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Mind the Gap: Trade Costs and Markups in the Philippines

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15 September 2020

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1 Introduction

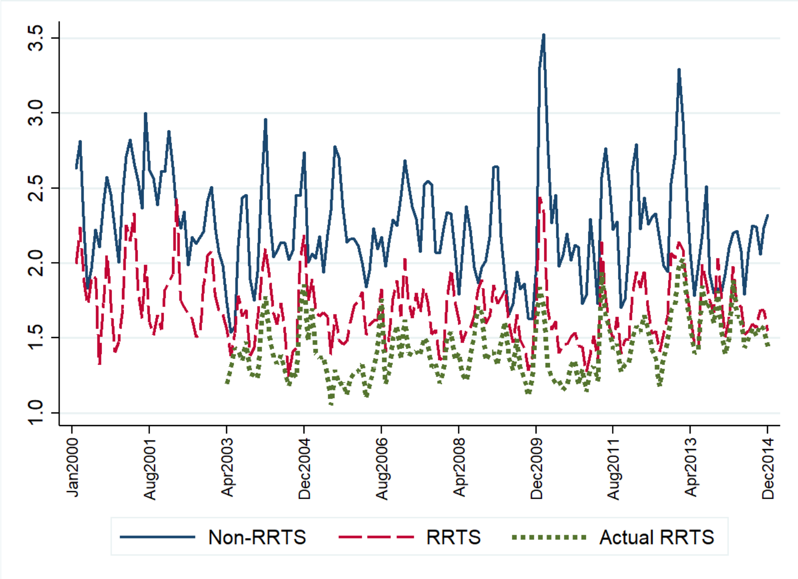
The Philippine Government launched the Roll-on Roll-off (RORO) Terminal System (RRTS) in 2003 with the aim of bringing down maritime transport costs within the Philippines. The RRTS integrates land-based highways with maritime routes of RORO ships to create a seamless interface between land and sea transport. Using RORO ships, a cargo-bearing truck can directly board on and off the ship in origin and destination ports, and make direct deliveries to institutional buyers. The sidestepping of cargo handling together with the simplified logistics and inventory operations represent a streamlined trade process that have been demonstrated to reduce trade costs (Go, 2020).

Trade costs drive a wedge between prices in origin and destination. This paper investigates the effect of RRTS-associated trade costs reductions on two aspects of spatial price patterns of agricultural products. First, I estimate the direct impact of RRTS on price gaps between origin and destination provinces. Ideally, lower trade costs reduce marketing costs and hence lead to smaller differences in spatial prices. For example, the expansion of the railway network in colonial India reduced transport costs and narrowed interregional price gaps between markets (Donaldson, 2018).

Second, and more subtly, I examine the impact of RRTS on markups. Markups form part of the price difference between markets, and are affected by the interaction between trade costs and market structure (Amiti et al., 2014, 2019; Atkin and Donaldson, 2020). Trade costs play a key role in enabling firms to price-to-market (Atkeson and Burstein, 2008). In a low trade costs world, competition arbitrages excess margins away, making discriminatory pricing non-viable.

This study uses a dataset that maps the actual supplier-market relationship of agricultural products between provinces, and information that tracks the availability of RRTS services to province pairs over time. The agricultural focus is primarily driven by data availability, but nonetheless coincides with the goals of the RRTS to spur rural development. Trade cost reduction from the RRTS has been demonstrated to result in trading patterns that confer advantage to agricultural products, which are traded in greater variety and

Figure 1: Mean spatial price gap ratio by RRTS status



Source: Author based on PSA (2018).

frequency along RRTS routes (Go, 2020).

Figure 1 presents the average origin-destination price gap ratio between province pairs without RRTS (solid line), pairs that eventually became part of the RRTS regardless of the time of connection (long dashed line), and pairs according to their actual connection status (short dashed line). Even prior to the program in 2003, province pairs that eventually had RRTS already exhibited lower price gaps compared to non-RRTS province pairs. Nonetheless, the introduction of the RRTS generally coincides with lower price gaps as can be seen by the wedge between the long and short dashed lines in the early stages of the RRTS program.

Table 1 shows that except in the case of mangoes, average price gap ratios are smaller in RRTS province pairs than in pairs that did not get RRTS access. Price differences also tend to be less dispersed in RRTS connected pairs. However, there are three cases where standard deviations suggest the possibility of greater volatility with RRTS connection — corn, mangoes, and onions.

Table 1: Mean price gap ratio by product

	Non-RRTS			**RRTS**			**Actual RRTS**		
	Mean gap ratio	Standard dev.	Obs.	Mean gap ratio	Standard dev.	Obs.	Mean gap ratio	Standard dev.	Obs.
Banana	2.21	1.16	6,570	2.08	0.90	1,788	1.71	0.64	948
Cabbage	3.76	2.36	1,971	3.17	2.31	1,959	2.51	1.88	730
Calamansi	2.74	2.84	5,357	1.37	1.33	702	1.47	1.33	513
Carrots	3.55	3.01	4,301	4.17	3.58	771	3.43	3.51	395
Coconut	3.10	1.56	1,365	2.23	1.29	548	2.07	1.11	294
Corn	0.51	0.27	492	0.35	0.29	293	0.39	0.29	129
Eggs	0.28	0.13	1,137	0.28	0.13	3,399	0.26	0.12	2,037
Mango	1.41	0.83	2,673	1.56	1.27	1,635	1.59	1.30	942
Onions	1.87	1.33	7,925	1.91	1.33	665	1.83	1.38	339
Pineapple	5.77	3.81	1,385	3.35	1.65	596	3.39	1.45	231
Potato	1.67	0.92	4,607	1.55	0.90	718	1.53	0.96	357
Rice	1.29	0.33	8,099	1.21	0.32	5,611	1.20	0.32	3,245
Tomato	2.59	2.02	2,828	2.55	1.88	1,676	2.33	1.66	795
Overall	2.14	2.01	48,710	1.69	1.68	20,361	1.45	1.42	10,955

I exploit local weather shocks as sources of exogenous price increases to uncover the RRTS effects on markups. Price shocks are opportunities to distinguish the impact of RRTS on markups from its effect on the marginal costs of trade, and hence test for its competitive effects on shipping and intermediation. Local weather shocks create a setting with three types of supplying provinces for a product k: (i) provinces directly affected by the weather shock; (ii) provinces where supplies are unaffected and have RRTS access; and finally, (iii) provinces where supplies are unaffected but are not connected by RRTS. The latter two sets of provinces can benefit from higher prices during episodes of sudden supply scarcity from the temporary elimination of a competing supplier province. In the presence of RRTS-induced competition in shipping and intermediation, the greater part of the price surplus from the weather shock should accrue to farmers and or consumers in connected provinces.

The results show that conditional on distance, price gap as a proportion of farmgate prices are on average 28% narrower in province pairs that are connected by RRTS compared to similar pairs that are unconnected. This is because RRTS supplier provinces enjoy higher farmgate prices without the corresponding price increase in their retail markets. RRTS connection also leads to a markup distribution that is overall welfare enhancing. During episodes of weather shocks, provinces where supplies are undamaged and are RRTS-linked experience larger passthroughs of price increases to farmgate prices compared to their unconnected counterparts. This implies revenue gains for RRTS farmers. Their gains do not come at the expense of consumers. Retail prices in RRTS connected markets are not significantly higher than unconnected provinces. The combined effects lead to a reduction in price gaps during price shocks, and suggest a squeezing of shipping and intermediary markups consistent with a competition inducing effect of the RRTS. Finally, there is no evidence that the RRTS significantly affected the volatility of farmgate or consumer prices.

2 Context: The Philippines and the RRTS

The Philippines is an archipelago of over 7,000 islands and maritime transport plays an important role in the economy. In 2017, domestic maritime trade amounted to USD 15.3 billion or around 5% of national output. The country's economic center is the capital Metro Manila, which accounts for 38% of the gross domestic product (PSA, 2019). Mega Manila, which encompass the capital and the neighboring regions of Central and Southern Luzon, together account for 62% of national output. One of the stated goals of the RRTS is to facilitate trade and movement of people between the more affluent regions of Luzon and the islands of Visayas and Mindanao in the central and southern part of the country, where agriculture continues to play a substantial role in output and employment. See Figure 2.

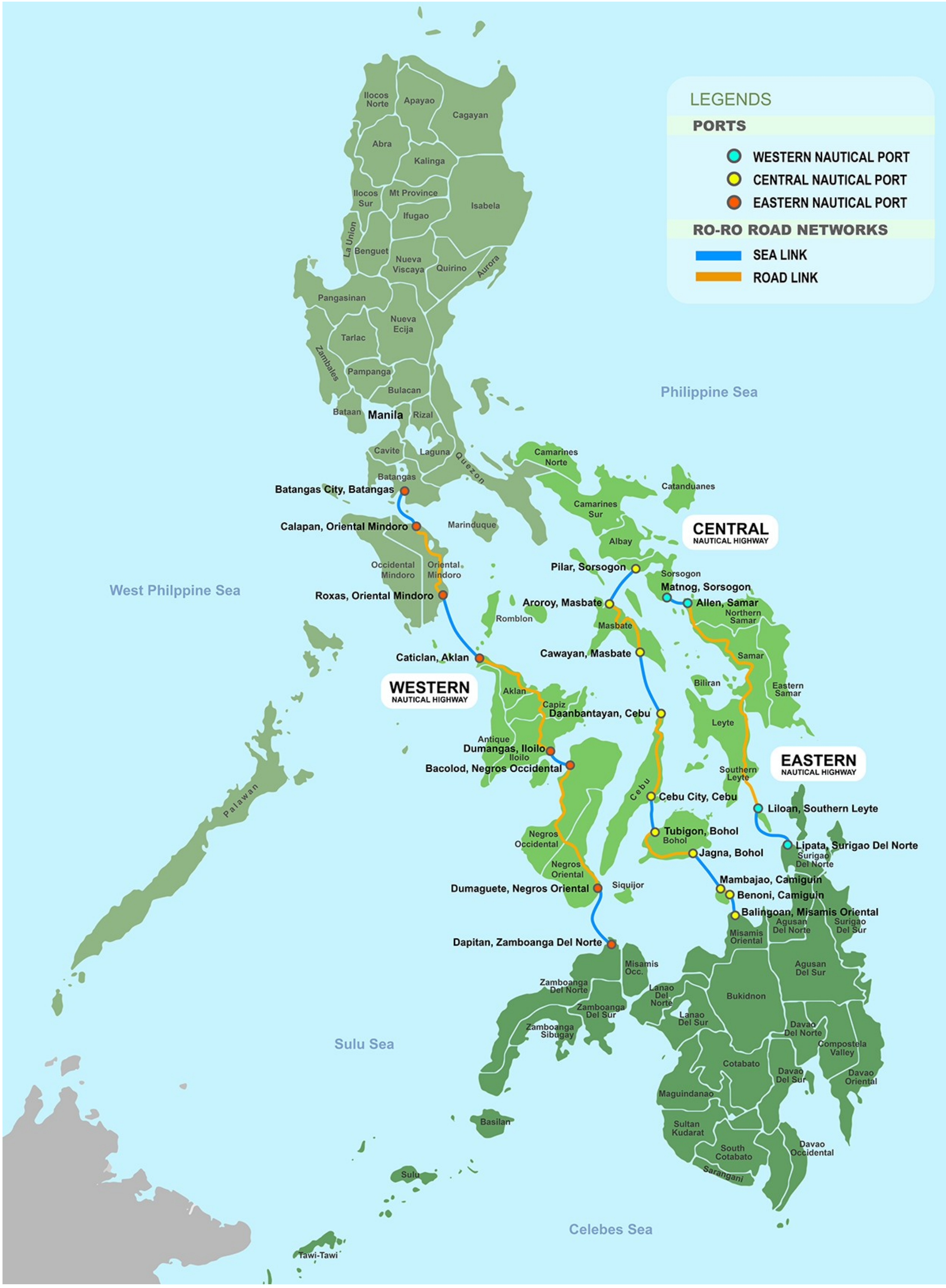
Domestic maritime shipping in the Philippines has been notoriously expensive. In the early 2000s, shipping a twenty-foot equivalent unit (TEU) container from Davao in the country's south to Manila cost USD 1.50 per nautical mile. In comparison, a TEU from Bangkok, Thailand or Port Klang, Malaysia to Manila costs around USD 0.50 (Basilio, 2008). Shipping and ports represent approximately 30% of wholesale prices of products, while total logistics costs can take up as much as 53%. This is substantially higher than other countries in the region where these expenses comprise less than 20% of wholesale prices (World Bank, 2014).

Against this backdrop, the RRTS was introduced in January 2003 through Executive Order 170 as a flagship project of the Office of the President. The overarching goal is to reduce domestic trade cost through the extensive use of RORO ships to facilitate intermodal transport by sea and land across the islands. The RRTS has three main vertical trunks which are called 'nautical highways' as shown Figure 2, that connect Luzon all the way to Mindanao. There are also lateral links that connect the central islands with each other.

The reforms that came with the RRTS are twofold. One group, directly affects shipping activities – the waiving of cargo handling and wharfage dues; freight charging based on lane meter;[1] registration fees in lieu of port author-

[1]Instead of commodity classification, freight is charged based on the space occupied by

Figure 2: The Philippines and the RRTS



Note: Lateral RORO services are not shown for purposes of readability
Source: Author

ities' share in port revenues; and simplified documentary requirements vis-à-vis conventional shipping. Another group promoted investments in RORO ports and ships – the participation of private ports; and financing from the Development Bank of the Philippines for port development and vessel acquisition.

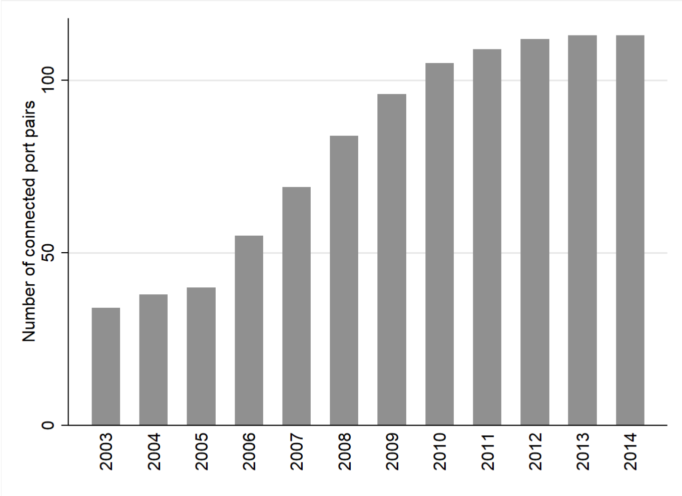
There were RORO operations in the Philippines before the RRTS. The Batangas City-Calapan route in the Western trunk was already experiencing growth in RORO-carried trade in the early 1990s. Likewise, RORO ships serviced routes in the Eastern trunk and a number of connections within the Western and Central nautical highways before 2003. Nonetheless, RORO as a transport mode did not take off prior to the RRTS. Its development was discouraged by bureaucratic controls and delays, as well as by irrational cargo handling policies. RORO ships had to pay cargo handling fees even when this service was unnecessary. Moreover, truck "clearances" were required for interisland movement as if cargoes were moving from one country to another (USAID, 1994). Llanto et al. (2005) also noted a conflict of interest between the Philippine Ports Authority (PPA) and the deployment of RORO ships. The PPA revenue generating structure was biased towards domestic cargo handling, which provide 18% of the total revenues from port operations.

Since the introduction of the program, the number of RRTS routes grew from 36 in 2003 to cover 113 routes by 2014. The most dramatic increases occurred between 2005 to 2009 (see Figure 3). The plateauing of new routes from 2010 onward coincides with a change in government that did not promote the RRTS as a priority project.

The choice of RRTS routes and their sequence of development were originally based on a scoring system which factored in existing and anticipated traffic demand; network formation potential; absorption capacity; and cost of RORO port construction or rehabilitation (JICA, 1992). By the mid 2000s, priorities have shifted to network formation, particularly toward enhancing connectivity surrounding the main trunks of the nautical highways (JICA, 2007). These, together with topographical and geological factors explain the deviations from planned 1992 roll-out sequence as shown in Figure A-1. In

the cargo and the distance that the vessel traveled.

Figure 3: Number of RRTS linkages over time



Source: Author

2014, there were 80 routes that were not evaluated by the 1992 plans but have RORO services. There were also seven routes in the original plan that remained undeveloped.

The two most direct trade cost reducing aspects of the RRTS are described briefly:[2]

> *Land-sea transport modal interface.* Cargo handling is one of the most time consuming and labor intensive processes in maritime trade (Brancaccio et al., 2019). RRTS leads to substantial financial and time savings because cargo-bearing trucks can arrive at a port, load directly into a RORO ship, and continue to their final destinations. The time savings are particularly important for perishable agricultural goods, and is expected to manifest strongly in passthrough of price changes because of shorter turnover period and marketing horizon (Ahn and Lee, 2015).
>
> The possibility of direct delivery through RRTS also implies savings in inventory costs, which are likely to be consequential. The

[2]Other trade cost reducing aspects of the RRTS are less immediately related to the price effects investigated in this paper. The interested reader is referred to Go (2020) for a more exhaustive treatment.

domestic logistics performance index documents that 50% of surveyed freight forwarders deem warehousing and transloading fees too high, and warehousing facilities are poor. Compulsory warehousing and transloading were also identified as the top source of major delays in ports (World Bank, 2018).

Scale and service frequency. The shipping industry has a high threshold of minimum efficient scale. The high costs of domestic shipping is in fact largely attributed to the lack of scale in areas outside regional centers such as Metro Manila and Cebu. The smaller RORO ships are better suited to trade along minor routes.[3] The median RORO ship has a capacity of 160 TEUs, while the median domestic container ship can handle over twice this volume (PLSA, 2017). The lower fixed costs of operating RORO ships means that more frequent trips and faster turnarounds are feasible. These, in turn, reinforce savings in storage, warehousing, and other logistics-related costs.

Smaller scale and greater frequency mean that RRTS can cover a broader network of feeder routes, opening regular trade schedules in areas where none previously existed. For example, regular trade between Jagna, Bohol and Mambadjao, Camiguin coincided with RRTS access. The same is observed between various cities for the provinces of Leyte and Cebu. Earlier, it was common for agricultural products in Mindanao to be first shipped to Manila and then re-shipped to other regions through a hub-spoke maritime network (JICA, 2007).

There are evidence that RRTS has been successful in reducing trade costs. Port-pairs that are connected by RRTS trade 35% more compared with similar unconnected pairs. Transactions are also 7 to 9% more frequent along

[3]RORO ships do not directly compete with liners. The latter's comparative advantage is on long haul, large scale trade whereas the RORO is suited to short haul routes. This is a practical consequence of ship sizes, the cost of alternative transport modes, and the ideal turnaround time for delivery operations that use RORO. Beyond 200 kilometers, liners become at least as competitive as the RORO (JICA, 2007).

RRTS routes, an indication of declining trade to inventory costs ratio (Go, 2020). Both these forces are expected strengthen contemporaneous price relationships between source and destination provinces of traded products.

While not directly stated as a program objective, an important channel through which RRTS can reduce trade costs is through its effect on the market structure of shipping and intermediation services. This competitive effect is crucial and should manifest in reduced markups. Trade costs savings from the RRTS would benefit neither consumers nor producers if services that mediate between the two markets do not become more competitive.

The scale required for shipping operations gives rise to an industry that is considerably concentrated. Forty percent of the domestic cargo services in liner routes are serviced by only one shipping operator, and the share rises to 77% for feeder routes (Austria, 2002; World Bank, 2014). Limited data suggest that up to 70% of RRTS routes are serviced by only one shipping company as of 2014. There are busy routes like Batangas City-Calapan and Dumangas-Iloilo City that have four or five RORO operators but minor routes tend to have sole providers. However, the pervasiveness of single-operator routes could be reflective of limited absorption capacities rather than lack of competition. Instead, greater contestability of shipping services from the RRTS could serve as a sufficient disciplinary mechanism. Smaller ships and government support for RORO vessel acquisition mean lower costs of market entry for shipping operators. Moreover, lanemeter freight charging means greater transparency in detecting excess profits.

The trade cost reduction from the RRTS also lowers the fixed costs of entry for intermediaries who source and market agricultural produce between locations. Agricultural producers in the Philippines tend to have small land holdings with 99% of them being household operated. Close to 60% of these are less than a hectare (PSA, 2012). Most of these small farmers rely on intermediaries to market their produce (Intal and Ranit, 2001; Andriesse, 2018). While vertical integration through contract growing arrangements are common in the livestock and poultry sector, and more prevalent in plantation crops for exports such as bananas and pineapples, other products and varieties destined for local consumption remain dependent on intermediation services. Various marketing cost structure studies (MCSS) of the Bureau of Agricultural Statistics (BAS) confirm this, and moreover paint a multilayered intermediation structure where the smallest consolidators are typically *barangay* (village) assemblers, followed by municipal and provincial consolidators, and regional and interregional assemblers who can also be operators of buying stations, and finally retailers. See Table A-1.

Intermediary market power has been shown to respond strongly to trade costs. In the context of an oligopolistic trucking service market, the increase in transport costs from the withdrawal of fuel subsidies in Ethiopia reduced purchase prices and incomes of grain farmers (Fuje, 2019). Transaction level data also reveal that the detrimental effects of monopsonistic intermediation is more pronounced for remoter Ethiopian grain producers (Osborne, 2005). In Uganda, intermediaries in the coffee market capture most of the rents from world price increases (Fafchamps and Hill, 2008). Intermediary market power can also mean higher prices food prices for consumers as Bergquist (2018) finds in Kenya.

3 Empirical Strategy

Agricultural products are ideal for spatial price analyses because supplies tend to be inelastic in the short run, and as such have strong price linkages in horizontal and downstream markets (Ahn and Lee, 2015). I study the effects of the RRTS on pricing patterns of 13 agricultural products that are largely produced and consumed within the Philippines with little or modest transformation.[4] This minimizes effects of price movements that originate in upstream and international markets.

The expected value of the difference between retail price $P^k_{d,t}$ and farmgate price $P^k_{o,t}$ of product k in month-year t is a function of cost shifters such as those traditionally used in gravity models like distance, colonial ties, language, etc., represented by $\tau^k_{od,t}$ in equation 1. Following Atkin and Donaldson (2020), I consider a model of imperfect competition where markups

[4] The share of imports to domestic consumption are most substantial for rice which averaged 11% from 2000 to 2014. The share is minimal for the other products.

$\mu^k_{od,t}$ also vary by $\tau^k_{od,t}$ through its effects on the marginal cost of marketing $c^k_{od,t}$, and the market structure dynamics in origin and destination markets (η^k_o, γ^k_d).

$$E[P^k_{d,t} - P^k_{o,t}] = \tau^k_{od,t} + \mu(c(\tau^k_{od,t}), \eta^k_o, \gamma^k_d) \tag{1}$$

3.1 RRTS and spatial price gaps

The analyses of price relationships between origin and destination is made possible by mapping supplier provinces to their actual markets. This is a step forward from most spatial price analyses that focus on their co-movement. The mapping process is described in detail in Section 4.

A gravity-like equation is used to estimate the effect of RRTS connection to price gaps. In equation 2, the dependent variable is $PGap^k_{od,t}$, the price gap between the retail price in market province d, and the farmgate price in supplying province o for product k in time t. Alternatively, the price gap is also expressed as a ratio to the farmgate price, $PRatio^k_{od,t} = \frac{PGap^k_{od,t}}{P^k_{o,t}}$. The level definition better captures the lane meter charging feature of RRTS which confers disproportionate advantage on higher value products (Go, 2020). On the other hand, the ratio definition normalizes against unit prices and better represents effects across products. The average farmgate and retail prices by product are shown in Table 2.

$$\begin{aligned} PGap^k_{od,t} = \alpha_0 + \delta\, RRTS_{od,t} + \beta_1\, lnDist_{od} + \beta_2\, Lang_{od} + \\ \eta_{oy} + \gamma_{dy} + \omega_{km} + \epsilon^k_{od,t} \end{aligned} \tag{2}$$

In equation 2, $lnDist_{od}$ is the logarithm of distance between the centroids of origin and destination provinces, $Lang_{od}$ is a dummy variable equal to one when the majority of the population in a province pair shares a common language.[5] The introduction of RRTS is related to changes in $\tau^k_{od,t}$

[5]Religion is not included as a control variable because a variance inflation factor analysis reveals high collinearity with distance. Eighty percent of the population in the Philippines identify as Roman Catholic, and other religions such as Islam exhibit strong patterns of

Table 2: Average farmgate and retail prices

	Farmgate		**Retail**		**Obs.**
	PhP/kilo	S.D.	PhP/kilo	S.D.	
Banana	6.7	3.9	18.9	7.7	8,358
Cabbage	11.6	6.9	41.4	14.8	3,930
Calamansi	14.4	7.8	39.4	16.0	6,059
Carrots	16.5	9.2	59.2	21.2	5,072
Coconut	4.1	2.0	14.2	5.4	1,913
Corn	10.8	2.9	15.4	4.3	785
Eggs	73.5	17.2	93.0	19.1	4,536
Mango	26.6	8.9	60.3	18.2	4,308
Onions	23.7	12.1	59.7	24.1	8,590
Pineapple	7.8	4.5	37.5	12.9	1,981
Potato	20.8	9.3	50.3	16.8	5,325
Rice	12.2	3.6	27.3	7.8	13,710
Tomato	11.3	6.4	32.4	12.3	4,504
Overall	18.6	17.9	42.8	25.4	69,071

using $RRTS_{od,t}$, which is a dummy variable that is equal to one once a province pair becomes connected by the RRTS. Finally, the estimating equation also includes province-year fixed effects by origin η_{oy}, destination γ_{dy}, and product-month fixed effects ω_{km} to control for product seasonality.

Anticipation of trade growth can encourage province-pairs to invest in an RRTS connection. The shift in route development priority toward network formation around the nautical highways in the mid 2000s may also lead some provinces to foresee connection. Deviations from route scores in Figure A-1 suggest some degree of exogeneity in the sequence of investments, but RRTS investment itself is unlikely to be independent of origin-destination characteristics. This is especially true in the context of analyses at the province level. With more than 1,400 seaports nationwide, each of the 66 coastal provinces have multiple ports that are candidates for the RRTS. Against this backdrop, selection is addressed through pair fixed effects that control for time-invariant pair characteristics that influence the likelihood of RRTS connection. This also controls for long-standing, product-specific market structure relationships between provinces. The identification strategy follows from the literature that estimate the effects of regional trade agreement

geographical clustering.

on trade flows between country pairs (Head and Mayer, 2014). The suite of province-pair fixed effects is introduced as α_{od} in equation 3. Product seasonality is accounted for by ω_{km}, and changes in market conditions within the country are captured by a set of year dummies ϕ_y. This leaves $\delta\, RRTS_{od,t}$ to capture the variation coming from the switching on of the RRTS connection for a pair of provinces.

$$PGap^k_{od,t} = \alpha_0 + \alpha_{od} + \delta\, RRTS_{od,t} + \omega_{km} + \phi_y + \epsilon^k_{od,t} \tag{3}$$

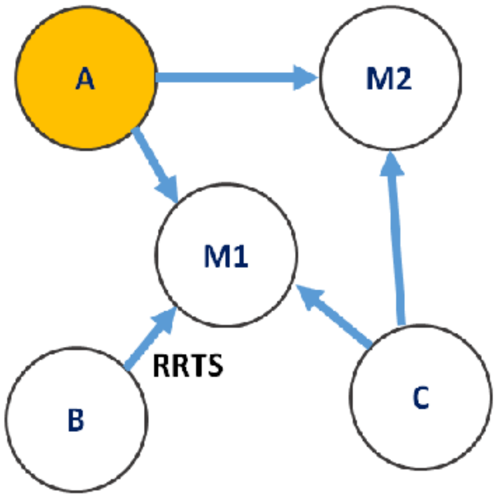
3.2 RRTS and surplus distribution

In Equation 1, RRTS is shown to directly influence $\tau^k_{od,t}$ because it brings down both the fixed and variable components of trade costs. In doing so, RRTS also affects $c^k_{od,t}$ and by extension $\mu^k_{od,t}$. At the same time, $c^k_{od,t}$ varies with product characteristics. For example, higher value products tend to have higher marginal costs of marketing because they require more specialized handling and have higher insurance costs (Hummels et al., 2009).

In the absence of detailed price cost margin information, I rely on an identification strategy that estimates the effect of RRTS on markups through price shocks from local weather disturbances. Price changes from weather shocks offer a scenario whereby product-specific marginal costs are held constant, while markup opportunities vary with RRTS connection. The differential passthrough rates of the price increase by RRTS status are taken as indicative of differences in surplus distribution. Under oligopolistic settings, passthrough rates capture markup response to price shocks (Atkin and Donaldson, 2020; Weyl and Fabinger, 2013). I am unfortunately unable to distinguish between the markup of intermediaries and shipping companies because of data limitations. Instead, based on the assumption of imperfect competition in shipping and intermediation services, existing literature suggests that trade cost reduction squeezes the markups of both sets of agents (Bergquist, 2018; Fuje, 2019; Hummels et al., 2009).

Figure 4 illustrates the identification setting. Three provinces, A, B, and C, are major suppliers of the same product to a common market, M1. A

Figure 4: Transmission of price shocks and RRTS



Source: Author

storm affects A in time t without affecting supplies in B and C. Because A is a major supplier and overall supplies of k are inelastic in the short run; the weather shock despite being local to A, induces a sudden supply scarcity across all markets which translates into an overall price increase. Farmers in B and C stand to benefit from the circumstances. However, the RRTS connection between B and M1 should mean that farmers in B will benefit more than farmers in province C from the price rise because of greater competition in shipping and intermediation. At the same time, M1, which has at least one RRTS connection should experience less increase in retail prices compared to the completely unconnected M2. The combined effects in farmgate and retail prices should reduce price gaps in between B and M1 more than between C and M2.

Price changes from weather shocks in affected provinces are measured as the deviation of farmgate prices (deflated by the provincial monthly CPI) from their monthly average from 2000 to 2014, $\Delta P^k_{\tilde{o},t}$. In equation 4, $\Delta P^k_{\tilde{o},t} \times RRTS_{od,t}$ captures the differential price gap changes based on RRTS linkage status of unaffected supply provinces. $\tilde{o}$ refers to supplying provinces that are affected by the weather shock in time t, which needs to be distinguished from unaffected provinces, o.

$$PGap^k_{od,t} = \alpha_0 + \alpha_{od} + \delta_1\, RRTS_{od,t} + \delta_2\, \Delta P^k_{\tilde{o},t} + \delta_3\, \Delta P^k_{\tilde{o},t} \times RRTS_{od,t} + \omega_{km} + \phi_y + \epsilon^k_{od,t} \quad (4)$$

$\Delta P^k_{\tilde{o},t}$ is instrumented with the deviation of rainfall levels from the average precipitation of a province for a given month from 1970 to 2018, $\Delta Rain_{\tilde{o},t}$. This addresses the bias that may arise from the simultaneous relationship between $\Delta P^k_{\tilde{o},t}$ and $PGap^k_{od,t}$.

Equation 5 describes the first stage of the IV estimation. RRTS is treated as exogenous given the pair fixed effects that control for selection into RRTS investment. This allows $\Delta Rain_{\tilde{o},t} \times RRTS_{od,t}$ to instrument for $\Delta P^k_{\tilde{o},t} \times RRTS_{od,t}$ to identify the differential effects of the price shocks by RRTS status.

$$\Delta P^k_{\tilde{o},t} = \alpha_0 + \alpha_{od} + \delta_1\, RRTS_{od,t} + \delta_2\, \Delta Rain_{\tilde{o},t} + \delta_3\, \Delta Rain_{\tilde{o},t} \times RRTS_{od,t} + \omega_{km} + \phi_y + \epsilon^k_{od,t} \quad (5)$$

Note that the structural equation in 4 only estimates the effect of the weather shock in $\tilde{o}$ to the price gap in province pairs with o as supplier. Provinces that directly experience the weather shock are excluded because their prices may change for reasons that do not reflect improved revenue opportunities such as input sourcing difficulties and infrastructure damage.

The exclusion restriction requires that the effect of $\Delta Rain_{\tilde{o},t}$ on prices in o is only mediated through changes in prices in $\tilde{o}$. This assumption is valid provided that a weather shock is sufficiently localized and leaves the supplies of some provinces unaffected, which is borne out by the weather data.

However, other threats to identification remain. First, weather shocks can change the direction of trade and hence prices in unaffected provinces. For example, governments and aid organizations can divert essential food stuffs like grains from original markets to affected supplier provinces. Second, scarcity can induce a redirection to areas with large market size and purchasing power such as Metro Manila and Cebu.

Trade data from the Philippine Statistics Authority (PSA) suggest that the first scenario is possible. While import volumes are negatively correlated with weather shocks in destination provinces, the relationship is statistically insignificant when considering only trade in rice. The second scenario is less consistent with actual trade patterns. There is no observed tendency to redirect exports to Metro Manila or Cebu during times of typhoons. Nonetheless, I progressively reduce the sample to exclude observations on grains, and Metro Manila and Cebu as markets, to preclude these potential channels.

I do not analyze price increases from weather shocks in destinations because these do not persist in the same way that shocks to supplying provinces do. This is a limitation imposed by the monthly nature of the price data and the different periods of data collection for farmgate and retail prices. Farmgate prices are recorded once within the last ten days of the month, whereas retail prices are collected three times per week on weekdays.

4 Data

The analyses focus on products that are (i) either homogeneous or are distinguished by major varieties; (ii) primarily produced and consumed within the Philippines; and (iii) have production locations that exhibit sufficient variation along RRTS linkage status.

Province pairs are limited to those where the mapping of production and consumption provinces is possible; and where contemporaneous farmgate and retail prices are available.

Mapping of origin-destination provinces. Various MCSS of the BAS have information on the main supply and demand locations for particular products. However, these sources cover a limited set of products and moreover only include main supply and demand provinces. I augment the MCSS sample using maritime domestic trade data from the PSA.

The PSA records monthly trade data by port, which is aggregated to the province level. However, there are concerns on transshipment because the records are based on outward coasting manifests which record vessel cargoes from the port of exit. Moreover, some ports serve as exit points for landlocked provinces. I minimize transshipment issues in several ways. First, only provinces that exhibit consistent production surplus from 2000 to 2014 are included as exporting provinces. Surplus is determined by comparing production data with utilization estimates from consumption surveys and the population projection data of the PSA. Second, only provinces that export at least an average of 10% of annual production are considered as supplier provinces. Third, exports from exit ports used by landlocked provinces are attributed to the producer province. For example, highland vegetables being shipped from Batangas or Manila are attributed to Benguet and the Mountain Province weighted according to the producer survey sampling distribution in the MCSS. Finally, the derived origin-destination relationships are verified through interviews with the Department of Agriculture. Figure A-2 in the Appendix illustrates the geographic distribution of exporters by product and RRTS access by 2014.

In reality, a province can be both an importer and exporter of a product because municipalities within a province have different endowments. I am unable to address this limitation since provinces are the smallest unit of observation for prices. For this reason, intraprovincial price observations are excluded from the analyses.

The National Food Authority (NFA) maintains a buffer stock system for rice through a combination of domestic procurement of paddy and rice imports. The PSA Supply Utilization Accounts suggest that NFA procurement activities can account for up to 8% of gross annual supplies. I minimize direct price effects from buffer stock operations by excluding exports from provinces where NFA paddy and rice warehouses are located.

Finally, maritime flows between adjacent provinces that are contiguous by land are also excluded to minimize price effects outside of maritime trade relationships.

Farmgate and retail prices. Monthly farmgate prices are employed for producer provinces, while retail prices are used for destination provinces. These are sourced from the PSA's CountryStat database.

The process of origin-destination mapping and price matching yields thirteen agricultural products, which make up 69,071 observations with 464 origin-destination-product-variety combinations. The mapping across the three data sets is summarized in Table A-2.

Weather shocks. Daily readings of rainfall and wind velocity come from the 59 synoptic stations of the Philippine Atmospheric Geophysical Astronomical Services Administration (PAGASA). These information are used to establish long term weather patterns in each province by month and substantial deviations from them. A province is deemed to have experienced a weather shock when the deviation of accumulated rainfall or the recorded wind velocity for the month exceeds its long term average by more than the interquartile range of its 1970 to 2018 distribution. Based on this criteria, weather shocks affect 4.1% of the observations.[6]

RORO services by route. This historical dataset was constructed with a survey of RORO service providers, complemented by sources from the Maritime Industry Authority, Philippine Ports Authority, PSA, aid agencies, and newspaper articles. The process of building data set is described in Go (2020). RRTS connected province pairs comprise 16% of observations.

5 Results

5.1 RRTS and price gaps

Table 3 summarizes the results from estimating equations 2 and 3. The top panel pertains to results with price gaps in levels as the dependent variable,

[6] I do not consider price shocks from droughts because their effects tend to cover broader geographical swathes than storms. The identification strategy relies on localized effects that leave supplies of some provinces unaffected. Moreover, drought spells, especially those that come from the El Niño Southern Oscillation are preceded by government warnings and are hence better anticipated in agricultural markets.

while the lower panel shows the effects on the price gap ratio.

The first column presents the results from estimating equation 2, which accord with the expectation that distance is associated with larger price gaps. A 10% increase in distance widens price gaps between origin and destination by an average of PhP 0.16 (USD 0.003) per kg. The impact of distance on the price gap ratio is likewise positive although not significant. In column (2) the RRTS effect is allowed to vary by distance thresholds to acknowledge its short-haul advantage. A dummy variable $Short_{od} = 1$ if the distance between a province pair is less than the median distance of RRTS connection for each product. The results show that shorter distances lead to narrower price gaps in both levels and ratio. However, while the effect for short distance RRTS connections in terms of price gap ratio is negative, the estimates also suggest that RRTS is associated with wider gaps in levels.

In columns (3) and (4), the relationship between RRTS and price gaps are estimated using the preferred specification with pair fixed effects (equation 3). The gap widening effect of the RRTS disappears, and RRTS is now associated with a narrower price gap of about PhP 1.3 (USD 0.03) per kg on average. The effect is magnified when the distance between pairs are relatively short, showing gaps to be narrower by PhP 1.7 per kg (1.086 +0.649 significant at 10%). RRTS province pairs also have lower price gap ratios that are on average narrower by 28% when conditioned on distance. The change in results suggest the importance of unobserved province pair characteristics in determining RRTS linkage and accounting for pairwise marketing relationships.[7]

I consider an alternative definition of RRTS in columns (5) to (8). Instead of a binary variable, RRTS access is defined in terms of the number of connections between province pairs. To some extent, connection intensity is already accounted for by province pair fixed effects. For example, the elongated geography of both Cebu and Leyte – two provinces that face each other, are time-invariant pair characteristics that explain the 13 connections between them, even as 76% of connected province pairs have at most

[7] Regressions with dependent variables that assume a period lag between farm and retail price relationships have similar results albeit less precisely estimated.

two links. Against this backdrop, RRTS connection intensity is employed as a crude attempt to account for the number of shipping service providers between a province pair, and hence competition. It is a highly imperfect measure in that it implicitly assumes each route within a province pair as being served by a distinct operator.[8]

The results in columns (5) to (8) largely accord with the outcomes where RRTS is defined as a binary variable. The level regressions suggest that an additional RRTS service between a province reduces the price gap by PhP 0.38 (USD 0.01) per kg, and this is largely driven by short distance RRTS services, which is significant at 5%. The RRTS impact is likewise negative for the price gap ratios albeit statistically insignificant.

[8]The incomplete response rates in the RORO shipping operators survey prevents a comprehensive assessment by route. Limited data suggest that a RORO shipping operator can service several routes within a pair of provinces.

Table 3: RRTS and price gaps

Dependent variable: Price gap level								
		RRTS = (1, 0)				**RRTS = no. of links**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	2.151***	2.558***	-1.347**	-1.086	0.537***	1.186*	-0.382***	-0.021
	(0.790)	(0.979)	(0.605)	(0.883)	(0.164)	(0.637)	(0.132)	(0.600)
RRTS x Short		-1.567		-0.649		-0.659		-0.401
		(1.288)		(1.161)		(0.636)		(0.611)
Short		-3.431***				-1.045		
		(1.250)				(1.443)		
Log distance	1.594**	-0.365			1.729**	0.978		
	(0.754)	(1.089)			(0.813)	(1.170)		
Language	-1.256	-1.274			-0.918	-1.066		
	(0.827)	(0.805)			(0.859)	(0.887)		
								**
Constant	27.01***	39.56***	29.88***	29.82***	26.782***	31.257***	29.18***	29.24***
	(4.792)	(6.627)	(3.808)	(3.791)	(5.181)	7.623791	(3.841)	(3.861)
R-squared	0.682	0.685	0.686	0.686	0.687	0.683	0.686	0.686
Dependent variable: Price gap ratio								
		RRTS = (1, 0)				**RRTS = no. of links**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	0.136*	0.262***	-0.0115	0.101	0.023	0.046	-0.002	0.008
	(0.0805)	(0.0875)	(0.0645)	(0.0826)	(0.017)	(0.065)	(0.0127)	(0.0543)
RRTS x Short		-0.315**		-0.280**		-0.023		-0.011
		(0.126)		(0.127)		(0.067)		(0.0531)
Short		-0.266**				-0.050		
		(0.130)				(0.145)		
Log distance	0.146	-0.0273			0.139	0.104		
	(0.105)	(0.127)			(0.109)	(0.128)		
Language	0.0263	0.0239			0.040	0.034		
	(0.109)	(0.112)			(0.115)	(0.115)		
Constant	-0.339	0.786	1.054***	1.029***	-0.264	-0.057	1.048***	1.049***
	(0.698)	(0.869)	(0.304)	(0.300)	(0.698)	(0.846)	(0.297)	(0.298)
R-squared	0.492	0.493	0.463	0.464	0.4916	0.4917	0.463	0.463
Observations	69,071	69,071	69,071	69,071	69,071	69,071	69,071	69,071
Product-month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Origin-year FE	Yes	Yes	No	No	Yes	Yes	No	No
Dest-year FE	Yes	Yes	No	No	Yes	Yes	No	No
Pair FE	No	No	Yes	Yes	No	No	Yes	Yes
Year FE	No	No	Yes	Yes	No	No	Yes	Yes

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

The price gap reduction associated with the RRTS is welfare enhancing when farmgate price increases are larger than those in retail prices, or when farmgate price reductions translate to decreases that are at least as large in retail markets. Table 4 shows the RRTS effects on farmgate and retail price components of the price gap. The preferred specifications in columns (3) and (4) suggest that RRTS producer provinces enjoy higher farmgate prices without passing on increases to retail prices. On average, a farmer in an RRTS connected supplier province receives PhP 2.9 (USD 0.06) per kg more for their product. This represents a 16% increase in farmgate prices based on the averages reported in Table 2. On the other hand, retail prices in RRTS market provinces are not statistically different than those in unconnected markets. Hence, the reduced price gaps in RRTS pairs observed in Table 3.

The stronger RRTS effects on producer prices compared to retail prices is not surprising. Importing provinces typically source a product from multiple origins. Regardless of RRTS access, a product-destination combination has an average of 5 suppliers. In contrast, the dependence of small farmers on intermediaries means limited options on the final destinations of their products. Under the most ideal conditions, lower transport costs from the RRTS was envisioned to encourage more direct marketing of farmers through cooperatives (Basilio, 2008).

Results using RRTS connection intensity suggest effects of similar directions but are imprecisely estimated, possibly suggesting that the fact of connection matters more than the number of connection once time-invariant characteristics are partialled out.[9]

[9]From hereon, I only present the results from the preferred specification with RRTS as binary variable. Results from estimation with gravity covariates are available upon request. Those that use RRTS connection intensity are in the Appendix.

Table 4: Price gap components

Dependent variable: Farmgate price								
		RRTS = (1, 0)				**RRTS = no. of links**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	0.0543	-0.571	2.916***	3.016***	-0.083	0.031	0.329	1.094
	(0.488)	(0.621)	(0.905)	(1.084)	(0.088)	(0.214)	(0.243)	(0.702)
RRTS x Short		1.262		-0.289		-0.109		-0.850
		(0.897)		(1.571)		(0.234)		(0.737)
Short		0.0506				-0.390		
		(0.468)				(0.521)		
Log distance	-0.675**	-0.490			-0.325	-0.583		
	(0.310)	(0.317)			(0.345)	(0.408)		
Language	-0.548*	-0.483*			-0.104	-0.150		
	(0.292)	(0.281)			(0.310)	(0.300)		
Constant	30.95***	34.67***	20.98***	25.35***	35.703***	37.259***	27.12***	27.25***
	(1.986)	(2.306)	(1.762)	(2.083)	(2.272)	2.70724	(1.914)	(1.896)
R-squared	0.898	0.900	0.871	0.873	0.906	0.9063	0.872	0.873
Dependent variable: Retail price								
		RRTS = (1, 0)				**RRTS = no. of links**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	1.507*	0.332	0.687	0.736	0.453***	1.217*	-0.052	1.073
	(0.776)	(1.031)	(0.973)	(1.304)	(0.176)	(0.635)	(0.228)	(0.871)
RRTS x Short		3.439**		-0.186		-0.768		-1.250
		(1.602)		(1.724)		(0.653)		(0.894)
Short		-0.530				-1.435		
		(0.996)				(1.400)		
Log distance	0.982	-1.660**			1.403*	0.395		
	(0.736)	(0.762)			(0.820)	(1.128)		
Language	-1.441*	-4.034***			-1.022	-1.215		
	(0.736)	(1.324)			(0.800)	(0.821)		
Constant	55.50***	73.73***	50.71***	55.83***	62.485***	68.516***	56.29***	56.48***
	(4.231)	(6.020)	(3.034)	(2.657)	(4.612)	(6.830)	(2.680)	(2.723)
R-squared	0.848	0.854	0.847	0.853	0.865	0.8653	0.853	0.854
Observations	69,071	69,071	69,071	69,071	69,071	69,071	69,071	69,071
Product-month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Origin-year FE	Yes	Yes	No	No	Yes	Yes	No	No
Dest-year FE	Yes	Yes	No	No	Yes	Yes	No	No
Pair FE	No	No	Yes	Yes	No	No	Yes	Yes
Year FE	No	No	Yes	Yes	No	No	Yes	Yes

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

Table 5: RRTS and unit values

Dependent variable: Price gap level				
	All		Without Eggs	
	(1)	(2)	(3)	(4)
RRTS	1.103	1.072	-2.752	-2.415
	(0.962)	(0.959)	(3.120)	(2.964)
$RRTS \times Uval$	-0.103***	-0.0829**	0.152	0.231
	(0.032)	(0.035)	(0.234)	(0.248)
$RRTS \times Uval \times Short$		-0.0512		-0.246**
		(0.0395)		(0.121)
Uval	1.200***	1.203***	1.077***	1.084***
	(0.387)	(0.387)	(0.353)	(0.351)
Constant	-80.67***	-80.71***	-15.48***	-15.62***
	(29.08)	(29.10)	(4.978)	(4.924)
Observations	69,071	69,071	64,535	64,535
R-squared	0.682	0.682	0.697	0.698

All regressions include product-month, province pair, and year fixed effects.
Robust standard errors in parentheses clustered at province pairs.
*** p<0.01, ** p<0.05, * p<0.1

The stronger and more precisely estimated effects of RRTS in levels compared to ratios suggest that higher value products experience greater absolute reduction in price gaps. Table 5 shows this to the case. Higher unit values are associated with larger price gaps across specifications and samples.[10] Consistent with expectations given lane meter charging, the full sample in columns (1) and (2) show that RRTS connection reduces the price gap by an average of PhP 0.10 (USD 0.002) per kg for each peso increase in unit price. The effect is larger at 13% and highly significant for short distance RRTS connections. In columns (3) and (4), eggs are excluded from the sample, the average price of which is 200% larger than mangoes (Figure A-3), the next highest value product in the sample. $RRTS_{od,t} \times Uval^k$ is only significant once conditioned on distance, suggesting a gap reduction of around 25%.

[10] $PGap^k_{od,t}$ is more suitable than $PRatio^k_{od,t}$ as dependent variable for this exercise.

5.2 RRTS and surplus distribution

The identification set up described in Figure 4 requires that local weather shocks have price influences that are felt across producer markets. I investigate this in equation 6. $P^k_{o,t}$ is the farmgate price of k in t in supplying province o; and $P^k_{\ddot{o},t}$ is the farmgate price of the same k at time t in other supplying provinces $\ddot{o}$, for all $o \neq \ddot{o}$.[11] ω_{km} and ϕ_y account for product seasonality and year trends respectively. An Augmented Dickey-Fuller Fisher panel unit root test suggests that a substantial portion of the price series in the panel are stationary (Pesaran, 2012). This is consistent with price theory predictions for agricultural commodities given their natural cycles of production and storage (Wang and Tomek, 2007).

$$P^k_{o,t} = \alpha_o + \rho_1 P^k_{\ddot{o},t} + \omega_{km} + \phi_y + \epsilon^k_{i,t} \tag{6}$$

The price relationship between supplying provinces is highly significant with about 10% of a peso increase in other provinces translating to price changes in a supplying province. The results are qualitatively similar when prices are expressed in terms of monthly changes. Moreover, as expected, price relationships are stronger when a pair of supplying provinces is connected by RRTS. RRTS increases price transmission by an additional 15 percentage points in levels or 9 percentage points in terms of changes. The results are summarized in Table A-4.

Localized weather shocks are sources of unexpected price increases and provide a setting whereby $\tau^k_{od,t}$ and $c^k_{od,t}$ are held constant in provinces unaffected by the typhoon. With this setting, I am able to attribute the differential response to the positive price shock by RRTS linkage status.

I exclude carrots and onions in this exercise since they are produced in concentrated regions in the country - the Cordillera Administrative Region for the former, and the Ilocos Region for the latter. This implies that they tend to be affected by the same weather shocks contemporaneously.

Results from the first stage equation 5 are summarized in Table 6. Each column represents a different set of observations to close off influences on

[11] The distinction between o and $\tilde{o}$ is temporarily suspended for equation 6.

prices that may come from potential redirection of trade. $\Delta Rain_{\tilde{o},t}$ and $\Delta Rain_{\tilde{o},t} \times RRTS_{od,t}$ are confirmed to be relevant instruments with $\Delta P^k_{\tilde{o},t}$ as dependent variable. The signs of the coefficients make intuitive sense. $\Delta Rain_{\tilde{o},t}$ increases deviations from long term price trends. On average, RRTS connection weakens the link between rainfall shocks and price changes. Moreover, the deviation-reducing effect of RRTS is large enough to overwhelm the tendency of excess rainfall to translate into price deviations.

In the lower panel, $\Delta Rain_{\tilde{o},t}$ is not significant across samples with $\Delta P^k_{\tilde{o},t} \times RRTS_{od,t}$ as dependent variable. However, this is not necessary for identification if the model without interaction is identified (Wooldridge, 2010). The combined results confirm that the rank condition of instruments is satisfied. Table A-5 in the Appendix summarizes the results with $\Delta P_{\tilde{o},t} \times RRTS_{od,t} \times Short_{od}$ as dependent variable.

The results from the structural equation 4 is summarized in Table 7. In general, weather shocks tend to reduce price gaps between province pairs. Having an RRTS connection reduces the gap further. This is true across samples. In the case of the sample that most satisfies the exclusion restriction in column (7), the reduction in price gap levels is twice as large as in non-RRTS pairs. The specification that distinguishes by RRTS distance thresholds in column (8) suggests that the gap-narrowing effect is larger by PhP 1.8 (USD 0.04) per kg for more proximate RRTS trading partners.

The bottom panel with price gap ratio as dependent variable confirms the gap reducing effect of the RRTS. Albeit less precisely estimated, the results from column (7) suggest that unaffected provinces with RRTS connection reduced their price gap by close to 25 percentage points more compared to non-RRTS province pairs. The effects of long versus short distance RRTS connections are statistically indistinguishable.

Table 6: First stage regressions

Dependent variable: $\Delta P^{k}_{\tilde{o},t}$	All unaffected	No grains	No hubs	No grains & hubs
	(1)	(2)	(3)	(4)
RRTS	-0.327**	-0.476**	-0.335*	-0.522*
	(0.153)	(0.219)	(0.193)	(0.291)
ΔRain	0.000843***	0.00173***	0.000839***	0.00169***
	(0.000132)	(0.000102)	(0.000152)	(0.000121)
RRTS x ΔRain	-0.200***	-0.264***	-0.439***	-0.675***
	(0.0767)	(0.0801)	(0.158)	(0.212)
Constant	0.260	0.332*	0.225	0.369*
	(0.192)	(0.186)	(0.166)	(0.198)
R-Squared	0.128	0.127	0.075	0.077
Dependent variable: $\Delta P^{k}_{\tilde{o},t} \times RRTS_{od,t}$	All unaffected	No grains	No hubs	No grains & hubs
	(1)	(2)	(3)	(4)
RRTS	0.00451	-0.0567	0.0622	0.0603
	(0.0669)	(0.100)	(0.0739)	(0.113)
Δ Rain	3.34e-05	0.000164***	3.46e-05	0.000142**
	(4.03e-05)	(5.63e-05)	(4.62e-05)	(6.59e-05)
RRTS x ΔRain	0.821***	0.799***	0.684***	0.658***
	(0.0601)	(0.0598)	(0.112)	(0.154)
Constant	-0.127*	-0.0848	-0.0820	-0.0927
	(0.0707)	(0.0871)	(0.0542)	(0.0890)
R-Squared	0.114	0.114	0.046	0.042
Observations	52,682	38,787	33,290	22,942

All regressions include province-pair, product-month, and year FE.
Robust standard errors in parentheses clustered at province pairs.
*** p<0.01, ** p<0.05, * p<0.1

Table 7: RRTS and passthrough to price gaps

Dependent variable: Price gap level

	All unaffected		No grains		No hubs		No grains & hubs	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	-1.362*	-0.515	-1.572	-0.399	-2.337**	-0.480	-2.569**	-0.651
	(0.695)	(1.259)	(0.956)	(1.311)	(0.941)	(1.933)	(1.302)	(1.927)
$\Delta P_{\tilde{o},t}$	-1.144	-1.139	-0.951*	-0.932*	-2.623***	-2.602***	-1.606***	-1.544***
	(0.765)	(0.758)	(0.515)	(0.511)	(0.743)	(0.741)	(0.453)	(0.440)
RRTS x $\Delta P_{\tilde{o},t}$	-0.837**	-0.649	-0.926**	-0.640	-3.032**	-2.180	-3.564**	-2.661
	(0.376)	(0.578)	(0.382)	(0.477)	(1.280)	(2.057)	(1.519)	(1.915)
RRTS x $\Delta P_{\tilde{o},t}$ x Short		-0.286		-0.475		-1.352		-1.771
		(0.555)		(0.508)		(2.237)		(2.773)
RRTS x Short		-0.912		-1.305		-2.039		-2.169
		(1.203)		(1.158)		(2.019)		(1.955)

Dependent variable: Price gap ratio

	All unaffected		No grains		No hubs		No grains & hubs	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	-0.0517	0.352	-0.117	0.306	-0.148*	0.393	-0.199*	0.340
	(0.0728)	(0.224)	(0.101)	(0.227)	(0.0794)	(0.348)	(0.110)	(0.339)
$\Delta P_{\tilde{o},t}$	-0.217***	-0.211**	-0.238***	-0.231***	-0.364***	-0.358***	-0.314***	-0.300***
	(0.0839)	(0.0841)	(0.0642)	(0.0646)	(0.0732)	(0.0742)	(0.0578)	(0.0579)
RRTS x $\Delta P_{\tilde{o},t}$	-0.0735	-0.165*	-0.173**	-0.224**	-0.191*	-0.116	-0.246*	-0.116
	(0.0713)	(0.0899)	(0.0709)	(0.103)	(0.110)	(0.145)	(0.139)	(0.130)
RRTS x $\Delta P_{\tilde{o},t}$ x Short		0.128		0.0728		-0.122		-0.253
		(0.106)		(0.140)		(0.166)		(0.220)
RRTS x Short		-0.436*		-0.469**		-0.587		-0.606*
		(0.231)		(0.238)		(0.361)		(0.360)
1st stage F-Stat	19.795	13.91	131.663	88.357	11.695	7.915	29.176	12.71
Observations	52,682	52,682	38,787	38,787	33,290	33,290	22,942	22,942

All regressions include product-month, province pair, and year fixed effects.
Robust standard errors in parentheses clustered at province pairs.
*** p<0.01, ** p<0.05, * p<0.1

Table 8 shows the RRTS passthrough effects on the price gap components. The top panel summarizes the RRTS effects on farmgate prices, which are positive and significant. Moreover, across samples and specifications, RRTS is shown to increase the passthrough of positive price shocks to farmgate prices. Farmers in non-RRTS supplier provinces also experience increase in revenues, but RRTS enhances this gain. The effect is largest in column (7) suggesting that the marginal revenue per kilo is three times as large in RRTS connected supplier provinces compared to similar non-RRTS provinces. Taking off from Table 2, this means that whereas non-RRTS supplying provinces have a passthrough of 9% in terms of average farmgate prices, the passthrough is close to 28% for RRTS supplying provinces. The results in column (8) shows that the effect rises to more than PhP 7 (USD 0.14) per kg or 4.6 times more than a non-RRTS supplying province in short distance connections.

In the bottom panel, RRTS is also shown to have significant price-raising effects on retail prices in contrast to Table 4. Nonetheless, increases in farmgate prices are consistently larger than retail price changes across all samples. Moreover, outside of markets of Metro Manila and Cebu, weather shocks do not induce significant changes in retail prices in RRTS destinations compared to markets without RRTS connection.

Together, these results demonstrate that supplying provinces connected by RRTS benefit from higher revenues during positive price shocks without passing this on to their retail markets. In column (7) of Table 8, the farmer in an RRTS source province receives PhP 5.13 (USD 0.10) more on average per kilo than non-RRTS provinces. The RRTS market provinces only increase their prices by PhP 1.56 (USD 0.03). The lack of differential effects of RRTS on retail prices can be partly explained by multiple sourcing in retail markets. The overall effect is an average reduction of the price gap levels by PhP 3.56 (PhP 1.56-PhP 5.13) which is reflected in the top panel of column (7) of Table 7. These are suggestive of a reduction in markups that accrue to agents that mediate between producer and consumer provinces.

Table 8: RRTS and passthrough of price shocks to farmgate and retail prices

Dependent variable: Farmgate prices	**All unaffected**		**No grains**		**No hubs**		**No grains & hubs**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	3.509***	4.527***	6.151***	6.734***	4.437***	5.437***	7.989***	8.713***
	(0.759)	(0.856)	(1.210)	(1.314)	(0.829)	(1.202)	(1.371)	(1.898)
$\Delta P_{\tilde{o},t}$	0.192	0.192	1.020***	1.029***	0.621	0.633	1.663***	1.612***
	(0.409)	(0.409)	(0.275)	(0.270)	(0.450)	(0.450)	(0.314)	(0.336)
RRTS x $\Delta P_{\tilde{o},t}$	1.970***	2.501***	2.864***	3.319***	3.052***	3.022*	5.126***	2.840
	(0.522)	(0.824)	(0.764)	(1.091)	(0.989)	(1.562)	(1.840)	(1.793)
RRTS x $\Delta P_{\tilde{o},t}$ x Short		-0.787		-0.731		0.0375		4.518
		(0.987)		(1.387)		(2.004)		(3.267)
RRTS x Short		-1.094*		-0.652		-1.079		-0.736
		(0.628)		(0.854)		(1.064)		(1.635)

Dependent variable: Retail prices	**All unaffected**		**No grains**		**No hubs**		**No grains and hubs**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	2.147**	4.012***	4.579***	6.335***	2.099*	4.957***	5.419***	8.061***
	(0.983)	(1.236)	(1.471)	(1.450)	(1.108)	(1.695)	(1.519)	(1.879)
$\Delta P_{\tilde{o},t}$	-0.952	-0.947	0.0689	0.0962	-2.002**	-1.969**	0.0565	0.0685
	(0.782)	(0.776)	(0.557)	(0.551)	(0.848)	(0.846)	(0.476)	(0.460)
RRTS x $\Delta P_{\tilde{o},t}$	1.133**	1.852**	1.938***	2.679***	0.0193	0.842	1.562	0.179
	(0.528)	(0.736)	(0.726)	(0.958)	(1.075)	(0.950)	(1.138)	(0.766)
RRTS x $\Delta P_{\tilde{o},t}$ x Short		-1.073		-1.206		-1.315		2.747
		(0.734)		(1.124)		(1.302)		(1.916)
RRTS x Short		-2.005*		-1.958**		-3.118*		-2.905*
		(1.023)		(0.947)		(1.671)		(1.609)
Observations	52,682	52,682	38,787	38,787	33,290	33,290	22,942	22,942

All regressions include product-month, province pair, and year fixed effects.
Robust standard errors in parentheses clustered at province pairs.
*** p<0.01, ** p<0.05, * p<0.1

The literature on variable markups typically take producer prices as given and trace markups from movements in retail or export prices. Fafchamps and Hill (2008), Fuje (2019), Martin (2012), and Osborne (2005) are among the few that relate transport and trade costs to changes in markup behavior through changes in producer prices. The findings of this study add to the literature that documents the importance of competition in improving welfare of small producers.

5.3 RRTS and price volatility

The positive effects of the RRTS on farm revenues may be eroded if they lead to greater price volatility. RRTS increases trade exposure of provinces. In this context, the literature on openness and volatility offer ambiguous predictions and results (Burgess and Donaldson, 2010; di Giovanni and Levchenko, 2009; Newberry and Stiglitz, 1981). On the one hand, price differences are easier to arbitrage in better integrated markets, which is a powerful means of reducing volatility (Jacks et al., 2011). On the other hand, lower trade costs mean greater transmission of external shocks to local economies. In India, declining trade costs from the expansion of the national highway network showed that market access increases the income volatility of exposed farmers but stabilized the consumer price index (CPI), with net effects suggesting greater volatility in real incomes (Allen and Atkin, 2019). Burgess and Donaldson (2010) likewise find greater farm income volatility following the rail network expansion in colonial India.

I investigate the effect of RRTS on price volatility following the structure in equation 3. Volatility is measured as the coefficient of variation of the price gap ratio and their components across RRTS connection status of province pairs by product. The results in Table 9 suggest that RRTS does not have a significant impact on price volatility. These results remain qualitatively similar after excluding observations during periods of weather shocks.

The results suggest that the improved farming profitability do not come with increased income volatility. But neither does RRTS contribute to more stable prices. This lack of effect is far from conclusive. Three mechanisms

Table 9: RRTS and price volatility

	Price gap ratio		Farmgate price		Retail price	
	(1)	(2)	(3)	(4)	(5)	(6)
RRTS	0.0168	0.00618	-0.00570	-0.0248	0.00335	-0.0181
	(0.0267)	(0.0363)	(0.0217)	(0.0255)	(0.0216)	(0.0285)
RRTS x Short		0.0252		0.0450		0.0506
		(0.0444)		(0.0319)		(0.0318)
Constant	0.417***	0.417***	0.515***	0.515***	0.485***	0.485***
	(0.103)	(0.102)	(0.0722)	(0.0700)	(0.0399)	(0.0403)
Prov Pair FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.874	0.875	0.905	0.907	0.842	0.848
Observations	514	514	514	514	514	514

All regressions include product fixed effects.
Robust standard errors in parentheses clustered at province pairs.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

determine the openness-volatility relationship. First, sectors that are more open to trade are more vulnerable to supply and demand shocks elsewhere. Second, a more open sector tends to co-move less with other sectors. Finally, openness encourages specialization. The first and third channels increase aggregate volatility, while the second attenuates it (di Giovanni and Levchenko, 2009). A thorough investigation requires a dissection of these mediums.

6 Conclusion

The RRTS brings down trade costs by facilitating intermodal land and sea transport across the Philippine islands. I study the consequences of these trade cost changes on spatial price gaps using an origin-destination mapped dataset of agricultural products and a dataset that tracks the development of RRTS services over time.

I find that conditional on distance, the average price gap as a proportion of farmgate prices is 28% smaller in province pairs that have RRTS connections. The gap narrowing effect is driven by higher farmgate prices in supply provinces without the corresponding differential increase in consumer prices in destinations.

I investigate the effects of RRTS-induced changes in trade costs to markups by exploiting localized weather shocks as exogenous sources of price increase across supplier markets. The setting captures the differential response of markups to RRTS as product-specific marginal costs are held constant by RRTS linkage status in provinces where supplies are not damaged by the weather. Results show that farmers in RRTS provinces enjoy passthroughs of price increases that are on average three times as large as non-RRTS suppliers without differential increases in RRTS retail markets. This leads to lower price gaps in RRTS province pairs as measured in both levels and ratios. The findings are consistent with an RRTS-induced competition in intermediation and shipping services. The welfare effects are potentially large in a country dominated by small farmers who rely on intermediaries in marketing their produce.

Finally, I do not find evidence that RRTS affected farmgate and retail price volatility. To the best of my knowledge, this is the first study that investigates changes in trade costs from the RRTS to pricing patterns and its implications on markups.

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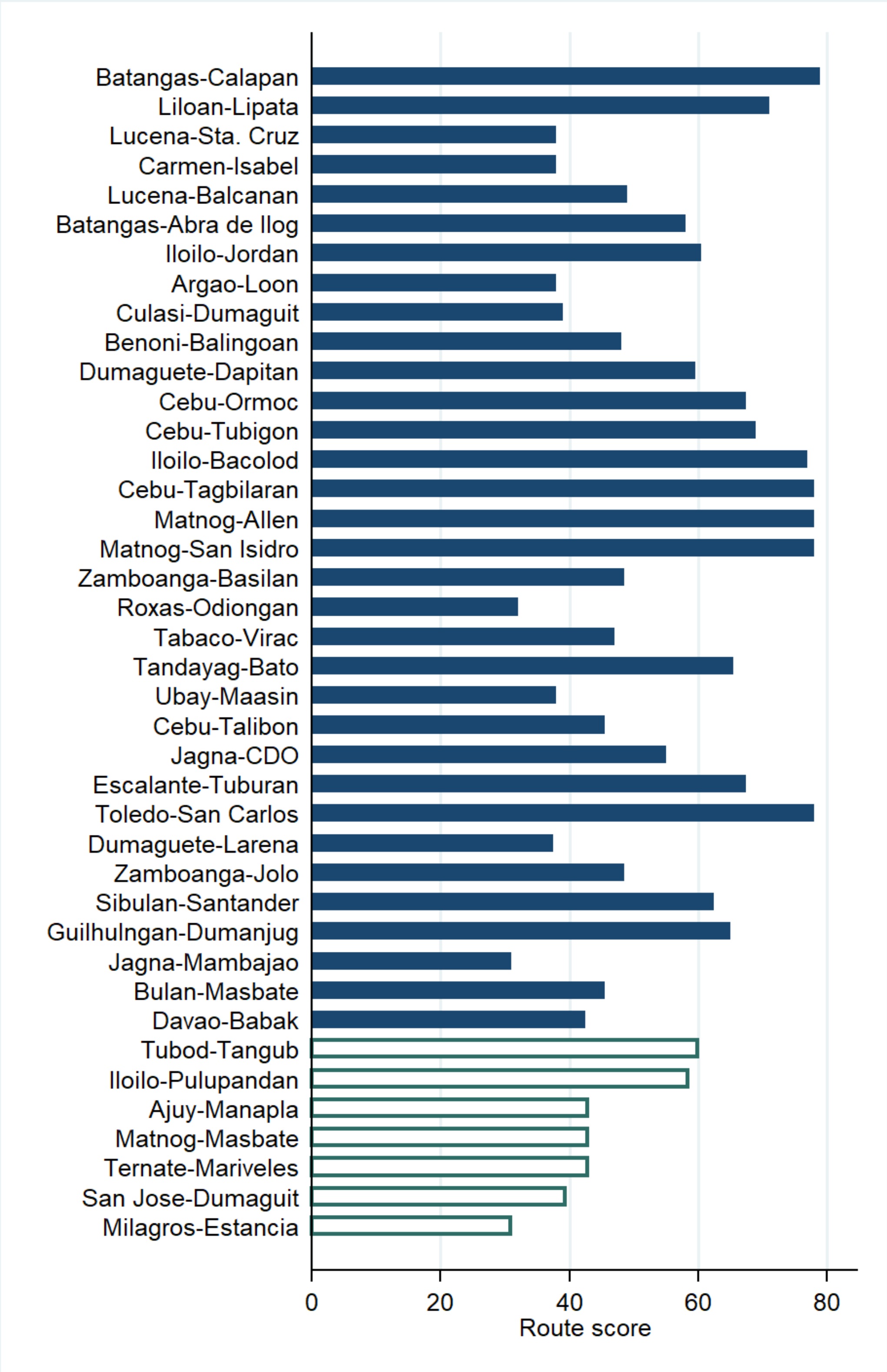
Appendices

Table A-1: Intermediary margins by product

Product	Province	Year	Estimated net margins (% of retail price)					
			Village	Municipal	Province	Region	Trader	Retailer
Calamansi*	Guimaras	2001			40.9			
	Mindoro Ori.				-4.2			
	Quezon				61.2			
Onion	Ilocos Norte	2006		1.9	16.7	2.1		9.3
	Nueva Ecjia		1.3	12.0	7.0		5.5	3.5
	Pangasinan		6.4	7.4	6.2		8.8	11.7
Palay	Bukidnon	2013		0.7				
	Bulacan		0.3		24.8			
	Cagayan			3.6	6.3			
	Iloilo		7.0	1.8				
	Nueva Ecjia		2.3	12.8	5.3	1.6	4.2	5.1
Potato*	Benguet	2001			35.0			
	Bukidnon				22.3			
	Davao City				27.3			
Rice	Bukidnon	2013	20.5	10.9	22.8		11.9	1.5
	Bulacan			2.0	10.1	3.4	1.7	1.4
	Cagayan				0.4			3.2
	Iloilo		6.8	2.1			2.3	1.8
	Nueva Ecjia					1.4	3.3	5.5
	Misamis Oriental		22.5		5.1		18.9	1.6
Tomato	Bukidnon	2003		23.2	19.2			23.4
	Iloilo						44.4	46.3
	Misamis Or.					24.1	3.1	44.3
	Pangasinan		16.9				10.2	41.6
Mango*	Davao City	2002			33.1			
	Guimaras & Ilolilo				32.5			
	Pangasinan				49.7			
Yellow corn (per 50 kg)	Batangas	2009					8.2	10.5
	Bukidnon				-9.1	-1.3	12.0	
	Bulacan						8.0	11.4
	Cagayan de Oro			6.9	8.2	0.5		29.7
	Cebu						5.1	
	Davao City				14.0	8.7	-4.9	18.8
	Ilocos Norte			6.9	9.0	2.1	9.4	
	Iloilo			5.4	9.0	5.7	9.9	34.5
	Isabela		1.8	4.7	0.1	2.0	-0.8	
	Metro Manila						7.2	8.2
	Pangasinan			-1.6	2.5		4.6	2.9
	South Cotabato		4.1	9.1	12.3	16.1		12.5
	Sarangani		5.6	9.7	3.8	10.7	9.5	16.9
White corn green (per 50 kg)	Batangas	2009	10.5	18.0	14.0	6.3		
	Bulacan			9.2				7.7
	Cebu		21.3		15.7			
	Iloilo		16.4		18.1			21.1
	Isabela				17.2			15.5
	Metro Manila			4.5		4.6	5.9	10.6
	Pangasinan				8.3			
	Sarangani				21.0			34.7
	South Cotabato			26.8	38.4			
White corn mature (per 50 kg)	Bukidnon				1.8	2.9		
	Cagayan de Oro			9.4		6.7		39.6
	Cebu						2.7	3.9
	Davao City				12.1	18.7	-0.3	14.4
	Ilocos Norte			2.1	4.2	4.0	3.6	
	Isabela			3.1	2.4			
	Metro Manila				12.2			15.6
	Pangasinan						-1.2	
	Sarangani		6.1	10.3	-4.9	20.3		8.3
	South Cotabato			12.9	16.1			

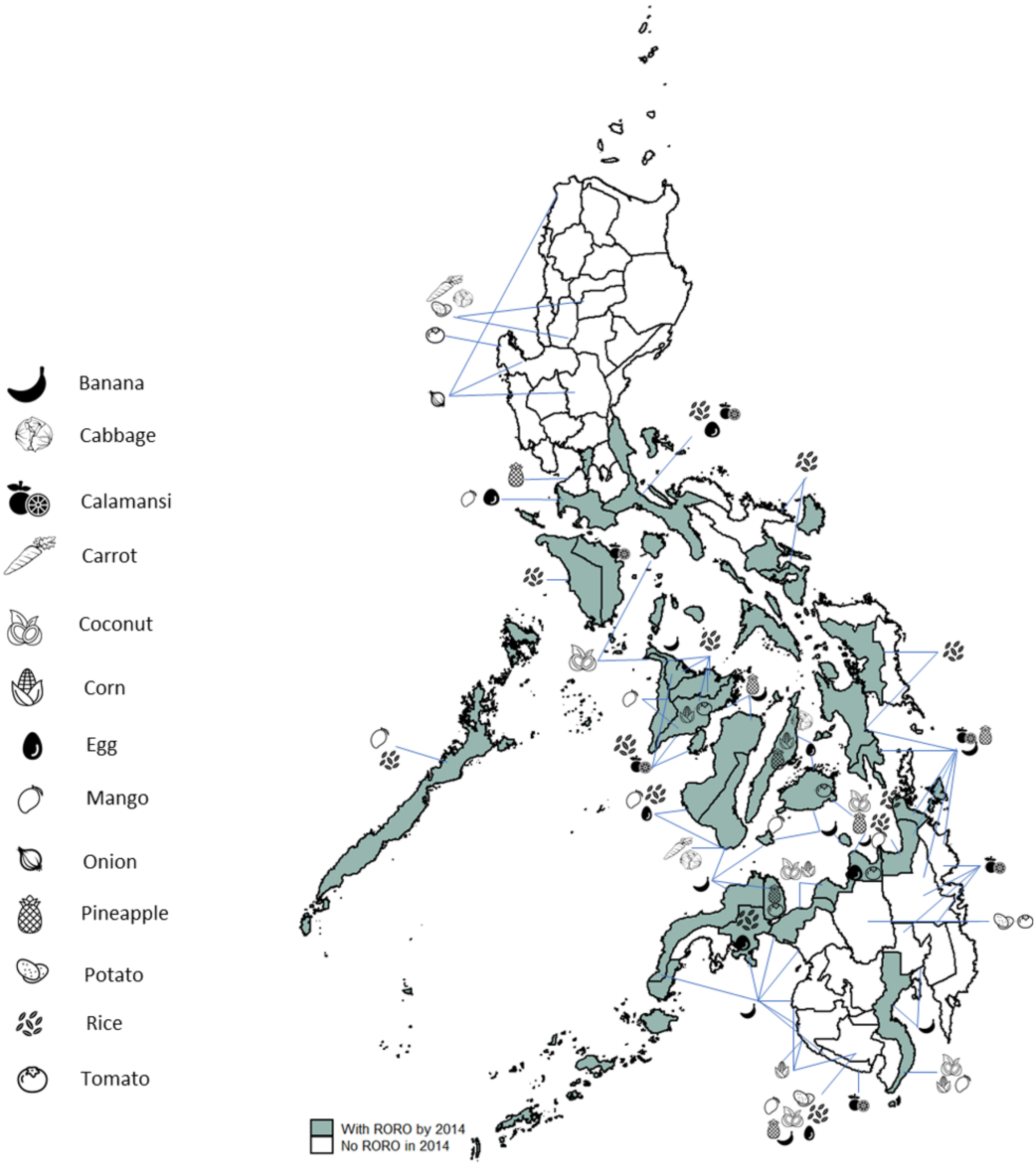
Notes: (1) Net margins are not necessarily additive across assembler levels.
(2)* information on assembly level is unavailable. Markups not necessarily attributed to provincial assemblers.
Source: Bureau of Agricultural Statistics (2002, 2003a, 2003b, 2003c, 2007, 2013, 2011a, 2011b)

Figure A-1: Planned prioritization of RORO route development



Source: Author and JICA(1992)

Figure A-2: Supplying provinces by product and RRTS access



Source: Author

Table A-2: Product-price mapping

Farmgate product	**PSA Product Code**	**Retail product**
Banana Lakatan, green	5730	Banana Lakatan, green
Banana Saba (plantain), green	5730	Banana Saba (plantain), green
Cabbage	5453	Cabbage
Calamansi	5729	Calamansi
Carrots	5455	Carrots
Chicken egg, commercial	2510	Chicken egg
Coconut matured	5771	Coconut matured
Corngrain [Maize] White, matured	4490	Corn, white
Corngrain [Maize] Yellow, matured	4490	Corn, yellow
Mango Carabao, green	5797	Mango Carabao, ripe
Onion native (red shallot), multiplier	5451	Red creole
Onion Red Creole (Bermuda Red)	5451	
Palay [Paddy] Other Variety, dry (conv. to 14% mc)	4210	Rice, regular milled
	4210	Rice, well milled
Pineapple Hawaiian	5795	Pineapple, Hawaiian
Pineapple Native	5795	
Tomato	5440	Tomato
White/Irish Potato	5410	White/Irish Potato

Table A-3: Product value and price gaps

Dependent variable: Price gap level				
	RRTS = no. of links			
	All		**Without Eggs**	
	(1)	(2)	(3)	(4)
RRTS	-0.131	-0.122	-0.185	-0.0661
	(0.253)	(0.242)	(0.497)	(0.417)
$RRTS \times Uval$	-0.0130	-0.0208	-0.00925	0.0894
	(0.0128)	(0.0150)	(0.0417)	(0.0893)
$RRTS \times Uval \times Short$		0.00842		-0.124*
		(0.0163)		(0.0735)
Uval	0.783***	0.783***	0.952***	0.951***
	(0.204)	(0.205)	(0.186)	(0.187)
Constant	8.285***	8.275***	9.195***	9.111***
	(3.128)	(3.106)	(3.103)	(3.371)
Observations	69,071	69,071	64,535	64,535
R-squared	0.686	0.686	0.703	0.704

Regressions include product-month, province pair, and year fixed effects.
Robust standard errors in parentheses clustered at province pairs.
*** p<0.01, ** p<0.05, * p<0.1

Table A-4: Spatial price relationships between supplying provinces

Dependent variable: Farmgate price				
	Levels		Differences	
	(1)	(2)	(3)	(4)
$Price_j$ (other suppliers)	0.108***	0.093***	0.122***	0.116***
	(0.0212)	(0.0217)	(0.0109)	(0.0102)
$Price_j \times RRTS$		0.153***		0.0922**
		(0.0436)		(0.0464)
RRTS		-1.409***		0.00327
		(0.492)		(0.0253)
Constant	65.97***	67.00***	-0.225	-0.228
	(2.163)	(2.172)	(0.265)	(0.265)
Observations	214,357	214,357	191,917	191,917
R-squared	0.816	0.817	0.119	0.119

Estimator: OLS.
All regressions include product-month and year fixed effects.
Robust standard errors in parentheses clustered at supplier province pairs.
*** p<0.01, ** p<0.05, * p<0.1

Table A-5: First stage regressions for $\Delta P_{ot} \times RRTS_{ij,t} \times Short$

Dependent variable: $\Delta P_{ot} \times RRTS_{ij,t} \times Short$	All unaffected (1)	No grains (2)	No hubs (3)	No grains & hubs (4)
RRTS	0.0158	-0.0296	0.0361	0.0185
	(0.0329)	(0.0491)	(0.0383)	(0.0608)
Rain	5.68e-06	0.000106**	1.75e-05	9.69e-05
	(3.68e-05)	(5.16e-05)	(4.22e-05)	(6.16e-05)
RRTS x Rain	-0.000913	-0.00760	-0.0261	-0.0347
	(0.00681)	(0.00801)	(0.0253)	(0.0348)
RRTS x Rain x Short	0.899***	0.871***	0.638***	0.527***
	(0.0386)	(0.0439)	(0.0992)	(0.135)
RRTS x Short	0.00155	-0.00716	0.0131	0.0247
	(0.0130)	(0.0177)	(0.0168)	(0.0223)
Constant	-0.108	0.0606	-0.0232	0.0312
	(0.0664)	(0.0564)	(0.0549)	(0.0648)
R-Squared	0.128	0.128	0.048	0.042
Observations	52,682	38,787	33,290	22,942

All regressions include province-pair, product-month, and year FE.
Robust standard errors in parentheses clustered at province pairs.
*** p<0.01, ** p<0.05, * p<0.1

Table A-6: Price gaps and RRTS linkage intensity during weather shocks

Dependent variable: Price gap level

	All unaffected		No grains		No hubs		No grains and hubs	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	-0.209	0.111	-0.213	0.229	-0.341*	0.138	-0.328	-0.535
	(0.132)	(0.607)	(0.171)	(0.798)	(0.188)	(0.715)	(0.222)	(1.204)
$\Delta P_{\tilde{o},t}$	-0.502**	-0.544**	-0.544**	-0.594***	-0.458**	-0.3899*	-0.478***	-2.0625***
	(0.257)	(0.253)	(0.249)	(0.247)	(0.201)	(0.227)	(0.201)	(0.385)
RRTS x $\Delta P_{\tilde{o},t}$	-0.4832	0.4148	-0.736	0.395	-0.521	-1.656	-0.557	-1.082
	(0.452)	(0.479)	(0.630)	(0.480)	(0.859)	(2.107)	(1.122)	(2.460)
RRTS x $\Delta P_{\tilde{o},t}$ x Short		-1.1012		-1.426		1.596		-2.073
		(0.684)		(0.939)		(2.866)		(3.870)
RRTS x Short		-0.3544		-0.476		-0.552		-0.197
		(0.616)		(0.804)		(0.724)		(1.228)

Dependent variable: Price gap ratio

	All unaffected		No grains		No hubs		No grains and hubs	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	-0.014	-0.095	-0.015	-0.108	-0.049	-0.138	-0.0625*	-0.189
	(0.021)	(0.074)	(0.035)	(0.098)	(0.026)	(0.086)	(0.038)	(0.134)
$\Delta P_{\tilde{o},t}$	-0.226***	-0.226***	-0.222***	-0.228***	-0.229***	-0.2329***	-0.226***	-0.297***
	(0.037)	(0.036)	(0.040)	(0.037)	(0.034)	(0.033)	(0.035)	(0.045)
RRTS x $\Delta P_{\tilde{o},t}$	-0.064	-0.083	-0.253	-0.116*	-0.2085	-0.180	-0.348*	-0.200
	(0.096)	(0.059)	(0.165)	(0.069)	(0.129)	(0.185)	(0.199)	(0.264)
RRTS x $\Delta P_{\tilde{o},t}$ x Short		0.031		-0.159		0.011		-0.297
		(0.114)		(0.234)		(0.275)		(0.450)
RRTS x Short		0.090		0.106		0.105		0.136
		(0.070)		(0.092)		(0.085)		(0.134)
1st stage F-Stat	43.37	29.47	46.625	31.324	29.940	16.235	10.671	8.168
Observations	52,682	52,682	38,787	38,787	33,290	33,290	22,942	22,942

RRTS variable refers to the number of links for each province pair at time t.
All regressions include product-month, province pair, and year fixed effects.
Robust standard errors in parentheses clustered at province pairs.

Table A-7: Prices and RRTS linkage intensity during weather shocks

Dependent variable: Farmgate prices

	All unaffected		No grains		No hubs		No grains and hubs	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	0.414	2.022***	0.671	2.383***	1.151***	2.194***	1.547***	2.346**
	(0.342)	(0.720)	0.499	(0.976)	(0.373)	(0.807)	(0.565)	(1.121)
$\Delta P_{\tilde{o},t}$	1.402***	1.389***	1.365***	1.391***	1.303***	1.381***	1.367***	0.997***
	(0.144)	(0.154)	0.165	(0.164)	(0.157)	(0.154)	(0.183)	(0.246)
RRTS x $\Delta P_{\tilde{o},t}$	1.879***	2.328***	2.816***	2.303***	2.435**	1.448	3.415**	0.461
	(0.642)	(0.853)	0.940	(0.826)	(1.109)	(1.366)	(1.703)	(1.451)
RRTS x $\Delta P_{\tilde{o},t}$ x Short		-0.674		0.471		0.883		2.352
		(1.124)		(1.538)		(2.324)		(3.025)
RRTS x Short		-1.768**		-1.932*		-1.219701		-1.113
		(0.777)		(1.070)		(0.871)		(1.253)

Dependent variable: Retail prices

	All unaffected		No grains		No hubs		No grains and hubs	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RRTS	0.205	2.133***	0.458	2.612**	0.810**	2.332***	1.218**	1.811
	(0.295)	(0.802)	(0.448)	(1.158)	(0.404)	(0.791)	(0.546)	(1.197)
$\Delta P_{\tilde{o},t}$	0.900***	0.846***	0.821***	0.797***	0.846***	0.991***	0.889	-1.065***
	(0.241)	(0.249)	(0.239)	(0.245)	(0.202)	(0.225)	0.205	(0.353)
RRTS x $\Delta P_{\tilde{o},t}$	1.396**	2.742***	2.080***	2.699***	1.914*	-0.208	2.858**	-0.622
	(0.665)	(1.007)	(0.784)	(0.966)	(1.097)	(1.540)	(1.281)	(1.808)
RRTS x $\Delta P_{\tilde{o},t}$ x Short		-1.775		-0.9551		2.479		0.279
		(1.175)		(1.322)		(2.502)		(2.705)
RRTS x Short		-2.122**		-2.408*		-1.772**		-1.310
		(0.839)		(1.236)		(0.822)		(1.235)
1st stage F-Stat	43.37	29.47	46.625	31.324	29.940	16.235	10.671	8.168
Observations	52,682	52,682	38,787	38,787	33,290	33,290	22,942	22,942

RRTS variable refers to the number of links for each province pair at time t.
All regressions include product-month, province pair, and year fixed effects.
Robust standard errors in parentheses clustered at province pairs.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

x

Figure A-3: Average farm and retail prices by product