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Impact of Market Information on Cashew Producers in Guinea-Bissau

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Abstract

We study how mobile technologies providing market information affect cashew producers in Guinea-Bissau. We ran a two-level cluster randomised control trial among 1988 cashew producers in 281 villages. We randomised treatment assignment both across and within-villages. Treated producers received weekly voice and text messages during the trading season in 2020. The messages provided up-to-date market news, farm-gate prices, and gave marketing advice. We find that treated producers were more likely to sell their cashews, as opposed to barter their production for rice. Moreover, treated producers sold their cashews more frequently relative to the control group. Treated producers failed to earn higher prices, but earned 16 percent more from all sales and barters, relative to the control group mean. Given the low cost of our intervention, market information can be a cost-effective tool to increase producers' revenues. Future analysis and data-collection will unpack the mechanisms driving these results.

Key words: Economic Development; International Linkages to Development; Role of International Organizations; Agricultural Markets and Marketing
JEL Classification: **O13, O19, Q13**

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Introduction

Traditional economic theory assumes that market agents have sufficient information to engage in optimal decision-making. However, in contexts where markets are dispersed and agents face infrastructural barriers, reliable and up-to-date information may be costly or limited. In these contexts, information frictions between sellers and buyers may affect their decision and result in inefficient market outcomes (Allen 2014). Information technologies may reduce these information frictions and improve market performance and prices to producers (e.g. Jensen, 2007; Aker, 2010; Casaburi, Glennester & Suri, 2013).

This study seeks to understand whether and how information technologies can affect market outcomes, through the communication of reliable information on market trends, prices, and concrete marketing advice to producers.

Our study is based in Guinea-Bissau, where we work with producers of cashew nuts, an export crop with high price volatility, in a data-scarce context with potentially high information asymmetries. We causally test the effect of providing timely and accurate market information through weekly voice messages to cashew producers during the 2020 marketing season. We introduced into Guinea-Bissau the n'kalo service, a market information system (MIS) designed by the French NGO Nitidae, which is already well established across cashew-exporting economies in West Africa.

We implement a two-level cluster randomized control trial to test the effectiveness of a market information system, randomizing treatment assignment both across and within-villages. In treated villages, a randomly selected group of cashew producers received weekly market information through voice messages and text messages to their mobile phones, for free, over the whole 2020 cashew trading season. These messages were tailored to be easy to understand and provided producers with up-to-date market news, ranges of farm-gate prices across the country, and a marketing advice based on the likely market trends. By having both treated and untreated producers in treated villages, our research design also allow us the estimation of within-village spillover effects.

This preliminary draft analyses the results of the intervention on a set of outcomes collected shortly after the end of the 2020 cashew nut trading season using phone-based interviews. The timing of these interviews coincided with the final weeks of activity of the main intervention.1

The goal of this analysis is to measure the impact that increased access to information about the cashew nut market had on cashew producers' trading outcomes in 2020. In order to study the mechanisms through which information affects market transactions among producers, we plan to collect a richer set of outcomes in a future endline survey, and continue analyzing our existing data to unpack further heterogeneities in the data, and run various robustness checks that we pre-specified in our pre-analysis plan. Our analysis plan was registered before the midline phone-based survey was completed.

Contribution to the literature

[1] The intervention is described in section 3.1.

Our study complements the literature on the use of ICT in agriculture.2 Previous economic evaluations of Market Information Systems (MIS) have found mixed results on the benefits of these services to farmers. Randomized evaluations of MIS in Colombia (Camacho and Conover 2019) and India ((Fafchamps and Minten 2012); (Mitra et al. 2018)) have failed to find a significant average treatment effect on producer prices. In contrast, Svensson and Yanagizawa (2009) and Hildebrandt et al. (2015) find that MIS in Uganda and Ghana, respectively, increased producer prices by 7-10 percent for specific crops. In a related intervention, Goyal (2010) studies the expansion of information kiosks in district markets in Andhra Pradesh, and finds that the kiosks increased producer prices by about 1-3 percent.

This study complements the literature both theoretically and empirically because of the particular characteristics of the Guinea-Bissau cashew market, the nature of the MIS provided and several features of the research design:

First, dispersed and small producers do not sell their production in local markets, but are mostly visited by trade intermediaries wishing to buy their products at the farm-gate. Since most producers do not meet in a centralized market, there are fewer opportunities for information about price developments to be shared among producers, relative to other contexts where sales occur in a market. Second, cashew nuts are an export crop collected and traded during a unique season per year (between March and August), subject to high price volatility due to developments in the international markets. Third, most rural producers in the country are highly specialized in a single crop (cashew nuts), which is, in practice, the only high value crop in the country. This makes the annual revenue of producers, the government and other stakeholders in the cashew value chain, such as intermediaries and exporters, highly dependent on their performance in this market. Given the salience of farm-gate prices, information about their expected evolution is frequently manipulated with economic and political interests. Fourth, most producers earn their annual revenue in a single large sale of their production, which is usually sold within the same trading season (with barely no storage across different years) making the timing and conditions of this transaction the most important economic event of the year. Objective and accurate information should be valuable in this context, allowing farmers to take better economic decisions. Among the different decisions that a cashew farmer in Guinea-Bissau must make along the year, there is a particularly relevant one: choosing the right time to sell the harvest of raw cashew nuts. In addition, competition among intermediaries is constrained by high search (transport) costs3, potentially allowing better-informed cashew producers to negotiate higher prices at a given point in time.

According to the existing literature on MIS and agricultural prices, these factors should contribute to a positive impact of increasing producers' access to quality price information on farm gate prices, and to the reduction of price dispersion, see Fafchamps and Hill 2008, Mitra and Sarkar 2003 and Cole and Fernando (2012) for the effects of farmers being relatively badly informed, or Dorosh et al. 2010 for the relationship between distance to markets, poor infrastructure and information deficiencies in rural areas in developing countries. Moreover, search cost models and studies of intermediaries' market power, such as Aker (2010), and cashew being a high-value crop, indicate that this market's conditions

[2] See Nakasone, Torero, and Minten (2014) for a review.

[3] The median road distance of our sample of villages from the capital, Bissau, from which the vast majority of raw cashew nuts are exported, is 160km (ranging between 30 and 300km). The median road distance of our sample of villages from the main regional market is 40km (ranging between 2 and 230km).

should produce a relatively large margin for bargaining between farmers and intermediaries. In summary, the existing evidence indicates that we should expect a strong positive effect from our intervention.

Departures from previous studies

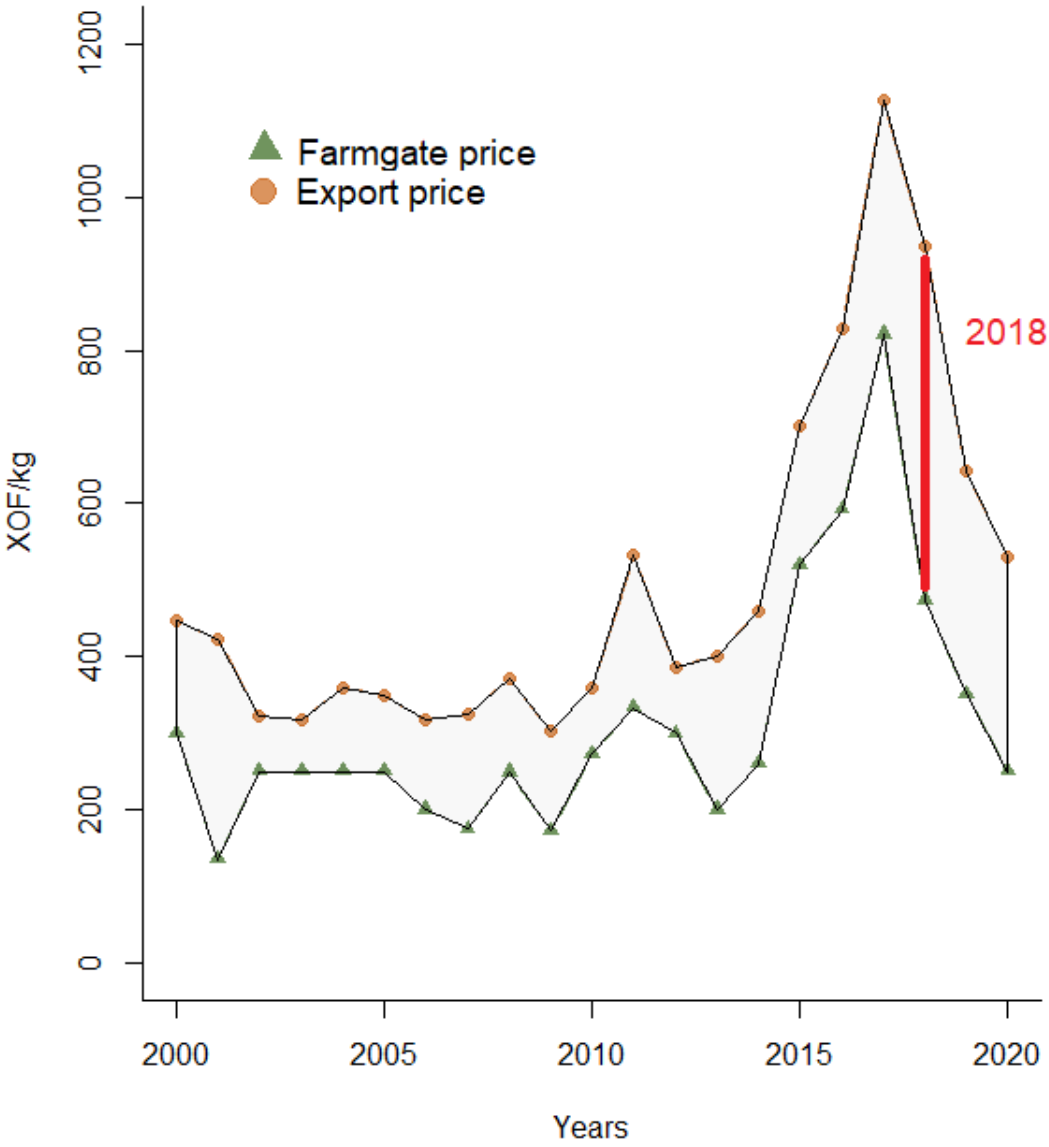
Together with the particular nature of the Bissau-Guinean cashew market, the following features make this study different from previous ones : (i) we test the effectiveness of a novel technology to disseminate price information (via audio-recorded messages), as opposed to SMS, which aims to address the barriers that low-literate users may face in trying to access this type of information. (ii) The content of our messages that does not just provide a point estimate for the wholesale market, as in Mitra et. al (2018), but a range of farm-gate prices for the specific region in which the producer is, additional market information on expected price developments and concrete marketing advice about when and at what price to sell production. (iii) Our experimental design restricted access to the service only to treated participants during the evaluation phase, reducing contamination (though not necessarily of the content of the messages). (iv) We focus on an export commodity, whose price is largely driven by exogenous international market fluctuations. Previous studies did not focus on export commodities explicitly.

Outline

This article is structured as follows. We begin by illustrating the main features of the market for cashew nuts that we study, briefly describing its supply chain (producers, intermediaries, and exporters), and the characteristics of the sample of producers we work with. In Section 3, we describe our intervention in more detail. Section 4 describes our sampling and randomization protocol. Section 5 describes our estimation and inference strategy and presents our preliminary results collected during a phone-based midline survey.

Context of the study

Guinea-Bissau is a country located on the west coast of Africa with a surface of 36,125km^2 and a tropical climate conducive to cashew cultivation, the country is in the fifth position on the list of the main producers of cashew nuts in 2019. In the last decades, the country's economy has been heavily dependent on the production and commercialization of cashew nuts, which is the main export product representing more than 90% of the total official exports. In general, the demand for Guinea-Bissau cashew nuts, according to the statistics of the Macroeconomic and Budgetary Framework Committee, is divided as follows: less than 10% for the domestic market (processing units) and, more than 90% absorbed by the international market, namely, Indian, Vietnamese, China. Although most of the production is exported as raw cashew nuts, to the aforementioned destinations there are also exports of processed nuts, although a small portion is consumed domestically, but the most dynamic and profitable markets are in high-income countries per capita. This market, like the other markets for agricultural products, is particularly influenced by the dynamics of supply and demand, especially of the international nut markets, however, as shown in Figure 1, there are often variable and large margins between the export and farm-gate prices, which suggest that frictions may be reducing pass-through rates to producers.



In Guinea-Bissau, production of raw cashew nuts is atomized. At least 40 percent of households in the country are involved in cashew production and about 85 percent of producers are smallholders. In the rest of this section, the baseline data is used to characterize producers in the market. Details of the baseline survey are provided in the next section.

Our preliminary descriptive statistics, in Table 1, show that almost all respondents are male (94 percent), are on average 43-years old, and around 90 percent are married (in a monogamous or polygamous household). Household size is large, on average 14 individuals per household – all producers live in rural areas. On average, respondents have completed 4 years of education and have worked in the cashew sector for the last 10 years. About 50 percent of respondents were unable to read a basic sentence, suggesting that developing a service that takes into account low literacy skills will prove crucial to increase compliance and take-up. The size of the median cashew plantation is around 3.4ha. Two thirds of our

respondents reported having no difficulties storing their cashew production. We expect these producers to potentially benefit from the information provided by the MIS more than those who have difficulty storing their production.

Sales

The respondents reported that the number of sales per trading season is fairly concentrated to 1-2 sales on average. The median number of potential buyers is two, but the median number of sales is just one. This finding has important implications because it means that the decision of when to sell has high-stakes for the majority of producers, as it provides them with the largest share of their annual income. For 90 percent of our sample, cashew sales constitute more than half of their total revenue from agricultural sales.

The average reported farmgate price across all sales is around 393 FCFA (0.52 GBP) per kilo. This is significantly below the reference price of 500 FCFA/kg that the government had originally proposed at the beginning of the last marketing season. However, 63 percent of the respondents stated they believed the government reference price to be an important factor in their sales decisions.

Spatial arbitrage is rare in this market, as 98 percent of sales occur by the producers' house or somewhere else in the producer's village. Producers rarely travel with their output to other markets, as doing so poses more risks and costs for them, because (anecdotally) most of them do not have a network of potential buyers beyond their villages. More than 55 percent of buyers are traders that temporarily visit the villages, whilst 39 percent are intermediaries that are from the same village. There are also 70 producers in our sample that act as intermediaries, buying from other producers and selling onto other traders quantities that range between 2-20 metric tons, much larger than what individual producers sell on average. How producers decide when to sell 92 percent of the respondents rely mostly on family and friends for marketing advice, with only a few producers relying on more formal channels such as producer associations. Only 6 percent of producers in our sample had heard of the previous MIS that had been launched by a previous World Bank-financed project, but was later discontinued. Nearly two thirds of producers claim having delayed the sales of cashews because they expected prices to rise in the future, with less than one third having instead decided to sell early because of a fear of prices falling.

Table 1: Summary statistics: Covariates at baseline

	(1)								
	mean	sd	min	p10	p25	p50	p75	p95	max
Individual-level characteristics:									
1 if female	0.06	0.23	0.00	0.00	0.00	0.00	0.00	1.00	1.00
Age	42.91	14.53	16.00	25.00	32.00	41.00	52.00	70.00	94.00
Household size	13.66	8.16	1.00	6.00	8.00	12.00	17.00	29.00	86.00
Years of education	3.95	3.85	0.00	0.00	0.00	3.00	6.00	11.00	15.00
1 if Kriol is the most spoken language at home	0.20	0.40	0.00	0.00	0.00	0.00	0.00	1.00	1.00
1 if cashew is the main source of income	0.80	0.40	0.00	0.00	1.00	1.00	1.00	1.00	1.00
Number of buyers that made offers	2.82	1.77	0.00	1.00	1.00	2.00	4.00	6.00	13.00
1 if trusts the official reference price	0.38	0.48	0.00	0.00	0.00	0.00	1.00	1.00	1.00
1 if faces storage limitations	0.31	0.46	0.00	0.00	0.00	0.00	1.00	1.00	1.00
Delayed sales expecting price increases	0.71	0.45	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Tells received price offers to N producers	6.55	8.04	0.00	0.00	2.00	5.00	9.00	21.00	100.00
Told price offers by N producers	4.87	6.11	-2.00	0.00	0.00	3.00	7.00	15.00	92.00
Minimum price at which sold most cashew in the last 3 years	316.56	86.41	50.00	250.00	250.00	300.00	350.00	500.00	1000.00
Expected price for season 2020	831.23	623.58	150.00	500.00	500.00	1000.00	1000.00	1000.00	25000.00
Desired reference price for 2020	1041.10	367.57	100.00	750.00	1000.00	1000.00	1000.00	1500.00	10000.00
Minimum age of trees	3.41	3.65	0.00	1.00	1.00	3.00	4.00	10.00	45.00
Max age of trees	17.29	8.38	1.00	8.00	10.00	16.00	23.00	33.00	56.00
1 if trees were plagued	0.67	0.47	0.00	0.00	0.00	1.00	1.00	1.00	1.00
1 if sells other crops	0.71	0.46	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Food insecurity standardised index	-0.00	1.00	-1.05	-1.05	-1.05	-0.20	0.65	2.35	3.20
1 if has a fixed buyer	0.33	0.47	0.00	0.00	0.00	0.00	1.00	1.00	1.00
Area plantation	3.45	2.58	0.10	1.00	2.00	3.00	4.00	8.00	25.00
Years of experience in cashew sector	10.41	7.11	1.00	3.00	5.00	9.00	15.00	25.00	42.00
1 if can read	0.29	0.45	0.00	0.00	0.00	0.00	1.00	1.00	1.00
Extremely risk averse	0.54	0.50	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Village-level characteristics:									
Number of cashew producers in the village	32.39	23.86	4.00	10.00	17.00	24.00	41.00	78.00	177.00
Number of cashew buyers in the village	3.61	3.41	0.00	0.00	1.00	3.00	5.00	10.00	20.00
Road distance in km to nearest sector capital	27.92	23.12	0.33	4.26	10.85	21.70	36.85	69.94	123.96
Road distance in km to nearest region capital	51.74	34.05	3.29	10.81	26.35	46.08	67.23	125.82	188.02
Road distance in km to the capital	160.79	68.15	32.08	57.75	103.47	155.56	215.86	274.59	298.74
Observations	1988								

Rice exchanges and interlinked contracts

Producers engaged in interlinked contracts are less likely to benefit from our intervention. 35 percent of producers took up a loan before the start of the trading season in 2019, and 85 percent of these loans were in-kind (rice), rather than in the form of cash. Most of these loans are repaid using cashews: 53 percent of cash loans were repaid using cashew nuts, whereas 80 percent of the in-kind loans were repaid with cashews. The majority of these informal loans are reported to take place in the months preceding the marketing season (November to January), when producers are most liquidity constrained. These interlinked contracts reduce the ability of producers to pick a better time during the marketing season to sell their production. However, even those that took up a loan (in-kind or in-cash) still made sales during the trading season.

While technically illegal (according to national legislation), in-kind exchanges and loans of rice and cashew are common, and represent an important margin on the marketing decision of producers in this market. In our baseline sample, 47 percent of the producers have either traded or borrowed rice in exchange for cashews, though the quantity involved in these transactions are generally only a small fraction of the overall production. We estimate that on average 14 percent of marketable production is used for exchanges with rice (either direct or through loans).

Costs of production

The production costs relate to the payment of labor for two main activities: cleaning of the field and collection of the nuts. The cleaning of the field under the cashew trees is necessary in order to have easier access to the nuts (or nuts and fruits) that have fallen from the trees. Family or hired seasonal labor is hired to clean the fields before fruits are ripe and start

falling. The second activity involves actually picking up fruits that have fallen from the trees. For the product to be ripe and of good quality, the fruit should be picked up from the floor after it has fallen from the tree. Occasionally, credit constrained producers may collect the fruits directly from the trees, but this means that the nut has not fully absorbed all nutrients from the tree and ends up being smaller and lower quality. Labor costs are noisy to measure, especially since they are often paid in-kind using a rule-of-thumb type of payment (e.g. every third day, the collection goes to the laborers), or through shared meals.

Study design, data, and empirical strategy

Intervention: a Mobile Market Information System

Our intervention provided market information to cashew producers in Guinea-Bissau during the marketing season, via weekly short text messages or robocalls between April and August 2020.4

The market information delivered through those weekly messages consisted of: (i) the current range of farmgate raw cashew nut prices across regions in Guinea-Bissau, (ii) important news about the market, and (iii) a sales advice based on the expected market trends.5

As a part of the intervention, our research team provided randomly selected producers with a one-hour training on the main factors determining the farmgate price and how receiving our weekly messages could improve their sales decisions. The research team provided the training on the same day of the baseline survey, shortly after the baseline interview took place.

Our weekly short text messages were sent to those randomly selected producers between the 1st of April and the 8th of May. From the 16th of May, the weekly messages were sent via robocalls.6 Finally, since the 26th of June, the information was also available on demand, as the audio content of the weekly robocalls could be accessed using an Interactive Voice Response (IVR) service.7

Sampling

Village-level sampling

Our sampling strategy has two main goals: (i) making the treatment and control groups statistically balanced across a set of baseline characteristics, and (ii) minimizing spillovers

[4] The 2020 marketing season started on the 27^{th} of May, two months after what would have been the usual start of the season. The delay was a result of COVID-19 and a contested presidential election held in December 2019. However, small trades of cashews were recorded from a number of buyers since March 2020.

[5] The content of the messages was developed weekly, in line with the methodology of the *n'kalô* service, a Market Information System already operating in other West African countries, which we introduced to Guinea-Bissau in collaboration with the Ministry of Finance.

[6] Section 3.3 details our randomization strategy.

[7] The Interactive Voice Response (IVR) service was active for only two months prior to the end of the season, due to delays associated with COVID-19 and the implementing mobile operator, MTN. Our original plan was to develop the IVR service before the start of the 2020 season. According to our original plan, we would have had two separate treatment arms, with the first one receiving the service for free and the other one only after subscribing to it, paying a small monthly price. Given the delay in setting up the IVR service, we decided to merge these two treatment arms into one, providing the service for free to every treated producer.

of the treatment to untreated villages. There is a trade-off between these two goals: minimizing spillovers requires that treatment and control groups be sufficiently far apart geographically; while statistical balance requires that treatment and control groups be similar to each other, which is in turn often requires geographical proximity. We address this trade-off as follows.

In order to select villages that would be part of our study, we created a grid containing $2.7km^2$ cells, covering the entirety of the country. We sample 290 villages from about 1,800 villages, using geo-coded census data, such that one village is chosen from each of those cells.8 We compute for each village the closest distance to another sampled village. We store the value of the minimum distance in the sample of villages drawn. We iterate these steps 999 times and choose the sample that has the largest minimum distance.

We excluded from our sampling frame villages that have the following characteristics:

- with less than 10 households according to the 2009 census (to allow a sufficiently large sample of cashew producers in every village),
- located on the islands (due to budget constraints),
- located in a circle of 15km in radius in the region of Tombali (in the South, blue in the map below), which are closest to the river estuary (due to budget constraints, as reaching those villages is logistically difficult),
- located in the sector of Boé, in the East of the country (due to budget constraints and poor phone signal in the area),
- for which we did not have reliable GPS and population data (so those unmatched from the fuzzy merging of the census and the GPS data),
- located in Biombo, the region to the West of the capital Bissau (as it was used for the pilot).

These exclusions account for 40% of producers in the country, mostly driven by exclusion of the smaller villages.9 Once the final sample of villages was selected, we sought the contact details of the village leaders of our final sample of villages. Whenever possible, we contacted the village leaders ahead of the data-collection baseline visit to inform them of the study and seek their collaboration.

Producer-level sampling

After the data-collection team reached the sampled village and the village-leaders granted them permission to work, they asked the village leader for a list of all producers living in the village owning a cashew plantation. In eliciting this list, the data-collection team stressed that every producer with a cashew plantation should be included, including small ones. On

[8] We constructed our sampling frame by merging the 2009 census data, the latest census available to-date, with GPS coordinates obtained from a geocoded administrative dataset maintained by the United Nations Office for the Coordination of Humanitarian Affairs.

[9] We posit that since most of the villages that were not included in the sampling frame are more remote and smaller, producers living in those excluded villages are likely to be most affected by lack of information and could benefit more from the intervention.

the day of the visit, the data-collection team used a random number generator to sample 7 producers from this list.

Randomization

Figure 2 shows how participants in the study were allocated across treatment, spillover and control groups. The rest of this section provides details on how we conducted the randomization to reach this allocation.

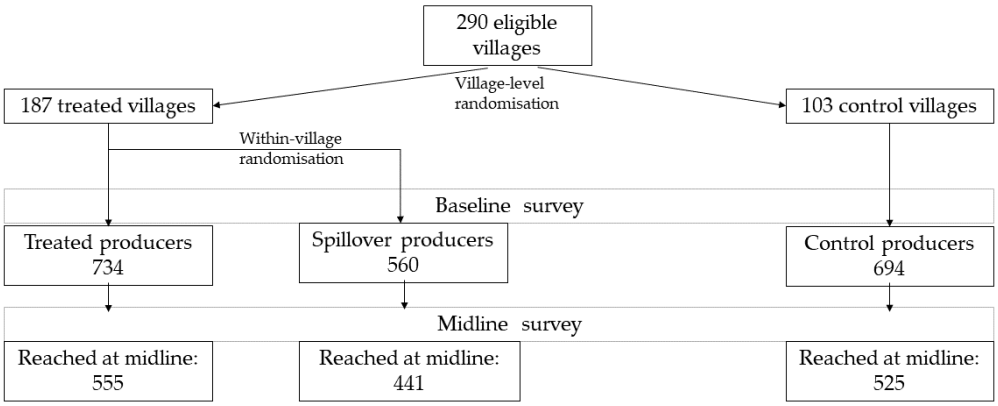


Figure 2: Flowchart of participants through the study

Village-level randomisation

We follow the recommendations of Bruhn and McKenzie (2009), stratifying our randomization to increase efficiency. Randomization of treatment across villages was implemented constructing, in each region, triplets of villages that are as similar as possible along a number of dimensions that are likely to affect the impact of treatment, and that were available to use. We combine the population data from 2009 census and other geo-coded databases to construct the following variables:

1. road distance to the nearest sectoral capital (to proxy the closest location where small intermediaries are based)
2. road distance to the nearest regional capital (to proxy the closest location where wholesale intermediaries are based)
3. road distance to the port in Bissau (to proxy for distance from the main export route, and inversely from distance to the closest borders)
4. linear distance to the nearest (MTN) mobile network tower, and
5. number of households for each village, according to the 2009 census.

Because these characteristics are likely to be correlated, we use the Mahalanobis distance as a metric of similarity across villages that takes into account of the correlation across these characteristics. The Mahalanobis distance between them is then defined as:

$$||z_l - z_j|| = ((z_l - z_j)'S^{-1}(z_l - z_j))^{1/2}$$

where z_l and z_j denote the vector or relevant characteristics from villages l and j, respectively, and S is the covariance matrix of characteristics z. Pairs of villages with a smaller Mahalanobis distance are more similar along these dimensions. Since these characteristics are weighted by the inverse of the covariance matrix S, correlation between characteristics - e.g. between our various distance measures - is given less weight.

We select, within each region, the allocation of villages into triplets that minimizes the sum, over all triplets, of the Mahalanobis distances within each triplet. The search is conducted using an algorithm that randomly tries different combinations of villages into triplets. Within each triplet, one village was then randomly assigned to control and two villages to treatment.

Within-village randomization

Once the 7 randomly sampled producers in treatment villages completed the baseline interview, an on-the-spot within-village lottery determined producer-level assignment to either the treatment or spillover groups. The supervisor of the data-collection administered the lottery. Each producer drew one of two kinds of goodies from a bag. Using this lottery, 4 producers were assigned to the treatment group and 3 to the spillover one. After the producer-level randomization, the treated producers took part in a training session about the intervention and the determinants of farmgate raw cashew nut prices.

Midline survey

Our analysis of the effects of the intervention is based on outcomes collected during a phone-based midline survey. This phone-based survey started while we were still providing weekly messages to treated producers. The phone-based survey served multiple purposes.

First, the data-collection team provided treated producers with additional information on the intervention, explaining how to use the IVR system to listen to the weekly voice messages again. The data-collection team provided this explanation at the beginning of the call, before starting the interview.

Second, the phone-based interview provided us with an initial set of outcomes to test the effects of the intervention. During the phone-based interview, we have collected the same set of outcomes from both treated and untreated producers. The phone-based interviews lasted approximately 15 minutes. We did not collect secondary outcomes that could help explain the mechanisms driving the effects of our intervention, which we plan to collect in a future round of data-collection.

Finally, because of the delays in setting up the IVR system, which was meant to be an integral part of our intervention, we have implemented the phone-survey in two phases. We first called the treated producers between July and early August, and later started calling untreated producers in September. We decided to reach treated producers ahead of the untreated ones in order to explain the functioning of the IVR system prior to the end of the current marketing season. We are mindful of the fact that calling treated and untreated producers at different points in time can compromise the interpretation of our estimated treatment effects, and so we have designed the questionnaire to make outcomes for both groups as comparable as possible. For every transaction recorded (sale, exchange

or loan), we also elicited the month in which the transaction took place. We also collected information from treated producers regarding cashew-related transaction that took place between July and August 2020, through a second shorter phone-call.

Empirical strategy

We estimate models of the form:

$$y_{iv} = treatment_{iv} \cdot \beta + spillover_{iv} \cdot \delta + y_{0iv} \cdot \gamma + \alpha_v + \epsilon_{iv} \qquad (2)$$

where:

- i and v index individuals, and villages, respectively,
- y_{iv} denotes the outcome of interest measured in the follow-up,
- y_{0iv} denotes the outcome of interest measured in the baseline,
- $treatment_{iv}$ denotes individual-level assignment to the treatment group,
- $spillover_{iv}$ denotes individual-level assignment to the spillover group in treated villages,
- α_v denotes the randomisation triplet fixed effect (as described in section 3.3),
- ϵ_{iv} is the unobserved variation in the outcome

We cluster standard errors at the village level.

Our coefficient of interest is β, the intent to treat (ITT) effect. To measure take-up of the intervention, we define a dummy variable equal to one if the respondent confirmed either reading or listening to the messages that were sent to them between April and May, denoted as $takeup_{iv}$, based on the responses from the phone-based survey. We also estimate treatment-on-the-treated (TOT) effects, by adapting (2), by replacing $treatment_{iv}$ with $takeup_{iv}$ instrumented by $treatment_{iv}$.

Inference and multiple-hypothesis testing adjustments

For each outcome of our pre-specified outcomes, we test the following hypothesis:

H_0: $\beta = 0$: The intervention had no effect;

H_0: $\delta = 0$: The intervention had no spillover effect;

H_0: $\beta = \delta$: The intervention had no effect relative to the spillover group;

For each of these hypothesis tests, we report the values False Discovery Rate (FDR) adjusted q-values, taken across the family of outcomes (Benjamini, Krieger, and Yekutieli 2006). (That is, for each type of test, we construct a q-value for that test across outcomes. For example, we construct a set of q-values using all p-values for the null hypothesis 'The intervention had no effect'; we construct a set of q-values using all p-values for the null hypothesis 'The intervention had no spillover effect'.)

Results

In this section, we present the preliminary results on the effects of the intervention using the data collected in the phone-based midline survey. We first focus on the primary outcomes of interest (prices and revenue), before turning our analysis to quantities of raw cashew nuts devoted to different transactions (sold for cash, exchanged for rice, or used to repay loans). The analysis follows our pre-analysis plan, and we note where deviations from the plan have been made in the exposition of the results.

Prices and revenue

Table 2: Results: Prices and revenue

	Control	ITT			TOT		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Mean (SD) Total obs.	Treatment	Spillover	Treat. vs. spillover	Treatment	Spillover	Treat. vs. spillover
Price per sale per kg	258.59	-8.30***	-2.40	-5.90**	-10.62***	-2.42	-8.20**
	(135.55)	(2.71)	(3.22)	(2.85)	(3.48)	(3.23)	(3.20)
	1461	[0.01]***	[0.67]	[0.09]*	[0.01]***	[0.66]	[0.04]**
Value of all sales and exchanges	296611.98	38090.52*	34782.65	3307.87	48649.35*	34811.20	13838.14
	(403789.50)	(22790.95)	(21596.62)	(22384.26)	(29099.35)	(21585.12)	(26368.23)
	1462	[0.09]*	[0.43]	[0.88]	[0.09]*	[0.43]	[0.60]

Notes: Intention-to-treat (ITT) estimates (columns 2-3) and treatment-on-the-treated (TOT) estimates (columns 5-6) where take-up is instrumented by treatment assignment. Columns 3 and 7 test for differences in parameters obtained in previous two columns. Outcome variables are listed on the left and described in detail in the pre-analysis plan. The unit of observation is the individual producer. All models control for the randomisation triplet fixed-effects and the baseline value of the outcome when it was available. Standard errors are in parentheses and are clustered at the village-level. Stars on the coefficient estimates reflect unadjusted p-values. Sharpened q-values controlling the false discovery rate across outcomes within each family are shown in brackets. * denotes significance at 10 pct.; ** at 5 pct.; and *** at 1 pct. level. Column 1 displays the control mean; standard deviation; and total number of observations.

Our intervention failed to increase the average price of sales among treated producers, but treated producers managed to gain a higher total value from all sales and exchanges conducted relative to the control group. Table 2 show our results from the midline phone-based survey on prices and revenue from sales and exchanges. We present both estimates of ITT and TOT effects. The estimation sample includes all producers contacted at midline.10 Our first finding is that the intervention did not increase the average price of sales among treated producers, but we find evidence of the contrary. The first row shows that treated producers reported sale prices that were, on average, 3-5 percent lower than the control group mean. The spillover group also reported sale prices that were 2-3 percent higher, on average, relative to the treated producers. To better understand the failure of our intervention to increase average producer prices, we plot the distribution of prices across treatment arms in figure 3. Two patterns emerge from the distribution of prices. First, treated producers report more frequently the median price of 300CFA/kg relative to both control and spillover group.11 The control group is also more likely to report no sales at all relative to the treated and spillover group, as shown by the left-most bars in the figure. Second, a small group of spillover and control group producers report prices that are above 450CFA/kg, which are well above the sale prices recorded by our analyst, which did not go above 400CFA/kg. This small group of producers is driving up the average price of sales

[10] In order to not condition our outcome on the decision to sell, we recode the price per sale to be equal to zero for producer that did not conduct any sales and add as a control an indicator equal to one for observations for which we impute the price. Our results are not affected by this imputation strategy.
[11] All monetary values are in nominal Central African Francs (CFA), which is pegged to the euro at an exchange rate of 1 EU for 650 CFA.

relative to the treatment group, which shows a much more concentrated distribution of prices.12

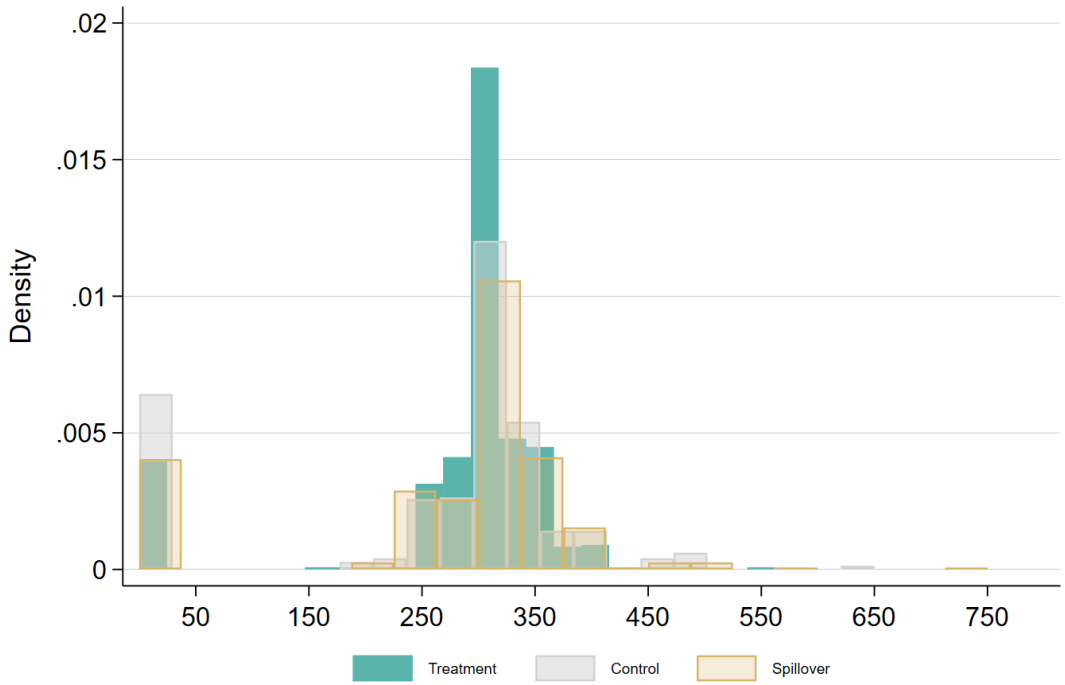


Figure 3: Distribution of sale prices by treatment arm

Despite the failure to increase average prices, the second row in table 2 shows that the total value of cashews that were either sold or exchanged (directly for rice) is 16 percent higher among treated producers relative to the control group mean, based on our preferred treatment-on-the-treated estimates reported in column (5). Relative to the spillover group, the treated producers earn a marginally higher revenue, on average, but the difference is not statistically different from zero. While the average price of sales is only computed for monetary transactions, the total value of all sales and exchanges measures the total revenue from sales and cashew trades that were repaid in rice.13 To unpack our second finding, we next analyze the producer's decision to either sell, exchange for rice, or use cashews in interlinked credit transactions.

Quantity sold or exchanged, for rice or loans

Treated producers are more likely to trade their cashew nuts in spot monetary sales rather than exchanges for rice or credit (either in cash or rice). Panel A, in table 3 looks at the effect of the treatment on the number of sales and the quantities exchanged. Panel B, looks at whether producers used their cashews to repay loans differently depending on treatment status. Focusing on the first row, we observe that 18 percent of control group producers did not engage in any spot cashew sales. Treated producers, on the other hand, were 11 percent points more likely to make at least one sale relative to the control group (q-value:

[12] We find no statistically significant effect of the intervention on sale prices in a sample restricted to producers that do not report prices above 425CFA/kg, the maximum farmgate price our national cashew analyst reported throughout 2020 campaign.

[13] As described in our pre-analysis plan, we value rice using the month-region specific retail value of rice. This price is likely to be an upper-bound on the actual monetary value of rice used in cashew exchanges, which anecdotally tends to be of lower quality than the one sold in market and shops.

0.00), and 7 percent more likely relative to the spillover group (q-value: 0.02). This effect was visually salient from inspecting the left-most bar in figure 3.14 In the second row, we see that the intervention induced producers to sell more frequently their cashews relative to the control and spillover groups. Treated producers are more likely to sell more than once during the campaign. This behavior is consistent with the advice provided by our intervention, which advised producers to sell cashews in multiple sales, given an expected increase in prices in the latter half of the trading season. On the extensive margin of sales, we see that treated producers sell more than 100kg of cashews for cash relative to both control (q-value: 0.04) and spillover group (q-value: 0.10), even if the difference with the latter group is not statistically significant at the 5% level. The larger number of sales, accounts for the overall increase in the total value we reported in table 2.

Table 3: Results: Cashew sales, exchanges, and loans

	Control	ITT			TOT		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Mean (SD) Total obs.	Treatment	Spillover	Treat. vs. spillover	Treatment	Spillover	Treat. vs. spillover
Sales and exchanges:							
1 if sold at least once	0.82	0.09***	0.04*	0.05**	0.11***	0.04*	0.07***
	(0.39)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
	1516	[0.00]***	[0.43]	[0.03]**	[0.00]***	[0.43]	[0.00]***
Number of sales	1.35	0.21***	0.01	0.20***	0.27***	0.01	0.26***
	(1.16)	(0.06)	(0.06)	(0.07)	(0.08)	(0.06)	(0.08)
	1516	[0.00]***	[0.88]	[0.00]***	[0.00]***	[0.88]	[0.00]***
Total quantity sold	633.56	132.68**	46.96	85.72	169.50**	47.07	122.44
	(1105.29)	(62.00)	(57.35)	(63.38)	(79.17)	(57.31)	(74.85)
	1462	[0.04]**	[0.69]	[0.18]	[0.04]**	[0.69]	[0.10]
1 if exchanged cashew for rice	0.64	-0.08**	0.02	-0.10***	-0.10**	0.02	-0.12***
	(0.48)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)	(0.03)
	1508	[0.03]**	[0.77]	[0.00]***	[0.03]**	[0.76]	[0.00]***
Total quantity exchanged	269.96	9.51	84.58***	-75.06***	12.05	84.54***	-72.48**
	(336.20)	(26.28)	(29.60)	(24.84)	(33.31)	(29.53)	(28.01)
	1497	[0.72]	[0.02]**	[0.00]***	[0.72]	[0.02]**	[0.01]**
Loans							
1 if borrowed money or rice in any month	0.63	-0.11***	-0.04	-0.07**	-0.15***	-0.04	-0.11***
	(0.48)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)
	1521	[0.00]***	[0.43]	[0.03]**	[0.00]***	[0.44]	[0.01]***
Total quantity paid for loans in any month	131.72	10.93	10.38	0.55	13.95	10.38	3.57
	(239.38)	(17.98)	(18.32)	(21.67)	(22.96)	(18.32)	(24.92)
	1516	[0.58]	[0.74]	[0.98]	[0.58]	[0.74]	[0.89]

Notes: Intention-to-treat (ITT) estimates (columns 2-3) and treatment-on-the-treated (TOT) estimates (columns 5-6) where take-up is instrumented by treatment assignment. Columns 3 and 7 test for differences in parameters obtained in previous two columns. Outcome variables are listed on the left and described in detail in the pre-analysis plan. The unit of observation is the individual producer. All models control for the randomisation triplet fixed-effects and the baseline value of the outcome when it was available. Standard errors are in parentheses and are clustered at the village-level. Stars on the coefficient estimates reflect unadjusted *p*-values. Sharpened q-values controlling the false discovery rate across outcomes within each family are shown in brackets. * denotes significance at 10 pct.; ** at 5 pct.; and *** at 1 pct. level. Column 1 displays the control mean; standard deviation; and total number of observations.

Rather than selling cashews in cash-based trades, spillover and control group producers are more likely to either exchange for rice or use cashews to repay loans. In the fourth row of the top panel of table 3, we see that treated producers are 10-12 percent less likely to exchange their cashew for the staple local food, rice, relative to both control (q-value: 0.03) and spillover producers (q-value: 0.00). Unexpectedly, we also find some evidence of spillover effects within treated villages, as producers in the spillover group in treated villages tend to exchange about 31 percent of the control group mean of kilos of cashews

[14] We did not pre-specify this outcome, because we did not expect such a high proportion of producers to not carry out any sales. International cashew prices were low during the early stages of the trading season, which is likely to have reduce cash-based transactions, regardless of treatment, and increase rice-based transactions, as the terms of trade of cashews relative to rice worsened.

in direct exchange for rice. The treatment coefficients on the quantity of cashews exchanged for rice are small and close to zero. We posit that our intervention might have made prices more salient among the treatment group, who is more likely to turn away from barters and seek more actively cash-based transactions. In turn, the spillover group might have been left with more buyers offering rice rather than cashew, especially towards the end of the trading season. In the appendix table 6, where we analyze the timing of the sales and exchanges, we observe that treated producers are less likely to exchange for rice in the last months of the trading season, relative to both spillover and control group.

In the lower panel of table 3, we find that treated producers reduce the amount of credit taken on the extensive, but not on the intensive margin. Rice sold on credit or money loans are common, 63 percent of the control group reports having entered in one of these credit contracts. Treated producers are 11-15 percent (q-value: 0.01) less likely to have borrowed relative to the control and spillover group.15 Because of the intervention, fewer producers had to pay interest to convert their output into consumable goods. Since we do not find any effects on the extensive margin, producers that needed to borrow did not change the amount of cashews used to repay loans.

Marketing behavior

To begin to understand the mechanisms behind our results, we next turn to the analysis of different marketing practices. Table 4 looks at the effect of the treatment on the marketing behavior that related to the content provided through our weekly messages. We first check whether treated producers were more likely to report sales because of better records. All producers had been given a sales diary to record their sales during the 2020 trading season by the survey team after the baseline. In the first two rows, we do not find evidence that treated producers are more likely to have kept or used the sales diary.16 Almost all producers report keeping the sales diary and about 67 percent report using it. In the first messages we sent during the 2020 campaign, we advised producers to dry their cashews. We do not find evidence that treated producers are more likely to dry their nuts, as this practice is common. 89 percent of control group producers report having dried their cashew nuts before sales.

In line with the idea that treated producers are better informed about market trends, we find that our intervention reduced the likelihood of producers having to delay their sales against their own willingness. During the phone-based survey, we asked producers whether their preferred timing to sell was affected by events out of their control (e.g. prices offers were too low, no buyers visiting the village) and find that treated producers are 26-30 percent (q-value: 0.00) less likely to report having had to unwillingly delayed their sales relative to both control and spillover group. We do not find strong evidence that the treatment induced producers to act as intermediary buyers. In our control group, only 3

[15] We had pre-specified to analyze only the probability of taking out a loan during the intervention period. But we preferred to report effects on all loans taken during the trading season. Treated producers might have been less likely to engage in credit contracts based on the training session conducted after the baseline. We do not find any treatment effects on the probability of taking out credit between April and August 2020, as shown in the appendix table 8.

[16] In future face-to-face data-collection, we plan to collect the diaries from producers to compare the interview responses with the written records. To incentive the use of the sales diary, the survey team promised that producers that kept records could participate in a lottery to win a 50kg bag of rice. The content of the placebo messages that were sent to all producers reminded producers to use the sales diary.

percent of producers report having bought cashews from other producers for resale. Our TOT estimates suggest that treated producers are 3 percent more likely to report as intermediaries relative to the spillover group (q-value: 0.12). Given how few producers report acting as intermediaries, we are cautious in interpreting the magnitude of this result.

Table 4: Results: Marketing behaviour

	Control	ITT			TOT		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Mean (SD) Total obs.	Treatment	Spillover	Treat. vs. spillover	Treatment	Spillover	Treat. vs. spillover
Pre-specified outcomes:							
1 if has diary to register sales	0.98	0.00	-0.01	0.01	0.00	-0.01	0.01
	(0.12)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	1505	[0.66]	[0.71]	[0.35]	[0.66]	[0.71]	[0.32]
1 if used diary to register sales	0.67	-0.02	-0.05	0.02	-0.03	-0.05	0.01
	(0.47)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)
	1490	[0.54]	[0.71]	[0.55]	[0.54]	[0.71]	[0.77]
1 if dried cashews before sale	0.89	-0.03	0.01	-0.04*	-0.04	0.01	-0.04*
	(0.32)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	1497	[0.28]	[0.87]	[0.19]	[0.28]	[0.87]	[0.15]
1 if unwillingly delayed sale	0.78	-0.23***	-0.03	-0.20***	-0.30***	-0.03	-0.26***
	(0.41)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)
	1476	[0.00]***	[0.71]	[0.00]***	[0.00]***	[0.71]	[0.00]***
1 if sold majority after May	0.43	-0.06**	0.03	-0.10***	-0.08**	0.03	-0.11***
	(0.50)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)
	1466	[0.09]*	[0.71]	[0.02]**	[0.09]*	[0.71]	[0.01]**
1 if acted as intermediary	0.03	0.02	-0.01	0.02**	0.02	-0.01	0.03**
	(0.16)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	1489	[0.28]	[0.71]	[0.12]	[0.28]	[0.71]	[0.12]
Additional outcomes not pre-specified:							
1 if sold most to local buyer	0.23	0.16***	0.07**	0.09***	0.21***	0.07**	0.13***
	(0.42)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
	1462	[0.00]***	[0.03]**	[0.01]***	[0.00]***	[0.03]**	[0.00]***
1 if sold most to itinerant buyer	0.51	-0.06**	-0.04	-0.02	-0.08**	-0.04	-0.04
	(0.50)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)
	1462	[0.07]*	[0.38]	[0.44]	[0.07]*	[0.38]	[0.31]
1 if sold most directly to a market	0.07	-0.01	0.00	-0.01	-0.02	0.00	-0.02
	(0.25)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
	1462	[0.34]	[0.97]	[0.44]	[0.34]	[0.97]	[0.31]

Notes: Intention-to-treat (ITT) estimates (columns 2-3) and treatment-on-the-treated (TOT) estimates (columns 5-6) where take-up is instrumented by treatment assignment. Columns 3 and 7 test for differences in parameters obtained in previous two columns. Outcome variables are listed on the left and described in detail in the pre-analysis plan. The unit of observation is the individual producer. All models control for the randomisation triplet fixed-effects and the baseline value of the outcome when it was available. Standard errors are in parentheses and are clustered at the village-level. Stars on the coefficient estimates reflect unadjusted *p*-values. Sharpened q-values controlling the false discovery rate across outcomes within each family are shown in brackets. * denotes significance at 10 pct.; ** at 5 pct.; and *** at 1 pct. level. Column 1 displays the control mean; standard deviation; and total number of observations.

In the lower panel of table 4, we find that producers in treated villages are more likely to sell to buyers that are based in the village, rather than to itinerant buyers.[17] Treated producers are 21 percent (q-value: 0.00) more likely to sell most of their cashews to a local intermediary and 8 percent (q-value: 0.00) less likely to sell to an intermediary relative to the control group. We interpret this result as evidence that treated producers react to the information by pro-actively striking deals with the intermediaries that live in the same village as them, rather than accepting offers from potential buyers that come from outside the village.

Heterogeneity

[17] In appendix table 8, we also show other pre-specified outcomes related to marketing practices, which are not different across study arms.

We test for heterogeneity of our effects relative to the following baseline measures, as defined in our pre-analysis plan. Specifically we test for heterogeneity by baseline measures of:18

1. The respondent's principal component of assets index, as a proxy for socio-economic status;
2. An indicator variable equal to one if the respondent could read a sentence in Bissau-Guinean Kriol, to understand whether literacy could be associated with our results;
3. The number of cashew producers that live in the village of the respondent, as a proxy for the level of competition among producers;
4. The road distance in km to the nearest sector capital, to proxy for the nearest trading market

To test for heterogeneous effects along these dimensions, we interact our treatment and spillover indicators with baseline measures of these variables. For each of the continuous characteristics listed, we trichotomize the variable – interacting in each case with (i) a dummy for whether the baseline value lies at or below the lower tercile, (ii) a dummy for whether the baseline value lies strictly between the two terciles, and (iii) a dummy for whether the baseline value lies at or above the upper tercile.

The exploration of these heterogeneous effects offer relevant insights about the impact of the treatment on different producers. In this section, we focus on the main outcomes from table 2: price per sale per kg and value of all sales and exchanges; and for the probability of exchanging cashew for rice, total sold quantity and total exchanged quantity, within the category "quantities and exchanges". It is important to note that the magnitude of these effects are comparable to our ITT estimates. Heterogeneous effects taking into account exposure to the treatment and treatment intensity will be explored in future analyses.

The results for some of the most relevant variables chosen to explore heterogeneous effects go in similar directions, such as plantation area and wealth, years of experience and being able to read, or the number of cashew producers and cashew buyers in the village. Hence, for the sake of brevity and clarity, we report our analysis: wealth, being able to read and the number of cashew producers in the village. Significant heterogeneous effects for other variables are much less common and, when they exist, these tend to be weaker.

The exploration of heterogeneous effects shows that the lower average price obtained by treated producers is more prevalent among producers with lower levels of wealth and (marginally) those cannot read, see respectively the top left graph and the top right graph in Figure 4. Similarly, treated producers with a larger plantation area and more years of

[18] We had also tested for heterogeneity of our results by other pre-specified variables for which we find weak or no heterogeneity: an indicator variable equal to one if respondent sells their output to a fixed buyer; the respondent's numeracy index; an indicator variable equal to one if the respondent is an hyperbolic discounter; an indicator variable equal to one if the respondent is extremely risk-averse. Moreover, we tested for heterogeneity of our effects by variables that move similarly to those reported in this draft: the respondent's area of cashew plantation (in hectares); the number of intermediaries that live in the village of the respondent, the respondent's years of experience in the cashew market. We also estimated heterogeneous treatment effects by the road distance to the nearest regional capital and the road distance in km to the country capital, Bissau, which generally showed no or weaker differences. These dimensions were used in our matching algorithm to assign village-level treatment status.

experience in the cashew market have not received a lower average price than comparable control producers, but those in the lowest tercile for these variables have. In terms of village characteristics, only those treated producers living in villages with few cashew producers have received a lower average price than comparable control producers.19 Being closer to the sector capital also tends to make the average price lower, but this heterogeneous effect is not statistically significant, see the bottom left graph and the bottom right graph in Figure 4, respectively.

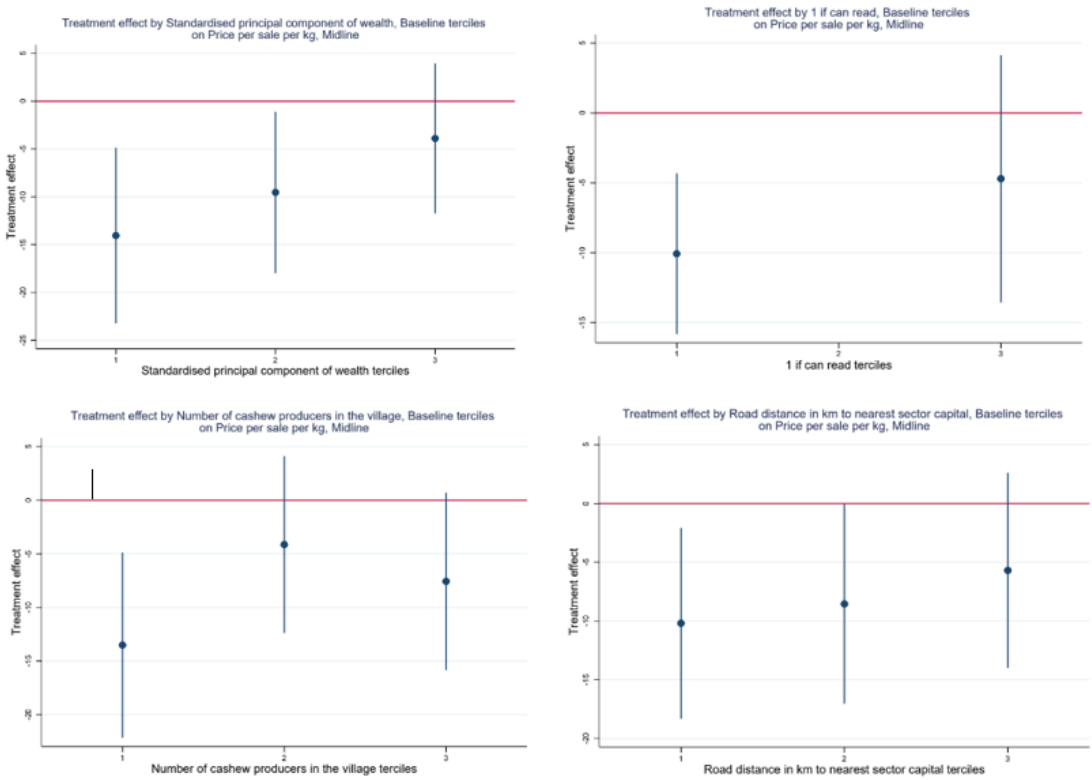


Figure 4: Heterogeneous effects for the average price

These findings show that treated producers that are poorer, less literate and less experienced, living in smaller villages report lower average prices. This impact on average prices was not observed for more experienced and for richer producers, nor for those in larger villages with more cashew producers and buyers.

Importantly, the lower average price observed for originally "worse-off" treated producers did not translate into a lower overall revenue from cashew trading for them.

Regarding the total value of all cashew sales and exchanges, heterogeneous effects go somehow in the opposite direction as those for average prices. While the higher value of this variable for treated producers with higher wealth does not reach statistical significant, as we can see in top left graph in Figure 5, the difference is large and statistically significant for treated producers with a plantation area in the top tercile of the distribution. As we can see on the top right graph of this same figure, treated producers able to read tend to get a higher value for their sales and exchanges than comparable producers in the control group, but again this difference is not statistically significant.

[19] This result is equivalent for living in villages with few cashew buyers.

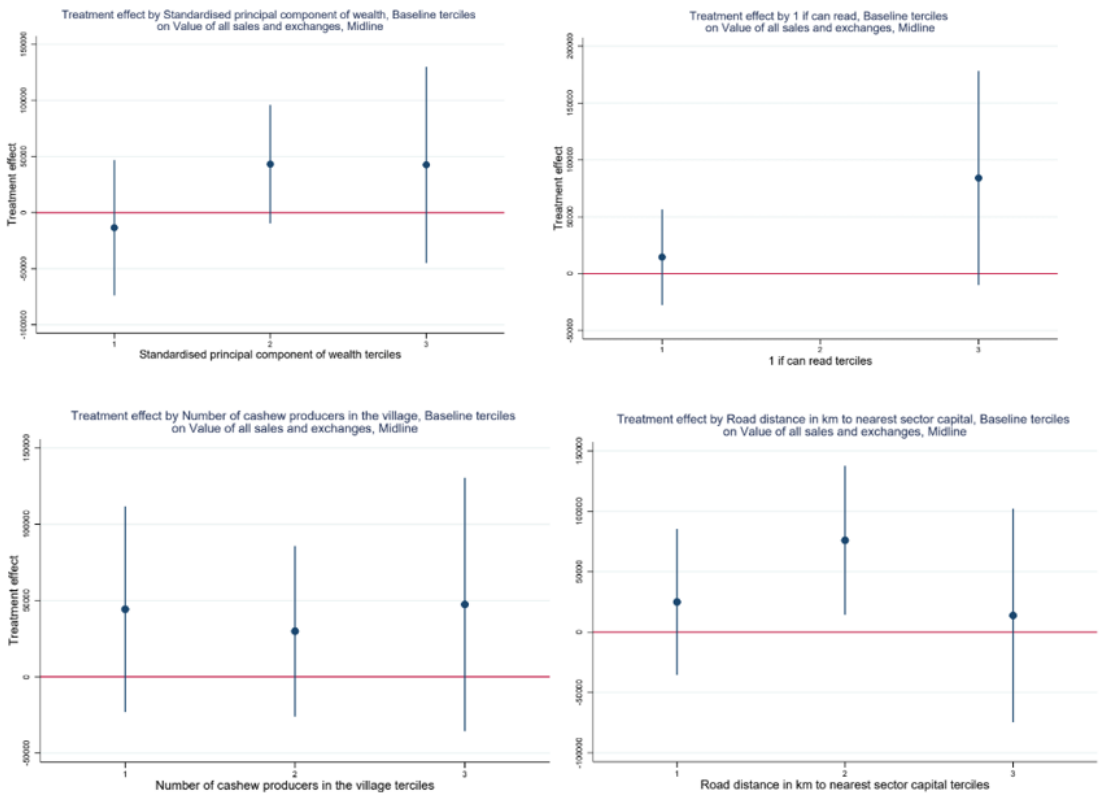


Figure 5: Heterogeneous effects for the total revenue from all sales and exchanges

While the rest of heterogeneous effects for this outcome variable do not show significant differences (see for example the two bottom graphs in Figure 5), the finding of those treated producers with a higher plantation area, and marginally those who are more literate, profiting most from the service deserves further exploration, as this is arguably the most relevant outcome variable for cashew producers.

Without a higher average price for originally "better-off" treated producers, their higher total revenue coming from cashew sales and exchanges must be somehow related to the quantities they trade. There is a particularly salient finding: richer producers, also those with larger plantations, those who are more literate, and who live in villages with more cashew producers (and more cashew buyers), are significantly less likely to exchange cashew for rice than comparable control producers, see Figure 6.

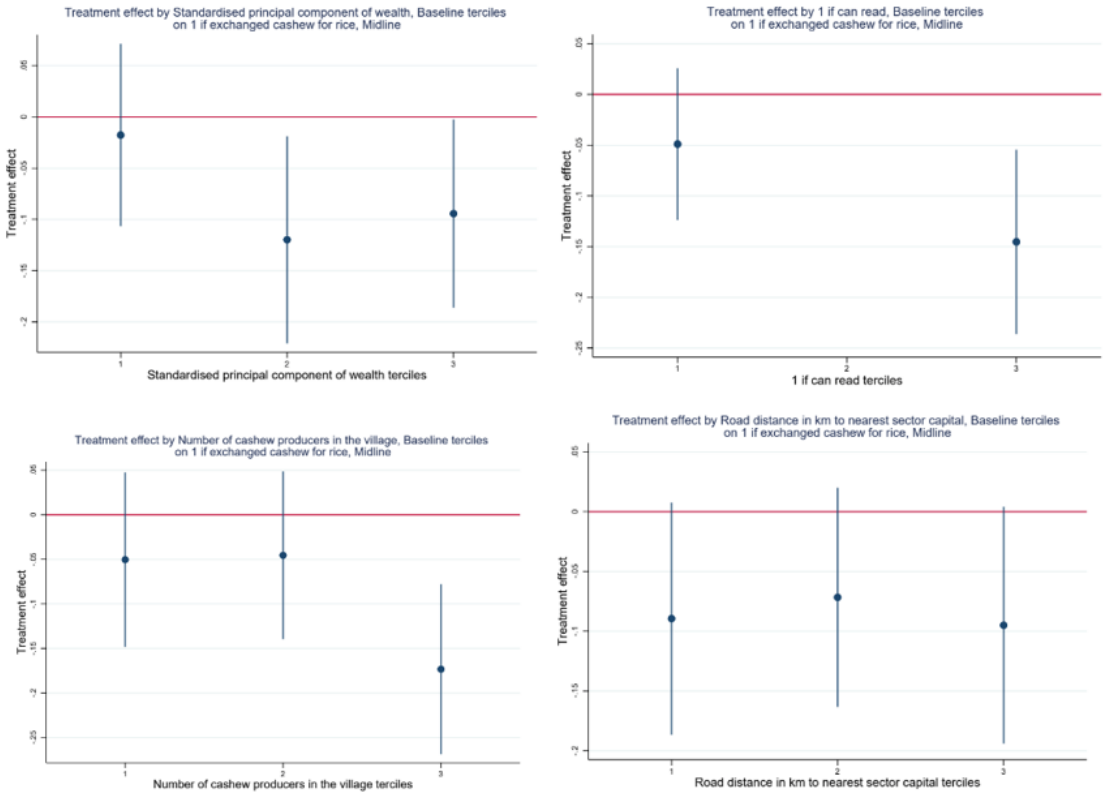


Figure 6: Heterogeneous effects for the probability of exchanging cashew for rice

However, when we look at the quantities of cashew that these "better-off" treated producers exchanged for rice, we find that the difference with comparable control producers is not statistically significant, see Figure 8 in the Appendix. This implies that their higher revenue must come from selling larger amounts of cashew, which is indeed the case, as we can see in Figure 7, also in the Appendix. Treated cashew producers with a larger wealth, a larger plantation area, and those who are able to read tended to sell more kg of cashew than comparable producers in the control group.

Conclusion

This paper estimates the effects of introducing a new market information system among cashew producers in Guinea-Bissau. The market information system provided weekly text and voice-messages during the 2020 trading season to treated producers. The information sent to producers contained up-to-date farmgate prices, market news, and marketing advice on when to sell. Treated producers change the timing of sales and their marketing decisions. We find that treated producers sell more frequently cashews at the farmgate, moving out of barter-exchanges and interlinked credit contracts. By doing so, treated producers earn a larger total revenue relative to untreated either living in treated villages or in control villages.

Our findings yield several policy implications. First, we find that the increased revenue among treated producers is substantial in magnitude. Providing up-to-date and reliable information on market conditions seems to improve the market outcomes of producers in this context. The user-fee that subscribers to the service would be charged could be quickly

repaid by the additional returns we observe among treated producers. Second, the baseline government policy of providing a reference price only at the beginning of the trading season can be improved upon, through the communication of more frequent price updates. There are several open questions that remain unanswered. We plan to tackle some of these questions in future research. For example, we need to better understand what are the reasons that drive producers' decision to exchange cashews for rice rather than selling them for a monetary return. We have found that information on cashew prices can influence this decision, but what are other factors that lead to this bartering in the first place? What is the level of competition and information that buyers of cashews have in this market? Since we find that treated producers sell more to local buyers, are there differences in the level of information or cost structure among local buyers relative to itinerant buyers?

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Appendix
Additional analysis of average treatment effects

Table 5: Results: Additional price and revenue outcomes

	Control	ITT			TOT		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Mean (SD) Total obs.	Treatment	Spillover	Treat. vs. spillover	Treatment	Spillover	Treat. vs. spillover
Additional outcomes not pre-specified:							
Implicit price of sales and exchanges	208.10	-18.08***	-6.54	-11.54***	-23.11***	-6.55	-16.56***
	(76.96)	(4.09)	(4.58)	(4.08)	(5.19)	(4.58)	(4.56)
	1459	[0.00]***	[0.31]	[0.01]***	[0.00]***	[0.31]	[0.00]***
Value of all sales	210778.14	35411.02	10801.10	24609.92	45241.67*	10842.84	34398.83
	(390984.26)	(21468.38)	(19917.40)	(21578.32)	(27404.80)	(19911.42)	(25474.87)
	1461	[0.10]	[0.59]	[0.25]	[0.10]*	[0.59]	[0.18]
Additional outcomes pre-specified:							
Maximum price across all sales	264.11	-7.27**	-2.20	-5.06*	-9.30**	-2.22	-7.08**
	(138.57)	(2.82)	(3.26)	(2.87)	(3.61)	(3.27)	(3.24)
	1461	[0.01]**	[0.67]	[0.10]	[0.01]**	[0.66]	[0.04]**
Coefficient of variation of price across all sales	0.03	0.01***	0.00	0.01**	0.01***	0.00	0.01**
	(0.06)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	1460	[0.01]**	[0.74]	[0.09]*	[0.01]**	[0.74]	[0.04]**

Notes: Intention-to-treat (ITT) estimates (columns 2-3) and treatment-on-the-treated (TOT) estimates (columns 5-6) where take-up is instrumented by treatment assignment. Columns 3 and 7 test for differences in parameters obtained in previous two columns. Outcome variables are listed on the left and described in detail in the pre-analysis plan. The unit of observation is the individual producer. All models control for the randomisation triplet fixed-effects and the baseline value of the outcome when it was available. Standard errors are in parentheses and are clustered at the village-level. Stars on the coefficient estimates reflect unadjusted *p*-values. Sharpened q-values controlling the false discovery rate across outcomes within each family are shown in brackets. * denotes significance at 10 pct.; ** at 5 pct.; and *** at 1 pct. level. Column 1 displays the control mean; standard deviation; and total number of observations.

Table 6: Results: Additional quantity-related outcomes and timing of sales

	Control	ITT			TOT		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Mean (SD) Total obs.	Treatment	Spillover	Treat. vs. spillover	Treatment	Spillover	Treat. vs. spillover
Additional outcomes not-prespecified:							
Cashew to rice exchange rate	0.73	9.70	2.88	6.82	12.33	2.84	9.48
	(0.56)	(9.87)	(3.05)	(7.08)	(12.54)	(3.01)	(9.76)
	1473	[0.40]	[0.76]	[0.53]	[0.40]	[0.76]	[0.46]
Total quantity sold or exchanged	1542.33	266.77**	165.96	100.82	339.24**	165.33	173.91
	(2241.83)	(128.80)	(118.09)	(129.16)	(163.83)	(117.83)	(152.61)
	1443	[0.07]*	[0.59]	[0.53]	[0.07]*	[0.59]	[0.40]
1 if sold cashews in April 2020 or before	0.08	0.02	-0.00	0.02	0.02	-0.00	0.02
	(0.27)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
	1338	[0.43]	[0.98]	[0.53]	[0.43]	[0.98]	[0.48]
1 if sold cashews in May 2020	0.33	0.08***	-0.00	0.08**	0.11***	-0.00	0.11***
	(0.47)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)
	1338	[0.00]***	[0.98]	[0.03]**	[0.00]***	[0.98]	[0.01]***
1 if sold cashews in June 2020	0.49	0.20***	0.10***	0.11***	0.26***	0.10***	0.16***
	(0.50)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)
	1338	[0.00]***	[0.04]**	[0.01]***	[0.00]***	[0.04]**	[0.00]***
1 if sold cashews in July 2020 or later	0.20	-0.17***	-0.02	-0.15***	-0.22***	-0.02	-0.20***
	(0.40)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)
	1338	[0.00]***	[0.79]	[0.00]***	[0.00]***	[0.80]	[0.00]***
1 if exchanged rice in April 2020 or before	0.05	0.01	0.01	0.01	0.02	0.01	0.01
	(0.21)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)
	1447	[0.39]	[0.98]	[0.62]	[0.39]	[0.98]	[0.51]
1 if exchanged rice in May 2020	0.19	-0.04*	0.03	-0.07***	-0.05*	0.03	-0.08***
	(0.40)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
	1447	[0.12]	[0.76]	[0.01]**	[0.12]	[0.76]	[0.01]***
1 if exchanged rice in June 2020	0.33	0.00	-0.00	0.01	0.01	-0.00	0.01
	(0.47)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)
	1447	[0.89]	[0.98]	[0.82]	[0.89]	[0.98]	[0.81]
1 if exchanged rice in July 2020 or later	0.06	-0.05***	0.00	-0.05***	-0.06***	0.00	-0.06***
	(0.23)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
	1447	[0.00]***	[0.98]	[0.00]***	[0.00]***	[0.98]	[0.00]***
Additional pre-specified outcomes:							
Share of quantity sold over quantity exchanged and sold	0.58	0.10***	0.04*	0.05**	0.12***	0.04*	0.08***
	(0.38)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)
	1453	[0.00]***	[0.24]	[0.01]**	[0.00]***	[0.24]	[0.00]***

Notes: Intention-to-treat (ITT) estimates (columns 2-3) and treatment-on-the-treated (TOT) estimates (columns 5-6) where take-up is instrumented by treatment assignment. Columns 3 and 7 test for differences in parameters obtained in previous two columns. Outcome variables are listed on the left and described in detail in the pre-analysis plan. The unit of observation is the individual producer. All models control for the randomisation triplet fixed-effects and the baseline value of the outcome when it was available. Standard errors are in parentheses and are clustered at the village-level. Stars on the coefficient estimates reflect unadjusted p-values. Sharpened q-values controlling the false discovery rate across outcomes within each family are shown in brackets. * denotes significance at 10 pct.; ** at 5 pct.; and *** at 1 pct. level. Column 1 displays the control mean; standard deviation; and total number of observations.

Table 7: Results: Additional credit-related outcomes

	Control	ITT			TOT		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Mean (SD) Total obs.	Treatment	Spillover	Treat. vs. spillover	Treatment	Spillover	Treat. vs. spillover
Additional outcomes not pre-specified:							
Value of all loans repaid in cashews	15919.54	-1517.91	-1069.04	-448.87	-1937.50	-1068.28	-869.22
	(56335.58)	(2769.92)	(3213.27)	(4195.06)	(3537.52)	(3214.26)	(4729.82)
	1516	[0.58]	[0.74]	[0.91]	[0.58]	[0.74]	[0.85]
Additional outcomes pre-specified:							
1 if borrowed money or rice	0.19	0.01	0.00	0.01	0.01	0.00	0.01
	(0.40)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
	1432	[0.66]	[0.90]	[0.80]	[0.66]	[0.90]	[0.75]
Total quantity paid for loans	54.32	8.08	-3.63	11.71	10.29	-3.63	13.91
	(186.02)	(11.29)	(10.87)	(15.65)	(14.37)	(10.86)	(17.98)
	1500	[0.63]	[0.90]	[0.61]	[0.63]	[0.90]	[0.59]
Implicit price of loans per kg of cashews	51.69	-5.45**	-1.38	-4.07	-6.92**	-1.38	-5.54
	(117.93)	(2.64)	(3.18)	(3.79)	(3.38)	(3.19)	(4.24)
	1368	[0.08]*	[0.90]	[0.57]	[0.08]*	[0.90]	[0.39]
Share of quantity sold over quantity exchanged and paid in loans	0.77	0.10***	0.06***	0.04*	0.12***	0.06***	0.06***
	(0.39)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
	1449	[0.00]***	[0.03]**	[0.31]	[0.00]***	[0.03]**	[0.03]**

Notes: Intention-to-treat (ITT) estimates (columns 2-3) and treatment-on-the-treated (TOT) estimates (columns 5-6) where take-up is instrumented by treatment assignment. Columns 3 and 7 test for differences in parameters obtained in previous two columns. Outcome variables are listed on the left and described in detail in the pre-analysis plan. The unit of observation is the individual producer. All models control for the randomisation triplet fixed-effects and the baseline value of the outcome when it was available. Standard errors are in parentheses and are clustered at the village-level. Stars on the coefficient estimates reflect unadjusted p-values. Sharpened q-values controlling the false discovery rate across outcomes within each family are shown in brackets. * denotes significance at 10 pct.; ** at 5 pct.; and *** at 1 pct. level. Column 1 displays the control mean; standard deviation; and total number of observations.

Table 8: Results: Additional marketing-related outcomes

	Control	ITT			TOT		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Mean (SD) Total obs.	Treatment	Spillover	Treat. vs. spillover	Treatment	Spillover	Treat. vs. spillover
Additional pre-specified outcome:							
Index of marketing	-0.02	-0.03	-0.03	0.00	-0.04	-0.03	-0.01
	(1.00)	(0.06)	(0.06)	(0.06)	(0.08)	(0.06)	(0.07)
	1521	[0.66]	[0.84]	[0.97]	[0.66]	[0.84]	[0.94]
1 if switched buyers across rounds	0.50	0.04	0.00	0.04	0.05	0.00	0.05
	(0.50)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)
	1466	[0.31]	[0.96]	[0.35]	[0.31]	[0.96]	[0.32]

Notes: Intention-to-treat (ITT) estimates (columns 2-3) and treatment-on-the-treated (TOT) estimates (columns 5-6) where take-up is instrumented by treatment assignment. Columns 3 and 7 test for differences in parameters obtained in previous two columns. Outcome variables are listed on the left and described in detail in the pre-analysis plan. The unit of observation is the individual producer. All models control for the randomisation triplet fixed-effects and the baseline value of the outcome when it was available. Standard errors are in parentheses and are clustered at the village-level. Stars on the coefficient estimates reflect unadjusted p-values. Sharpened q-values controlling the false discovery rate across outcomes within each family are shown in brackets. * denotes significance at 10 pct.; ** at 5 pct.; and *** at 1 pct. level. Column 1 displays the control mean; standard deviation; and total number of observations. The index of marketing is a composite measure of whether producers kept their sales diary, used the sales diary, dried their cashew nuts, sold the majority of cashews after May 2020, or whether they acted as intermediary buyer, following Anderson (2008). A producer is thought to switch buyers across rounds if during the 2020 trading season they sold more than 50 percent of their cashews went to a different buyer (e.g. itinerant intermediary, sedentary intermediary, sold directly to a market) relative to buyer they main buyer they sold to at baseline.

A.2 Additional analysis of heterogeneous treatment effects

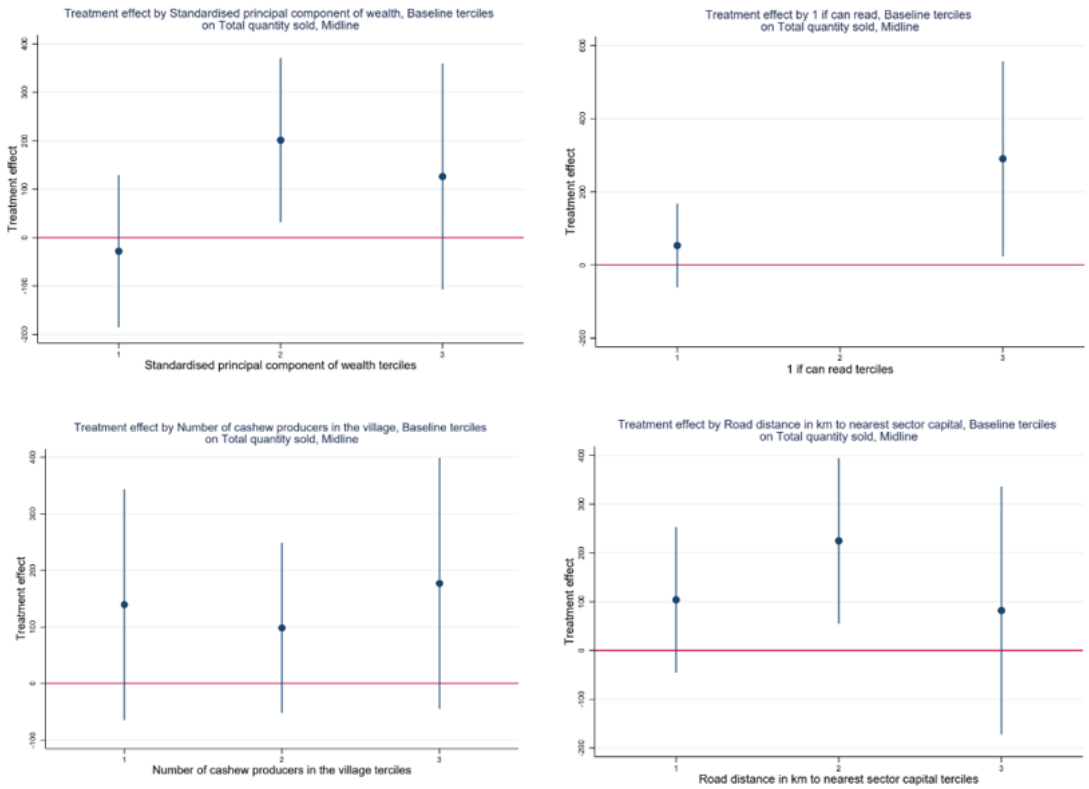

Figure 7: Heterogeneous effects for the total quantity sold

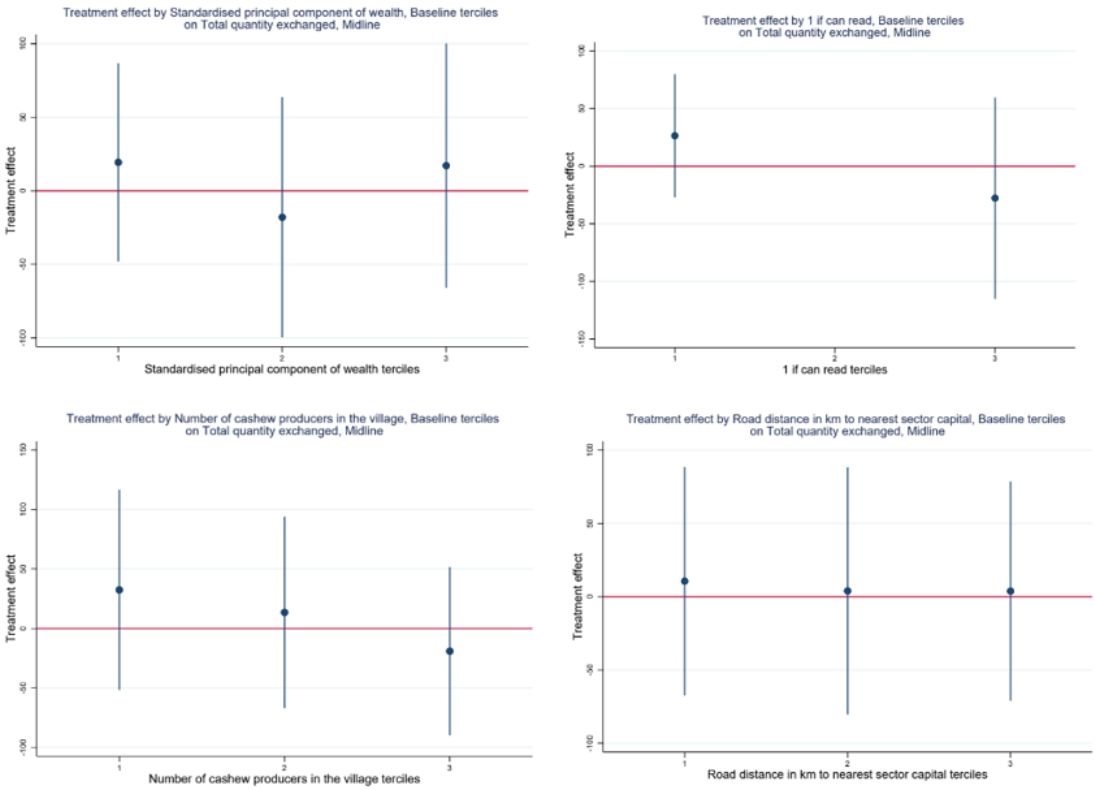

Figure 8: Heterogeneous effects for the total quantity exchanged