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Over Land and Over Sea: Domestic Trade Frictions in the Philippines

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Abstract: This paper evaluates the effects of the introduction of Roll-On Roll-Off (RORO) Terminal System (RRTS) on agricultural trade and on provincial trade frictions within the Philippines. To do so, two datasets are created: (i) the starting dates of RORO services by route; and (ii) intra-provincial trade by product. Results suggest that provinces linked by RRTS increased trade by 35% compared with unconnected provinces. At the same time, RRTS is associated with an average reduction of province trade frictions. However, the distribution of gains among provinces is highly uneven and may have exacerbated pre-existing trade imbalances.

JEL classification: F10; F14; R28

Key words: trade costs; domestic trade

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0.1 Introduction

This paper aims to study the effects of the Roll-on Roll-off (RORO) Terminal System (RRTS) to domestic trade costs in the Philippines.

The Philippines is an interesting country for studying domestic trade costs. It is an archipelagic country with over 7000 islands and 83 provinces, and faces considerable connectivity challenges within its borders. Distances between the major islands are substantial, and the seabed structure is deemed too complex for connection through subterranean tunnels or long-span bridges (JICA, 2007). A provincial map of the Philippines is provided in Figure 1. It is easy to appreciate the importance of the domestic shipping industry, especially for the smaller islands where maritime transport is the only viable means of sustained trade. In 2013, total value of domestic maritime trade reached PhP 639 billion (roughly USD 14.2 billion), corresponding to 21.6 million metric tons of goods as shown in Figure 2. [†]

However, despite its centrality to internal connectivity, domestic shipping is notoriously expensive, especially when compared with international shipping. Freight cost per nautical mile from Manila to Davao on a twenty foot container equivalent (TEU) is estimated to be USD 1.50 in early 2000, whereas those from Hong Kong, Bangkok, and Port Klang to Manila are at most USD 0.50 (Basilio, 2008). Llanto and Navarro (2014) document that in 2010, transporting a TEU from Manila to Cagayan de Oro in the South of the country is over 100% more expensive than moving the same cargo via transshipment through Kaoshung in Taiwan.

To a large extent, the large differential in the cost of domestic and international shipping is not surprising since the shipping industry is known to have high fixed costs and is therefore sensitive to scale. Calculations using PSA (2017) data reveal that domestic maritime trade is at most just 43% of the combined volume of international imports and exports conducted by sea. In terms of value, it is at most 16%, indicating that domestic trade is dominated by products with low value to bulk ratio.

It is in this context that this paper finds a trade enhancing effect from the introduction of the RRTS. This is observed in the intensive margins of

[†] The pleteauing of the trade volume over time is noticeable. This cannot be explained by increased trade by air which exhibits a similar trend. Instead, discussions with government and industry stakeholders suggest the movement of production activities closer to their markets.

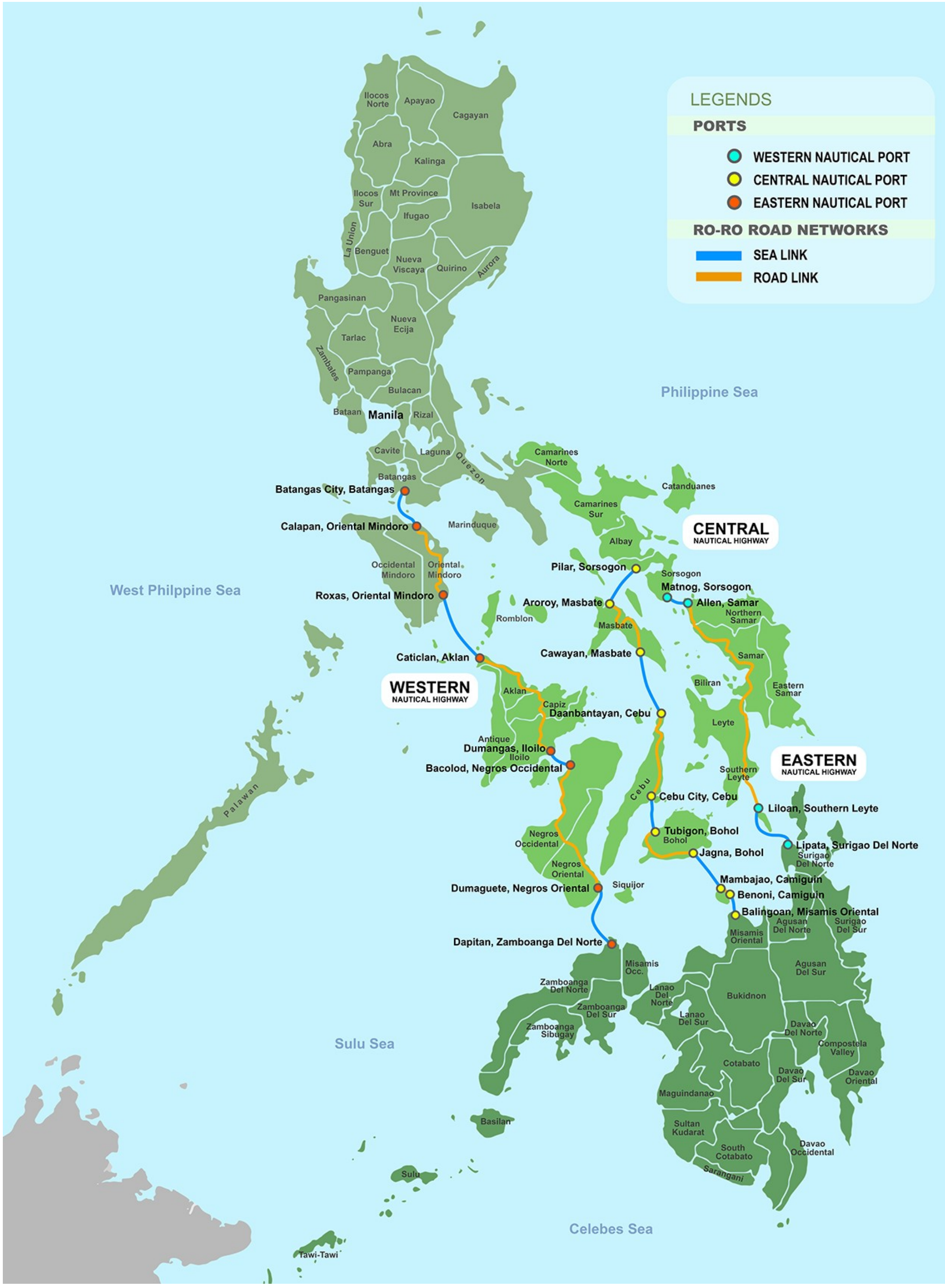
maritime inter-provincial trade, and in the reduction of overall provincial border frictions. However, further examinations reveal considerable heterogeneity across products and provinces.

The Policy Reform - The Roll-on Roll-off Terminal System

The RRTS launched through Executive Order (EO) 170 in January 2003 is an attempt to bring down inter-island domestic trade costs by integrating RORO shipping routes with land-based national highway networks. The idea is to create a seamless interface between land and sea transport throughout the country. Goods are loaded and discharged by self-powered vehicles by their drivers between RORO vessel and shore without handling of goods (Odchimar and Hanaoka, 2015). This is foreseen to result to time and monetary savings. There are also positive spillovers in reduction of spoilage and pilfreage. Substantial savings also arise from inventory managment as RORO enable direct delivery of goods to institutional buyers without warehousing.

Aside from RORO, other primary means of waterborne trade are liner shipping, and trampers. The liner system is termed load on/load off (LOLO) where goods are shipped using containers, and are loaded and unloaded into and from ships by cranes and other dock equipment in the port of origin and destination. Meanwhile, trampers can be any kind of ship, and can even be a RORO vessel that are hired on a contractual basis to transport bulky commodities (Austria, 2002).

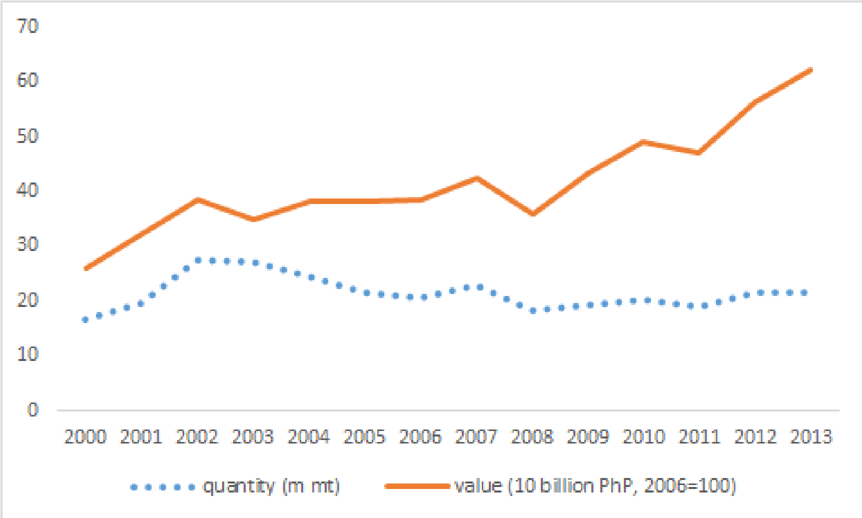
Figure 1 Provincial map of the Philippines and the RRTS



Source: Guillermo (2018)

Note: Only the three main trunks are presented in the Figure. Lateral links are not shown to preserve readability.

Figure 2 Domestic maritme trade, volume and value



Source: PSA (2016)

RORO as a shipping mode addresses costs issues arising from the lack of scale. The smallest container ships have a capacity of 250 TEUs, which biases cargo transport towards long-haul international shipping centered on hubs like Hong Kong, and Singapore (Faustino and Morales, 2010). RORO can be operated on smaller vessels with capacities of 100 to 200 TEUs, which are able to make more frequent trips and faster turn arounds. Being able to ship in smaller batches and greater frequency reinformces savings in storage and warehousing, and other logistics-related costs for traders, and possibly small scale producers. This effectively expands transport options since liner services mainly cater to principal routes and only to larger islands. While transport by tramper is an alternative to liners, the lack of regular service increases uncertainty and costs, and access is often limited to entities that can consolidate sufficient volumes.

By enabling smaller shipments, RORO can alleviate the cargo imbalance that afflict particular routes, which should have the overall effect of reducing shipping costs. Finally, the RORO expansion potentially opens up new trading outlets for provinces that do not have resources to refit ports for handling container ships. The RRTS, does not have a *de jure* distance limit (EO 170-A 2003). But RORO ships operating within the RRTS tend to serve short distances. JICA (2007) explains this as a practical consequence of the cost of alternative transports and the ideal turnaround time for delivery operations. The competitiveness of transport via RRTS declines with distance, and is estimated to be commercially inferior once the 200 km threshold is breached.

The RRTS has three main trunks which are called nautical highways: the Eastern highway also known as the Pan Philippine Highway, the RORO operations of which pre-date EO 170; the Western highway, which started operating as part of the RRTS in 2003; and the Central highway, which became fully operational in 2008. A representation of the main RRTS linkages is shown in Figure 1. The amber lines indicate the main land highways, while the blue lines indicate the sea routes linked by RRTS.

The reforms of EO 170 can be classified along two strands. First, those that directly affect shipping cost activities:

- No cargo handling charges and wharfage dues;
- Freight charging based on lane meter for rolling cargoes. Instead of commodity classification, freight is charged based on the space occupied by the cargo and the distance that the vessel traveled;
- Simplified documentary requirements vis-à-vis conventional shipping.

The second set of reforms promote investments in RORO ports and vessels:

- Waiver of port authorities' share in port revenues, registration fee is collected instead;
- Participation of private ports equipped to handle RORO vessels; and
- Financing from the Development Bank of the Philippines for port development and vessel acquisition.

The first group of reforms are expected to be felt immediately in terms of monetary and inventory costs associated with shipping; time savings from the simplification of procedures; and increased schedule flexibility. The latter is of significant concern for products that are sensitive to transport time and storage conditions such as perishables. The second set of reforms are expected to reduce shipping cost in the longer run. For purposes of empirical analyses, it is more pragmatic to focus on the first set of reforms.

It is important to distinguish between RORO, which is a vessel type, and the RRTS which is a transport system. There are RORO ships that do not function within the RRTS. For example, a number of liner companies use RORO to load containers (mounted on chassis) in lieu of container cranes. But these chassis-mounted container will still need to be unloaded by a truck head at the port of destination.

There were RORO ships operating before EO 170. Nonetheless, RORO as a mode of transport could not fully take off. Its development was discouraged by government controls and bureaucratic delays, as well as by irrational *arrastre* (the operation of receiving, conveying, and loading or unloading merchandise on piers or wharves) interference and expense. Moreover, truck "clearances" were required for inter-island movement as if a cargo was moving from one country to another (USAID, 1994). Llanto et al. (2005) also noted a conflict of interest between the Philippine Ports Authority (PPA) and the deployment of RORO as a mode of transport. There was an inherent bias for the PPA towards cargo handling operations. In 2001, handling fees from domestic cargoes accounted for 18% of the total revenues generated by the PPA from port operations. At the same time, without clear support and priority from the government, PPA was reluctant to invest in providing RORO berths without the assurance of utilization (USAID, 1994).

In this context, this paper focuses on the 2003 reforms rather than RORO as a transport modality in itself. Various studies report positive impacts of the RRTS in terms of passenger and cargo mobility with increases of 300% and 500% respectively between 2003 and 2006, and reduction in cargo transport costs of as much as 20% to 68% over a range of routes and products (ADB, 2010; Basilio, 2008; Llanto et al., 2005). The RRTS was hailed to be such a success that the Philippines, together with Indonesia were designated to shepherd the implementation of the Association of Southeast Asian Nations (ASEAN) RORO as part of the ASEAN Highway Network (Faustino and Morales, 2010). The first RORO link plying between Davao-General Santos City in the Philippines and Bitung, Indonesia started in April 2017.

Though informative, these numbers are from case studies that tend to be limited in scope and the nature of the shipper. A systematic and empirically rigorous study has yet to be conducted, if and how the RRTS affected the overall connectivity of the country.

This paper's focus on agricultural products is dictated by data availability, as the estimation of province trade frictions require production and consumption data by geolocation which is more readily available for the agricultural sector. At the same time, the agricultural focus is motivated by its role as the main source of livelihood for the poorest provinces, and their sensitivity to trade costs because of their nature (shelf life, and relatively lower value to weight ratio). In 2013, 6.2 million metric tons of food and live animals were transported by water, representing over 30% of recorded volume of waterborne trade (PSA, 2017). Finally, EO 170 cites rural development and food security as one of the primary motivations for the RRTS.

Against this backdrop, this paper contributes to the nascent literature on intra-national trade cost through:

- Evaluation of the RRTS on inter-provincial trade;
- Creating a historical database for the starting date of service of RORO by route;
- Obtaining measures of provincial border barrier effects and tracking its evolution through time; and
- The recovery of intra-provincial agricultural trade and inter-provincial trade by land.

The next section reviews the relevant literature for this study. Section 3 discusses the methodology. Section 4 documents the data sources and how they were processed. Section 5 presents the results and their analyses. Finally, Section 6 concludes and suggests areas for future research.

0.2 Review of related literature

Two groups of literature based on the gravity model form the basis this study. The first group reviews the literature that evaluates the effect of varying an observable trade cost factor, in this case the RRTS, to trade flows. The second set reviews the literature on trade costs which informs the exercise on deriving provincial trade frictions.

When trade cost between two points come down, one expects consequences to trade flows. Exploiting the variation in timing, and 'containerizability' of particular products, Bernhofen et al. (2016) find that the technology explains as much as 68% of the growth in trade compared to the pre-adoption period. Containerization reduced trade costs by streamlining the process of cargo handling which resulted to time and money savings, and minimized cargo damage. The efficiency gains are particularly huge from the improved interface between sea and land based transport since port costs are found to account for the largest share of ocean shipping cost (Bernhofen et al., 2016).

Albeit in a considerably less dramatic way, the RRTS can be thought of in similar terms as the container technology. The reforms introduced by EO 170 made RORO a viable transport alternative. The efficiency of RORO fundamentally stems from the improved interface between land and water transport, which in practical terms are experienced through time savings. Dynamic effects come in the form of willingness of ports and operators to make investments on RORO and its complementary infrastructure.

The effect of RRTS on trade flows can also be related to studies on the effect of Regional Trade Agreements (RTAs). The main empirical challenge in these studies involves addressing the endogeneity of RTAs. Countries that choose to have RTAs with each other likely do so because of foreseen trade benefits. Similarly, province pairs and municipality pairs conceivably self-select into investing in RORO links. Indeed, the prioritization of RORO route development follows a logic based on market potential, infrastructure feasibility, and potential of a linkage to reinforce a network of existing routes (JICA, 1992).

Baier and Bergstrand (2007) reviews the different methods in estimating the relationship between RTAs and trade flows, such as the use of instrumental variables, Heckman control functions, and find that a panel estimation approach controlling for non-time-varying pair characteristics best account for endogeneity. Under the panel approach, the cumulative effect of RTAs are twice the magnitude than those found in other methods. This paper folows the panel approach, which is discussed in more detail in the methodology section.

The exercise on estimating trade frictions leans on the literature on trade costs. Trade costs comprise of all the costs of bringing one product from its production to the final consumer (Anderson and Van Wincoop, 2004). They include transport and storage, administrative requirements, distribution and mark-ups, exchange rate costs; but also costs imposed exogenously such as distance, language, culture, etc.

Existing estimates on Philippine maritime transport suggest that the endogenous component of trade costs in the form of logistics and shipping are prohibitive. Llanto and Navarro (2014), and Basilio (2008) suggest that shipping within major ports in the country is more expensive than transshipment through Asian port hubs like Hong Kong and Taiwan. While their numbers are based on transporting TEUs along highest traffic routes in the country, their estimates unlikely represent the overall inter-island shipping situation because of the crucial role of economies of scale. In many provinces, demand or production are not sufficiently large to regularly fill up containers. PPA (2017) statistics reveal that containerized shipments only account for 46% of total domestic cargo throughput in 2016. The rest are comprised of break bulk and bulk shipments. The costs associated with alternative modes such as fast crafts and other loose cargo tranport may not necessarily be as large since smaller vessels are likely to have smaller fixed costs.

Meanwhile, Allen (2014) attributes most of the weakness of domestic agricultural trade flows in the Philippines to information frictions rather than distance and transport costs. However, Allen's study covering 1995 to 2009 coincides with a period of major institutional changes in the domestic economy that were not considered in his work. Among others, they incluce the rapid increase in mobile telephony uptake; massive land conversion from agriculture to non-agricultural use in the context of the Comprehensive Agrarian Reform Program; and freight and route liberalization in the domestic shipping industry. Moreover, a farmer market search model grounded in the reality of credit provision relationships with traders would also enhance the practical utility of the study's findings.

Intra-national trade supposedly face substantially less trade frictions compared to international trade. Costs imposed by policy barriers and exchange rates are expected to disappear, and differences in culture and language are expected to play less prominent roles compared to the international setting. Indeed, while the size of estimates vary, studies consistently find strong bias towards domestic trade (Hillberry and Hummels, 2003; Wolf, 2000). But most studies of home bias are made with an international-national dichotomy and say little about domestic trade itself being conducted between different regions in a country. As Agnosteva et al. (2015) show in the Canadian setting, intra-provincial barriers can be high and vary widely among provinces with non-trivial implications for regional development policies.

Trade costs information and its various components are not easily obtainable. The literature is replete with efforts to quantify and decompose these costs into economically meaningful components. Moreover, the importance of each component varies with the product in question, as well as exporter and importer characteristics. Approaches to measuring trade costs are generally grouped into three categories: direct measures, estimates from prices, and indirect measures from trade volumes (Anderson and Van Wincoop, 2004).

Direct measures of trade costs are sparse. In the international context, tariffs and non-tariff measures (NTMs) are typically used as indicators of policy barriers. For the transport costs component, shipping and freight costs are ideal measures but are rarely publicly accessible in a systematic way except in some developed countries. It has been common for studies to resort to matched partner c.i.f.-f.o.b. ratio from UN Comtrade and IMF DOTS as proxy for *ad valorem* equivalents of transport costs. But Hummels and Lugovskyy (2006) compared these derivations with highly detailed national source data from US and New Zealand and found them to be error-ridden, with little information that can be exploited for analyzing variations across time or commodities.

Infrastructure, and institutions can also be considered as direct costs measures. They are usually proxied for by road networks, telephony density, ease of doing business and logistics performance indicators. While informative, these measures tend to encompass a broad array of factors that do not necessarily pertain to trade costs.

Working in the intra-national context has the advantage of being freed from considering some components of trade costs such as exchange rates, trade agreement memberships, tariffs, and NTBs. However, the challenges can be even more difficult since trade barriers take less explicit forms, and locally disaggregated data are not easy to find nor organized systematically.

The second approach uses spatial price gaps to infer trade costs. Agricultural products are frequently the subject of such studies as they are produced over extensive geographies and are expensive to transport (Fackler and Goodwin, 2001). The trade theory strand of the approach, which focuses on prices in international and domestic wholesale markets is less relevant for our study's context. More germane is the macro strand which focuses on retail prices, their transmission, and speed of price adjustment estimated through vector error correction models.

Atkin and Donaldson (2015) takes the price gap analysis substantially further using the pass through estimates from origin to destination, and by explicitly modelling mark-ups as a function of observed cost shifters such as distance, demand conditions, marginal costs incurred by the intermediary, and market competition. The authors demonstrate that under an oligopolistic setting, pass through rates of price shocks capture the response of mark-ups to changes in trade costs. In doing so, the study is able to decompose observed price gaps between components that are due to mark-ups, and those that are due to trade cost. Their normalized metrics imply that the effect of distance on trade costs within Ethiopia and Nigeria are higher by four to five times than within the US. Their results offer evidence that remoteness of a market affects not just trade costs but also how intermediaries and shipping firms behave in passing rents through the market chain. Nonetheless, it was only made possible by access to data that allowed for: (i) highly disaggregated product classification for precise comparability of products across space; and (ii) intra-national production and trade data that inform on origin and destination for each product. This is a tough information set to obtain.

In light of the practical difficulties involved in direct measurements, trade cost inference from trade volumes can be appealing, and is the approach taken by this paper. Gravity models have mostly been employed to analyze the extent of influence of observable components of trade costs on trade flows. Its properties can be used to estimate trade cost as in Arvis et al. (2016) and Jacks et al. (2008) by using an inverse gravity model expressing trade cost as the ratio of internal trade within two trading countries, and their trade flows to each other. In Arvis et al. (2016), *ad valorem* equivalents of trade costs were estimated for 178 countries from 1995 to 2010 for agricultural and manufacturing products. The estimated value captures both direct costs such as shipping, documentary requirements, and associated indirect costs such as storage requirements, and time delays. Nonetheless, the resulting estimates do not give much information for policy makers on trade frictions that affect bilateral trading patterns.

Gravity-derived trade cost can also be expressed in the form of border effects, which expresses the factor by which a country trades more with itself than with other countries.Anderson et al. (2018) derive border barrier estimates for 28 countries in 12 services sectors. A key contribution of the work involves the estimation of intra-national services trade using the gravity model. The border barriers were estimated by effectively accounting for intra-national trade costs, and by doing so distinguishes between cost that vary for each country, and those that vary when a country trades with another.

Extant empirical studies in domestic trade cost use gravity as a take-off point. Agnosteva et al. (2015) estimate regional bilateral trade costs from inter and intra-regional flows in Canada, and find them to vary widely. In a goal parallel to this paper's in the context of RRTS, Anderson and Yotov (2010) evaluate the effects of Canadas Agreement on Internal Trade (AIT) in 1995 which aimed to reduce inter-provincial trade costs and encourage trade among Canadian provinces. The effects of the AIT are found to be negligible, but their simulations imply that a 30% AIT-induced reduction in trade costs will have tremendous positive welfare effects across Canadian provinces, with the remotest areas gaining the most.

0.3 Methodology

Gravity models provide a framework for linking trade flows with observable and unobservable trade cost variables, and is used both to evaluate the effect of the RRTS on trade flows, and for the estimation of provincial trade frictions.

The structural gravity system of equation from Anderson and Van Wincoop (2003) is as follows:

$$X_{ij}^{k} = \frac{E_j^k Y_i^k}{Y^k} \left(\frac{\tau_{ij}^k}{P_j^k \Pi_i^k} \right)^{1-\sigma_k} \tag{1}$$

$$(\Pi_i^k)^{1-\sigma_k} = \Sigma_j \left(\frac{\tau_{ij}^k}{P_j^k} \right)^{1-\sigma_k} \frac{E_j^k}{Y^k} \tag{2}$$

$$(P_j^k)^{1-\sigma_k} = \Sigma_i \left(\frac{\tau_{ij}^k}{\Pi_i^k} \right)^{1-\sigma_k} \frac{Y_i^k}{Y^k} \tag{3}$$

Where X_{ij}^k is export of province i to province j of product k; E is expenditure of province j; Y is national output; τ represents a host of trade barriers; P_j^k and Π_i^k are the inward and outward multilatral resisitance terms which summarize trade resistance between a province and all its domestic partners, and σ is the trade elasticity of substitution for product or sector k across origin provinces.

Several issues need to be considered in using gravity to derive trade cost estimates:

1. Equations (1) to (3) imply estimates of trade costs from a gravity specification necessarily have a relative interpretation. A change in trade costs between two trading partners induces changes in trade flows of province i with other trading partners. At the same time, a change in trade costs within a province, τ_{ii} will also imply alteration of trade with j partners. Supposing i to be a province, the decline in trade cost due to the RRTS is expected to tilt trade towards inter-provincial trade and away from within province trade, leading to a reduction in home bias.

2. The gravity framework relies on an assumption of separability of trade flows, and production and consumption decisions within trading units where the Armington assumption of product differentiation by source is implied, as captured by σ in gravity equations. Estimates from gravity are sensitive to assumptions on the value of σ (Anderson and Van Wincoop, 2004). This presents a challenge in an intra-national agricultural trade context because one expects σ to be higher for regularly consumed agricultural products. Nonetheless, the Armington assumption is still consistent if demand is characterized by monopolistic competition and free entry; or supply is described with multiple producer homogenous goods model based on Eaton and Kortum (2002). In the latter case, $1-\sigma$ is alternatively interpreted as embodying comparative advantage with a Frechet distribution (Anderson and Yotov, 2010).

3. It is highly likely that for many provincial pairs, $P_j^k \neq \Pi_i^k$. Refining P_j^k and Π_i^k to represent the sellers and buyers incidence of trade cost, Anderson and Yotov (2010) find that the proportion of trade costs borne by sellers fall over time due to 'learning by selling' while

> that of the buyers' remain constant and even rise. Austria (2002) identifies trade imbalance as a key factor in the lack of maritime shipping services in some routes; and for determining shipping charges. For every three southbound containers exiting from NCR, two return northbound empty (PSA, 2017; PLSA, 2017).

As in the latest developments in gravity literature, bilateral trade is assumed to have a Poisson distribution with the conditional mean of observed trade flows following an exponential form. This specification allows for a robust estimation in a context where zero trade flows take large shares of the observation, and addresses concerns on heteroscedasticity in multiplicative models (Head and Mayer, 2013; Santos Silva and Tenreyro, 2006). The underlying data need not follow a Poisson distribution provided that the conditional mean is correctly specified. Equation (1) is therefore expressed as (4):

$$E(X_{ij}|Z) \equiv \exp(Z'\beta) = \frac{E_j^k Y_i^k}{Y^k} \left(\frac{\tau_{ij}^k}{P_j^k \Pi_i^k} \right)^{1-\sigma_k} \tag{4}$$

0.3.1 Evaluating the trade effects of the RRTS

To estimate the effect of RRTS on inter-province trade flows, the host of observable trade cost proxies is modelled accounting for traditional gravity variables.

$$\tau_{ij} = \exp[\beta_1 lnDist_{ij} + \beta_2 Lang_{ij} + \beta_3 Relg_{ij} + \beta_4 Land_{ij} + \psi RRTS_{ij,t}] \tag{5}$$

$lnDist_{ij}$ is the log of distance between the centroids of provinces i and j. $Lang_{ij}$ takes a value of 1 if the majority of the population in a province pair share a common language and 0 otherwise. $Relg_{ij}$ is a dummy variable equal to 1 if the majority of populations in i and j share a common religion. The religion variable takes the place of colonial ties in the international gravity context, and can capture interesting relationships given that a number of provinces are predominantly of the Islamic faith. $Land_{ij}$ takes a value of 1 if a pair of province is contiguous by land, and bilateral trade flow can occur by land rather than by sea. Finally, $RRTS_{ij,t}$ is a binary variable equal to one when a province pair is serviced by a RORO ship.

However, estimating equation (5) introduces potential endogeneity into the estimating equation because: (i) provincial pairs that foresee trade potentials are more likely to invest in RORO infrastructure; and (ii) the RRTS variable is binary and does not capture the quality and capacity of the infrastructure in place and therefore introduces measurement errors. These problems are analogous to the estimation issues involved in analyzing the impact of RTAs on bilateral trade flows. Using an RTA dummy between country as an explanatory variable ignores the fact that RTAs are far from exogenous decisions. Baier and Bergstrand (2007)account for endogeneity of RTAs by introducing non-time varying fixed effects as covariates, represented by γ_{ij} in (6). γ_{ij} captures all the non-time-varying characteristics between provincial pairs that make them more likely to trade with each other. By controlling for the time varying characteristics of origin, η_{it}, destination θ_{jt}, and product, δ_{kt}, ψ captures the variation coming from provincial RRTS linkage.

$$X_{ij,t}^{k} = \exp[\gamma_{ij} + \psi RRTS_{ij,t} + \eta_{it} + \theta_{jt} + \delta_{kt}] \tag{6}$$

0.3.2 Provincial trade frictions

The method for estimating province trade friction follows the strategy of Anderson et al. (2018) in estimating border barrier effects. In the first instance, this requires information of intra province trade along with inter-province trade. The former is not readily available and requires a process of calculation which is detailed in the next section.

The province border effect is obtained by modelling τ_{ij}^{k} as follows:

$$\tau_{ij} = \exp[\beta_1 lnDist_{ij} + \beta_2 Lang_{ij} + \beta_3 Relg_{ij} + \beta_4 Land_{ij} + \psi Smprov_{ij}] \tag{7}$$

$Smprov_{ij}$ is a dummy variable that takes the value of 1 when trade is within the province, $i = j$; and 0 if it is inter-provincial trade $i \neq j$. *Smprov* is an adaptation of how 'same country' has been used in the gravity literature to distinguish between intra and international trade. The resulting coefficient is interpreted as the border barrier effect. In an intra-national context, 'same country' would analogously be the 'same province' dummy, and hence interpreted as the province-border effect. If inter-province trade were frictionless, *smprov* estimates should not be statistically different from zero.

Incorporating (7) to the structural gravity equation yields:

$$X_{ij,t}^k = \exp[\beta_m^k lnDist_{ij,m} + \beta_2 Lang_{ij} + \beta_3 Relg_{ij} + \beta_4 Land_{ij} + \psi Smprov_{ij}^k + \eta_{it} + \theta_{jt} + \delta_{kt} + \epsilon_{ij,t}] \quad (8)$$

where $\epsilon_{ij,t}$ is the error term.

As in Anderson et al. (2018), *Smprov* is first estimated off a homogeneity assumption across provinces and time. This assumption is then relaxed to allow *Smprov* to vary across the dimensions of product, provinces, and time. In terms of equation (8), ψ is estimated as a scalar in the first instance, and then later broken up into its different components.

The influence of RRTS on province borders is captured by introducing a variable that lets *Smprov* vary according to a province's RRTS linkage status, $RRTS_{ij,t} \times Smprov_{ij}$. $RRTS_{ij,t}$ takes the value of one if the exporting province has at least one established RORO service with an importer.

0.4 Data sources and methods

0.4.1 Starting dates of RORO services

The Western and Eastern nautical highways became operational as part of the RRTS in 2003. The entire central link became so in 2008. But there are routes that were operational within the central link as early as 2003, and there are also lateral links that are not captured by the three trunks shown in Figure 1 that focus on vertical connectivity. This means that the inaguration of the nautical highways cannot be naively taken as the starting date of RRTS operations when analyzing bilateral trade. The historical information required was built using information from various sources. This dataset forms a distinct part of this paper's contribution.

The data sources and the data creation process are described below in the order in which they have been employed:

1. There are 39 RORO shipping companies servicing around 150 distinct routes according to the Maritime Industry Authority (MARINA) inventory of RORO routes as of 17 April 2017. Thirty-five of the companies have operations that span the period of study. These companies

were given a questionnaire containing information on the routes they service, and the names of the vessels servicing each route. They were requested to supply information on the starting date of operations for each route. Twenty companies responded with the requested data, while two companies could not be tracked down.

2. The certificates of public convenience (CPC), and their amendments specify the route and schedule franchise of a shipping company. The CPCs of ten shipping companies registered with the MARINA central and Region IV office were accessed. These records are not digitized, and are physically distributed across the 13 MARINA regional offices in the Philippines. The historical records of CPCs only go as far back as 2008 (earlier records are either lost, as in the fire in the central office, or could not be located after being warehoused).[‡]

3. The information obtained from the shipping companies were verified against the information provided by the PPA of the operation dates of RORO ports. However, there are RORO-equipped ports that do not have actual operations. As such, it is important to verify that a route is actually being serviced by a RORO ship.

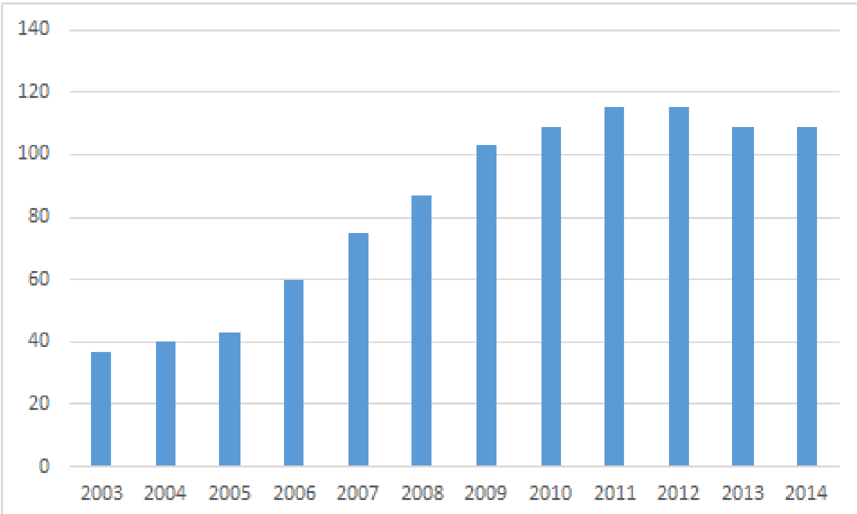
4. Reports and feasibility studies of institutions and international aid agencies have information on starting dates of RORO services of some routes. Among them, the following sources proved useful: ADB (2010), JICA (1992, 2007), accomplishment reports of the PPA, USAID (1994, 2014). Local news articles were also used to verify and complete the database. Less formally, information from the Philippine Ship Spotters was also used to verify that a route is actually serviced by a RORO ship.

5. Finally, the information from different sources were mapped with each other. Among the sources, only the PSA employs a universal port classification system that directly links a port of origin and destination to trade flows. Other sources tend to simply employ port names. Hence, substantial effort was expended in ensuring geographical accuracy in the identification of RRTS ports.

[‡]CPC issuance also changed from being vessel-based to company-based in 2004. This means CPC as a means of establising route starting dates can only be used for routes where services started from 2005 onwards.

Figure 3 shows the evolution of RRTS links in the Philippines. The number of RRTS linked port pairs have increased over time from under 40 in the program's inception to over 100 by 2014. The drop between 2012 to 2013 is due to a number of closures of services because of unprofitability.

Figure 3 Number of port-to-port RRTS linkages over time



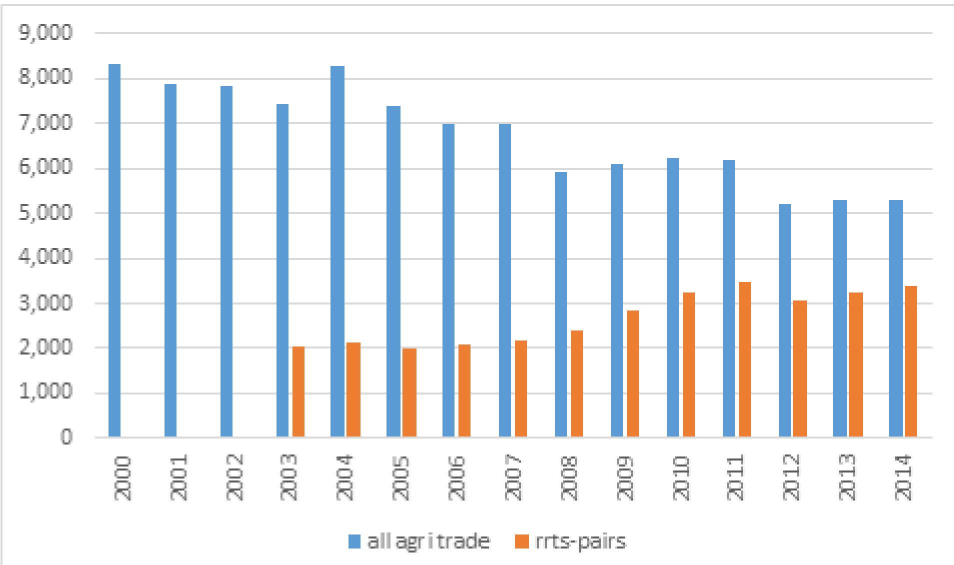
Source: Author

Figure 4 presents agricultural trade between province pairs that are linked by RRTS, compared to those that are not (excluding intra-province and derived land-based trade). In general, trade between RRTS province pairs grew fast, reaching the levels of trade of non-linked pairs in terms of both volume and value by 2009. At the same time, provinces linked by RRTS exhibited increasing frequency of transactions even as the total frequency for the fourteen agricultural products in this study are declining. This is demonstrated in Figure 5. To a considerable extent, the trends in Figures 4 and 5 are artefacts of the increasing number of trading pairs being transferred from the non-RRTS bin to the RRTS-linked category. They are therefore not suggestive of the effectiveness of RRTS in bringing down trade costs, and increasing trade flows. Against this backdrop, the importance of evaluating the effects of RRTS on trade costs and trade flows becomes even more important before further resources are devoted to its expansion.

Figure 4 Agricultural trade, RRTS versus non-RRTS provinces

Source: Author

Figure 5 Monthly frequency of trade, RRTS versus non-RRTS ports



Source: Author

0.4.2 Provincial trade data

1. Maritime trade by origin and destination
   The Philippine Statistical Authority (PSA) records monthly bilateral

coastwise volume and value flows of maritime trade by port of origin and destination at the 5-digit Philippine Standard Commodity Classification (PSCC), which can be mapped to the SITC and HS codes at the 6-digit level.

The geographic configuration of the Philippines means that maritime trade data fall short of giving a comprehensive picture of provincial trade in the country. Some provinces are islands in themselves such as Bohol and Palawan, while others are contiguous by land with other provinces such as those that make up most of Luzon and Mindanao.

2. Inter-province land trade

   The PSA unfortunately does not track commodities transported by land, and yet this is a key component of the information needed for estimating province trading frictions. Without this, derived intra-province trade will be larger than it actually is because exports by land will be unaccounted for. To remedy the data gap, land trade flows are reconstructed using Marketing Cost Structure Studies (MCSS). MCSS were prepared by the Bureau of Agricultural Statistics (BAS) for a number of products in selected years. These studies identify the main supply and destination provinces for certain commodities. The difference between production and consumption of a supply province is assumed to be the amount available for export to demand provinces. A summary of the geographic flow for each commodity in the study is described in Table A1.

3. Intra-provincial trade is derived as follows:

   $X_{ii}^k = Prod_i^k \times A^k - \Sigma_{i \neq j} X_{ij}^k$

   if $X_{ii}^k > 0$

   Otherwise $X_{ii}^k = Prod_i^k \times A^k$

   Where X_{ij}^k refers to exports of province i to other provinces and exports to international markets, j, of product k. X_{ij}^k also includes processed forms of bananas, mangoes, and pineapples which are exported in substantial volumes to international markets. For purposes of tractability, a one to one correspondence is used. For example, a kilo of fresh pineapple is assumed to be equivalent to one kilo of canned pineapple. This is clearly not the case. Inquiries with processors suggest a transformation rate of about 60 to 70%. But international trade data is in units of gross kilograms and hence include the weight of packaging, and other additives. Information on international exports by province are sourced from the PSA. The PhP equivalent of USD f.o.b. values were derived using the average monthly exchange rate from the Banko Sentral ng Pilipinas (BSP, 2016).

A^k is an adjustment factor sourced from the Technical Notes on the National Agricultural Statistics of the PSA. This accounts for the proportion of product k that is used as seeds, feeds, and waste. For provinces that are known to be main processing centers of certain products, such as bananas in the Davao region, A^k also accounts for the proportion of the products that are processed.

4. Transshipment

The issue of transshipment figures prominently in trade data, and is termed the Rotterdam effect in the international trade literature. International transshipments need not be a prominent concern to the extent that the products in this study are mostly produced and consumed within the Philippines. Among the products covered in this study, chicken (12.5%), and pork (10.7%) have the highest share of imports in domestic consumption (PSA, 2016).

Nonetheless, transshipment is also a concern for inter-provincial trade. The PSA trade data are sourced from the outward coasting manifest submitted by vessels, and do not identify the final destination of the products on board. This becomes an issue especially with regards to the RRTS. Refering to Figure 1, this means a delivery truck loaded in the port of Batangas, which passes through Mindoro, may actually be destined for Aklan. The implication is that Mindoro will appear as if it is increasing its exports to Aklan whereas it is actually Batangas that is shipping to Aklan. In terms of trade friction measurement, Mindoro would appear to have lowered its trade frictions relative to other provinces that are not transshipment points. The trade-enhancing effects of the RRTS will also be artificially magnified. There is no systematic way by which this can be corrected. But several things mitigate this concern.

First, cargo trucks tend to only use one or two chains in the link at most (JICA, 2007). For example, in the Batangas to Aklan route, comprising of two RRTS links, interviews with truckers reveal that 80% of those departing from Batangas are destined for Mindoro, and only 20% are moving further on to Aklan. Second, and related to the first point, RRTS loses its advantage vis-à-vis liner shipping as distance increases. The JICA (2007) report estimated the threshold to be around 200 km. The fact that boarding RORO ships is on a first come first served basis complicates the coordination process as the number of links to be traversed increases. Based on field interviews, it was not until 2016 that a company - Archipelago Philippine Ferries Corporation - offered schedule guarantees for entire links of the main trunks of RRTS. Finally, accounting of land trade flows mitigates this concern at least in cases of two-province islands such as Mindoro and Negros.

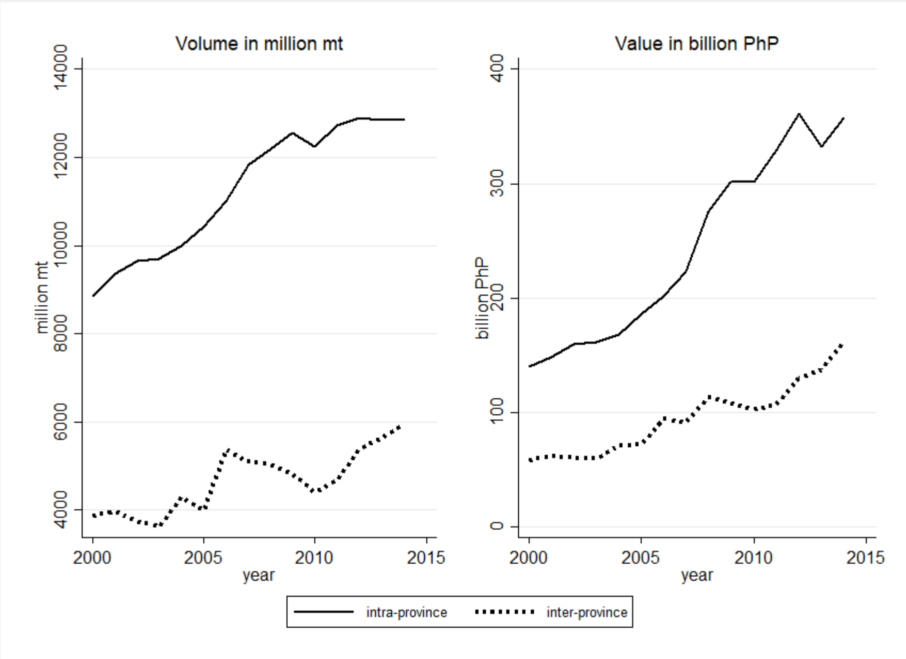
Even outside of RRTS, transshipment is a persistent feature of the trade data especially with regards to domestic trading hubs. The issue is most easily appreciated in the case of NCR which does not produce commercial quantities of agricultural products and yet serves as an import and export hub to other provinces. This problem is overcome by mapping NCR exports to their origin provinces using the MCSS as described in the Appendix, and summarized in Table A2.

5. Zero flows

   Missing flows were assumed to be zero if a pair of provinces recorded positive trade in at least one year in the period of observation.

The information compiled from (1) to (4) yields Figure 6, which shows the evolution of inter and intra-provincial agricultural trade over the period of observation. Both are generally increasing, but it is clear that intra-province trade is at least twice as much as inter-province trade and has moreover increased faster. This is observed in both volume and value, and is suggestive of biting province borders. Nonetheless, this figure belies heterogeneity across products and provinces. Table 1 provides a summary of the average intra and inter province trade by commodity.

Figure 6 Inter and intra provincial trade in agriculture



The resulting dataset is a balanced panel of 40,650 observations, covering exports of 60 provinces and bilateral trade of 822 province pairs. Out of the 60 provinces, 29 have at least one RRTS connection with another province. Four percent of the observations comprise of land-trade, and intra-province flows account for 13%. Close to 51% of the observations consist of zeroes, suggesting highly irregular trade flows between provincial pairs across products. Among seaborne inter-provincial trade, 32% of the province pairs are treated with the RRTS reform during the period of study.

Table 1: Average inter and intra provincial trade by product

Product	Inter-province		Intra -province		Observations	
	quantity (MT)	value (million PhP)	quantity (MT)	value (million PhP)	% zeroes	total
banana	659.9	10.3	80912.3	1257.7	51.7	3930
cabbage	10.7	0.2	4131.3	71.5	57.0	1440
calamansi	38.6	0.7	780.3	17.5	58.9	1905
carrots	18.7	0.6	2136.3	69.4	59.6	1605
cassava	1695.2	21.3	20150.6	271.0	52.0	2250
chicken	17.5	1.2	2093.7	133.0	54.5	1920
corn	5961.9	74.6	50042.5	679.2	44.7	4410
mango	1754.6	52.5	10050.8	321.7	44.0	3540
onion	332.4	14.3	1487.6	70.2	45.8	3255
pineapple	52.0	1.1	30415.6	649.3	52.1	3015
pork	640.9	24.1	13920.7	951.3	52.6	1545
potato	531.6	15.3	1150.7	37.1	56.9	1890
rice	5134.6	124.2	106081.7	2475.0	51.3	7530
tomato	343.1	6.3	1575.6	31.0	50.1	2415
mean	2076.0	42.5	29890.6	640.0	50.9	40650

Source: Author

0.4.3 Production and consumption

The PSA assembles production data of major crops and animals at the provincial level. In cases where production information for a province are missing, the gaps were filled using the production trend of the region to which a province belongs. Most production data are in annual frequencies, except for rice and corn that have quarterly production surveys.

The adjustment factors for the production data are sourced from the Technical Notes on the National Agricultural Statistics from the PSA (2016). This enables matching of production with consumption and trade data. For example, production data is in terms of paddy whereas trade is in both rice and paddy, and consumption is in terms of rice. Details of the adjustment factors are in Table A3, and derivation for some products are explained in the Appendix.

Consumption patterns are assumed to change slowly, and hence not surveyed regularly. The per capita consumption figures for 2008 and 2012 are used to infer annual provincial consumption by multiplying the per capita consumption data with provincial population estimates from the Census on Population and Housing and the resulting projections for periods in between the census years of 2000, 2007 and 2010.[§]

0.4.4 Prices

Annual provincial wholesale prices were used to derive the value equivalent of intra-provincial trade, and land-based inter-provincial flows. These were sourced from the PSAs Integrated Agricultural Marketing Information System and Agricultural Marketing News Services (AGMARIS-AMNEWSS). When gaps in price observations exist, these were derived in the following sources in order of priority:

1. Provincial retail prices trends;
2. Regional wholesale price trends, and
3. Regional retail price trends.

Table A4 summarizes how the consumption, production, price, and trade data sets are mapped against each other to produce this study's dataset.

[§]Consumption estimates are available for 1999. However, a change in sampling methodology was instituted in the 2008 round of Survey of Food Demand

0.4.5 Distance and contiguity

Geodesic distance between the centroids of provincial trading pairs were derived from geographical coordinates provided in http://www.diva-gis.org/Data.

Transport costs ideally take the place of distance as an explanatory variable, but these are notoriously hard to obtain. The maritime trade data maintained by the PSA has a record of freight revenue listed along with the exported volume and value. Nonetheless, these are not recorded consistently even within ports. Neither can discernable patterns be made across time. Moreover, because the data is on a monthly basis, it cannot be ensured that the freight revenue recorded corresponds to actual total shipments.

0.4.6 Language and religion

Information on language and religion were obtained from the Philippine Census of Population and Housing 2000. Language was inferred from ethnic affiliation, while religion was inferred from the questionnaire on religious affiliation.

0.5 Results

0.5.1 Evaluating the trade effects of the RRTS

As a baseline, the effect of RRTS is first estimated explicity controlling for traditional gravity covariates, and accounting for origin, destination, time, and product fixed effects. The results in column (1) of Table 2 suggest that RRTS increased trade in connected provinces by as much as 85%. In the second estimation, the static fixed effects are replaced with time-varying fixed effects. The latter are better able to control for yearly changes in trade that do not arise from the RRTS. This specification suggests the RRTS increased trade by over 200%. Finally, the preferred specification in column (3) replaces the gravity covariates wtih pair fixed effects that account for all the non-time varying characteristics that determine province pair trading behaviors including the investment in an RRTS link. This specification suggests a more modest magnitude of RRTS effect of 36% for linked provinces. ¶

[¶] For these estimations, the sample exlcudes intra-province trade and land flows.

Table 2: RRTS and inter-provincial seaborne trade

	(1)	(2)	(3)	(4)
rrtspair	0.623***	1.219***	0.308***	-0.052
	(0.205)	(0.249)	(0.117)	(0.037)
log distance	-1.072***	-0.757***		
	(0.232)	(0.0846)		
language	0.0756	-0.0660		
	(0.281)	(0.246)		
religion	-0.992	-0.332		
	(1.465)	(0.333)		
origin FE	yes			
destination FE	yes			
product FE	yes			
time FE	yes			
origin-time FE		yes	yes	yes
destination-time FE		yes	yes	yes
product-time FE		yes	yes	yes
pair FE			yes	yes
Observations	30,270	30,270	30,270	21,073

Robust standard errors in parentheses, clustered at province pairs
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

In column(4), the dependent vairable is replaced with $P^k_{ij,t}$, or the difference between the retail prices of exporting and importing provinces at time t for product k. Other factors being held constant, spatial price gaps are expected to narrow with lower trade costs and greater trade flows as arbitrage opportunities expand. The estimated reduction on price wedges is very modest at 5%, and moreover statistically insignificant. The lack of manifestations in terms of price wedges can be possibly explained by the attrition in the sample size. The sample size is reduced by 30% in the price estimates due to the absence of price data. The ohter possible explanation is that provinces may be too large as a unit of observation if sea ports within a province are not easily reachable to the inland municipalities.

Morever, the findings of this exercise only pertain to the fourteen agricultural products in their raw and semi-processed form. However, these may also not be the best products to reap the benefits of the RRTS, the delivery mode of which appeals most to consumer manufactures that is most amenable to direct delivery to institutional buyers (ADB, 2010). A linear probability model (LPM) including a broader set of products (all products except for fuels and minerals) estimated as (4) with municipal pairs as unit of observation (sample size = 777,690) suggests that being linked by RRTS increases the probability of positive trade flows between municipalities by 13.9% points. An LPM is used because the proportion of zeroes in the dataset rises to almost 70%.

0.5.2 Provincial trade frictions

This section estimates trade frictions between provinces and examine how the RRTS influenced them.

Table 3 summarizes the results for the first set of estimates. Intra-provincial flows are excluded in the first instance as a baseline comparison. The distance coefficient exhibit the expected sign and magnitude of elasticity. Overall, religion is not a major predictor of trade, while trading by land is a very strong influence in bilateral trade. The coefficient on langauge suggests that provinces sharing a major common language trade 43% more with each other. Nonetheless, this negative effect disappears when allowing for possible non-linear effects of distance in column (2). Distance is classified as short if centroids of provinces are less than 402 km apart. This represents the distance between Zamboanga del Sur and Tawi-tawi, which is the second farthest pair of points currently serviced by a RORO ship in the dataset.‖

The estimation behind columns (3) and (4) include intra-province trade but is limited to maritime flows. The distance elasticities are in line with expectations, and sharing a common religion is predicted to increase trade by 79% to 86%. Province friction is positive and highly significant, although the effect disappears under a non-linear distance specification. This points to possible collinearity in larger overlaps with *Smprov* and the short distance indicator in a reduced sample size. Finally, columns (5) and (6) present the

‖The farthest distace is over 500km between the centroids of NCR and Palawan. But this represents a special case since NCR is only connected by RRTS with Palawan. A closer look at details of RORO services also suggest they mainly cater to passenger and tourists rather than cargo operations

Table 3: Province border frictions

	(1)	(2)	(3)	(4)	(5)	(6)
	base	base	sea	sea	full	full
log distance	-0.624***	-0.852***	-0.506***	-0.530***	-0.412***	-0.542***
	(0.107)	(0.139)	(0.126)	(0.125)	(0.0865)	(0.0926)
logdistance x sh		0.140		-0.391		0.252
		(0.230)		(0.290)		(0.210)
short distance		-1.578		1.623		-1.759
		(1.336)		(1.621)		(1.191)
language	-0.561**	-0.298	0.251	0.254	0.192	0.274
	(0.268)	(0.247)	(0.248)	(0.288)	(0.187)	(0.190)
religion	-0.393	0.451	0.583**	0.618**	0.0930	0.297
	(0.509)	(0.404)	(0.269)	(0.271)	(0.213)	(0.262)
land	3.851***	4.170***			4.356***	4.511***
	(0.237)	(0.279)			(0.202)	(0.240)
smprov			3.593***	1.592	3.374***	4.302***
			(0.780)	(1.573)	(0.485)	(1.049)
Observations	35,040	35,040	39,105	39,105	40,650	40,650

Robust standard errors in parentheses, clustered at province pairs.
Regressions include origin-time, destination-time, product-time FEs.
*** p<0.01, ** p<0.05, * p<0.1

results for the entire dataset, showing province frictions to be positive and highly signficant under both the linear and non-linear distance set up.

Overall, the estimated trade friction coefficient ranges from 3.4 to 4.3. This border effect indicates by how much more provinces are trading within themselves rather than trading with other provinces. It is not to be interpreted trade cost per se, but rather captures a whole range of different frictions that prevent trade from freely flowing between provinces. Among others, they include transport and storage costs, product characteristics, marketing costs, and information frictions. The border friction estimates also largely correspond to the magnitudes obtained in the literature. In a highly similar set up, Anderson and Yotov (2010) find province border effects for agricultural products in Canada in the order of 1.1, and a home bias effect of 2.3.

Thus far, equation (8) has been estimated off a homogeneity assumption across provinces, time, and products. These assumptions are relaxed in the next set of estimates below. For purposes of tractability, $Smprov$ in equation (8) is replaced by $Border_z$, the definition of which is varied according to the aspect of trade flow, z, being examined. The main results are presented and discussed in the subsections that follow, whereas the gravity covariates for the varying regressions are collectively presented in Table A5 of the Appendix.

Varying by product

Equation (8) is first allowed to vary by product, letting $z = k$:

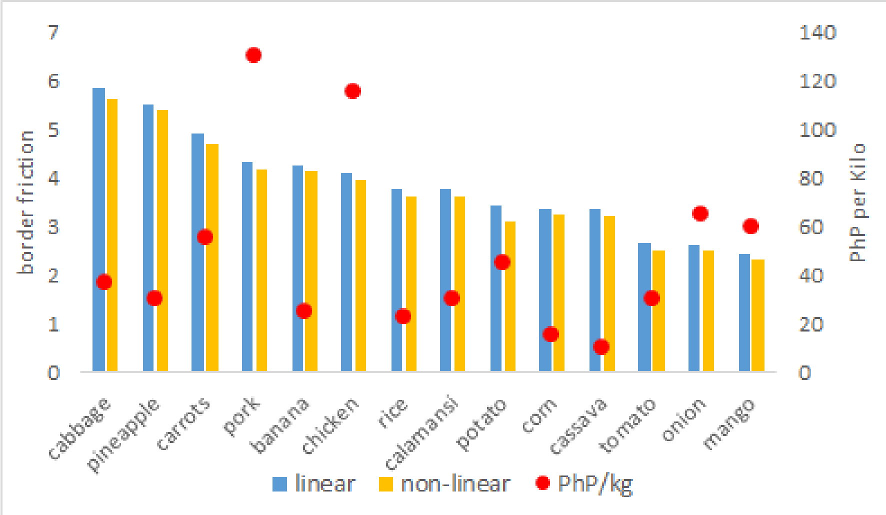
$$Border_{ij,k} = \psi_k Smprov_{ij} \times \delta^k$$

Where δ^k is a dummy variable for each of the 14 products in the dataset. Figure 7 presents the province border estimates by product. The linear and non-linear distance estimates all return postive and statistically significant border effects for the fourteen products, although the latter set produces slightly smaller magnitudes.

Setting aside product characteristics, lower value products ought to have higher border effects because low value to weight ratio means the share of shipping costs in the delivery price is higher. To a certain extent, this is part of the story in Figure 7. But it is also clear that other product characteristics play important roles in determining tradability.

For example, chicken and pork, despite their higher value, require special handling in the form of refrigeration. Pork is also not consumed, and therefore barely traded in predominantly Muslim provinces. The border estimates likewise capture policies that apply to certain products. For instance, until 2015 (BAI), pork from Luzon cannot be transported to Mindanao and Visayas without quarantine clearance, the latter two regions being recognized by the World Organisation for Animal Health as free from foot and mouth disease.

Figure 7 Border frictions by product



Source: Author

Bananas and pineapples, on the other hand, have postharvest losses averaging above 30%, and thus also require careful handling because of their high perishability (Andales, 2000). Both products are traded internationally in high volumes, but are mostly exported in their processed forms, with processing plants locating near the sources of raw materials. These exporting and processing activities are accounted for in the imputation of intra-province and land based trade. But both products also exhibit heterogeneity in terms of the variety exported, and those consumed locally. For example, Cavendish bananas are destined for exports whereas local consumption is more often that of sweet plantains and lacatan, which are of lower value.

Mangoes, onions, and tomatoes have the lowest border effects. This appears to be driven by a mix of higher unit values and geographic specificity in terms of production - tomatoes in Bukidnon, and onions in Nueva Ecija and Pangasinan. And yet, the geographic specificity of carrots and cabbage, both highland vegetables predominantly produced in Benguet, did not translate to higher tradability. A possible explanation could be that of Mutuc et al. (2007) who find Philippine household consumption of some vegetables such as cabbages to be highly income elastic at 1.9%, compared to others such tomatoes at 0.78%.

Grains are widely produced throughout the country, and also widely traded at the same time. They comprise the majority of the volume traded among the 14 products, and yet exhibit substantial border effects. On the one hand, the borders can be thought of as lower than might be expected given the bulky and low value nature of grains and cereals. Nonetheless, three aspects may counter the transport cost effect: (i) they are staples. This is most apparent in the case with rice where government's rice buffer stocking system directs about 5% of rice trade flows (NFA, 2017); (ii) cassava, and especially corn, aside from being staples, are also main feed ingredients for the livestock and poultry sectors; and (iii) they generally require lesser degree of specialized handling or storage conditions.

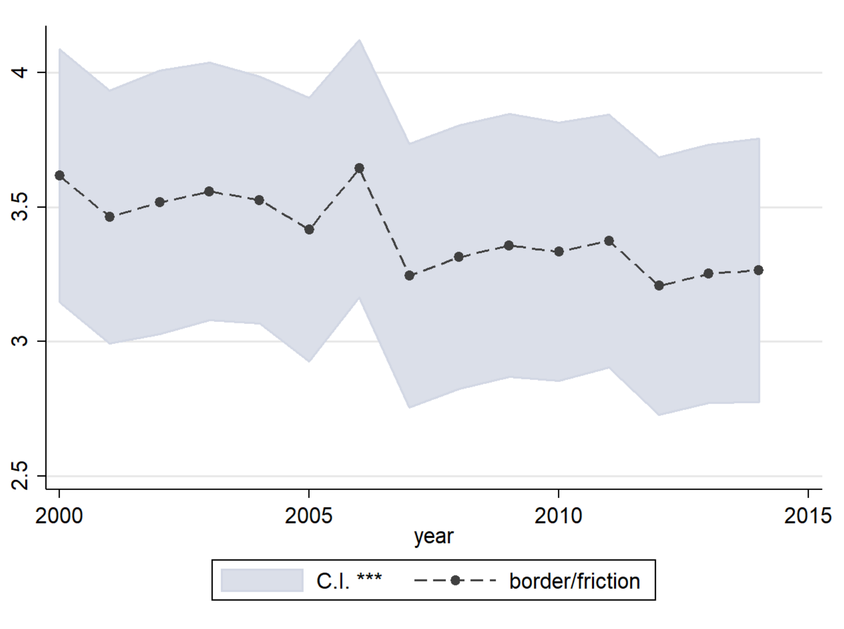
Varying across time

In this exercise, $z = t$, such that,

$Border_{ij,t} = \psi_t Smprov_{ij} \times Yr_t$

Where Yr_t is a dummy for each of the fifteen years in the dataset. The province borders across the years for the linear distance specification are illustrated in Figure 8. The non-linear distance specification gives a fairly similar story, albeit with slightly higher estimates. The Figure suggests province borders remained stable over time with possible modest declines. The spike in frictions is noticeable for 2006, and coincides with a sudden 15% increase in cargo handling charges after remaining constant for the previous four years (ADB, 2010). However, taking into account the confidence intervals shown by the faint blue shade in the figure suggest that the border friction in 2014 is not necessarily different from the starting point in 2000.

Figure 8 Border frictions through time



Source: Author

Varying by province

The coefficients of interest are estimated by letting $z = i$.

$$Border_{ij} = \psi_i Smprov_{ij} \times \eta_i$$

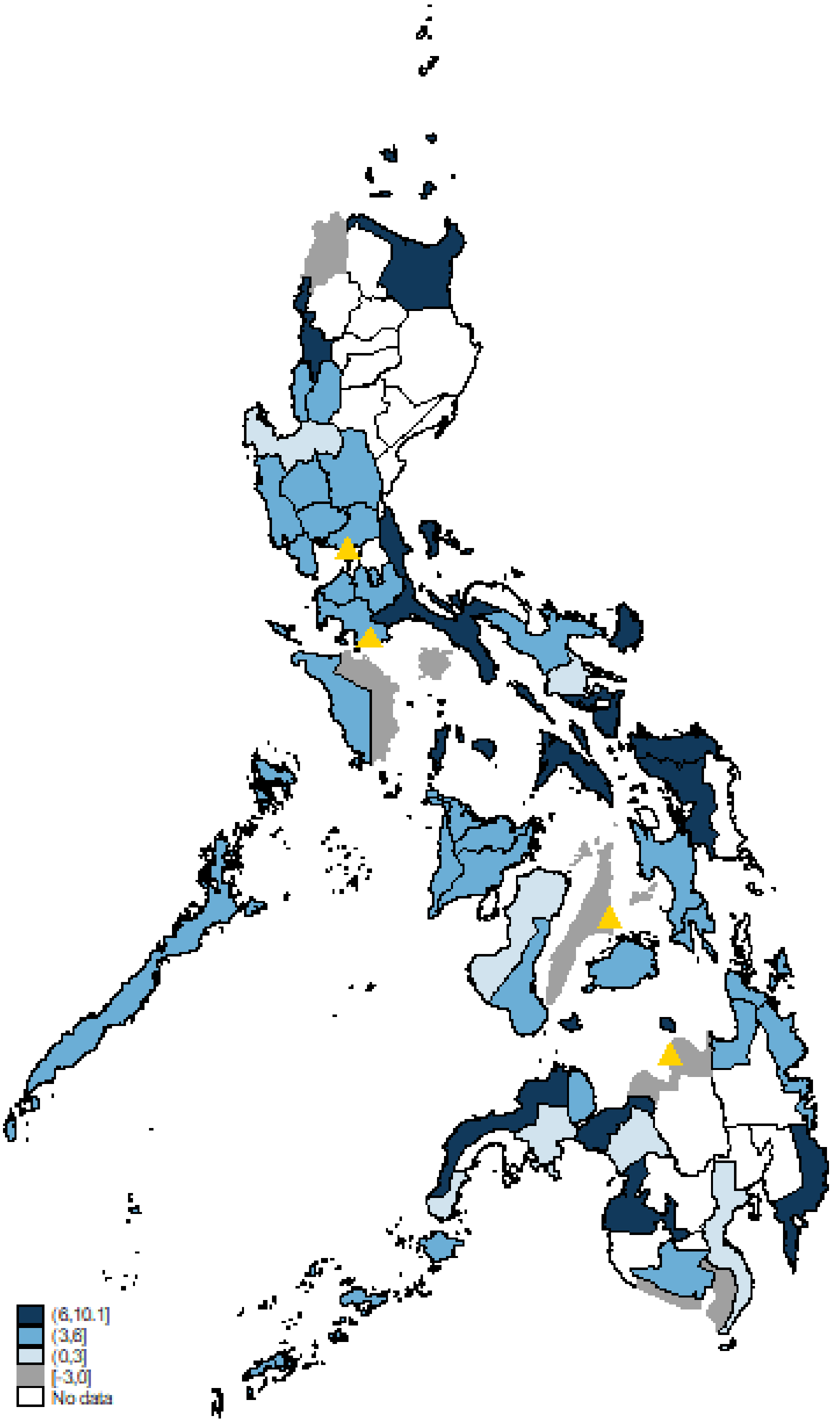
η_{ij} is an indicator for the 60 provinces in the dataset. Figure 9 visualizes the estimated border frictions in the Philippine map for 54 (out of 60) exporting provinces that can be retrieved using the estimates from the linear specification. The estimates behind the figure are in Table A6 together with the estimates from the alternative distance specification.

The map shows that border frictions vary widely across provinces. Darker shades represent higher borders, and these tend to congregate in the Eastern seaboard. Aside from geographic remoteness from major economic regions, they also tend to be where hurricanes forming in the Pacific Ocean frequently make their first landfalls.

With the exception of Batangas, provinces with large ports indicated by a triangle in the figure have zero or negative province borders —Cagayan de Oro in Misamis Oriental, and Cebu. The high border estimate in Batangas despite its major port operations can be explained by several factors. First, it is a highly populated province which consumes a substantial portion of its own production. It is a net importer of 12 out the 14 products considered in this study. Second, the products in the dataset comprise a small fraction of its outbound cargo operations - roughly 1% in 2000, rising to 5% in 2014 (PPA, 2017). In contrast, the proportions for the port in Cagayan de Oro are 7% and 25% respectively.

Comparing against Figure 1, provinces along the three main RRTS trunks do not necessarily coincide with having lower province borders. A possible exception is the Western trunk although the Southern end of the link in Zamboanga del Norte has a high province border. On the other hand, Sorsogon, the northern tip of the central and eastern trunks, exhibits a high border effect.

Figure 9 Province border frictions



Source: Author

A number of provinces surrounding NCR exhibit moderately significant trade frictions. These provinces fall in the region of Central (Region III) and Southern Luzon (Region IV-A or CALABARZON). This may at first be surprising given their proximity to a large market. But while being large producers and exporters, these regions are also considerable markets in themselves with high urban populations and light industry manufacturing firms. CALABARZON, in particular, is the most populous region of the country (PSA, 2015).

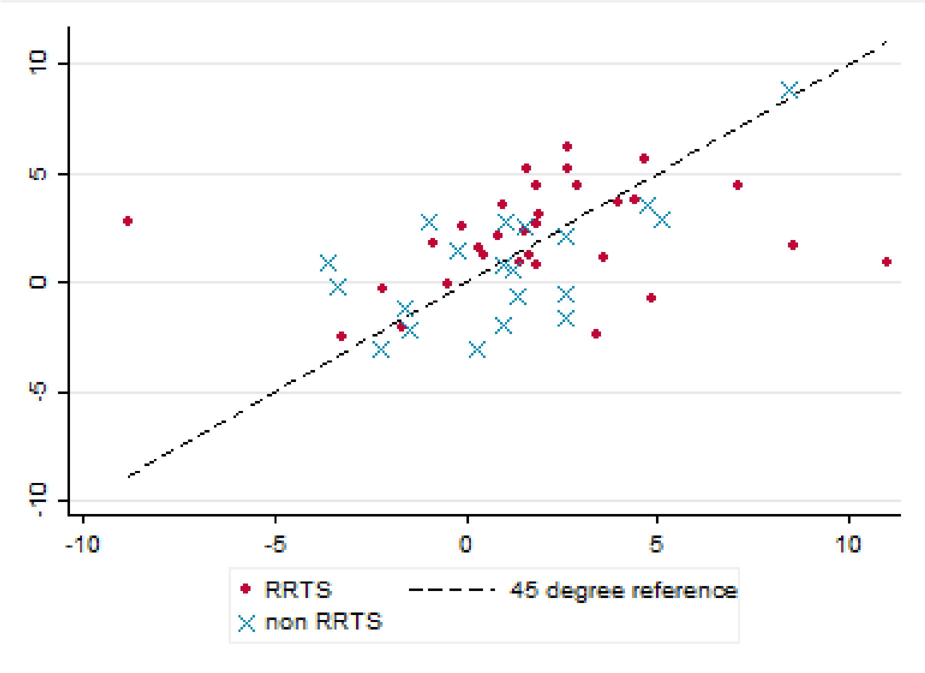
The evolution of border frictions for each province can be examined by letting $z = it$.

$$Border_{ij,t} = \psi_{it} Smprov_{ij} \times \eta_i \times Yr_t$$

Linear and non-linear distance specifications yield largely similar coefficients. The lower estimates from the linear set up are used to plot the distribution of the 900 time varying province border frictions in Figure A1 in the Appendix.

In Figure 10, the starting border estimates of provinces are plotted against their 2014 levels. For provinces that are linked by RRTS to other provinces, the earliest border estimates refer to the first year of RRTS connection. The dots represent provinces that have RRTS links whereas the crosses are provinces that are not linked (landlocked provinces are not included). The 45 degree line plots the starting province friction levels. Provinces above the line increased their border frictions relative to their 2000 or RRTS starting year levels, whereas those below experienced decline. A larger share of non-RRTS provinces decreased their 2000 borders relative to their 2014 levels compared to those that are connected to RRTS. Hence, the association between RRTS linkage and declining borders is not clear. In the next section, the effects of RRTS on province borders are formally examined.

Figure 10 Pre and post RRTS borders by province



Source: Author

0.5.3 Provincial trade frictions and the RRTS

By improving connectivity, RRTS should promote inter-province relative to intra provincial trade, thereby manifesting in lower province border frictions.

For this set of analyses, only provinces that have the potential of being connected by RRTS are included i.e. landlocked provinces are excluded. This reduces the number of provinces from 60 to 51.

The impact of RRTS on province border frictions is estimated by:

$$Border_{RRTS} = \psi_i Smprovij + \omega_{i,RRTS} Smprovij \times RRTS_{i,RRTS}$$

where $RRTS_{i,RRTS} = 1$ when a province is linked by RRTS with at least one trading partner.

The reults in Table 5 suggest that the RRTS reduced the overall province friction by roughly 35% to 36%. The importance of distance and land access to trade are confirmed. Sharing a common language also increases trade by over 50%.

Table 4: RRTS and province borders

	(1)	(2)
log distance	-0.388***	-0.467***
	(0.0959)	(0.0944)
log distance_short		-1.216
		(1.515)
short distance		0.178
		(0.270)
language	0.433***	0.482***
	(0.165)	(0.186)
religion	-0.0897	0.0290
	(0.258)	(0.289)
land	4.568***	4.663***
	(0.237)	(0.292)
smprov	3.893***	4.556***
	(0.552)	(1.369)
rrts x smprov	-0.450**	-0.435**
	(0.185)	(0.183)
Observations	36,600	36,600

Note: Robust standard errors in parentheses, clustered at province pairs
Regressions include origin-time, destination-time, product-time FEs.
*** p<0.01, ** p<0.05, * p<0.1

The succeeding subsections proceed to estimate the effect of RRTS on borders along the dimensions of product, time, and province. Estimates for traditional gravity covariates are collected in Table A-6 in the Appendix.

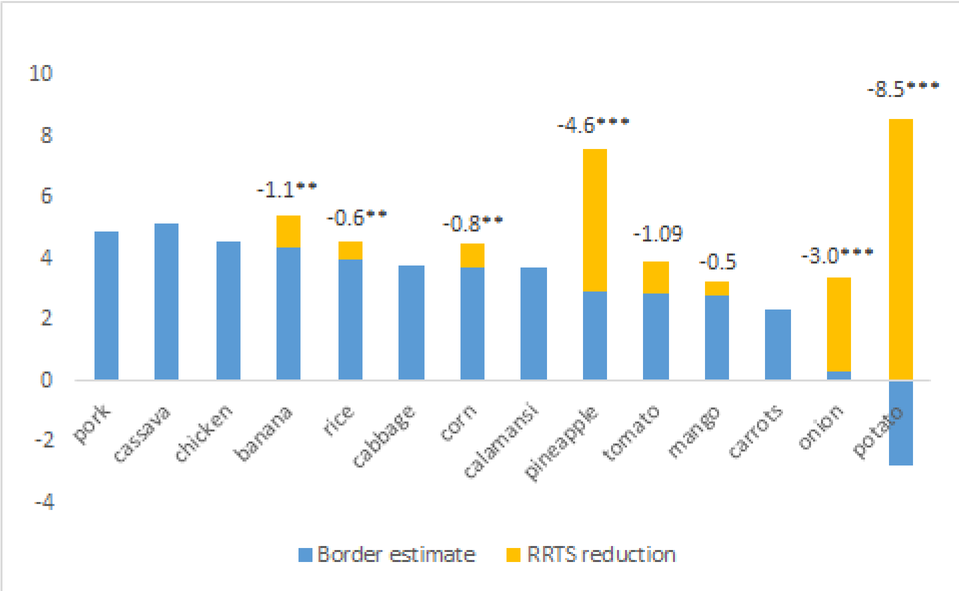
Varying across products

Differences in product characteristics mean that the RRTS may have affected frictions across products heterogenously. This is explored as $z = k, RRTS$.

$$Border_{k,RRTS} = \psi_k Smprov_{ij} \times \delta^k + \omega_{k,RRTS} Smprov_{ij} \times RRTS_{i,RRTS} \times \delta^k$$

The border estimates by product are shown in Figure 11. The full length of the bars are the estimated ψ_k whereas the yellow bars represent $\omega_{k,RRTS}$, or the reduction in trade friction due to RRTS. Products that tend to be produced in specific provinces such as onions adnd potatoes benefitted the most from the RRTS. In particular, the RRTS obliterated the border effect on potatoes. Bananas and pineapples, with their highly perishable nature also exhibited considerable reductions. Border frictions for the staples rice and corn also decreased modestly. But the effect on other products are negligible.

Figure 11 Reduction of border frictions from RRTS, by product



Source: Author

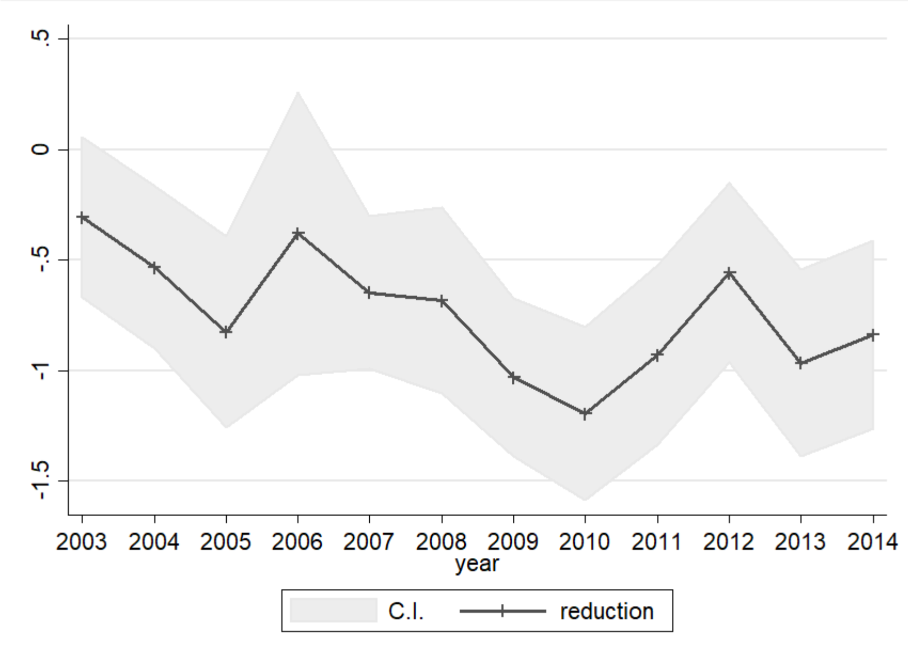
Varying across time

The growing network of RRTS ought to translate to greater dampening of border frictions over time. The effect of RRTS on the evolution of province trade frictions are estimated as $z = t, RRTS$.

$$Border_{t,RRTS} = \psi_t Smprov_{ij} \times Yr_t + \omega_{t,RRTS} Smprov_{ij} \times RRTS_{i,RRTS} \times Yr_t$$

In Figure 12, RRTS is shown to reduce border frictions in a number of years, rather than a continous and compounded decline accompanying the expansion of the RRTS network. The largest reductions are most substantial in 2009 and 2010, which coincide with the expansion of RRTS links in Batangas-Masbate, Capiz-Masbate, Cebu-Camiguin, Cebu-Masbate, Cebu-Misamis Oriental, Cebu-Surigao del Norte, and Lanao del Norte-Misamis Occidental. These were however not sustained into the latter years, which calls for a better understanding of the network interaction effects of RRTS with other shipping services.

Figure 12 Reduction of border frictions from RRTS, by year



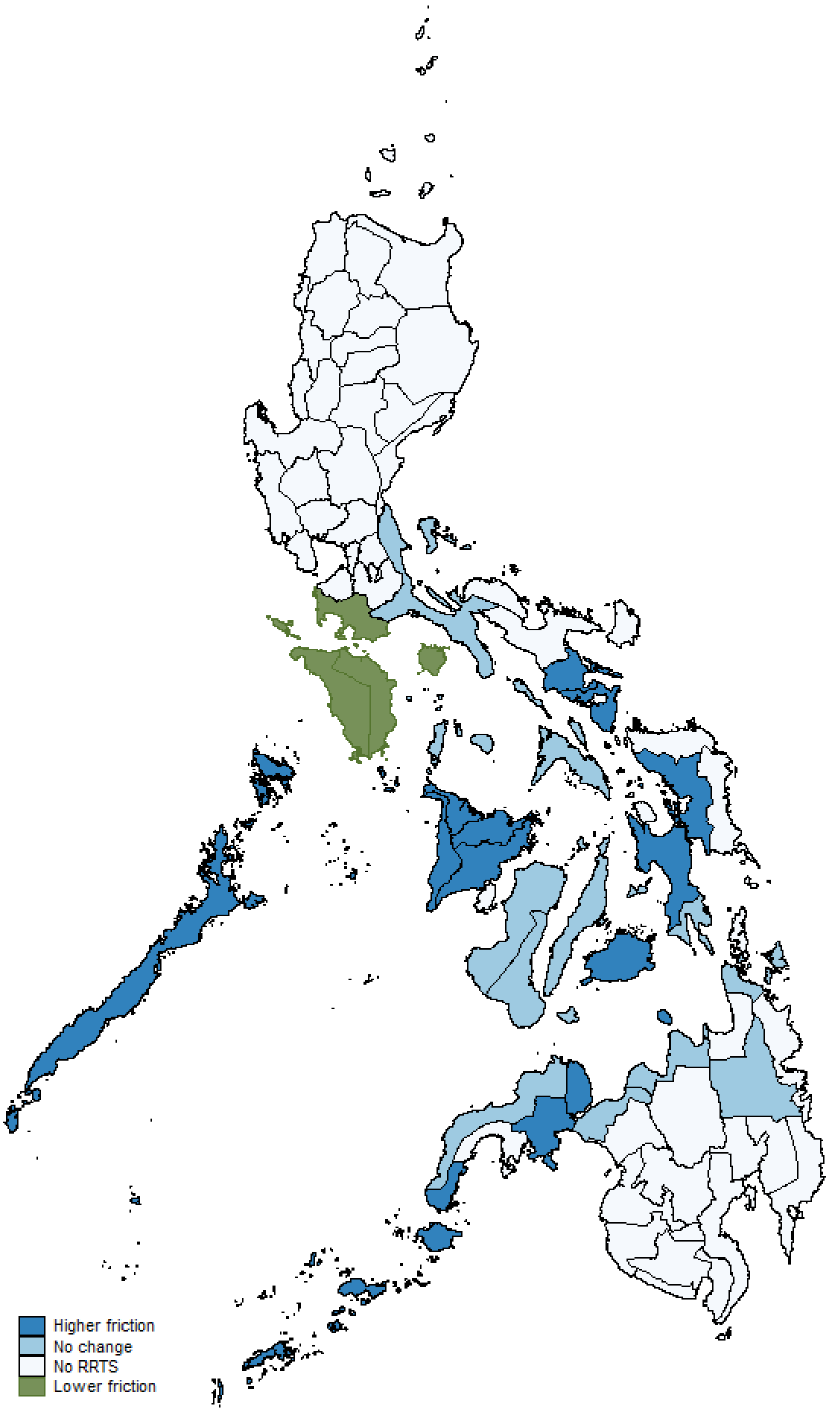
Varying across provinces

Finally, the impact of the RRTS on the border effect of each province is estimated with $Border_{i,RRTS}$. Estimates for each province is presented in Table A8. The change by province - increased, decreased, no change - is visualized in Figure 13.

$$Border_{i,RRTS} = \psi_i Smprov_{ij} \times \eta_i + \omega_{i,RRTS} Smprov_{ij} \times RRTS_{i,RRTS} \times \eta_i \quad (9)$$

RRTS had widely different effects on border frictions of provinces. Batangas, Occidental and Oriental Mindoro, colored in green, reduced their border effects significantly. The same applies to Marinduque even though its border friction was negligible even prior to the RRTS. All four provinces are geographically proximate and linked by RRTS with each other. The proximity to NCR is also easily appreciated from the map.

Figure 13 Change in border frictions from RRTS, by province



Source: Author

There are also provinces for which the RRTS heightened border frictions. The increases are largest for Basilan (+3.6), Sorsogon (+3.2), and Tawi-tawi (+3.2) . The small island of Camiguin (+2.9), albeit being linked by RRTS to Bohol, Cebu, and Misamis Oriental heightened its border frictions. Nonetheless, the Camiguin-Cebu RORO service only operates once a week, and that of Bohol-Camiguin once a day. As suggested by JICA (2007) frequency of service is key to reaping the benefits of RRTS. Discussions with liner shipping also suggest likewise - they view that RRTS main advantage is schedule frequency.

At the same time, it is notable that the RRTS linked group of provinces in the southwestern extremities of the Philippines - Basilan, Sulu, Tawi-tawi, and Zamboanga del Sur - all heightened their borders after RRTS linkage, suggesting a possible crowding out of trade in regions that are less well-connected to the major sea ports such as Cagayan de Oro and Cebu. The uneven contributions of the RRTS in lowering province border effects may be indicative of intensifying geographic concentration of trade activities. In particular, provinces that lowered border effects are concentrated to those that are near the NCR. Taken at face value, this suggests a reinforcement of the North to South trade imbalance that liner shipping operators allude to. In this sense, the goal of EO 170 of facilitating export of agricultural products from the poorer and more rural provinces to big demand centers may not have materialized. The welfare implications of these results are worthy of a separate in depth empirical inquiry.

Nonetheless, it is also important to keep in mind some limitations of the border friction estimations. First, border effects only capture the exporting activities of provinces. Consider as example the RRTS-linked provinces of Cebu and Leyte. Suppose the RRTS caused Cebu's exports to Leyte to increase, but not vice-versa, then Cebu will show up as having lowered border frictions while Leyte's frictions may not change, or may even increase if its production is rising but it remains a deficit province. This is a potential explanation for the intensification of borders for Albay, Bohol, and Leyte. Morever, it is useful to keep in mind the relative nature of the border estimates. An intensification does not necessarily imply a higher trade costs in absolute terms. Rather, they increased relative to that of other provinces.

Second, in using provinces as unit of observation, connectivity issues within a province is implicitly assumed to be negligible. This can affect border estimates in several ways. A province may show up as increasing its borders if municipalities within a province are becoming better connected with each other by land, and this is developing faster than improvement of maritime links with other provinces. The flip side of this is that provinces may be too broad as a unit of observation if road networks within a province are not good, such that the benefits of the RRTS are only confined to the municipality linked by RRTS but do not trickle through to the rest of the province. Finally, RRTS can potentially increase border estimates if it improves connectivity within a province, since some provinces comprise of several islands themselves. Nonetheless, examination of within province maritime trade suggest this mechanism can be ruled out for the period of study.

The operational definition of the RRTS at this point does not incorporate information about frequency of services, which is key to reaping the full benefits of connection (JICA 2007). Albeit only 58% complete in terms of frequency and number of firms servicing a route, the database indicates that a number of routes are only serviced as seldom as once or thrice a week, by only one ship and firm such as Catbalogan, Samar - Cebu City, or Batangas City-Masbate. The inclusion of information on frequency can therefore allow for finer unpicking of the how RRTS contributes to better connectivity.

Finally, this study does not incorporate analyses on possible trade diversion effects of the RRTS, which requires a good understanding of shipping networks for sound execution. This is something left for future work.

0.6 Conclusions and policy implications

This paper finds that the introduction of the RRTS had beneficial effects on inter-provincial maritime trade flows of agricultural products. RRTS is also shown to dampen overall trade frictions between provinces. However, a closer examination reveals heterogeneity in the distribution of benefits. In particular, provinces close to NCR experienced declines in their frictions, whereas the remoter provinces in the Southwest Mindanao heightened their frictions. This combination of results suggest a possibility of crowding out of trading activities in poorly connected provinces, and a reinforcement of the North-South trade imbalance feature of domestic trade in the Philippines.

Against this backdrop and with the caveats of the methodology in mind, the RRTS' goal of creating market access to spur rural development for poorer provinces does not seem to have materialized. In this sense, the goals of the RRTS must be analyzed and articulated with a clear understanding of the interaction and network effects of servicing particular routes, to predict possible effects on routes that are unserviced or poorly serviced.

This study is one of the first in terms of empirical evaluation that seriously takes into account historical and institutional realities of RRTS as a transport system. The historical dataset on starting date of RORO services and the retrieval of intra-province trade flows form important parts of this paper's contribution. Nonetheless, the analysis of the effects of RRTS can be enriched in many dimensions. In particular, valuable insights can be learned from taking into account the effects of RRTS on routes that are not serviced by RORO. For routes that are entirely serviced by trampers, trade costs may have gone down from positive spillover effects of more competition and also being networked with RORO-serviced routes. At the same time, trade diversion effects are thus far not considered in this work. The introduction of the RRTS conceivably leads to a reconfiguration of the trade networks available to remoter island provinces.

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Appendix

0.1 Maritime trade by origin and destination

The analysis is limited to a set of agricultural commodities effectively covering 101,159 monthly flows. About 5% of these exhibit highly improbable derived unit values suggesting encoding errors. More formally, provincial retail and farm gate prices are used as upper and lower bounds of unit values to check for outliers. In such cases, more weight is given to the volume record as advised by the PSA, and values were adjusted according to the average unit price of the exports from the port of the nearest available month before and after the outlier observation.

0.2 Inter-province land trade

Inter-province land trade flows were derived using Marketing Cost Structure Studies (MCSS) were prepared by the Bureau of Agricultural Statistics (BAS) for a number of products in selected years. These studies identify the main supply and destination provinces for certain commodities. The difference between production and consumption of a supply province is assumed to be the amount available for export to demand provinces.

The derivation of imports of a demand province is straightforward when an importing province only has one source province. In cases where a demand province sources from multiple suppliers, such as the case of NCR, the supplying provinces are weighted according to the sample proportions in the survey. For example, NCR sources onions from Ilocos Norte, Pangasinan, and Nueva Ecija. Following the sample proportion of traders in each supply province, it is assumed that 26% of NCR imports came from Ilocos Norte, 34% from Pangasinan, and 39% from Nueva Ecija.

The exports of supplying provinces are capped at the difference between production and consumption. In cases where supplying provinces are unable to fill the requirements in all demand provinces, importing provinces are prioritized by importance of markets as indicated by their sample proportion, and by the availability of production information. These imputations were checked against coastwise trade data to avoid double counting. A summary of the geographic flow for each of the commodity in the study is described in Table A1.

In cases where only two provinces sit on the same island (i.e. the eastern and western halves of Mindoro and Negros), land trade between the two neighboring provinces can also be derived.

Trade between east (E) and west (W) was derived as follows:

$X_{EW} = Prod_E - \Sigma^n_{E \neq W} X_E j + \Sigma^n_{E \neq W} M_{Ej} - C_E$

Where C is the consumption in the (E)ast, X_{Ej} are the exports of the eastern province to provincial and international trading partners, and M_{Ej} are its imports. Exports from the west to the east are similarly derived.

0.3 NCR Transshipment

Products exported by NCR have two potential sources - other provinces from mainland Luzon, and international imports, IM. If $NCR_c \geq IM$, it is assumed that international imports are all consumed in NCR and whatever is exported is originally sourced from other provinces that are part of the Luzon mainland. An implicit assumption is that there are no quality discrimination for destination markets. It turns out that $NCR_c \geq IM$ is true for all products except for corn, which exceed consumption in NCR by at least nine thousand metric tons during the period of study. Presumably, this is because they are used as inputs to the feed milling industry, the majority and largest of which are located in NCR and the nearby Central Luzon provinces (Cruz, 1997). This simplifies the problem since processed feeds move to another product classification. The re-accounting of source provinces is summarized in Table A2.

0.4 Production data

Adjustment factors for products are summarized in Table A3.

Production information on hogs and chicken are not available at the provincial level for the entire period of the study. Instead, information relies on quarterly inventories of animals. To come up with the production data, the quarter with the largest inventory is chosen for each year. This is then converted to live weight equivalent using 80kg for hogs and 1.45kg for chickens. Finally, live weight is converted into carcass weight by a ratio of 0.70 and 0.77 respectively.

Table A1: Supply and demand provinces for land trade

Product	Supply province	Demand province
Calamansi	Nueva Ecija	NCR
	NCR	Laguna, Rizal
Cassava	Apayao, Quirino	Isabela
	Isabela	Cagayan
	Bukidnon	D. del Sur, Mis. Oriental, Sarang.
	South Cotabato	Lanao del Sur
	Batangas, Quezon, Pampanga	NCR
	NCR	Bulacan, Cavite, Rizal, Tarlac
Corn	Bukidnon, Lanao del Sur	Misamis Oriental
	South Cotabato	Davao del Sur, Misamis Oriental
	North Cotabato	Davao del Sur, Misamis Oriental
	Isabela	Batangas, Bulacan, Ilocos N., NCR
	Cagayan	Batangas, Bulacan, Ilocos N., NCR
	Ilocos Norte	Benguet, Bulacan, Pangasinan
Hog	Bulacan	Batangas, NCR, N. Ecija
	Dav. del Norte, Saranggani, S. Cotabato	Davao del Sur
Mango	Bulacan, Panagasinan, Zambales	NCR
	NCR	Cavite, Laguna, Rizal
	Ilocos Sur, La Union, Nueva Ecija, Tarlac	Pangasinan
	North Cotabato, South Cotabato	Davao del Sur
	Sultan Kudarat	South Cotabato
Onion	Ilocos Norte	Cagayan, Isabela, Pangasinan
	Pangasinan	Al.,Batang,Bul.,Pampga,Zamb.
	Nueva Ecija	Batang,Cavite,Laguna, Quez, Rizal
Potato	Benguet	NCR, Pangasinan
	Benguet, Pangasinan	Nueva Ecija
	Mountain Province	Benguet
	Bukidnon	Misamis Oriental
Rice	Cagayan, Isabela, N. Ecija, Pangasinan, Tarlac	NCR
	Cagayan	Benguet, La Union
	Nueva Ecija	Bulacan, Pampanga, Rizal
	Bukidnon	Misamis Oriental
Tomato	Pangasinan	NCR
	Bukidnon	Misamis Oriental, Zamboanga City
	Misamis Oriental	Zamboanga City
	Nueva Vizcaya	Pangasinan

Table A2: Attribution of NCR exports

Product	MCSS	Provinces
Banana	no	Isabela (100%)
Cabbage	no	Benguet (100%)
Calamansi	yes	Nueva Ecija (100%)
Carrots	no	Benguet (100%)
		Batangas (7%)
Cassava	yes	Pampanga (9%)
		Quezon (84%)
Corn	yes	Cagayan (15%)
		Isabela (85%)
		Bulacan (2%)
Mango	yes	Pangasinan (94%)
		Zambales (4%)
		Ilocos Norte (33%)
Onion	yes	Nueva Ecijca (52%)
		Pangasinan (15%)
Pineapple	no	Cavite (100%)
Pork	yes	Bulacan (100%)
Potato	yes	Benguet (100%)
		Cagayan (15%)
		Isabela (40%)
Rice	yes	Pangasinan (19%)
		Nueva Ecija (13%)
		Tarlac (13%)
Tomato	yes	Pangasinan (100%)

Source: Author

Table A3: Adjustment factors by product

Product	Adjustment factor
Banana	6% as feed and waste
Cabbage	8% as feed and waste
Calamansi	6% as feed and waste
Carrot	8% as feed and waste
Cassava	6% as feed and waste
Chicken	
Liveweight	Number dressed x 1.45 kg
Dressweight	total liveweight x 0.77
Corn	kg of corn yields x 0.65
Mango	6% as feed and waste
Onion	8% as feed and waste; 7% as seed
Pineaple	6% as feed and waste
Pork	
Liveweight	Number slaughtered x 80 kg
Dressweight	total liveweight x 0.70
Potato	5% as feed and waste
Rice	kg of Paddy x 0.65
Tomato	7% as feed and waste

Source: PSA Technical Notes on Agriculture (2016)

A modified method of imputation is necessary for products that have a large share that is processed because these are not picked up by the provincial consumption data. Corn, as the main feedstock ingredient for feeds in the Philippines, have over 50% of production destined for feeds and non-food use (PSA, 2016). The hog and chicken consumption of provinces is accounted for by the feed conversion ratios (FCR) for livestock and poultry documented in (Sison, 2014) and the ratio of backyard to commercial farm inventory from the PSA (2016). This is the same methodology that the Department of Agriculture employs in estimating annual demand for corn. A full grown hog of 80 kilos is assumed to have consumed 91.3 kg to 345.0 kg of feeds over its life cycle, while the numbers are 15.3 kg to 28.8 kg for chickens. The lower values refer to backyard animals while higher values refer to animals in commercial farms.

Substantial shares of other products also go into processing: pineapple (45%), banana (25%), potato (25%), and tomato (15%). Nonetheless, knowledge of their processing locations allow us to impute consumption in areas where processing activities do not exist.

0.5 Intra-province trade

The derivation of intra-province trade rests on being able to map a concordance of products across datasets on consumption and production, prices, and trade. The concordance developed in this paper is presented in Table 4.

0.6 Results tables

The province border friction estimates behind Figure 9 is presented in Table A5, while the gravity covariates for the varying border estimates are shown in Table A6. Table A7 presents the gravity covariates of the varying border-rrts estimates.

The lower estimates of the provice-time varying border frictions from the linear set up are used to plot the distribution of the 900 time varying province border frictions in Figure 1. Majority of the estimated province-year border effects are in the range between one and five. But there are also province-year combinations that exhibit negative borders throughout the period, indicating that their internal trade are smaller than their inter-province trade. This is true and unsurprising for Cebu and Misamis Oriental, which are domestic shipping hubs, and may partly be caused by transshipment activities. But there are also a number of other provinces that exhibit negative borders such as Bukidnon, Davao Oriental, Ilocos Norte, Isabela, North Cotabato, Oriental Mindoro, Sarangani, and Sultan Kudarat. These provinces tend to export much of what they produce to more populous provinces.

Finally, the impact of the RRTS on the border effect of each province is estimated with $Border_{i,RRTS}$. Estimates for each province is presented in Table A8.

Table A4: Concordance mapping for PSCC, prices, production, and consumption

PSCC	commodity description	Price (monthly)			Production (annual)	Per capita cons (annual)
		Farmgate	Wholesale	Retail		
1221	meat of swine, fresh or chilled	hogs for slaughter	hogs for slaughter	meat with bones, lean meat, front leg	# of heads (inventory)	pork
1222	meat of swine, frozen					
1231	poultry, not in pieces, fresh	native/improved	native/improved	fully dressed	# of birds (inventory)	chicken
1232	poultry, not in pieces, frozen					
1234	poultry cuts & offal (ex. liver), fresh or chilled					
1235	poultry cuts & offal (ex. liver), frozen					
4210	rice in the husk (paddy /rough rice)	paddy fancy, paddy other variety	paddy fancy, paddy other variety	special, premium, well milled regular milled	paddy	rice
4231	rice, semi or wholly milled (ex. broken rice)					
4410	maize seed (ex. sweet corn), unmilled	corngrain (white & yellow)	corngrain (white & yellow)	corngrits (white & yellow)	yellow, white	corn
4490	other maize (ex. sweet corn), unmilled					
5410	potatoes, fresh or chilled (ex. sweet potatoes)	white	white	white	white	white
5440	tomatoes (fresh or chilled)	tomato	tomato	tomato	tomato	tomato
5451	Onions and shallots, fresh or chilled	shallot, red creole, granex	shallot, red creole, granex	red creole, granex	onion	onion
5453	cabbage & edible brasicas	cabbage	cabbage	cabbage	cabbage	cabbage
5455	carrots and other edible roots	carrots	carrots	carrots	carrots	carrots
5481	manioc (cassava), fresh or dried	dried chips, fresh tubers	dried chips, fresh tubers		cassava	cassava
5729	citrus fruit, N.E.S., fresh or dried	calamansi	calamansi	calamansi	calamansi	calamansi
5730	bananas (incl. plantains)	latundan, saba	lakatan, latundan, saba		lakatan, saba	all variety
5795	pineappeles, fresh or dried	hawaiian	hawaiian	hawaiian	pineapple	pineapple
5797	avocados, guavas, mangoes	carabao, indian, piko	carabao, indian, piko	carabao	carabao	ripe

Source: Author

Table A5: Province border friction estimates

province	linear dist	nl dist	province	linear dist	nl dist
Agusan Norte	3.922***	4.004***	Misamis Occ.	4.929***	5.052***
Albay	2.177***	2.311	Misamis Or.	0.376	0.469
Basilan	3.679***	3.939***	Negros Occ.	2.310***	2.519**
Bataan	5.513***	5.847***	Negros Or.	3.090***	3.440***
Batangas	4.793***	5.145***	Northern Samar	6.144***	6.391***
Benguet	3.636***	3.523***	Nueva Ecija	5.811***	6.099***
Bohol	4.513***	4.780***	Occ. Mindoro	3.869***	4.211***
Bulacan	3.843***	4.375***	Or. Mindoro	0.0676	0.588
Cagayan	7.135***	7.597***	Palawan	4.470***	4.815***
Camarines Sur	5.218***	5.145***	Pampanga	5.127***	5.458***
Camiguin	8.193***	8.519***	Pangasinan	1.740***	1.893
Catanduanes	6.598***	7.070***	Quezon	7.873***	8.235***
Cavite	4.098***	4.448***	Romblon	10.02***	9.972***
Cebu	-0.137	0.0222	Samar	7.134***	7.118***
Davao Sur	2.822***	3.127**	Sarangani	0.145	0.175
Davao Oriental	9.241***	9.783***	Siquijor	6.281***	6.445***
Ilocos Norte	0.188	0.514	Sorsogon	8.205***	8.398***
Ilocos Sur	9.495***	9.412***	South Cotabato	3.541***	3.935***
Iloilo	3.053***	3.096**	Southern Leyte	5.107***	5.276***
La Union	5.282***	5.460***	Sulu	4.034***	4.139***
Laguna	4.253***	4.584***	Surigao Norte	3.124***	3.164**
Lanao Norte	6.113***	6.332***	Surigao Sur	4.650***	4.674***
Lanao Sur	2.983**	1.990*	Tarlac	5.350***	5.487***
Leyte	5.554***	5.658***	Tawi-Tawi	5.229***	5.535***
Maguindanao	8.544***	7.787***	Zambales	5.995***	6.230***
Marinduque	-2.091	-2.014	Zamboanga Norte	6.659***	6.760***
Masbate	6.297***	6.322***	Zamboanga Sur	2.985*	2.100*

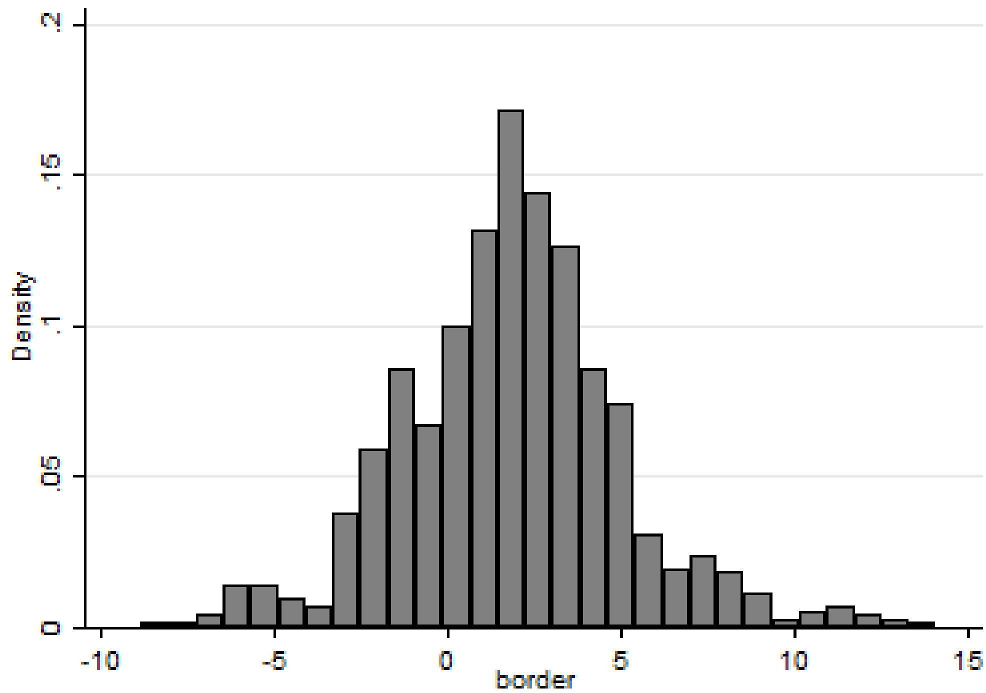
*** p<0.01, ** p<0.05, * p<0.1

Table A6: Gravity covariates for varying border frictions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	product	product	year	year	province	province	province-yr	province-yr
log distance	-0.395***	-0.419***	-0.415***	-0.544***	-0.437***	-0.542***	-0.688***	-0.948***
	(0.0967)	(0.0907)	(0.0860)	(0.0911)	(0.123)	(0.129)	(0.0987)	(0.120)
log distance x short		-0.102		-1.763		-0.446		-2.948**
		(1.234)		(1.185)		(1.393)		(1.278)
short distance		-0.0308		0.252		-0.00390		0.367
		(0.224)		(0.209)		(0.241)		(0.224)
language	0.247	0.273	0.191	0.273	-0.156	-0.0546	-0.612**	-0.255
	(0.196)	(0.203)	(0.187)	(0.189)	(0.246)	(0.237)	(0.288)	(0.257)
religion	0.327	0.383	0.101	0.307	-0.249	0.356	-0.430	0.684*
	(0.241)	(0.256)	(0.211)	(0.259)	(0.785)	(0.569)	(0.486)	(0.395)
land	4.259***	4.331***	4.358***	4.514***	4.050***	4.236***	3.909***	4.366***
	(0.225)	(0.252)	(0.201)	(0.239)	(0.235)	(0.252)	(0.248)	(0.281)
Observations	40,650	40,650	40,650	40,650	40,650	40,650	40,650	40,650

Robust standard errors in parentheses, clustered at province pairs.
Regressions include origin-time, destination-time, product-time FEs.
*** p<0.01, ** p<0.05, * p<0.1

Figure A1 Distribution of province-year border frictions



Source: Author

Table A7: Gravity covariates for varying border frictions and RRTS

	(1)	(2)	(3)	(4)	(5)	(6)
	product	product	year	year	province	province
log distance	-0.290***	-0.311***	-0.576***	-0.680***	-0.517***	-0.464***
	(0.100)	(0.0939)	(0.0822)	(0.0674)	(0.113)	(0.125)
log distance x short		-0.193		-5.158***		2.647
		(1.584)		(1.366)		(1.617)
short distance		0.00773		0.899***		-0.555*
		(0.282)		(0.249)		(0.284)
language	0.469***	0.488**	-0.130	0.231	0.234	0.277
	(0.176)	(0.200)	(0.245)	(0.211)	(0.258)	(0.248)
religion	-0.0766	-0.0375	-0.759***	-0.106	0.183	0.208
	(0.307)	(0.333)	(0.245)	(0.342)	(0.528)	(0.576)
land	4.672***	4.702***	4.210***	4.699***	4.194***	4.389***
	(0.252)	(0.305)	(0.190)	(0.253)	(0.259)	(0.294)
Observations	36,600	36,600	36,600	36,600	36,600	36,600

Robust standard errors in parentheses, clustered at province pairs.
Regressions include origin-time, destination-time, product-time FEs.
*** p<0.01, ** p<0.05, * p<0.1

Table A8: Province border frictions and RRTS

province	linear dist		non linear dist	
	smprov	RRTS	smprov	RRTS
Agusan del Norte	3.742***	0.102	1.300	0.113
Albay	2.653***	2.465***	-0.0669	2.385***
Basilan	1.423*	3.590***	-0.772	3.526***
Batangas	6.170***	-1.427***	4.082**	-1.478***
Bohol	4.555***	0.511*	2.485*	0.556*
Camiguin	6.461***	2.889**	4.789***	2.950**
Cebu	0.250	-0.158	-2.214	-0.178
Iloilo	2.485***	0.588*	-0.253	0.601*
Lanao de l Norte	6.022***	0.440	3.643**	0.374
Leyte	4.535***	1.102**	2.131	1.104**
Marinduque	-0.584	-1.717*	-2.713	-1.825**
Masbate	5.269***	0.747	2.611	0.768
Misamis Occidental	3.392***	2.077***	0.899	2.074***
Misamis Oriental	0.922	-0.129	-1.843	-0.126
Negros Occidental	2.706***	-0.327	0.616	-0.356
Negros Oriental	3.734***	-0.315	1.585	-0.288
Occidental Mindoro	4.336***	-0.504***	2.169	-0.506***
Oriental Mindoro	1.859	-0.677***	0.288	-0.675***
Palawan	4.443***	0.813**	1.935	0.858**
Quezon	7.198***	1.008	4.951***	1.049
Romblon	9.680***	0.492	7.068***	0.498
Samar	6.239***	2.832***	3.686**	2.825***
Siquijor	6.803***	-0.00864	4.440***	0.0162
Sorsogon	6.285***	3.242***	4.450***	3.287***
Southern Leyte	5.168***	0.249	2.821*	0.259
Sulu	3.116***	1.673***	0.697	1.691***
Surigao del Norte	2.867***	0.0946	0.353	0.0893
Tawi-Tawi	3.832***	3.168**	0.909	3.192**
Zamboanga del Norte	6.719***	0.306	4.157**	0.262
Zamboanga del Sur	1.839*	0.935***	-0.892	0.873**

Robust standard errors in parentheses, clustered at province pairs.
Regressions include origin-time, destination-time, product-time FEs.
*** p<0.01, ** p<0.05, * p<0.1