T.B.A. (To Be Arbitraged)?:
Extensive and Intensive Margin in Rice Trading in Madagascar

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Abstract

Spatial arbitrage is the driving force for the law of one price, and traders are economic agents who are specializing in arbitrage. Using trader-level biweekly survey in Antananarivo, the capital city of Madagascar, we investigate the extensive margin and the intensive margin in response to the price differences across districts. We first document that only a fraction of traders visited other districts to purchase rice, and these active traders tend to be larger than passive traders who do not other districts but only purchase rice from rice sellers visiting the city from their local districts, suggesting the importance of heterogeneity in traders. We find that active traders on average did not respond to the price differences both in terms of extensive and intensive margin. Our randomized experiment of providing price information through SMS suggests the importance of the existing trade linkages in the response to price information. We then provide a framework to infer trade costs and trade linkage setup costs of active traders, finding the importance of linkage setup costs in addition to the trade costs in explaining trader's location choice.

Keywords: extensive margin, intensive margin, market integration, information friction, trade costs

JEL Classification: L81, O13, Q13

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1 Introduction

The law of one price (LOP) plays the crucial role in achieving the allocative efficiency in the market mechanism by equalizing the marginal cost of production across individual producers. While many international trade models and spatial economics models introduce transport costs to allow the price differences across regions (Fujita, Krugman, and Venables, 2001; Melitz, 2003), the price net of the transport costs is assumed to be the same, the extended version of the LOP. Models estimating or simulating policy outcomes basically assume the LOP or the extended version of the LOP.

The extended version of the LOP implies that the prices in different regions should comove, and the difference in the price should never exceed the transport costs (Baulch, 1997). Many studies, however, find that agricultural markets are spatially integrated only partially (Fackler and Goodwin, 2001). Butler and Moser (2010) and Moser, Barrett, and Minten (2009) use the price data in Madagascar to show the incomplete spatial arbitrage, and they attribute it to high crime rates, remoteness, and lack of information. But their analyses only look at the pattern of price movement in different regions, and do not illustrate the underlying mechanism or the role of economic agents.

Main economic agents who engage in spatial arbitrage are traders. Through arbitrage, traders contribute to improving economic efficiency and facilitating market integration. Despite the important role played by traders, however, little studies have focused on trader's behavior. Some researchers have investigated the trade pattern. Allen (2014) estimates the model of heterogeneous producers with a costly sequential price search by using regional agricultural trade data in the Philippines, finding that information frictions explain roughly half of the observed regional price dispersion. Kano, Kano, and Takechi (2013) estimate the model of heterogeneous producers and product delivery, finding that distance plays the important role in transport costs. Fafchamps and Minten (2012) conducted an randomized controlled trial (RCT) of providing market information to farmers through mobile phones, finding positive effects on spatial arbitrage by farmers selling at distant wholesale markets. However, little work have done to investigate how responsive the traders are to the arbitrage opportunities and what is the barriers the traders face in their arbitrage behavior.

In this paper, we investigate rice trader's behavior using the detailed data on rice trading for 224 rice traders based in Greater Antananarivo Area in Madagascar from August 2012 to August 2013.[1] We conducted the survey biweekly to collect information on rice trade at the transaction level including the transacted price, quantity, variety, milled or paddy, the district of origin, and transport costs they spent for the transaction. We found that only a fraction of traders visited other districts to purchase rice, and these active

[1] Using the same data, Arimoto et al. (2015) document that rice traders in Madagascar are not fully exploiting the regional arbitrage opportunities and attribute this to price information, quality of products, and matching with reliable business partners.

inter-district traders tend to be larger than passive inter-district traders who do not visit other districts but only purchase rice from rice sellers visiting Antananarivo from their local districts, suggesting the importance of heterogeneity as suggested in the international trade literature (Melitz, 2003; Bernard et al., 2007; Mayer and Ottaviano, 2008). Then we investigate the response of the extensive margin and intensive margin of active and passive traders to the price differences, where the extensive margin is the participation in trade with the district with lower prices, and the intensive margin means the trade quantity increase when they face lower prices. We found that active traders on average did not respond to the price differences both in terms of extensive and intensive margin, while passive traders were more responsive to the price differences. One possible constraint on the extensive margin of the active traders will be the availability of price information (Jensen, 2007, 2010; Aker, 2010; Fafchamps and Minten, 2012; Aker and Fafchamps, 2014). During the survey, we provide price information of 10 major districts via SMS for randomly selected traders to examine the importance of price information for traders' arbitrage behavior. We found that this SMS intervention increased the active trade with the district with which the trader had previous trade experiences, but did not influence the extensive margin in the districts without previous trade experiences, implying the importance of the trade linkage setup costs as well as the price information. Based on these observations, we construct the trader's location choice model incorporating the trade linkage setup costs and trade costs, finding the importance of the trade linkage setup costs along with the trade costs.

To our knowledge, this is the first study investigating the extensive margin and intensive margin of traders based on the trader-level data. Our results show the important heterogeneity in arbitrage and participation in the active trade, indicating the necessity of the equilibrium model with heterogeneous traders as in Melitz (2003). Further, we quantify the trade linkage costs along with the trade costs, which can be interpreted as the decomposition of Allen (2014)'s fixed trade costs which he interpret the information friction. Policies reducing the trade linkage costs such as supporting the intermediaries or licensing the reliable trade agents at each local market would improve the arbitrage efficiency and resultant market allocative efficiency.

The paper is organized as follows. Section 2 describes the background of rice trade in Madagascar and our survey design. Section 3 provides the analytical framework and Section 4 reports our empirical results. Section 5 propose a framework to infer trade costs and trade linkage costs with the empirical results. Section 6 offers concluding remarks.

2 Background and Survey Design

2.1 Rice Market in Madagascar

Rice is the main staple food in Madagascar. As the land of Madagascar extends north to south, the harvesting period of rice varies across regions, which would raise the necessity of spatial arbitrage. The capital city, Antananarivo, or commonly called Tana, is the largest market which attracts rice from many districts.

The rice varieties distributed in Madagascar can be broadly categorized into the following four categories: (1) Vary Gasy, (2) Tsipala, (3) Makalioka, and (4) imported rice. Vary Gasy literally means "Malagasy rice", and in general refers to any locally produced rice other than Tsipala and Makalioka. There are to some extent differences in taste and quality in Vary Gasy rice across regions. Tsipala and Makalioka, on the other hand, are very specific varieties, though they are not single varieties in the agronomic sense. Tsipala is relatively short and round, while Makalioka is longer. Makalioka is considered high grade, and cleanly processed Makalioka is the most expensive rice in Madagascar. Tsipala is cultivated nation-wide, while Makalioka is mainly produced around Ambatondrazaka district (Alaotra-Mangoro region). Imported rice is in most case of low grade, imported from Pakistan or India. Since imported rice is basically traded through a couple of authorized importers, we do not include imported rice in our analysis. We also exclude the transaction of the rice whose varieties the responding trader answered unknown, because the quality and thus the market price would be quite different in this category.

Previous studies have shown that the Malagasy rice market is spatially disintegrated, exhibiting large price dispersion over time and space. Moser, Barrett, and Minten (2009) use 2001 national census of communes (counties) to find that the rice markets was spatially not well-integrated at the provincial or national level. Butler and Moser (2010) show that the average probability of interprovincial integration of rice market is only about 56%. Studies exploiting weekly district-level price data after mid-2000s find that the degree of market integration is improving (Miyake and Sakurai, 2012), but markets are still not integrated well even between cities near to Antananarivo (Arimoto et al., 2014).

Figure 1 depicts the price variation of Vary Gasy in 10 distant markets we collected through April 2012 to August 2013. The figure shows the large difference in the price across markets, while the extended version of the law of one price predicts that the price net of the transport cost should be the same. In our trader survey, the maximum of the transport costs between Tana and any other districts is 250 Malagasy Ariary (MGA)/kg and its mean is 76 MGA/kg, which cannot explain this large gap in the price across markets.

It is the rice traders who play a key role in the spatial arbitrage. The modes of their purchase can be classified into three categories: (1) active inter-district trade; (2) passive inter-district trade; and (3) within-Tana trade. Inter-district trades are those between Tana and districts outside Tana. Active inter-district trades

are purchases that are made outside of Tana by traders actively visiting other districts. Passive inter-district trades are purchases made in Tana from sellers (trucks) who visit Tana from other districts to sell rice. Such purchases may take place at the traders' store where sellers directly visit regularly, or at the parking place at major wholesale markets in the city center such as the Anousibe and Andravoahangy markets. On the other hand, within-Tana trades are those that do not directly incorporate inter-district trade: (1) purchase at the Anousibe market; (2) purchase at the Andravoahangy market; and (3) purchase from local sellers in Tana such as farmers, wholesalers, and millers. These three modes are not mutually exclusive, and many active inter-district traders also engage in passive inter-district trade and within-Tana trade.

2.2 Survey

We conducted rice trader survey in Tana through July 2012 to August 2013. Since our interest is in spatial pattern of rice trading, we surveyed inter-district rice traders who engage in trade between Tana and districts outside Tana.[2] Given that there were no reliable public census on rice traders and the number of inter-district rice traders is not large, we surveyed the rice traders in the following way. First we selected 44 out of 192 wards in the city center and 17 out of 40 communes in the suburb where there is a high probability of finding inter-district rice traders, and made a list of rice traders by visiting markets and key informants in these clusters. All the listed traders were then visited and identified whether they engaged in inter-district trading, resulting in the final list of 318 inter-district rice traders.

In July 2012, we conducted a baseline survey to collect general information about the characteristics of the traders and their trading activities. Out of 318 (76%) listed traders, 241 traders agreed to cooperate and completed the baseline survey. Then, we conducted the biweekly survey from August 6, 2012 to August 13, 2013, with 27 rounds in total. The biweekly survey collected information on: (1) price search; (2) details of all purchases of rice, including information on districts of purchase, transportation modes and costs, price and payment; and (3) management indicators such as stock, quantity of purchases and sales, average price and margin, and costs. Among 241 traders who completed the baseline survey, 234 initially agreed to participate in the biweekly survey, but 10 dropped during the course. A follow-up survey was conducted in February 2014 to collect additional information. We obtained responses from 219 out of 224 traders who completed the periodic survey.

Summary statistics of traders are presented in Tables 1 and 2. Eighty four percent of the sampled inter-district traders own a store to sell rice, while 16 percent of the traders operate their own rice mill. Seventy percent of the traders sell other food than rice as well, and nearly a half of the traders sell non-food items.

[2] Ideally the survey should include inter-district rice traders throughout the country to understand the spatial pattern of rice trade, it was out of our budget to cover the rice traders in other districts than Tana.

The average year of experience in rice trading is 8.25 years, and the most experienced traders have engaged in rice trading for 32 years. The average of the total capacity of storage is 27 ton, whereas its standard deviation is quite large. 13.4 percent of the traders do not have the storage, and the median storage capacity is 6 tons. Less than 5 percent of the traders have the storage with capacity equal to or more than 100 tons. The annual trading volume before the baseline survey also has substantial dispersion. Nine percent of the traders had the annual trade volume less than 10 tons and the median traders had the annual trade volume of 67 tons, and 7 traders in our sample had the annual trade volume more than 1,000 tons. 90 percent of the traders had cell phones, indicating that the cost of obtaining price information in other districts would not be expensive for most traders if they know someone in that district. Only a fraction of the traders utilize newspaper, radio and TV for obtaining price information, with 198 out of 232 traders not using any of these modes to collect price information.

Through the surveyed round, 27 percent of the trader-round observations engaged in active inter-district rice trading. The proportion of engaging in passive inter-district trading is quite high (83 percent). The average number of districts with active trade is 0.32, and its maximum is 4, indicating that active traders visited only a small number of districts. Average traders engaged in passive trading with more than 1 districts, which is quite greater than in active trading. For the stock level, Tsipala exhibits much lower proportion compared to Vary Gasy and Makalioka. Appendix Figure 1 depicts the composition of the variety traded. In active trade, the most frequent combination is purchase of Vary Gasy and Tsipala, followed by purchase of Makalioka only and then purchase of Vary Gasy only. In passive trade, on the other hand, the majority of the transactions include all of the three varieties, reflecting the fact that most retailers sell all the three varieties.

While Makalioka constitute a substantial portion in transactions of the rice traders, the spatial variation of the origin district is quite limited as it is cultivated only in specific regions. Appendix Table 1 lists the names of the districts from which the surveyed rice traders purchased rice, restricting to the observations with no less than five transactions. Active traders in our sample only visited four districts to purchase Makalioka, while they visited 11 districts to purchase Vary Gasy and Tsipala. The similar patterns are found in passive trading.

The upper panel of Table 3 reports the summary statistics of price variables at district level. To ensure the comparability of prices over districts, we converted all the observed purchase prices to the adjusted milled-rice equivalent price (hereafter, referred to as “adjusted ME-price”), which represent the cost of purchasing 1 kg of milled rice, including transport costs to Tana (recall that our sample traders are all based and operating in Tana) and milling fees, with adjustment for price differences between paddy and milled rice. Note that these price information is available only for the districts from which any traders made purchase in that

round. Since the traded prices differ across traders within the same district, we use the median of actual prices paid by the sampled traders for each variety at each survey round in each district. Since we surveyed the transaction during the two weeks, it is quite possible that traders face different prices in the same district.

When we look at the cheapest district median price, the active traders face the lower purchase price than passive traders even after adjusting the transport costs. However, when we look at the price difference of the district from the cheapest district, defined by the district median price minus the cheapest district median price and denoted by Dif.dist.opt.price in the Table, the active trading records a greater difference between the district where active trader made purchase and the cheapest district than passive traders. This would suggest that spatial arbitrage works better in passive trading. This is plausible because passive traders transact with sellers visiting Tana from other districts, and can easily compare the rice price of those sellers from different origins.

For within-Tana trade, Anousibe market is the largest rice market where some wholesalers and many retail traders agglomerate. Local consumers also purchase rice from retailers in Anousibe market. Hence we regard the rice price in Anousibe market (recorded in within-Tana trade) as the market price of rice in Tana. Dif.dist.ANSB.price in the Table refers to the district median price minus the Anousibe market price. In order for the trade to be profitable, this variable should be negative. However, as suggested by the quite large positive value in the column indicating the maximum and relatively large standard deviation, rice trade sometimes result in the loss.

The lower panel of Table 3 reports the transaction price and transaction amount at the trade level. The trade amount of active trade is much larger than that of passive trade. The trade amount of Vary Gasy and Makalioka is much larger than that of Tsipala. Greater trade amount of Makalioka compared to Vary Gasy is partly explained by the fact that Makalioka is cultivated only in the limited area which enjoys a relatively good condition of the road connected to Tana.

2.3 SMS Intervention

Since information friction is considered as one of the major obstacles of efficient arbitrage, we experimentally filled the information gap by sending regional price information via SMS to half (112 out of 224) of the randomly selected traders after round 16 (out of 27) of the periodic survey. The SMS was sent every week on Wednesday. The information sent was the local price of milled rice at millers for the previous week, collected by Madagascar's Rice Observatory (Observatoire du riz or OdR, in French), a government agency responsible for collecting and disseminating agricultural commodity price information. We sent prices in 10 most major rice-producing districts (Arivonimamo, Miarinarivo, Tsiroanomandidy, Ankazobe, Ambat-

ondrazaka, Mahabo, Bealanana, Befandriana, Mandritsara, and Marovoay), which include distant districts in Sofia region where prices are generally quite cheaper than the major purchasing districts near Tana. We expected that this information would trigger trade with new districts.

3 Analytical Framework

3.1 Extensive Margin

To investigate the extensive margin, we consider active trader i's choice on which market to visit. The trader purchases rice from districts j and sell it in Tana. We denote the selling price of variety v originated from district j in round t in Tana by p^S_{vjt}, which could vary depending on the origin of the rice given that fact that the quality of rice varies across regions to some extent.[3] To be specific, we assume that the selling price in Tana is expressed as $p^S_{vjt} = p^*_{vt} + \gamma_{vj} + \epsilon^p_{vjt}$, where p^*_{vt} is the quality-adjusted rice price, γ_{vj} is the district fixed effects for variety v reflecting the difference in quality across districts, and ϵ^p_{vjt} the measurement errors and idiosyncratic shocks. In the empirical analysis, we use the median trade price at Anousibe market as the proxy for p^*_{vt}.

In visiting district j in round t, the trader faces the local rice price p^{AC}_{vjt} for variety j. As we have the direct observations on the transport costs, we denote by p^{AC}_{vjt} the local rice price net of the transport costs, the adjusted ME price. Hence the trade margin per unit of rice traded can be expressed as $p^S_{vjt} - p^{AC}_{vjt}$[4].

Active trader i can choose the trade volume q_{ivjt} of variety v from district j in round t, under the truck capacity constraint TR_i. A Larger trade volume would result in a higher level of rice stock, which incurs the stock costs, which will be lower given the same stock level if trader i has the capacity to sell a larger volume than others. We use the annual trade amount of rice at the baseline survey as the proxy for the sales capacity. We denote these trader-level characteristics variables by $\mathbf{x}_{it}$.

When he does not visit any districts, he will receive the reservation payoff, which could be the profit when he only engaged in passive rice trading. The rice price in passive trading directly affects the reservation payoff, but this might also affect the subjective expectation on the purchase price of active trading. Hence we include the rice price in passive trade to control these effects.

[3] Rice produced in Sophia region, for example, is known for its low quality and its market price in Tana is considerably lower than the rice produced in other regions.

[4] Transport costs considered in the calculation of the adjusted ME price are only the monetary expenses for transportation, and do not include the time costs. In our informal interview with active traders, some of them told it would take two weeks to visit Sophia region where the rice price is lower, and that during that time they could visit closer districts three to four times, which would generate more profits.

Given these environmental setup, we estimate the price sensitivity of the extensive margin by multinomial logit model

$$\Pr(y_{it} = j|\mathbf{x}_{it}) = \Pr(V^*_{ijt} \geq V^*_{ikt} \; \forall k = 1, \ldots, J|DP_{ijt}, \mathbf{x}_{it})$$

where

$$V^*_{ijt} \quad = \quad \alpha_0 + \alpha_1 DP_{ijt} + \mathbf{x}_{it}\boldsymbol{\delta}_j + \epsilon_{ijt},$$

DP_{jt} is the percentage deviation from the price in Tana ($j = 0$)

$$DP_{jt} = \frac{p_{jt} - p_{0t}}{p_{0t}}$$

and ϵ_{ijt} follows the extreme value distribution. We drop the observations visiting multiple districts in the estimation. The extensive margin is captured by the coefficient α_1.

In order to check that the results are not driven by those observations with at most one district visit, we also estimate the binomial fixed effect conditional logit model where we estimate the probability of visiting district j. This framework allows to have multiple district choices, but ignore the interdependency of district choice that district choices will be influenced not only by its own attractiveness but also by the attractiveness of other districts. To mitigate this problem, we estimate the binomial conditional logit model with including the price difference from the cheapest district to capture how the district price is attractive compared to the cheapest district.

To focus on the importance of trade link, or previous experiences of trade, in the district choice, we also estimate the multinomial logit model where we categorize the choice set into the following three: no active trading, visiting districts with the trade experiences, and visiting districts without trade experiences.[5] In the baseline survey, we collected data on active and passive trade in the past 12 months. We define that the trader has trade experience with district j if he had any active trade with district j in the past twelve months. Because of the imprecise recall and the mismatch of the list of the district between the baseline survey and biweekly survey, we only find a limited number of districts with which traders have trade experiences. Hence we also define that the trader has trade experience with district j if he had active trade with district j in the first and second biweekly survey. For estimation, we only use the observations after these two biweekly survey.

[5]Since we only have the price data on the district where any traders visited in that round and there are only a few districts to which any traders visited in all the round, implementing the multinomial logit with the choice set being each district results in the substantial restriction of the choice set to these small number of districts. Since our focus is spatial arbitrage, restricting the choice set to these limited districts is not appropriate.

3.2 Intensive Margin

Theoretically the absence of the extensive margin does not necessarily imply the inefficiency in the spatial arbitrage. Suppose that every district has at least one trader who transports rice from there to Tana, and traders never change the trading districts. Even in this extreme case of no extensive margin, if traders facing lower prices import sufficient amount of rice until the rice price is equalize across districts, then spatial arbitrage efficiency will be achieved. Hence it is important to examine the extent of the intensive margin: how responsive the traders are to to the price differences.

To conduct the intensive margin analysis, we use the trader-variety-district-round observations with positive trading amounts to estimate

$$ln(q_{ivjt}) = \beta_{0i} + \beta_1 DP_{ivjt} + \beta_2 x_{ivjt} + \delta_v + \delta_j + \delta_t + u_{ivjt} \quad (1)$$

where q_{ivjt} is the total amount of rice (variety v) transacted by trader i from district j in round t, DP_{ivjt} the percentage deviation from the price in Anousibe market defined as

$$DP_{ivjt} = \frac{p_{ivjt} - p^*_{vt}}{p^*_{vt}},$$

x_{ivjt} are the vector of control variables, δ_v is the variety fixed effect, δ_j is the destination fixed effect, δ_t is the round fixed effect, and β_{0i} is the trader fixed effect. The parameter of interest is β_1, which capture the trade volume response to the price change. Note that the OLS estimates of β_1 might be biased if volume discount is applied and DP_{ivdt} becomes endogenous. In order to correct this endogeneity problem, we use the district median price of passive trade, p_{vjt}, as the instrument.

4 Results

4.1 Patterns of Active Trade Participation

Not all the traders engage in active trading. Before presenting the extensive and intensive margin analysis, we present what types of the traders engage in inter-district active trading.

Figure 2 shows that while more than a half of traders engaged in passive trading in all of the survey round, more than a half traders never engaged in active trading throughout the survey period. Only seven percent of the surveyed traders engaged in active trading in every round, and only a quarter of the surveyed traders engaged in active trading in no less than 14 rounds out of 27 rounds in total. Appendix Figure 2 depicts the number of district visited for active trading for each trader who engaged in active trading more than 3 rounds out of 27 rounds. The number of the district visited fluctuates for most of traders, suggesting that traders faced decision making on trade mode at each round.

Appendix Figure 3- 5 depicts the number of district with active trading and passive trading for each variety (Vary Gasy, Tsipala, and Makalioka). Though some traders visited more than one district, most active traders visited only one district for each variety at each round, confirming the relevance of the alternative-specific conditional logit model where the traders are supposed to choose one alternative among the choice set.

Table 5 reports the cross-tabulation of the number of districts with active trading and passive trading using the trader-round observation. It shows that 73 percent of the trader-round observation does not contain any active trade, and most traders engaging in active trading only visited no more than two districts. On the other hand, only one-third of active trading were done together with passive trading. This indicates that when traders decide whether to do active trading, they have the outside option of passive trading. Appendix Figure 3- 5 suggest the interaction of active trading and passive trading is rather substitute than complimentary. This is confirmed by the result presented in Column (1) of Table 5 where we regress the number of districts with active trading on the number of districts with passive trading with the trader fixed effects using the sample of traders who did active trading at least once during the survey period. The coefficient is small but significantly negative, indicating that when active traders decrease the number of districts to visit by 1, they will increase the number of passive trading districts by 0.3.

Columns (2)-(4) in Table 5 shows the estimation results of the Probit model to examine the determinants of active trading. In Column (2), the dependent variable is an indicator variable for having at least one active trading during the surveyed period, while the dependent variables in Column (3) and (4) are indicator variables for having active trading at least once in twenty rounds, and once in ten rounds, respectively. The numbers presented in the tables is the average marginal effects, with the standard errors clustered at trader level in the parentheses.

The results show that active traders are more likely to deal with larger amount of rice at the baseline survey, interpreted as the sales capacity, which is consistent with our analytical framework. Consistent with this, it is found that active traders are also more likely to operate rice mills, as many within-Tana traders purchase rice from big wholesalers who generally operate rice mills. Traders who own big trucks (10 ton or more) and thus greater truck capacity TR_i is also found to be more likely to engage in active trading, consistent with our framework. The result also shows that active traders are less likely to have a store to sell rice, indicating that some active traders specialize in transportation business. Traders selling other food than rice and non-food items are more likely to engage in active trading. If the economy of scope is working, this result suggests that traders with greater sales capacity are more likely to engage in active trading. Interestingly, active traders are more likely to be credit constrained, reflecting the fact that active trade requires a larger amount of cash. Having cell phone or being more educated are not associated with

the likelihood of engaging active trading. After controlling the sales capacity, the storage capacity does not explain the likelihood of engaging in active trading.

4.2 Extensive Margin

To examine the extensive margin, we first report the estimation results of the alternative-specific conditional logit model of the district choice. Traders can choose at most one district to visit for active trading, or can choose not to visit any district. The reference category is set to be no active trade. We drop the trader-round observations where the trader visit more than one district. Since the zero visit cannot happen in the alternative-specific conditional logit model and the multinomial logit model, we drop the observations of the districts which have less than five active trades through the survey period. We mainly report the results on Vary Gasy trading, with the results on Tsipala and Makalioka reported in Appendix, as Vary Gasy is produced nation-wide, while Tsipala and Malalioka are not.

Table 6 presents the estimated results, where we only reports the coefficient on the price related variables. Column (1) is the baseline estimation of the district choice of Vary Gasy rice trading. District choice of the Vary Gasy trading did not significantly respond to the difference in the price margin of Vary Gasy. Further, the point estimate is positive, indicating that traders rather visited districts with higher purchasing price. In Column (2), we include the price differences in passive trading, which would capture the variation in the value of the outside option. However, this did not change the results, and this outside option variable is also insignificant. Hence we do not find any evidence supporting the significant extensive margin.

In Column (3), we include the interaction term of the SMS price information provision and the price differences[6], which turns out to be insignificant. Hence the lack of the extensive margin cannot be explained by the friction on the price information.

In Column (4), we include the indicator variable for having any past trade experience of that district, which is statistically significant and whose magnitude is quite large. This implies that trade experience, or having the linkage to that market, is quite important for explaining the trader's district choice. Having trade experience, though, did not make the traders respondent to the price difference, as reported in Column (5).

One might concern the validity of the estimation above due to the exclusion of the observations where the trader visited multiple districts. In Table 7, we employ the binomial conditional logit model with the trader, round, and district fixed effects, where the observation of the estimation is the trader-round-district level. In addition to the price margin (the price difference between the district median price and the price at Anousibe market), we also include the price difference between the district median price and cheapest

[6]The regression also includes the level term of the SMS price information, whose coefficient is not significant and not reported in the Table.

district median price to capture the attractiveness of the district compared to other options. The results using the analogous linear probability model are reported in Colulmn (1). The reported numbers in the tables are the estimates of the coefficients.

Similar to the alternative-specific conditional logit model, we do not find significant response of the extensive margin to the price margin or the price difference from the cheapest district. In Column (3), we include the price difference in the passive trading to capture the attractiveness of the outside option for active trade, which are also insignificant.

In Column (4), we include the deviation of the rice stock amount from the trader's average through the sample period. If this variable is positive, it indicates that the stock level in the previous period is greater than the trader's own average. Traders visited other districts more likely when they have more rice stock than their time average, which could reflect the seasonality of rice production.

In Column (5), we include the interaction term of the price differences and the log of the annual trade volume at the baseline, which would capture the sales capacity in our analytical framework. The interaction term of the price margin and the annual trade volume is negative and statistically significant at 1 percent level, indicating that large traders are more responsive to the price difference, consistent with the prediction of our framework.

Table 8 reports the analogous analysis for passive trade using the alternative-specific conditional logit model. Passive traders are more responsive to the difference in the price margin, providing the evidence for the extensive margin. In passive trade, traders transact with rice sellers who transport rice from their origin district to Tana, and these rice sellers tend to arrive in some focal location. Hence passive traders can easily compare the price of rice between these rice sellers. It is plausible that spatial arbitrage works well for passive trade. However, the evidence for the extensive margin in passive trade only suggests the spatial arbitrage within Tana. For examining the spatial arbitrage, we need data on rice sellers who transport rice from their origin to investigate if they are more likely to visit Tana when the price margin is higher, which is beyond the scope of our dataset.[7]

Table 9 report the results of the binomial conditional logit model for passive trade. Traders are more likely to engage in passive trade if the rice price of that district is closer to the cheapest district price. On the other hand, they are more likely to engage in passive trade if the price margin is lower. This seems counter-intuitive, but might reflect the general equilibrium effect that when many traders purchase the rice then the price margin decrease, causing the reverse causality. Further analysis would be required to understand this trade pattern. The larger traders are found to be more price-responsive.

[7] If we can assume that Tana market is spatially completely integrated, then one can measure the difference in the quality of rice from the price differences.

We have found that trade experience played a quite important role for the trader's district choice. In Table 10, we use the multinomial logit model where the reference category is no active trading, and we set the choice set one to be the active trading with the district where the trader had any trade experiences at the baseline survey and the first two biweekly survey, and the choice set two to be the active trading with the district without any trade experience. We use the observations after these two biweekly survey for the analysis.

The result suggests that traders significantly responded to the price difference in the districts with trade experiences, while they did not respond to the price difference in the districts without previous trade experiences. This suggests the importance of the trade linkage costs.

Another interpretation of this result is the price information (Allen, 2014). One can argue that the results that the price difference affects district choice only in the district with trade experiences is due to the fact that traders have information on price only in the district with trade experiences. To examine the causes of the trader's pattern, we use the exogenous variation in the price information created by the randomly allocated SMS interventions. If the price information is the main cause, then our SMS intervention will increase the active trade with the districts without previous trade experiences, or it will increase the responsiveness to the price differences in the districts without previous trade experiences. Our results from the multinomial logit model, reported in Columns (1) and (2), does not match this story. Hence the information friction itself does not explain the pattern of active trader's behavior.

Rather, our results are consistent with the trade linkage costs along with the information friction. If there is no information friction, the SMS intervention will not change the trader's decision. However, the result shows that the SMS intervention increased the probability of visiting districts with previous trade experiences, but did not affect the decision on visiting unexperienced districts. This implies that traders did not know the price of some districts with previous experiences as well, and acquiring the price information induced them to visit those districts. But for the districts without trade experiences, the linkage setup costs hindered them from visiting there.

In Column (3), we include the deviation of the stock level and its interaction terms with the price differences. The extensive margin in response to the price differences was not affected by the stock level.

4.3 Intensive Margin

Table 11 shows the result of the intensive margin analysis for the active traders. We use the trade-level observations and standard errors are clustered at the trader level. Unlike the extensive margin analysis, we use the transaction price instead of the district mean price as our interest is whether and how much traders

will increase the trade volume when they face the lower price. Suppose a trader facing the lower price compared to other districts trades sufficient amount rice, and after this trade, the district price becomes equal to the price in other districts. Then if we use the district median price, the data looks like this trader trade quite a lot of rice though the price level is equal to other districts, which is not what we intend to capture. Hence it is appropriate to use the transaction price in the intensive margin analysis.

Use of the transaction price causes another problem. If traders got a discount price with the condition of a large trade volume (volume discount), then the negative correlation of the price and trade amount is not due to the intensive margin response, but the volume discount. In order to deal with this problem, we use the district median price as the instrument for the transaction price. It is highly correlated with the transaction price, and will not affect the transaction volume of the trade because the trader should respond to the transaction price, not the district median price, which ensures the validity of the instrument.

We report the OLS and fixed effects model in Columns (1) and (2), respectively, and report the result of the fixed effect IV model in Columns (3)-(5), which are our main specification. In all, we find no evidence for the effect of the price differences on the intensive margin. Even if traders face lower prices, their trading volume on average would not increase.

Table 14 reports some additional analysis. Column (1) examines if there is nonlinear response to the price change, only to find insignificant coefficients on the level term and the square term. In Column (2), we add the lagged variable of the deviation of the rice stock amount from each trader's average over the rounds. The coefficient is turned out to be positive and significant, suggesting that traders purchase more rice when their rice stock is large. This appears counter-intuitive at first sight, but it may indicate the seasonality. In the harvest season, traders tend to purchase larger amount of rice, and at the same time, the stock level becomes high as well.

In Column (3), we include the interaction term of the price variable and the lagged rice stock. The coefficient is negative and significant, indicating that the trade volume is price sensitive when traders have enough stock. With enough stock, traders can choose not to purchase when the price is high. But when the stock is low, then traders need to fill the deficit of the stock irrespective of the price. Column (4) includes the interaction terms of the price variable and the indicator of owning a rice mill, and of the price variables and the indicator of facing credit constraint. While the first interaction term becomes significant, the linear combination of this interaction term and the price term is insignificant. The price unresponsiveness is not due to the credit constraint.

Table 13 shows the result of the intensive margin analysis for the passive inter-district traders. While the OLS estimates indicate that trade volume is responsive to price changes and the magnitude of the elasticity is quite large, the fixed effect and fixed effect IV estimates do not find any evidence that traders facing

lower prices increased trading volumes. This pattern suggests that traders who purchase large volumes tend to face lower prices than other traders, probably because of better negotiation power and volume discount. However, after controlling such selection and volume discount, we do not find that the trade volume is responsive to the price differences.

Table **??** is the analogous analysis of passive traders to Table 14. There is some evidence of the nonlinearity in the price response. The positive coefficient on the square of the price margin indicates that when the price margin is larger, they will increase the trade volume quite a lot. They become more price sensitive when they have sufficient level of rice stock. The interaction term of the price difference and rice mill is positive and significant, but the linear combination of this term and the price difference is insignificant, indicating that passive traders operating rice mill do not respond to the price difference significantly.

Appendix Tables 6 and 7 report the results when we separately run the regression for each variety, but the results are quite similar. The trade amount on average did not respond to the price differences, and it only responded to the price when passive traders had large amount of rice stock.

5 Inferring Trade Link Costs

Based on these observation, we estimate the extent of the trade cost and linkage setup cost based on the model of trader's trading market choice. For the ease of expression, we drop the variety subscript v. Trader i decides which district to visit depending on the selling price p^S_{jt}, which is expressed as $p^S_{jt} = p^*_t + \gamma_j$, where p^*_t is the "base" rice price and γ_j is the district fixed effects reflecting the quality differences across districts. In each period, the traders form the subject belief in purchase price from district j (transport cost adjusted) $\tilde{p}_{jt} = p_{jt} + \epsilon_{jt}$, where ϵ_{jt} is iid normal. The traders need to pay fixed costs for trading with district j, such as transportation time and security costs. In addition, if the traders visit districts where they never had trade experiences, they also have to incur the linkage setup cost, η. By using an indicator variable for having linkage with district j, L_{ijt}, the linkage setup cost can be expressed as $(1 - L_{ijt})\eta$. Based on the observation of no intensive margin, we assume that the trade amount q_{ijt} is fixed across districts, $\bar{q}_{it}$.[8] Traders need to pay stock cost $c_i(S_{it} + q_{ijt})$ depending on how much they purchase, where S_{it} is the current stock.

Then the profit from trading with district j can be expressed as

$$\Pi_{ijt} = (p^*_t + \gamma_j - p_{jt} - \epsilon_{jt})\bar{q}_{it} - c(S_{it} + q_{ijt}, R_i) - \xi_j - (1 - L_{ijt})\eta$$

[8]No intensive margin does not necessarily imply that the trade amount is fixed across districts, as it only implies that the individual trader's trade amount is fixed within districts given our fixed effect framework.

By comparing the payoff between district j and k, we can cancel out the stock cost and estimate the trade cost and linkage set up cost by using the standard multinomial logit model.

$$\begin{aligned}\Pi_{ijt} - \Pi_{ikt} &= (\gamma_j - \gamma_k - (p_{jt} - p_{kt}))\bar{q}_{it} - (\xi_r - \xi_{r'}) + (L_{ijt} - L_{ikt})\eta \\ &\quad +(\epsilon_{jt} - \epsilon_{kt})\bar{q}_{it}\end{aligned}$$

Note that we are estimating the trade cost and trade linkage costs by assuming that the traders maximize their expected profit. If traders actually failed in maximizing their profit from the rice trade through the price arbitrage, then such lost profit is captured by the trade cost ξ_r when the lost profit opportunities are driven by the price differences across the districts, and by the trade linkage cost η when the lost profit opportunities are driven by the price differences between the districts with trade experiences and districts without trade experiences. Hence when traders do not maximize arbitrage profits, then we should interpret the trade costs and trade linkage costs as the potential monetary gain from the efficient arbitrage, or the room for arbitrage.

The estimated result is reported in Table 16. Since we set the coefficient of p_{vjt}^{AC} to be one, the reported coefficients are represented in the monetary term (,000 MGA). The variable name of LinvQ_AC in the table represents $\frac{1-L_{irt}}{\bar{q}_{it}}$ in the expression above and its coefficient captures $-\eta$, the trade linkage costs. The variable name of invQ_AC is $\frac{1}{\bar{q}_{it}}$ in the expression and there coefficients are the estimates of ξ_r, the trade costs.

We found that the trade linkage cost is statistically significantly different from zero, and its magnitude is almost the same as the difference in the fixed trade cost between the minimum fixed trade cost district and the maximum fixed trade cost district. But compared to the average biweekly profits, its magnitude is moderate, about 17.5 percent of the average biweekly profits. It should be noted, however, our analytical framework have ignored the dynamic effect of visiting a new district on the future expected profit. If this effect is taken into considered, the linkage cost should become higher.

It should be noted that Ambatondrazaka is the main production market for Makalioka, and that the trade with Bealanana only occurred during few weeks after the harvest, which makes the number of observations visiting these two markets for Vary Gasy trade is quite small. In Column (2) of Table 16, we exclude these two districts. The quantitative results are quite similar, adding credibility to our main results.

Our framework above assumed that traders have the price information in each district, which might not be true. Hence in Column (3), we restrict our sample to those observations who received the SMS price information. We found that the magnitude of the trade linkage setup costs becomes greater, which amounts to 27 percent of the average biweekly profits. On the other hand, the largest difference in the trade cost across markets was found between that of Tsiroanomandidy and Ambohidratrimo, resulting in 142.45 MGA. Hence the trade linkage setup costs explains the quite important portion of the trader's market choice

behavior.

6 Concluding Remarks

Traders are the economic agent whose main role is arbitrage. However, our survey in Madagascar shows that rice traders does not seem to do arbitrage well. They did not respond to the price difference both in terms of the extensive margin and intensive margin, especially when they engage in active trade. The price information provision increased the visit to the districts with previous trade experiences, but it did not increase the visit to the district without previous trade experiences. We also infer the trade linkage setup costs and trade costs by active trader's district choice for Vary Gasy rice, finding the moderate level of the linkage setup costs, which could be more important than the heterogeneity in the trade costs across markets in explaining the behavior of the traders.

Our study focusing on trader-level behavior reveals that individual traders on average did not arbitrage well. However, incomplete arbitrage at the average individual trader level does not necessarily mean the incomplete arbitrage at the market level. We have found some evidence that large traders are more responsive to the price differences. Our data do not include some huge rice traders, but if these big players actively engage in spatial arbitrage and their arbitrage action brings the spatial price dispersion down to the sufficiently small level, then it would not be profitable for small traders to do active trading by incurring the fixed trade costs. In evaluating the market level arbitrage efficiency, we might miss the point if we exclude these big players in our analysis. Hence for evaluating the extent of spatial integration and coming up with any policy implications, combining the aggregate level data and individual trader level data in the equilibrium analysis is quite important, though sometimes it would be very difficult to obtain the credible aggregate transaction data as in our study. Another approach will be imposing some distributional assumptions on the scale of traders, and construct a spatial equilibrium model with heterogeneous traders to predict the policy outcomes. In any cases, incorporating the trader's arbitrage behavior is quite important for evaluating and predicting the economic integration and outcomes of the policy such as infrastructure projects aiming at reducing transport costs and improving the flow of goods.

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Table 1: Summary statistics: Trader level

	count	mean	sd	min	max
Have a store to sell rice	234	0.84	0.37	0	1
Operate rice mill	234	0.16	0.37	0	1
Sell food other than rice	234	0.70	0.46	0	1
Sell non-food items	234	0.44	0.50	0	1
Years of experience in rice trading	234	8.25	6.72	1	32
Total capacity of storage (ton)	234	27.09	92.43	0	1000
Total trading volume 07/11-06/12 (ton)	234	189.14	320.30	0	2200
Have cell phone	233	0.90	0.30	0	1
Checked price using newspaper	232	0.10	0.31	0	1
Checked price using radio	232	0.06	0.24	0	1
Checked price using TV	232	0.09	0.29	0	1
Credit constrained	234	0.17	0.38	0	1

Table 2: Summary statistics: Trader-round level

	count	mean	sd	min	max
Engage in active inter-dist. trade	6081	0.27	0.44	0	1
Number of districts traded:AC	6088	0.32	0.60	0	4
Active trade for Vary gasy	6088	0.16	0.37	0	1
Active trade for Makalioka	6088	0.12	0.32	0	1
Engage in passive inter-dist. trade	6087	0.83	0.38	0	1
Number of districts traded:PS	6088	1.23	1.04	0	6
Passive trade for Vary gasy	6088	0.50	0.50	0	1
Passive trade for Makalioka	6088	0.56	0.50	0	1
Stock of rice	6081	3.60	10.08	0	202
Stock of Vary gasy (ton)	5706	1.19	3.92	0	100
Stock of Tsipala (ton)	5704	0.66	1.65	0	35
Stock of Makalioka (ton)	5711	1.36	5.40	0	120
Biweekly profit, net salary (,000 Ar)	3661	644.11	1178.22	-1186	24050

Table 3: Summary statistics: Price and trade volume

	count	mean	sd	min	max
Dif.dist.ANSB.price:AC,Mak	58	-0.09	0.13	-0.49	0.11
Dif.dist.ANSB.price:AC,Tsi	167	0.02	0.10	-0.26	0.36
Dif.dist.ANSB.price:AC,Var	203	-0.03	0.08	-0.42	0.15
Dif.dist.ANSB.price:PS,Mak	76	-0.02	0.05	-0.17	0.11
Dif.dist.ANSB.price:PS,Tsi	218	-0.01	0.07	-0.22	0.14
Dif.dist.ANSB.price:PS,Var	204	-0.00	0.07	-0.26	0.24

	count	mean	sd	min	max
Dif.ANSB.price:AC,Mak	6875	-0.06	0.18	-0.87	0.00
Dif.ANSB.price:AC,Tsi	6950	-0.06	0.17	-0.71	0.00
Dif.ANSB.price:AC,Var	7165	-0.07	0.19	-0.82	0.00
Dif.ANSB.price:PS,Mak	9497	-0.23	0.32	-0.87	0.00
Dif.ANSB.price:PS,Tsi	8864	-0.18	0.28	-0.76	0.00
Dif.ANSB.price:PS,Var	9336	-0.20	0.28	-0.78	0.00
Mak totalamountAC	676	36095.17	28417.29	300.00	191520.02
Tsi totalamountAC	728	13790.14	12719.79	300.00	119000.00
Var totalamountAC	907	20743.07	22864.84	200.00	183600.02
Mak totalamountPS	3371	6871.06	12652.21	0.00	280000.00
Tsi totalamountPS	2705	5364.07	8585.45	0.00	130000.00
Var totalamountPS	3168	6865.92	13096.65	0.00	255000.00

Table 4: Number of districts with active trading and passive trading

	# dist:PS						
# dist:AC	0	1	2	3	4	6	Total
0	14.27	17.56	30.45	10.96	0.57	0.02	73.83
1	13.50	6.60	0.57	0.13	0.00	0.00	20.81
2	3.60	0.85	0.07	0.03	0.00	0.00	4.55
3	0.57	0.10	0.05	0.00	0.00	0.00	0.72
4	0.05	0.03	0.00	0.00	0.00	0.00	0.08
Total	32.00	25.15	31.14	11.12	0.57	0.02	100.00

Table 5: Active Trade Participation

	(1)	(2)	(3)	(4)
	# of AC trade dist	Active	Active(> 0.1)	% of AC trade round
Number of districts traded:PS	-0.316***			
	(0.034)			
BS:log(Annual trade volume)		0.097***	0.107***	0.066*
		(0.021)	(0.022)	(0.038)
Operate rice mill		0.189**	0.124*	-0.089
		(0.077)	(0.074)	(0.081)
Have truck (0-9 ton) (dummy)		0.074	0.082	-0.001
		(0.064)	(0.064)	(0.074)
Have truck(10+ ton)(dummy)		0.159*	0.145*	0.026
		(0.094)	(0.087)	(0.081)
Have a store to sell rice		-0.409***	-0.364***	0.003
		(0.085)	(0.078)	(0.078)
Sell food other than rice		0.069	0.125*	-0.004
		(0.073)	(0.075)	(0.106)
Sell non-food items		0.114*	0.085	-0.059
		(0.063)	(0.063)	(0.087)
Total capacity of storage (ton)		0.000	-0.000	0.000
		(0.000)	(0.000)	(0.000)
Credit constrained		0.127**	0.144**	0.149*
		(0.064)	(0.062)	(0.077)
Years of experience in rice trading		0.006	0.007*	0.005
		(0.004)	(0.004)	(0.005)
Education		-0.004	-0.002	0.001
		(0.006)	(0.006)	(0.008)
Risky choices		-0.005	-0.021*	-0.004
		(0.012)	(0.012)	(0.017)
Observations	2815	216	216	99

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Extensive margin of active trading: Alternative-specific conditional logit model

	(1)	(2)	(3)	(4)	(5)
	Vary	Vary	Vary	Vary	Vary
Dif.dist.ANSB.price:AC,Var	0.431	0.719	0.529	1.427	0.566
	(0.455)	(0.480)	(0.650)	(2.407)	(0.490)
Dif.dist.ANSB.price:PS,Var		0.026			
		(0.634)			
Dif.ANSB.price× SMS			-0.509		
			(1.244)		
Dif.ANSB.price× evertrade_AC				-0.781	
				(2.386)	
evertrade_AC				4.826***	4.759***
				(0.253)	(0.259)
SMS× evertrade_AC					0.530
					(0.421)
Observations	45629	43232	44129	45629	44129

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Extensive margin of active trade (Vary Gasy): Conditional logit model

	(1)	(2)	(3)	(4)	(5)
	FE-LP	CLOGIT	CLOGIT	CLOGIT	CLOGIT
main					
Dif.dist.ANSB.price:AC	-0.049	-2.123	-1.320	-1.116	3.712*
	(0.035)	(1.502)	(2.477)	(2.694)	(2.094)
Dif.dist.opt.price:AC	0.048	2.040	1.229	0.857	2.654*
	(0.032)	(1.384)	(2.245)	(2.596)	(1.553)
Dif.dist.ANSB.price:PS			-1.645		
			(5.521)		
Dif.dist.opt.price:PS			1.297		
			(5.459)		
Dev_stock(t-1)				0.042	
				(0.032)	
Dif.dist.ANSB.price:AC × Dev_stock(t-1)				0.540*	
				(0.328)	
Dif.dist.opt.price:AC × Dev_stock(t-1)				0.243	
				(0.224)	
Dif.dist.ANSB.price:AC × BS:Annual trade volume					-1.161***
					(0.276)
Dif.dist.opt.price:AC × BS:Annual trade volume					-0.057
					(0.193)
Observations	45630	17160	14696	14196	16965

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Extensive margin of passive trading: Alternative-specific conditional logit model

	(1)	(2)	(3)	(4)
	Vary	Tsipala	Vary	Maka
District of purchase / origin district of seller				
Dif.dist.ANSB.price:PS,Var	-0.954**	0.275	-0.682	-0.121
	(0.439)	(0.381)	(0.477)	(0.290)
Dif.dist.ANSB.price:PS,Tsi	-0.110	-2.896***		
	(0.378)	(0.536)		
Dif.dist.ANSB.price:PS,Mak			-0.495	-2.698***
			(0.489)	(0.819)
Observations	46093	44915	15524	18082

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Extensive margin: Passive trading (Vary Gasy)

	(1)	(2)	(3)	(4)	(5)
	FE-LP	CLOGIT	CLOGIT	CLOGIT	CLOGIT
main					
Dif.dist.ANSB.price(level):PS	0.148**	2.526**	6.734**	2.670*	5.531***
	(0.069)	(1.284)	(2.897)	(1.584)	(1.874)
Dif.dist.opt.price(level):PS	-0.175**	-3.541**	-7.718***	-3.746**	-2.755*
	(0.073)	(1.401)	(2.935)	(1.669)	(1.453)
Dif.dist.ANSB.price(level):AC			-2.152*		
			(1.238)		
Dif.dist.opt.price(level):AC			2.728**		
			(1.194)		
Dev_stock(t-1)				0.048**	
				(0.019)	
Dif.dist.ANSB.price(level):PS × Dev_stock(t-1)				0.065	
				(0.371)	
Dif.dist.opt.price(level):PS × Dev_stock(t-1)				-0.096	
				(0.133)	
Dif.dist.ANSB.price(level):PS × BS:Annual trade volume					-0.645**
					(0.306)
Dif.dist.opt.price(level):PS × BS:Annual trade volume					-0.192**
					(0.082)
Observations	54522	46367	33490	40153	45435

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Extensive margin of active trading (Vary Gasy): Multinomial logit model

	(1)	(2)	(3)
	Var:AC	Var:AC	m3ACVar
1			
Dif.dist.ANSB.price:AC,Var(CS1)	-4.264***	-5.444***	-3.885**
	(1.624)	(1.712)	(1.622)
Dif.dist.ANSB.price:AC,Var(CS2)	-12.413***	-12.669***	-11.568***
	(3.606)	(3.570)	(3.515)
SMS Treatment (dummy)=1	0.906**	1.274**	1.140**
	(0.427)	(0.517)	(0.461)
SMS Treatment (dummy)=1 × Dif.dist.ANSB.price:AC,Var(CS1)		2.725	
		(1.988)	
SMS Treatment (dummy)=1 × Dif.dist.ANSB.price:AC,Var(CS2)		1.301	
		(1.622)	
Dev_stockVar(t-1)			0.023
			(0.080)
Dif.dist.ANSB.price:AC,Var(CS1) × Dev_stockVar(t-1)			0.027
			(0.615)
Dif.dist.ANSB.price:AC,Var(CS2) × Dev_stockVar(t-1)			-0.647
			(0.575)
2			
Dif.dist.ANSB.price:AC,Var(CS1)	-5.443	-6.467*	-5.358
	(3.406)	(3.625)	(3.683)
Dif.dist.ANSB.price:AC,Var(CS2)	-1.137	-1.369	-1.355
	(5.846)	(6.099)	(6.218)
SMS Treatment (dummy)=1	-0.088	-0.441	0.049
	(0.656)	(0.776)	(0.636)
SMS Treatment (dummy)=1 × Dif.dist.ANSB.price:AC,Var(CS1)		1.603	
		(2.773)	
SMS Treatment (dummy)=1 × Dif.dist.ANSB.price:AC,Var(CS2)		-2.634	
		(3.544)	
Dev_stockVar(t-1)			0.176*
			(0.095)
Dif.dist.ANSB.price:AC,Var(CS1) × Dev_stockVar(t-1)			-0.753
			(0.819)
Dif.dist.ANSB.price:AC,Var(CS2) × Dev_stockVar(t-1)			0.637
			(0.916)
Observations	2058	2058	1874

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Active: Intensive margin

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE	FE	FE IV	FE IV
Dif.ANSB.price(%)	1.784**		0.144		0.004	
	(0.889)		(0.435)		(1.146)	
Dif.opt.price(%)		0.708		-0.053		-0.175
		(0.429)		(0.159)		(0.180)
Dev_stock(t-1)	0.066**	0.066**	0.025	0.025	0.025	0.025
	(0.025)	(0.025)	(0.018)	(0.018)	(0.017)	(0.018)
Observations	1601	1601	1601	1601	1601	1601
Effective_F					140.730	1610.626

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Active: Intensive margin, nonlinearity and heterogeneity

	(1)	(2)	(3)	(4)	(5)
	FE IV	FE IV	FE IV	FE IV	FE IV
Dif.ANSB.price(%)	-42.615**	-0.834	0.182	-1.651	-0.438
	(19.478)	(1.576)	(1.342)	(1.375)	(1.465)
Dif.price(%) square	-46.467**				
	(21.330)				
Dev_stock(t-1)	0.013	-0.153	0.024	0.025	0.026
	(0.019)	(0.262)	(0.017)	(0.018)	(0.019)
Dif.price(%)× Dev_stock(t-1)		-1.018			
		(1.371)			
Dif.price(%)× Rice mill			-0.672		
			(1.555)		
Dif.price(%)× trade amount(BS)				1.922**	
				(0.908)	
Dif.price(%)× Credit constraint					1.651
					(2.474)
Observations	1601	1601	1601	1601	1601

	(1)	(2)	(3)	(4)	(5)
	FE IV	FE IV	FE IV	FE IV	FE IV
Dif.opt.price(%)	0.270	-0.159	-0.105	-0.153	0.026
	(1.774)	(0.179)	(0.212)	(0.223)	(0.182)
Dif.price(%) square	0.685				
	(2.905)				
Dev_stock(t-1)	0.025	0.010	0.025	0.025	0.024
	(0.018)	(0.014)	(0.017)	(0.018)	(0.018)
Dif.price(%)× Dev_stock(t-1)		-0.099			
		(0.110)			
Dif.price(%)× Rice mill			-0.324		
			(0.339)		
Dif.price(%)× trade amount(BS)				-0.043	
				(0.249)	
Dif.price(%)× Credit constraint					-1.010*
					(0.574)
Observations	1601	1601	1601	1601	1601

Table 13: Passive: Intensive margin

	(1) OLS	(2) OLS	(3) FE	(4) FE	(5) FE IV	(6) FE IV
Dif.ANSB.price(%)	4.465***		1.287***		-0.321	
	(1.614)		(0.447)		(1.013)	
Dif.opt.price(%)		1.864**		0.311*		-0.124
		(0.742)		(0.182)		(0.131)
Dev_stock(t-1)	0.049***	0.055***	0.049***	0.050***	0.050***	0.050***
	(0.016)	(0.015)	(0.013)	(0.013)	(0.012)	(0.012)
Observations	5302	5302	5302	5302	5302	5302
Effective_F					550.672	1.4e+04

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: Passive: Intensive margin, nonlinearity and heterogeneity

	(1)	(2)	(3)	(4)	(5)
	FE IV	FE IV	FE IV	FE IV	FE IV
Dif.ANSB.price(%)	2.569	-0.629	-0.372	-0.346	-0.576
	(17.074)	(0.965)	(1.009)	(1.002)	(0.999)
Dif.price(%) square	2.927				
	(17.138)				
Dev_stock(t-1)	0.049***	0.023	0.050***	0.050***	0.050***
	(0.014)	(0.014)	(0.012)	(0.012)	(0.012)
Dif.price(%)× Dev_stock(t-1)		-0.478***			
		(0.152)			
Dif.price(%)× Rice mill			0.519		
			(1.760)		
Dif.price(%)× trade amount(BS)				-0.470	
				(0.685)	
Dif.price(%)× Credit constraint					3.019
					(1.957)
Observations	5302	5302	5302	5302	5302

	(1)	(2)	(3)	(4)	(5)
	FE IV	FE IV	FE IV	FE IV	FE IV
Dif.opt.price(%)	0.273	-0.148	-0.090	-0.124	-0.089
	(0.819)	(0.131)	(0.128)	(0.131)	(0.139)
Dif.price(%) square	0.740				
	(1.633)				
Dev_stock(t-1)	0.050***	0.020*	0.050***	0.050***	0.050***
	(0.012)	(0.010)	(0.012)	(0.012)	(0.012)
Dif.price(%)× Dev_stock(t-1)		-0.562***			
		(0.085)			
Dif.price(%)× Rice mill			-0.284		
			(0.423)		
Dif.price(%)× trade amount(BS)				0.036	
				(0.118)	
Dif.price(%)× Credit constraint					-0.306
					(0.244)
Observations	5302	5302	5302	5302	5302

Table 15: Intensive margin, weighted by baseline annual trade volume

	(1)	(2)	(3)	(4)
	AC	AC	AC	AC
Dif.ANSB.price(%)	0.241		-36.592**	
	(1.089)		(18.240)	
Dif.opt.price(%)		-0.137		-0.409
		(0.177)		(1.641)
Dev_stock(t-1)	0.023	0.022	0.013	0.022
	(0.017)	(0.018)	(0.018)	(0.017)
Dif.price(%) square			-40.121**	
			(20.072)	
Dif.price(%) square				-0.421
				(2.724)
Observations	1595	1595	1595	1595

	(1)	(2)	(3)	(4)
	PS	PS	PS	PS
Dif.ANSB.price(%)	-0.494		7.026	
	(0.548)		(9.319)	
Dif.opt.price(%)		-0.073		0.674
		(0.111)		(0.542)
Dev_stock(t-1)	0.048***	0.048***	0.047***	0.048***
	(0.013)	(0.013)	(0.014)	(0.013)
Dif.price(%) square			7.625	
			(9.494)	
Dif.price(%) square				1.372
				(1.084)
Observations	8955	8955	8955	8955

Table 16: Inferring trade costs

	(1)	(2)	(3)
	Vary	Vary:6 markets	Vary:SMS only
District of purchase / origin district of seller			
LinvQ_AC	-112.73***	-129.12***	-173.80***
	(17.70)	(20.86)	(55.41)
Tsiroanomandidy			
invQ_AC	-89.46***	-87.55***	-103.97***
	(16.38)	(17.82)	(19.07)
Anjozorobe			
invQ_AC	-26.26	-32.88**	-101.91
	(16.19)	(16.14)	(76.20)
Ambohidratrimo			
invQ_AC	33.12**	18.67**	40.54***
	(16.11)	(8.34)	(13.60)
Miarinarivo			
invQ_AC	-64.18*	-62.05*	-51.49*
	(35.99)	(34.92)	(28.32)
Ankazobe			
invQ_AC	3.04	0.66	12.39
	(11.25)	(9.61)	(22.18)
Ambatondrazaka			
invQ_AC	-82.94***		
	(27.61)		
Bealanana			
invQ_AC	-104.57***		
	(21.94)		
Observations	6150	4564	1361

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 1: Price movement of 10 major markets

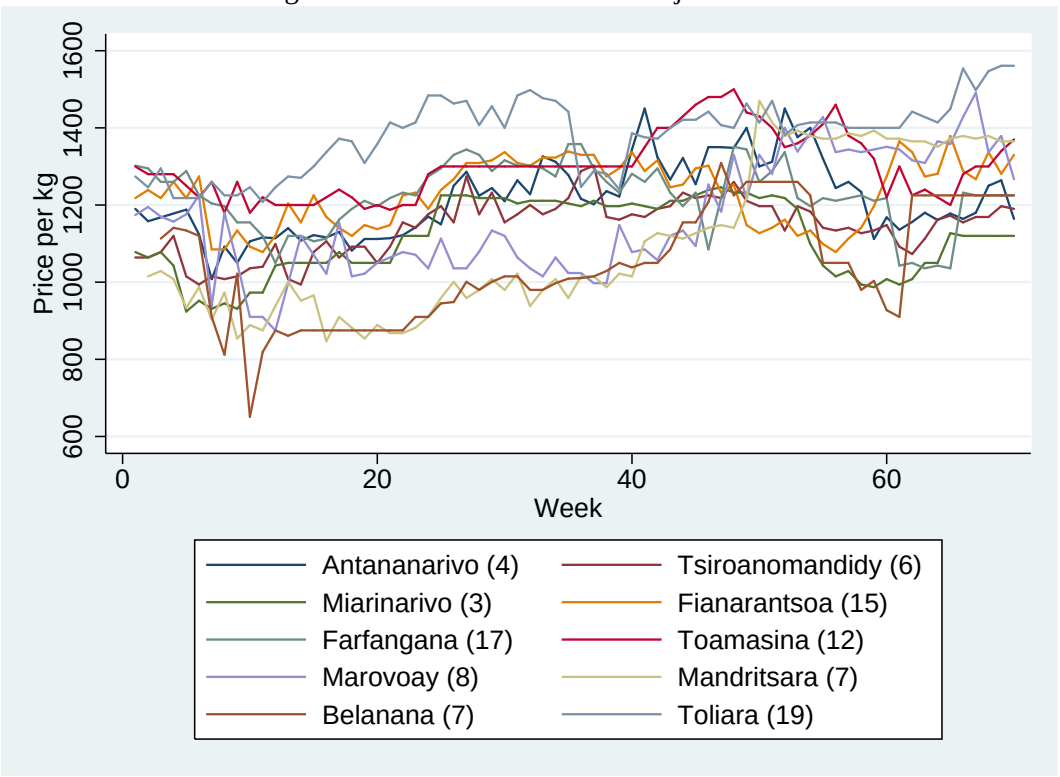
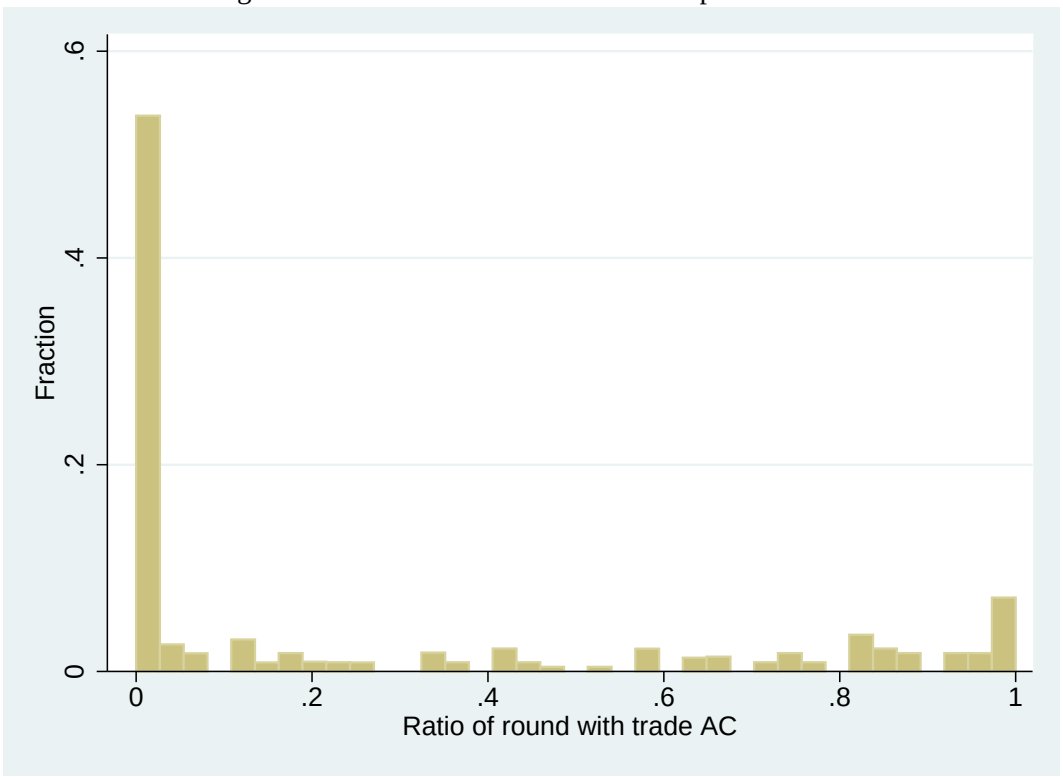
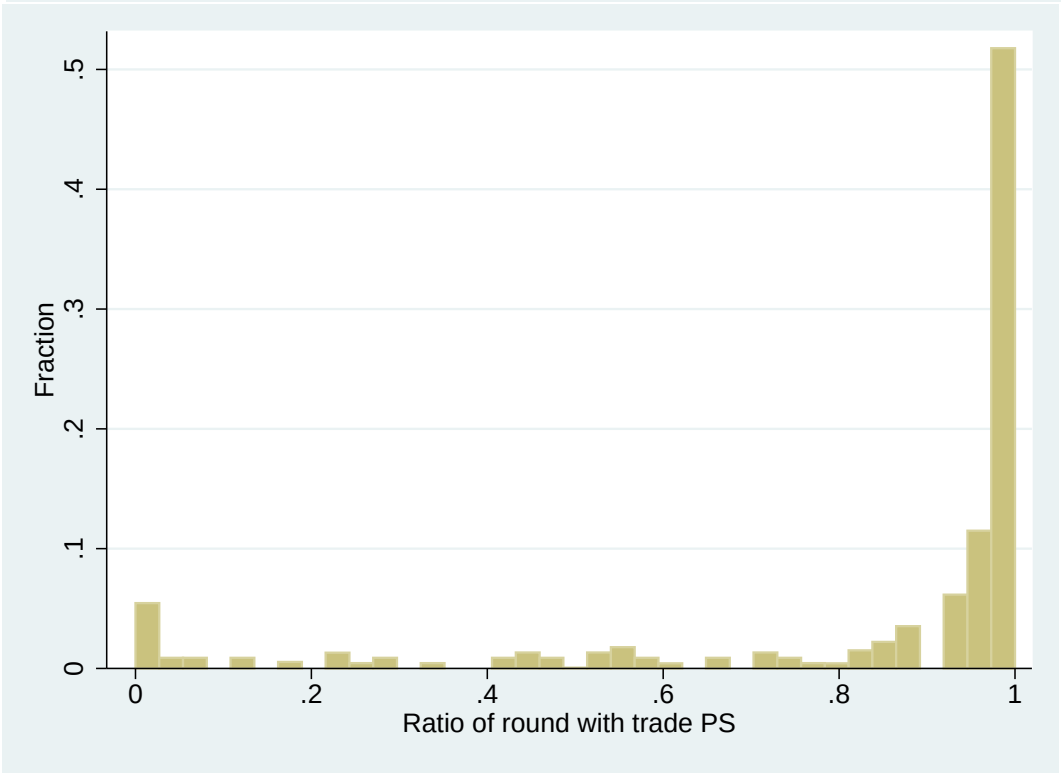


Figure 2: Ratio of rounds with active and passive trade





A Appendix Tables

Appendix Table 1: Names of districts with trade frequency no less than five observations

	AC trade:Var
No trade	5351
Arivonimamo	334
Tsiroanomandidy	259
Anjozorobe	157
Ambohidratrimo	51
Miarinarivo	33
Ankazobe	30
Ambatondrazaka	26
Bealanana	17

	PS trade:Var
No trade	3213
Arivonimamo	1099
Tsiroanomandidy	554
Anjozorobe	971
Ambohidratrimo	114
Miarinarivo	80
Ankazobe	233
Ambatondrazaka	54
Bealanana	34

	AC trade:Tsi
No trade	5528
Arivonimamo	414
Tsiroanomandidy	183
Anjozorobe	11
Ambohidratrimo	43
Miarinarivo	30
Ankazobe	17
Ambatondrazaka	3
Bealanana	27

	PS trade:Tsi
No trade	3540
Arivonimamo	1006
Tsiroanomandidy	624
Anjozorobe	416
Ambohidratrimo	95
Miarinarivo	83
Ankazobe	163
Ambatondrazaka	27
Bealanana	259

	AC trade:Mak
No trade	5584
Arivonimamo	21
Tsiroanomandidy	1
Anjozorobe	27
Miarinarivo	1
Ambatondrazaka	626

	PS trade:Mak
No trade	2887
Arivonimamo	29
Tsiroanomandidy	13
Anjozorobe	16
Ambohidratrimo	2
Ankazobe	2
Ambatondrazaka	3281

Appendix Table 2: Extensive margin of active trade (Tsipala): Conditional logit model

	(1)	(2)	(3)	(4)	(5)
	FE-LP	CLOGIT	CLOGIT	CLOGIT	CLOGIT
main					
Dif.dist.ANSB.price:AC	-0.067	-4.771	-2.087	-5.461	1.739
	(0.087)	(4.801)	(2.979)	(6.581)	(6.003)
Dif.dist.opt.price:AC	0.076	4.774	2.841	4.829	0.638
	(0.089)	(4.874)	(2.681)	(6.364)	(4.995)
Dif.dist.ANSB.price:PS			-6.521		
			(4.350)		
Dif.dist.opt.price:PS			-0.116		
			(4.015)		
Dev_stock(t-1)				0.027	
				(0.041)	
Dif.dist.ANSB.price:AC × Dev_stock(t-1)				0.335	
				(0.355)	
Dif.dist.opt.price:AC × Dev_stock(t-1)				0.242	
				(0.201)	
Dif.dist.ANSB.price:AC × BS:Annual trade volume					-1.327
					(0.825)
Dif.dist.opt.price:AC × BS:Annual trade volume					0.840*
					(0.449)
Observations	44226	15687	13197	12450	15687

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 3: Extensive margin of active trade (Makalioka): Conditional logit model

	(1)	(2)	(3)	(4)	(5)
	FE-LP	CLOGIT	CLOGIT	CLOGIT	CLOGIT
main					
Dif.dist.ANSB.price:AC	-0.066	-1.274	-0.520	-0.489	0.496
	(0.051)	(2.655)	(5.596)	(4.633)	(3.499)
Dif.dist.opt.price:AC	0.009	1.013	2.387	5.128	2.414
	(0.042)	(1.378)	(1.458)	(5.787)	(2.397)
Dif.dist.ANSB.price:PS			-9.445		
			(8.922)		
Dif.dist.opt.price:PS			-6.949		
			(6.051)		
Dev_stock(t-1)				0.155**	
				(0.061)	
Dif.dist.ANSB.price:AC × Dev_stock(t-1)				-0.183	
				(0.916)	
Dif.dist.opt.price:AC × Dev_stock(t-1)				-0.843***	
				(0.319)	
Dif.dist.ANSB.price:AC × BS:Annual trade volume					-0.312
					(0.545)
Dif.dist.opt.price:AC × BS:Annual trade volume					-0.276
					(0.334)
Observations	15444	4290	2752	3523	4290

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 4: Extensive margin: Passive trading (Tsipala)

	(1)	(2)	(3)	(4)	(5)
	FE-LP	CLOGIT	CLOGIT	CLOGIT	CLOGIT
main					
Dif.dist.ANSB.price(level):PS	0.127**	2.788*	2.405	17.860***	5.440**
	(0.054)	(1.585)	(2.331)	(6.752)	(2.203)
Dif.dist.opt.price(level):PS	-0.256***	-7.208***	-10.360***	-22.527***	-2.378
	(0.057)	(1.596)	(2.080)	(7.004)	(2.949)
Dif.dist.ANSB.price(level):AC			-0.265		
			(1.251)		
Dif.dist.opt.price(level):AC			1.381		
			(1.069)		
Dev_stock(t-1)				0.082***	
				(0.030)	
Dif.dist.ANSB.price(level):PS × Dev_stock(t-1)				0.065	
				(0.290)	
Dif.dist.opt.price(level):PS × Dev_stock(t-1)				-0.636*	
				(0.326)	
Dif.dist.ANSB.price(level):PS × BS:Annual trade volume					-0.634
					(0.400)
Dif.dist.opt.price(level):PS × BS:Annual trade volume					-1.139**
					(0.540)
Observations	65286	52452	28980	45076	51894

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 5: Extensive margin: Passive trading (Makalioka)

	(1)	(2)	(3)	(4)	(5)
	FE-LP	CLOGIT	CLOGIT	CLOGIT	CLOGIT
main					
Dif.dist.ANSB.price(level):PS	-0.719***	-24.934***	-8.083	-26.349***	-18.055**
	(0.238)	(7.807)	(6.228)	(8.206)	(8.447)
Dif.dist.opt.price(level):PS	0.717***	23.605***	3.426	25.194***	18.832**
	(0.245)	(8.119)	(5.643)	(8.789)	(9.047)
Dif.dist.ANSB.price(level):AC			7.424*		
			(4.502)		
Dif.dist.opt.price(level):AC			-2.940**		
			(1.179)		
Dev_stock(t-1)				0.034	
				(0.062)	
Dif.dist.ANSB.price(level):PS × Dev_stock(t-1)				1.478	
				(0.978)	
Dif.dist.opt.price(level):PS × Dev_stock(t-1)				-0.054	
				(0.933)	
Dif.dist.ANSB.price(level):PS × BS:Annual trade volume					-1.585***
					(0.585)
Dif.dist.opt.price(level):PS × BS:Annual trade volume					1.236**
					(0.611)
Observations	22932	19306	8624	15882	18914

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 6: Intensive margin (elasticity): Active

	(1)	(2)	(3)	(4)	(5)	(6)
	Vary gasy	Tsipala	Makalioka	Vary gasy	Tsipala	Makalioka
Dif.ANSB.price(%)	-1.356	0.747	33.707	-0.963	0.896	1.982
	(1.259)	(1.353)	(32.557)	(2.230)	(1.726)	(13.464)
Dev_stockVar(t-1)	0.072***	0.043	-0.063	0.044	0.016	-0.126
	(0.017)	(0.028)	(0.184)	(0.181)	(0.094)	(0.816)
Dev_stockTsi(t-1)	-0.005	0.014	-0.256	-0.005	-0.003	-0.194
	(0.010)	(0.019)	(0.316)	(0.027)	(0.021)	(0.384)
Dev_stockMak(t-1)	0.003	0.002	-0.083	-0.027	-0.026	-0.670
	(0.009)	(0.028)	(0.227)	(0.130)	(0.039)	(0.942)
Dif.price(%)× Dev_stockVar(t-1)				0.706		
				(3.878)		
Dev_stock(t-1)				0.194	0.109	0.819
				(1.103)	(0.098)	(2.599)
Dif.price(%)× Dev_stockTsi(t-1)					0.121	
					(1.012)	
Dif.price(%)× Dev_stockMak(t-1)						-0.567
						(0.621)
Observations	672	583	34	664	579	31

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

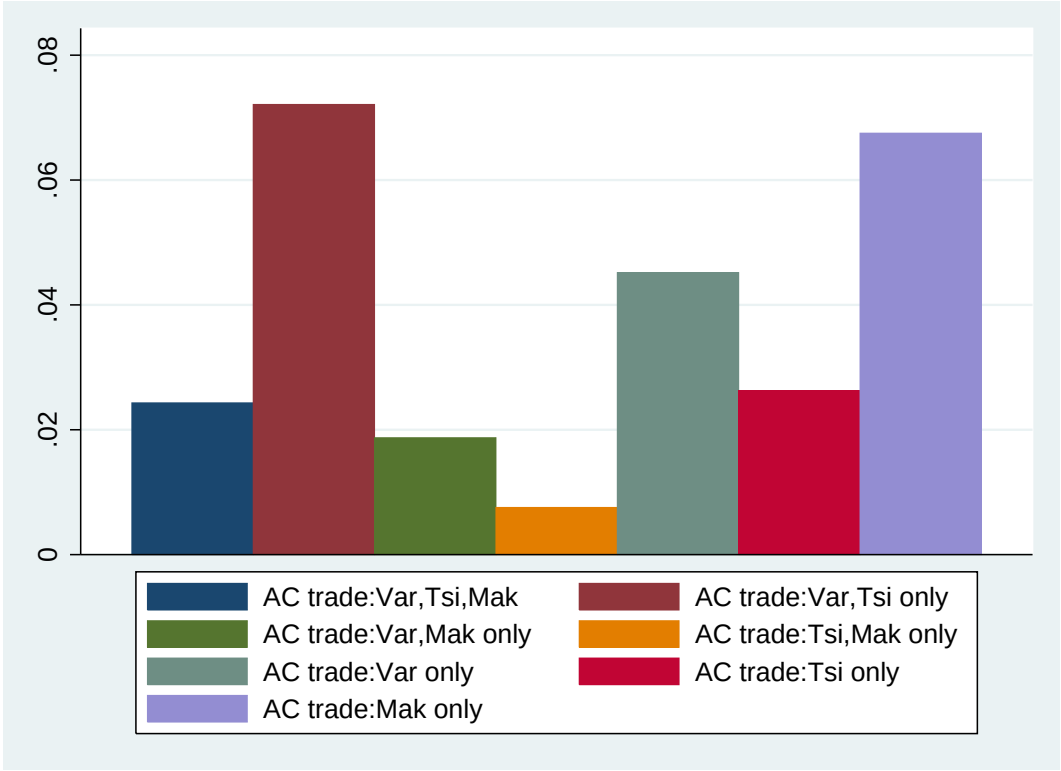
Appendix Table 7: Intensive margin (elasticity): Passive

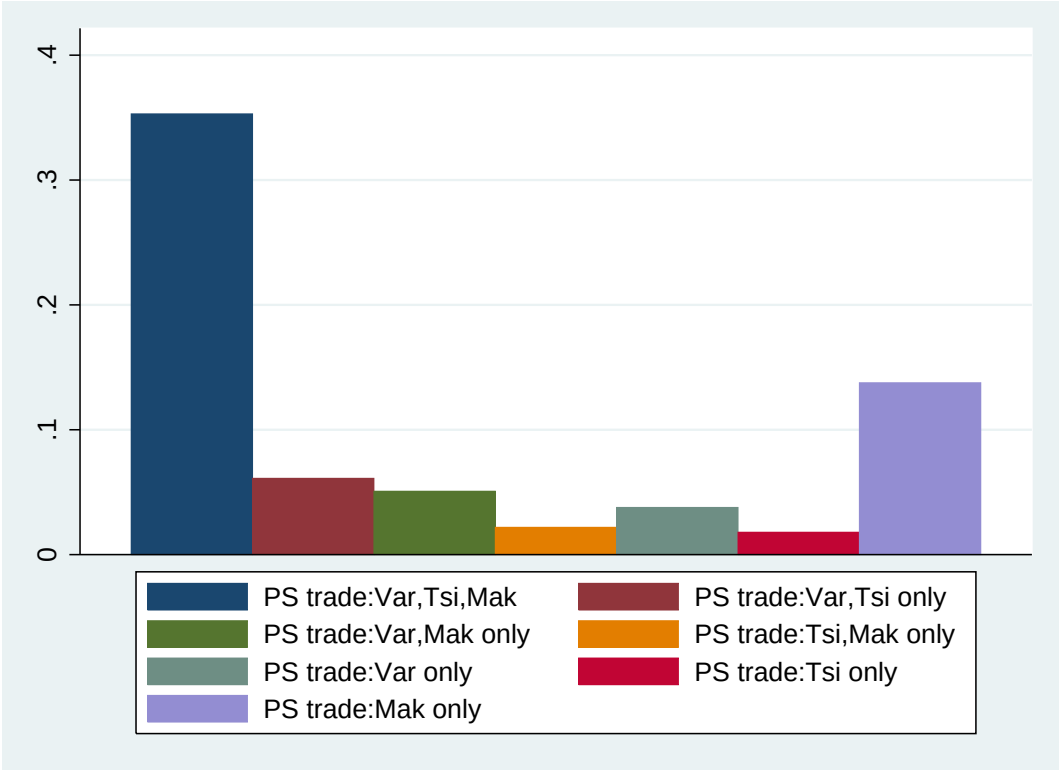
	(1)	(2)	(3)	(4)	(5)	(6)
	Vary gasy	Tsipala	Makalioka	Vary gasy	Tsipala	Makalioka
Dif.ANSB.price(%)	-1.318	-0.578	-0.434	-1.349	-1.030	-0.599
	(1.690)	(1.068)	(2.869)	(1.589)	(1.018)	(3.628)
Dev_stockVar(t-1)	0.035**	-0.006	0.018	0.031*	-0.009	0.013
	(0.017)	(0.012)	(0.011)	(0.017)	(0.016)	(0.014)
Dev_stockTsi(t-1)	0.012	0.044***	0.012	0.010	0.025	0.006
	(0.012)	(0.014)	(0.008)	(0.010)	(0.017)	(0.008)
Dev_stockMak(t-1)	0.017*	0.015	0.025**	0.019*	0.020*	0.029*
	(0.010)	(0.012)	(0.013)	(0.011)	(0.011)	(0.017)
Dif.price(%)× Dev_stockVar(t-1)				-0.281***		
				(0.104)		
Dev_stock(t-1)				-0.010	0.003	0.003
				(0.024)	(0.029)	(0.026)
Dif.price(%)× Dev_stockTsi(t-1)					-0.284***	
					(0.070)	
Dif.price(%)× Dev_stockMak(t-1)						-0.312***
						(0.045)
Observations	2868	2697	3154	2854	2686	3135

Standard errors in parentheses

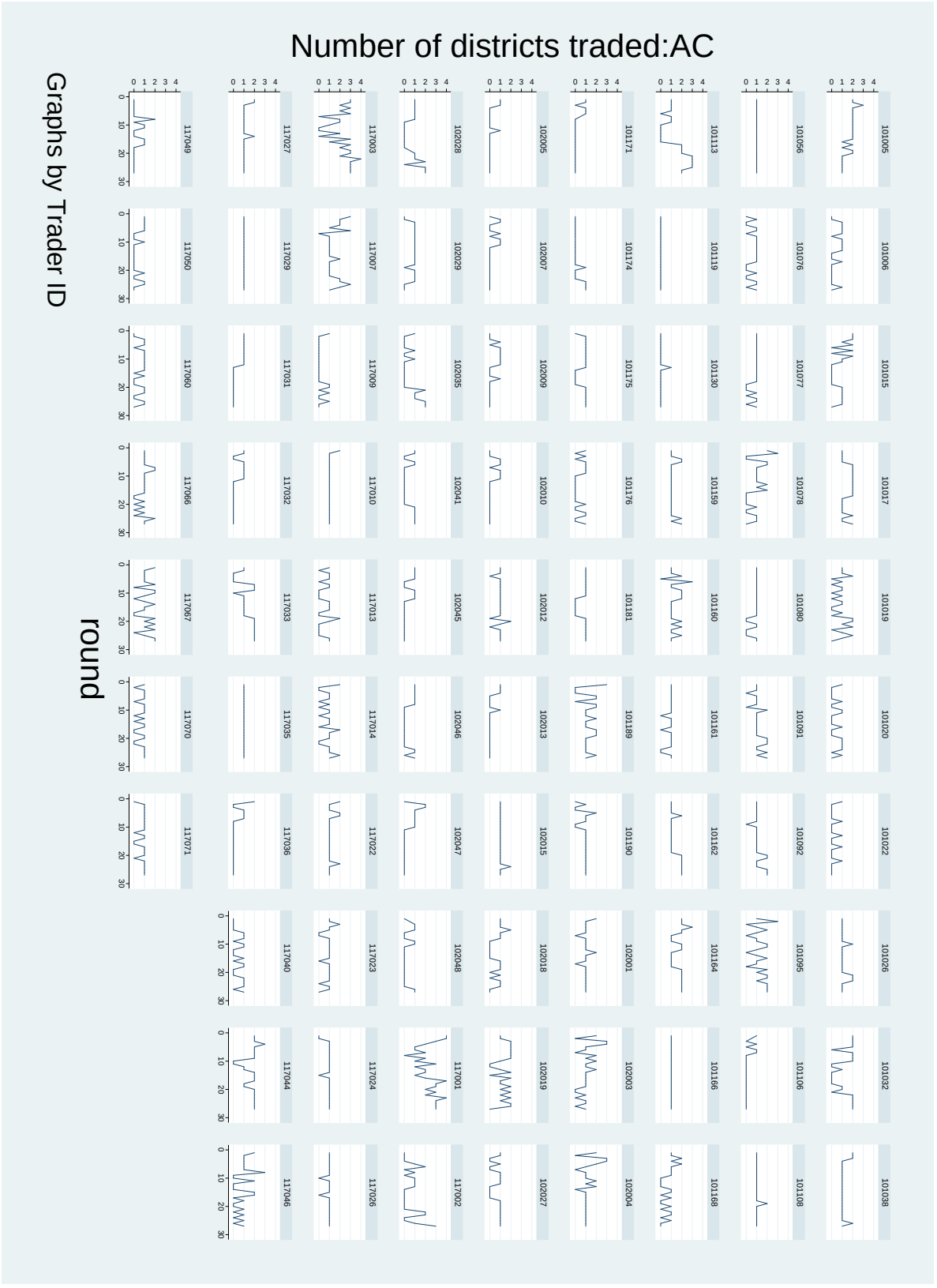
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Figure 1: Combination of varieties traded in active and passive trade



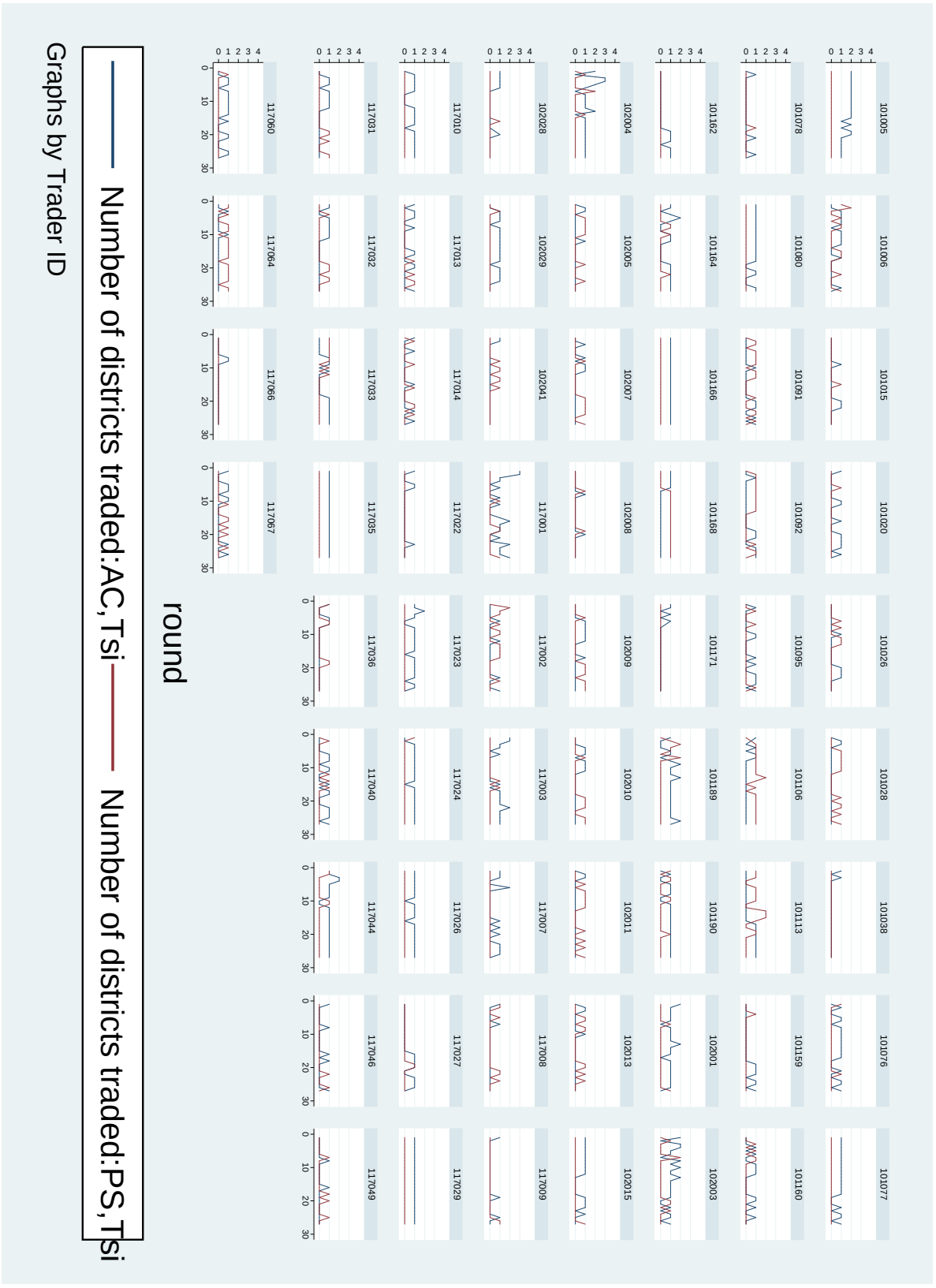


Appendix Figure 2: Number of district visited across rounds



Appendix Figure 3: Number of district with active and passive trading: Vary Gasy

Appendix Figure 4: Number of district with active and passive trading: Tsipala



Appendix Figure 5: Number of district with active and passive trading: Makalioka