INSTITUTE OF DEVELOPING ECONOMIES

IDE Discussion Papers are preliminary materials circulated
to stimulate discussions and critical comments

IDE DISCUSSION PAPER No. 505

Understanding traders' regional arbitrage: The case of rice traders in Antananarivo, Madagascar

Yutaka Arimoto, Hisaki Kono, Tsilavo Ralandison, Takeshi Sakurai, Kazushi Takahashi

March 2015

Abstract

Many studies find that agricultural markets in developing countries are poorly integrated spatially. Traders' regional arbitrage plays a key role in integrating markets across space. We investigate the performance of regional arbitrage and the associated obstacles for rice traders in Antananarivo, Madagascar. On the basis of a trader-level biweekly survey spanning 2012–2013, we find that traders are not fully exploiting the regional arbitrage opportunities: most of them fail to purchase from the cheapest district and are paying higher prices than those in the cheapest district. One apparent obstacle is obtaining price information from many different regions. To reduce search costs, we provided regional price information via SMS to randomly selected traders, but found that this had a null-effect on improving arbitrage performance. Traders tend to concentrate on trading with a few fixed districts, even if they are informed about cheaper prices in other new districts, because they worry about quality uncertainty and the trustworthiness of new partners. These findings suggest that not only transmission of price information but also issues related to produce quality and matching prevent the performance of arbitrage and market integration.

Keywords: regional arbitrage, market integration, information friction, price information, search
JEL classification: L81, O13, Q13

---

* Development Studies Center, IDE (yutaka_arimoto@ide.go.jp)

The Institute of Developing Economies (IDE) is a semigovernmental, nonpartisan, nonprofit research institute, founded in 1958. The Institute merged with the Japan External Trade Organization (JETRO) on July 1, 1998. The Institute conducts basic and comprehensive studies on economic and related affairs in all developing countries and regions, including Asia, the Middle East, Africa, Latin America, Oceania, and Eastern Europe.

The views expressed in this publication are those of the author(s). Publication does not imply endorsement by the Institute of Developing Economies of any of the views expressed within.

INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO
3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI
CHIBA 261-8545, JAPAN

©2015 by Institute of Developing Economies, JETRO
No part of this publication may be reproduced without the prior permission of the IDE-JETRO.

Understanding traders' regional arbitrage
The case of rice traders in Antananarivo, Madagascar*

Yutaka Arimoto[a], Hisaki Kono[b], Tsilavo Ralandison[c],
Takeshi Sakurai[d], Kazushi Takahashi[e],

[a] *Institute of Developing Economies-Japan External Trade Organization (IDE-JETRO)* (Email: arimoty@gmail.com)

[b] *Department of Economics, Kyoto University* (Email: kono@econ.kyoto-u.ac.jp)

[c] *Institut Superieur de Technologie d'Antananarivo* (Email: ralandisontsilavo@yahoo.fr)

[d] *Department of Agricultural and Resource Economics, University of Tokyo* (Email: atsakura@mail.ecc.u-tokyo.ac.jp)

[e] *Institute of Developing Economies-Japan External Trade Organization (IDE-JETRO)* (Email: Kazushi_Takahashi@ide.go.jp)

March 18, 2015

Abstract

Many studies find that agricultural markets in developing countries are poorly integrated spatially. Traders' regional arbitrage plays a key role in integrating markets across space. We investigate the performance of regional arbitrage and the associated obstacles for rice traders in Antananarivo, Madagascar. On the basis of a trader-level biweekly survey spanning 2012–2013, we find that traders are not fully exploiting the regional arbitrage opportunities: most of them fail to purchase from the cheapest district and are paying higher prices than those in the cheapest district. One apparent obstacle is obtaining price information from many different regions. To reduce search costs, we provided regional price information via SMS to randomly selected traders, but found that this had a null-effect on improving arbitrage performance. Traders tend to concentrate on trading with a few fixed districts, even if they are informed about cheaper prices in other new districts, because they worry about quality uncertainty and the trustworthiness of new partners. These findings suggest that not only transmission of price information but also issues related to produce quality and matching prevent the performance of arbitrage and market integration.

Keywords: regional arbitrage, market integration, information friction, price information, search
JEL code: L81, O13, Q13

* This survey was conducted as part of rice market studies in Madagascar for the Project for Rice Productivity Improvement in Central Highland (PAPRIZ) implemented by the Japan International Cooperation Agency (JICA). We are grateful to project experts and the staff at the JICA Madagascar office. This paper was financially supported by Hitotsubashi University, the Institute of Developing Economies-Japan External Trade Organization, and JSPS KAKENHI Grant Numbers 22223003 and 25245038.

1. Introduction

A well-functioning agricultural market is vital for efficient marketing and distribution of food across time and space. When markets function well, prices would signal surpluses and deficiencies across regions, and induce traders to arbitrage. Through arbitrage, markets eventually clear and prices converge across regions to form the law-of-one-price. Well-integrated markets also enhance social welfare: on the production side, they provide outlets for local food production surpluses, preventing drops in food prices and thereby fostering incentives for producers to adopt new technology to increase food production and their income. On the consumption side, well-integrated markets protect consumers from local supply shocks by facilitating trade across spaces, leading to price stability (Moser et al. 2009).

Many studies, however, find that agricultural markets are only partially integrated spatially (see for example Fackler and Goodwin 2001, and Sexton et al. 1991). A number of obstacles can raise transaction costs and prevent the full integration of agricultural markets. Among those, the availability of market information is often cited as one of the most crucial factors determining market disintegration. Indeed, a study of regional rice markets in Philippines indicates that the presence of substantial information frictions leads to the failure of arbitrage (Allen 2014). One promising technical solution to this issue is the expansion of mobile phone networks (see Aker and Mbiti 2010, and Nakasone et al. 2014 for a review). Evidence indicates that mobile phone coverage is associated with regional price convergence (Jensen 2007, 2010; Aker 2010; Aker and Fafchamps forthcoming) and increased search activity of agricultural traders (Tack and Aker 2014)[2]. A growing number of studies have used randomized controlled trials (RCTs) to examine the impact of providing market information to farmers through mobile phones[3]. For example, Fafchamps and Minten (2012) report positive effects on spatial arbitrage by traders' selling at distant wholesale markets rather than at the farm-gate in India, but find no effect on price received. Nakasone (2014) finds that treated farmers obtained higher sales prices in Peru; however, no such effect was found in Colombia (Camacho and Conover 2011).

Although these experimental studies are informative, they focus only on producers, not on the traders who play a major role in trade across regions. Moreover, not much is known about even the basic facts of traders' arbitrage itself, despite it being a fundamental economic activity. Since spatial market integration can be achieved through countless transactions across space by traders who are motivated by profit maximization via exploiting arbitrage opportunities, understanding how and how well traders make actual transactions across space is critically important for determining the barriers

[2] See also Goyal (2010) for evidence that the regional dispersion of soybean prices decreased after the establishment of internet kiosks that provide wholesale price information to farmers in India.

[3] In a non-experimental study, Svensson and Yanagizawa (2009) report that the market information broadcasted through the radio is associated with increased sales prices for farmers in Uganda. Using a matching method, Courtois and Subervie (forthcoming) find that farmers with access to a mobile-based market information service received higher prices in Ghana.

of market integration and formulating policies to improve the efficiency of agricultural markets.

The purpose of this study is to investigate the performance of traders' regional arbitrage and the potential obstacles that prevent traders' from making better arbitrage, where the arbitrage performance is measured by whether a trader purchased from the cheapest district and the gap between the price paid and the price in the cheapest district. In particular, we attempt to answer the following questions: To what regional extent do traders search and trade? How and how extensively do they obtain price information in various regions? Are they fully exploiting arbitrage opportunities? What prevents them from making a better arbitrage? Does provision of price information improve arbitrage performance?

To elucidate trader's behavior in practice, we study the case of rice traders in Madagascar. While rice is the country's most important staple food, the Malagasy rice market is known to be spatially disintegrated, exhibiting large price dispersion over time and space. Mendoza and Randrianarisoa (1998) found that, in 1996–97, only 8.8% of wholesalers made purchases from areas that were more than 100 km away. Evidence based on the 2001 national census of communes (counties) indicates that rice markets in Madagascar were relatively well integrated spatially only at the subregion level, but not at the provincial or national level (Moser et al. 2009). Furthermore, the average probability of interprovincial integration of rice markets is only approximately 56%, though the degree of integration varies largely across provinces (Butler and Moser 2010). Studies exploiting weekly district-level price data after the mid-2000s find that the degree of market integration is improving (Miyake and Sakurai 2012), but at the same time, markets have yet to be well integrated even between cities near the national capital (Arimoto et al. 2014). Thus, there seems to be significant scope for better arbitrage.

We collected detailed data on rice trading for 224 rice traders based in the Greater Antananarivo Area formed by the city center and suburb (also referred to as "Tana," the capital of Madagascar). The data covered one year from August 2012 to August 2013, biweekly (every two weeks) for 27 rounds. Additionally, to rigorously examine whether information friction is the key factor affecting successful arbitrage, we implemented an RCT, whereby half of the randomly selected sample traders were sent price information in 10 major rice-producing districts via SMS halfway through the survey.

Our main findings can be summarized as follows. First, there is indeed scope for better arbitrage: many traders purchase rice from districts where prices, including transportation costs, were not the cheapest, and are paying much higher prices than those charged in the cheapest district. For example, of the traders visiting other districts to purchase the most common variety of rice (*Vary gasy*), only 8% of the trader–round observations saw traders make purchases in the cheapest district, and the average price paid was 17% higher than the median price in the cheapest district. Second, most traders specialize in trading with few common districts, where they regularly visit and purchase from

the same trading partners, even though these districts do not always have the lowest prices. Third, traders are often "price blind," meaning that they know little about prices in districts other than those in which they usually make purchases. Moreover, their knowledge on price is concentrated in few districts. Fourth, our intervention to provide regional price information had a null-effect on purchasing behavior and arbitrage performance. Fifth, in addition to price, traders were concerned about product quality and matching with trustworthy sellers. We also found that before traders start visiting a new district, they usually establish a "link" to that district by purchasing from sellers who come to sell in Tana, or asking a mediator for an introduction.

These findings imply that traders are not fully exploiting the arbitrage opportunities, and the provision of price information alone is not effective in improving the situation. This is because traders are also concerned about non-price issues, which they overcome by limiting their trading districts to those in which they have "links." Traders cannot visit a new district without this "link" and therefore pass up the opportunities of better arbitrage even if they are informed about cheaper districts.

This study adds to our knowledge on agricultural traders' arbitrage and marketing activities in the following ways: First, to the best of our knowledge, this is the first study that directly investigates traders' arbitrage and quantifies its performance in a systematic way. Second, we contribute to the understanding of the barriers of rice market integration in Madagascar. As discussed previously, existing studies have repeatedly reported that Malagasy rice markets are spatially disintegrated (Moser et al. 2009; Butler and Moser 2010; Miyake and Sakurai 2012; Arimoto et al. 2014). We support this finding by adding a direct micro-foundation that the basis of market integration, traders' arbitrage, is imperfect. Third, we provide additional evidence on the impact of providing price information on arbitrage in developing countries. Unlike previous experimental studies that provided information to farmers (Fafchamps and Minten 2012; Nakasone 2014; Camacho and Conover 2011), we disseminate information to traders. Since traders are specialized in trading and arbitrage and bear the fundamental role in both regional marketing and distribution of the agricultural products, we believe that the provision price information to traders is more relevant for the understanding of agricultural market integration.

The paper is organized as follows. Section 2 describes the survey and data. Section 3 presents descriptive evidence that traders are not fully exploiting existing arbitrage opportunities and discusses potential obstacles. Section 4 reports the results of the RCT and discusses why the provision of price information was not effective. Finally, Section 5 provides conclusions.

2. Survey and data

2.1. Surveys

The subjects of our survey are rice traders operating in Tana, Madagascar. Since we are interested in regional arbitrage, the population of focus is the rice traders who engage in inter-district rice trade (i.e., trade between Tana and districts outside Tana)[4].

The survey was conducted from June 2012 through August 2013. To create a list of rice traders, we first identified the geographical cluster offering a high probability of finding rice traders engaged in inter-district trade. We selected 44 out of 192 wards in the city center, and 17 out of a total of 40 communes in the suburb based on five criteria[5]. We then created a list of rice traders by visiting markets and key informants in these clusters[6]. All the listed traders were then visited, and we confirmed whether they engaged in inter-district trade. We ended up with a list of 318 inter-district rice traders.

In July 2012, we conducted a baseline survey to collect general information about the characteristics of these traders and their trading activities. Out of the 318 listed traders, 241 (76%) agreed to cooperate and completed the baseline survey. Then, we conducted periodic surveys every two weeks between August 6, 2012 and August 13, 2013, making 27 rounds in total. The periodic survey collected information on the following: (1) price searches; (2) details of all rice purchases, including information on district of purchase, transportation, price, and payment; and (3) management indicators such as stock, quantities of purchases and sales, average price and margin, and costs. Of the 241 traders who completed the baseline survey, 234 initially agreed to participate in the periodic survey, but 10 dropped before completion of all rounds. Our final number of sampled traders is thus 224 and the number of observation at the trader–round level is 6,033[7].

Finally, we conducted a follow-up survey in February 2014 to collect additional information after

---

[4] Rice traders such as retailers who only purchase from wholesalers or farmers in Tana and sell at retail are not considered as potential subjects because they are not likely to participate in inter-regional arbitrage.

[5] The five criteria are (1) wards where the city's main wholesale markets (Anosibe Andrefana and Andravoahangy Tsena) are located (2 wards), (2) wards surrounding those two markets where rice traders most likely own a shop and/or live (10 wards), (3) wards in which there is a market managed by Antananarivo city government (32 wards), (4) communes where traders reside according to the list of registered traders and wholesalers provided by the National Statistics Institute (Institut National de la Statistique or INSTAT, in French) (12 communes), and (5) communes located along the national highways that are potentially active in rice trading (5 communes).

[6] The list of traders was made by (1) visiting the ward markets for Antananarivo city and the largest markets in the commune for the suburbs, and listing all rice traders (retailers/wholesalers/traders/millers) operating in these markets; (2) visiting ward and municipality officials to introduce us to the largest rice traders that they know in their area, including wholesalers, collectors, and millers; (3) visiting millers and asking for information about traders based in the ward and municipality.

[7] The total number of observations at the trader–round level should be $224 \times 27 = 6{,}044$. We had 11 missing trader–rounds due to refusal or questionnaire losses.

preliminary analyses of the periodic survey. We obtained responses from 219 out of 224 traders who completed the periodic survey.

2.2. Intervention

Since information friction is considered as one of the major obstacles to 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 on Wednesday each week. The information sent was the local price of milled rice at millers for the previous week[8], 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 the 10 most major rice-producing districts (Arivonimamo, Miarinarivo, Tsiroanomandidy, Ankazobe, Ambatondrazaka, Mahabo, Bealanana, Befandriana, Mandritsara, and Marovoay), which include distant districts in Sofia region where prices are generally quite cheaper than those in the major purchasing districts near Tana (see **Figure 1** and **Figure 2** for map of Madagascar). We expected that this information would trigger trade with new districts.

== Figure 1. Map of Madagascar (regions) ==

== Figure 2. Map of Madagascar (districts) ==

2.3. Modes of purchase

We classify traders' mode of purchase 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 made *outside Tana* by traders actively visiting other districts[9]. On the other hand, passive inter-district trades are purchases made *in Tana* from sellers (trucks) who came from other districts to sell in Tana. Such purchases may take place at the traders' store where sellers regularly come directly, or at the parking areas at major wholesale markets in the city center such as the Anosibe and Andravoahangy markets. On the other hand, within-Tana trades are those that do not directly incorporate inter-district trade but instead (1) purchase at the Anosibe market; (2) purchase at the Andravoahangy market; and/or (3) purchase

[8] OdR agents collect the rice price for week 1 from Monday to Saturday. Information is then sent to the OdR headquarter in Tana by Monday of week 2. We receive the information from OdR Tana on Tuesday evening or the latest on Wednesday morning. Therefore, we are able to send the information to traders every Wednesday.

[9] Traders engaged in active trades are often called collectors ("collecteur" in French).

from local sellers in Tana such as farmers[10], wholesalers, and millers. These three modes are not mutually exclusive, and most active inter-district traders engage in both passive inter-district trade and within-Tana trade.

Note that passive inter-district trade and within-Tana trade are conducted in Tana. From the traders' perspective on *where* to make a purchase, these two modes are alternatives once they decide to purchase in Tana (i.e., do not visit districts outside Tana).

2.4. Price of rice

We classify the varieties of rice into the following five categories: *Vary gasy*, *Tsipala*, *Makalioka*, imported rice, and unknown[11]. Vary gasy and Tsipala are the major common varieties. Makalioka is considered to be high grade and is the most expensive rice, mainly produced around Ambatondrazaka district (Alaotra-Mangoro region). Imported rice constitutes low-grade rice in Madagascar and usually comes from Pakistan or India.

To be able to compare prices across districts, we converted all 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 transportation 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 (see **Appendix A** for details). When we discuss regional price differences, we represent the district price by the median of actual prices paid by our sample traders for each variety at each survey round in each district.

2.5. Measures of arbitrage performance

We construct two indicators to measure arbitrage performance at the trader transaction (purchase) level. Since our sample traders are based and operating in Tana, we regard that their sales prices are similar; thus, we concentrate on purchase price. For each trader, we identified the cheapest purchase within round–activity (active or passive)–variety[12]. In total, we have 14,422 trader–round–activity–variety level observations.

The first performance measure is a dummy variable indicating whether a trader purchased from the cheapest district for the same round–activity–variety. The second measure is the actual–optimal

[10] Rice cultivation is still common in Tana.

[11] Vary gasy literally means Malagasy rice, and includes any locally produced rice other than Tsipala and Makalioka. Some are improved varieties introduced from outside the country, but their origins are not known. On the other hand, Tsipala and Makalioka are more specific although they do not seem to be single varieties in the agronomic sense. We assume that both are improved varieties introduced by donors or the Ministry of Agriculture. Their appearances are quite different and they are easily distinguished in the market: Tsipala is relatively short and round, while Makalioka is relatively long.

[12] Some traders purchased rice from multiple districts. In such cases, we selected the cheapest purchase.

price ratio θ, defined as

$$\theta = \frac{p_{itav}}{p^*_{tav}},$$

where p_{itav} is the actual adjusted ME-price paid for the cheapest purchase by trader i in round t for activity a in purchases for variety v, and p^*_{tav} is the median of actual observed adjusted ME-prices in the cheapest district for the same round–activity–variety. The larger the value of θ, the greater is the gap between the optimum price and the actual purchase price—an indication of potential scope for better arbitrage. In both measures, for passive inter-district purchases, we count three modes of within-Tana trades (purchase at the Anosibe market, purchase at the Andravoahangy market, and purchase from local sellers in Tana) as "districts," since these are good alternatives for purchase *in Tana*.

3. Descriptive statistics

3.1. Characteristics of the sample traders

Table 1 reports the summary statistics of the study subjects. Out of 224 sampled traders, 104 (46%) engaged in active inter-district trade, 209 (93%) engaged in passive inter-district trade[13], and 91 (41%) engaged in within-Tana trade during the one-year period survey. The average annual milled-rice equivalent volume of rice purchased was 341.8 (SD = 581.6) ton. The sample traders had 8.2 (SD = 6.7) years of experience in rice trading. The business is somewhat diversified: 43% of the traders also dealt with non-food items, 16% operated a rice mill, and 21% rented out a truck or vehicle. As a result, the mean profit share of rice trading was 0.647 (SD = 0.311). The mean age of the representatives was 37.1 (SD = 9.6). Half (50%) of the sample traders are male and they are almost completely (99%) literate. Regarding assets, more than 80% of the traders have a store to sell rice and a private storage facility with a mean capacity of 28.2 (SD = 94.3) ton. Furthermore, 34% of the traders own a truck and 28% own a vehicle. They usually (90%) have a mobile phone.

== Table 1. Summary statistics of sample traders ==

3.2. Regional extent of inter-district trade

We define the scope of spatial arbitrage on the basis of districts where we observe actual trade by

[13] Out of 104 active inter-district traders, 91 (88%, or 41% among all traders) also engaged in passive inter-district trade.

our sample traders. Observing actual purchases suggested that trade with that district was practically feasible and profitable, while districts without observed purchases were likely ones in which trade was not reasonable.

Table 2 reports the summary statistics of the number of different districts where we observed actual purchases for inter-district trade, by round–activity–variety. Averaged over 27 rounds, for passive purchases, Vary gasy was purchased from sellers who came from 8.6 different-origin districts, Tsipala was purchased from those who came from 10.3 districts, and Makalioka was purchased from those who came from 3.6 districts, in the same round. Districts where rice was purchased by active inter-district trade were less diverse: Vary gasy was purchased from 7.9, Tsipala from 7.5, and Makalioka from 2.7 different districts on average. The number of different districts from which Makalioka is purchased is small because it is grown in a limited number of regions.

== Table 2. Number of different districts purchased from in inter-district trade **==**

3.3. Arbitrage performance

Table 3 reports the summary statistics of arbitrage performance. We limit our attention to the most common varieties, namely, Vary gasy, Tsipala, and Makalioka. In only 11.6% of the total observations, the purchase was made from the cheapest district (Panel A).

Table 4 shows the degree to which traders pay more if they fail to purchase from the cheapest district. The table reports the mean and maximum of the district-level ratio of price in each district to the price in the cheapest district, averaged over rounds[14]. Within the same round–variety, the price ratios for passive inter-district trade (including within-Tana trade) are 1.078 (max = 1.159) and 1.076 (max = 1.155) for Vary gasy and Tsipala, respectively. Similarly, the same price ratios are on average 1.138 (max = 1.239) and 1.130 (max = 1.253) for active Vary gasy and Tsipala purchases, respectively. This indicates that traders visiting the "wrong" district paid 14% to 13% higher prices than those visiting the cheapest district, on average.

== Table 3. Summary statistics on arbitrage performance ==

== Table 4. Price dispersion across purchase districts ==

Indeed, the actual–optimal price ratio at the transaction level (trader–round–activity–variety level) reported in Panel B of **Table 3** is 1.072, indicating that, on average, traders paid 7.2% higher

[14] Statistics (mean, maximum, and S.D.) were calculated for each round–activity–variety ($N = 27 \times 2 \times 3 = 162$) first, and then averaged over 27 rounds.

prices than the median price in the cheapest district. The price premium is almost completely due to purchasing from a "wrong" district; if a trader purchased from the cheapest district, the average price premium is 0.5%.

Comparison between active and passive trades reveals that active purchases were relatively well targeted toward the cheapest district: the percentage of observations of purchases made from the cheapest districts, aggregating all varieties, is 18.7% for active vs. 10.2% for passive. However, the actual–optimal price premium is twice as large as that of passive purchases (1.128 for active vs. 1.061 for passive). This implies that although active purchases were well targeted, they were of lower performance than passive purchases. This is because the passive prices were relatively converged. The standard deviation of district-level prices within each round–activity–variety, averaged over rounds, is much smaller for passive trades than active trades (**Table 4**, column (4)). The relative convergence of passive prices is most likely due to competition *in Tana*. Therefore, the choice of origin district to purchase from did not make a large difference in purchase prices.

3.4. Challenges for better arbitrage

We found that the under-performance of arbitrage is largely caused by failure to visit the cheapest, optimal district. To identify the optimal district, **Appendix Tables A1 and A2** report the median adjusted ME-price in each district by round–activity–variety. For example, for active purchase for Tsipala, we found that Marovoay and districts in Sofia (Madritsara, Bealanana, and Mampikony) tended to be the cheapest in the earlier rounds, whereas Ambohidratrimo, Arivonimamo, Ankazobe, and Tsiroanomandidy became the optimal choice in later rounds.

The tables suggest two challenges for traders to fully exploit arbitrage opportunities. First, the cheapest district changes over time, and therefore, traders need to constantly track prices in several districts. Second, to fully exploit arbitrage opportunities, traders need to purchase from many different districts depending on the season. For active purchases, 11 different districts became the cheapest district at least once during the one-year survey period for Vary gasy and Tsipala, while 7 different districts became the cheapest at one point for Makalioka. Passive purchases were harder as traders needed to purchase from 14 districts (including two purchase modes of within-Tana trade) for Vary gasy, 12 for Tsipala, and 9 for Makalioka.

The first challenge calls for extensive searches, and the second challenge calls for traders to trade with many different districts. In the following subsections, we examine whether these two conditions were met.

3.5. Extent of search

How extensively are traders searching for the cheapest price? In each survey round, we asked

whether the trader knew the purchasing price in 36 major rice-producing districts[15]. **Table 5** reports the summary statistics. Searching for prices in these rice-producing districts was common, though not many districts were searched. At the trader level, 95% (213/224) of the traders searched for prices in the listed 36 districts at least once during the survey period. Among those who did search, the average number of districts where they knew the price was 5.1 (SD = 3.1). At the trader–round level (per round, or every two weeks), searches were conducted in 76% (4,599/6,033) of the observations, in which traders checked the price in 2.1 (SD = 1.8) districts, on average. Active traders were more likely to search than passive-only traders.

== Table 5. Price searches in 36 listed districts ==

Interestingly, traders' knowledge on prices was concentrated in few common districts. For each round, we calculated the percentage of traders who searched for prices in each district, taking the total number of traders searched in that round as the denominator. Averaged over rounds, the most common district where traders knew the price was Antananarivo Renivohitra (79%), followed by Ambatondrazaka (46%), Miarinarivo (27%), Tsiroanomandidy (20%), and Ankazobe (19%). Therefore, many traders were "price-blind"; the extent of their knowledge on regional prices was limited.

3.6. Extent of trade

The second condition of making better arbitrage is to purchase from many different districts. We find that, in fact, traders tend to purchase from few fixed districts. **Table 6** reports the summary statistics of the number of different purchase districts for inter-district trades. For active traders, we report the number of districts without distinguishing active and passive inter-district purchases, as well as the number of districts for active and passive purchases separately. **Panel A of Table 6** indicates that on average, traders purchased from 4.0 different districts during the survey period. By variety, Vary gasy and Tsipala were purchased from 2.5 and 2.7 different districts, respectively. **Panel B of Table 6** reveals that, on average, traders purchased from 1.9 different districts per round, but for each variety, traders purchased from only one district. There were no substantial differences between active and passive-only traders.

[15] The 36 districts are all 22 region capitals and 14 major rice-producing districts in Boeny, Sofia, Sava, and Diana regions. They are as follows: Antananarivo Renivohitra, Ankazobe, Antsirabe I, Tsiroanomandidy, Miarinarivo, Fianarantsoa I, Ambositra, Manakara, Farafangana, Ihosy, Toamasina I, Fenoarivo Atsinanana, Ambatondrazaka, Mahajanga I, Maevatanana, Marovoay, Port-Berge, Mandritsara, Befandriana Avaratra, Antsohihy, Bealanana, Maintirano, Mampikony, Toliara I, Morondava, Taolagnaro, Ambovombe, Sambava, Antsiranana I, Vohemar, Ambilobe, Ambanja, Other districts in Boeny, Other districts in Sofia, Other districts in Sava, and Other districts in Diana. We decided to specify these districts to help improve traders' memory during interviews.

== Table 6. Summary statistics of the number of districts purchased ==

A more detailed examination of the data depicts that at the trader level, 62% of passive-only traders and 60% of active traders purchased Vary gasy from at most two different districts throughout the year. Similarly, 46% of passive-only traders and 58% of active traders did so for Tsipala. For the purchase of Makalioka, 80% of the passive-only traders and 70% of the active traders purchased from only one district, which was almost exclusively Ambatondrazaka, the major production region of Makalioka. At the trader–round level, almost all traders concentrated on purchasing each variety from a single district. These facts imply that more than half of the traders switched between only two districts per variety throughout the year.

Traders not only tend to operate in only a few districts, but these districts tend to be common across traders. **Tables A3–A6 in the Appendix** report the percentages of traders who purchased from each district, taking the total trader–district observations for each round–activity–variety as the denominator. Districts attracting more traders per round are highlighted in dark red. We immediately recognize that the traders' purchases were concentrated in two to three districts for active inter-district trade. Origin districts for passive purchases (including within-Tana trades) were relatively more dispersed, but still concentrated in around four districts.

These common districts were, however, not always the cheapest districts to purchase in. In **Tables A3–A6**, we used bold squares to mark the cheapest district on the basis of median adjusted ME-price for each round. If these squares match with darker red areas, then it indicates that many traders were indeed purchasing from the cheapest district. For active–Vary gasy purchases, Tsiroanomandidy, which turned out to be the cheapest in 4 out of 27 rounds, did attract many traders. However, other common districts such as Arivonimamo and Anjozorobe were each cheapest for only one round. Frequently cheapest districts such as Ankazobe (cheapest in six rounds), or Maevatanana and Ambatondrazaka (cheapest in five rounds) were not so popular. Active–Tsipala purchases were slightly well targeted, where the top three popular districts (Arivonimamo, Tsiroanomandidy, and Ambohidratrimo) were the cheapest in 11 out of 27 rounds. However, not many traders visited the northern regions such as Marovoay, Mandritsara, Bealanana, and Mampikony, which was found to be the cheapest district in the earlier rounds. Passive purchases were also not well targeted; the top four popular origins (Arivonimamo, Anjozorobe, Tsiroanomandidy, and Anosibe markets) were the cheapest for only six and seven rounds for Vary gasy and Tsipala, respectively.

3.7. Constraints on trading with new districts

Why do traders trade with a limited number of districts? In the follow-up survey, we asked about the difficulty and constraints of starting to visit a new district.

Nearly 60% of the traders felt some difficulties in starting to visit new districts. In response to the question "How hard is it to start visiting a new district you have never visited before?," 42 among 209 valid responses (20%) replied "very hard" and 80 (38%) replied "somewhat hard."[16]

Table 7 reports the obstacles to start visiting a new district, determined by asking the traders to provide three reasons. In aggregate, we obtained 582 valid responses. "Finding a trustworthy trading partner" was the most mentioned obstacle (25%), followed by "obtaining price information" (21%), "quality, variety, characteristics are uncertain" (16%), "safety" (16%), "collect necessary quantity" (10%), "lack of experience" (7%), and "payment will be inflexible/unable to purchase on credit" (3%).

== Table 7. Obstacles to starting to visit a new district ==

Table 8 reports answers regarding the most important information needed to start visiting a new district. Again, we asked the traders to offer three reasons. Price information is indeed the most important information, comprising 33% out of the 640 aggregate valid responses. It is, however, not a single decisive factor. In fact, traders are also aware of "quality, variety, and characteristics" (26%), "contact of trading partner" (19%), and "availability (quantity) of rice" (18%).

== Table 8. Most valuable information when starting to trade with a new district ==

In summary, descriptive evidence revealed that many traders are "price-blind," despite considering price information as the major constraint and also most important to start visiting a new district to exploit arbitrage opportunities. This suggests that information friction is indeed one of the major potential factors that prevent better arbitrage. In the next section, we examine whether eliminating this friction improves the situation.

4. Impact of providing price information on arbitrage performance

In this section, we examine the impact of our price information provision on traders' behavior and arbitrage performance. We estimate the following simple difference-in-differences (DID) regression:

$$y_{it} = \beta_0 + \beta_1 \mathrm{TREAT}_i + \beta_2 \mathrm{AFTER}_t + \beta_3 \mathrm{TREAT}_i \times \mathrm{AFTER}_t + \varepsilon_{it},$$

where TREAT_i is the dummy indicating that the trader was sent an SMS, and AFTER_t is the

[16] The remaining responses were "Neither hard nor easy" (n = 60, 29%), "Somewhat easy" (n = 19, 9%), and "Very easy" (n = 8, 4%).

dummy indicating rounds after intervention. The coefficient of interest is β_3, which captures the average treatment effect of our intervention.

4.1. Results

The randomization was mostly successful; most of the differences in pre-intervention characteristics between the treatment and control groups were statistically insignificant (**Appendix Table A7**), except that traders in the treatment group were more likely to search (control 72% vs. treatment 80%, $p < 0.001$) though the number of district searched is slightly smaller (control 1.8 vs. treatment 1.6, $p < 0.001$), engage in more active inter-district trade (control 24% vs. treatment 33%, $p < 0.001$)[17] and visit more districts (control 1.9 vs. 2.1, $p = 0.044$), but passively purchase from smaller number of districts (control 1.9 vs. 1.8, $p = 0.024$).

Table 9 reports the estimates for search and purchasing. The unit of observation is trader–round. The DID estimate (β_3) is positive and significant for whether a trader searched for price in other districts (column 1) and the number of districts for which prices were known (column 2). This implies that the intervention successfully improved the traders' knowledge of prices in diverse districts. However, the intervention had no impact on purchasing behavior. The treated traders did not engage in increased active trading after intervention (column 3), and the number of districts purchased from in each round did not increase (columns 4 and 5).

== Table 9. SMS treatment effects for search and purchasing ==

Table 10 reports the estimates for arbitrage performance. The unit of observation is trader–round–activity–variety. We find no statistically significant impact on either purchases from the cheapest district or actual–optimal price ratio, except for a *positive* coefficient for actual–optimal price ratio for active–Vary gasy purchase, implying that the intervention worsened the arbitrage performance. As a consequence, the provision of price information had no impact on profits. For each round, we obtained a crude measure of management indicators by asking the overall quantity and average price of purchases and sales, and margins. The estimates reported in **Table 11** indicate that the intervention had no impact on quantity and price of purchases and sales, and margin.

== Table 10. SMS treatment effects for arbitrage performance ==

== Table 11. SMS treatment effects for management indicators ==

[17] To deal with these systematic differences between treatment and control groups, we conducted the following estimations with trader fixed-effects. The results reported in the Online Appendix were significantly similar to those obtained without using trader fixed-effects.

4.2. Discussion

Why did the provision of price information not alter traders' behavior and improve arbitrage performance? In a follow-up survey, we asked a number of questions to understand why the intervention had no impact.

The first possible reason and also a potential limitation of this study is that the price information provided was not sufficiently reliable or timely. We asked how the traders utilized the information. Of the 219 respondents of the follow-up survey, 107 (49%) were in the treatment group but only 95 (43%) actually received the price information[18]. Among these 95 traders, only 2 (2%) used it to visit new districts. However, price information was used in some other ways; 31 (33%) passed the information to others, 42 (44%) used it to check the adequacy of prices, and 18 (19%) used it to negotiate a price with a seller. This suggests that the information was considered valuable, but not sufficient to motivate a visit to a new district.

Why was the information not used for a visit to a new district? **Table 12** summarizes the responses to our asking for three reasons from those who received the information but did not use it to visit a new district ($N = 93$). In aggregate, we obtained 184 valid responses. Ignoring the rank of responses, one of the major reasons indicated was the inadequacy of the supplied information: "information was not reliable" (32%), "price may change during travel or transportation" (21%), and "information was not timely" (14%).

== Table 12. Reasons for not using SMS price information to visit a new district ==

These responses are understandable given that cheap districts (mostly in Sofia region) are often far away and the road conditions are so poor that it takes several days or even weeks to make a round trip. Traders may care about road conditions because car parts wear easily with bad roads, thus increasing maintenance costs.

Discussions with the traders also made us aware of the possibility of underestimating the effective prices in distant districts because of opportunity costs. For example, districts in Sofia region take at least one or two weeks to make a round trip. In contrast, popular proximate districts such as Arivonimamo, Tsiroanomandidy, and Anjozorobe can be visited within 3–7 days. This implies that traders can visit these districts twice for the same amount of time it would take to visit Sofia region once. Time taken for purchases is critical since traders seek to buy and sell as soon as possible to speed up capital turnover. Although direct transportation costs are captured in our prices, these hidden opportunity costs are not well accounted for, and the effective prices in Sofia region may be much higher than the prices used in the analyses. The prices provided were also one-week lagged.

[18] The major reasons for those not receiving the information were changes in phone number and losing a SIM card.

In any case, this is unfortunate given that the prices we provided are by far the most detailed, updated, systematically collected, and reliable publicly available information that one can obtain in Madagascar. The prices provided are those at each district's millers and we believe that they do reflect local wholesale prices. However, some traders who deeply search into remote villages and purchase at farm-gates might feel that the provided prices were not sufficiently informative.

We are more interested in the second possible reason that stops traders from readily visiting a new district. We have already seen in section 3.6 that traders continue to visit few fixed districts (**Table 6**), and more than half of the traders traded with only two districts per rice variety. **Table 12** adds to this by revealing that the third most indicated reason in aggregate (and next most frequently indicated primary reason) for not using the provided price information to visit a new region was that the respondents only buy from fixed place/seller (11% in aggregate, or 21% among those providing this as their first reason). This indicates that traders will forgo the arbitrage opportunity and stay with familiar trading partners, even if they are informed about a cheaper price in a new district.

Why do traders continue to visit the same fixed districts? Section 3.7 discussed the constraints on visiting a new district; nearly 60% of the traders expressed having some difficulty in starting to visit a new district, and non-price issues such as finding a trustworthy trading partner, quality uncertainty, and safety were cited as the major obstacles (**Table 7**). While traders considered price as the most important information needed to start a visit to a new area, information on quality, variety, and characteristics, contact information on a potential trading partner, and availability of rice were also essential (**Table 8**). These facts imply that lack of price information is not the only decisive factor that prevents traders from visiting a new area.

The follow-up survey also revealed that traders had established a "link" before they started actively visiting the most frequently visited district. Of the 90 active inter-district traders who replied to the follow-up survey, 46 (51%) answered that they had purchased from a seller from that district in Tana before actually visiting there by themselves. This "trial purchase" could serve as a device to check the produce quality as well as to collect information on potential sellers and their trustworthiness in that district. Moreover, 74 (82%) indicated that they were introduced by a mediator during the first visit, who was a friend/relative in that district (63%), retailer/wholesaler/trader in Tana (28%), or seller/trader from that district (8%).

Once traders are "linked" to a destination, they tend to continuously and exclusively trade with fixed trading partners. Of the active traders, 93% (84/90) replied that they "always" (57%), "most of the time" (32%), or "sometimes" (4%) purchase from the same trading partners. The average number of partners whom traders contact in the most frequently visited district is 4.0 (SD = 5.5), where these partners are collectors/agents (39%, 33/84), farmers (38%), or millers (23%).

Field interviews with the traders revealed that obtaining an introduction and establishing regular

relationships are crucial. First, as there are so many collectors[19], farmers typically prefer to sell to a familiar buyer over an unfamiliar one, so that local buyers who make frequent visits to the villages have the advantage of getting the produce first. To compete with these local buyers, traders in Tana need to make frequent visits and maintain regular relationships. Second, having a regular and trustworthy trading partner is very important in ensuring a secure supply, as the trade does not occur in an open market but on an individual negotiation basis. Additionally, conflict resolution after a contract breach appears to be costly. To secure supply in quantity and quality, and to save time spent in remote villages for product collection, traders occasionally make an advance payment when they place an order[20]. Then, they visit the trading partner at a mutually agreed time for collecting the products. The problems that traders may encounter if the partner is not trustworthy are late delivery, poor quality product, side-selling, or even money loss (the partner disappears).

These findings suggest that traders cannot readily visit a new district because they are also concerned about quality uncertainty and matching with sellers. Traders are able to overcome these issues by concentrating on trading exclusively with only a few districts, where they establish a "link" by paying fixed costs before starting a visit.

5. Concluding remarks

In this study, we investigated the performance of regional arbitrage and its potential obstacles for the rice traders in Antananarivo, Madagascar. Our major finding is that traders are not fully exploiting arbitrage opportunities, and providing price information alone does not improve the situation. When considering a visit to a new district, traders are concerned not only about price but also about produce quality and characteristics, matching with trustworthy sellers, and collecting the necessary quantity of produce. Traders tend to concentrate on trading with a few fixed districts, which are often "linked" by "trial purchases" from sellers in that district or asking a mediator for an introduction, before starting to visit there.

On the basis of these findings, we interpret that the key obstacle preventing better arbitrage and market integration is not only lack of access to price information but also non-price issues related to starting trade in a new district. Traders overcome these issues by trading exclusively with "linked" districts. Because there is a fixed cost to establish a "link," traders cannot easily increase the number of the "links," and without such "links," they cannot readily spontaneously visit a new district in response to information transmitting cheaper prices. Since obtaining price information in unlinked districts is of little use, many traders do not have incentive to search extensively and therefore, become "price-blind."

[19] One trader said that many people entered the rice-collecting business because of the recent availability of funds from a microfinance institution.

[20] In our data, 16% (719/4,494) of active inter-district purchases involved an advance payment.

Our finding and interpretation are in line with Fafchamps and Minten (2001, 2002), who report that agricultural traders in Madagascar tend to narrow their extent and scope of trade. They emphasize trust-based relationships as the dominant contract-enforcement mechanism among grain traders, given that legal institutions do not play an important role in contract enforcement.

Moreover, our experimental results showing that the price information provision had no effect on arbitrage behavior and purchase prices add evidence supporting the notion that price information alone may not be sufficient to foster better arbitrage, as suggested by some previous studies (Fafchamps and Minten 2012; Camacho and Conover 2011). However, other studies do find a positive impact of price information provision on arbitrage and increased sales prices (Nakasone 2014; Svensson and Yanagizawa 2009). At the current stage of research, a micro–macro paradox seems to exist where several rigorous evidence based on RCTs indicate a null-effect or at least mixed evidence of market information provision at the micro level (i.e., farmers and traders), while the expansion of mobile phone networks does seem to foster market integration at the macro (regional) level (Jensen 2007; Aker 2010). Further study is required to identify the conditions in which price information provision improves arbitrage performance and market integration.

The policy implication derived from our findings and interpretations is that interventions that mitigate non-price issues or reduce the fixed cost of establishing a new link may foster better arbitrage and market integration. Standards, grading, and a certification system can mitigate the quality issue and enable smooth transactions without a trader needing to conduct a direct on-the-spot inspection. Issues related to matching can be resolved by opening a periodic market at fixed focal locations where sellers and buyers meet regularly.

We are aware of several limitations of our findings and interpretations. First, as discussed in detail in section 4.2, the null-effect of our intervention may be due to limited reliability and timeliness of the information provided. In any case, our price information is the best available in the context and there is currently no way to improve. We speculate that the traders' perception of unreliability toward our prices (local millers' price) comes from the gap with their actual purchase prices (most likely farm-gate price), and that such a gap is larger for those who make intensive searches in remote villages. Investigating the extent of this price gap and its correlation with trader characteristics may be an interesting topic for future research, with important implication on the choice of price in studying regional market integration.

Second, our finding of arbitrage under-performance may be exaggerated if rice is more finely differentiated than our classification of major varieties. Primary Hedonic pricing analysis does indicate price differences within each variety depending on product characteristics (Sakurai and Arimoto 2014), which can imply that some traders may be purchasing at a higher price because the produce characteristics or quality is different. How suppliers, traders, and consumers recognize and evaluate variety, quality, and other characteristics is an important question that remains to be

understood in Madagascar's rice market.

Third, our study sample is limited to traders in Tana, who are buyers. Traders based in production districts acting as sellers may behave differently; therefore, we should be cautious when generalizing our findings and interpretations.

Given the first limitation on price information provided, while we safely claim that the provision of the best price information currently available in Madagascar to rice traders did not improve arbitrage performance, we do not interpret and assert that our result provides conclusive evidence that transmitting market information is meaningless or that information friction is not a major obstacle to improving arbitrage. In fact, supporting descriptive evidence does suggest the importance of information friction. However, we also emphasize the presence of obstacles other than information friction, and call for attention to non-price factors such as quality uncertainty and matching to improve arbitrage and develop efficient agricultural markets.

References

Allen, Treb (2014) "Information frictions in trade," *Econometrica*, 82(6): 2041-2083.

Aker, Jenny C. (2010) "Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger," *American Economic Journal: Applied Economics*, 2:46–59.

Aker, Jenny C., and Fafchamps, Marcel (forthcoming) "Mobile Phone Coverage and Producer Markets: Evidence from West Africa," *World Bank Econ Review.* (first published online October 8, 2014 doi:10.1093/wber/lhu006)

Aker, Jenny C., and Mbiti, Isaac M. (2010) "Mobile Phones and Economic Development in Africa," *Journal of Economic Perspectives*, 24(3): 207-232.

Arimoto, Yutaka., Kono, Hisaki, Sakurai, Takeshi., and Takahashi, Kazushi (2014) "Toward a Better Understanding of the Rice Market in Madagascar: Preliminary Analysis with the Threshold Autoregression (TAR) Model," in *An Evidence-Based Study of the Innovative Anti-Poverty Practices and Market Institution (Interim Report)*, ed. Kazushi Takahashi. Chiba: IDE-JETRO.

Butler , J. S., and Moser, Christine (2010) "Structural Model of Agricultural Markets in Developing Countries," *American Journal of Agricultural Economics*, 92(5):1364–1378.

Camacho, Adriana., and Conover, Emily (2011) "The Impact of Receiving Price and Climate Information in the Agricultural Sector," *IDB Working Paper Series*, No. IDB-WP-220.

Courtois, Pierre., and Subervie, Julie (forthcoming) "Farmer Bargaining Power and Market Information Services," *American Journal of Agricultural Economics*. (first published online June 22, 2014 doi:10.1093/ajae/aau051)

Fafchamps, Marcel., and Minten, Bart (2001) "Property Rights in a Flea Market Economy,"

Economic Development and Cultural Change, 49(2): 229-267.

Fafchamps, Marcel., and Minten, Bart. (2002) "Returns to social network capital among traders," *Oxford Economic Papers* 54(2): 173-206.

Fafchamps, Marcel., and Minten, Bart (2012) "Impact of SMS-based Agricultural Information on Indian Farmers," *The World Bank Economic Review*, 26(3): 383-414.

Fackler, Paul L., and Barry K. Goodwin (2001) "Spatial price analysis," in *Handbook of Agricultural Economics*, Vol 1, eds. B. Gardner and G. Rausser, ch. 17, pp.971–1024.

Goyal, Aparajita (2010) "Information, Direct Access to Farmers, and Rural Market Performance in Central India," *American Economic Journal: Applied Economics*, 2:22–45.

Jensen, Robert (2007) "The Digital Provide: Information (Technology), Market Performance and Welfare in the South Indian Fisheries Sector," *Quarterly Journal of Economics*, 122(3): 879–924.

Jensen, Robert (2010) "Information, Efficiency and Welfare in Agricultural Markets," *Agricultural Economics*, 41(s1): 203–216.

Mendoza, M., and J. C. Randrianarisoa (1998) "Structure and Behavior of Traders: The Case of Market Reform in Madagascar," International Food Policy Research Institute, *mimeo*.

Miyake, Hajime., and Sakurai, Takeshi (2012) "Improvement of Transportation Infrastructure and Integration of Agricultural Market: An Analysis of Rice Market in Madagascar," *Economic Research (Keizai Kenkyu)*, 63(3): 209–226. (in Japanese)

Moser, Christine., Barret, Christopher., and Minten, Bart (2009) "Spatial integration at multiple scales: rice markets in Madagascar," *Agricultural Economics*, 40(3):281–294.

Nakasone, Eduardo (2014) "The Role of Price Information in Agricultural Markets: Experimental Evidence from Rural Peru," *mimeo*.

Nakasone, Eduardo., Torero, Maximo., and Minten, Bart (2014) "The Power of Information: The ICT Revolution in Agricultural Development," *Annual Review of Resource Economics*, 6:533-550.

Sakurai, Takeshi., and Arimoto, Yutaka (2014) "Characterization of Rice Market in Madagascar: Focusing on Price and Quality Relationship," in *An Evidence-Based Study of the Innovative Anti-Poverty Practices and Market Institution (Interim Report)*, ed. Kazushi Takahashi. Chiba: IDE-JETRO.

Sexton, Richard J., Kling, Catherine L., and Carman, Hoy F. (1991) "Market integration, efficiency of arbitrage and imperfect competition: Methodology and an application to U.S. celery," *American Journal of Agricultural Economics*, 73(3):568–580.

Svensson, Jacob., and David Yanagizawa (2009) "Getting prices right: the impact of the market information service in Ugadan," *Journal of European Economic Association*, 7(2–3):435–445.

Tack, Jesse., and Aker, Jenny C. (2014) "Information, Mobile Telephony and Traders' Search

Behavior in Niger," *American Journal of Agricultural Economics*, 96(5): 1439–1454.

Figures

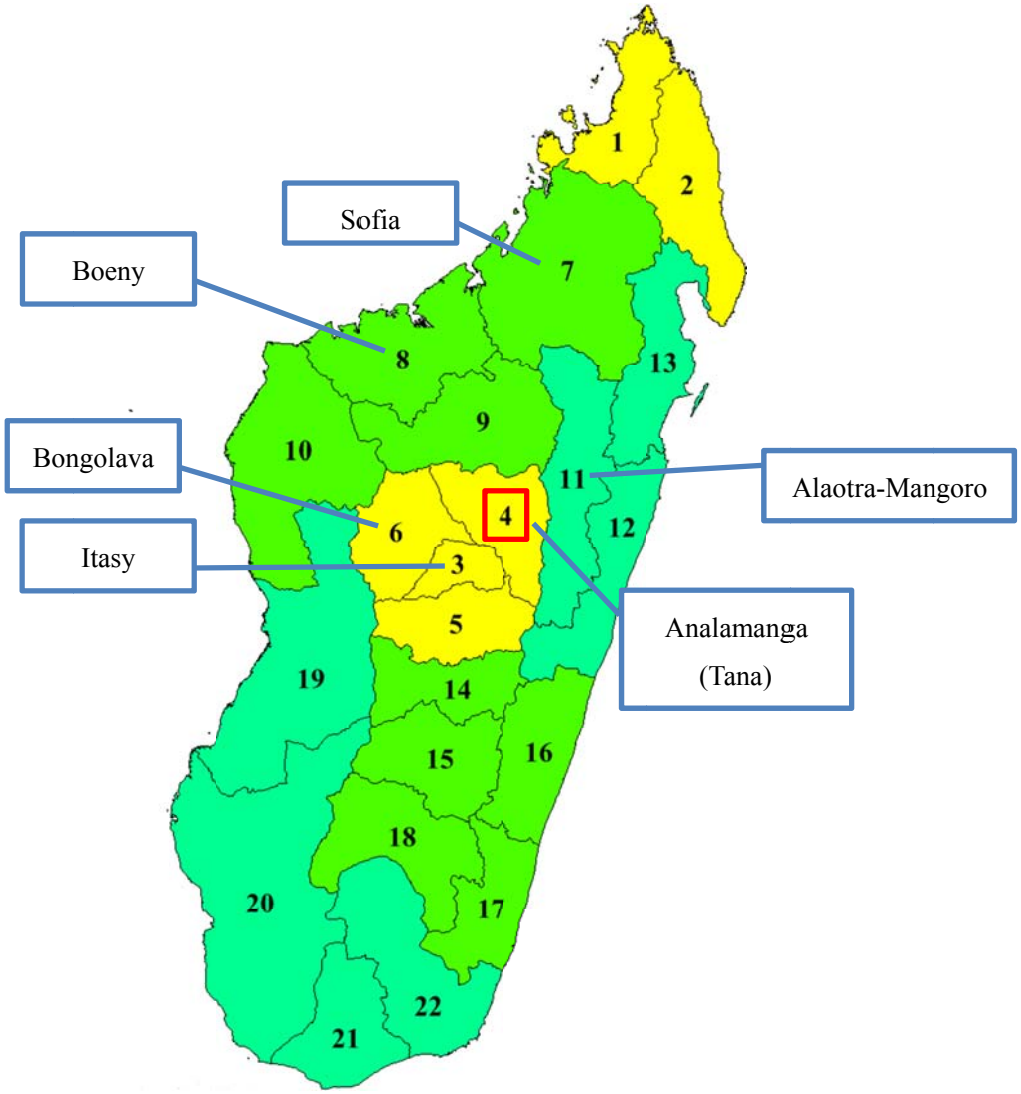

Figure 1. Map of Madagascar (regions)

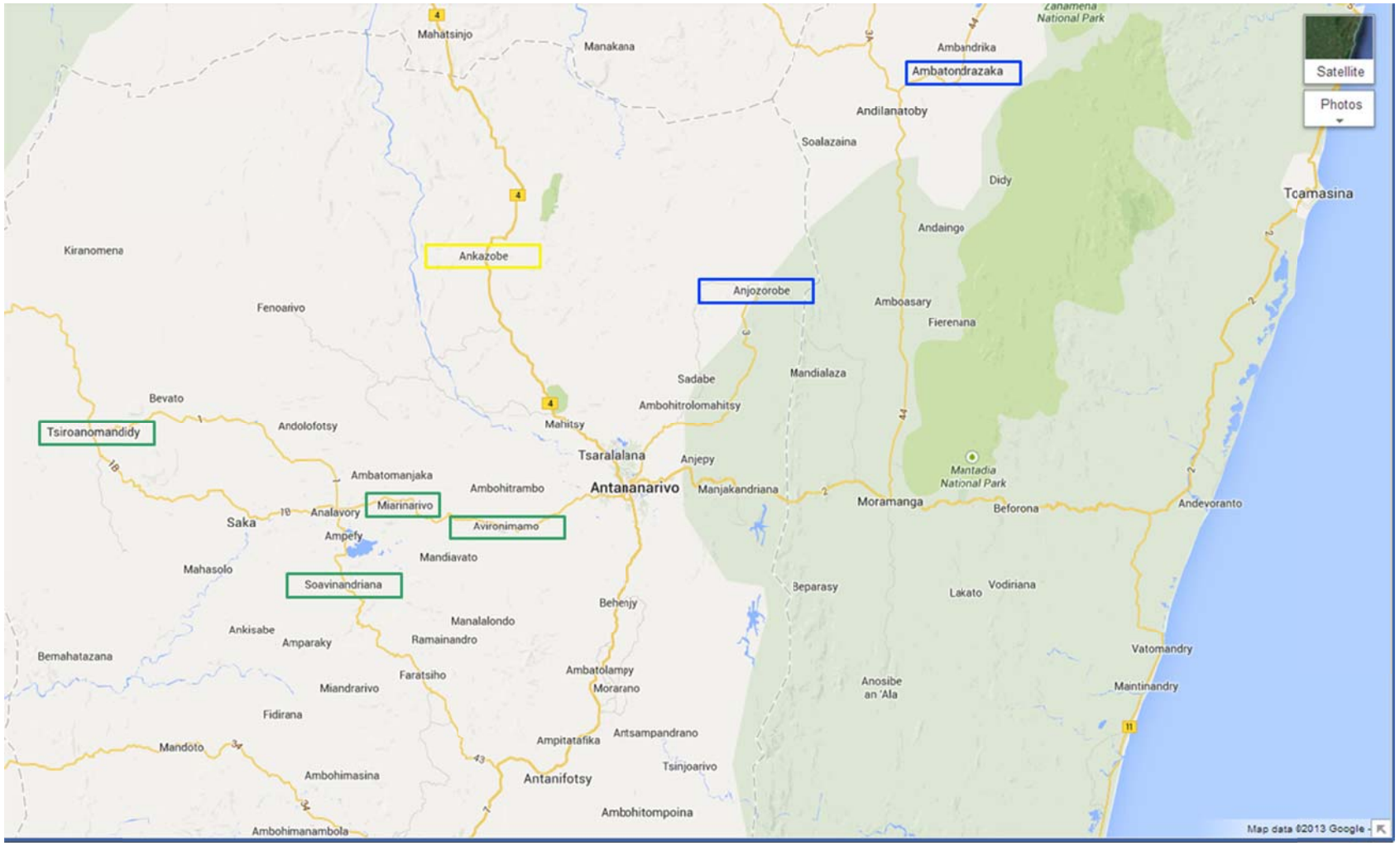

Figure 2. Map of Madagascar (districts)

Tables

Table 1. Summary statistics of sample traders

Variable	Source	Obs	Mean or *n*	S.D. or *%*	Min	Max
Rice trading						
Engaged in active inter-district trade, 2012–13 (dummy)	Periodic	224	*104*	*46.4%*	0	1
Engaged in passive inter-district trade, 2012–13 (dummy)	Periodic	224	*209*	*93.3%*	0	1
Engaged in within-Tana trade, 2012–13 (dummy)	Periodic	224	*198*	*88.4%*	0	1
(within-Tana trade) Purchased at Anosibe market (dummy)	Periodic	198	*129*	*65.2%*	0	1
(within-Tana trade) Purchased at Androavoahangy market (dummy)	Periodic	198	*49*	*24.7%*	0	1
(within-Tana trade) Purchased from local sellers in Tana (dummy)	Periodic	198	*140*	*70.7%*	0	1
Total amount of rice purchased, 2012–13 (milled-rice equivalent, ton)	Periodic	224	341.8	581.6	0	6749.6
Number of workers engaged in rice trading	Baseline	224	5.4	4.2	1	49
Years running rice trading	Baseline	224	8.2	6.7	1	32
Have updated "carte collecter" (dummy)	Baseline	224	*82*	*36.6%*	0	1
Pay wholesale tax (dummy)	Baseline	224	*152*	*67.9%*	0	1
Keep income statements (dummy)	Baseline	224	*90*	*40.2%*	0	1
Sell imported rice (dummy)	Baseline	224	*173*	*77.2%*	0	1
Business diversification						
Sell food other than rice (dummy)	Baseline	224	*156*	*69.6%*	0	1
Sell non-food items (dummy)	Baseline	224	*97*	*43.3%*	0	1
Operate rice mill (dummy)	Baseline	224	*36*	*16.1%*	0	1
Rent out truck or vehicle (dummy)	Baseline	224	*47*	*21.0%*	0	1
Profit share of rice trading	Baseline	222	0.647	0.311	0.02	1
Representative						
Representative's age	Baseline	220	37.1	9.6	20	69
Representative is male (dummy)	Baseline	224	*111*	*49.6%*	0	1
Representative is literate (dummy)	Baseline	224	*221*	*98.7%*	0	1
Representative's education level (dummy)						
None	Baseline	221	2	*0.9%*	0	1
Primary	Baseline	221	42	*19.0%*	0	1
Lower secondary	Baseline	221	79	*35.7%*	0	1
Upper secondary	Baseline	221	61	*27.6%*	0	1
Higher	Baseline	221	37	*16.7%*	0	1
Asset						
Have store for selling rice (dummy)	Baseline	224	*186*	*83.0%*	0	1
Have private storage (dummy)	Baseline	224	*194*	*86.6%*	0	1
Total capacity of private storage (ton)	Baseline	224	28.2	94.3	0	1000
Own vehicle (dummy)	Baseline	221	*61*	*27.6%*	0	1
Own truck (dummy)	Baseline	224	*77*	*34.4%*	0	1
Own cell phone (dummy)	Baseline	223	*201*	*90.1%*	0	1
Use mobile money for general purpose (dummy)	Baseline	223	*24*	*10.8%*	0	1
Use mobile money for rice trading (dummy)	Baseline	223	*6*	*2.7%*	0	1

Table 2. Number of different districts purchased from in inter-district trade

Activity	Variety	Mean	S.D.	Min	Max
Passive	Vary gasy	8.6	1.2	7	11
	Tsipala	10.3	1.7	8	15
	Makalioka	3.6	1.4	2	8
Active	Vary gasy	7.9	1.5	4	11
	Tsipala	7.5	1.6	5	11
	Makalioka	2.7	1.6	1	7

Note: "Number of different districts purchased from" is the number of different districts in which our sampled traders made actual purchases. The unit of observation is round–activity–variety ($N = 27 \times 2 \times 3 = 162$). The summary statistics are calculated over rounds ($N = 27$).

Table 3. Summary statistics on arbitrage performance

Variable	Obs	Mean or *n*	S.D. or *%*	Min	Max
A. Dummy if purchased from the cheapest district					
All transactions	14,422	*1,675*	*11.6%*	0	1
Passive inter-district trades (incl. within-Tana trades)	11,954	*1,214*	*10.2%*	0	1
Vary gasy	4,130	*264*	*6.4%*	0	1
Tsipala	3,619	*336*	*9.3%*	0	1
Makalioka	4,205	*614*	*14.6%*	0	1
Active inter-district trades	2,468	*461*	*18.7%*	0	1
Vary gasy	969	*93*	*9.6%*	0	1
Tsipala	783	*102*	*13.0%*	0	1
Makalioka	716	*266*	*37.2%*	0	1
B. Actual–optimal price ratio					
All transactions	14,422	1.072	0.099	0.638	2.509
If purchased from the optimal district	1,675	1.005	0.057	0.680	1.480
If not purchased from the cheapest district	12,747	1.081	0.100	0.638	2.509
Passive inter-district trades (incl. within-Tana trades)	11,954	1.061	0.070	0.729	1.759
Vary gasy	4,130	1.071	0.083	0.743	1.759
Tsipala	3,619	1.073	0.070	0.729	1.653
Makalioka	4,205	1.040	0.050	0.790	1.386
Active inter-district trades	2,468	1.128	0.171	0.638	2.509
Vary gasy	969	1.143	0.165	0.680	1.847
Tsipala	783	1.108	0.112	0.788	1.891
Makalioka	716	1.129	0.224	0.638	2.509

Note: The unit of observation is trader–round–activity–variety.

Table 4. Price dispersion across purchase districts

		(1)	(2)	(3)	(4)
		Number of districts	Price ratio compared to the cheapest district		Adjusted ME-price
Activity	Variety	purchased	Mean	Max	S.D.
Passive (incl. within-Tana trade)	Vary gasy	11.6	1.078	1.159	50.3
	Tsipala	13.3	1.076	1.155	51.4
	Makalioka	6.6	1.043	1.080	34.0
Active	Vary gasy	7.9	1.138	1.239	79.9
	Tsipala	7.5	1.130	1.253	104.5
	Makalioka	2.7	1.093	1.162	98.7

Note: All statistics (mean, max, and S.D.) are calculated for each round–activity–variety ($N = 27 \times 2 \times 3 = 162$) based on district-level price, and then averaged over 27 rounds. "Number of districts purchased from" is the number of different districts where we observed actual purchases made by our sampled traders. For passive purchases, three modes of within-Tana trade are also considered as "districts." "Price ratio compared to the cheapest district" represents the ratio of price in each district to the price in the cheapest district. "Adjusted ME-price" (S.D.) in column (4) is the standard deviation of district prices within each round–activity–variety.

Table 5. Price searches in 36 listed districts

Variable	Obs	Mean or *n*	S.D. or *%*	Min	Max
A. Trader level					
Searched price in 36 listed districts (dummy)					
All traders	224	*213*	*95.1%*	0	1
Passive-only traders	120	*109*	*90.8%*	0	1
Active traders	104	*104*	*100.0%*	0	1
(If searched) Number of districts searched price					
All traders	213	5.1	3.1	1	20
Passive-only traders	109	4.5	3.0	1	12
Active traders	104	5.8	3.1	1	20
B. Trader-round level (per round)					
Searched price in 36 listed districts (dummy)					
All traders	6,033	*4,599*	*76.2%*	0	1
Passive-only traders	4,405	*3,030*	*68.8%*	0	1
Active traders	1,628	*1,569*	*96.4%*	0	1
(If searched) Number of districts searched price					
All traders	4,599	2.1	1.8	1	12
Passive-only traders	3,030	2.0	1.9	1	11
Active traders	1,569	2.3	1.6	1	12

Table 6. Summary statistics of the number of districts purchased from in inter-district trade

	Trader types															Active traders									
	All traders					Passive-only traders					Active traders					Passive purchase					Active purchase				
Variety	Obs	Mean	S.D.	Min	Max	Obs	Mean	S.D.	Min	Max	Obs	Mean	S.D.	Min	Max	Obs	Mean	S.D.	Min	Max	Obs	Mean	S.D.	Min	Max
A. Trader level																									
All varieties	222	4.0	1.9	1	10	118	4.2	2.2	1	10	104	3.8	1.7	1	10	91	3.2	1.5	1	7	104	2.3	1.5	1	10
Vary gasy	212	2.5	1.2	1	7	112	2.4	1.3	1	7	100	2.5	1.2	1	7	81	2.1	1.0	1	6	87	1.8	1.1	1	6
Tsipala	200	2.7	1.5	1	8	107	2.9	1.7	1	8	93	2.5	1.3	1	6	75	2.2	1.1	1	5	81	1.7	1.0	1	6
Makalioka	210	1.3	0.6	1	4	114	1.2	0.5	1	4	96	1.3	0.6	1	3	78	1.2	0.5	1	3	66	1.2	0.5	1	3
Import	61	1.1	0.3	1	2	38	1.1	0.2	1	2	23	1.2	0.4	1	2	20	1.1	0.3	1	2	6	1.3	0.5	1	2
Don't know	19	1.3	0.6	1	3	5	1.0	0.0	1	1	14	1.4	0.6	1	3	6	1.0	0.0	1	1	9	1.4	0.5	1	2
B. Trader-round level (per round)																									
All varieties	5,221	1.9	0.8	1	6	2,783	2.1	0.7	1	6	2,438	1.6	0.7	1	6	1,373	1.4	0.6	1	4	1,628	1.3	0.6	1	5
Vary gasy	3,990	1.0	0.2	1	3	2,311	1.0	0.2	1	3	1,679	1.0	0.2	1	3	762	1.0	0.2	1	2	969	1.0	0.2	1	3
Tsipala	3,526	1.0	0.2	1	3	2,169	1.0	0.2	1	3	1,357	1.1	0.2	1	3	603	1.0	0.2	1	2	785	1.1	0.3	1	3
Makalioka	4,139	1.0	0.1	1	2	2,451	1.0	0.1	1	2	1,688	1.0	0.1	1	2	989	1.0	0.1	1	2	716	1.0	0.1	1	2
Import	331	1.0	0.0	1	1	163	1.0	0.0	1	1	168	1.0	0.0	1	1	77	1.0	0.0	1	1	91	1.0	0.0	1	1
Don't know	33	1.2	0.4	1	2	10	1.0	0.0	1	1	23	1.2	0.4	1	2	6	1.0	0.0	1	1	17	1.3	0.5	1	2

Note: Number of districts purchased from does not include the three modes of within-Tana trade.

Table 7. Obstacles to starting to visit a new district

	Total	First	Second	Third
Obtaining price information	*21.1%*	*24.1%*	*17.8%*	*21.4%*
Collect necessary quantity	*9.8%*	*8.4%*	*9.6%*	*11.5%*
Finding trustworthy trading partner	*25.1%*	*30.0%*	*25.9%*	*18.7%*
Payment will be inflexible / unable to purchase on credit	*3.4%*	*1.0%*	*5.6%*	*3.8%*
Quality, variety, characteristics is uncertain	*16.3%*	*7.4%*	*23.4%*	*18.7%*
Safety	*16.2%*	*18.7%*	*11.7%*	*18.1%*
Lack of experience	*7.4%*	*10.3%*	*5.1%*	*6.6%*
Lack of money	*0.5%*	*0.0%*	*1.0%*	*0.5%*
Other	*0.2%*	*0.0%*	*0.0%*	*0.5%*
Total	*100.0%*	*100.0%*	*100.0%*	*100.0%*
Obs.	582	203	197	182

Note: Based on the follow-up survey. Respondents are all traders who participated in the follow-up survey ($N = 219$).

Table 8. Most valuable information when starting to trade with a new district

	Total	First	Second	Third
Price	*33.0%*	*51.1%*	*29.4%*	*17.2%*
Availability (quantity)	*18.1%*	*6.8%*	*24.8%*	*23.2%*
Quality, variety, and characteristics	*26.1%*	*22.8%*	*30.3%*	*25.1%*
Contact of trading partner	*19.1%*	*16.0%*	*13.3%*	*28.6%*
Safety information	*1.4%*	*2.7%*	*0.5%*	*1.0%*
Road condition	*1.3%*	*0.5%*	*0.9%*	*2.5%*
Credit information	*0.5%*	*0.0%*	*0.9%*	*0.5%*
Other	*0.6%*	*0.0%*	*0.0%*	*2.0%*
Total	*100.0%*	*100.0%*	*100.0%*	*100.0%*
Obs.	640	219	218	203

Note: Based on the follow-up survey. Respondents are all traders who participated in the follow-up survey ($N = 219$).

Table 9. SMS treatment effects for search and purchasing

	(1)	(2)	(3)	(4)	(5)
	Searched price in other districts	Number of districts knowing price	Engaged in active trading	Number of active districts purchased	Number of passive districts purchased
Treatment	0.0810	0.0213	0.0981	-0.0152	-0.0736
	(0.0500)	(0.115)	(0.0503)	(0.0950)	(0.0888)
After	-0.136***	-0.587***	-0.0492	0.0712	0.0160
	(0.0262)	(0.169)	(0.0271)	(0.109)	(0.0793)
Treatment x After	0.0753***	1.504***	-0.00880	-0.136	-0.00130
	(0.0215)	(0.217)	(0.0221)	(0.0924)	(0.0484)
Constant	0.834***	1.771***	0.281***	1.374***	1.826***
	(0.0342)	(0.116)	(0.0375)	(0.106)	(0.0839)
N	6033	6033	6033	1628	4156
R-sq	0.025	0.125	0.018	0.026	0.009

Note: Unit of observation is trader–round. Standard errors clustered by trader in parentheses. Round fixed effects included. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10. SMS treatment effects for arbitrage performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All transactions			Active transactions			Passive transactions		
	Vary gasy & Tsipala	Vary gasy	Tsipala	Vary gasy & Tsipala	Vary gasy	Tsipala	Vary gasy & Tsipala	Vary gasy	Tsipala
Panel A. Dummy if purchased from cheapest district									
Treatment	0.017	0.0114	0.0252	0.0218	0.0122	0.0182	0.0094	0.00865	0.0121
	-0.00991	-0.0109	-0.0149	-0.0192	-0.025	-0.0292	-0.00849	-0.0107	-0.0123
After	0.107***	-0.00719	0.246***	0.0131	-0.0252	0.0488	0.121***	-0.00632	0.276***
	-0.0213	-0.0177	-0.0389	-0.0404	-0.0574	-0.057	-0.0239	-0.0173	-0.0443
Treatment x After	-0.0349	-0.0151	-0.0598	0.0109	0.00607	0.0325	-0.0333	-0.0143	-0.059
	-0.0212	-0.0163	-0.0337	-0.0343	-0.0377	-0.0512	-0.0225	-0.0174	-0.0352
Variety (base = Vary gasy)									
Tsipala	0.0287***			0.0335*			0.0284***		
	-0.00737			-0.0148			-0.00831		
Constant	0.00125	0.0299*	-0.00745	-0.00336	0.0404	-0.0108	0.00518	0.0282	0.00204
	-0.0107	-0.0145	-0.0103	-0.025	-0.0381	-0.0175	-0.0115	-0.0152	-0.0105
N	9501	5099	4402	1752	969	783	7749	4130	3619
R-sq	0.05	0.059	0.092	0.128	0.144	0.371	0.078	0.095	0.153
Panel B. Actual–optimal price ratio									
Treatment	-0.00478	-0.00434	-0.00668	-0.00992	-0.00454	-0.0200	-0.00572	-0.00694	-0.00481
	(0.00496)	(0.00505)	(0.00620)	(0.0133)	(0.0122)	(0.0180)	(0.00441)	(0.00414)	(0.00577)
After	-0.0560***	-0.0433***	-0.0736***	-0.117***	-0.151***	-0.0815*	-0.0354***	-0.0141*	-0.0635***
	(0.00852)	(0.00881)	(0.0104)	(0.0294)	(0.0309)	(0.0316)	(0.00523)	(0.00626)	(0.00626)
Treatment x After	0.0138	0.0169	0.0114	0.0361	0.0460*	0.0382	0.00557	0.00727	0.00416
	(0.00779)	(0.00866)	(0.00825)	(0.0208)	(0.0232)	(0.0234)	(0.00712)	(0.00777)	(0.00744)
Variety (base = Vary gasy)									
Tsipala	-0.00581*			-0.0366***			0.00155		
	(0.00239)			(0.00734)			(0.00187)		
Constant	1.099***	1.078***	1.121***	1.219***	1.192***	1.216***	1.066***	1.048***	1.092***
	(0.00785)	(0.00762)	(0.00943)	(0.0244)	(0.0237)	(0.0309)	(0.00441)	(0.00516)	(0.00520)
N	9501	5099	4402	1752	969	783	7749	4130	3619
R-sq	0.158	0.321	0.117	0.305	0.694	0.395	0.228	0.453	0.163

Note: Unit of observation is trader–round–activity–variety. Standard errors clustered by trader in parentheses. Round fixed effects included. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 11. SMS treatment effects for management indicators

	(1)	(2)	(3)	(4)	(5)
	Biweekly amount sold (ton)	Biweekly amount purchased (ton)	Selling price (Ar/kg)	Purchasing price (Ar/kg)	Margin (Ar/kg)
Treatment	5.866	5.701	-3.030	-5.496	0.383
	(3.113)	(3.248)	(8.786)	(8.618)	(3.593)
After	2.054	-0.0435	103.8***	108.3***	-0.891
	(1.734)	(1.739)	(6.739)	(6.709)	(3.294)
Treatment x After	-2.179	-2.188	-5.529	-2.184	-0.721
	(1.127)	(1.180)	(7.762)	(7.202)	(2.280)
Constant	8.260***	11.91***	1125.5***	1069.0***	52.56***
	(1.656)	(1.905)	(6.245)	(6.355)	(3.145)
N	5769	5862	5830	5716	5814
R-sq	0.012	0.011	0.274	0.280	0.007

Note: Unit of observation is trader–round. Standard errors clustered by trader in parentheses. Round fixed effects included. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12. Reasons for not using SMS price information to visit a new district

	Total	First	Second	Third
Information was not timely	*14.1%*	*3.3%*	*15.0%*	*42.4%*
Information was not reliable	*31.5%*	*34.1%*	*38.3%*	*12.1%*
Price may change during travel or transportation	*20.7%*	*13.2%*	*35.0%*	*15.2%*
Price is not important	*6.0%*	*2.2%*	*3.3%*	*21.2%*
SMS price was expensive	*3.8%*	*7.7%*	*0.0%*	*0.0%*
Bad transportation	*0.5%*	*0.0%*	*0.0%*	*3.0%*
Lack of money	*1.1%*	*2.2%*	*0.0%*	*0.0%*
Only buy from fixed place/seller	*11.4%*	*20.9%*	*1.7%*	*3.0%*
Other	*10.9%*	*16.5%*	*6.7%*	*3.0%*
Total	*100.0%*	*100.0%*	*100.0%*	*100.0%*
Obs.	184	91	60	33

Note: Based on the follow-up survey. Respondents are traders who received our price information via SMS and did not use this information to start a visit to a new district ($n = 93$).

Appendix A. Imputation of (adjusted) milled-rice equivalent price

In this Appendix, we describe how we imputed and adjusted the purchase price of rice. The main concern is that a certain fraction of purchases were made in paddy, and the price for paddy is generally lesser than that for milled rice because paddy needs to be processed. To obtain comparability between the two prices, we construct a *milled-rice equivalent price* (hereafter, ME-price), which represents the price equivalent to purchasing milled rice per kg, including transportation costs and milling fees.

When the purchased rice is milled rice, the ME-price is simply the raw purchase price plus transportation costs. For purchases made in paddy, we impute the ME-price on the basis of the following equation:

$$\hat{p}_{\text{milled}} = \frac{p_{\text{paddy}} + \tau + c - \alpha_{\text{bran}} p_{\text{bran}}}{\alpha_{\text{milled}}}$$

where p_{paddy} is the purchase price of paddy, τ is the transportation cost (of paddy), c is the milling fee (per kg of paddy), α_{paddy} and α_{bran} are the conversion rates from paddy to milled rice and paddy to bran, respectively, and p_{bran} is the sales price of bran. All prices and costs are measured per kg. The numerator is the total cost of purchasing 1 kg of paddy, net of sales of bran. The denominator is the quantity of milled rice obtained from 1 kg of paddy.

For all purchases made during the periodic surveys, we have information on p_{paddy} and τ but not on the others. We thus collected information on the rest of the parameters $(c, \alpha_{\text{bran}}, \alpha_{\text{milled}}, p_{\text{bran}})$ in the follow-up survey. Out of 219 respondents in the follow-up survey, 70 (32%) purchased rice in paddy. For those who purchased in paddy, we asked about the details of milling for each variety, obtaining 133 trader–variety observations. **Table OA1** and **Table OA2** in the online appendix present the summary statistics. Of the 130 available observations, 110 (85%) were milled in Antananarivo Renivohitra. For milling cost c, we use the milling fee in low season[21]. It is common for the traders to obtain and sell the bran. Out of 133 trader–variety observations, 52% were milled by the trader, thus retaining the bran. Even where a trader asked a miller to carry out the milling, the trader answered that they "always get the bran" in 71% of the observations. This indicates that the traders obtained the bran in 86% $(= 0.52 + (1 - 0.52) \times 0.71)$ of the cases. The bran is almost always sold (89%). We therefore assume that when traders purchase paddy, they get the bran and sell it, which requires bran sales to be deducted from the purchase cost.

To impute $\hat{p}_{\text{milled}}$, we use the median of variety-specific parameter (**Table OA2**). Suppose a

[21] The milling fee for low season (non-harvest season: September to April) is higher than that in the high season (harvest season: May to August), though the difference is marginal. The fee for the high season is lower because of higher operation costs and competition. However, millers make up for these with the increase in operation volumes.

trader purchased Vary gasy in paddy at a price of 780 Ar/kg and transportation cost of 20 Ar/kg. Then, the imputed ME-price per kg is

$$\hat{p}_{\text{milled}} = \frac{p_{\text{paddy}} + \tau + c - \alpha_{\text{bran}} p_{\text{bran}}}{\alpha_{\text{milled}}} = \frac{780 + 20 + 20 - 0.10 \times 600}{0.70} = 1{,}086.$$

Thus, purchasing 1,000 kg of paddy at a price of 780 Ar/kg and transportation cost of 20 Ar/kg is equivalent to purchasing 700 kg of milled rice at a price of 1,086 Ar/kg (including transportation cost).

Since the ME-price is imputed for purchase in paddy, we checked whether it is systematically different from the purchase prices for milled rice. Fixed effect estimates of ME-prices with a dummy indicating purchase in paddy, with activity–round–variety–district fixed effects and using all 19,422 purchased prices for Vary gasy, Tsipala, and Makalioka, indicate that the ME-price in paddy is 127.9 Ar/kg lower than the price of milled rice (**Table OA3** column (1)). The constant (i.e., the price for milled rice) is 1210.2, which indicates that paddy is 9.9% ($= 1 - (1210.2 - 127.9)/1210.2$) cheaper than milled rice.

This price difference between paddy and milled rice might cause a bias. Out of the 1,339 activity–round–variety–district observations, 248 (19%) were for purchased in paddy only, 748 (56%) were for purchased in milled rice only, and 343 (26%) were for purchased both in-paddy and milled rice (**Table OA4**). The percentage of purchases in paddy only is larger for active inter-district trades than passive trades (49% vs. 2%), implying that the potential bias, if any, is more serious for active purchases.

To take into account this potential bias, we construct the *adjusted milled-rice equivalent price*, which adjusts the price difference between paddy and milled rice by adding the paddy's price discount compared to milled rice for purchases in paddy. We estimate the price discount for each activity–variety by regressing the ME-price price with a dummy indicating purchase in paddy with round–district fixed effects (**Table OA3** columns (2)–(7)). The adjusted ME-price is constructed by adding the activity–variety specific price discount. For example, the price discount is 1190.5 Ar/kg for active–Vary gasy purchases. Thus, the adjusted ME-price of Vary gasy in paddy with a price of 780 Ar/kg and transportation cost of 20 Ar/kg is

$$\hat{p}^{\text{adj.}}_{\text{milled}} = 1{,}086 + 119.5 = 1205.5.$$

Appendix Tables

Table A1. Median adjusted milled-rice price by round–variety–district (passive incl. within-Tana trade)

Variety	District \ Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Vary gasy	Ambohidratrimo	1000			1150	1260	1300	1130	1195	1290	1295	1280	1265	1230	1270	1270	1250	1255	1230	1260	1145	1240	1025	1180	1175	1170	1180	1120
Vary gasy	Ankazobe	1018	1080	1080	1140	1260	1295	1160	1200	1255	1290	1280	1260	1210	1250	1250	1250	1240	1255	1240	1260	1080	1250	1180	1190	1190	1240	1170
Vary gasy	Arivonimamo	1060	1080	1125	1180	1240	1200	1200	1200	1220	1210	1200	1220	1220	1275	1280	1250	1250	1170	1160	1140	1150	1135	1140	1140	1150	1140	1150
Vary gasy	Manjakandriana														1323	1300												
Vary gasy	Anjozorobe	1055	1070	1100	1150	1180	1240	1240	1240	1180	1170	1190	1180	1200	1250	1300	1290	1300	1275	1180	1102	1075	1060	1132	1175	1180	1219	1180
Vary gasy	Ambatolampy																			960	960							
Vary gasy	Tsiroanomandidy	1026	1041	1100	1200	1160	1195	1190	1189	1180	1200	1190	1190	1200	1280	1280	1280	1200	1100	1100	1090	1080	1080	1090	1105	1160	1120	1130
Vary gasy	Miarinarivo	1080	1100	1095	1100	1280	1305	1200	1210	1210	1220	1240	1255	1190		1290	1290	1245	1250	1240	1240	1265	1245	1220	1135	1210	1250	1205
Vary gasy	Soavinandriana															1260												
Vary gasy	Antananarivo Atsimondrano	1050		1120	1100	1150	1260		1220	1180	1160	1200	1160	1180				1250	1280	1180	1240	1140	1200	1200	1180	1180	1180	1160
Vary gasy	Toamasina I								1250																			
Vary gasy	Ambatondrazaka	1000	1000	1040	1125	1180	1195	1169	1185	1018	1190	1180	1195	1180	1350		1300	1240	1380	1300	996				1289		1220	
Vary gasy	Andilamena						1140																					
Vary gasy	Marovoay									1160	1160	1160	1160												960			
Vary gasy	Mandritsara		1080	1080														1150					1190				
Vary gasy	Befandriana Avaratra									1220																		
Vary gasy	Bealanana		1080				1240	1389	1389	1230	1354	1250	1263	1250						1240			1220	1220				
Vary gasy	Mampikony										1518																	
Vary gasy	Other districts in Boeny					1100																						
Vary gasy	Tana: Anosibe	1090	1070	1110	1180	1220	1210	1150	1200	1280	1200	1220	1250	1300	1350	1290	1280	1250	1260	1200	1115	1100	1130	1120	1140	1143	1140	1135
Vary gasy	Tana: Andravoahangy	1100	1080	1080	1165	1180	1200	1200	1200	1200	1200	1200	1200	1250	1325	1290	1240	1220	1205	1140	1100	1100	1125	1120	1180	1160	1140	1190
Vary gasy	Tana: Seller in Tana	1040	1050	1050	1080	1180	1180	1146	1200	1220	1220	1220	1190	1300	1300	1300	1295	1250	1270	1120	1100	1080	1080	1100	1175	1180	1180	1170
Tsipala	Ambohidratrimo				1140	1260	1290	1160	1190	1290	1290	1265	1260	1240	1255	1300	1260	1250	1220	1250	1250	1250	1230	1200	1195	1180	1120	1160
Tsipala	Ankazobe	1000	1039	1080	1140	1270	1285	1135	1190	1290	1290	1260	1250	1200	1255	1220	1270	1250	1240	1250	1250	1240	1250	1190	1190	1175	1245	1160
Tsipala	Arivonimamo	1050	1070	1150	1160	1180	1200	1180	1200	1200	1200	1180	1220	1200	1200	1200	1220	1240	1210	1200	1140	1155	1220	1140	1140	1166	1150	1160
Tsipala	Anjozorobe	1035	1070	1080	1150	1170	1270	1220	1230	1140	1140	1170	1170	1180	1180	1180	1280	1280	1300	1280	1240	1200	1180	1175	1250	1180	1250	1180
Tsipala	Tsiroanomandidy	1020	1050	1080	1150	1180	1140	1155	1180	1172	1160	1200	1140	1200	1260	1200	1200	1155	1100	1100	1090	1060	1060	1065	1080	1125	1120	1120
Tsipala	Miarinarivo	1060	1100	1100		1280	1305	1180	1200	1200	1200	1250	1250	1220	1200	1225	1245	1265	1238	1175	1230	1253	1235	1225	1200	1225	1240	1160
Tsipala	Soavinandriana		1040											1140	1250		1200					1080	1080	1060	1080			
Tsipala	Antananarivo Atsimondrano	1050		1120	1120	1150	1260		1220	1160	1140	1180	1140	1180				1250	1270	1160	1240	1120	1160	1200	1160	1160	1160	1160
Tsipala	Fianarantsoa I						1160																					
Tsipala	Ambatondrazaka	1100	1060	1105		1180			1250		1200	1200	1230	1200					1040	1080							1230	
Tsipala	Mahajanga I	1050																										
Tsipala	Marovoay	990	1029	980			1160	1200	1200	1130	1100	1100	1100	1155		1250												1130
Tsipala	Port-Berge														1150													
Tsipala	Mandritsara	1050	1050	1040	1110	1120	1100	1130	1100	1100	1110	1100	1120	1160	1200	1190				1100	1040	1070	1080	1110	1140	1160		
Tsipala	Befandriana Avaratra	980	1020	1020	1080	1100	1100	1090		1245																		
Tsipala	Antsohihy	1000	1100																									
Tsipala	Bealanana	985	1030	1080	1120	1160	1180	1140	1135	1150	1115	1140	1150	1180	1200	1200	1180	1150	1200	1100	1040	1070	1220	1240	1140	1155		
Tsipala	Mampikony	980				1200					1332	1200			1140													
Tsipala	Other districts in Boeny	950																										
Tsipala	Tana: Anosibe	1040	1050	1095	1170	1220	1230	1160	1215	1210	1215	1210	1230	1260	1240	1310	1300	1250	1265	1190	1110	1110	1135	1110	1140	1150	1140	1135
Tsipala	Tana: Andravoahangy	1080	1130	1080	1160	1200	1170	1160	1195	1150	1140	1180	1175	1190	1210	1215	1260	1270	1165	1120	1060	1100	1150	1120	1150	1160	1150	1120
Tsipala	Tana: Seller in Tana	1050	1060	1060	1150	1160	1160	1160		1200	1200	1180	1200	1340	1390	1260	1295	1250	1276	1020	1060	1080	1080	1070	1150	1180	1180	1180
Makalioka	Ambohidratrimo															1400									1260			
Makalioka	Ankazobe	1200	1100																									
Makalioka	Arivonimamo	1090	1060	1160	1240	1265	1250	1300	1270	1200	1280	1310	1320	1375	1420	1400			1380		1400	1400			1300			1300
Makalioka	Anjozorobe	1120	1120		1200			1296	1320	1230	1221	1300	1290												1125	1300		1214
Makalioka	Tsiroanomandidy	1100	1100					1280							1350		1370		1300									
Makalioka	Antananarivo Atsimondrano	1160	1160	1200			1290	1340		1260	1290	1290	1280	1290	1300	1350	1380	1370	1380	1380	1350	1260	1290	1340	1280	1285	1295	1285
Makalioka	Ambatondrazaka	1100	1120	1190	1220	1250	1270	1260	1270	1280	1280	1300	1300	1360	1400	1400	1410	1420	1380	1380	1350	1300	1240	1240	1248	1250	1250	1250
Makalioka	Mahajanga I	1050																										
Makalioka	Marovoay	1100		1200				1200	1200																			
Makalioka	Tana: Anosibe	1100	1100	1150	1250	1275	1275	1250	1280	1290	1300	1320	1340	1380	1410	1400	1425	1430	1450	1400	1300	1290	1355	1260	1300	1340	1270	1295
Makalioka	Tana: Andravoahangy	1130	1050	1190	1200	1250	1280	1270	1260	1280	1270	1300	1320	1375	1440	1440	1450	1420	1430	1400	1250	1260	1260	1200	1200	1210	1250	1300
Makalioka	Tana: Seller in Tana	1140	1100	1120	1240	1260	1280	1275	1270	1270	1285	1320	1340	1410	1420	1415	1440	1440	1445	1400	1380	1275	1240	1240	1270	1260	1270	1300

TableA2. Median adjusted milled-rice price by round–variety–district (active)

Variety	District \ Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Vary gasy	Ambohidratrimo		1070	1100	1130	1255	1299		1138	1160	1221	1280	1263	1190		1220	1225	1260	1203	1240	1133	1200	1170	1140	1070	1080	1110	1120
Vary gasy	Ankazobe	1020	1062	1062	1091	1205		1134		1200	1203	1205	1230	1200				1220	1213	920	920	1210	848	948	948	1105	1123	1090
Vary gasy	Arivonimamo	1020	1028	1120	1150	1210	1245	1270	1210	1195	1230	1190	1160	1170	1230	1230	1230	1230	1240	1205	1170	1085	1110	1100	1120	1125	1120	1150
Vary gasy	Anjozorobe	1062	1062	1084	1134	1177	1205	1205	1212	1205	1212	1205	1262	1262					1234	1005	1020	1062	1091	1091	1105	1134	1191	1177
Vary gasy	Antsirabe I																	1020										
Vary gasy	Ambatolampy																962	962	962	962	962							
Vary gasy	Tsiroanomandidy	1091	1010	1205	1234	1205	1205	1234	1234	1220	1177	1205	1155	1177	1277	1205	1205	1212	862	1162	1077	1077	1077	1105	1112	1134	1170	1166
Vary gasy	Miarinarivo	1020	1205	1140	1160	1205	1348	1134			1205	1205	1191	1191	1205	1241	1062	1062	1062	1062	991	991		1062	1062	1134	1134	1177
Vary gasy	Soavinandriana	877		1205	1205	762																						
Vary gasy	Toamasina I	1115	1115																									
Vary gasy	Ambatondrazaka	1070	1020	1062	1070	1291		1148	1305	1305	1205	1348		1020		1091	1420			777				1062			1205	
Vary gasy	Mahajanga I	920	920																									
Vary gasy	Maevatanana		1205	1062	1205	1205	1205	1277	1277	1205	1305	1305		1134	1134			1205	1205	920	920					1120	1120	1062
Vary gasy	Marovoay			1220																								
Vary gasy	Mandritsara																	1241										
Vary gasy	Befandriana Avaratra										1320																	
Vary gasy	Bealanana		1205					1300	1300	1320	1320	1334	1334			1277						1077	1148	1105		1205	1177	
Vary gasy	Mampikony																							1120				
Vary gasy	Ambanja						1348																					
Tsipala	Ambohidratrimo		1100	1100	1100	1255	1294		1128	1135	1160	1290	1268	1185		1220	1225	1270	1203	1245	1215	1190	1160	1145	1065	1095	1105	
Tsipala	Ankazobe	992								1190	1200		1240	1200				1210	1218		1205	1200	1152	930	1020		1135	1016
Tsipala	Arivonimamo	1020	1038	1120	1168	1170	1210	1260	1200	1185	1188	1163	1150	1170	1190	1220	1220	1220	1230	1205	1155	1070	1110	1090	1120	1115	1117	1153
Tsipala	Anjozorobe	1112	1162	1266	1288	1288	1288				1466										1045							
Tsipala	Tsiroanomandidy	1100	1066	1195	1266	1266	1309	1223	1266	1202	1123	1123	1209	1209	1266	1238	1166	1252	1138	1223	1223	1088	1052	1152	1173	1216	1216	1209
Tsipala	Miarinarivo	1020	1020	1130	1140	1266	1409	1195					1252	1252	1230	1302	1123	1266	1409	1138	1052	1052	1080	1123	1123	1166	1195	1238
Tsipala	Soavinandriana	980		1266	1045		966																					
Tsipala	Fianarantsoa I							1290	1290																			
Tsipala	Ambatondrazaka			1280		1309	1266																					
Tsipala	Marovoay	873	1009	1016			1395	1295	1380	1395	1395	1395	1395	1466	1509	1466	1509	1538		1466	1466		966	1180	1180	1180		1252
Tsipala	Mandritsara	1000	1040		1240		1140	1120			1150	1150					1250											
Tsipala	Befandriana Avaratra										1423																	
Tsipala	Bealanana	935	975	1238	1309		1280	1290	1300	1409	1409	1402	1409									1138	1195	1152		1238	1230	
Tsipala	Mampikony	887	995	1016		1140	1295	1280	1380	1395	1395	1395	1395	1466	1509	1466		1538	1552	1466	1466	909		1173			1123	
Makalioka	Arivonimamo	1065	1095	1130	1230	1270	1290	1290	1295																			
Makalioka	Anjozorobe	1099	1099	1099	1110	1150	1150	1217	1217	1026		1099	1173	1209							878	952						
Makalioka	Ambatolampy																			1217	1217							
Makalioka	Tsiroanomandidy					1300																						
Makalioka	Miarinarivo	673																										
Makalioka	Soavinandriana						790																					
Makalioka	Amparafaravola	980	1110	1210	1230	1084	1099	1099	1114	1128				1128	1305		1364			1276		1158		1128		1261	1276	
Makalioka	Ambatondrazaka	1026	1055	1114	1187	1187	1187	1270	1320	1224	1246	1237	1246	1290	1393	1467	1467	1496	1496	1380	1408	1170	1246	1136	1143	1143	1158	1151
Makalioka	Andilamena			864																								
Makalioka	Marovoay	768																										
Makalioka	Mampikony	614																										

Notes for Table A1 and Table A2: Each price is the median price for all observed paid prices in each round–activity–variety–district. The price is based on the adjusted milled-rice equivalent price. The cheapest district for each round–variety is highlighted in red.

Table A3. Percentage of traders purchasing from each district (active, Vary gasy)

District \ Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Ambohidratrimo	0%	2%	7%	10%	4%	5%	0%	7%	8%	8%	9%	10%	8%	0%	8%	5%	6%	9%	8%	5%	3%	7%	6%	6%	7%	5%	3%
Ankazobe	6%	2%	2%	2%	2%	0%	3%	0%	3%	4%	2%	3%	5%	0%	0%	0%	3%	9%	3%	5%	9%	7%	8%	6%	2%	5%	3%
Arivonimamo	26%	33%	39%	36%	40%	46%	47%	41%	39%	35%	42%	45%	41%	54%	48%	43%	45%	41%	32%	22%	26%	34%	25%	23%	24%	24%	22%
Anjozorobe	19%	22%	22%	21%	23%	20%	18%	18%	21%	21%	12%	13%	5%	0%	0%	0%	0%	5%	8%	10%	18%	17%	19%	20%	17%	21%	24%
Antsirabe I	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Ambatolampy	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	3%	5%	3%	2%	0%	0%	0%	0%	0%	0%	0%
Tsiroanomandidy	28%	20%	15%	21%	19%	22%	15%	23%	18%	13%	21%	19%	31%	35%	28%	29%	26%	23%	37%	49%	38%	32%	28%	37%	39%	34%	43%
Miarinarivo	9%	7%	5%	2%	2%	2%	3%	0%	0%	2%	2%	3%	3%	8%	4%	14%	3%	5%	5%	5%	3%	0%	6%	9%	5%	3%	3%
Soavinandriana	4%	0%	2%	2%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Toamasina I	2%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Ambatondrazaka	4%	4%	2%	2%	6%	0%	9%	7%	3%	8%	2%	0%	5%	0%	8%	5%	0%	0%	3%	0%	0%	0%	3%	0%	0%	3%	0%
Mahajanga I	2%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Maevatanana	0%	2%	2%	2%	2%	2%	3%	2%	3%	2%	2%	0%	3%	4%	0%	0%	3%	5%	3%	2%	0%	0%	0%	0%	2%	3%	3%
Marovoay	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Mandritsara	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Befandriana Avaratra	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Bealanana	0%	2%	0%	0%	0%	0%	3%	2%	5%	4%	7%	6%	0%	0%	4%	0%	0%	0%	0%	0%	3%	2%	3%	0%	2%	3%	0%
Mampikony	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%
Ambanja	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total trader–district	47	45	41	42	48	41	34	44	38	48	43	31	39	26	25	21	31	22	38	41	34	41	36	35	41	38	37

Note: The numerator is the number of traders purchasing from each district. The denominator is the total trader–district purchased. Districts with a higher percentage of purchasing traders for each round are highlighted in dark red. The cheapest district based on median adjusted ME-price for each round–variety is marked by a bold square.

Table A4. Percentage of traders purchasing from each district (active, Tsipala)

District \ Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Ambohidratrimo	0%	3%	5%	6%	6%	5%	0%	9%	10%	12%	16%	11%	8%	0%	9%	4%	8%	8%	7%	3%	3%	6%	7%	7%	6%	7%	0%
Ankazobe	5%	0%	0%	0%	0%	0%	0%	0%	3%	3%	0%	4%	8%	0%	0%	0%	4%	8%	0%	3%	9%	9%	10%	3%	0%	3%	6%
Arivonimamo	30%	53%	59%	59%	64%	49%	58%	66%	65%	59%	63%	64%	65%	79%	52%	56%	50%	46%	27%	29%	41%	38%	40%	37%	47%	50%	52%
Anjozorobe	5%	6%	3%	3%	6%	3%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%
Tsiroanomandidy	32%	17%	13%	6%	8%	21%	19%	13%	6%	6%	3%	4%	8%	5%	26%	20%	23%	29%	50%	51%	34%	38%	30%	43%	38%	30%	35%
Miarinarivo	9%	3%	5%	3%	3%	3%	4%	0%	0%	0%	0%	4%	4%	5%	4%	12%	8%	4%	10%	6%	6%	3%	3%	7%	3%	3%	3%
Soavinandriana	2%	0%	3%	6%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fianarantsoa I	0%	0%	0%	0%	0%	0%	4%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Ambatondrazaka	0%	0%	3%	0%	6%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Marovoay	2%	3%	3%	3%	3%	5%	4%	3%	3%	3%	3%	4%	4%	5%	4%	4%	4%	0%	3%	3%	0%	3%	3%	3%	3%	0%	3%
Mandritsara	5%	3%	0%	3%	0%	3%	4%	0%	0%	3%	3%	0%	0%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Befandriana Avaratra	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Bealanana	5%	8%	5%	9%	0%	3%	4%	3%	10%	6%	9%	7%	0%	0%	0%	0%	0%	0%	0%	0%	3%	3%	3%	0%	3%	3%	0%
Mampikony	7%	6%	3%	3%	6%	5%	4%	3%	3%	3%	3%	4%	4%	5%	4%	0%	4%	4%	3%	3%	3%	0%	3%	0%	0%	3%	0%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total trader–district	44	36	39	34	36	39	26	32	31	34	32	28	26	19	23	25	26	24	30	35	32	32	30	30	32	30	31

Note: The numerator is the number of traders purchasing from each district. The denominator is the total trader–district purchased. Districts with a higher percentage of purchasing traders for each round are highlighted in dark red. The cheapest district based on median adjusted ME-price for each round–variety is marked by a bold square.

Table A5. Percentage of traders purchasing from each district (passive incl. within-Tana trade, Vary gasy)

District \ Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Ambohidratrimo	1%	0%	0%	4%	4%	3%	4%	4%	4%	4%	2%	1%	1%	5%	5%	4%	2%	2%	2%	1%	3%	2%	3%	3%	1%	1%	2%
Ankazobe	6%	5%	4%	3%	3%	3%	5%	5%	5%	7%	3%	6%	5%	3%	6%	5%	6%	6%	5%	6%	14%	3%	5%	5%	4%	4%	6%
Arivonimamo	24%	24%	21%	25%	29%	34%	38%	33%	29%	30%	32%	25%	24%	27%	25%	24%	21%	20%	26%	22%	16%	19%	22%	18%	23%	20%	20%
Manjakandriana	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Anjozorobe	18%	21%	22%	21%	22%	20%	21%	23%	23%	22%	28%	27%	22%	21%	20%	21%	20%	19%	20%	21%	20%	23%	23%	21%	26%	24%	20%
Ambatolampy	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%
Tsiroanomandidy	13%	10%	14%	16%	10%	4%	4%	9%	12%	10%	8%	13%	11%	8%	9%	11%	12%	15%	20%	16%	17%	19%	15%	18%	13%	20%	22%
Miarinarivo	3%	1%	3%	1%	1%	1%	3%	1%	1%	1%	1%	1%	1%	0%	1%	2%	1%	1%	2%	3%	2%	2%	2%	4%	2%	3%	5%
Soavinandriana	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Antananarivo Atsimondrano	1%	0%	1%	1%	1%	1%	0%	1%	1%	1%	1%	1%	1%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Toamasina I	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Ambatondrazaka	3%	5%	3%	3%	1%	1%	1%	3%	1%	1%	1%	1%	3%	1%	0%	1%	1%	1%	1%	1%	0%	0%	0%	1%	0%	1%	0%
Andilamena	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Marovoay	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%
Mandritsara	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%
Befandriana Avaratra	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Bealanana	0%	1%	0%	0%	0%	1%	4%	3%	1%	2%	3%	4%	1%	0%	0%	0%	0%	0%	1%	0%	0%	1%	1%	0%	0%	0%	0%
Mampikony	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Other districts in Boeny	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Tana: Anosibe	18%	15%	18%	14%	13%	19%	11%	11%	15%	11%	13%	14%	12%	12%	16%	11%	16%	15%	11%	14%	15%	14%	17%	18%	17%	16%	13%
Tana: Andravoahangy	4%	3%	4%	5%	4%	5%	4%	4%	4%	6%	5%	3%	4%	4%	4%	4%	3%	5%	2%	4%	3%	5%	4%	6%	4%	5%	4%
Tana: Seller in Tana	10%	15%	11%	9%	11%	7%	4%	3%	3%	5%	3%	2%	15%	18%	13%	18%	17%	15%	10%	10%	9%	10%	8%	6%	8%	6%	8%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total trader–district	164	164	156	154	156	149	160	166	162	152	151	150	171	177	179	169	168	170	168	180	172	182	164	169	157	157	172

Note: The numerator is the number of traders purchasing from each district. The denominator is the total trader–district purchased. Three modes of within-Tana trade are included. Districts with a higher percentage of purchasing traders for each round are highlighted in dark red. The cheapest district for each round–variety is marked by a bold square.

Table A6. Percentage of traders purchasing from each district (passive incl. within-Tana trade, Tsipala)

District \ Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Ambohidratrimo	0%	0%	0%	4%	4%	4%	4%	4%	4%	4%	3%	1%	1%	6%	4%	3%	3%	1%	3%	1%	3%	2%	3%	3%	1%	1%	1%
Ankazobe	6%	5%	3%	3%	2%	3%	4%	5%	4%	5%	4%	6%	3%	3%	5%	5%	4%	7%	4%	5%	6%	3%	3%	4%	3%	4%	6%
Arivonimamo	25%	20%	21%	27%	37%	30%	37%	35%	30%	31%	29%	28%	34%	40%	29%	25%	25%	19%	20%	18%	20%	18%	21%	18%	16%	24%	27%
Anjozorobe	3%	13%	9%	12%	12%	11%	11%	14%	11%	10%	14%	12%	11%	12%	9%	10%	10%	11%	12%	13%	11%	9%	11%	10%	13%	10%	10%
Tsiroanomandidy	18%	19%	10%	11%	9%	7%	7%	6%	10%	6%	4%	6%	5%	4%	8%	14%	14%	23%	30%	26%	29%	31%	23%	30%	27%	31%	26%
Miarinarivo	4%	1%	2%	0%	1%	1%	2%	1%	1%	1%	1%	2%	1%	1%	1%	3%	3%	1%	4%	5%	3%	3%	3%	2%	3%	2%	6%
Soavinandriana	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	1%	0%	0%	0%	0%	1%	1%	1%	1%	0%	0%	0%
Antananarivo Atsimondrano	1%	0%	1%	1%	1%	1%	0%	1%	1%	1%	1%	1%	1%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Fianarantsoa I	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Ambatondrazaka	2%	2%	2%	0%	1%	0%	0%	1%	0%	1%	1%	2%	4%	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	1%	0%
Mahajanga I	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Marovoay	2%	1%	1%	0%	0%	1%	1%	2%	1%	1%	1%	2%	2%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Port-Berge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Mandritsara	1%	1%	6%	4%	4%	6%	6%	6%	6%	3%	4%	3%	1%	2%	1%	0%	0%	0%	2%	2%	3%	4%	4%	1%	1%	0%	0%
Befandriana Avaratra	1%	1%	1%	1%	1%	1%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Antsohihy	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Bealanana	4%	6%	12%	7%	4%	8%	11%	11%	11%	19%	18%	20%	12%	8%	9%	9%	7%	4%	3%	2%	1%	1%	1%	3%	3%	0%	0%
Mampikony	2%	0%	0%	0%	1%	0%	0%	0%	0%	1%	1%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Other districts in Boeny	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Tana: Anosibe	19%	13%	19%	20%	13%	18%	13%	14%	16%	10%	15%	16%	14%	11%	14%	12%	15%	15%	10%	16%	17%	16%	18%	19%	21%	19%	14%
Tana: Andravoahangy	4%	1%	2%	2%	1%	3%	1%	2%	1%	4%	3%	2%	1%	1%	1%	1%	1%	1%	3%	3%	1%	3%	4%	3%	3%	3%	1%
Tana: Seller in Tana	6%	15%	12%	9%	10%	6%	3%	0%	2%	2%	2%	1%	9%	12%	16%	16%	19%	15%	9%	9%	6%	9%	7%	5%	9%	5%	8%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total trader–district	126	141	126	138	134	139	139	131	141	134	137	127	153	139	159	153	151	149	156	154	150	157	145	150	141	139	144

Note: The numerator is the number of traders purchasing from each district. The denominator is the total trader–district purchased. Three modes of within-Tana trade are included. Districts with a higher percentage of purchasing traders for each round are highlighted in dark red. The cheapest district for each round–variety is marked by a bold square.

Table A7. Balancing test of randomization

	Control	Treatment	Difference	
	(C)	(T)	(T-C)	*p* -value
Search and trade (periodic, trader–round level, pre-treatment)				
Searched price in 36 listed districts (dummy)	0.723	0.804	0.081	0.000
(If searched) Number of districts searched price	1.794	1.640	-0.154	0.000
Engage in active inter-district rice trading (dummy)	0.236	0.334	0.098	0.000
(If yes) Number of districts purchased	1.944	2.077	0.133	0.044
Engage in passive inter-district rice trading (dummy)	0.815	0.836	0.020	0.123
(If yes) Number of districts purchased	1.877	1.804	-0.073	0.024
Rice trading (baseline)				
Number of workers engaged in rice trading	5.0	5.7	0.6	0.260
Years running rice trading	7.2	9.2	2.0	0.024
Have updated "carte collecter" (dummy)	0.304	0.429	0.125	0.052
Pay wholesale tax (dummy)	0.688	0.670	-0.018	0.776
Keep income statements (dummy)	0.438	0.366	-0.071	0.278
Sell imported rice (dummy)	0.741	0.804	0.063	0.267
Business diversification (baseline)				
Sell food other than rice (dummy)	0.688	0.705	0.018	0.773
Sell non-food items (dummy)	0.438	0.429	-0.009	0.893
Operate rice mill (dummy)	0.170	0.152	-0.018	0.717
Rent out truck or vehicle (dummy)	0.259	0.161	-0.098	0.072
Profit share of rice trading	0.647	0.647	0.000	0.991
Characteristics of the representative (baseline)				
Representative's age	37.1	37.1	0.0	0.983
Representative is male (dummy)	0.482	0.509	0.027	0.690
Representative is literate (dummy)	0.973	1.000	0.027	0.083
Representative's education level (dummy)				
None	0.009	0.009	0.000	0.995
Primary	0.189	0.191	0.002	0.974
Lower secondary	0.351	0.364	0.012	0.850
Upper secondary	0.279	0.273	-0.007	0.914
Higher	0.171	0.164	-0.008	0.881
Asset (baseline)				
Have store for selling rice (dummy)	0.821	0.839	0.018	0.723
Have private storage (dummy)	0.902	0.830	-0.071	0.118
Total capacity of private storage (ton)	22.6	33.8	11.2	0.376
Own vehicle (dummy)	0.255	0.297	0.043	0.479
Own truck (dummy)	0.304	0.384	0.080	0.207
Own cell phone (dummy)	0.901	0.902	0.001	0.982
Use mobile money for general purpuse (dummy)	0.099	0.116	0.017	0.684
Use mobile money for rice trading (dummy)	0.009	0.045	0.036	0.101

Note: *p*-value of Welch's two sample *t*-test on the equality of means reported.

Online Appendix

Table OA1. Summary statistics of milling

Variable	Obs	Mean or *n*	S.D. or *%*	Min	Max
Variety					
Vary gasy	133	*53*	*39.8%*	0	1
Tsipala	133	*30*	*22.6%*	0	1
Makalioka	133	*50*	*37.6%*	0	1
Paddy–milled rice conversion rate (%)	133	69.2	3.6	50	85
Milled by the trader (dummy)	132	*68*	*51.5%*	0	1
(If ask the miller to mill the paddy)					
Milling fee (low season)	63	21.3	5.4	7	40
Milling fee (high season)	64	20.7	4.8	5	30
Usually get bran?					
Yes, always	55	*39*	*70.9%*	0	1
Yes, most of the time	55	*0*	*0.0%*	0	1
Yes, sometimes	55	*4*	*7.3%*	0	1
No, always the miller	55	*12*	*21.8%*	0	1
(All traders who purchased paddy in the last year)					
Paddy–bran conversion rate (%)	119	11.7	4.5	5	30
Sell bran? (dummy)	116	*103*	*88.8%*	0	1
(If yes) Sales price of bran (Ar/kg)	107	636.1	137.7	250	850

Table OA2. Summary statistics of milling by variety

	Stats.	Vary gasy	Tsipala	Makalioka	All varieties
Obs.		53	30	50	133
Paddy–milled rice conversion rate (%)	Mean	70.8	70.3	66.9	69.2
	Median	70.0	70.0	68.0	69.0
Milling fee (low season)	Mean	19.8	20.0	23.8	21.3
	Median	20.0	20.0	22.0	20.0
Milling fee (high season)	Mean	19.4	19.6	23.0	20.7
	Median	20.0	20.0	20.0	20.0
Paddy–bran conversion rate (%)	Mean	10.6	11.5	13.0	11.7
	Median	10.0	10.0	12.5	10.0
Sales price of bran (Ar/kg)	Mean	620.7	671.7	633.2	636.1
	Median	600.0	680.0	650.0	650.0
Milled by the trader (dummy)		0.472	0.567	0.531	0.515
Sell bran? (dummy)		0.936	0.885	0.837	0.888
Usually get bran?					
Yes, always		76.9%	55.6%	70.0%	70.9%
Yes, most of the time		0.0%	0.0%	0.0%	0.0%
Yes, sometimes		7.7%	0.0%	10.0%	7.3%
No, always the miller		15.4%	44.4%	20.0%	21.8%
Total		100.0%	100.0%	100.0%	100.0%
Obs.		26	9	20	55

Table OA3: Difference in milled-rice equivalent price between paddy and milled rice

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	All	Passive	Passive	Passive	Active	Active	Active
	purchases	Vary gasy	Tsipala	Makalioka	Vary gasy	Tsipala	Makalioka
Paddy	-129.0***	-160.4***	-168.8***	-127.0***	-119.5***	-191.9***	-12.51
	(6.951)	(9.627)	(21.50)	(11.18)	(16.62)	(19.15)	(12.96)
Constant	1210.4***	1179.3***	1169.2***	1285.1***	1152.1***	1179.2***	1222.0***
	(1.243)	(0.821)	(0.687)	(0.318)	(9.798)	(7.203)	(10.91)
Activity–round–variety–district FE	Yes	No	No	No	No	No	No
Round–district FE	No	Yes	Yes	Yes	Yes	Yes	Yes
N	19422	5298	4538	5100	1801	1268	1417
R-sq	0.169	0.320	0.205	0.149	0.131	0.259	0.002

Note: Unit of observation is purchase. Standard errors clustered at activity–round–variety–district in column (1) and at round–variety level in columns (2)–(7). * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table OA4: Summary statistics of milled–rice equivalent prices

Variable	Obs	Mean or *n*	S.D. or *%*	Min	Max
Mean milled-rice equivalent price (Ar/kg)	1,339	1155.3	120.9	601.3	1453.3
Mean adjusted milled-rice equivalent price (Ar/kg)	1,339	1188.9	107.6	613.8	1551.9
Median milled-rice equivalent price (Ar/kg)	1,339	1157.0	124.2	601.3	1483.6
Median adjusted milled-rice equivalent price (Ar/kg)	1,339	1188.9	111.0	613.8	1551.9
Mode of purchase					
Inter-district, active	1,339	*487*	*36.4%*	0	1
Inter-district, passive	1,339	*610*	*45.6%*	0	1
Within-district	1,339	*242*	*18.1%*	0	1
Variety					
Vary gasy	1,339	*528*	*39.4%*	0	1
Tsipala	1,339	*558*	*41.7%*	0	1
Makalioka	1,339	*253*	*18.9%*	0	1
Fraction of observations purchased in milled rice	1,339	0.737	0.405	0	1
Activity–round–variety–district observations with:					
Paddy only	1,339	*248*	*18.5%*	0	1
Paddy and milled rice	1,339	*343*	*25.6%*	0	1
Milled rice only	1,339	*748*	*55.9%*	0	1

Note: Unit of observation is activity–round–variety–district.

Table OA5: SMS treatment effects for search and purchasing with trader fixed-effects

	(1)	(2)	(3)	(4)	(5)
	Searched price in other districts	Number of districts knowing price	Engaged in active trading	Number of active districts purchased	Number of passive districts purchased
After	-0.140***	-0.208	-0.0630*	-0.189*	0.0377
	(0.0266)	(0.148)	(0.0260)	(0.0752)	(0.0716)
Treatment x After	0.0746***	1.500***	-0.00797	-0.125	-0.0335
	(0.0215)	(0.217)	(0.0221)	(0.0784)	(0.0441)
Constant	0.875***	1.782***	0.331***	1.386***	1.784***
	(0.0202)	(0.0912)	(0.0199)	(0.0616)	(0.0532)
N	6033	6033	6033	1628	4156
R-sq	0.029	0.140	0.020	0.042	0.018

Note: Unit of observation is trader–round–activity–variety. Standard errors clustered by trader in parentheses. Round fixed effects included. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table OA6: SMS treatment effects for arbitrage performance with trader fixed-effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All transactions			Active transactions			Passive transactions		
	Vary gasy & Tsipala	Vary gasy	Tsipala	Vary gasy & Tsipala	Vary gasy	Tsipala	Vary gasy & Tsipala	Vary gasy	Tsipala
Panel A. Dummy if purchased from cheapest district									
After	0.0599**	0.0168	0.260***	0.0424	0.160	0.281*	0.227***	0.187***	0.338***
	(0.0203)	(0.0204)	(0.0389)	(0.0518)	(0.108)	(0.115)	(0.0264)	(0.0345)	(0.0471)
Treatment x After	-0.0338	-0.0158	-0.0600	0.0194	0.0186	0.0526	-0.0342	-0.0155	-0.0603
	(0.0214)	(0.0160)	(0.0344)	(0.0381)	(0.0416)	(0.0596)	(0.0230)	(0.0175)	(0.0365)
Variety (base = Vary gasy)									
Tsipala	0.0317***			0.0497***			0.0288***		
	(0.00699)			(0.0132)			(0.00793)		
Constant	0.00241	0.0326**	-0.00885	-0.00251	0.0520	-0.0271	0.00335	0.0238*	0.0000908
	(0.0102)	(0.0112)	(0.00980)	(0.0257)	(0.0360)	(0.0230)	(0.0111)	(0.0104)	(0.0118)
N	9501	5099	4402	1752	969	783	7749	4130	3619
R-sq	0.054	0.066	0.104	0.130	0.166	0.380	0.083	0.106	0.171
Panel B. Actual–optimal price ratio									
	(0.00496)	(0.00505)	(0.00620)	(0.0133)	(0.0122)	(0.0180)	(0.00441)	(0.00414)	(0.00577)
After	-0.0490***	-0.0362***	-0.0741***	-0.0311	0.128**	-0.124**	-0.0449***	-0.00370	-0.0469***
	(0.00910)	(0.0106)	(0.0101)	(0.0337)	(0.0469)	(0.0378)	(0.00554)	(0.00680)	(0.00651)
Treatment x After	0.0127	0.0168	0.0101	0.0305	0.0440	0.0349	0.00600	0.00911	0.00283
	(0.00763)	(0.00858)	(0.00774)	(0.0230)	(0.0249)	(0.0256)	(0.00703)	(0.00781)	(0.00704)
Variety (base = Vary gasy)									
Tsipala	-0.00653**			-0.0440***			0.000179		
	(0.00217)			(0.00689)			(0.00166)		
Constant	1.099***	1.076***	1.121***	1.223***	1.191***	1.211***	1.066***	1.046***	1.091***
	(0.00656)	(0.00641)	(0.00764)	(0.0198)	(0.0215)	(0.0255)	(0.00430)	(0.00468)	(0.00473)
N	9501	5099	4402	1752	969	783	7749	4130	3619
R-sq	0.180	0.364	0.153	0.331	0.753	0.477	0.293	0.550	0.247

Note: Unit of observation is trader–round–activity–variety. Standard errors clustered by trader in parentheses. Round fixed effects included. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table OA7: SMS treatment effects for management indicators with trader fixed-effects

	(1)	(2)	(3)	(4)	(5)
	Biweekly amount sold (ton)	Biweekly amount purchased (ton)	Selling price (Ar/kg)	Purchasing price (Ar/kg)	Margin (Ar/kg)
After	2.959	0.499	162.3***	233.8***	2.336
	(2.199)	(1.525)	(9.585)	(7.351)	(3.369)
Treatment x After	-2.153	-2.031	-7.900	-5.964	-0.803
	(1.134)	(1.169)	(7.545)	(6.911)	(2.281)
Constant	11.22***	14.71***	1125.2***	1066.0***	53.60***
	(1.060)	(1.184)	(4.392)	(4.398)	(2.256)
N	5769	5862	5830	5716	5814
R-sq	0.008	0.009	0.462	0.460	0.017

Note: Unit of observation is trader–round–activity–variety. Standard errors clustered by trader in parentheses. Round fixed effects included. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.