, the magnitude of the estimated coefficients for infrastructure indices using PPML estimator are lower than the estimated coefficients using the Tobit estimator. For the PPML estimates, all coefficients for infrastructure indices are statistically significant except importers' ports index and importers' airports index. The signs of the estimated coefficients for all hard infrastructure indicators show a positive relationship with animal trade except for importers' roads indices, which suggest that the quality of importers' roads is negatively related to trade.

For vegetable products trade, the coefficients for the indicators of transport infrastructure have the expected sign except the coefficients for importers’ overall hard infrastructure and importers’ ports, using the PPML estimation method. The level of significance of the estimated coefficients has improved from the 10 percent and 5 percent levels using Tobit estimates to the 5 percent and the 1 percent levels using PPML estimates. However, the coefficient for importers’ airports index is statistically insignificant when using PPML estimator. The estimated coefficients of the indices have lower magnitude using the PPML estimator compared to Tobit estimation, which is consistent with food, animal and total agricultural trade estimates.

In general, the differences in the magnitude and sign of the estimated coefficients for infrastructure indices between PPML and Tobit estimates could be due to the difference in the form of the models in relation to infrastructure indices. The PPML model takes the form of linear-log, while Tobit model has the form of log-log for the relationship between import value and infrastructure indices.

Table 3: Hard infrastructure impact on agricultural bilateral trade, Tobit estimates

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral	-0.3613***	-0.3625***	-0.3614***	-0.3524***	-0.3633***	-0.3648***
tariff rate	(0.0348)	(0.0348)	(0.0348)	(0.0369)	(0.0347)	(0.0347)
GDP	2.2251***	2.3285***	2.1663***	2.4098***	2.3273***	2.6350***
importer	(0.5060)	(0.5724)	(0.5347)	(0.5839)	(0.5289)	(0.5385)
GDP	1.3728**	0.8397	1.3227**	1.3227***	1.0797*	1.0698*
exporter	(0.5649)	(0.6149)	(0.5841)	(0.6516)	(0.6015)	(0.5898)
Distance	-1.4386***	-1.4386***	-1.4388***	-1.5374***	-1.4385***	-1.4364***
	(0.0668)	(0.0668)	(0.0668)	(0.0689)	(0.0667)	(0.0668)
PTA	1.1829***	1.1828***	1.1829***	1.0485***	1.1828***	1.1813***
	(0.0657)	(0.0657)	(0.0657)	(0.0720)	(0.0657)	(0.0657)
Common	1.5232***	1.5229***	1.5231***	1.2816***	1.5234***	1.5228***
Language	(0.0869)	(0.0869)	(0.0869)	(0.1152)	(0.0868)	(0.0868)
Common	0.1798*	0.1796*	0.1799*	0.1006	0.1790*	0.1810*
Border	(0.1037)	(0.1036)	(0.1037)	(0.1003)	(0.1035)	(0.1036)
Infrastructure		0.6043*				
importer		(0.3583)				
Infrastructure		0.8635**				
exporter		(0.4191)				
Roads			0.7212**			
importer			(0.2871)			
Roads			0.6007*			
exporter			(0.3161)			
Railroads				-0.2718*		
importer				(0.1636)		
Railroads				0.3206*		
exporter				(0.1646)		
Ports					0.7416***	
importer					(0.2071)	
Ports					0.6145*	
exporter					(0.3392)	
Airports						0.8932***
importer						(0.3067)
Airports						0.5894
exporter						(0.3907)
Constant	-23.2399***	-19.2664**	-22.2229**	-23.0866**	-21.5852**	-24.2908***
	(8.6805)	(9.3114)	(8.9522)	(10.0280)	(8.9226)	(8.7907)
Observations	4950	4950	4950	4185	4950	4950
Pseudo R2	0.26	0.26	0.26	0.27	0.26	0.26
F	222.63	216.66	216.48	206.44	216.57	216.40
Prob > F=	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: The estimated coefficients represent the marginal effects; all variables are in terms of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Table 4: Hard infrastructure impact on food bilateral trade, Tobit estimates

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral tariff rate	-0.4929***	-0.4955***	-0.4935***	-0.5179***	-0.4958***	-0.4957***
	(0.0311)	(0.0312)	(0.0311)	(0.0336)	(0.0311)	(0.0310)
GDP importer	1.0833**	1.1377*	1.0586**	1.3807**	1.2531**	1.4585***
	(0.5079)	(0.5823)	(0.5369)	(0.5739)	(0.5366)	(0.5468)
GDP exporter	1.7404***	0.8030	1.5240**	1.8013**	1.3538**	1.0870*
	(0.5917)	(0.6498)	(0.6239)	(0.7048)	(0.6374)	(0.5948)
Distance	-1.3629***	-1.3635***	-1.3632***	-1.4035***	-1.3625***	-1.3617***
	(0.0653)	(0.0652)	(0.0653)	(0.0701)	(0.0652)	(0.0629)
PTA	0.6201***	0.6183***	0.6192***	0.4240***	0.6177***	0.6163***
	(0.0696)	(0.0694)	(0.0695)	(0.0751)	(0.0695)	(0.0694)
Common Language	1.7243***	1.7217***	1.7243***	1.5012***	1.7247***	1.7261***
	(0.0906)	(0.0907)	(0.0905)	(0.1199)	(0.0906)	(0.0906)
Common Border	0.2589**	0.2571**	0.2584**	0.2737**	0.2576**	0.2603**
	(0.1055)	(0.1052)	(0.1054)	(0.1082)	(0.1052)	(0.1054)
Infrastructure importer		0.7027*				
		(0.3707)				
Infrastructure exporter		1.3315***				
		(0.4180)				
Roads importer			0.7343***			
			(0.2736)			
Roads exporter			0.6887***			
			(0.2677)			
Railroads importer				-0.3876**		
				(0.1796)		
Railroads exporter				0.3327*		
				(0.1816)		
Ports importer					0.8946***	
					(0.2800)	
Ports exporter					0.8332**	
					(0.3803)	
Airports importer						0.6791**
						(0.3229)
Airports exporter						1.3615***
						(0.4121)
Constant	-16.3613*	-8.2006	-14.1373	-19.1737*	-14.5118	-14.1219
	(8.9249)	(9.6254)	(9.1988)	(10.4540)	(9.3542)	(9.0183)
Observations	4950	4950	4950	4225	4950	4950
Pseudo R2	0.24	0.24	0.24	0.24	0.24	0.24
F	188.33	183.43	183.27	164.36	183.64	183.29
Prob > F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: The estimated coefficients represent the marginal effects; all variables are in terms of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Table 5: Hard infrastructure impact on animal bilateral trade, Tobit estimates

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral tariff rate	-0.2714***	-0.2729***	-0.2701***	-0.2587***	-0.2735***	-0.2727***
	(0.0394)	(0.0394)	(0.0394)	(0.0419)	(0.0394)	(0.0393)
GDP importer	3.0139***	3.4362**	3.1609***	2.8366***	3.4373***	3.2884***
	(0.7121)	(0.8318)	(0.7789)	(0.8128)	(0.7358)	(0.7588)
GDP exporter	-0.2219	-0.9581	-0.7698	0.3219	-0.5759	-0.8140
	(0.7691)	(0.8667)	(0.8049)	(0.8622)	(0.8427)	(0.8155)
Distance	-1.6074***	-1.6082***	-1.6063***	-1.7452***	-1.6080***	-1.6073***
	(0.1037)	(0.1037)	(0.1037)	(0.1094)	(0.1036)	(0.1037)
PTA	1.0630***	1.0642***	1.0645***	1.1493***	1.0633***	1.0633***
	(0.0967)	(0.0966)	(0.0966)	(0.1047)	(0.0967)	(0.0966)
Common Language	0.6669***	0.6659***	0.6673***	0.2715	0.6657***	0.6707***
	(0.1384)	(0.1383)	(0.1384)	(0.1676)	(0.1382)	(0.1383)
Common Border	0.9212***	0.9193***	0.9227***	0.7721***	0.9218***	0.9204***
	(0.1492)	(0.1492)	(0.1492)	(0.1527)	(0.1491)	(0.1492)
Infrastructure importer		0.6504				
		(0.5018)				
Infrastructure exporter		1.0610*				
		(0.5939)				
Roads importer			0.7734**			
			(0.3617)			
Roads exporter			0.8759*			
			(0.4600)			
Railroads importer				0.5566***		
				(0.1605)		
Railroads exporter				0.6977***		
				(0.2252)		
Ports importer					0.7995***	
					(0.2330)	
Ports exporter					0.5863	
					(0.4988)	
Airports importer						-0.8631*
						(0.4809)
Airports exporter						0.9251*
						(0.5452)
Constant	-13.3382	-10.3889	-9.6738	-15.5810	-14.1030	-10.5339
	(11.6725)	(12.9593)	(12.2781)	(13.3178)	(12.1470)	(11.8310)
Observations	4375	4375	4375	3834	4375	4375
Pseudo R2	0.19	0.19	0.19	0.20	0.19	0.19
F	106.76	103.27	103.35	105.15	103.41	103.55
Prob > F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: The estimated coefficients represent the marginal effects; all variables are in terms of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Table 6: Hard infrastructure impact on vegetable bilateral trade, Tobit estimates

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral tariff rate	-0.3883***	0.3890***	-0.3876***	-0.3887***	-0.3886***	-0.3893***
	(0.0386)	(0.0385)	(0.03854)	(0.0427)	(0.0386)	(0.0385)
GDP importer	2.6990***	2.8252***	2.3109***	2.3967***	2.8252***	2.8634***
	(0.6463)	(0.7196)	(0.6807)	(0.7475)	(0.6670)	(0.6753)
GDP exporter	2.8367***	2.3997***	2.9462***	3.2394***	2.8424***	2.6053***
	(0.7429)	(0.8413)	(0.7789)	(0.8414)	(0.7854)	(0.7728)
Distance	-1.3184***	-1.3177***	-1.3189***	-1.3157***	-1.3178***	-1.3178***
	(0.0806)	(0.0806)	(0.0806)	(0.0858)	(0.0806)	(0.0807)
PTA	1.6059***	1.6066***	1.6056***	1.4153***	1.6058***	1.6057***
	(0.0883)	(0.0882)	(0.0883)	(0.0958)	(0.0883)	(0.0883)
Common Language	0.9201***	0.9186***	0.9206***	0.3520**	0.9199***	0.9201***
	(0.1247)	(0.1247)	(0.1246)	(0.1689)	(0.1247)	(0.1246)
Common Border	0.3877***	0.3888***	0.3870***	0.5125***	0.3880***	0.3885***
	(0.1183)	(0.1182)	(0.1184)	(0.1194)	(0.1182)	(0.1183)
Infrastructure importer		0.8962**				
		(0.4502)				
Infrastructure exporter		0.9885*				
		(0.5051)				
Roads importer			0.6352*			
			(0.3846)			
Roads exporter			-0.6595*			
			(0.3616)			
Railroads importer				0.3411		
				(0.2098)		
Railroads exporter				0.3939*		
				(0.2068)		
Ports importer					0.7660**	
					(0.3286)	
Ports exporter					0.6615*	
					(0.3777)	
Airports importer						-0.8153*
						(0.4276)
Airports exporter						0.8835**
						(0.4466)
Constant	-47.8363***	-44.8797***	-45.2440***	-48.0366***	-49.0364***	-47.1487***
	(11.3247)	(12.2295)	(11.7373)	(13.0099)	(11.5341)	(11.4566)
Observations	4625	4625	4625	3995	4625	4625
Pseudo R2	0.24	0.24	0.24	0.23	0.24	0.24
F	163.50	158.87	158.62	144.50	158.57	158.86
Prob > F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: The estimated coefficients represent the marginal effects; all variables are in terms of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Table 7: Tobit estimates for model 1, overall infrastructure

Variable	Aggregated agricultural products	Food	Animal	Vegetable
Infrastructure,	0.6043*	0.7027*	0.6504	0.8962**
importer	(0.3583)	(0.3707)	(0.5018)	(0.4502)
Infrastructure,	0.8635**	1.3315***	1.0610*	0.9885*
exporter	(0.4191)	(0.4180)	(0.5939)	(0.5051)

Note: ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Table 8: Hard infrastructure impact on agricultural bilateral trade, PPML estimates

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral tariff rate	-0.1018***	-0.0976***	-0.1022***	-0.0878***	-0.0956***	-0.1021***
	(0.0254)	(0.0271)	(0.0251)	(0.0235)	(0.0256)	(0.0250)
GDP importer	1.6122***	2.0858***	1.5587***	1.7612***	1.9247***	1.5830***
	(0.3603)	(0.4336)	(0.4012)	(0.4017)	(0.3831)	(0.3612)
GDP exporter	0.3058	0.1352	0.1903	0.2174	0.1496	0.3366
	(0.3385)	(0.4159)	(0.3712)	(0.3535)	(0.3998)	(0.3438)
Distance	-0.6875***	-0.6879***	-0.6875***	-0.7672***	-0.6879***	-0.6874***
	(0.0514)	(0.0514)	(0.0515)	(0.0567)	(0.0513)	(0.0513)
PTA	0.7089***	0.7100***	0.7088***	0.6951***	0.7104***	0.7088***
	(0.0601)	(0.0599)	(0.0602)	(0.0604)	(0.0599)	(0.0600)
Common Language	-0.8130***	-0.8177***	-0.8130***	-1.1082***	-0.8189***	-0.8128***
	(0.1199)	(0.1201)	(0.1197)	(0.1375)	(0.1202)	(0.1197)
Common Border	0.7088***	0.7114***	0.7085***	0.6967***	0.7126***	0.7087***
	(0.0715)	(0.0717)	(0.0712)	(0.0692)	(0.0716)	(0.0711)
Infrastructure importer		0.5410**				
		(0.2330)				
Infrastructure exporter		0.8924***				
		(0.2246)				
Roads importer			0.7201***			
			(0.2451)			
Roads exporter			0.4886**			
			(0.2011)			
Railroads importer				0.2179**		
				(0.0865)		
Railroads exporter				0.2403***		
				(0.0852)		
Ports importer					0.7655***	
					(0.2246)	
Ports exporter					0.6484***	
					(0.2026)	
Airports importer						0.7451***
						(0.2559)
Airports exporter						0.4301*
						(0.2465)
Constant	-6.4574	-9.4901	-4.7868	-6.1373	-8.0174	-6.6660
	(5.1961)	(6.4702)	(5.8633)	(5.7506)	(5.8281)	(5.1865)
Observations	4950	4950	4950	4185	4950	4950
Pseudo R2	0.95	0.95	0.95	0.95	0.95	0.95
Wald chi2	71558.60	75297.45	70950.54	81440.44	75459.33	73028.04
Prob > chi2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: All variables are in terms of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Table 9: Hard infrastructure impact on food bilateral trade, PPML estimates

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral tariff rate	-0.1862***	-0.1872***	-0.1916***	-0.1902***	-0.1866***	-0.1855***
	(0.0308)	(0.0299)	(0.0292)	(0.0313)	(0.0297)	(0.0308)
GDP importer	2.0204***	1.8922***	1.6473***	2.0300***	1.9719***	1.9874***
	(0.3471)	(0.4261)	(0.3870)	(0.3725)	(0.3684)	(0.3542)
GDP exporter	-0.7837*	-0.5804	-0.7863*	-0.8504*	-0.8952*	-0.7686*
	(0.4138)	(0.5132)	(0.4484)	(0.4414)	(0.5086)	(0.4066)
Distance	-0.7980***	-0.7983***	-0.7996***	-0.8122***	-0.7980***	-0.7976***
	(0.0468)	(0.0467)	(0.0464)	(0.0477)	(0.0466)	(0.0469)
PTA	0.0644	0.0640	0.0622	-0.0119	0.0644	0.0649
	(0.0582)	(0.0582)	(0.0582)	(0.0566)	(0.0582)	(0.0582)
Common Language	0.5017***	0.5021***	0.5023***	0.3592***	0.5015***	0.5018***
	(0.0960)	(0.0958)	(0.0956)	(0.1065)	(0.0959)	(0.0961)
Common Border	0.6822***	0.6815***	0.6782***	0.7058***	0.6822***	0.6828***
	(0.0797)	(0.0791)	(0.0780)	(0.0794)	(0.0789)	(0.0798)
Infrastructure importer		0.8148***				
		(0.2506)				
Infrastructure exporter		0.6024***				
		(0.2043)				
Roads importer			0.6524***			
			(0.2205)			
Roads exporter			0.3810**			
			(0.1773)			
Railroads importer				0.2255**		
				(0.1103)		
Railroads exporter				0.4125***		
				(0.0723)		
Ports importer					0.5117**	
					(0.2306)	
Ports exporter					0.8351***	
					(0.1906)	
Airports importer						0.5416**
						(0.2538)
Airports exporter						0.1961
						(0.3236)
Constant	0.1955	-0.5811	3.9491	1.1139	1.7666	-0.0616
	(4.8876)	(6.7566)	(5.8086)	(5.5326)	(6.0176)	(4.8238)
Observations	4950	4950	4950	4225	4950	4950
Pseudo R2	0.95	0.95	0.95	0.95	0.95	0.95
Wald chi2	71804.91	71236.77	73437.62	65123.30	73395.95	74004.77
Prob > chi2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: All variables are in terms of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Table 10: Hard infrastructure impact on animal bilateral trade, PPML estimates

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral tariff rate	-0.0666***	-0.0610***	-0.0715***	-0.0573***	-0.0569***	-0.0716***
	(0.0193)	(0.0202)	(0.0214)	(0.0196)	(0.0209)	(0.0192)
GDP importer	4.9058***	5.3160***	4.5116***	5.3276***	5.3221***	4.9585***
	(0.6976)	(0.9653)	(0.8017)	(0.7878)	(0.8099)	(0.6936)
GDP exporter	-0.2412	-0.5232	-0.4596	-0.5915	-0.4029	-0.0160
	(0.5651)	(0.6032)	(0.5782)	(0.5316)	(0.5695)	(0.5916)
Distance	-0.5481***	-0.5484***	-0.5492***	-0.6396***	-0.5484***	-0.5502***
	(0.0915)	(0.0917)	(0.0914)	(0.0954)	(0.0913)	(0.0916)
PTA	0.9836***	0.9849***	0.9829***	1.0307***	0.9864***	0.9829***
	(0.1126)	(0.1125)	(0.1123)	(0.1161)	(0.1122)	(0.1120)
Common Language	-0.5187***	-0.5251***	-0.5178***	-0.8329***	-0.5294***	-0.5215***
	(0.1601)	(0.1603)	(0.1607)	(0.1747)	(0.1604)	(0.1602)
Common Border	1.4399***	1.4438***	1.4354***	1.3999***	1.4474***	1.4354***
	(0.1369)	(0.1374)	(0.1366)	(0.1372)	(0.1367)	(0.1364)
Infrastructure importer		0.6418*				
		(0.3745)				
Infrastructure exporter		0.6723*				
		(0.3450)				
Roads importer			-0.7211**			
			(0.3346)			
Roads exporter			0.7695***			
			(0.2373)			
Railroads importer				0.4966**		
				(0.2026)		
Railroads exporter				0.4038**		
				(0.1871)		
Ports importer					0.1509	
					(0.3182)	
Ports exporter					0.7468**	
					(0.3194)	
Airports importer						0.7658
						(0.5039)
Airports exporter						0.8581***
						(0.2639)
Constant	-38.4945***	-39.7161***	-32.4577***	-38.1698***	-40.8645***	-42.1611***
	(8.4265)	(11.3263)	(9.5489)	(9.1751)	(9.8211)	(8.7574)
Observations	4375	4375	4375	3834	4375	4375
Pseudo R2	0.94	0.94	0.94	0.94	0.94	0.94
Wald chi2	52202.45	49674.29	51146.57	44593.18	47379.25	54900.65
Prob > chi2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: All variables are in terms of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Table 11: Hard infrastructure impact on vegetable bilateral trade, PPML estimates

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral tariff rate	-0.1323***	-0.1256***	-0.1265***	-0.1228***	-0.1252***	-0.1337***
	(0.0294)	(0.0294)	(0.0299)	(0.0290)	(0.0301)	(0.0288)
GDP importer	0.5601	1.4820**	0.7771	0.6985	1.0033*	0.5653
	(0.5203)	(0.6213)	(0.5553)	(0.5706)	(0.5386)	(0.5181)
GDP exporter	1.0984**	0.7206	0.9252*	1.0492**	0.9017	1.1389**
	(0.4681)	(0.5980)	(0.5212)	(0.5101)	(0.5602)	(0.4754)
Distance	-0.7847***	-0.7868***	-0.7862***	-0.8344***	-0.7868***	-0.7843***
	(0.0725)	(0.0723)	(0.0725)	(0.0739)	(0.0723)	(0.0723)
PTA	1.0635***	1.0648***	1.0641***	1.0663***	1.0637***	1.0634***
	(0.0985)	(0.0982)	(0.0984)	(0.0987)	(0.0982)	(0.0984)
Common Language	-2.3403***	-2.3408***	-2.3411***	-2.5150***	-2.3406***	-2.3399***
	(0.1512)	(0.1513)	(0.1513)	(0.1559)	(0.1516)	(0.1509)
Common Border	0.5385***	0.5388***	0.5390***	0.5349***	0.5391***	0.5383***
	(0.0756)	(0.0754)	(0.0754)	(0.0750)	(0.0755)	(0.0753)
Infrastructure importer		-0.8251**				
		(0.3946)				
Infrastructure exporter		0.7911***				
		(0.2704)				
Roads importer			0.5032**			
			(0.2301)			
Roads exporter			0.5702**			
			(0.2323)			
Railroads importer				0.3153**		
				(0.1528)		
Railroads exporter				0.4133***		
				(0.1395)		
Ports importer					-0.4592*	
					(0.2691)	
Ports exporter					0.5868**	
					(0.2667)	
Airports importer						0.2319
						(0.3960)
Airports exporter						0.7841*
						(0.4172)
Constant	-3.6192	-9.0838	-4.0463	-3.9294	-6.0565	-3.8930
	(7.7799)	(9.2104)	(8.2756)	(8.3672)	(8.1723)	(7.8452)
Observations	4625	4625	4625	3995	4625	4625
Pseudo R2	0.93	0.93	0.93	0.93	0.93	0.93
Wald chi2	46003.03	49579.19	48244.13	47460.49	47234.94	45677.71
Prob > chi2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: All variables are in terms of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Table 12: PPML estimates for model 1, overall infrastructure

Variable	Aggregated agricultural products	Food	Animal	Vegetable
Infrastructure importer	0.5410** (0.2330)	0.8148*** (0.2506)	0.6418* (0.3745)	-0.8251** (0.3946)
Infrastructure exporter	0.8924*** (0.2246)	0.6024*** (0.2043)	0.6723* (0.3450)	0.7911*** (0.2704)

Note: ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

CHAPTER 6/SUMMARY AND CONCLUSIONS

Trade of agricultural products, unlike manufacturing products, is sensitive to a wide variety of barriers to trade in addition to tariff rates. These barriers are technical barriers related to protection, safety, and product labeling, and other indirect barriers such as geographic factors, poor infrastructure and transportation costs. Specifically, the demand, supply, and prices of agricultural commodities may be unstable and fluctuate, especially in the long run, due to different factors that influence agricultural production such as seasonality, cost of production, availability of natural and capital resources, climate, and other marketing and economic costs including transportation. The uncertainty that arises from fluctuating prices and unknown access to trade markets are both important issues for global agricultural markets.

Countries may want to focus on increasing agricultural imports for different reasons. Some countries have high domestic prices for food products, so it might be cheaper to import specific products from foreign countries with greater production efficiency that allows for lower prices. In addition, some countries with large populations and low agricultural production are required to buy agricultural products abroad to meet food security needs. Some agricultural products are not grown in some countries or are domestically supplied in low quantities, while other countries may have a comparative advantage in producing these products. Therefore, there is an incentive for a country to export that product for which it has a comparative advantage, and with foreign capital, the importer can benefit from purchasing the products at cheaper price. For example, some Latin American counties including Brazil, Argentina, Colombia, Costs Rica, Ecuador, Guatemala and Peru are producers of coffee, given that mountains in Latin America are productive and sustainable climates and lands to grow coffee plants. This suggests that other

North and Latin American counties may benefit from importing coffee, because they either do not produce it at all, or it is relatively more expensive to produce coffee in their region. Given the main benefits of agricultural imports and exports and production advantage of countries, the trade flows of these products require different support systems to help reduce trade costs. Hard infrastructure improvements are one example of trade facilitation that may decrease transportation costs of agricultural product shipments.

However, trade models that address the effects of trade barriers include both direct and indirect variables, to measure the impact on trade volumes, including geographic variables, tariff costs, GDP and population of a country. In this study, we are concerned with the impacts of hard infrastructure and transport costs on trade volumes. Poor hard infrastructure and long distances are identified as potential barriers to trade, as they increase transportation costs, and subsequently, market efficiency.

The objective of this study was to estimate the impacts of hard infrastructure quality on agricultural trade volumes. Specifically, the study investigates the effects of developing the quality of physical networks on agricultural bilateral trade among North and Latin American countries for the years 2006 to 2014. The study addresses three sub-objectives. First, we estimate the effects of the quality of hard infrastructure on agricultural trade for a time period of nine years. Second, we investigate the impacts of physical infrastructure development on both aggregated and disaggregated agricultural bilateral trade flows. Third, we assess the impacts of each mode of hard infrastructure (e.g. roads, railroads, ports, airports) on agricultural trade volumes.

A modified gravity model of trade was employed to measure the impacts of the quality of hard infrastructure on agricultural trade flows. The traditional gravity model of trade includes variables such as income level, distance and other geographic variables, common language and the presence of free trade agreements, to represent the determinants of bilateral trade. In this study, we add hard infrastructure indices, and applied tariff rates to understand the effects of imports. By employing hard infrastructure indices and other geographic variables in the model, we intend to capture the influence of transport costs on agricultural imports. Tobit and Poisson Pseudo Maximum Likelihood estimators are used to estimate the gravity model of trade.

Food, animal and vegetable import data were collected from the World Integrated Trade Solution database for bilateral trade flows from 2006 to 2014. A sample of 25 North and Latin American countries was selected to assess the impact of transport costs on agricultural trade volume. Hard infrastructure data was obtained from the Global Competitiveness Report (2006-2014), which has been provided in term of indices, valued from 1 to 7, to represent the average quality of hard infrastructure across key categories.

The estimated results using the Tobit estimator show that the estimated coefficients for GDP have the largest impacts on agricultural bilateral trade, among all explanatory variables. As expected, the coefficient for distance is negatively related to both aggregated and disaggregated agricultural trade flows. The sign of the estimated coefficient for distance indicates that countries with the shortest travel route tend to trade more with each other due to reduced transportation expenses. Similarly, the coefficients of applied tariff rates are negatively related to aggregated and disaggregated agricultural trade. This suggests that low tariff rates allow countries to import more. The estimated coefficients for the dummy variables for free trade agreement, common border and common language have significant and positive impacts on food, animal, vegetable and total agricultural trade.

This study finds that the quality of physical infrastructure is positively related to agricultural bilateral trade. However, the estimated coefficients show that the quality of hard infrastructure networks is more important for exporters than for importers of agricultural trade. Results suggest that a 10 percent improvement in the quality of hard infrastructure is expected to increase agricultural trade by approximately 8.8 percent for exporting countries and by 6.0 percent for importing countries. For example, in order to increase the volume of agricultural imports from other countries by 8.8 percent, Argentina, with a hard infrastructure index value of 3.5, needs to increase the actual quality of their infrastructure by 10 percent. This means that the country would need to invest in repairing and redeveloping the old physical infrastructure including roads, railroads, ports and airport systems; in addition, expanding the capacity of hard networks that are used more intensively to move cargo around the country and to other countries is important. Specifically, Argentina would benefit from investing in ground networks to trade with Bolivia, Paraguay and Chile, where they share a common border; moreover, upgrading the quality of ports, as they are important for trade with other North and Latin American countries.

Importers' airport infrastructure has the largest impacts on agricultural trade flows. The quality of roads and ports infrastructure has similar and large effects on agricultural bilateral trade. Port infrastructure is important for total agricultural trade because most of the sample countries are coastal countries and most of their products are shipped and traded via water. Similarly, roads are important for the trade of agricultural products given that some countries in North and South America share an inland common border, such as the U.S. and Mexico, and Brazil and Colombia. These results imply that developing hard infrastructure can encourage more agricultural trade in both directions between countries in North and Latin America.

Food, animal and vegetable bilateral trade are similarly influenced by hard infrastructure indices. The study finds that the quality of exporters' hard infrastructure has a larger impact on disaggregated agricultural products trade than importers' hard infrastructure. Food imports are most impacted by overall hard infrastructure, while animal imports are least impacted by the quality of hard infrastructure. This can be attributed to the relatively more inelastic demand of food products, which are necessary products for consumers. In the case of animal imports, it has the lowest impact, which may be due to elastic demand and substitutability across some types of animal products such as meat. However, the variation in the impact by infrastructure type could be driven by the differences in quality and quantity of imported food, vegetable and animal products. Even though animal imports are affected the least by the quality of overall hard infrastructure, they face the largest impact when products are shipped through railroads, compared to food and vegetable products. This could be due to the state or form of the products at the border; where at the border, food and vegetable products may be processed, while animal products may be shipped in an unprocessed state.

For the specific modes of transport infrastructure, the estimated results show that the importers' port infrastructure and the exporters' airport infrastructure have the highest effects on trade volumes of food, animal and vegetable products, compared to other modes of physical transportation networks. Railroad infrastructure is found to have the lowest impacts on aggregated and disaggregated agricultural bilateral trade.

Even though this study generates important results in the field of agricultural trade, there is still additional research that is warranted. It is important to acknowledge the data limitations present in this study. The impacts of the variables in the gravity model of trade have been limited by employing a specific sample of countries (North and Latin American countries) in the analysis. In addition, 10 Latin American countries have been dropped due to missing and unreported agricultural import values and hard infrastructure indices. Accordingly, the inclusion of more countries around the world would enable the exploration of additional variation in trade volumes explained by transport cost determinants. For example, including additional geographic variables to the model, such as landlocked and island status, to reflect the impacts of shipment costs on agricultural trade may improve estimation results among a larger sample of countries. However, since the sample countries included only have three island and two landlocked countries, these geographic factors are not considered in this analysis. In addition, the inclusion of a larger sample of countries would enable the measurement of the impacts of infrastructure development at a more general level, where the impacts on agricultural trade can be observed more thoroughly if a country has a larger number of trading partners. However, the scope of the study is to estimate the effects of infrastructure on agricultural trade between North and Latin American countries, and results are important given that most of the sample countries are active agricultural producers and exporters. Results may be applicable to other parts of the world since hard infrastructure development is positively related to agricultural trade volumes.

The other limitation to the study is that some estimated coefficients for infrastructure indices have an unexpected sign and others are statistically insignificant. This could be a result of the potential bias when the model approximates the data. However, future research could use the same gravity model of trade framework to address the impact of transport infrastructure on agricultural trade using a larger sample of countries around the world. This would give a more general assessment than is presented herein. This study could be expanded to examine the bilateral trade impacts among North-Latin America and compare agricultural trade between other regions of the world. Another opportunity to expand this analysis is to add the multilateral resistance terms other than importers and exporters fixed effects in order to control for the impacts of the changes in policy variables faced by a country. An example of the multilateral resistance terms includes accounting for different prices faced by importing and exporting countries, or remoteness of a country, which requires further data collection and estimation which is beyond the scope of this study.

Generally, the estimated marginal effects suggest that the investment in physical networks encourages global trade and reduces transportation and shipment expenses. The quality of physical infrastructure modes, including roads, railroads, ports and airports, plays a vital role in determining transport costs incurred for the shipment of traded commodities. However, the impacts of the quality of each mode of physical networks on trade flows depend heavily on the common transportation modes used by countries and the volume of trade. For example, some countries use roads and railroads infrastructure for shipments across the country and ports infrastructure for agricultural products shipment at the border to international markets, while other countries use only roads for shipments across the country and at the border, which may depend on the type of a common border (e.g. land or sea) and distance.

In general, investment in hard infrastructure, specifically in underdeveloped countries, is costly and often inadequate to meet transportation needs in the country. Insufficient infrastructure systems slow and limit access to large cities in a country, making it difficult to meet national and international market demand and impacting economic activities of a country. Improvements of hard infrastructure are expected to positively benefit the trade pattern of a country. Therefore, countries are expected to benefit from developing their hard network system not just because it is a means for transportation, but because it is essential in creating connection points between cities and rural areas both within the country and among different countries.

Poor quality hard networks could be attributed to the intensive use of a transportation system over time without upgrading the damaged network or adding new transportation systems. In addition, some countries experience different crises or natural disasters which could lead to the deterioration of some physical infrastructure in the country at a given time. Improving the physical networks would require a substantial increase in project funding. However, increased investment in such projects may reduce delays and traffic in the roads and highway system and reduce maintenance costs for all modes of transport. Countries with no railroads, such as Barbados and Trinidad and Tobago, could benefit from building and creating a new railroad system to move shipments of agricultural goods between cities and to reduce pressure on trucks and roads. This is particularly important for the trade of animal products, where our results found that railroad quality has the largest impact on imports of animal products compared to other agricultural products. Similarly, countries with low to medium quality ground networks such as Suriname, Paraguay, Honduras, Guatemala, Costa Rica and Brazil, may benefit from investing in repairing and expanding the old networks and building additional roads and railroads to expand the transportation capacity in their countries. However, counties with hard infrastructure indices of 5 to 7, such as Canada and the U.S., may benefit from repairing and reforming the existing physical networks, while concentrating investment funds into railroads and roads, as they already have high quality ports and airport systems.

In summary, hard infrastructure is an essential facilitation investment that is required to stimulate agricultural production and to enhance trade. Therefore, improving physical network systems has the potential to reduce transport costs of agricultural goods shipped locally or internationally. The policy implications based on the findings of the study are that the development of hard infrastructure for both exporting and importing countries are important to increase quantities traded, lower shipment costs, and to in order help producers in rural areas have better access to domestic and international markets. Accordingly, infrastructure improvements for both importers and exporters are worthwhile, as both consumers and producers may benefit from investment in physical network systems. Therefore, countries may benefit from concentrating investment projects in developing the modes that are used more commonly to trade across the country and at the border. As results show that exporters' airport infrastructure is important for agricultural trade, net exporters of agricultural products may benefit from investing in airport infrastructure developments. In addition, the large positive impact of the estimated results for ports indices show that it may be worthwhile to invest in developing port infrastructure from both an importer and exporter perspective, as this may result in increasing both aggregated and disaggregated agricultural trade volumes for trading countries. Ports are essential physical infrastructure for agricultural trade for almost all North and Latin American countries. For example, the U.S. depends on water shipments to trade agricultural products, where about 99% of foreign trade with the U.S. is through sea shipments. The ports of South Louisiana and Houston are examples of the top ranking U.S. ports in term of cargo volume for both domestic and foreign trade. In general, investments in hard infrastructure are expected to increase trade in both developed and developing countries. Even though developed countries have historically supported high quality and well developed networks, overall, there may be a deterioration of some hard infrastructure facilities over time in specific areas around the country where physical infrastructure is intensively used for transportation. Therefore, investments in improving roads, railroads, airports and ports, or building new network systems, are essential as one method to increase trade of agricultural commodities between North and Latin American countries.

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APPENDIX

Table 13: Sample countries

Central America and Caribbean	**South America**	**North America**
Barbados	Argentina	Canada
Costa Rica	Bolivia	Mexico
Dominican Republic	Brazil	United States of America
El Salvador	Chile	
Guatemala	Colombia	
Honduras	Ecuador	
Jamaica	Guyana	
Nicaragua	Paraguay	
Panama	Peru	
Trinidad and Tobago	Suriname	
	Uruguay	
	Venezuela	

Summary of variables:

Table 14: Summary of agricultural product variables

Variable		Mean	Std. Dev.	Min	Max	Observations
	Overall		1535562	0	2.65e+07	N= 4950
Agricultural	Between		509417.9	5450.488	2413716	n= 25
imports	Within	238903.4	1448275	-21601164	2.43e+07	T-bar= 198
Tariff on	Overall		10.20994	0	189.1133	N= 4950
agricultural	Between		5.430311	2.345802	26.55879	n= 25
Imports	Within	8.602972	8.727353	-17.95582	179.9099	T-bar= 198
	Overall		8.88e+07	1094.8	5.15e+08	N= 4950
GDP	Between		8.80e+07	1113.356	4.35e+08	n= 25
Importer	Within	2.54e+07	1.01e+07	-4.71e+07	1.05e+08	T-bar= 198
	Overall		8.89e+07	1094.8	5.15e+08	N= 4950
GDP	Between		4104055	7564954	3.05e+07	n= 25
Exporter	Within	2.58e+07	8.88e+07	-4700141	5.17e+08	T-bar= 198
	Overall		1932.964	181.1133	9155.327	N= 4950
	Between		879..094	2460.001	5068.291	n= 25
Distance	Within	3358.258	1730.146	-1372.408	7567.844	T-bar= 198
PTA	Overall	0.480506	0.499668	0	1	N= 4950

	Between		0.145933	0.282927	0.835051	n= 25
	Within		0.478774	-0.354545	1.19758	T-bar= 198
	Overall		0.492872	0	1	N= 4950
Common	Between		0.277566	0	0.916666	n= 25
language	Within	0.584405	0.410938	-0.3322612	1.540927	T-bar= 198
	Overall		0.316697	0	1	N= 4950
	Between		0.083708	0	0.360190	n= 25
Common border	Within	0.113060	0.305860	-0.247129	1.071394	T-bar= 198
	Overall		0.9826417	1.91	6.14	N= 4950
Infrastructure	Between		0.937938	2.345029	5.876667	n= 25
Importer	Within	3.6946	0.336463	2.837889	4.617856	T-bar= 198
Road	Overall		1.064334	1.8	6.2	N= 4950
infrastructure	Between		1.02382	2.195429	5.877778	n= 25
importer	Within	3.7245	0.354916	2.721483	4.921483	T-bar= 198
Railroad	Overall		1.216461	0	5.4	N= 4950
infrastructure	Between		1.161706	0	5.155556	n= 25
Importer	Within	1.9135	0.3912304	1.098528	3.798528	T-bar= 198
Ports	Overall		1.131213	1.3	6.4	N= 4950
infrastructure	Between		1.071012	2.522222	6.011111	n= 25
importer	Within	3.9784	0.396739	2.555013	5.211715	T-bar= 198
Airports	Overall		1.001288	2.2	6.4	N= 4950
infrastructure	Between		0.9733132	2.566857	6.066667	n= 25
Importer	Within	4.5726	0.3300004	3.639298	5.695245	T-bar= 198
	Overall		0.9743852	1.91	6.14	N= 4950
Infrastructure	Between		0.0713011	3.533457	3.877657	n= 25
Exporter	Within	3.6927	0.9720041	1.842537	6.299272	T-bar= 198
Road	Overall		1.068556	1.8	6.2	N= 4950
infrastructure	Between		0.0630738	3.607216	3.861714	n= 25
exporter	Within	3.722943	1.066823	1.749997	6.315727	T-bar= 198
Railroad	Overall		1.20867	0	5.4	N= 4950
infrastructure	Between		0.075948	1.753241	2.069022	n= 25
exporter	Within	1.9149	1.206423	-0.154148	5.552836	T-bar= 198
Ports	Overall		1.123819	1.3	6.4	N= 4950
infrastructure	Between		0.0534342	3.880402	4.06	n= 25
exporter	Within	3.9754	1.122607	1.215419	6.495017	T-bar= 198
Airports	Overall		0.9924087	2.2	6.4	N= 4950
infrastructure	Between		0.0683654	4.479787	4.762286	n= 25
exporter	Within	4.579	0.9902334	2.118553	6.488012	T-bar= 198

Source: Authors' calculation (or estimates). Notes: GDP represents Gross Domestic Products, PTA refers to Preferential or free trade agreement; Agricultural import values are in thousand US dollar, GDP values are in million US dollar; T-bar refers to the number of total pairs with in the data, n is the number of importers groups, N is the number of observations.

Table 15: Summary of food product variables

Variable		Mean	Std. Dev.	Min	Max	Observations
Food imports	Overall	92712.07	644207.8	0	1.22e+07	N= 4950
	Between		190642.5	3623.629	892566.6	n= 25
	Within		614238	-799854.5	1.18e+07	T-bar= 198
Tariff on Food	Overall	11.2364	19.05925	0	517.23	N= 4950
Imports	Between		6.51024	3.29662	30.74785	n= 25
	Within		17.9812	-19.51144	497.7186	T-bar= 198
GDP	Overall	2.53e+07	8.79e+07	1094.8	5.15e+08	N= 4950
importer	Between		8.81e+07	1113.297	4.36e+08	n= 25
	Within		1.01e+07	-4.74e+07	1.05e+08	T-bar= 198
GDP	Overall	2.68e+07	9.04e+07	1094.8	5.15e+08	N= 4950
Exporter	Between		4569203	8042338	3.34e+07	n= 25
	Within		9.03e+07	-6585231	5.19e+08	T-bar= 198
Distance	Overall	3342.093	1958.369	181.1133	9155.327	N= 4950
	Between		859.9739	2462.507	5028.501	n= 25
	Within		1767.562	-1319.521	7647.065	T-bar= 198
PTA	Overall	0.494945	0.500025	0	1	N= 4950
	Between		0.141413	0.3134328	0.805970	n= 25
	Within		0.480015	-0.311025	1.181513	T-bar= 198
Common	Overall	0.602305	0.489471	0	1	N= 4950
language	Between		0.289060	0	0.9166667	n= 25
	Within		0.399296	-0.3143618	1.557529	T-bar= 198
Common border	Overall	0.116458	0.320805	0	1	N= 4950
	Between		0.085638	0	0.3469388	n= 25
	Within		0.309773	-0.230481	1.074791	T-bar= 198
Infrastructure	Overall	3.7048	0.9903347	1.91	6.14	N= 4950
Importer	Between		0.938295	2.338889	5.876667	n= 25
	Within		0.334798	2.841202	4.62863	T-bar= 198
Road	Overall	3.7363	1.07391	1.8	6.2	N= 4950
infrastructure	Between		1.023564	2.188889	5.877778	n= 25
importer	Within		0.3521753	2.734114	4.934114	T-bar= 198
Railroad	Overall	1.9280	1.229133	0	5.4	N= 4950
infrastructure	Between		1.161949	0	5.155556	n= 25
importer	Within		0.3872959	1.113696	3.813696	T-bar= 198
Ports	Overall	3.9882	1.135389	1.3	6.4	N= 4950
infrastructure	Between		1.071665	2.522222	6.0125	n= 25
importer	Within		0.3957925	2.568632	5.20658	T-bar= 198
Airports	Overall	4.5808	1.003926	2.2	6.4	N= 4950
infrastructure	Between		0.972836	2.566667	6.065174	n= 25
importer	Within		0.325800	3.64153	5.20658	T-bar= 198
Infrastructure	Overall	3.7119	0.974692	1.91	6.14	N= 4950
Exporter	Between		0.067554	3.589722	3.902749	n= 25
	Within		0.972488	1.833923	6.262231	T-bar= 198
Road	Overall	3.7321	1.072949	1.8	6.2	N= 4950
infrastructure	Between		0.061433	3.605473	3.890643	n= 25
exporter	Within		1.071282	1.741463	6.326634	T-bar= 198
Railroad	Overall	1.9357	1.219107	0	5.4	N= 4950
infrastructure	Between		0.098139	1.753241	2.189157	n= 25
exporter	Within		1.215477	-0.172380	5.573628	T-bar= 198
Ports	Overall	3.9937	1.127339	1.3	6.4	N= 4950
infrastructure	Between		0.054969	3.88408	4.07602	n= 25
exporter	Within		1.126033	1.217671	6.509612	T-bar= 198

Airports infrastructure exporter	Overall	4.5997	0.987538	2.2	6.4	N= 4950
	Between		0.066658	4.490741	4.787719	n= 25
	Within		0.985406	2.107798	6.508976	T-bar= 198

Source: Authors' calculation (or estimates). Notes: GDP represents Gross Domestic Products, PTA refers to Preferential or free trade agreement; Food import values are in thousand US dollar, GDP values are in million US dollar; T-bar refers to the number of total pairs with in the data, n is the number of importers groups, N is the number of observations.

Table 16: Summary of animal product variables

Variable		Mean	Std. Dev.	Min	Max	Observations
Animal imports	Overall	50405.37	374154.5	0	7656122	N= 4375
	Between		98040.58	868.6546	455342	n= 25
	Within		359122.9	-404925	7251185	T-bar= 175
Tariff on Animal Imports	Overall	9.333403	14.69617	0	142.34	N= 4375
	Between		6.517481	0.667634	27.4915	n= 25
	Within		13.25903	-18.1581	136.8083	T-bar= 175
GDP importer	Overall	2.63e+07	9.04e+07	1094.8	5.15e+08	N= 4375
	Between		8.81e+07	1113.356	4.36e+08	n= 25
	Within		1.03e+07	-4.69e+07	1.06e+08	T-bar= 175
GDP Exporter	Overall	2.87e+07	9.38e+07	1094.8	5.15e+08	N= 4375
	Between		8875802	7924035	5.63e+07	n= 25
	Within		9.34e+07	-2.76e+07	5.19e+08	T-bar= 175
Distance	Overall	3312.884	2003.757	181.1133	9155.327	N= 4375
	Between		859.7846	2372.455	5028.501	n= 25
	Within		1808.044	-1450.919	7745.767	T-bar= 175
PTA	Overall	0.53939	0.498502	0	1	N= 4375
	Between		0.152072	0.2631579	0.9	n= 25
	Within		0.4751774	-0.360607	1.276235	T-bar= 175
Common language	Overall	0.62434	0.484347	0	1	N= 4375
	Between		0.289064	0	0.916666	n= 25
	Within		0.395672	-0.292323	1.56552	T-bar= 175
Common border	Overall	0.126056	0.3319506	0	1	N= 4375
	Between		0.0974623	0	0.3865031	n= 25
	Within		0.3182678	-0.2604469	1.08439	T-bar= 175
Infrastructure Importer	Overall	3.7483	1.006644	1.91	6.14	N= 4375
	Between		0.9396615	2.32828	5.876667	n= 25
	Within		0.332173	2.889046	4.66904	T-bar= 175
Road infrastructure importer	Overall	3.7830	1.080964	1.8	6.2	N= 4375
	Between		1.024913	2.178495	5.877778	n= 25
	Within		0.3555582	2.776932	4.976932	T-bar= 175
Railroad infrastructure importer	Overall	1.9821	1.268709	0	5.4	N= 4375
	Between		1.161832	0	5.155556	n= 25
	Within		0.3915087	1.163887	3.863887	T-bar= 175
Ports infrastructure importer	Overall	4.0170	1.146631	1.3	6.4	N= 4375
	Between		1.070983	2.52623	6.011111	n= 25
	Within		0.3885252	2.583703	5.250369	T-bar= 175
Airports infrastructure	Overall	4.6302	0.9864307	2.2	6.4	N= 4375
	Between		0.9736718	2.567742	6.066667	n= 25

importer	Within		0.3266606	3.696879	5.7516	T-bar= 175
Infrastructure	Overall	3.7177	0.9731702	1.91	6.14	N= 4375
Exporter	Between		0.1028602	3.589722	4.043333	n= 25
	Within		0.9688767	1.882111	6.267944	T-bar= 175
Road	Overall	3.7256	1.085003	1.8	6.2	N= 4375
infrastructure	Between		0.0717699	3.583889	3.877273	n= 25
exporter	Within		1.082826	1.771108	6.341711	T-bar= 175
Railroad	Overall	2.0304	1.224665	0	5.4	N= 4375
infrastructure	Between		0.145914	1.753241	2.431183	n= 25
exporter	Within		1.21696	-0.1094893	5.668358	T-bar= 175
Ports	Overall	3.9559	1.135661	1.3	6.4	N= 4375
infrastructure	Between		0.0686049	3.826667	4.122222	n= 25
exporter	Within		1.133688	1.20037	6.529191	T-bar= 175
Airports	Overall	4.5660	0.9723558	2.2	6.4	N= 4375
infrastructure	Between		0.0850135	4.414136	4.759477	n= 25
exporter	Within		0.9688719	2.154727	6.551815	T-bar= 175

Source: Authors' calculation (or estimates). Notes: GDP represents Gross Domestic Products, PTA refers to Preferential or free trade agreement; Animal import values are in thousand US dollar, GDP values are in million US dollar; T-bar refers to the number of total pairs with in the data, n is the number of importers groups, N is the number of observations.

Table 17: Summary of vegetable product variables

Variable		Mean	Std. Dev.	Min	Max	Observations
Vegetable	Overall	118214.3	658957.6	0	1.09e+07	N= 4625
imports	Between		228115.5	1215.038	1065808	n= 25
	Within		614716	-947593.6	9961701	T-bar= 185
Tariff on	Overall	8.014253	12.51366	0	160.31	N= 4625
vegetable	Between		6.149899	0.334213	28.62319	n= 25
Imports	Within		10.84074	-20.60894	139.7011	T-bar= 185
GDP	Overall	2.56e+07	8.95e+07	1094.8	5.51e+08	N= 4625
importer	Between		8.80e+07	1113.356	4.35e+08	n= 25
	Within		1.02e+07	-4.68e+07	1.06e+08	T-bar= 185
GDP	Overall	2.85e+07	9.32e+07	1094.8	5.15e+08	N= 4625
Exporter	Between		6555922	8209764	4.61e+07	n= 25
	Within		9.30e+07	-1.76e+07	5.19e+08	T-bar= 185
Distance	Overall	3339.19	1979.458	181.1133	9155.327	N= 4625
	Between		804.577	2531.378	5028.501	n= 25
	Within		1810.523	-1285.236	7830.908	T-bar= 185
PTA	Overall	0.523984	0.499478	0	1	N= 4625
	Between		0.161310	0.2916667	0.895028	n= 25
	Within		0.474036	-0.371043	1.232318	T-bar= 185
Common	Overall	0.623163	0.484646	0	1	N= 4625
language	Between		0.291851	0	0.9166667	n= 25
	Within		0.393470	-0.293503	1.553933	T-bar= 185
Common border	Overall	0.128349	0.334514	0	1	N= 4625
	Between		0.100259	0	0.4378378	n= 25
	Within		0.319556	-0.309489	1.086683	T-bar= 185
Infrastructure	Overall	3.7456	1.000276	1.91	6.14	N= 4625

Importer	Between		0.938394	2.337117	5.876667	n= 25
	Within		0.330947	2.884842	4.668733	T-bar= 185
Road	Overall	3.7699	1.078125	1.8	6.2	N= 4625
infrastructure	Between		1.023475	2.186486	5.877778	n= 25
importer	Within		0.347339	2.768033	4.968033	T-bar= 185
Railroad	Overall	1.9380	1.265766	0	5.4	N= 4625
infrastructure	Between		1.161347	0	5.155556	n= 25
importer	Within		0.389021	1.117669	3.817669	T-bar= 185
Ports	Overall	4.0105	1.144047	1.3	6.4	N= 4625
infrastructure	Between		1.069965	2.5265	6.008	n= 25
importer	Within		0.382858	2.579559	5.230458	T-bar= 185
Airports	Overall	4.6397	0.987412	2.2	6.4	N= 4625
infrastructure	Between		0.973229	2.571171	6.066667	n= 25
importer	Within		0.321517	3.704352	5.763546	T-bar= 185
Infrastructure	Overall	3.7015	0.985402	1.91	6.14	N= 4625
Exporter	Between		0.121872	3.555949	4.044462	n= 25
	Within		0.979064	1.795187	6.285607	T-bar= 185
Road	Overall	3.7171	1.091516	1.8	6.2	N= 4625
infrastructure	Between		0.105852	3.581768	4.032308	n= 25
exporter	Within		1.087228	1.715051	6.335388	T-bar= 185
Railroad	Overall	2.0018	1.209818	0	5.4	N= 4625
infrastructure	Between		0.138567	1.753241	2.408108	n= 25
exporter	Within		1.203196	-0.157394	5.6398	T-bar= 185
Ports	Overall	3.9810	1.13551	1.3	6.4	N= 4625
infrastructure	Between		0.102658	3.812	4.282308	n= 25
exporter	Within		1.131512	1.166292	6.528648	T-bar= 185
Airports	Overall	4.5573	1.000113	2.2	6.4	N= 4625
infrastructure	Between		0.1064008	4.4065	4.883077	n= 25
exporter	Within		0.9952632	2.069957	6.506531	T-bar= 185

Source: Authors' calculation (or estimates). Notes: GDP represents Gross Domestic Products, PTA refers to Preferential or free trade agreement; vegetable import values are in thousand US dollar, GDP values are in million US dollar; T-bar refers to the number of total pairs with in the data, n is the number of importers groups, N is the number of observations.

Correlation between variables:

Table 18: Correlation between agricultural product variables

	Agricultural imports	Bilateral tariff rate	GDP importer	GDP exporter	Distance	PTA	Common Language	Common Border	Infrastructure importer	Roads importer	Railroads importer	Ports importer
Agricultural imports	1.0000											
Bilateral tariff rate	-0.2488	1.0000										
GDP importer	0.0022	-0.1209	1.0000									
GDP exporter	0.0208	0.0576	-0.9048	1.0000								
Distance	-0.5102	-0.4665	-0.1205	0.1533	1.0000							
PTA	0.1870	-0.2245	0.4570	-0.4255	0.0461	1.0000						
Common Language	0.2157	-0.4887	0.1654	-0.1208	0.0247	0.5041	1.0000					
Common Border	-0.0549	-0.5156	0.2679	-0.2361	0.2018	0.2374	0.0530	1.0000				
Infrastructure importer	0.6550	0.1618	-0.0006	0.0014	0.4751	0.0307	-0.1045	-0.2982	1.0000			
Roads importer	0.6064	0.1491	-0.1053	0.1015	0.3984	0.0652	0.0022	-0.4676	0.8884	1.0000		
Railroads importer	0.7592	-0.4286	-0.0262	0.0725	0.5679	0.1720	0.2217	0.0217	0.6036	0.6010	1.0000	
Ports importer	0.4284	0.2832	-0.0800	0.0647	0.2765	-0.0955	-0.0288	-0.5115	0.7992	0.8358	0.4761	1.0000
Airports importer	0.4432	0.3417	0.0174	-0.0223	0.0717	0.1188	0.0333	-0.5047	0.8374	0.8400	0.4658	0.7996
Infrastructure exporter	0.2048	0.1444	0.1589	-0.1314	-0.0914	0.3465	0.0185	0.0211	0.2285	0.1895	0.3376	0.1786
Roads exporter	0.2070	0.1927	0.1748	-0.1519	-0.0917	0.3040	-0.0482	0.0388	0.2583	0.1535	0.3071	0.1702
Railroads exporter	-0.1226	0.1813	0.1715	-0.1479	-0.1409	0.2769	0.0999	0.1620	0.0327	-0.0177	-0.0315	0.0288
Ports	0.2618	0.1145	0.1794	-0.1467	-0.0543	0.3687	-0.0105	0.0591	0.2826	0.2002	0.3666	0.1140

exporter												
Airports exporter	0.2647	0.1427	0.1528	-0.1262	0.0077	0.3355	-0.0308	0.0464	0.3168	0.2429	0.3739	0.2088

Source: Authors’ calculation (or estimates).

Table 18: Correlation between agricultural product variables

	Airports importer	Infrastructure exporter	Roads exporter	Railroads exporter	Railroads exporter	Airports exporter
Airports importer	1.0000					
Infrastructure exporter	0.4016	1.0000				
Roads exporter	0.4021	0.9849	1.0000			
Railroads exporter	0.2004	0.7771	0.7616	1.0000		
Ports exporter	0.4192	0.9751	0.9799	0.7312	1.0000	
Airports exporter	0.4205	0.9859	0.9873	0.7562	0.9819	1.0000

Source: Authors’ calculation (or estimates).

Table 19: Correlation between food product variables

	Food imports	Bilateral tariff rate	GDP importer	GDP exporter	Distance	PTA	Common Language	Common Border	Infrastructure importer	Roads importer	Railroads importer	Ports importer
Food imports	1.0000											
Bilateral tariff rate	-0.2629	1.0000										
GDP importer	-0.0047	-0.1784	1.0000									
GDP exporter	0.0267	0.0954	-0.9042	1.0000								
Distance	-0.5872	-0.4005	-0.0955	0.1297	1.0000							
PTA	0.1248	-0.3020	0.4904	-0.4483	0.1294	1.0000						
Common Language	0.1988	-0.5775	0.1730	-0.1142	0.0362	0.5350	1.0000					
Common Border	-0.1105	-0.4421	0.2798	-0.2373	0.2281	0.2164	0.1154	1.0000				
Infrastructure importer	0.7116	0.0204	0.0013	-0.0040	0.5341	0.0689	-0.1053	-0.3012	1.0000			
Roads importer	0.6634	0.0013	-0.0896	0.0881	0.4774	0.0972	-0.0120	-0.4440	0.9019	1.0000		
Railroads importer	0.8090	-0.5317	-0.0241	0.0733	0.6398	0.1825	0.2098	0.0205	0.6395	0.6342	1.0000	
Ports importer	0.5113	0.0781	-0.0724	0.0673	0.3390	-0.0509	-0.0455	-0.4829	0.8171	0.8505	0.5172	1.0000
Airports importer	0.5090	0.0980	0.0170	-0.0228	0.1794	0.1381	0.0140	-0.4983	0.8628	0.8574	0.5088	0.8216
Infrastructure exporter	0.2993	0.0742	0.1602	-0.0914	0.1168	0.3256	-0.0273	-0.0502	0.4088	0.3660	0.4154	0.3384
Roads exporter	0.3046	0.1269	0.1126	-0.1047	0.1075	0.2971	-0.0671	-0.0676	0.4447	0.3635	0.3961	0.3571
Railroads exporter	0.0148	0.0140	0.1354	-0.1096	-0.0107	0.3497	0.0838	0.0658	0.1986	0.1783	0.1107	0.1636
Ports exporter	0.3376	0.0838	0.1105	-0.0964	0.1400	0.3338	-0.0585	-0.0092	0.4499	0.3758	0.4386	0.2900
Airports exporter	0.3447	0.0858	0.1145	-0.1031	0.1691	0.3289	-0.0509	-0.0298	0.4621	0.4032	0.4404	0.3498

Source: Authors' calculation (or estimates).

Table 19: Correlation between food product variables

	Airports importer	Infrastructure exporter	Roads exporter	Railroads exporter	Railroads exporter	Airports exporter
Airports importer	1.0000					
Infrastructure exporter	0.5252	1.0000				
Roads exporter	0.5496	0.9928	1.0000			
Railroads exporter	0.3336	0.7516	0.7403	1.0000		
Ports exporter	0.5380	0.9818	0.9828	0.7298	1.0000	
Airports exporter	0.5418	0.9939	0.9923	0.7316	0.9897	1.0000

Source: Authors' calculation (or estimates).

Table 20: Correlation between animal product variables

	Animal imports	Bilateral tariff rate	GDP importer	GDP exporter	Distance	PTA	Common Language	Common Border	Infrastructure importer	Roads importer	Railroads importer	Ports importer
Animal imports	1.0000											
Bilateral tariff rate	-0.0915	1.0000										
GDP importer	-0.0287	-0.0996	1.0000									
GDP exporter	0.1412	-0.3586	-0.6566	1.0000								
Distance	-0.6150	-0.1125	-0.0282	0.1398	1.0000							
PTA	0.2964	-0.0802	0.4530	-0.1081	0.2284	1.0000						
Common Language	0.3321	-0.2827	0.1965	0.1147	0.1999	0.5993	1.0000					
Common Border	-0.0552	-0.6257	0.3017	0.0312	0.1107	0.2379	0.1541	1.0000				
Infrastructure importer	0.6670	0.3042	0.0353	-0.1499	0.7368	0.1919	0.1305	-0.2569	1.0000			
Roads importer	0.6499	0.3006	-0.0461	-0.0666	0.7029	0.2177	0.2089	-0.3819	0.9365	1.0000		
Railroads importer	0.7298	-0.1099	-0.0093	0.2658	0.7343	0.2349	0.3016	-0.0015	0.7394	0.7347	1.0000	
Ports importer	0.5104	0.4081	-0.0286	-0.1073	0.5854	0.0787	0.1524	-0.4236	0.8835	0.9070	0.6487	1.0000
Airports importer	0.5280	0.4917	0.0554	-0.1462	0.5258	0.2778	0.2606	-0.4113	0.9007	0.9048	0.6432	0.8892
Infrastructure exporter	0.5146	0.3622	0.1043	-0.0252	0.5750	0.4692	0.3813	-0.1506	0.6946	0.6924	0.6292	0.6171
Roads exporter	0.5046	0.3670	0.1105	-0.0355	0.5820	0.4540	0.3817	-0.1326	0.7058	0.6839	0.6256	0.6267
Railroads exporter	0.2936	0.3168	0.2064	-0.1474	0.4939	0.4756	0.4904	0.0413	0.5557	0.5294	0.4139	0.5010
Ports exporter	0.5215	0.3690	0.1099	-0.0407	0.5792	0.4641	0.3670	-0.1454	0.7014	0.6895	0.6215	0.6080
Airports exporter	0.5195	0.0927	0.0927	-0.0216	0.5910	0.4583	0.3673	-0.1508	0.7123	0.7050	0.6358	0.6307

Source: Authors' calculation (or estimates).

Table 20: Correlation between animal products variables

	Airports importer	Infrastructure exporter	Roads exporter	Railroads exporter	Railroads exporter	Airports exporter
Airports importer	1.0000					
Infrastructure exporter	0.7861	1.0000				
Roads exporter	0.7933	0.9967	1.0000			
Railroads exporter	0.6871	0.9033	0.9177	1.0000		
Ports exporter	0.7835	0.9980	0.9956	0.8995	1.0000	
Airports exporter	0.7922	0.9978	0.9964	0.9003	0.9964	1.0000

Source: Authors' calculation (or estimates).

Table 21 : Correlation between vegetable products variables

	Vegetable imports	Bilateral tariff rate	GDP importer	GDP exporter	Distance	PTA	Common Language	Common Border	Infrastructure importer	Roads importer	Railroads importer	Ports importer
Vegetable imports	1.0000											
Bilateral tariff rate	-0.3345	1.0000										
GDP importer	0.0293	-0.0598	1.0000									
GDP exporter	0.0054	0.0520	-0.9000	1.0000								
Distance	-0.6007	-0.3559	-0.0744	0.1426	1.0000							
PTA	0.2328	-0.2808	0.4897	-0.4361	0.1840	1.0000						
Common Language	0.2523	-0.3656	0.1869	-0.1194	0.1193	0.5603	1.0000					
Common Border	-0.0136	-0.4206	0.2437	-0.2345	0.1388	0.2760	0.0419	1.0000				
Infrastructure importer	0.6061	0.1899	0.0097	0.0596	0.6946	0.0888	0.0289	-0.2944	1.0000			
Roads importer	0.5741	0.1675	-0.0735	0.1329	0.6413	0.1010	0.1230	-0.4378	0.9274	1.0000		
Railroads importer	0.7475	-0.4518	-0.0158	0.0637	0.6954	0.1920	0.2904	0.0031	0.6073	0.6151	1.0000	
Ports importer	0.4342	0.3176	-0.0548	0.0982	0.5020	-0.0200	0.0816	-0.4774	0.8679	0.8921	0.5210	1.0000
Airports importer	0.4217	0.3294	0.0236	0.0552	0.4597	0.1372	0.1638	-0.4611	0.8970	0.8968	0.4870	0.8794
Infrastructure exporter	0.3079	0.2446	0.0891	0.0037	0.4062	0.2237	0.2506	-0.1359	0.6516	0.6041	0.3893	0.5597
Roads exporter	0.3045	0.2506	0.1117	-0.0191	0.4058	0.2284	0.2423	-0.1086	0.6539	0.5870	0.3881	0.5484
Railroads exporter	0.1147	0.2856	0.1704	-0.0568	0.3683	0.3685	0.3698	0.0085	0.5591	0.4914	0.2118	0.4633
Ports exporter	0.3218	0.2334	0.0886	0.0075	0.4292	0.2288	0.2302	-0.1220	0.6680	0.6035	0.3916	0.5411
Airports exporter	0.3241	0.2323	0.0789	0.0148	0.4475	0.2344	0.2635	-0.1331	0.6780	0.6281	0.4042	0.5768

Source: Authors' calculation (or estimates).

Table 21: Correlation between vegetable products variables

	Airports importer	Infrastructure exporter	Roads exporter	Railroads exporter	Railroads exporter	Airports exporter
Airports importer	1.0000					
Infrastructure exporter	0.7953	1.0000				
Roads exporter	0.7874	0.9972	1.0000			
Railroads exporter	0.7093	0.8915	0.8996	1.0000		
Ports exporter	0.7951	0.9954	0.9962	0.8946	1.0000	
Airports exporter	0.8038	0.9966	0.9956	0.8958	0.9951	1.0000

Source: Authors' calculation (or estimates).

Cross-validation of the estimation methods:

Heteroskedasticity in data:

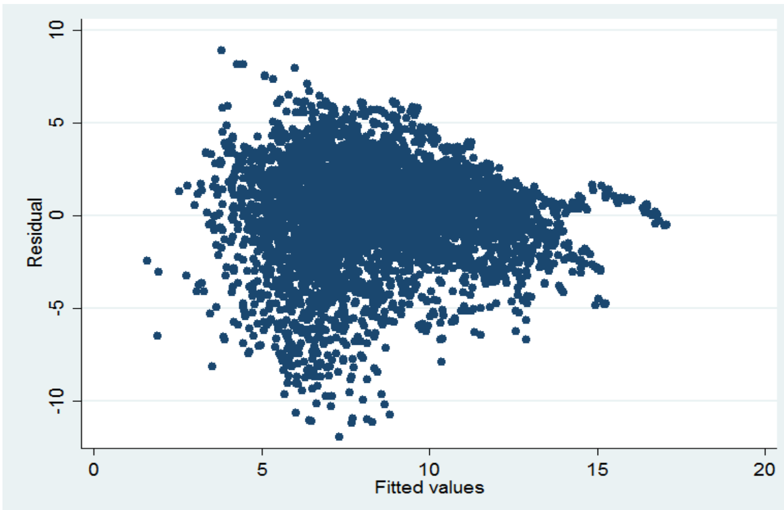

Figure 5: Heteroskedasticity in food import data

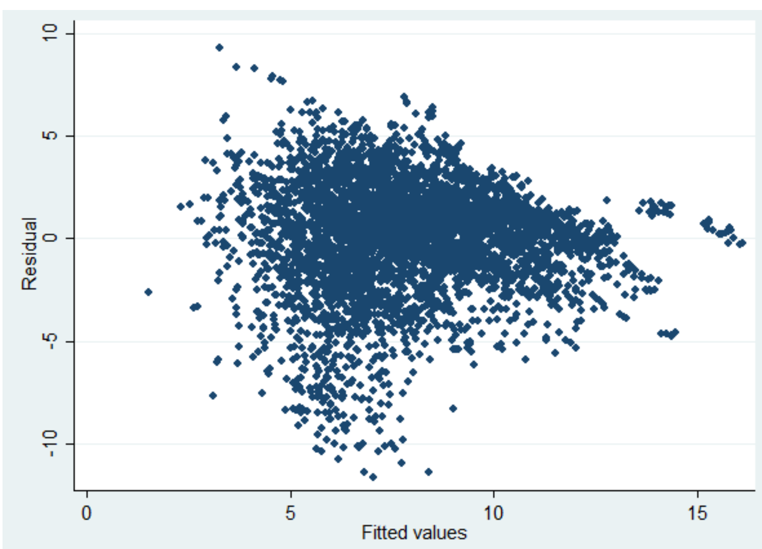

Figure 6: Heteroskedasticity in animal import data

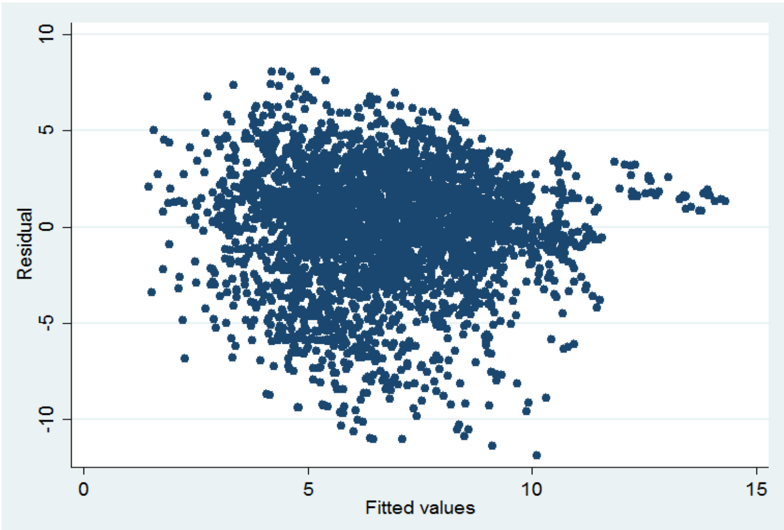

Figure 7: Heteroskedasticity in vegetable import data

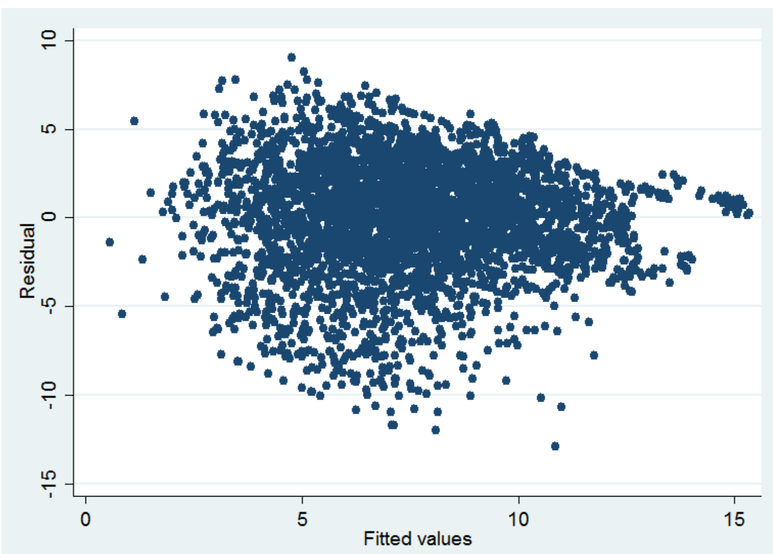

Figure 8: Heteroskedasticity in total agricultural import data

Tobit estimator:

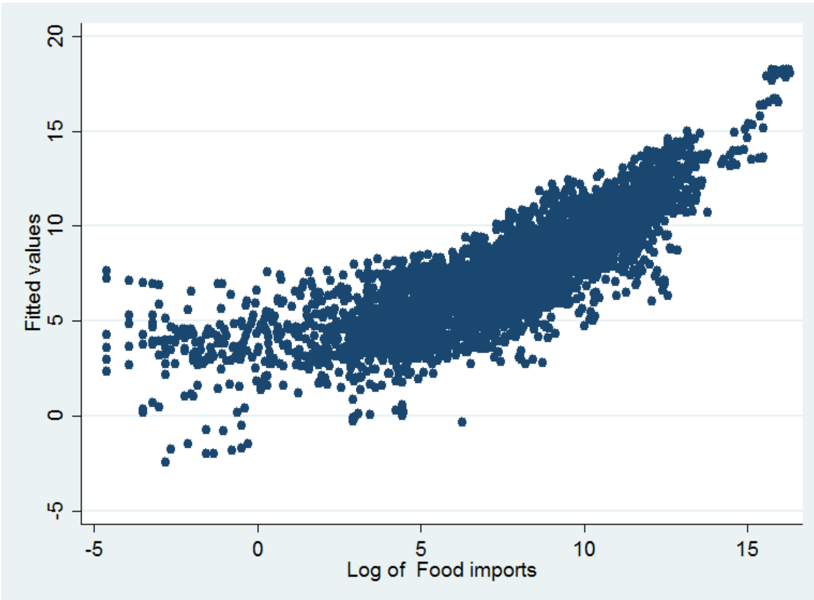

Figure 9: Tobit estimator fitted values vs log (food imports)

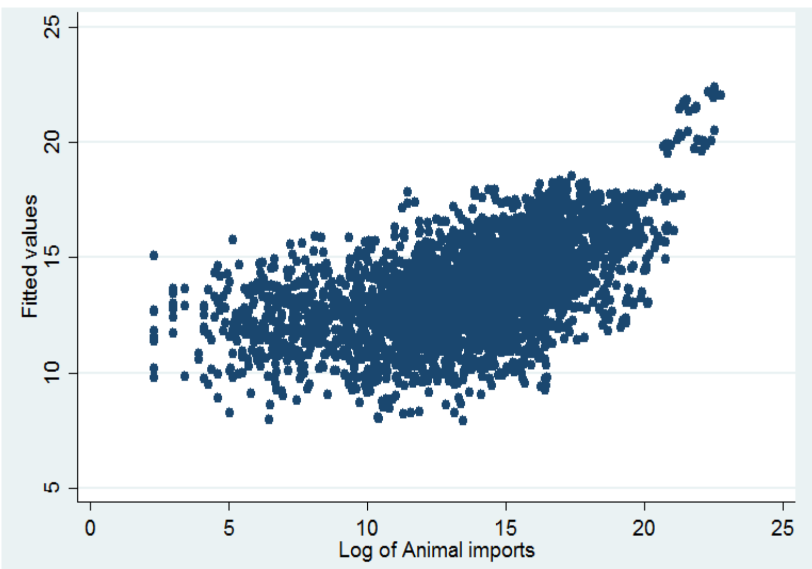

Figure 10: Tobit estimator fitted values vs log (animal imports)

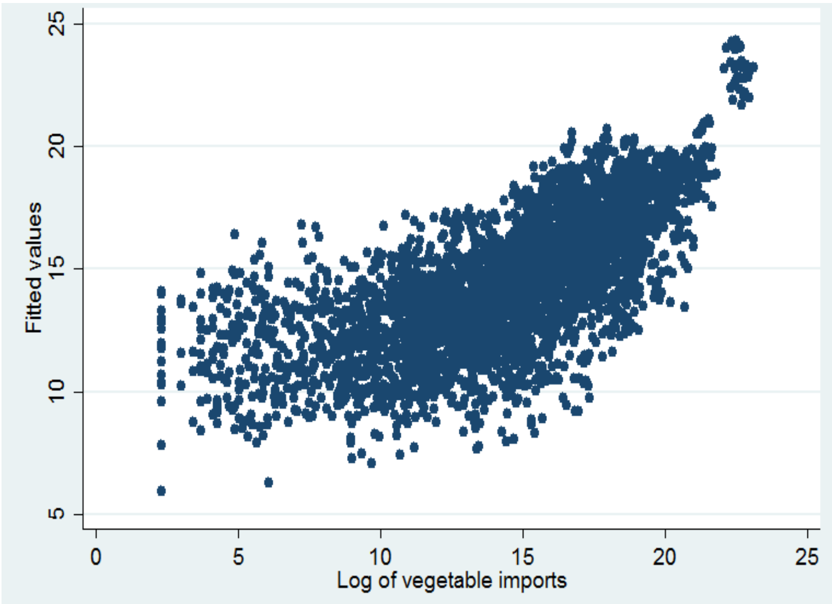

Figure 11: Tobit estimator fitted values vs log (vegetable imports)

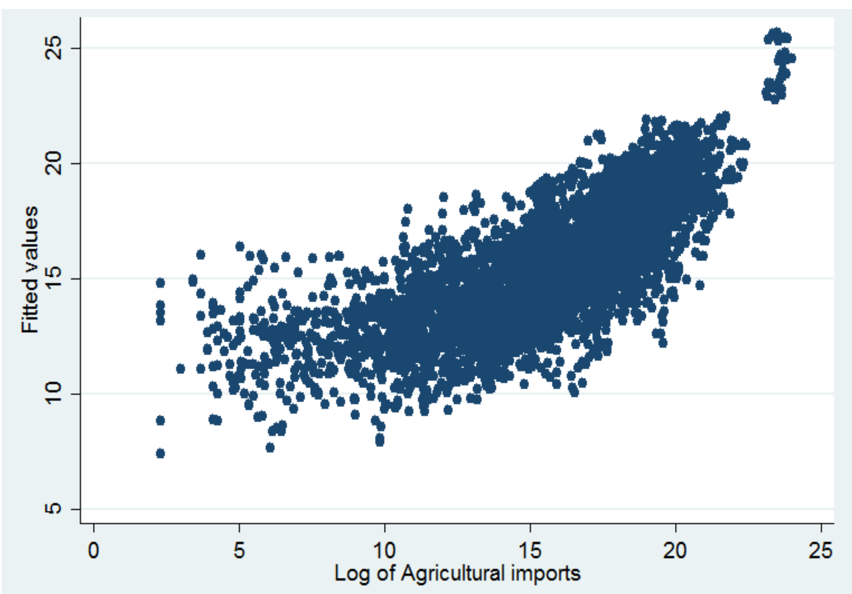

Figure 12: Tobit estimator fitted values vs log (agricultural imports)

PPML estimator:

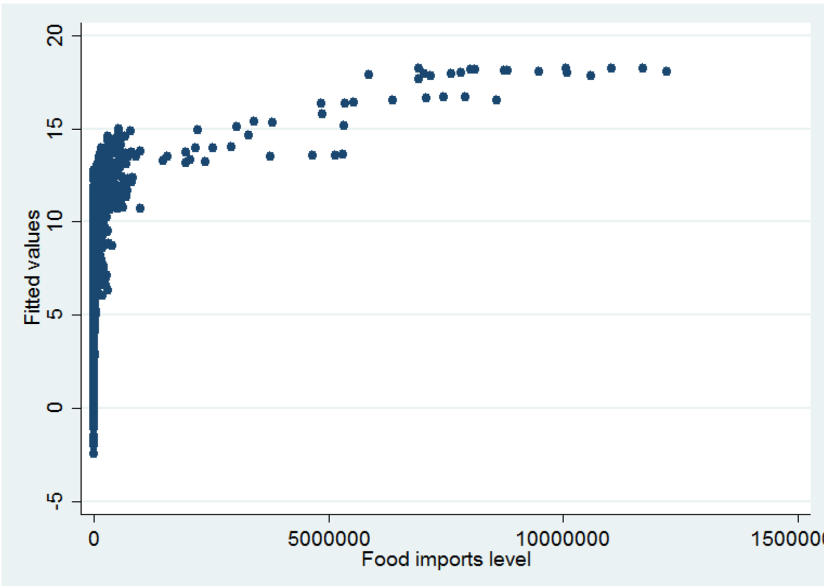

Figure 13: PPML estimator fitted values vs log (Food imports)

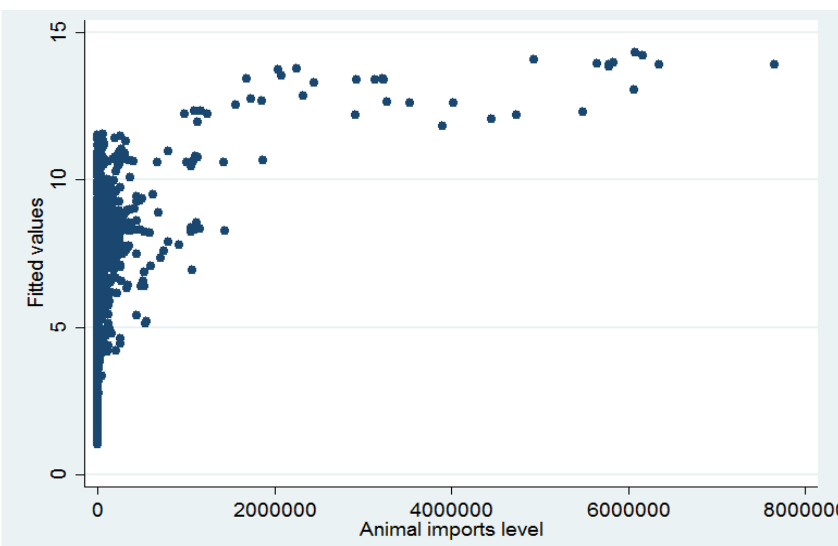

Figure 14: PPML estimator fitted values vs log (animal imports)

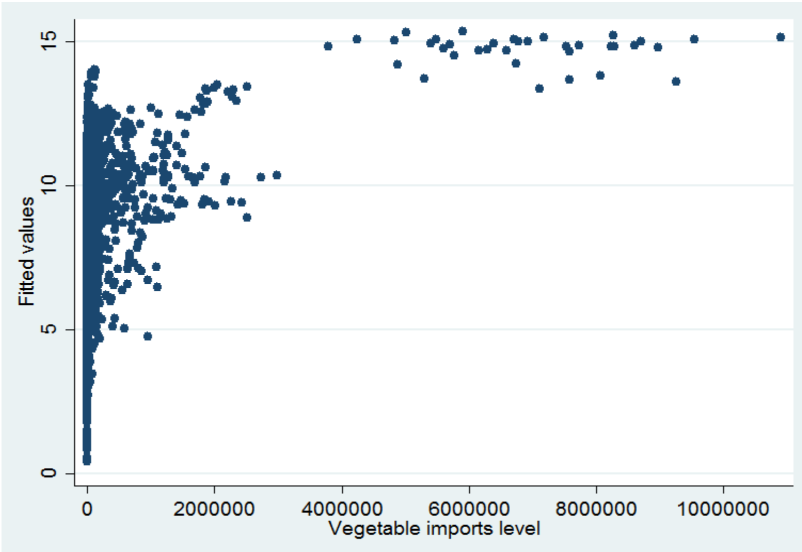

Figure 15: PPML estimator fitted values vs log (vegetable imports)

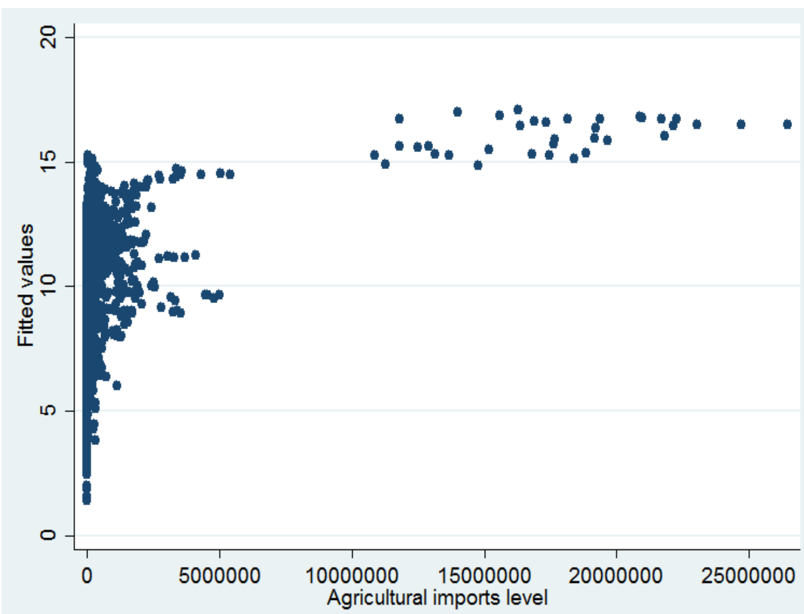

Figure 16: PPML estimator fitted values vs log (agricultural imports)

Tobit results after clearing outliers from the data:

We assessed results after dropping outliers for each product class that we estiamted. For aggregated agricultural products, we dropped bilateral trade pairs that have import values more than 10 billion U.S. dollars, which includes the imports of the U.S. from Canada and Mexico, the imports of Canada from U.S., and the imports of Mexico from U.S. For food products, we dropped bilateral trade pairs that have import values more than 1 billion U.S. dollars, which includes the imports of the U.S. from Canada and Mexico, the imports of Canada from U.S., and the imports of Mexico from U.S. We dropped bilateral trade pairs for animal products that have import values more than 1 billion U.S. dollars, which includes the imports of the U.S. from Canada and Mexico, the imports of Canada from U.S., the imports of Mexico from U.S., the imports of the U.S. from Chile, and the imports of Venezuela from Brazil. We dropped bilateral trade pairs for vegetable products that have import values more than 1 billion U.S. dollars, which includes the imports of the U.S. from Canada and Mexico, the imports of Canada from U.S., the imports of Mexico from U.S., and the imports of Brazil from Argentina.

The estimated results for both aggregated and disaggregated agricultural products did not show large differences from previous results when outliers are removed from the data, as shown in Tables 22-24 and Figures 17-24, below. However, there have been slight increases in the value of the estimated coefficents for food, animal, vegatable and aggregated agricultural products.The only noticable variation that can be observed is the coefficient for the common border variable, where the magnitude of the estimated coefficent has increased and the statistical significance has improved to the 1 percent level.

Aggregated agricultural products:

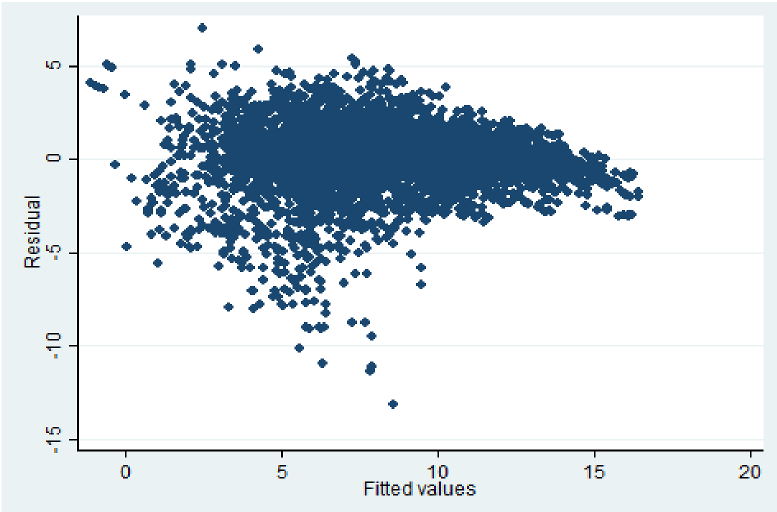

Figure 17: Heteroskedasticity in agricultural imports after clearing outliers in data

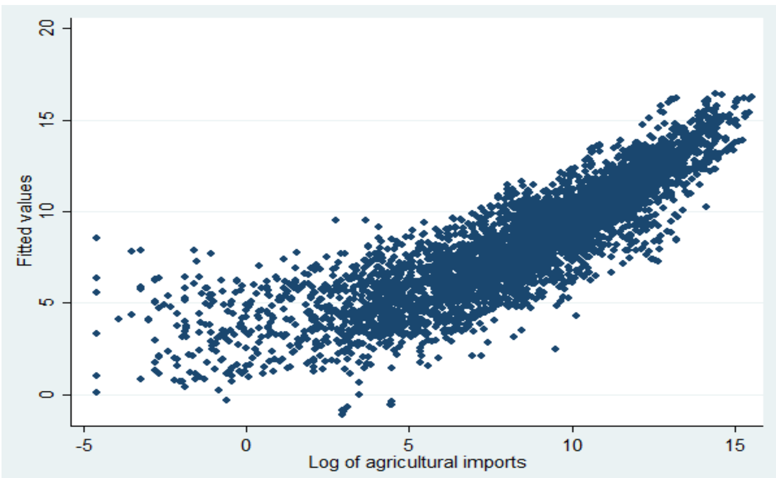

Figure 18: Tobit estimator fitted values vs log (agricultural imports), after clearing outliers in data

Table 22: Hard infrastructure impact on agricultural bilateral trade, Tobit estimates after clearing outliers

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral tariff rate	-0.3376*** (0.0347)	-0.3391*** (0.0347)	-0.3377*** (0.0347)	-0.3272*** (0.0367)	-0.3397*** (0.0346)	-0.3412*** (0.0346)
GDP importer	2.2433*** (0.5049)	2.3348*** (0.5735)	2.1841*** (0.5354)	2.4377*** (0.5819)	2.3428*** (0.5286)	2.6462*** (0.5368)
GDP exporter	1.3765** (0.5630)	0.8353 (0.6147)	1.3229** (0.5839)	1.3530** (0.6465)	1.0827* (0.5995)	1.0752* (0.5774)
Distance	-1.5175*** (0.0672)	-1.5173*** (0.0671)	-1.5176*** (0.0671)	-1.6314*** (0.0689)	-1.5172*** (0.0671)	-1.5151*** (0.0672)
PTA	1.1666*** (0.0657)	1.1665*** (0.0657)	1.1666*** (0.0657)	1.0295*** (0.0719)	1.1664*** (0.0658)	1.1650*** (0.0657)
Common Language	1.5703*** (0.0878)	1.5700*** (0.0879)	1.5703*** (0.0878)	1.4273*** (0.1157)	1.5706*** (0.0878)	1.5699*** (0.0877)
Common Border	0.3054*** (0.1072)	0.3052*** (0.1070)	0.3053*** (0.1072)	0.2040** (0.1049)	0.3047*** (0.1069)	0.3078*** (0.1071)
Infrastructure importer		0.6258* (0.3541)				
Infrastructure exporter		0.8827** (0.4159)				
Roads importer			0.7292** (0.2853)			
Roads exporter			0.6070* (0.3144)			
Railroads importer				-0.2195 (0.1668)		
Railroads exporter				0.3285** (0.1637)		
Ports importer					0.7818*** (0.2077)	
Ports exporter					0.6220* (0.3364)	
Airports importer						0.9221*** (0.3073)
Airports exporter						0.6034 (0.3907)
Constant	-22.9879*** (8.6268)	-18.8403** (9.3009)	-21.9363** (8.9308)	-23.2122** (9.9463)	-21.3098** (8.8819)	-23.9205*** (8.7348)
Observations	4914	4914	4914	4149	4914	4914
Pseudo R2	0.26	0.26	0.26	0.27	0.26	0.26
F	255.96	249.34	249.45	232.09	248.82	248.54
Prob > F=	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: The estimated coefficients represent the marginal effects; all variables are in terms of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Food products:

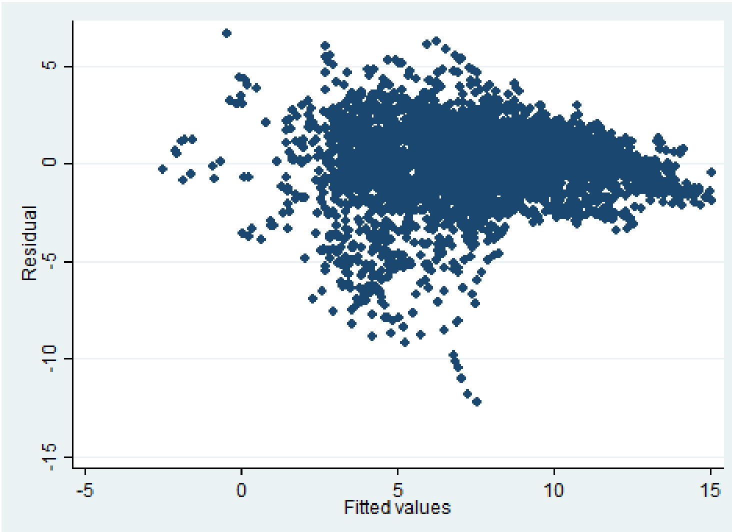

Figure 19: Heteroskedasticity in food imports after clearing outliers in data

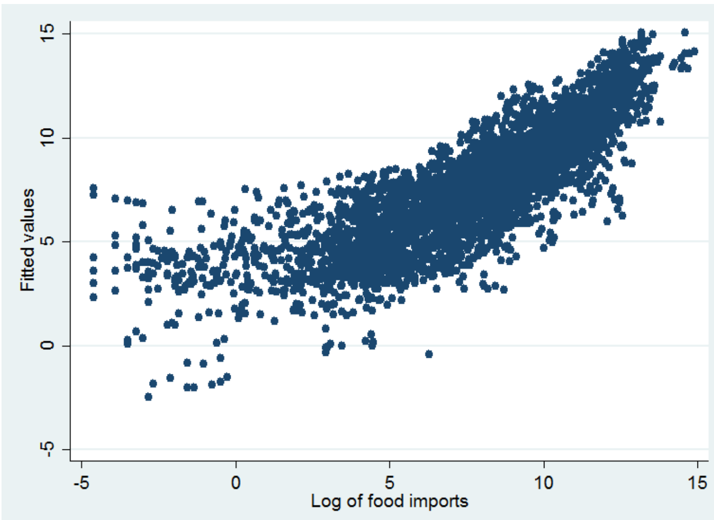

Figure 20: Tobit estimator fitted values vs log (food imports), after clearing outliers in data

Table 23: Hard infrastructure impact on food bilateral trade, Tobit estimates after clearing outliers

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral tariff rate	-0.4783***	-0.4813***	-0.4789***	-0.5022***	-0.4815***	-0.4813***
	(0.0315)	(0.0316)	(0.0315)	(0.0342)	(0.0315)	(0.0315)
GDP importer	1.1134**	1.1637**	1.0951**	1.4282**	1.2854**	1.4824***
	(0.5112)	(0.5851)	(0.5402)	(0.5795)	(0.5396)	(0.5496)
GDP exporter	1.7690***	0.8194	1.5487**	1.8549***	1.3811**	1.1057*
	(0.5951)	(0.6524)	(0.6273)	(0.7098)	(0.6402)	(0.5984)
Distance	-1.4060***	-1.4064***	-1.4063***	-1.4512***	-1.4053***	-1.4047***
	(0.672)	(0.0670)	(0.0671)	(0.0727)	(0.0670)	(0.0672)
PTA	0.6174***	0.6154***	0.6163***	0.4213***	0.6148***	0.6135***
	(0.0697)	(0.0695)	(0.0696)	(0.0751)	(0.0696)	(0.0695)
Common Language	1.7578***	1.7550***	1.7577***	1.5941***	1.7580***	1.7595***
	(0.0913)	(0.0914)	(0.0912)	(0.1225)	(0.0913)	(0.0912)
Common Border	0.3178***	0.3159***	0.3172***	0.3273***	0.3163***	0.3194**
	(0.1100)	(0.1095)	(0.1099)	(0.1136)	(0.1097)	(0.1099)
Infrastructure importer		0.7393**				
		(0.3727)				
Infrastructure exporter		1.3727***				
		(0.4198)				
Roads importer			0.7269***			
			(0.2749)			
Roads exporter			0.7106***			
			(0.2678)			
Railroads importer				-0.3861**		
				(0.1797)		
Railroads exporter				0.3424*		
				(0.1815)		
Ports importer					0.9232***	
					(0.2817)	
Ports exporter					0.8476**	
					(0.3809)	
Airports importer						0.7005**
						(0.3237)
Airports exporter						1.3656***
						(0.4188)
Constant	-16.7534*	-8.4720	-14.5609	-20.0612*	-14.9245	-14.3716
	(9.0118)	(9.6927)	(9.2811)	(10.6071)	(9.4276)	(9.1023)
Observations	4914	4914	4914	4189	4914	4914
Pseudo R2	0.24	0.24	0.24	0.24	0.24	0.24
F	177.93	173.37	173.20	152.54	173.48	173.27
Prob > F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: The estimated coefficients represent the marginal effects; all variables are in term of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Animal products:

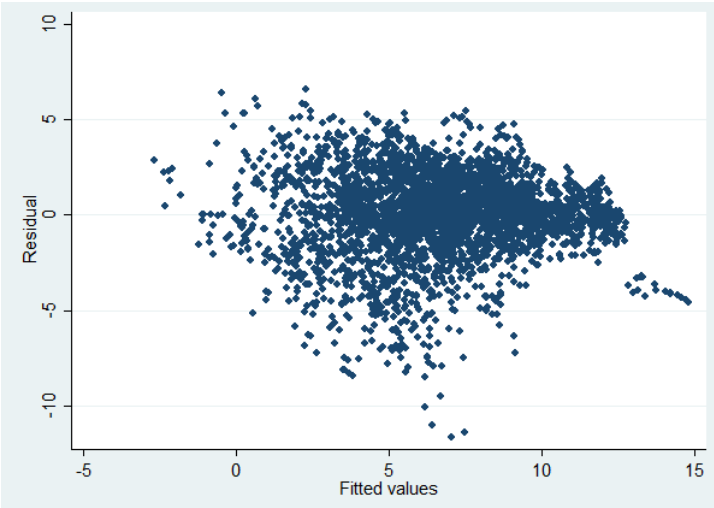

Figure 21: Heteroskedasticity in animal imports after clearing outliers in data

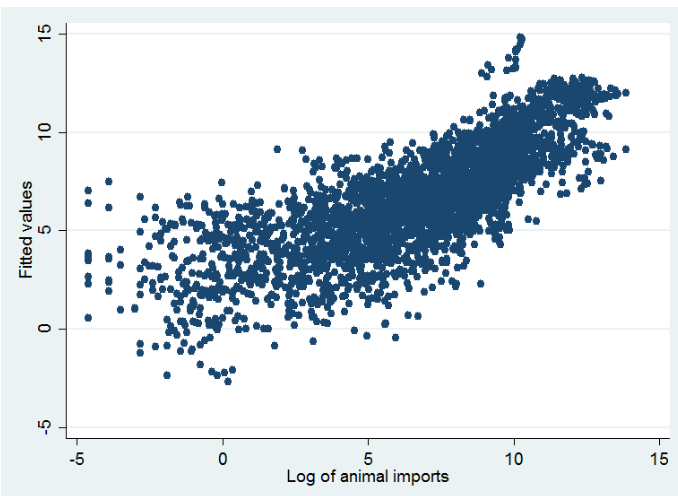

Figure 22: Tobit estimator fitted values vs log (animal imports), after clearing outliers in data

Table 24: Hard infrastructure impact on animal bilateral trade, Tobit estimates after clearing outliers

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral tariff rate	-0.2493***	-0.2511***	-0.2482***	-0.2395***	-0.2515***	-0.2506***
	(0.0397)	(0.0397)	(0.0397)	(0.0424)	(0.0397)	(0.0397)
GDP importer	3.0951***	3.4993**	3.2508***	2.9407***	3.5162***	3.3753***
	(0.7153)	(0.8348)	(0.7847)	(0.8177)	(0.7392)	(0.7611)
GDP exporter	-0.2091	-0.9745	-0.7608	0.3645	-0.5798	-0.8471
	(0.7663)	(0.8671)	(0.8037)	(0.8587)	(0.8422)	(0.8116)
Distance	-1.7694***	-1.7701***	-1.7682***	-1.9176***	-1.7699***	-1.7693***
	(0.1080)	(0.1079)	(0.1079)	(0.1155)	(0.1079)	(0.1080)
PTA	1.0551***	1.0563***	1.0565***	1.1430***	1.0555***	1.0555***
	(0.0969)	(0.0969)	(0.0969)	(0.1045)	(0.0969)	(0.0969)
Common Language	0.7688***	0.7675***	0.7692***	0.5109***	0.7675***	0.7730***
	(0.1380)	(0.1379)	(0.1379)	(0.1682)	(0.1378)	(0.1379)
Common Border	0.8923***	0.8901***	0.8937***	0.7247***	0.8933***	0.8915***
	(0.1567)	(0.1566)	(0.1567)	(0.1622)	(0.1565)	(0.1566)
Infrastructure importer		0.6951				
		(0.5017)				
Infrastructure exporter		1.1088*				
		(0.5963)				
Roads importer			0.7943**			
			(0.3613)			
Roads exporter			0.8894*			
			(0.4627)			
Railroads importer				0.6462***		
				(0.1612)		
Railroads exporter				0.7177***		
				(0.2259)		
Ports importer					0.9873***	
					(0.2335)	
Ports exporter					0.6222	
					(0.5033)	
Airports importer						-0.7425
						(0.4874)
Airports exporter						0.9970*
						(0.5460)
Constant	-13.4776	-10.0981	-9.8756	-16.3424	-14.0761	-10.3271
	(11.6492)	(12.9736)	(12.2897)	(13.3325)	(12.1439)	(11.7858)
Observations	4321	4321	4321	3780	4321	4321
Pseudo R2	0.19	0.19	0.19	0.19	0.19	0.19
F	114.63	110.84	110.93	109.14	111.03	111.27
Prob > F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: The estimated coefficients represent the marginal effects; all variables are in terms of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Vegetable products:

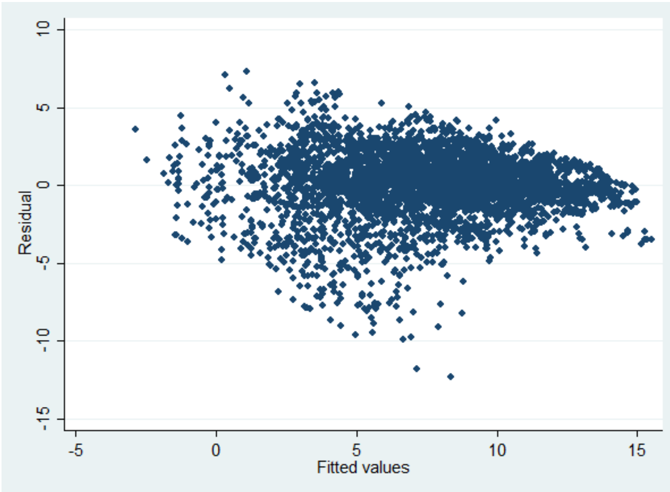

Figure 23: Heteroskedasticity in vegetable imports after clearing outliers in data

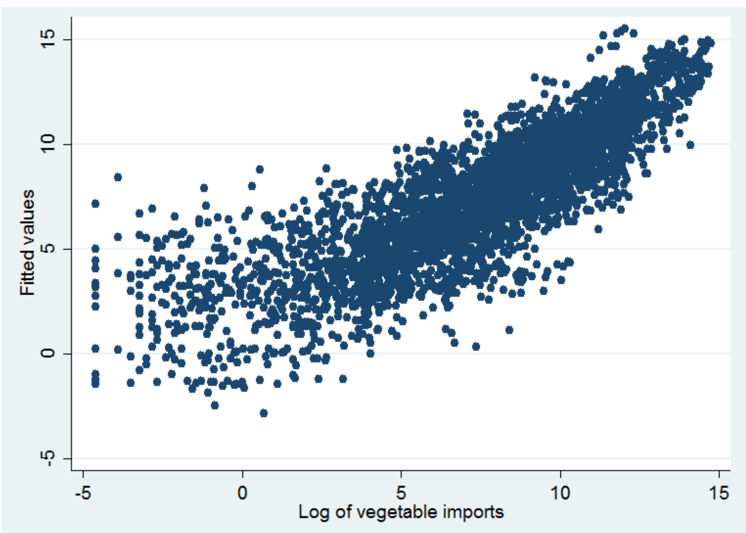

Figure 24: Tobit estimator fitted values vs log (vegetable imports), after clearing outliers in data

Table 25: Hard infrastructure impact on vegetable bilateral trade, Tobit estimates after clearing outliers

	Basic model	Infrastructure	Roads	Railroads	Ports	Airports
Bilateral tariff rate	-0.3718***	0.3726***	-0.3710***	-0.3669***	-0.3722***	-0.3729***
	(0.0387)	(0.0387)	(0.03867)	(0.0428)	(0.0387)	(0.0386)
GDP importer	2.7290***	2.8311***	2.3419***	2.4692***	2.848***	2.8908***
	(0.6465)	(0.7223)	(0.6831)	(0.7486)	(0.6682)	(0.6760)
GDP exporter	2.8128***	2.3708***	2.9207***	3.2815***	2.8098***	2.5682***
	(0.7406)	(0.8427)	(0.7805)	(0.8343)	(0.7844)	(0.7708)
Distance	-1.4242***	-1.4236***	-1.4248***	-1.4297***	-1.4234***	-1.4237***
	(0.0813)	(0.0813)	(0.0812)	(0.0871)	(0.0813)	(0.0814)
PTA	1.6007***	1.6013***	1.6003***	1.4082***	1.6005***	1.6005***
	(0.0884)	(0.0884)	(0.0885)	(0.0959)	(0.0884)	(0.0884)
Common Language	1.0252***	1.0236***	1.0258***	0.6041**	1.0249***	1.0253***
	(0.1262)	(0.1262)	(0.1262)	(0.1674)	(0.1263)	(0.1261)
Common Border	0.4894***	0.4905***	0.4885***	0.6042***	0.4896***	0.4902***
	(0.1232)	(0.1231)	(0.1233)	(0.1257)	(0.1231)	(0.1231)
Infrastructure importer		0.9300**				
		(0.4470)				
Infrastructure exporter		0.9755*				
		(0.5020)				
Roads importer			0.6389*			
			(0.3833)			
Roads exporter			-0.7016*			
			(0.3611)			
Railroads importer				0.3530*		
				(0.2089)		
Railroads exporter				0.4180**		
				(0.2068)		
Ports importer					0.7838**	
					(0.3269)	
Ports exporter					0.7100*	
					(0.3782)	
Airports importer						-0.7739*
						(0.4313)
Airports exporter						0.9042**
						(0.4508)
Constant	-47.2441***	-44.0232***	-44.6527***	-48.7443***	-48.2969***	-46.4163***
	(11.2917)	(12.2798)	(11.7688)	(12.9188)	(11.5357)	(11.4302)
Observations	4580	4580	4580	3950	4580	4580
Pseudo R2	0.23	0.23	0.23	0.23	0.23	0.23
F	202.01	196.46	195.98	173.01	196.22	196.18
Prob > F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Source: Authors' calculation (or estimates). Notes: The estimated coefficients represent the marginal effects; all variables are in terms of log except the dummy variables; numbers in the parentheses are robust check standard error; the model estimated with addition of country dummy variables and time fixed effects; ***, **,* represent statistical significance at the 1, 5 and 10 percent levels.

Report of missing information

1. Infrastructure data:

The infrastructure index values are taken from the Global Competitiveness report. They are provided in term of the weighted average quality of infrastructure, scaled from 1 to 7, where 1 indicates the lowest quality and 7 indicates the highest quality. However, some counties' indices were not provided for some years. The missing data has been estimated using interpolation of data in excel. The following is the summary for the missing infrastructure data:

Dominican Republic: Rail road index was not reported for year 2014.

Ecuador: No index for 2014 (overall infrastructure, roads, railroads, airports, ports).

El Salvador: Railroad index values were not reported for year 2014.

Guatemala: Railroad index values were not reported for 2014.

Guyana: Railroad index values were not reported for 2009 and 2014.

Honduras: Railroad index values were not reported for 2014.

Jamaica: Railroad index values were not reported for 2010 and 2014.

Nicaragua: Railroad index values were not reported for 2010 and 2014.

Paraguay: Railroad index values were not reported for 2013 and 2014.

Suriname: Railroad index values were not reported for 2009 and 2014, No index for 2010(overall infrastructure, roads, railroads, airports, ports).

2. Import values[19] and tariff rates:

- We dropped 2015 data due to either unreported import values or unreported tariff rates.
- Unreported import values observations are assumed to be zero trade following previous studies.

[19] Country-pairs with no bilateral trade for the years 2006-2014 (all years) have been dropped from the sample to avoid perfect correlation between GDP variables and between infrastructure indices.

- Unreported tariff rates data (for years other than 2015) have been calculated using weighted average tariff rate formula using past two years data:

Weighted average tariff (year3) = ((import value of year1 * tariff rate year1) + (import value of year2 *tariff rate year2))/ (import value of year1+ import value of year2)

Food products, summary of missing import values and tariff rates:

Argentina

- There were zero or unreported import trade from Barbados for all years except 2006 and 2011, El Salvador for 2010-2012, and 2014, Honduras for 2007, Jamaica for 2010, 2011 and 2013, Panama for 2011 and Trinidad and Tobago for 2013.
- No bilateral trade with Guyana and Suriname for the period 2006 to 2014.
- Tariff rates of import from Jamaica and Trinidad and Tobago for 2014 have not been reported.

Barbados

- Zero or unreported import values from Bolivia for all years except 2012, El Salvador for 2006, 2007, Suriname for 2006, 2007, Uruguay for 2011 and 2014 and Venezuela for 2013 and 2014.
- No bilateral trade with Paraguay for 2006-2014.
- Tariff rates of import from all partner countries for 2008, 2009 and 2014 have not been reported.

Bolivia

- Zero or unreported import values flows from Barbados for all years except 2006, Costa Rica for 2009 and 2014, Dominican Republic for 2012, El Salvador for 2006-2012, Honduras for all years except 2010, Jamaica for 2006,2007, 2010-2012 and 2014 and Venezuela for 2014.

- No bilateral trade with Guyana, Suriname and Trinidad and Tobago for 2006-2014.

Canada

- No missing or unreported data.

Brazil

- Zero or unreported import values from Barbados for 2007, Costa Rica for 2006, El Salvador for 2006-2012, Guatemala for 2007, Guyana for 2006-2008, 2011 and 2013, Jamaica for 2007, 2008, Panama for 2006, 2012 and 2013, Trinidad and Tobago for 2006, 2007, 2010 and 2013 and Venezuela for 2011-2014.
- No bilateral trade with Suriname for 2006-2014.

Chile

- Zero or unreported import values from Barbados for 2006-2011, 2014 and Guyana for 2007-2013.
- No bilateral trade with Suriname for 2006-2014.
- Tariff rates of import from all partners for 2014 have not been reported.

Colombia

- Zero or unreported import values from Barbados for 2007, El Salvador for 2008, 2009, Guyana for 2008-2012 and Jamaica for 2011-2014.
- No bilateral trade with Suriname for 2006-2014.

Costa Rica

- Unreported import values from all partner countries for 2014.

- Zero trade with Barbados for 2009, Bolivia for 2008, Guyana for 2006, 2007 and 2009, Paraguay for 2007 and Suriname for 2010 and 2013.

Dominican Republic

- Tariff rates for 2009 and 2014 were not reported for all pairs.
- Zero or unreported trade with Bolivia for 2006-2009, Guyana for 2006-2010, 2012-2013, Paraguay for 2006 and Suriname for all years except 2009.

Ecuador

- Unreported tariff rates for 2013 for all pairs.
- Zero or unreported import values from Barbados for all years except 2007, El Salvador for 2006,2007, 2009 and 2011, Honduras for 2006-2010, 2013-2014, Jamaica for 2009, Nicaragua for 2014 and Paraguay for 2006-2007, 2009-2012.
- No bilateral trade with Guyana, Suriname and Trinidad and Tobago for 2006-2014.

El Salvador

- Zero or unreported bilateral trade values with Barbados for 2007-2008, 2011-2014, Bolivia for 2006-2011, 2014, Paraguay for 2011 and Trinidad and Tobago for 2008 and 2009.
- No bilateral trade with Guyana and Suriname for 2006-2014.

Guatemala

- Zero or unreported import values from Barbados for all years except 2009, Bolivia for 2006-2007, 2011-2014 and Paraguay for 2006, 2008,2010,2012,2014.
- No bilateral trade with Guyana and Suriname for the years 2006-2014.

Guyana

- Tariff rates corresponding to import values of 2014 have not been reported for all pairs.

- Zero or unreported import values from Bolivia for 2006, 2008-2010, Ecuador for 2006, 2012-2014, El Salvador for all years except 2009 and 2014, Honduras for 2006-2008, 2014, Nicaragua for 2006-2008, Peru for 2011, Uruguay for 2006, 2007,2009,2012,2014 and Venezuela for 2010.
- No bilateral trade with Paraguay for the years 2006-2014.

Honduras

- Tariff rates corresponding to import values of 2014 have not been reported for all pairs.
- Unreported import values from all partner countries for 2008 and 2013.
- Zero or unreported import values from Barbados for all years except 2007 and 2010, Bolivia for 2006-2010 and 2013, Guyana for all years except 2012, Paraguay for all years except 2010, Suriname for 2006-2008, 2013-2014, Trinidad and Tobago for 2007-2008 and 2013 and Venezuela for 2008, 2012-2013.

Jamaica

- Tariff rates corresponding to import values of 2008, 2009 and 2014 have not been reported for all pairs.
- Zero or unreported import values from El Salvador for 2006, Paraguay for all years except 2012 and 2013, Suriname for 2006-2007, 2009-2010 and 2012 and Venezuela for 2010-2014.
- No bilateral trade with Bolivia for the years 2006-2014.

Mexico

- Zero trade with Dominican Republic in 2013, Suriname in 2006, 2007 and 2009 and Trinidad and Tobago for the year 2006

Nicaragua

- Zero or unreported import values with Barbados for all years except 2013, Bolivia for 2007-2012, Jamaica for 2010, Paraguay for 2008-2010, 2012 and Uruguay for 2006
- No bilateral trade with Guyana and Suriname for 2006-2014.

Panama

- 2014 tariff rates have not been reported for all pairs.
- Zero or unreported trade import values from Barbados for 2008, 2012-2014, Bolivia for all years except 2014, Dominican Republic for 2014, Guyana for 2006-2009, 2011,2012, Jamaica for 2014, Paraguay for 2014 and Suriname for 2006-2007, 2009, 2012-2014.

Paraguay

- Zero or unreported trade import values from Barbados for 2006 and 2010, Costa Rica for 2006, 2008 and 2014, Dominican Republic for 2006-2007, 2010-2011, 2013-2014, El Salvador for 2006-2009, 2011, Guatemala for 2006-2010, Nicaragua for 2006, 2012,2013, Panama in 2006, 2008,2009, Peru for 2006, Trinidad and Tobago for 2006-2012.
- No bilateral trade with Guyana, Honduras, Jamaica, Suriname and Venezuela for 2006-2014.

Peru

- 2012 tariff rates have not been reported for all pairs.
- Zero or unreported trade import values from Barbados for 2006-2012, El Salvador for 2006, 2009,2010,2013, Guyana for 2008-2010, Honduras for 2006-2010, 2013, Trinidad and Tobago for 2006, 2007, 2010-2012,
- No bilateral trade with Suriname for 2006-2014.

Suriname

- 2008 and 2014 tariff rates have not been reported for all pairs.
- Zero or unreported trade import values from Ecuador for 2006, 2009 2010, El Salvador for 2006- 2011, Honduras for 2006, 2007, 2012, Nicaragua for 2006-2008, Paraguay for 2006-2011, Uruguay for 2009 and Venezuela for 2009-2014.
- No bilateral trade with Bolivia for 2006-2014.

Trinidad and Tobago

- 2009 tariff rates data have not been reported for all pairs.
- Unreported trade import values for 2011-2014 for all pairs (systematic).
- No bilateral trade with Bolivia for 2006-2014.
- Zero or unreported import trade values from Nicaragua for 2007, 2011-2014, Paraguay for 2006, 2009-2014 and Venezuela for 2010-2014.

United States

- Zero trade with Suriname in 2011.

Uruguay

- No bilateral trade with Barbados, Guyana, Suriname and Trinidad and Tobago for 2006-2014.
- Zero trade with Costa Rica in 2006, Unreported or zero import values from El Salvador for 2006-2009, Guatemala for 2006-2008, Honduras for 2006-2010, Jamaica for all years except 2013 and Nicaragua for all years except 2013, Panama for 2006 and Venezuela for 2011, 2012 and 2014.

Venezuela

- Unreported trade values for 2014 for all pairs.

- Zero or unreported import values from Barbados for 2013-2014, Dominican Republic for 2006, 2014, El Salvador for 2007,2008 and 2014, Guyana for all years except for 2012, Honduras for 2008-2011, 2013 , 2014, Jamaica for 2006, 2007, 2010, 2011, 2013, 2014, Paraguay for 2007, 2014 and Trinidad and Tobago for 2011, 2012 and 2014.
- Unreported tariff rate data corresponding to import from El Salvador for 2011-2013.
- No bilateral trade with Suriname for 2006-2014.

Animal products, summary of missing import values and tariff rates:

Argentina

- No bilateral trade with Barbados, Honduras and Trinidad and Tobago for 2006-2014.
- Zero or unreported trade import values from Bolivia for 2007, 2010-2014, Costa Rica for 2007-2014, Dominican Republic for 2007-2014, El Salvador for 2006-2010, Guatemala for all years except 2008,2009, Guyana for 2006-2011, Jamaica for all years except 2012, Nicaragua for 2006-2011, Panama for 2006-2008, 2010, 2013, Suriname for all years except 2012 and Venezuela for 2009-2014.

Barbados

- Tariff rates were unreported for 2008, 2009 and 2014 for all pairs.
- Unreported tariff rates corresponding to imports from Brazil for the year 2012, 2013, Ecuador for 2012, Mexico for 2012 and 2013, Suriname for 2013 and Trinidad and Tobago for 2010 , 2012 and 2013.
- Zero or unreported import values from Bolivia for the years 2008-2014, Brazil for 2006, 2008, 2009 and 2014, Chile for 2012, Costa Rica for 2007, 2008, 2011, 2012,

Dominican Republic for 2008, 2009, 2012, Ecuador for 2011-2013, Honduras for all years except 2010 and 2013, Mexico for 2006-2009, Nicaragua for all years except 2007 and 2014 and Venezuela for all years except 2008.

- No bilateral trade with Colombia, El Salvador, Guatemala and Paraguay for 2006-2014.

Bolivia

- Zero or unreported import values from Costa Rica for 2007-2009, Dominican Republic for 2006-2009, El Salvador for all years except 2011, Guatemala for 2007, 2012, Honduras for 2006-2010 and 2014, Mexico for 2006, Nicaragua for 2006-2008 , 2011 and 2013, Panama for 2006-2012 and Venezuela for 2006, 2009 and 2012.
- No bilateral trade with Barbados, Guyana, Jamaica, Suriname and Trinidad and Tobago for 2006-2014.

Canada

- Zero or unreported import values with Bolivia for 2006, 2007, 2009-2011.

Brazil

- Zero or unreported import values from Bolivia for 2006, Dominican Republic for 2006-2008, 2010, El Salvador for 2006 and 2014, Guatemala for all years except 2014,Mexico for 2006, Nicaragua for 2006-2010, Panama for 2006-2009 and 2012, Trinidad and Tobago for 2006-2009, 2013-2014 and Venezuela for 2008-2013.
- No bilateral trade with Barbados, Guyana, Honduras, Jamaica and Suriname for 2006-2014.

Chile

- Applied tariff rates have not been reported for the year 2014 for all pairs.

- No bilateral trade with Barbados, Guyana, Jamaica and Suriname for 2006-2014.
- Zero or unreported import values from Bolivia for the year 2012, Dominican Republic for 2006, 2007, 2010 and 2013, El Salvador for 2006, 2010-2012 and 2014, Guatemala for 2014, Honduras for all years except 2006 and 2010, Nicaragua for all years except 2008 and 2010, Panama for 2006, 2007 and 2010, Trinidad and Tobago for all years except 2010 and Venezuela for all years except 2010 and 2012.

Colombia

- Zero or unreported import values from Argentina for the year 2014, Dominican Republic for 2006, 2007, 2010 and 2013, El Salvador for the years 2006-2012, Guyana for the all years except 2011 and 2012, Honduras for 2006, 2008, 2009 and 2011, Nicaragua for 2010 and 2012, Paraguay for 2012 and 2013, Suriname for 2009 and 2010 and Trinidad and Tobago for 2006.
- Unreported Tariff rates for the year 2014 corresponding to import from Dominican Republic, Paraguay for 2014.
- No bilateral trade with Barbados and Jamaica for 2006-2014.

Costa Rica

- Unreported import values for 2014 for all partner countries with Costa Rica.
- No bilateral trade with Barbados, Guyana, Paraguay for 2006-2014.
- Zero or unreported import values from Bolivia for all years except 2012, Brazil for 2006, 2008 and2014, Jamaica for all years except 2012, Suriname for 2006-2008, 2012-2014 and Trinidad and Tobago for 2006 and 2014.

Dominican Republic

- Unreported applied tariff rates for the year 2009 and 2014 for all pairs.

- No bilateral trade with Barbados for 2006-2014.
- Zero or unreported import values from Bolivia for 2006-2012, El Salvador for 2007, 2009, 2011 and 2014, Guatemala for 2006, 2007, Honduras for all years except 2006, Jamaica for 2007-2013, Nicaragua for 2006, Paraguay for 2006, 2007, 2009-2012, Suriname for 2006, 2007, Trinidad and Tobago for 2006, 2008, 2009, 2012-2014, Uruguay for 2013, and Venezuela for 2010 and 201.

Ecuador

- Applied tariff rates for 2013 have not been reported for all pairs.
- No bilateral trade with Barbados, Guyana, Jamaica for 2006-2014.
- Zero or unreported import values from Bolivia for 2008-2010 and 2014, Dominican Republic for 2006, 2008-2010, 2012 and 2014, El Salvador for 2006, 2007, 2010, 2012, 2013, Guatemala for 2007, 2009-2012, 2014, Honduras for 2007-2014, Nicaragua for 2007-2010, 2012, Paraguay for 2012-2014, Suriname for 2006-2008, 2012-2014, Trinidad and Tobago for 2006, 2010-2012, 2014.

El Salvador

- No bilateral trade with Barbados, Bolivia, Dominican Republic, Guyana, Jamaica, Paraguay, Suriname and Trinidad and Tobago for 2006-2014.
- Zero or unreported import values from Colombia for 2007-2011, Ecuador for 2006, 2008, 2010, 2013 and 2014, Uruguay for all years except 2012 and Venezuela for 2011, 2013 and 2014.

Guatemala:

- No bilateral trade with Barbados, Guyana and Suriname for 2006-2014.

- Zero or unreported import values from Bolivia for 2006-2008, 2011 and 2013, Brazil for 2009, 2010, Dominican Republic for 2006, 2008, Jamaica for all years except 2010, Paraguay for all years except 2009, Peru for 2008, Trinidad and Tobago for all years except 2010, Uruguay for 2006, 2008, 2009, 2011, 2012 and Venezuela for 2006.

Guyana

- Zero or unreported import values from Bolivia for all years except 2012, Colombia for 2008-2011, Chile for all years except 2007, Costa Rica for 2009, 2011-2014, Dominican Republic for 2006-2008, 2012, 2013, Guatemala for 2006-2012, Jamaica for 2007, 2014, Mexico for 2006, 2008 and 2014, Nicaragua for all years except 2009, 2010, Panama for 2006, 2007, 2010, Suriname for 2008 and Uruguay for 2006-2008, 2010-2012.
- No bilateral trade with Ecuador, El Salvador, Honduras, Paraguay and Venezuela for 2006-2014.
- Applied tariff rates for 2014 have not been reported for all pairs.

Honduras

- Zero or unreported import values from Argentina for 2006-2009 and 2013, Brazil for 2008, 2012, 2013, Colombia for 2006-2008, 2013, Dominican Republic for all years except 2009, Ecuador for 2006-2010, and 2013, Suriname for all years except 2006, Uruguay for all years except 2007 and 2012 and Venezuela for all years except 2014.
- Applied tariff rates corresponding to year 2014 has not been reported for all pairs.
- Import values for year 2008 and 2013 has not been reported for all pairing (systematic).
- No bilateral trade with Barbados, Bolivia, Guyana, Jamaica, Paraguay and Trinidad and Tobago for 2006-2014.

Jamaica

- Applied tariff rates for year 2008, 2009 and 2014 have not been reported for all pairs.
- No bilateral trade with Barbados, Bolivia, El Salvador, Paraguay and Venezuela for 2006-2014.
- Zero or unreported import values from Brazil for 2006, 2008, 2010, 2013 and 2014, Colombia for 2006-2008, Chile for 2007, Dominican Republic for 2008-2011, Ecuador for 2012-2014, Guatemala for all years except 2008, Honduras for 2006-2008, and 2011, Peru for 2006, 2010-2013 and Uruguay for all years except 2012.

Mexico

- Zero or unreported import values from Barbados for 2006, 2007, 2009, 2011, 2014, Bolivia for 2012, Dominican Republic for 2013, Jamaica for all years except 2012, Paraguay for 2009, 2010 and 2013, Suriname for 2007, 2008, 2011 and 2012, Trinidad and Tobago for all years except 2008.

Nicaragua

- Zero or unreported import values from Argentina for 2007, 2008, Bolivia for all years except 2006, Brazil for 2007, 2010, 2011, 2013, Colombia for 2012, Dominican Republic for all years except 2007, Jamaica for all years except 2008 and 2013, Suriname for all years except 2009, 2013, Trinidad and Tobago for all years except 2007 and Venezuela for 2010 and 2014.
- No bilateral trade with Barbados, Guyana, Paraguay and Uruguay for 2006-2014.
- Applied tariff rates for year 2014 have not been reported for the imports from Brazil and for the imports from Colombia in year 2013.

Panama

- Applied tariff rate for year 2014 have not been reported for all pairs.

- No bilateral trade with Barbados and Bolivia, Paraguay for 2006-2014.
- Zero or unreported import values from Dominican Republic for 2006-2010 and 2014, El Salvador for 2007-2010 and 2013, Honduras 2006, 2009-2012, Jamaica for 2006, 2007, 2009, 2014, Suriname for all years except 2014, Trinidad and Tobago for 2006-2011 and Uruguay for 2006, 2010, 2012, 2013.

Paraguay

- Zero or unreported import values from Colombia for all years except 2011, Costa Rica for all years except 2014, Mexico for all years except 2008 and Peru for all years except 2010 and 2012.
- No bilateral trade with Barbados, Bolivia, Dominican Republic, El Salvador, Guatemala, Guyana, Honduras, Nicaragua, Panama, Suriname, Trinidad and Tobago and Venezuela for 2006-2014.

Peru

- Applied tariff rates corresponding to the import from all partner countries for the year 2012 have not been reported.
- No bilateral trade with Barbados, Dominican Republic, Guyana, Jamaica, Nicaragua and Trinidad and Tobago for 2006-2014.
- Zero or unreported import values from Costa Rica for 2007, 2009, 2010, 2012-2014, El Salvador for 2006, 2008-2010, Guatemala for 2006-2009, 2014, Honduras for all years except 2013, Suriname for 2006-2009, 2012, 2014, Venezuela for 2012 and 2014.

Suriname

- Applied tariff rates for 2008 and 2014 have not been reported for all pairs.

- Zero or unreported import values from Argentina for 2008, Barbados for all years except 2012, Colombia for 2010 and 2011, Chile for all years except 2009, Costa Rica for all years except 2012, Dominican Republic for 2006 and 2014, Ecuador for all years except 2012, Jamaica for all years except 2006 and 2011, Panama for 2007-2011, Peru for 2012 and 2013, Uruguay for all years except 2006 and Venezuela for 2009-2014.
- No bilateral trade with Bolivia, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Paraguay for 2006-2014.

Trinidad and Tobago

- 2009 applied tariff rates have not been reported for all pairs.
- Import values of 2011-2014 have not been reported (systematic).
- No bilateral trade with Bolivia, El Salvador, Guatemala, Honduras, Nicaragua and Paraguay for 2006-2014.
- Zero or unreported import values from Costa Rica for the year 2006, 2011-2014, Dominican Republic for 2006, 2007, 2009, 2011-2014, Ecuador for 2007, 2009, 2011-2014, Mexico for 2006, 2007 and 2011-2014, and Venezuela for 2006, 2007 and 2011-2014.

United States

- No missing data.

Uruguay

- No bilateral trade with Barbados, Jamaica, Paraguay and Venezuela for 2006-2014.
- Zero or unreported import values for 2006, 2008-2011, 2014, Colombia for 2006-2009, Costa Rica for 2008-2010, 2014, Dominican Republic for all years except 2011 and 2012, El Salvador for all years except 2008, Guatemala for all years except 2013, Guyana for

all years except 2007 and 2011, Honduras for 2011, 2013 and 2014, Mexico for 2007, 2011-2013, Nicaragua for 2008, 2011-2014, Panama for 2006, 2012 and 2013, Suriname for all years except 2014, Trinidad and Tobago for 2006, 2007.

Venezuela

- Unreported import values for 2014 for all pairs (systematic).
- Zero or unreported import values from Barbados for 2006, 2007, 2013, 2014, Bolivia for 2006, 2007, 2009, 2013, 2014, Costa Rica for 2006-2008, 2014, Dominican Republic for 2008-2011, 2013, 2014, Guatemala for 2006, 2009, 2010, 2012, 2014, Guyana for all years except 2012 and 2013, Honduras for all years except 2008 and 2012, Jamaica for all years except 2012, Nicaragua for 2006, 2014, Panama for 2013 and 2014, Paraguay for 2006, 2007, 2014, Suriname for all years except 2009, Trinidad and Tobago for 2010, 2011, 2013, 2014.
- No bilateral trade with El Salvador for 2006-2014.

Vegetables products, summary of missing import values and tariff rates:

Argentina

- Zero or unreported import values from Barbados for all years except 2014, Dominican Republic for 2006, 2010, 2013, 2014, Guyana for all years except 2007, Jamaica for 2012-2014, Nicaragua for 2006-2009, 2012-2013, Panama for 2009, 2011-2013, Trinidad and Tobago for all years except 2007, and Venezuela for 2014.
- No bilateral trade with Suriname for 2006-2014.

Barbados

- Applied tariff rates for the years 2008, 2009 and 2014 have not been reported for all pairs.

- Zero or unreported import values from Bolivia for the years 2006, 2008 and 2014, El Salvador for 2006-2010, 2012, Guatemala for 2006, Nicaragua for 2008, 2010, 2012, 2014, Paraguay for all years except 2010, Suriname for 2007, 2010, Uruguay for 2006-2008 and Venezuela for 2006, 2008, 2011-2014.
- Tariff rates have not been reported for the imports from Bolivia for years 2012, 2013, Canada for 2011, Colombia for 2013, Dominican Republic for 2013, Ecuador for 2012, 2013, Honduras for 2012, 2013, Panama for 2012, 2013, Peru for 2013, Trinidad and Tobago for 2012, 2013, Uruguay for 2012.

Bolivia

- No bilateral trade with Barbados, Guyana and Trinidad and Tobago for 2006-2014.
- Zero or unreported import values from Dominican Republic for 2007-2012 and 2014, El Salvador for 2006-2008, 2011, Guatemala for 2012-2014, Honduras for 2007, 2009, 2011-2014, Jamaica for all years except 2011, Nicaragua for all years except 2008, 2009, Panama for 2006, 2009, 2010, 2012-2014, Suriname for all years except 2006 and Venezuela for 2006, 2008, 2009, 2012-2014.

Canada

- No missing or unreported data.

Brazil

- Zero or unreported bilateral trade from Barbados for all years except 2013, El Salvador for 2007-2011, Guyana for 2006, 2008-2012, Jamaica for all years except 2010, Nicaragua for all years except 2012 and 2014, Panama for 2006, 2008, 2009, 2011, 2012, 2014, Suriname for 2008-2012 and Venezuela for all years except 2008.
- No bilateral trade with Dominican Republic and Trinidad and Tobago for 2006-2014.

Chile

- Applied tariff rates have not been reported for the year 2014 for all pairs.
- No bilateral trade with Barbados, Suriname and Trinidad and Tobago for all years.
- Zero or unreported import values from Dominican Republic for 2010 and 2012, El Salvador for 2006, 2007, 2010, and Guyana for all years except 2014, Jamaica for all years except 2011, and Nicaragua for 2006-2010.
- Applied tariff rates for the import from Guyana for year 2007, 2010 and 2014 have not been reported.

Colombia

- Zero or unreported import values from Barbados for all years except 2009, 2012, Dominican Republic for 2010 and 2012, El Salvador for 2007, 2009, Guyana for 2006-2008, 2010, 2012, Panama for 2009, Suriname for all years except 2011.
- No bilateral trade with Jamaica and Trinidad and Tobago for 2006-2014.

Costa Rica

- Unreported import values from all 24 counties for the year 2014 (systematic).
- Zero or unreported import values from Barbados for all years except 2009 and 2011, Guyana for all years except 2011, Jamaica for 2008-2010, Trinidad and Tobago for all years except 2013, Uruguay for 2009, 2014, Venezuela for 2012, 2014.
- No bilateral trade with Suriname for 2006-2014.

Dominican Republic

- Applied tariff rates have not been reported for the import corresponding to year 2009, 2014 for all pairs.

- Zero or unreported import value from Barbados for 2006-2010, Guyana for 2006, Paraguay for 2006-2008, Trinidad and Tobago for 2012-2014 and Venezuela for 2012.
- No bilateral trade with Suriname for 2006-2014.

Ecuador

- Applied tariff rates for year 2013 has not been reported for all pairs.
- No bilateral trade with Barbados, Guyana, Jamaica, Nicaragua, Trinidad and Tobago for 2006-2014.
- Zero or unreported import values from Dominican Republic for year 2007, 2008, 2012-2014, El Salvador for all years except 2014, Panama for 2011, 2013, 2014, Suriname for all years except 2009, 2014, and Venezuela for all years except 2007, 2008.

El Salvador

- No bilateral trade with Barbados, Jamaica, Suriname for 2006-2014.
- Zero or unreported import values from Bolivia for 2006, Dominican Republic for 2009, 2010, Guyana for 2007- 2013, Paraguay for 2006, 2010, 2012, 2014, Trinidad and Tobago for all years except 2007, 2008, and Venezuela for 2008, 2010, 2012-2014.

Guatemala

- Zero or unreported import values from 2006-2011, Guyana for 2007, 2011-2014, Jamaica for 2007, 2009, 2010, 2014, Paraguay for 2006, 2007, 2012, Trinidad and Tobago for 2009, 2010, 2014, and Uruguay for 2006.
- No bilateral trade with Suriname for 2006-2014.

Guyana

- Applied tariff rates for 2014 have not been reported for all pairs.

- Zero or unreported import values from Argentina for 2007, Bolivia for all years except 2013, Chile 2009, 2013, 2014, Costa Rica for 2006, 2007, Dominican Republic for 2006, 2007, 2009, 2010, 2013, Ecuador for all years 2007, 2010, Guatemala for 2006, 2007, 2011, 2012, Panama for 2006, Peru for 2007-2013, Uruguay for all years except 2010 and 2014 and Venezuela for 2006, 2008-2010, 2013.
- No bilateral trade with El Salvador, Honduras, Nicaragua and Paraguay for 2006-2014.

Honduras

- Applied tariff rates for 2014 has not been reported for all pairs.
- Unreported import values for the years 2008 and 2013 for all pairs (systematic).
- Zero or unreported import values from Barbados for all years except 2009, Bolivia for all years except 2010, Guyana for 2008-2014, Jamaica for 2006, 2008, 2009, 2012-2014, Trinidad and Tobago for 2008, 2009, 2013 and Venezuela for all years except 2007, 2012.
- No bilateral trade with Paraguay and Suriname for 2006-2014.

Jamaica

- Applied tariff rates have not been reported for 2008, 2009 and 2014 for all pairs.
- Zero or unreported import values from Bolivia for 2006-2009, 2011, 2012, El Salvador for all years except 2014, Guatemala for 2007, Honduras for 2007, 2010, 2011, Paraguay for all years except 2012, Uruguay for 2007, 2008, 2012, 2013.
- No bilateral trade with Nicaragua and Venezuela for 2006-2014.

Mexico

- Zero or unreported import values from Barbados for all years except 2014, Dominican Republic for 2006, 2013, 2014, Jamaica for 2007, Panama for 2007, Trinidad and Tobago for all years except 2008 and 2009.
- No bilateral trade with Guyana, Suriname for 2006-2014.

Nicaragua

- Zero or unreported import values from Barbados for 2006, 2014, Bolivia for all years except 2012, Dominican Republic for 2009-2011, Guyana for 2006-2013, Jamaica for 2009-2014, Paraguay for 2006, 2008-2011, Suriname for all years except 2007, 2014, Uruguay for 2006, 2007, and Venezuela for 2009, 2010.
- No bilateral trade with Trinidad and Tobago for 2006-2014.

Panama

- Applied tariff rates for 2014 have not been reported for all pairs.
- No bilateral trade with Barbados for 2006-2014.
- Zero or unreported import values from Dominican Republic for 2014, Guyana for 2012 and 2013, Jamaica for 2006 and 2014, Paraguay for 2006, 2009-2011, Suriname for 2006-2009, 2011, Trinidad and Tobago for 2008-2014 and Venezuela for 2006-2009, 2013, 2014.

Paraguay

- No bilateral trade with Barbados, Costa Rica, Dominican Republic, El Salvador, Guatemala, Guyana, Jamaica, Nicaragua, Suriname, Trinidad and Tobago and Venezuela for 2006-2014.

- Zero or unreported import values from Colombia for 2006, 2008 and 2009, Ecuador for 2006, and Honduras for all years except 2008, Mexico for 2006, 2008, Panama for all years except 2007 and 2014.

Peru

- Applied tariff rates for year 2012 have not been reported for all pairs.
- Zero or unreported import values from Barbados for all years except 2011, Dominican Republic for 2007, 2008, 2013, 2014, El Salvador for 2006-2008, 2010, 2011, 2013, Guatemala for 2006, 2011, 2014, Jamaica for all years except 2012, Nicaragua for all years except 2014, Panama for 2006-2011, 2014, Trinidad and Tobago for all years except 2009, and Venezuela for 2009-2014.
- No bilateral trade with Guyana and Suriname for 2006-2014.

Suriname

- Applied tariff rates for 2008 and 2014 have not been reported for all pairs.
- Zero or unreported import values from Barbados for all years except 2009, Chile for all years except 2007 and 2012, Dominican Republic for all years except 2006 and 2012, Ecuador for all years except 2010 and 2013, Jamaica for 2010, Mexico for 2006, Panama for 2006, 2007, Peru for 2007-2010 and 2012-2013.
- No bilateral trade with Bolivia, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Paraguay, Uruguay and Venezuela for 2006-2014.

Trinidad and Tobago

- Applied tariff rates for 2009 have not been reported for all pairs.
- Import values of 2011-2014 have not been reported for all pairs (systematic).

- Zero or unreported import values from Bolivia for 2006, 2011-2014, Guatemala for 2006, 2011-2014, Nicaragua for all years except 2010, Panama for 2010-2014, Paraguay for 2006, 2007, 2011-2014, Uruguay for 2010-2014, Venezuela for 2009, 2011-2014.
- No bilateral trade with El Salvador for all years.

United States

- Zero or unreported import values from Suriname for 2006, 2007, 2009, 2010.

Uruguay

- No bilateral trade with Barbados, Dominican Republic, Guyana, Suriname and Trinidad and Tobago for 2006-2014.
- Zero or unreported import values from Colombia for 2008, 2010, Costa Rica for 2011, 2012, El Salvador for all years except 2014, Honduras for all years except 2014, Jamaica for 2006, Nicaragua for all years except 2014, Panama for 2007, 2009, 2010 and 2014, Venezuela for 2006-2009, 2014.

Venezuela

- Import values of 2014 have not been reported for all pairs (systematic).
- Zero or unreported import values from Barbados for 2006, 2013, 2014, Costa Rica for 2013 and 2014, El Salvador for 2006-2009, 2012, 2014, Guyana for 2006, 2008-2010, 2014, Honduras for 2006, 2009, 2010, 2014, Trinidad and Tobago for all years except 2006.
- No bilateral trade with Jamaica and Suriname for 2006-2014.