Domestic trade costs are anecdotally high in the Philippines, and yet a systematic and spatially comparable metric of trade costs is unavailable. This paper fills this gap by estimating province border effects, or a province’s tendency to trade with itself rather than with other provinces. Subsequently, the effects of a maritime transport program based on roll-on roll-off (RORO) ships on province border effects are assessed. Using two novel datasets—the starting dates of RORO shipping services by route, and the intraprovince trade of agricultural products—this study finds that province border effects are substantial, with a typical province trading 51 times more with itself than with other provinces. The RORO transport program is associated with an average reduction of 35% of this home province bias. However, the border effect reductions are unevenly distributed, with the largest reductions concentrated in provinces near the biggest demand centers.
I. Introduction

Domestic trade costs play an important role in economic development. The effect of policies and shocks on a particular location depends not just on its own exposure to these changes, but also on the relative distribution of trade costs with other locations. For example, studies of agricultural markets in Sub-Saharan Africa find that higher domestic trade costs are associated with surplus gains being skewed toward intermediaries, while the incidence of costs is larger for producers and consumers (Osborne 2005, Fafchamps and Hill 2008, Bergquist and Dinerstein 2020). During the times of falling world prices, the share of surplus captured by intermediaries in Ethiopia and Nigeria is larger for more remote consumers (Atkin and Donaldson 2015). The increase in transportation costs in Ethiopia following the withdrawal of fuel subsidies was substantially more detrimental for farmers who were far away from the urban markets (Fuje 2019).

Evidence suggests domestic trade costs can be substantial. Atkin and Donaldson (2015) found that the elasticity of trade costs to distance is four–five times higher within the poorly connected Ethiopia and Nigeria compared to the United States (US). In some cases, trade costs can be so prohibitive as to prevent the trade between regions from taking place.

Despite its far-reaching consequences for development, the lack of subnational data has meant that studies on domestic trade costs remain limited, and they are less appreciated than the international trade costs (Agnosteva, Anderson, and Yotov 2019). International trade models typically assume domestic trade to be frictionless, and this has resulted in inconsistencies of predictions against observed economic outcomes (Ramondo, Rodríguez-Clare, and Saborío-Rodríguez 2016). Yotov (2021) argued that including domestic trade flows is key to more precise estimates of the (i) impacts of international trade policies and a more accurate appreciation of their distributional implications through channels such as the extensive margin of domestic trade (Anderson and Yotov 2020); (ii) asymmetries in country-specific trade costs and country-specific effects of trade policies (Felbermayr and Yotov 2021); and (iii) trade diversion effects of trade agreements (Dai, Yotov, and Zylkin 2014).

This work contributes to the literature on domestic trade costs and how transport infrastructure investments can influence their distribution across space. It does so by
estimating home bias or border effects—the tendency of a country, or in this context, a province, to trade with itself—and mapping how they change following a maritime transport program that facilitates interisland trade using roll-on roll-off (RORO) ships.

In the absence of direct trade cost information, home bias can be an informative measure of trade costs. The pioneering work of McCallum (1995) found that Canada trades 22 times more with itself than with the US. A meta-analysis by Havranek and Irsova (2017) confirmed that international border effects remain sizable, especially for the emerging countries. Border effects in developed economies indicate that they trade around 1.6–9 times more with themselves than with the other countries, whereas this factor is substantially larger for emerging countries at 24.5 times. Border effects have also been documented in international trade in services (Anderson et al. 2018).

Border effects capture 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 government policies affecting the movement of products such as quarantine regulations. They also include information frictions, which, according to Allen (2014), explain a substantial portion of price dispersion patterns of agricultural products in the Philippines.

Within countries, individual US states are shown to trade more with themselves than with the other states (Wolf 2000, Coughlin and Novy 2013). Regional border effects are also significant in Canada (Anderson and Yotov 2010; Agnosteva, Anderson, and Yotov 2019), and evidence suggests that intranational borders are significant factors in explaining the wage disparities within Brazil (Fally, Paillacar, and Terra 2010), as well as discontinuities in economic outcomes such as urbanization, exports, and manufacturing output in the People’s Republic of China (Poncet 2005, Guo and Minier 2021).

Studies that bring domestic and international border effects into a unified framework suggest that intranational trade costs pose substantial barriers to domestic integration. Anderson and Yotov (2010) found that intraprovince border effects in Canada are larger than both interprovince and international border effects. Coughlin and Novy (2013) uncovered a similar pattern in the US.

The Philippines is an interesting setting for studying domestic trade costs. It is an archipelago with over 7,000 islands that faces considerable connectivity challenges. In some smaller islands, maritime transport is the only viable means of sustained trade. In 2017, the total value of domestic maritime trade reached $15.3 billion, or 5% of the gross domestic product, corresponding to 23 million metric tons of goods (Philippine Statistics Authority [PSA] 2018a).
However, domestic maritime transport is notoriously expensive in the Philippines. Freight cost per nautical mile from Manila, the capital in the north, to Davao, a major port in the south, for a 20-foot container equivalent unit (TEU) was estimated to be $1.50 in early 2000, whereas those from Hong Kong, China; Bangkok, Thailand; and Port Klang, Malaysia to Manila were at most $0.50 per nautical mile (Basilio 2008). Transporting a TEU from Manila to Cagayan de Oro in the south of the country was twice as expensive as moving the same cargo via transshipment through Kaoshung in Taipei, China (Llanto and Navarro 2014). These figures as well as anecdotes from business groups suggest that domestic trade costs can be prohibitive (Intal and Ranit 2001, National Economic Development Authority 2015). Yet, a systematic and subnationally comparable metric of domestic trade costs is not available.

This paper estimates provincial border effects in the Philippines and investigates the impact of a transport program based on RORO ships on the home bias for agricultural products. The RORO-associated changes to border effects are mapped across products, time, and provinces. These exercises required the construction of two new datasets that form part of this paper’s contribution to the literature: (i) historical data that track the starting date of RORO services by route; and (ii) the recovery of intraprovince agricultural trade and interprovince land trade, which are not tracked by the Philippine Statistics Authority.

Results show that province border effects in the Philippines are large. Provinces trade 51 times more with themselves than with other provinces. The RORO transport program reduced this tendency to 32 times—an attenuation of 35%. The larger interprovince maritime trade flows associated with RORO-connected province pairs confirm the border-effect-reducing impact of the program. There is suggestive evidence of border effects declining over time, but the most significant reductions are clustered in provinces near Metro Manila, the capital and main economic center in the country.

A. The Roll-On Roll-Off Terminal System

The Government of the Philippines launched the Roll-On Roll-Off Terminal System (RRTS) in January 2003 with the aim of reducing domestic trade costs by promoting the use of RORO ships for interisland trade. RORO-carried cargoes were exempted from cargo handling and wharfage fees, benefited from simplified administrative procedures, paid fees based on lane meter in lieu of charges based on product classification, and paid fixed registration fees instead of revenue shares to port
authorities. The program also provided financing support for RORO vessel acquisition and RORO port development.

The RRTS can reduce trade costs through several mechanisms. First, it facilitates intermodal freight transport between land and sea. Cargo-bearing vehicles can embark and disembark from RORO ships without having to go through cargo handling, which is one of the most time-consuming activities in maritime trade (Brancaccio, Kalouptsidi, and Papageorgiou 2020). Second, because of their smaller size, RORO ship operations involve lower fixed costs along short-distance routes compared to container-carrying liner ships. This makes RORO suitable for regular interisland trade. Third, the seamless interface between land and sea transport through RORO means that firms can directly deliver to institutional buyers, thereby saving on warehousing and inventory costs. Finally, RORO can further reduce trade costs by lowering the cost of market entry in intermediation services (Go 2020a).

The program started with 36 routes in 2003 and expanded to cover 114 routes by 2014 (Figure 1). The sequence of development for the 42 preidentified routes was supposed to have followed a scoring system based on traffic demand, extensiveness of inland road and transport networks, and port construction costs (Japan International Cooperation Agency [JICA] 1992). However, there were considerable deviations from the original planned sequence (Figure 2). By 2014, seven of the original routes remained undeveloped, whereas the overall network had expanded beyond the original plans. A systematic tracking of the reasons for plan deviations has unfortunately proved infeasible. As such, the exogeneity of the RRTS placement is not argued. Rather, this paper focuses on estimating home bias and tracing its evolution following the RRTS access of some provinces.

There were RORO ships operating before the RRTS. For example, the Batangas–Calapan route experienced growth in the RORO-carried trade in the early 1990s. However, the transport mode could not fully take off because of incongruent policies, such as having to pay the cargo handling fees even when cargo handling was unnecessary (Basilio 2008), and the imposition of tariffs on trucks when they moved between islands (United States Agency for International Development 1994).

The paper is organized further as follows. Section II outlines the theoretical motivation and the empirical strategy for estimating border effects. Section III describes data sources and the underlying derivation processes. Section IV discusses and contextualizes the results. Finally, Section V summarizes the findings and offers policy implications.
Figure 1. Roll-On Roll-Off Terminal System Network in the Philippines, 2003 and 2014

(A) 2003
Note: The figures show the Roll-On Roll-Off Terminal System network with 36 routes in 2003, growing to cover 114 routes by 2014.
Source: Author’s illustration.
Notes: The order of the bar represents the actual sequence of Roll-On Roll-Off (RORO) route development with Batangas–Calapan, the topmost route, being developed first. The length of each bar pertains to the priority score for the 42 RORO routes identified for development in 1992. The hollow bars at the bottom refer to routes that did not have RORO as of 2014.

Source: Author’s compilation based on various data sources.
II. Empirical Strategy

Gravity models provide a framework for linking trade flows with observable and unobservable trade cost variables. This paper adopts the structural gravity system of equations from Anderson and van Wincoop (2004):

\[ X_{ij}^k = \frac{E_j^k Y_i^k}{\pi_i^k} \left( \frac{\tau_{ij}^k}{P_j^k} \right)^{1-\sigma_k}, \]  

\[ (\pi_i^k)^{1-\sigma_k} = \sum_j \left( \frac{\tau_{ij}^k}{P_j^k} \right)^{1-\sigma_k} \frac{E_j^k}{Y^k}, \]  

\[ (P_j^k)^{1-\sigma_k} = \sum_i \left( \frac{\tau_{ij}^k}{\pi_i^k} \right)^{1-\sigma_k} \frac{Y_i^k}{Y^k}. \]

Here, \( X_{ij}^k \) is the export of province \( i \) to province \( j \) in sector \( k \); \( E_j^k \) is the expenditure of province \( j \) in sector \( k \); \( Y \) is national output; \( \tau_{ij}^k \) represents a host of trade barriers between trading partners; and \( P_j^k \) and \( \pi_i^k \) are the inward and outward multilateral resistance (MR) terms, which summarize trade resistance between a province and all its partners. Finally, \( \sigma \) is the trade elasticity of substitution for sector \( k \) across the origin provinces.

As is standard in the gravity literature, the model is estimated using a Poisson pseudo-maximum likelihood estimator. The underlying data need not follow a Poisson distribution provided that the conditional mean is correctly specified. The specification addresses heteroscedasticity inherent in the log-linearization of multiplicative models, and it allows for a robust estimation in settings where zeroes comprise a large share of the observations (Santos Silva and Tenreyro 2006, 2011).

Equations (1)–(3) imply that gravity-derived estimates of trade costs necessarily have a relative interpretation. A change in trade costs between trading partners induces changes in the trade flows of province \( i \) with other trading partners. Similarly, a change in trade costs within a province, \( \tau_{ii} \), will alter \( \tau_{ij} \). Supposing \( i \) to be a province, the decline in trade costs from RORO tilts trade toward interprovince trade and away from intraprovince trade, leading to a reduction in home bias.

The gravity model relies on an assumption of separability of trade flows and production and consumption decisions within trading units. This Armington assumption of product differentiation is sensitive to the value of \( \sigma \) (Anderson and van Wincoop 2004), which is expected to be high for regularly consumed agricultural products in an intranational context. Nonetheless, the assumption is still consistent under a demand characterized by monopolistic competition and free entry, or supply akin to a multiproducer homogeneous goods model (Eaton and Kortum 2002).
latter case, $1 - \sigma$ is interpreted as embodying comparative advantage with a Frechet distribution (Anderson and Yotov 2010).

Aggregation methods in gravity models introduce biases even though the direction of the bias remains unclear (Anderson and van Wincoop 2004). Bias stemming from product aggregation is not a big concern in this context since estimations are conducted at the four-digit HS code level. However, bias can also occur spatially. Coughlin and Novy (2021) demonstrated that spatial aggregation influences the size of border estimates. Large US states tend to exhibit lower border effects—“spatial attenuation”—because their physical expansiveness makes it relatively more expensive to trade within a state’s borders. This is something to be considered in interpreting the results of this paper.

Estimating province border effects involves modeling the host of observable trade cost proxies as comprising traditional gravity variables, while including a variable for intraprovince trade, Smprov$_{ij}$, which takes the value of 1 when $i = j$ and zero when $i \neq j$. If interprovince trade is frictionless, \( \hat{\psi} \) will be statistically zero or even negative:

\[
X_{ij,t}^q = \exp\{\beta_1 \ln\text{Dist}_{ij} + \beta_2 \text{Lang}_{ij} + \beta_3 \text{Land}_{ij} + \psi \text{Smprov}_{ij} + \eta_{i,t} + \theta_{j,t} + \delta_t^q + \epsilon_{ij,t}^q\}. \tag{4}
\]

Here, \( \ln\text{Dist}_{ij} \) is the log of distance between the provinces $i$ and $j$. \( \text{Lang}_{ij} \) takes a value of 1 if a majority of the population in a province pair share a common language and 0 otherwise.\(^1\) \( \text{Land}_{ij} \) takes a value of 1 if a bilateral trade flow occurs by land rather than by sea. The unobservable inward and outward multilateral resistance terms are accounted for by exporter and importer fixed effects interacted with time—\( \eta_{i,t} \) and \( \theta_{j,t} \), respectively—which control for province-specific trends.\(^2\) \( \delta_t^q \) accounts for product-specific seasonality, and \( \epsilon_{ij,t}^q \) is the error term.

\(^1\)Religion could not be included in the specification because a variance inflation factor analysis reveals it to be highly collinear with distance.

\(^2\)A referee suggested that the MR terms should include a product dimension for strict theory consistency. Doing so entails a suite of 26,460 fixed effects (as opposed to 2,100 under the simpler direction–year combined with product–year specification). This becomes computationally demanding and runs into convergence problems even with the routine of Correia, Guimarães, and Zylkin (2020) for a high-dimensional fixed effects Poisson pseudo-maximum likelihood estimator. The smaller number of cases per group under a direction–product–year MR can potentially explain the difficulty of achieving convergence. For example, the median number of cases per group are 12 and 8 for the origin–product–year MR and destination–product–year MR, respectively. In comparison, the counterparts for origin–year and destination–year MR terms are 80 and 90 cases per group, respectively. Unlike most gravity-model-based studies, this paper does not aggregate to the sectoral level, which has the advantage of keeping product-level variation and avoiding aggregation bias. Instead, product–year fixed effects capture time-invariant product characteristics as well as product-specific yearly changes in demand and supply conditions.
Smprov is first estimated as a homogeneous effect. This is later relaxed to capture heterogeneity across products, time, and provinces. The influence of RORO on province borders is estimated by letting $\text{Smprov}_{ij}$ vary according to a province’s RRTS linkage status; $\text{RRTS}_{i,t} \times \text{Smprov}_{ij}$, where $\text{RRTS}_{i,t}$ is a binary indicator equal to 1 if the exporting province has at least one established RORO service.

Best practices in border effect estimation are applied such as the inclusion of zero flows, controlling for multilateral resistance, and consistent measurement of internal and external distances, which has been demonstrated to attenuate border effects by about one-third (Havranek and Irsova 2017).

### III. Data

**Provincial trade data.** The PSA records the monthly bilateral volume and value of maritime trade by port of origin and destination at the five-digit Philippine Standard Commodity Classification.

**Interprovince land trade.** The PSA does not track commodities transported by land, and yet this is a key component of provincial trade. Failing to account for land-based trade will overestimate the intraprovince flows. Land-based trade flows are retrieved using Marketing Costs Structure Studies (MCSS) from the Bureau of Agricultural Statistics. These studies identify the main supply and destination provinces for certain commodities for selected years. A summary of the land-based geographic flow for each commodity is described in Table A1.1 in Appendix 1. The difference between production and consumption of a supply province together with the portion of production that is wasted or used as seeds, is assumed to be the amount available for export. Such an approach potentially tends toward larger estimates of interprovince trade and, concurrently, smaller estimates of home bias.

**Intraprovince trade.** For exporting provinces, intraprovince trade, $X_{qii}$, refers to what is left for consumption in province $i$ after exports to other provinces and international markets $j$ of product $q$, $X_{qij}$. $X_{qii}$ includes both processed and unprocessed forms of $q$. Provincial production is deflated by $A_{qi}$, an adjustment factor to deduct the proportion used as seeds, feeds, and waste, which is sourced from the PSA’s Technical Notes on the National Agricultural Statistics. For nonexporting provinces, $X_{qii}$ simply refers to the deflated production volume, as described in the following equation:

$$X_{qii} = \begin{cases} 
\text{Prod}_{i}^{q} \times A_{qi} - \sum_{i \neq j}^{\text{Prod}_{j}^{q}} X_{qij} & \text{if } i \text{ is an exporter, } \quad X_{qii} > 0, \\
\text{Prod}_{i}^{q} \times A_{qi} & \text{otherwise}.
\end{cases}$$

(5)
Transshipment. The “Rotterdam effect” is a frequent feature of international trade data. This refers to the inflation of trade records because transiting shipments are counted among the import and export statistics. Similarly, the PSA trade data are sourced from outward coasting manifests of vessels and do not identify the final destinations of the products on board.

There is no comprehensive way to remedy for transshipment. But several points mitigate this concern. First, cargo trucks tend to use only one or two chains in the RRTS at most (JICA 2007). For example, for the Batangas–Aklan route, comprising two RRTS links, interviews with truckers reveal that 80% of those departing from Batangas are destined for Mindoro, and only 20% move further on to Aklan. This is because ROROs lose advantage over liners as the distance increases. Second, the MCSS is used to reassign exports from trading hubs such as Metro Manila to their original producer provinces as described in Table A1.2 in Appendix 1.

Production and consumption. The PSA has production data of major crops and animals at the province level. The adjustment factors in the PSA’s Technical Notes on the National Agricultural Statistics enable matching of production with consumption and trade data. For example, production data is in terms of paddy, whereas trade is in terms of both rice and paddy, and consumption is in terms of rice. Details of the adjustment factors are in Table A1.3 in Appendix 1.

The per-capita consumption figures for 2008 and 2012 are used to infer annual provincial consumption by multiplying per-capita consumption with province population estimates from the Census on Population and Housing and the resulting projections for the intercensal years.

Prices. Annual provincial wholesale prices were used to derive the value equivalent of intraprovincial trade and land-based interprovincial flows. These are available in the PSA’s Integrated Agricultural Marketing Information System and Agricultural Marketing News Services. Gaps in price observations were imputed using the following sources in order of priority: (i) provincial retail price trends, (ii) regional wholesale price trends, and (iii) regional retail price trends.

The mapping of consumption, production, price, and trade datasets is summarized in Table A1.4 in Appendix 1.

Distance and language. Geodesic distances between province pairs were derived from geographical coordinates from the DIVA-GIS database. The transport costs or freight charges ideally take the place of distance as an explanatory variable, but the available sources are unreliable. The maritime trade data maintained by the PSA has a record of freight revenue along with trade volume and value. However, these are not recorded consistently within ports and over time. Moreover, because the data is recorded by month, the reported freight revenue may not correspond to the actual total shipments.
on language is obtained from the 2010 Philippine Census of Population and Housing.

**Starting dates of RRTS service between provinces.** The historical information on RORO services by route is constructed using information from various sources. The primary source is a survey of the 39 RORO operators serving around 150 distinct routes as of 2017. These companies were requested to provide the starting date of their operations for each route. Twenty companies responded with the requested data. Information on 10 of the nonresponders was obtained from the certificates of public convenience records of the Maritime Industry Authority, which specify the route and schedule franchise of a shipping company.

Information obtained from the survey and the certificates of public convenience was verified and supplemented using operation commencement dates of RORO ports from the Philippine Ports Authority. Some reports and feasibility studies of institutions and international aid agencies have information on the starting dates of RORO services for some routes. Among them, the following sources proved useful: Asian Development Bank (2010), JICA (1992, 2007), accomplishment reports of the Philippine Ports Authority, and the United States Agency for International Development (1994, 2014). Local news articles were also used to verify and complete the database. Less formally, information from the Philippine Ship Spotters Society was also utilized.

The resulting dataset is a balanced panel of 40,650 observations, covering the agricultural exports of 60 out of the Philippines’ 83 provinces and the bilateral trade of 822 province pairs. About 4% of the observations comprise land-trade, and intraprovince flows account for about 13%. Zeroes comprise 51% of the observations, suggesting highly irregular trade flows between the province pairs across products. An unreported flow is assumed to be zero if a province pair has recorded positive trade for at least 1 year from 2000 to 2014. Among the maritime interprovincial trade, 32% of the province pairs became linked by RRTS.

The information compiled from all the sources yields Figure 3. Figure 3(A) shows the evolutions of inter- and intra-province agricultural trade. Both are generally increasing, but intraprovince trade is at least twice as large as interprovince trade and has moreover increased faster. This is observed in both volume and value, and indicates palpable province border effects. Figure 3(B) shows that for the province pairs that became connected by RRTS, interprovince trade increased faster than intraprovince trade within 3 years of the start of the service. Table 1 provides a summary of the average intra- and inter-province trade by product.
Figure 3. **Agricultural Intra- and Inter-Province Trade**

(A) Total Intra- and Inter-Province Trade

(B) Intra- and Inter-Province Trade of RRTS Province Pairs

MT = metric tons, PHP = Philippine peso, RRTS = Roll-On Roll-Off Terminal System.

Notes: Panel (A) shows the total volume and value of intra- and inter-province trade of 14 agricultural products from 2000 to 2014. Panel (B) shows the average (log) trade values of intra- and inter-province trade 3 years before and after a province pair becomes connected by RRTS.

Sources: Author’s calculations based on data from the Philippine Statistics Authority on maritime trade, production, consumption, and population; Bureau of Agricultural Statistics’ (2003a, 2003b, 2003c, 2003d, 2003e, 2007, 2011a, 2011b) Marketing Costs Structure Studies.
Table 2 summarizes the results from estimating equation (4). Intraprovince flows are excluded in the first instance in column (1) as a baseline comparison. The distance coefficient exhibits the expected sign and magnitude. The role of trade by land is prominent and reflective of its large share in domestic trade for bigger islands in the Philippines. The coefficient on language suggests that provinces sharing a common language trade 43% less with each other. This negative effect is unexpected and could be driven by the fact that provinces that speak the same language are also contiguous by land and are likely to produce the same agricultural products. Indeed, distance and language are significantly correlated at 0.46 for this sample. The trade-attenuating

Table 1. Mean Intra- and Inter-Province Trade in Agriculture

| Product  | Intraprovince |  | Interprovince |  | Observations |
|----------|---------------|---|----------------|---|--------------|
|          | Quantity (MT) | Value (PHP Billion) | Quantity (MT) | Value (PHP Billion) | % Zeroes | Total |
| Banana   | 80,912.3      | 1,257.7                | 659.9          | 10.3                 | 51.7    | 3,930 |
| Cabbage  | 4,131.3       | 71.5                    | 10.7           | 0.2                  | 57      | 1,440 |
| Calamansi| 780.3         | 17.5                    | 38.6           | 0.7                  | 58.9    | 1,905 |
| Carrots  | 2,136.3       | 69.4                    | 18.7           | 0.6                  | 59.6    | 1,605 |
| Cassava  | 20,150.6      | 271                     | 1,695.2        | 21.3                 | 52      | 2,250 |
| Chicken  | 2,093.7       | 133                     | 17.5           | 1.2                  | 54.5    | 1,920 |
| Corn     | 50,042.5      | 679.2                   | 5,961.9        | 74.6                 | 44.7    | 4,410 |
| Mango    | 10,050.8      | 321.7                   | 1,754.6        | 52.5                 | 44      | 3,540 |
| Onion    | 1,487.6       | 70.2                    | 332.4          | 14.3                 | 45.8    | 3,255 |
| Pineapple| 30,415.6      | 649.3                   | 52             | 1.1                  | 52.1    | 3,015 |
| Pork     | 13,920.7      | 951.3                   | 640.9          | 24.1                 | 52.6    | 1,545 |
| Potato   | 1,150.7       | 37.1                    | 531.6          | 15.3                 | 56.9    | 1,890 |
| Rice     | 106,081.7     | 2,475                   | 5,134.6        | 124.2                | 51.3    | 7,530 |
| Tomato   | 1,575.6       | 31                      | 343.1          | 6.3                  | 50.1    | 2,415 |
| Mean     | 126,999.3     | 3,592                   | 113,822.1      | 1,501                | 50.9    | 40,650 |

MT = metric tons, PHP = Philippine peso.
Sources: Author’s calculations based on the Philippine Statistics Authority data on maritime trade, production, consumption, and population; Bureau of Agricultural Statistics’ (2003a, 2003b, 2003c, 2003d, 2003e, 2007, 2011a, 2011b, 2013) Marketing Costs Structure Studies.

IV. Results

Table 2 summarizes the results from estimating equation (4). Intraprovince flows are excluded in the first instance in column (1) as a baseline comparison. The distance coefficient exhibits the expected sign and magnitude. The role of trade by land is prominent and reflective of its large share in domestic trade for bigger islands in the Philippines. The coefficient on language suggests that provinces sharing a common language trade 43% less with each other. This negative effect is unexpected and could be driven by the fact that provinces that speak the same language are also contiguous by land and are likely to produce the same agricultural products. Indeed, distance and language are significantly correlated at 0.46 for this sample. The trade-attenuating

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4Regressions including a contiguity indicator yield qualitatively similar results to those presented in Table 2. The contiguity variable is, however, statistically insignificant and tends toward a negative effect. Moreover, its inclusion comes at the expense of dropping over 100 origin–year and destination–year fixed effects for the maximum likelihood estimator to convergence. To a large extent, the contiguous character of bilateral partners is controlled for through the land dummy, which is correlated to the contiguity indicator (0.40***).
effect of language disappears once intraprovincial flows are included in columns (2) and (3).

Column (2) of Table 2 presents the results for the full sample with intraprovincial flows, showing the province border effect to be positive and highly significant at 3.3.\(^5\) This indicates that provinces trade 27 times more with themselves than with other provinces. This is a large home bias effect, but it is not surprising given that agricultural goods are generally low-value-to-bulk-ratio products. This impacts their transportability especially within the archipelagic geography of a developing country. In comparison, the province border effects for agricultural products in Canada are

\(^5\)A nonlinear distance specification that distinguishes between short-distance (province pairs that are less than 402 kilometers apart) and long-distance trade yield results that are qualitatively similar to the linear distance specification. The results from the former are not reproduced in this paper for brevity. The interested reader is referred to Go (2020b), the working paper version of the study, for the full set of results.
estimated to be around 2.3 (Anderson and Yotov 2010), while the domestic border effects in the US range from 1.35 to 1.37 (Coughlin and Novy 2021). The average domestic border effect in the People’s Republic of China was around 3.16 in the 1990s and even higher at 4.40 for agricultural products (Poncet 2005).

The impact of RRTS on domestic border effects is captured by estimating equation (4) with the interaction term $\text{RRTS}_{i,t} \times \text{Smprov}_{ij}$, where $\text{RRTS}_{i,t} = 1$ if the exporting province has an RRTS connection. For this set of analysis, only provinces that can potentially be connected by RRTS are included (i.e., landlocked provinces are excluded). This reduces the number of provinces in the sample from 60 to 51. The results in column (3) of Table 2 suggest that the border effect is large and significant for maritime trading provinces, and that the RRTS is associated with reducing this from 3.9 to 3.5. After the launch of the RRTS, provinces traded 32 times more with themselves than with other provinces, down from 51 times prior to connection. This represents a 35% attenuation of home bias.6

Border effects represent a range of different costs that prevent trade between provinces such as logistics costs, marketing costs, and policy-imposed costs. While this study does not disentangle the determinants of the border effect, Allen (2014) suggested that information costs can account for as much as half of the trade costs between provinces. However, there is reason to believe that information frictions have become less prominent in hindering interprovince trade. Mobile phone access, which Allen (2014) used to proxy for information costs, improved drastically during the study period—increasing from nine per 100 people in 2000 to 110 in 2014 (The World Bank 2021). Meanwhile, transport costs, which the RRTS directly impinges on, are a necessary hurdle to realizing cost advantages from information gains (Gao and Lei 2021). In Go (2020a), the RRTS is associated with a 28% reduction in farmgate-retail price wedges between the supplying and market provinces.

The border-effect-attenuating influence of RRTS is confirmed from its impact on interprovince maritime trade flows as summarized in Table 3. In this exercise, only interprovincial maritime flows are included, and $\text{RRTSPair}_{ij,t} = 1$ when a province pair is connected by the RRTS. In column (1), a RORO connection is associated with increasing trade between provinces by close to 300\% $[e^{1.363} - 1] \times 100\%$. However, the specification in column (1) does not account for the possible endogeneity of RRTS placement. Province pairs that foresee trade potential are more likely to invest in an

\[6\] Using the number of services instead of a binary RRTS indicator preserves the results in so far as estimates of the border effect and RRTS impact are concerned. However, the number of RRTS links is highly correlated with log distance ($-0.213***$) such that the distance coefficient becomes statistically zero. The results also become less stable once estimations move from the homogeneous RRTS effect to those varying by product, year, and province.
Table 3. Impact of Roll-On Roll-Off Terminal System on Interprovincial Maritime Trade Flows

|                  | (1) Gravity | (2) Pair | (3) Pair with \textit{Border Trend} | (4) Pair Spillover |
|------------------|------------|---------|-------------------------------------|------------------|
| RRTSPair_{ij,t} | 1.363***   | 0.348***| 0.330***                            | 0.343***         |
|                  | (0.255)    | (0.120) | (0.116)                             | (0.118)          |
| lnDist_{ij}     | -0.433***  |         |                                     |                  |
|                  | (0.125)    |         |                                     |                  |
| Lang_{ij}       | 0.0144     |         |                                     |                  |
|                  | (0.253)    |         |                                     |                  |
| Spillover_{ij}  |            |         | 0.197                               |                  |
|                  |            |         | (0.212)                             |                  |
| Smprov_{ij} \times 2000 | 0.350**   |         |                                     |                  |
|                  | (0.157)    |         |                                     |                  |
| Smprov_{ij} \times 2001 | 0.374**   |         |                                     |                  |
|                  | (0.147)    |         |                                     |                  |
| Smprov_{ij} \times 2002 | 0.367**   |         |                                     |                  |
|                  | (0.158)    |         |                                     |                  |
| Smprov_{ij} \times 2003 | 0.413***  |         |                                     |                  |
|                  | (0.153)    |         |                                     |                  |
| Smprov_{ij} \times 2004 | 0.520***  |         |                                     |                  |
|                  | (0.135)    |         |                                     |                  |
| Smprov_{ij} \times 2005 | 0.575***  |         |                                     |                  |
|                  | (0.148)    |         |                                     |                  |
| Smprov_{ij} \times 2006 | 0.467***  |         |                                     |                  |
|                  | (0.170)    |         |                                     |                  |
| Smprov_{ij} \times 2007 | 0.626***  |         |                                     |                  |
|                  | (0.135)    |         |                                     |                  |
| Smprov_{ij} \times 2008 | 0.792***  |         |                                     |                  |
|                  | (0.138)    |         |                                     |                  |
| Smprov_{ij} \times 2009 | 0.857***  |         |                                     |                  |
|                  | (0.144)    |         |                                     |                  |
| Smprov_{ij} \times 2010 | 0.853***  |         |                                     |                  |
|                  | (0.173)    |         |                                     |                  |
| Smprov_{ij} \times 2011 | 0.982***  |         |                                     |                  |
|                  | (0.156)    |         |                                     |                  |
| Smprov_{ij} \times 2012 | 1.505***  |         |                                     |                  |
|                  | (0.290)    |         |                                     |                  |
| Smprov_{ij} \times 2013 | 1.002***  |         |                                     |                  |
|                  | (0.183)    |         |                                     |                  |
| Smprov_{ij} \times 2014 | 0.821***  |         |                                     |                  |
|                  | (0.144)    |         |                                     |                  |

Continued.
RORO connection. To control for this, traditional gravity covariates are replaced with pair fixed effects, $\alpha_{ij}$, in equation (6), the specification behind the results in column (2). This identification strategy is broadly used in the literature estimating the effects of policy changes such as international agreements on trade flows (Baier and Bergstrand 2007, Head and Mayer 2014). Pair fixed effects represent the comprehensive set of time-invariant characteristics between province pairs that influence the trade costs. Controlling for $\delta^q_t$ to absorb changes in demand and supply conditions of each product and the directional multilateral resistance terms, $\text{RRTSPair}_{ij,t}$ captures the remaining variation coming from the timing of RORO access. The results in column (2) suggest that RRTS-linked provinces increase interprovincial flows by 41.6% compared to the unconnected province pairs:

$$X^q_{ij,t} = \exp\{\alpha_{ij} + \text{RRTSPair}_{ij,t} + \eta_{i,t} + \theta_{j,t} + \delta^q_t + \epsilon^q_{ij,t}\}. \tag{6}$$

However, equation (6) may not adequately control for pairwise changes in trade costs that are exogenous to the RRTS. Bergstrand, Larch, and Yotov (2015) proposed to control for these “globalization effects” by adding time-interacted border indicators.

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Table 3. Continued.

|          | (1) Gravity | (2) Pair | (3) Pair with Border Trend | (4) Pair Spillover |
|----------|------------|---------|---------------------------|-------------------|
| Observations | 30,300 | 30,300 | 36,600 | 30,300 |
| Product–year fixed effects | Yes | Yes | No | Yes |
| Product fixed effects | Yes | Yes | Yes | Yes |
| Pair fixed effects | No | Yes | Yes | No |

Notes: The dependent variable is the value of trade between the province pairs. The gravity specification is estimated using a Poisson pseudo-maximum likelihood estimator with robust standard errors in parentheses clustered at province pairs. Column (1) presents the results with the traditional gravity covariates, whereas column (2) shows the results when controlling for province-pair fixed effects. In column (3), border trends are introduced to account for changing exogenous bilateral trade cost factors other than RRTS. Finally, column (4) presents the result from a specification that accounts for possible spillover effects to trading partners that are not connected by RRTS. ***$p < 0.01$ and **$p < 0.05$. Source: Author’s calculations.

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7 A referee pointed out that a specification with pair-product fixed effects is preferable to equation (6). However, adopting the suggested specification leads to nonconvergence of the maximum likelihood estimator. The suite of fixed effects increases from 2,982 to 14,238, while reducing the median number of cases per group from 105 in the pair fixed effects specification to 15 in the pair-product specification. Similar to the explanation in footnote 2, time-varying and time-invariant characteristics are controlled for through product–year fixed effects. While it is conceivable that preexisting trade in some products influences the likelihood of investing in RORO, data from the Philippine Ports Authority (2017) suggest that the sectoral characteristics are more important determinants. RORO cargo throughput shares are the largest for transport equipment and manufactures, while the average shares of fruits and vegetables, feeds, and fishery products are broadly the same.
Smprov\(_{ij} \times \text{Yr}_t\). In the international trade literature, accounting for these is demonstrated to reduce the estimated impact of trade agreements. Following this recommendation entails using a sample that includes intraprovince flows. The resulting coefficient for RRTSPair\(_{ij,t}\) in column (3) is close to the result without the border effect trend in column (2), albeit slightly smaller in magnitude. Interestingly, time-varying pairwise trade costs that are not directly RRTS-related are generally increasing until 2012, which follow the pattern of global oil prices.\(^8\)

Finally, in column (4) in Table 3, a binary indicator Spillover\(_{ij}\) is equal to one for an unlinked province that is trading with an RRTS-connected province. This tests for the possibility that the growth in interprovincial flows in RRTS province pairs comes from displacing the unconnected provinces. The results show that RRTS-induced maritime interprovincial flows did not come at the expense of unconnected province pairs. This is congruent with the findings in Go (2021) for a more universal set of products.

A. Province–Product Border Effect

Product-specific border effects, \(\hat{\psi}_q\), are estimated by interacting Smprov\(_{ij}\) with an indicator for each product \(q\), Smprov\(_{ij}\) \(\times \delta^q\). The full specification is described as follows:

\[
X^q_{ij,t} = \exp \left[ \beta_1 \ln \text{Dist}_{ij} + \beta_2 \text{Lang}_{ij} + \beta_3 \text{Land}_{ij} + \sum_{q=1}^{14} \psi_q \text{Smprov}_{ij} \right. \nonumber \\
\times \delta^q + \eta_{i,t} + \theta_{j,t} + e^q_{ij,t} \right],
\]

(7)

The resulting coefficients are summarized in Figure 4, which shows positive and statistically significant border effects for all agricultural products. Average unit prices for each product are also represented in the figure. Setting aside product characteristics, lower-value products ought to have higher border effects because the shares of shipping cost in the delivery price are higher. This is part of the story in Figure 3 to some extent. But other product characteristics also determine tradability.

For example, chicken and pork, despite their higher value, require special handling such as refrigeration. Pork is also not consumed, and therefore barely traded, in predominantly Muslim provinces. The border estimates likewise capture policies

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\(^8\)Albeit with only 15 data points, the average prices of crude oil and the coefficients from Smprov\(_{ij} \times \text{Yr}_t\) are correlated by 0.86 at the significance level of 0.01.
that apply to certain products. For instance, until 2015, trade of swine and pork within the Philippines required quarantine clearance as part of measures against the foot-and-mouth disease (Casa 2015).

Bananas and pineapples are highly perishable products with postharvest losses averaging more than 30% (Andales and Gragasin 2000). Both products are traded internationally in high volumes, and 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 derivation of intraprovince and land-based trade. Nonetheless, both products exhibit heterogeneity in terms of varieties exported and those consumed locally. For example, Cavendish bananas are destined for exports whereas local consumption is predominantly that of plantains and lacatan.

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 production—tomatoes in Bukidnon Province and onions in Nueva Ecija and Pangasinan provinces. Yet, the geographic specificity of carrots and cabbages, highland vegetables predominantly produced in the provinces of Benguet and Bukidnon, did not translate to higher tradability. A possible explanation is that Philippine household consumption of some vegetables such as cabbages is highly income-elastic at 1.9, compared to tomatoes at 0.8 (Mutuc, Pan, and Rejesus 2007).

![Figure 4. Border Effects by Product](image-url)
Grains are widely produced and traded domestically, comprising a majority of the traded volume among the 14 products considered in the study. In some respects, the estimated border effect can be thought of as lower than expected given the bulky and low-value nature of grains and cereals. Nonetheless, three aspects may counter the impact of transport cost. First, they are staples. This is most apparent in the case of rice where the government’s buffer stocking system directs about 5% of rice trade flows (National Food Authority [NFA] 2020). Second, cassava and especially corn, aside from being staples, are also the main feed ingredients for the livestock and poultry sectors. Finally, they generally require less specialized handling and storage.

Differences in product characteristics mean that the RRTS impacts border effects across products heterogeneously. The coefficients, \( \hat{\psi}_{q,RRTS} \), from \( \text{Smprov}_{ij} \times \delta^q \times \text{RRTS}_{i,t} \) are presented in Figure 5. Products that are produced in specific provinces such as onions and potatoes benefited the most from the RRTS. In particular, the RRTS obliterated the border effect on potatoes. Bananas and pineapples also exhibit considerable reductions despite their highly perishable nature. Border effects for staples—rice and corn—also decreased modestly. But the effects on products that are likely to be more income-elastic—such as meats, cabbages, and citrus—are negligible.

![Figure 5. Reduction of Border Frictions from Roll-On Roll-Off Terminal System by Product](image)

Notes: The figure shows \( \hat{\psi}_{q,RRTS} \), the coefficients from \( \text{Smprov}_{ij} \times \delta^q \times \text{RRTS}_{i,t} \). A negative estimate implies an RRTS-associated reduction in border effects. Whiskers represent 95% confidence intervals. Detailed results are in Tables A2.1 (coefficients of gravity covariates) and A2.2 (border effect estimates, \( \psi_q \), and RRTS-associated reductions, \( \hat{\psi}_{q,RRTS} \)) in Appendix 2.
Source: Author’s calculations.
B. Province–Time Border Effect

The evolution of border effects over time is estimated by interacting the border indicator with a dummy for each of the 15 years in the dataset, \( \text{Smprov}_{ij} \times \text{Yr}_t \). Figure 6(A) summarizes \( \hat{\psi}_t \), which suggests that border effects are generally stable.

Figure 6. Province–Time Border Effect

(A) Evolution of the Border Effect

(B) RRTS Impact on the Border Effect over Time

RRTS = Roll-On Roll-Off Terminal System.
Notes: Panel (A) presents the estimated border effects, \( \hat{\psi}_t \), from \( \text{Smprov}_{ij} \times \text{Yr}_t \), while Panel (B) presents \( \hat{\psi}_{t,RRTS} \) from \( \text{Smprov}_{ij} \times \text{Yr}_t \times \text{RRTS}_{it} \). Results are detailed in Tables A2.1 (coefficients of gravity covariates) and A2.3 (year-specific border effect estimates, \( \psi_t \), and RRTS-associated reduction per year, \( \psi_{t,RRTS} \)) in Appendix 2. Source: Author’s calculations.
over time and have possibly declined modestly. The spike in 2006 is noticeable and coincides with a sudden 15% increase in cargo handling charges after remaining constant for the previous 4 years (Asian Development Bank 2010).

Figure 6(B) summarizes $\hat{\psi}_{i,RRTS}$, the estimated effect of RRTS on borders for each year from $\text{Smprov}_{ij} \times Y_t \times \text{RRTS}_{i,t}$. RRTS is shown to have reduced border effects for most years. However, the effects are not significant enough to be perceived until 2005, the third year of the program. Moreover, the reduction is not continuous and cumulative as one would expect given the expanding RRTS network over time. The largest reductions are in 2009 and 2010, which coincide with the opening of RRTS links between islands in the Central Philippines: Batangas–Masbate, Capiz–Masbate, Cebu–Camiguin, Cebu–Masbate, Cebu–Misamis Oriental, Cebu–Surigao del Norte, and Lanao del Norte–Misamis Occidental.

C. Province-Specific Border Effect

Province-specific border effects, $\hat{\psi}_i$, are estimated from $\text{Smprov}_{ij} \times \eta_i$, where $\eta_i$ is an indicator for each exporting province. The map in Figure 7(A) visualizes the province border effects for 54 exporting provinces that can be retrieved. Darker shades represent larger border effects, and these tend to congregate along the eastern seaboard, which are some of the poorest provinces in the Philippines. Aside from their remoteness from major economic centers, they also tend to be the locations where hurricanes forming in the Pacific Ocean make their first landfall.

Nearly all provinces with large ports, indicated by a triangle in Figure 7(A), have either zero or negative province border effects (e.g., Misamis Oriental and Cebu). The only exception is Batangas, which has a significant border estimate despite its major port operations. This can be explained by several factors. First, it is a populous province that consumes a substantial portion of its own production. It is a net importer of 12 out of the 14 products considered in this study. Second, the products in the study comprise a small fraction of its outbound cargo operations—roughly 1% in 2000, rising to 5% in 2014 (Philippine Ports Authority 2017). In contrast, the proportions for Misamis Oriental are 7% and 25%, respectively.

An examination of the relationship between the log of provincial land area, a proxy for internal distance, and province border effects suggests that the spatial attenuation bias described by Coughlin and Novy (2021) is a mild concern. The two variables are indeed negatively correlated by 10%, but the relationship is not statistically significant. The island geography of some provinces potentially counters biases arising from spatial aggregation.
Figure 7. **Province-Specific Border Effects in the Philippines**

(A) Province-Specific Border Effect
Figure 7. Continued.

(B) Change in Province-Specific Border Effect with RRTS

RRTS = Roll-On Roll-Off Terminal System.

Notes: Estimated province border effects, $\hat{\psi}_i$, from $\text{Smprov}_{ij} \times \eta_i$, are shown in Panel (A) with the darker shades representing larger border effects. The triangles denote the four largest seaports in the Philippines in terms of cargo operations. Panel (B) shows the change in province border effects, $\psi_{i,RRTS}$, from $\text{Smprov}_{ij} \times \eta_i \times \text{RRTS}_{i,t}$, following the RRTS connection. Results are detailed in Tables A2.1 (coefficients of gravity covariates) and A2.4 (province border effects, $\psi_i$, and RRTS impact on province-specific borders, $\psi_{i,RRTS}$) in Appendix 2.

Source: Author’s illustration.
Changes in border effect by province from the RRTS are represented by $\hat{\psi}_{i, \text{RRTS}}$, the coefficients from $\text{Smprov}_{ij} \times \eta_i \times \text{RRTS}_{i,t}$—whether increased, decreased, or no change—and are summarized in Figure 7(B), which shows that the RRTS impacts border effects differently across provinces. Batangas, Occidental Mindoro, Oriental Mindoro, and Marinduque reduced their border effects significantly. All four provinces are near Metro Manila and are linked by the RRTS with each other. Nonetheless, there are also provinces that experienced heightened border effects following the introduction of the RRTS. The increases are largest for provinces in the Southwestern Philippines—Basilan (3.6), Tawi-Tawi (3.2), and Zamboanga del Sur (0.9)—suggesting a possible crowding out of exports in areas that are not well connected to major regional seaports.

The uneven contributions of the RRTS in lowering province border effects may be indicative of intensifying geographic concentration of trade activities. Provinces that lowered border effects are clustered near Metro Manila. At the same time, the operational design of the RRTS matters. The small island province of Camiguin, although linked by the RRTS to Bohol, Cebu, and Misamis Oriental, experienced a rise in border effects by 2.9. Nonetheless, RORO services to Camiguin are less frequent than in other routes. The Camiguin–Cebu RORO service only operates once a week, and that of Bohol–Camiguin operates once a day. Yet, service frequency is key to reaping the inventory and warehousing savings of RORO transport. JICA’s (2007) feasibility study recommends at least two–three services a day in each route to ensure that delivery vehicles, a prized asset in logistics operations, can return to their origin within a day.

Notwithstanding the findings, it is important to keep in mind some methodological limitations. First, border effects only capture the exporting activities of provinces. Consider the RRTS-linked provinces of Cebu and Leyte. Suppose the RRTS causes Cebu’s exports to Leyte to increase but not vice versa, then Cebu will show up as having lowered the border effects while Leyte’s 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 border effects for Albay, Bohol, and Leyte.

Second, connectivity issues within a province are implicitly assumed to be negligible. This can affect the border estimates. A province may show up as having an increased border effect if municipalities within a province become better connected with each other by land, and this land connectivity is developing faster than the improvements in 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 poor, such that the benefits are confined to the municipality linked by the RRTS but do not trickle through to the rest of the province. Finally, the RRTS can potentially increase border effects if it improves connectivity within a province, since some provinces are made up of several islands. Nonetheless, an examination of intraprovince maritime trade suggests this channel can be ruled out.

V. Conclusion

Domestic trade costs are consequential to the trajectory of economic development of regions but remain understudied because of a lack of subnational data. This paper contributes to the emerging literature on intranational trade costs by estimating the province border effects and mapping how the RORO transport program in the Philippines affected the distribution of trade costs across products, time, and provinces. The exercise involved the construction of two original datasets. The first tracks the historical development of RORO services, and the second retrieves intraprovince and land-based trade flows.

The results suggest that the province border effect in the Philippines is substantial. Conditional on pairwise gravity variables and province characteristics, provinces in the Philippines trade 51 times more with themselves than with other provinces. The introduction of the RRTS reduced this tendency to 32 times—an average attenuation of 35%. This is confirmed by more trade between provinces following the RRTS connection. Province pairs linked by the RRTS trade from 39% to 41.6% more than similar province pairs that do not have access to the same infrastructure.

Provincial border effects are heterogeneous across products and provinces. Among the products, tomatoes, onions, and mangoes have the lowest border effects, while cabbages and pineapples have the highest. This pattern is likely due to a mixture of product characteristics having to do with geographic specificity in production and income elasticity of demand. Over half of the products in the study saw a decline in border effects following the introduction of the RRTS. The border effect practically disappeared for onions and potatoes—products that are produced in limited locations in the Philippines—but the effects were negligible for products that are more income-elastic such as meats and higher-value vegetables.

Border effects are the lowest for major trading provinces such as Cebu and Misamis Oriental, and the highest for provinces that are far from the main economic centers of their regions. The introduction of RRTS is associated with lower border
effects for the provinces near Metro Manila, but it has limited effects for more remote provinces. There are provinces in the Southwestern Philippines that experienced heightened border effects after the introduction of RRTS. This suggests a possible crowding out of trading activities in provinces that are far from the major demand centers, and that operational details such as schedule frequency play an important role in optimizing the trade-cost-reducing potential of the RRTS.

This study provides empirical evidence of the magnitude of domestic trade costs in the Philippines. Anecdotal evidence of high domestic trade costs is plentiful, but to the best of our knowledge, a systematic and nationally comparable assessment is not yet available. This paper demonstrates how transport infrastructure investments like the RRTS can impact trade costs and their distribution. The heterogeneity of the RRTS effects in terms of product and geography can inform policymakers on the nuanced welfare effects of infrastructure programs and how they can be better designed and sequenced to target specific geographic areas for development.

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Appendix 1. Data Appendix

A. Maritime Trade by Origin and Destination

The analysis is limited to a set of 14 agricultural commodities for which price, consumption, production, and trade data are available. This corresponds to 101,159 monthly trade values and volume flows by product in the PSA’s maritime trade database. About 5% of the records exhibit highly improbable unit values, suggesting...
encoding errors. More formally, provincial retail and farmgate prices are used as the 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.

**B. Interprovince Land Trade**

Interprovince land trade flows were derived using the MCSS, which identify the main supply and destination provinces for certain commodities. 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 Metro Manila, the supplying provinces are weighted according to the sample proportions in the survey. For example, Metro Manila 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 Metro Manila imports came from Ilocos Norte, 34% from Pangasinan, and 39% from Nueva Ecija.

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 the importance of markets, as indicated by their sample proportion, and by the availability of production information. These imputations were checked against maritime trade data to avoid double counting. A summary of the geographic flow for each of the commodity in the study is described in Table A1.1.

In cases where only two provinces share the same island (e.g., the eastern and western halves of Mindoro and Negros), land trade between the two neighboring provinces was derived as follows:

\[
X_{ew} = \text{Prod}_e - \sum_{j \neq w} X_{ej} + \sum_{j \neq w} M_{ej} - C_e,
\]

where \( C \) is the consumption in the (e)ast, \( X_{ej} \) represents 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.

**C. Transshipment**

Products exported by Metro Manila have two potential sources—other provinces from mainland Luzon, and international imports (IM). Since MetroM_c \( \geq \) IM is true
Table A1.1. Supply and Demand Provinces for Land-Based Trade

| Product  | Supply Province                  | Demand Province                                           |
|----------|----------------------------------|-----------------------------------------------------------|
| Calamansi| Nueva Ecija                       | Metro Manila                                             |
|          | Metro Manila                     | Laguna, Rizal                                             |
| Cassava  | Apayao, Quirino                  | Isabela                                                   |
|          | Isabela                           | Cagayan                                                   |
|          | Bukidnon                          | Davao del Sur, Misamis Oriental, Sarangani                |
|          | South Cotabato                    | Lhanao del Sur                                            |
|          | Batangas, Quezon, Pampanga        | Metro Manila                                             |
|          | Metro Manila                      | Bulacan, Cavite, Rizal, Tarlac                           |
| Corn     | Bukidnon, Lhanao del Sur          | Misamis Oriental                                          |
|          | South Cotabato                    | Davao del Sur, Misamis Oriental                            |
|          | North Cotabato                    | Davao del Sur, Misamis Oriental                            |
|          | Isabela                           | Batangas, Bulacan, Ilocos Norte, Metro Manila             |
|          | Cagayan                           | Batangas, Bulacan, Ilocos Norte, Metro Manila             |
|          | Ilocos Norte                      | Benguet, Bulacan, Pangasinan                              |
| Hog      | Bulacan                           | Batangas, Metro Manila, Nueva Ecija                       |
|          | Davao del Norte, Sarangani, South Cotabato | Davao del Sur                                           |
| Mango    | Bulacan, Pangasinan, Zambales     | Metro Manila                                             |
|          | Metro Manila                      | 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                        | Albay, Bataan, Batangas, Bulacan, Pampanga, Zambales      |
|          | Nueva Ecija                       | Batangas, Cavite, Laguna, Quezon, Rizal                   |
| Potato   | Benguet                           | Metro Manila, Pangasinan                                  |
|          | Benguet, Pangasinan               | Nueva Ecija                                               |
|          | Mountain Province                 | Benguet                                                   |
|          | Bukidnon                          | Misamis Oriental                                          |
| Rice     | Cagayan, Isabela, Nueva Ecija, Pangasinan, Tarlac | Metro Manila                                           |
|          | Cagayan                           | Benguet, La Union                                         |
|          | Nueva Ecija                       | Bulacan, Pampanga, Rizal                                  |
|          | Bukidnon                          | Misamis Oriental                                          |
| Tomato   | Pangasinan                        | Metro Manila                                             |
|          | Bukidnon                          | Misamis Oriental, Zamboanga City                           |
|          | Misamis Oriental                  | Zamboanga City                                            |
|          | Nueva Vizcaya                     | Pangasinan                                                 |

Source: Author’s compilation derived from land-based trade data from various Bureau of Agricultural Statistics’ (2003a, 2003b, 2003c, 2003d, 2003e, 2007, 2011a, 2011b, 2013) Marketing Costs Structure Studies and production and consumption data from the Philippine Statistics Authority.
for all products except for corn, it is assumed that international imports are all consumed in Metro Manila and whatever is exported is originally sourced from other provinces that are part of the Luzon Mainland. An implicit assumption is that there is no quality discrimination for destination markets.

For corn, the excess in supplies is likely because they are used as inputs to the feed milling industry, the majority and largest of which are in Metro Manila and the nearby provinces (Cruz 1997). This simplifies the problem since processed feeds move to another product classification. The reaccounting of source provinces is summarized in Table A1.2.

### D. Production Data

Missing information was imputed using the production trend of the region to which a province belongs. Adjustment factors for each product are summarized in Table A1.3.

Production information on hog and chicken meat is not available at the provincial level for the entire period of the study. Production volumes were derived based on quarterly inventories of animals. The quarter with the largest inventory is chosen for each year. This was then converted to liveweight equivalent using 80 kilograms (kg) for hogs and 1.45 kg for chickens. Finally, liveweight was converted into carcass weight by the ratios of 0.70 and 0.77, respectively.

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

MCSS = Marketing Costs Structure Studies.

Source: Author’s compilation derived from various Bureau of Agricultural Statistics’ (2003a, 2003b, 2003c, 2003d, 2003e, 2007, 2011a, 2011b, 2013) Marketing Costs Structure Studies.
A modified method of derivation of production data is necessary in the case of corn because 50% of production is destined for feeds and nonfood use (PSA 2018b). Demand for feeds is accounted for by using: (i) hog and chicken production data, (ii) the feed conversion ratios for livestock and poultry documented in Sison (2014), and (iii) the ratio of backyard to commercial farm inventory from PSA (2018b). This is the same methodology that the Department of Agriculture employs in estimating the annual demand for corn. A fully grown hog of 80 kg is assumed to have consumed from 91.3 kg to 345 kg of feed over its life cycle, while the numbers are from 15.3 kg to 28.8 kg for chickens. The lower values refer to backyard animals, while higher values refer to animals raised on commercial farms.

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

Table A1.3. Production Adjustment Factors

| 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 × 1.45 kg |
|         | Dressed weight: Total liveweight × 0.77 |
| Corn     | kg of corn yields × 0.65           |
| Mango    | 6% as feed and waste              |
| Onion    | 8% as feed and waste; 7% as seed  |
| Pineapple| 6% as feed and waste              |
| Pork     |                                  |
|         | Liveweight: Number slaughtered × 80 kg |
|         | Dressed weight: Total liveweight × 0.70 |
| Potato   | 5% as feed and waste              |
| Rice     | kg of paddy × 0.65                |
| Tomato   | 7% as feed and waste              |

kg = kilogram.

Note: The adjustment factors were used to deflate production volumes in each province to account for waste, seeds, and feeds.

Source: Philippine Statistics Authority. 2018b. Technical Notes on the National Agricultural Statistics. Metro Manila: Philippine Statistics Authority.
Table A1.4.  **Data Concordance at the Provincial Level**

| PSCC  | Commodity Description                              | Price (Monthly) | Production (Annual) | Per-Capita Consumption (Annual) |
|-------|-----------------------------------------------------|----------------|---------------------|---------------------------------|
|       |                                                     | Farmgate       | Wholesale           | Retail                          | Number of heads (inventory) | Pork                           |
| 01221 | Meat of swine, fresh or chilled                     | Hogs for slaughter | Hogs for slaughter | Meat with bones, lean meat, pork (front leg) | Number of heads (inventory) | Pork                           |
| 01222 | Meat of swine, frozen                               |                |                     |                                 |                                |                                |
| 01231 | Poultry not cut in pieces, fresh                    | Chicken native and improved | Chicken native and improved | Chicken fully dressed | Number of birds (inventory) | Chicken                        |
| 01232 | Poultry not cut in pieces, frozen                   |                |                     |                                 |                                |                                |
| 01234 | Poultry cuts and other offal, fresh or chilled      |                |                     |                                 |                                |                                |
| 01235 | Poultry cuts and offal (other than liver), frozen   |                |                     |                                 |                                |                                |
| 04210 | Rice in the husk (paddy or rough rice)              | Paddy fancy, paddy other variety | Paddy fancy, paddy other variety | Rice special, rice premium, well-milled rice, regular milled rice | Paddy | Rice |
| 04231 | Rice, semi or wholly milled, whether or not polished, glazed, parboiled, or converted (excluding broken rice) |                |                     |                                 |                                |                                |

*Continued.*
| PSCC  | Commodity Description                                      | Price (Monthly) | Production (Annual) | Per-Capita Consumption (Annual) |
|-------|------------------------------------------------------------|-----------------|---------------------|---------------------------------|
| 04410 | Maize seed (not including sweet corn), unmilled            | Corngrain white, corngrain yellow | Corngrain white, corngrain yellow | Corngrits (white and yellow) | Yellow corn, white corn | Corn |
| 04490 | Other maize (not including sweet corn), unmilled           |                 |                     |                                 |                                 |                |
| 05410 | Potatoes, fresh or chilled (not including sweet potatoes)  | Potatoes white  | Potatoes white      | Potatoes white                  | Potatoes white                  | Potatoes white |
| 05440 | Tomatoes, fresh or chilled                                | Tomato          | Tomato              | Tomato                          | Tomato                          | Tomato         |
| 05451 | Onions and shallots, fresh or chilled                     | Native (shallot), red creole, white (granex) | Native (shallot), red creole, white (granex) | Red creole, white (granex)     | Onion                           | Onion          |
| 05453 | Cabbage and similar edible brassicas, fresh or chilled     | Cabbage         | Cabbage             | Cabbage                         | Cabbage                         | Cabbage        |
| 05455 | Carrots, turnips, beetroot, salsify, celeriac, radishes, and similar edible roots, fresh or chilled | Carrot          | Carrot              | Carrot                          | Carrot                          | Carrot         |

Continued.
Table A1.4. Continued.

| PSCC  | Commodity Description                                      | Farmgate                  | Wholesale                  | Retail                      | Production (Annual) | Per-Capita Consumption (Annual) |
|-------|------------------------------------------------------------|---------------------------|----------------------------|-----------------------------|---------------------|---------------------------------|
| 05481 | Manioc (cassava), fresh or dried, sliced or in the form of pellets | Cassava dried chips, cassava fresh tubers | Cassava dried chips, cassava fresh tubers | Cassava | Cassava |
| 05729 | Citrus fruit, n.e.s., fresh or dried                        | Calamansi                 | Calamansi                 | Calamansi              | Calamansi  | Calamansi |
| 05730 | Bananas (including plantains), fresh or dried               | Banana latundan, banana saba | Banana latundan, banana saba | Lacatan, latundan, saba | Lacatan, saba | Banana (all varieties) |
| 05795 | Pineapples, fresh or dried                                  | Pineapple Hawaiian         | Pineapple Hawaiian         | Pineapple Hawaiian       | Pineapple     | Pineapple |
| 05797 | Avocados, guavas, mangoes, and mangosteens, fresh or dried  | Mango carabao, mango piko | Mango carabao, mango piko | Mango carabao           | Mango ripe |

n.e.s. = not elsewhere specified, PSCC = Philippine Standard Commodity Classification.
Source: Author’s compilation.
E. Intraprovince Trade

The derivation of intraprovince 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 A1.4.

Appendix 2. Results Appendix

Table A2.1. Gravity Covariates for Product-, Year-, and Province-Specific Border Effect Estimates

|                  | Base Estimates | With RRTS |
|------------------|----------------|-----------|
|                  | (1a) Product   | (2a) Year  | (3a) Province |
| lnDist$_{ij}$    | $-0.38^{***}$  | $-0.41^{***}$ | $-0.46^{***}$ |
|                  | (0.092)        | (0.082)   | (0.077)       |
| Lang$_{ij}$      | 0.27           | 0.20      | -0.17         |
|                  | (0.192)        | (0.185)   | (0.243)       |
| Land$_{ij}$      | 4.30$^{***}$   | 4.37$^{***}$ | 4.02$^{***}$ |
|                  | (0.213)        | (0.189)   | (0.218)       |
| Observations     | 40,650         | 40,650    | 40,650        |
| Origin–year FE   | Yes            | No        | No            |
| Destination–year FE | Yes          | No        | No            |
| Product–year FE  | No             | No        | Yes           |
| Origin FE        | No             | Yes       | No            |
| Destination FE   | No             | Yes       | Yes           |
| Product FE       | No             | Yes       | No            |

FE = fixed effects, RRTS = Roll-On Roll-Off Terminal System.
Notes: The dependent variable is the value of trade between province pairs. The results are estimates from a Poisson pseudo-maximum likelihood estimator with robust standard errors in parentheses clustered at province pairs. The table summarizes coefficients for gravity covariates of regressions estimating the product-, year-, and province-specific border effects. Border effect estimates for the three groups of regressions are summarized in Tables A2.2–A2.4. ***$p < 0.01$.
Source: Author’s calculations.
### Table A2.2. Product Border Effects

|                | Overall Estimate | With RRTS |
|----------------|------------------|-----------|
|                | \( \text{Smprov}_{ij} \) | \( \text{Smprov}_{ij} \) | \( \text{RRTS}_{i,t} \times \text{Smprov}_{ij} \) |
| Banana         | 4.26***          | 5.421***  | -1.078**  |
|                | (0.599)          | (0.741)   | (0.430)   |
| Cabbage        | 5.842***         | 3.358***  | 0.401     |
|                | (1.098)          | (0.850)   | (0.665)   |
| Carrot         | 4.92***          | 2.171**   | 0.163     |
|                | (1.098)          | (1.086)   | (0.687)   |
| Calamansi      | 3.763***         | 3.546***  | 0.146     |
|                | (0.659)          | (1.012)   | (0.606)   |
| Cassava        | 3.34***          | 4.900***  | 0.231     |
|                | (0.921)          | (1.013)   | (0.714)   |
| Chicken        | 4.098***         | 4.524***  | 0.350     |
|                | (0.593)          | (0.741)   | (0.346)   |
| Corn           | 3.369***         | 4.529***  | -0.827**  |
|                | (0.659)          | (0.731)   | (0.405)   |
| Mango          | 2.433***         | 3.292***  | -0.488    |
|                | (0.866)          | (0.643)   | (0.412)   |
| Onion          | 2.622***         | 3.369***  | -3.040*** |
|                | (0.911)          | (1.071)   | (0.956)   |
| Pineapple      | 5.512***         | 7.574***  | -4.635*** |
|                | (0.866)          | (1.023)   | (0.957)   |
| Pork           | 4.308***         | 4.530***  | 0.0296    |
|                | (0.710)          | (0.654)   | (0.387)   |
| Potato         | 3.438***         | 5.836***  | -8.548*** |
|                | (0.958)          | (1.172)   | (1.207)   |
| Rice           | 3.765***         | 4.555***  | -0.563**  |
|                | (0.565)          | (0.682)   | (0.280)   |
| Tomato         | 2.657***         | 3.938***  | -1.094    |
|                | (0.904)          | (1.004)   | (0.674)   |

Observations: 40,650 36,600

**RRTS** = Roll-On Roll-Off Terminal System.

Notes: Column (1) presents the product-specific border effects, \( \hat{\psi}_q \), coefficients of \( \text{Smprov}_{ij} \times \delta^q \). The subcolumns of column (2) summarize the joint estimates for \( \hat{\psi}_q \) and \( \hat{\psi}_{q,RRTS} \). The dependent variable is the value of trade between province pairs. The regressions are estimated using a Poisson pseudo-maximum likelihood estimator with robust standard errors in parentheses clustered at province pairs. Regressions include origin–year and destination–year fixed effects. *** \( p < 0.01 \) and ** \( p < 0.05 \).

Source: Author’s calculations.
### Table A2.3. Province Border Effects Over Time

| Year | Smprov<sub>ij</sub> | Smprov<sub>ij</sub> | RRTS<sub>t, i</sub> × Smprov<sub>ij</sub> |
|------|---------------------|---------------------|-----------------------------------------------|
| 2000 | 3.617 (0.92)        |                     |                                               |
| 2001 | 3.464 (0.92)        |                     |                                               |
| 2002 | 3.518 (0.96)        |                     |                                               |
| 2003 | 3.559 (0.94)        | 2.040*** (0.545)    | −0.305 (0.361)                                |
| 2004 | 3.527 (0.90)        | 2.103*** (0.530)    | −0.533 (0.369)                                |
| 2005 | 3.417 (0.96)        | 2.303*** (0.570)    | −0.826* (0.433)                               |
| 2006 | 3.644 (0.94)        | 2.212*** (0.699)    | −0.380 (0.641)                                |
| 2007 | 3.245 (0.96)        | 2.022*** (0.508)    | −0.646* (0.345)                               |
| 2008 | 3.314 (0.96)        | 2.131*** (0.556)    | −0.684 (0.420)                                |
| 2009 | 3.358 (0.96)        | 2.453*** (0.535)    | −1.030*** (0.359)                             |
| 2010 | 3.334 (0.94)        | 2.572*** (0.527)    | −1.196*** (0.391)                             |
| 2011 | 3.375 (0.92)        | 2.326*** (0.550)    | −0.929** (0.407)                              |
| 2012 | 3.207 (0.94)        | 1.843*** (0.548)    | −0.556 (0.405)                                |
| 2013 | 3.253 (0.94)        | 2.228*** (0.559)    | −0.966** (0.424)                              |
| 2014 | 3.265 (0.96)        | 2.106*** (0.536)    | −0.837** (0.427)                              |

Observations: 40,650 (1) 36,600 (2)

RRTS = Roll-On Roll-Off Terminal System.

Notes: Column (1) presents the year-specific border effects, \( \hat{\psi}_t \), coefficients of Smprov<sub>ij</sub> × Yr<sub>t</sub>. The subcolumns of column (2) summarize the joint estimates for \( \hat{\psi}_t \) and \( \hat{\psi}_{t, \text{RRTS}} \). The dependent variable is the value of trade between province pairs. Regressions are estimated with a Poisson pseudo-maximum likelihood estimator with robust standard errors in parentheses, clustered at province pairs. Regressions include origin, destination, and product fixed effects. ***p < 0.01, **p < 0.05, and *p < 0.1.

Source: Author’s calculations.
Table A2.4. Province-specific Border Effects

| Province                  | Overall Estimates | RRTS          | Province                  | Overall Estimates | RRTS          |
|---------------------------|------------------|---------------|---------------------------|------------------|---------------|
|                           | S_{ij}           | S_{ijt} \times S_{ij} |                           | S_{ij}           | S_{ijt} \times S_{ij} |
| **Province**              | **(1)**          | **(2)**       | **Province**              | **(1)**          | **(2)**       |
| Agusan del Norte          | 3.922***         | 3.742***      | Misamis Occidental        | 4.929***         | 3.922***      | 2.077***      |
| Albay                     | 2.177***         | 2.653***      | Misamis Oriental          | 0.376            | 0.922         | −0.129        |
| Basilan                   | 3.679***         | 1.423*        | Negros Occidental         | 2.310***         | 2.706***      | −0.327        |
| Bataan                    | 5.513***         | 3.590***      | Negros Oriental           | 3.090***         | 3.734***      | −0.315        |
| Batangas                  | 4.793***         | 6.170***      | Northern Samar            | 6.144***         |               |              |
| Benguet                   | 3.636***         | −1.427***     | Nueva Ecija               | 5.811***         |               |              |
| Bohol                     | 4.513***         | 4.555***      | Occidental Mindoro        | 3.869***         | 4.336***      | −0.504***     |
| Bulacan                   | 3.843***         | 0.511*        | Oriental Mindoro          | 0.0676           | 1.859         | −0.677***     |
| Cagayan                   | 7.135***         |               | Palawan                   | 4.470***         | 4.443***      | 0.813***      |
| Camarines Sur             | 5.218***         |               | Pampanga                  | 5.127***         |               |              |
| Camiguin                  | 8.193***         | 2.889**       | Pangasinan                | 1.740**          |               |              |
| Catanduanes               | 6.598***         |               | Quezon                    | 7.873***         | 7.198***      | 1.008         |
| Cavite                    | 4.908***         |               | Romblon                   | 10.02***         | 9.680***      | 0.492         |
| Cebu                      | −0.137           | 0.250         | −0.158                    | 7.134***         | 6.239***      | 2.832***      |
| Davao del Sur             | 2.822***         |               | Sarangani                 | 0.145            |               |              |
| Davao Oriental            | 9.241***         |               | Siquijor                  | 6.281***         | 6.803***      | −0.00864      |
| Ilocos Norte              | 0.188            |               | Sorsogon                  | 8.205***         | 6.285***      | 3.242***      |
| Ilocos Sur                | 9.495***         |               | South Cotabato            | 3.541***         |               |              |
| Iloilo                    | 3.053***         | 2.485***      | Southern Leyte            | 5.107***         | 5.168***      | 0.249         |
| La Union                  | 5.282***         | 0.588*        | Sulu                      | 4.034***         | 3.116***      | 1.673***      |
| Laguna                    | 4.253***         |               | Surigao del Norte         | 3.124***         | 2.867***      | 0.0946        |
| Lanao del Norte           | 6.113***         | 6.022***      | Surigao del Sur           | 4.650***         |               |              |
| Lanao del Sur             | 2.983**          | 0.440         | Tarlac                    | 5.350***         |               |              |

Continued.
Table A2.4.  Continued.

| Province       | Smprov$_{ij}$ | Smprov$_{ij}$ | RRTS$_{i,t} \times$ Smprov$_{ij}$ | Province       | Smprov$_{ij}$ | Smprov$_{ij}$ | RRTS$_{i,t} \times$ Smprov$_{ij}$ |
|----------------|---------------|---------------|-----------------------------------|----------------|---------------|-----------------------------------|
| Leyte          | 5.554***      | 4.535***      | 1.102**                           | Tawi-Tawi      | 5.229***      | 3.832***                          |
| Maguindanao    | 8.544***      |               |                                   | Zamboanga Norte| 6.659***      | 6.719***                          |
| Marinduque     | -2.091        | -0.584        | -1.717*                           | Zamboanga del Sur| 2.985*       | 1.839*                            |
| Masbate        | 6.297***      | 5.269***      | 0.747                             |                |               |                                   |

RRTS = Roll-On Roll-Off Terminal System.

Notes: Column (1) presents the province-specific border effects, $\hat{\psi}_b$, coefficients of Smprov$_{ij} \times \eta_i$. The subcolumns of column (2) summarize the joint estimates for $\hat{\psi}_b$ and $\hat{\psi}_{i,RRTS}$. The dependent variable is the value of trade between province pairs. Regressions are estimated with a Poisson pseudo-maximum likelihood estimator with robust standard errors in parentheses, clustered at province pairs. Regressions include destination–year and product–year fixed effects. ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

Source: Author’s calculations.