The value of information: Evidence from Burkina-Faso sesame producers

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October 2020

Abstract

Does market information enable African farmers to value their products better? To answer this question, we run an RCT in Burkina Faso, focusing on sesame producers: an important cash-crop production. We consider two types of treatment. The first provides information on prices estimated at the regional level, provides information on price trends, and gives selling advice. On average, we find that providing price information increases prices paid to farmers by 4%. However, impacts differ according to the type of information received. Gains are concentrated among those receiving price information only. These gains occur through a change in marketing behavior: sellers reduce their sales frequency, concentrating their sales during peak price periods.

Keywords: Information technology; agriculture; impact evaluation; Price information; Mobile phone; cash crops; Burkina Faso.

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We are grateful to Pierre-Noël Giraud and Ahmed Tritah for comments and remarks. We gratefully acknowledge Nitidae for its collaboration and support

1 Introduction

The agricultural sector is a key source of income for a large part of Africa's population and an important sector in most African economies (23 percent of sub-Saharan Africa's GDP), and the principal source of revenue in rural households. Agricultural production in Africa is subsistence farming and can also be intended for export, including cotton, cashews, coffee, cocoa, peanut, sesame, etc... Cash crop production represents a direct source of household income and their gains constitute an opportunity to improve farmers' financial situation. Therefore, farmers try their best to increase their profits by being strategic in their production process and their marketing decisions by choosing where to sell (spatial arbitrage) or when to sell (temporal arbitrage) to sell at the highest price market.

Cash crop price received by farmers depends on: the international supply from other producing countries, international demand for the crop, transport costs from the farm to the point of export, and the specificity of the supply chain. As a price-taker, the small farmer has a minimal intervention in controlling the international price but has a margin of gain on his local price (different between production cost and market price). Instantly, this margin gain price depends on transaction cost that covers (i) transportation cost and (ii) cost of researching price information. Transportation costs depend on the degree of farm remoteness and other issues like security in the area. Transportation costs could be very high due to poor road infrastructure and insufficient transport of vehicles from carts to trucks.

Price information plays a vital role in arbitrage behavior and market efficiency (Enke (1951), Samuelson (1952), Takayama & Judge (1971). (Stigler (1961)) economists have been trying to explain how asymmetric information (see by Akerlof *et al.* (2001)) and costly search can result in equilibrium price dispersion for homogeneous goods (Malkiel & Fama (1970)). This imperfect information situation can deeply affect the small farmer's position in the agriculture sector in developing countries where they are often poorly integrated and suffer from a lack of information in market price fluctuations because of high information costs. Searching for price information is very expensive for farmers, as they have to be connected to the market by frequent visits to the marketplace or by receiving this information instantaneously through other channels such as other producers, cooperatives, or through developed information and communication technologies (ICTs)(De Silva & Ratnadiwakara (2008)). However, it cannot be available for those small farmers because they generally produce small quantities, and traveling to find the best price is not cost-effective. On the other hand, these remote areas suffer from a lack of transportation infrastructure. Better access to information can encourage agents to increase their participation in markets by reducing marketing costs, optimizing their position in markets, and having arguments and capacity to negotiate the price.

In this context, mobile phone as the first available modern telecommunication infrastructure spreading rapidly [1] in rural Africa technology for diffusion information has the potential to provide cost-effective communication and reduce the search costs incurred by farmers and traders in developing countries (De Silva & Ratnadiwakara (2008)) (where the cost of information is very high). Mobile phones connect users and have significantly reduced communication and marketing costs by providing information quickly and cheaply (Aker & Mbiti (2010)). It represents an opportunity for the agriculture sector to increase farmer's welfare by improving access to information. Farmers' profits can be increased by improving sales distribution over time according to local and international demand mainly for cash crops and arbitrage between markets and allowing them to be more strategic.

This paper examines whether the distribution of agricultural market information through mobile phones generates important benefits for small farmers in developing countries. We also analyze through which mechanism this market information enhances farmers' benefices, (i) is a better arbitrage across space, as Jensen (2007). Using micro-level survey data Jensen (2007) states that mobile phones help fishermen choose a fish market to sell their fish at the highest prices. He shows that this contributes to increase welfare for both fishermen and consumers. According to this study, fisherman's profits increased by 8%, consumer surplus increased by 6%, and prices declined by 4%. When fishermen are well informed via mobile phones, they can improve their products' allocation across markets.

(ii) Or a better arbitrage on time; that is why we analyze the impact of the market information on turnover through semi-perishable cash-crops where trade is critical during the selling period. We expect that market information through an available ICT service like mobile phones helps farmers better manage their selling stock of crops.

(iii) Or whether this market information strengthens farmers' bargaining position in regards to the trackers(Courtois & Subervie (2014)). Consequently, we set up a randomized controlled trial (RCT) of a commercial service entitled. n'kalô provides instant information about crop prices, the price trend, and advice about crop quantities to sell. The RCT procedure consists of providing to a random sample of farmers with information about the agricultural campaign to analyze n'kalô information's impact on farmers' prices received.

This article contributes to the available literature in several ways. First, it complements the work of other impact evaluation studies of assessing the impact mobile phone market information services (m-services agriculture market information services that are developed and offered through the mobile phone) Jensen (2007) Fafchamps & Minten (2012) Courtois & Subervie (2014),Ca-

[1]Mobile phone subscriptions are now almost nine times higher in Africa than in the year 2000, reaching about 4131 million people available at https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx and last access in 28st of January 2020

macho & Conover (2010), Baumüller (2015),Islam & Grönlund (2010), Nakasone *et al.* (2014),) rather than an analysis of a spread of mobile phone or an expansion of the network in a rural area. It also enriches limited existing papers that have used microeconomic data to assess market information services' direct impact via mobile phones on rural livelihoods. Fafchamps & Minten (2012) study the spatial aspect by working on micro-level data and using a randomized experiment in 100 villages of Maharashtra, India, in micro-level sampling data Fafchamps & Minten (2012) investigate the impact of Reuters Market Light (RML). This service provides farmers with agricultural information through mobile phones in Maharashtra, India. They implemented an experimental evaluation in which a random sample of farmers received a free RML subscription for a year. While the authors find that younger farmers, less experienced farmers get slightly higher prices for their crops, unlike Jensen (2007), they do not find differences in average prices for farmers with RML subscriptions. They suggest that low levels of actual RML usage and the fact that farmers are mostly sold to a single local market may have contributed to this result.

Other papers are interested in expanding the network distribution in rural areas on the price fluctuation around markets, focusing on the relationship between mobile phone coverage and price realization and reduction of waste. In Niger, Aker (2010) compares markets with mobile phone coverage and markets without it. The study finds that the introduction of mobile phone coverage reduces agricultural price dispersion across markets by 10 percent. The effect is more massive for remote markets and those connected by unpaved roads (see Muto & Yamano (2009) and Aker (2010)). Muto & Yamano (2009) estimate the impact of mobile phone network expansion on farmers' market participation in Uganda, focusing on the banana and maize market. They show that mobile phone network reduces the informational asymmetry regarding prices. However, the effects vary across crops, farmers, and the geographical location. They suggest that mobile phone coverage expansion in Uganda has encouraged farmers' market participation in remote areas and perishable crops (Banana). Aker & Fafchamps (2014) assessed the impact of mobile phones on agricultural price dispersion in Niger. The study found that while mobile phone coverage reduced the spatial dispersion of producer prices for semi perishable commodities like cowpea; it had no impact on non-perishable commodities such as millet and sorghum. The study further found that farmers owning mobile phones obtained more price information but did not receive higher prices. The explanation given was the non-participation of farmers in spatial arbitrage.

Second, to understand why the research findings on the impact of price information on the prices that farmers receive are mixed. Where some studies conclude that farmers using m-services were able to obtain higher prices for their crops, through a spatial arbitrage, or an increase in the bargaining power (Islam & Grönlund (2010), Nakasone *et al.* (2014), Jensen (2007), Courtois

& Subervie (2014)).[2] However, other studies find a limited impact on prices received by farmers (Fafchamps & Minten (2012),Camacho & Conover (2010)) owing to limited spatial arbitrage, where farmers sell at the nearest market. In developing countries, smallholder farmers are not well connected to markets because of the lack of transportation infrastructures or a high transportation cost for small production or security problems. This paper is more interested in better management on harvest selling stock through a relevant market instant market information by giving farmer price information in a semi-perishable cash-crop that they could sell during the selling campaign. Consequently, we analyze another aspect by allowing time arbitrage to consider the farmer's ability to be connected to the market in remote areas.

Third, we investigate the impact of information conception by analyzing which market information is much relevant for farmers, is it information on current prices or maybe it is beneficial to assist farmers during their sales period by providing selling instructions; thus, we generate two treated groups, the first group is informed about the current price in the region the second treated group is delivered information about current price in the region, price trend and a piece of advice about quantity to sell) in order to understand different farmers' strategies depending on the different information received, how this impacts the price received, turnover, and marketing behaviors by analyzing the impact of n'kalô information on farmers strategies as well as sales' frequency and kind of buyers, in order to identify the pertinent information to farmers employing an empirical approach.

Other studies have looked at the design of the information services and have studied whether it is suitable for farmers. They use a qualitative approach to understand Kenyan farmers' mobile phone usage patterns, and their interactions with MFarm, a commercially available agricultural market information services via SMS (Wyche & Steinfield (2016)). They discovered a mismatch between this service's design and smallholder farmers' perceptions of their mobile phones' communication capabilities. They find that innovations must not be solely technological; educational innovations are also necessary. They highlight the importance of educational interventions to accompany the introduction of all new services and applications. In this experiment, the rate of farmers who affirmed receiving information was 60%, one of the reasons for the failure to spread this information is illiteracy, and farmers could not read n'kalô SMS. Farmers are aware of the importance of market information in selling management. During the survey, n'kalô users hope to receive information more than once per week because sometimes the price may fluctuate in the same week. Thanks to n'kalô information, they can negotiate their price using an argument (Courtois & Subervie (2014)). They often show the text message received to trackers or intermediates; they do not have to travel to marketplaces.

n'kalô users are more likely to sell at a good price even if they sell at the farm-gate without traveling to the marketplace. This conclusion is not the

[2]Baumüller (2018) review the empirical literature on agriculture-related services that are developed and offered through the mobile phone.

same that Fafchamps & Minten (2012) make, where they indicate that farmers are less likely to sell at the farm-gate and more likely to change the market. Furthermore, they are aware of the appropriate timing to sell.

In this paper, we differentiate between market price information and consulting services where we assess farmers by providing instructions on their selling process. In our case of analysis, we show that n'kalô information helps farmers to be strategic by being aware of price fluctuations and enhancing their bargaining power. n'kalô users, in order to be able to sell using n'kalô argument at the current price. According to our estimation, n'kalô market on price is limited to 4% on average for the experiment treatment assignment. The difference in the effect on price and turnover explains the farmers' selling strategy, where the major part of the treated groups' production was sold during the price peaks.
We proceed by quantile treatment effects to capture the heterogeneous effect that may limit the average effect. To explain how the intervention of n'kalô services affects the distribution of selling price and turnover. We conclude that the impact of the treatment on price and turnover is positive and significant for the first three quartiles, refer to farmers who receive low prices and have a reverse impact for farmers who receive high prices.

The rest of the paper is organized as follows. In Section 2, we present the experimental design, and we describe n'kalô services. More information about sesame markets is presented in Section 3. The data are summarized in Section 4. The testing strategy is discussed in Section 5. Estimation results are presented in Section 7.

2 The background & Experimental Design

2.1 The intervention and program

n'kalô is a commercial service offered by Nitidae[3], an NGO to diffuse and provide farmers with agriculture market information for several cash crops and inputs in twelve African countries. n'kalô subscribers receive text messages (SMS) to their mobile phone in French once a week for different crops (sesame, cashew nut, peanut..etc). The information includes the current local price (see figure3 as an example of the text message sent by n'kalô to farmers), the price trend, and usually a piece of advice on the quantity to sell. This information is based on Nitidae market monitoring, taking into account the international demand and the transaction cost through a weekly market price survey with an analysis of the market international demand analysis and other exporter market situations. Nitidae has the farmers' location at the regional level. Therefore n'kalô services inform farmers of the minimum and maximum price at which they can sell (see figure3) to account for price differentials within

[3]Nitidae goals are to design, develop, and lead projects that combine the environment and strengthen local economies.

the same region due to transaction costs between remote areas and those closest to major markets.
n'kalô [4] services have already been available before we start our study, but the take up is not universal in Burkina Faso. Thus, our incentive design is to provide farmers with free information by SMS.

Burkina Faso is a developing country in West Africa. The population of Burkina Faso is estimated at 19.75 million (according to World Bank 2020)[5] 70.64% of the population lives in the rural area. In 2014, 43.8% of the population lived with less than 1.9$ a day. Agriculture is the primary source of income and employs more than 80% of the population. The economy is mainly dependent on the primary sector, including cotton cultivation, which was structured and represented the most extensive export product. However, the Burkina Faso cotton sector has been experiencing problems for several years and is in a crisis state.

Our study focuses on sesame production, a cash crop of which the major production is exported to the Asian market (about 90% of its production is mainly intended for export).Sesame is the second most important cash crop after cotton, making Burkina Faso the fourth-largest producer of sesame in Africa after Ethiopia, Nigeria, and Sudan.Sesame represents an opportunity for small farmers to improve their revenue because this cash crop is easy to produce it. We consider the expected payoff of sesame production sold directly impacting the revenue of farmer's households. A household may sell all the harvest sesame between November and March. They usually keep a small part of their sesame production to be sowed in their fields. Sesame is not a perishable crop, and farmers can store their production during the sesame campaign; it is considered semi-perishable. Sesame crops are considered a competitive market compared to other cash crops, owing to the simplicity during the production process (production not required expensive input, as phytosanitary products and it could be planted on slightly degraded soils). Producers' main enthusiasm for this crop is linked to demand and prices that are holding up better than for other cash crops, such as cotton (the fall in global cotton prices). The global demand is growing and remains unfulfilled, so prices continue to rise. Exclusively for export, the country's production has increased by 150% in ten years. However, the market supply chain is not well organized and suffers from many intermediates and no transparency on prices. Even if demand is not completely satisfied, the commercialization of sesame by small farmers is complicated by the presence of a mitigated sales process and farmers need the best strategy to sell at the highest price. Farmers have more than one option to sell the harvest, they can sell their harvest to an intermediary at the farmer gate or to a cooperative or travel to the marketplace and sell the harvest. The

[4] n'kalô services have launched early 2019 a voice message service in local Burkinabeze languages.

[5] Available at https://data.worldbank.org/indicator/SP.POP.TOTL?locations=BF and last access in 28st of January 2020

development of the sesame value chain presents itself as an opportunity for growth and income sources for the players in this chain. In this context, many public and private organizations try to enhance the sesame value chain to increase the income and employment opportunities of producers and generate multiple sources of income to improve household economic security.

Several marketing channels are used to bring sesame to market, including (1) explain principal channels of marketing sesame:
The channel from collectors or trackers is the primary channel used for sesame flow in Burkina Faso. This channel is used in the Boucle du Mouhoun, Hauts Bassins, East, and Cascades regions. The collectors group the products to send them to wholesalers who are in charge of exports. This channel is the oldest of the methods used and allows the collectors to have perfect control of the production areas and producers. However, this weakens producers' bargaining power and excludes producer organizations from the marketing process.
The channel from direct purchases from intermediate traders or wholesalers Through this channel, wholesalers, and exporters (occasional opportunistic buyers) buy the sesame directly to producers for export. This channel's use is estimated at 20.75% [6] on average for the Boucle du Mouhoun, Hauts Bassins, East, and Cascades regions. However, it should be noted that in the Boucle du Mouhoun region, 66% of producers are involved in this channel. This channel contributes to the disorganization of the sector regarding the quality of the participants and poses the problem of traceability with certain unhealthy commercial practices.

Grouped sales channel This channel concerns sesame producers' production within their organizations for a grouped sale generally to wholesalers or exporters or to a local trader who resells it to a more massive intermediate trader (wholesaler). This channel's use is estimated at 23.5% [7] on average for the regions of the Boucle du Mouhoun, the Hauts Bassins, the East, and the Cascades.

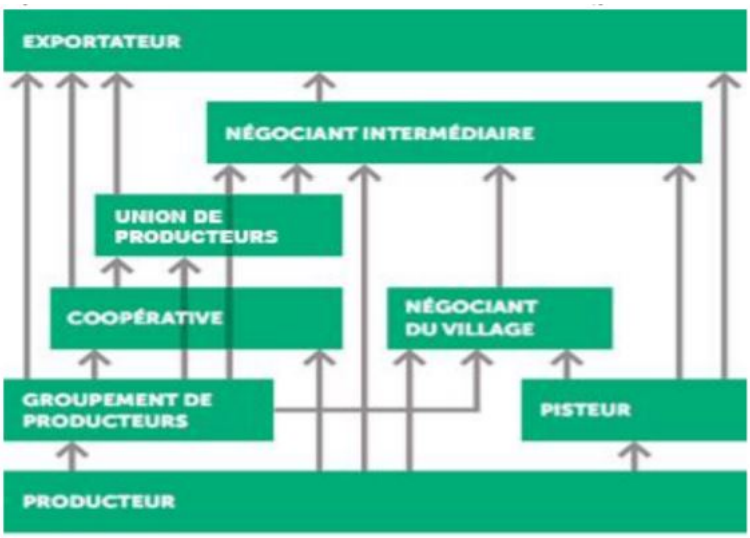
Rural and urban market channels: In most villages and urban markets in Burkina Faso, sesame is available in varying quantities and prices depending on the period of the year and production level. These markets are mainly supplied through direct sales channels by producers, producers' reserves, and those involving collectors (sale of collected reserves).

The option to sell is made depending on their expected selling price. Farmers also have to choose when to sell their harvest at the beginning or during or at the end of the marketing campaign. Price received by farmers depends on the international price of the commodity and other issues such as the transaction cost, which includes transportation cost, which is very high because of

[6] Report "Analyse de la chaine de valeur du sesame au Burkina Faso 2018."
[7] Report "Analyse de la chaine de valeur du sesame au Burkina Faso 2018."

poor road infrastructures and inadequate means of transport and market price information. Farmers are isolated actors who lack or have limited access to market information. Farmers often complain about being less Informed about prices and having no price reference. The provision of relevant information can allow producers to re-balance negotiations with traders.

Figure 1: Main marketing channels for sesame



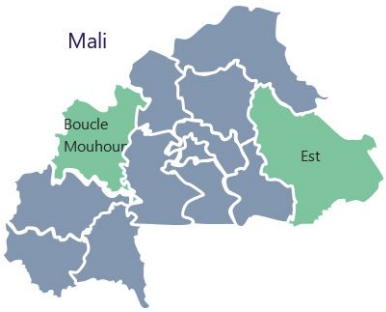
Source: International Marketing – Management Consulting Group

2.2 Details about the treatment and the data

We organized a randomized controlled trial (RCT) to test the n'kalô market information service's effect on the price received by farmers; the randomization happened at the household level. The RCT underlying this study has been conducted in two regions in Burkina Faso (Region Est and Boucle du Mouhoun). They represent the regions where sesame is widely grown (the main sesame production regions are the Boucle du Mouhoun, the East, the Hauts Bassins, and the Cascades. Over the period, these four regions produced 69.04% of national production, with 70% of the total area under cultivation). Boucle du Mouhoun is situated in the western part of the country. It shares a border with Mali, where the security situation (as represented in figure2) is not stable and subject to frequent attacks. We have to take into account this particular characteristic of this region. The other region is Est, as its name indicates, is located in the eastern part of the country.

For each region, we selected three groups. Two groups were treated by two treatments, and the third is the control group. Farmers in treated groups were given a free subscription to the n'kalô service. They received SMS information alerts (see an example of a text message received in 3 for each treated group and region). We have to emphasize that we start the treatment after harvesting

Figure 2: Map of Burkina Faso Regions



to limit any impact of the experiment on farmer production choices and focus on farmers' marketing and commercial behavior.

- In the first treatment group (t_1) we send SMS to farmers about the current regional price during selling period;
- In the second treatment, we inform the second treated group (t_2) by SMS about the current regional price, the expected short term future price, and we give them suggested quantity to sell during selling periods.

This experimental design is used to investigate which information is relevant for farmers or if they need assistance in managing their harvest stock sale, leading to a better time arbitrage to sell their harvest optimally. Suppose We suppose that any additional and relevant information and advice are helpful. Knowing the price, the trend, and the advisers' recommendations allow farmers to follow instructions and plan the best sale time at the best price regarding the market analysis to maximize their profit. However, we may also expect that the trend information can help farmers make the best strategy by selling at the best moment or may confuse and limit their bargaining capacity immediately if there is a downtrend, because he will rush to sell the harvest, in this case, the farmer may accept a lower price in order to avoid a price drop. Price varies between two regions and within each region; thus, the SMS received price information contains a minimum price and maximum price. Price variation inside the region is mainly related to locality remoteness and the transaction cost (see the figure 3 as an example of SMS received).

On average, the field's surface used to cultivate is about 2.5 hectares and producer about "590 Kg ". Sesame has long been grown in Burkina Faso; we expected that all farmers have different backgrounds in his cultivation and commercialization experience. We take into account this heterogeneity using the date when farmers start to cultivate sesame. The sample size is 760 farmers. [8] The survey was conducted by mobile phone, and the questionnaire focuses

[8]This sample size was determined as reported by Fafchamps & Minten (2012) and Dixit *et al.* (2010). The primary channel through which we expect SMS information to affect welfare is through producers' prices. Therefore, we want a sample size large enough to test whether SMS information raises the price received by farmers. Dixit *et al.* (2010) present

on agriculture practices and the use of the information provided by SMS.
We collect data: on the price and the moment of the farmer's transaction; and other characteristics of farmers like education, age, where they live, their needs of liquidity. The same questionnaire was used for treated and control groups. We ask respondents for treated groups if they informed other sesame producers. We ask the control group if other people informed them about the price information provided by SMS n'kalô to catch spillover effects. Our initial data contains information about the localization at the region's level detailed, so we randomized at the regional level.
We stratify our sample considering the other crops cultivated by the farmers and the mobile phone operators; stratifying enhances efficiency. The data used in this paper was collected in March 2019. We choose the third week of March to start the survey as the last week of the harvest, and usually, farmers had already sold the majority of their production, and the information is still fresh in their mind. The survey was realized by mobile phone in ten days to avoid any externality effects and includes the three groups.

results suggesting that price information raises the price received by Indian farmers by 1.6% on average. Based on this estimate and its standard error, a simple power calculation indicates that a total sample size of 500 farmers should be sufficient to identify a 1.6% effect at a 5% significance level. To protect against loss of power due to an expected loss of the sample size between 10% and 25% caused by the SIM change and deactivation's numbers, it is a common phenomenon in Burkina Faso where a large part of the of the population rarely opts for a telephone subscription because of its high price in this case they should feed their sim card with prepaid top-ups to conserve it. We increase our sample size by 25%.

Figure 3: SMS received by both treated groups in regions Boucle du Mouhoun Est

Region Boucle du Mouhoun

BM – Groupe traité (prix, tendance, conseil)
Nkalo sésame : Très forte demande bord-champ. Prix bord-champ : 675-700 FCFA/kg. Evolution court-terme : légère hausse. Conseil : vendez un quart de votre stock.

BM – Groupe traité (niveau du prix)
Nkalo sésame : Très forte demande bord-champ. Prix bord-champ : 675-700 FCFA/kg.

BM - Group treated (price, trend, advice)
Nkalo sesame Very high demand at the farm gate the prix b. Farm gate price: 675-700 FCFA / kg. Short-term trend: slight increase. Tip : sell a quarter of your stock.

BM - Group treated (price level)
Nkalo sesame Very high demand at the farm gate the prix b. Farm gate price: 675-700 FCFA / kg.

Region Est

E – Groupe traité (prix, tendance, conseil)
Nkalo sésame : Très forte demande bord-champ. Prix bord-champ : 700-735 FCFA/kg. Evolution court-terme : légère hausse. Conseil : vendez un quart de votre stock.

E – Groupe traité (niveau du prix)
Nkalo sésame : Très forte demande bord-champ. Prix bord-champ : 700-735 FCFA/kg.

E - Group treated (price, trend, advice)
Nkalo sesame Very high demand at the farm gate the prix b. Farm gate price: 700-735 FCFA/kg. Short-term trend: slight increase. Tip : sell a quarter of your stock.

E - Group treated (price level)
Nkalo sesame Very high demand at the farm gate the prix b. Farm gate price: 700-735 FCFA/kg.

Source : Nitidae text message send in 16 November 2018

3 Descriptive statistics

In this section, we describe our data collected during the survey. One of the problems that we encountered was non-response (rate of non-response 30%). The main reasons for non-response are (i) farmers may cancel or change their Sim card, (ii) network problems [9], (iii) security problems in the country, as the farmers are very vigilant and prefer not to talk to foreigners by phone. This phenomenon can affect the quality of our randomization experiment. However, we do not have data on non-respondents, and then we can learn the effect on the respondents. We inspect if farmers who respond in the treatment group

[9]presence in Burkina Faso, and we could not manage to call. Sometimes it depends on the location; indeed, there are more efficient network operators than others depending on the location and vice versa

are similar to the control group by comparing their main characteristics.
Table 1 reports baseline summary statistics for the full sample and separately by treatment status. This table compares a set of household head characteristics, geographical situation and agricultural production choices, and life quality between treated and control groups. In the first column we report the average value for the whole sample, the second for the control group the third and fourth column reports the average of the characteristics for the treated group by the first treatment (information about current price) and the second treatment (information about the current price, trend and a piece of advice about the quantity to sell) respectively.
Farmers who received the first treatment are the least represented in our database. We correct that by re-weighting our data and test characteristics groups to balance between the treatment and control group. In the full sample, farmers are 41 years old on average and predominantly male; women represent less than 5% of the entire sample. The sample is not highly educated as in Burkina Faso and other Sub-Saharan countries: while 37% have completed their primary school, nearly 56% have no formal education. About 9.6% of the sample are farmers and have a commercial activity; they play intermediary roles by buying the crop from other farmers and reselling it.

Table 1: Farmers Characteristics

	(1) **All sample**	(2) **control**	(3) t_1	(4) t_2	(5) Difference (3)-(2)	(6) Difference (4)-(2)
	533	195	148	190		
Individual Characteristics						
Age	41.2	42.8	40.4	40.3	-2.3*	-2.4*
% Mal farmers	95.4	94.68	93.8	97.3	-0.01	0.01
% Finish his primary school	37.3	24.07	42.2	41	18.35***	16.9***
Life quality						
% Having electricity	85	78.9	91.1	84.6	12.22*	5.7
% Being in debt	33.6	27.27	39.2	32.8	11.91**	5.5
Home building						
% of house build by mud brick	81.1	82.5	80.0	81	-4.1	-2.5
% of house build by cement brick	7.97	8.4	6.9	8.5	-1.6	0.0
% of house build by cut stone	8.81	7.7	8.3	10.1	0.4	2.3
Geographical situation						
% of people living in region EST	39	36.36	37.4	41.3	0.79	4.68
% of people living in region BOUCLE DU MOUHOUN	43	51.04	39.5	42.3	-11.85**	-8.94
% of people living in region HAUTS BASSINS	13	6.29	17	12.2	10.6**	5.8*
% of people living in OTHER REGION	5	6.29	3.33	4.2	-2.12	-2.08
Distance to the nearest city	20.6	20.8	21.4	19.7	0.62	-1.25
Distance to the nearest marketplace	7.5	7.78	7.6	6.8	-0.16	-0.95
Agricultural information						
Field Area of sesame production	2.4	2.3	2.4	2.6	0.12	0.28*
% of sesame as a principal crops revenue	61.7	64.1	56.8	63.2	-0.07*	-0.01
% of Cotton producer	49.3	44.1	54.4	50.5	-0.1*	-0.06
% of peanut producer	66.5	65.6	62.6	70.6	0.03*	-0.05
% Of member in a cooperative	69.9	67.7	73.6	69.1	-0.06*	-0.01
Average years of sesame production	7.4	7.2	7.8	7.5	0.39	0.27
% Being visited by buyer more than one time in a week	48.78	50.3	52.03	42.63	1.6	-7
n'kalô Usage						
% of those who know n'kalô	37	26.1	41	45	-0.15***	-0.19***
% of those who use n'kalô	48	26.3	56.2	64	0.29***	0.37***
% of those who use n'kalô need to translate the SMS	41.3	39.4	38.7	44.1	0.18***	0.16***
% less than two sells	71	86.6	90	88	-0.15***	0.02
Commercial						
% of Commercial	9.6	6.3	10.8	12.1	4	6

Note: Authors' computation based on data 2019 after the survey, *** indicates statistical difference of means significant at ***1%, **5%, *10%. t_1 represent the treated group by an unique information on price. t_2 label the treated group by all information (price, trend and advice). *control* present the control group.

We consider the life quality [10] by two proxy variables: the first is to have electricity in the house, and the second concerns the house's building materials. 85% of the sample have electricity in their houses, and 70% use solar energy to generate electricity. 80% of housing is built from mud brick [11]. We also ask them about their liquidity needs using a proxy variable. Therefore we ask farmers whether they have taken a new debt in the last 12 months and for the following reasons [12]. On average, 26% of the sample goes into debt for agricultural expenses and 7% for other reasons. On average, the control and the treated group have the same distance to the nearest city and local market. Farmers in Burkina Faso produce other cash crops like cotton, shea, and cashew. On average, the control and treated groups have approximately the same percentage of crop production, and more than 60% of farmers view sesame as a principal crop revenue.

3.1 Signing up for the treatment

Table 1 describes how the experiment was implemented in practice. We note that only 60% of farmers being offered n'kalô service declare to receive information by SMS (56% for the first treatment group and 64% for the second treatment); this is referred to as partial (or imperfect) compliance, one of the reasons of this phenomenon is the capacity to read French, could not read SMS messages and thus could not use the service. Besides, 26% of those farmers who did not receive a n'kalô SMS did not know if they received text messages or not; all were illiterate and could not read SMS messages and could not benefit from n'kalô service. In table 14 in appendix B, we can observe another phenomenon: a high rate of contamination: 25% of control farmers use n'kalô. The control group who received the information we put in a fourth group separately in column 5 named. $treat_3$[13] This is explained by a particular situation in many sub-Saharan countries where the cost of communication at the same operator is lower from one operator to another. Therefore, it is more advantageous to have several sim cards to switch between them to communicate. Thus, they could register at the service using different numbers than those registered in the initial database.

Table 2 reports the characteristics of the n'kalô farmers who sign up or not. Farmers who sign up have characteristics different from those who did not sign up. They are more educated and live near the city. Living closer to the city promotes the education of the population.

[10] We did not ask farmers about household composition, revenue, and some sensitive issues because farmers see this as a personal issue, and in this situation, we can not finish our questionnaire via mobile phone.

[11] Household composition brings us to know their expenditures and liquidity requirements.

[12] To pay for school fees or medical needs or everyday needs; to invest in agriculture or other investments; we also ask them about a widespread specific debt in sub-Saharan money from intermediaries at the start of production and pay them credit during the harvest period by nature or in cash

[13] This group was dropped from the control group in the econometric analysis.

During the survey, treated farmers, who received n'kalô information, asked for such information more frequently because prices may fluctuate during the same week on the one hand, on the other hand, farmers who used the n'kalô information might be more aware of the importance of this information to allocate the sales better. Furthermore, traders have access to information and knowledge of the market through their network organization and their frequent movements in several markets. Due to high transport costs, most of the harvest sales are made in the local farmers' community: 56% of transactions between farmers occur on the local market and 29% at the farm gate to intermediates.

Farmers who sign up for the treatment do not have a precarious electricity source; their primary source is solar energy or electricity proposed by Burkina Faso's national electricity company. Besides, their houses are also built of more sophisticated material; we can assume that farmers who are assigned to the treatment but who did not sign up to n'kalô may be different from farmers assigned to n'kalô. These differences may be associated with the outcomes of interest, thereby invalidating simple comparisons of outcomes by treatment received. In other words, the randomization that validates comparisons by treatment status does not validate comparisons by post-treatment variables such as the treatment received. These issues come up both in randomized experiments as well as in observational studies. The general term for these complications in the econometric literature is the endogeneity of the treatment received. Random assignment ensures that the treatment assignment is exogenous, but it does not refer to the exogeneity of the treatment reception if the receipt of treatment is different from the assignment to treatment. To deal with noncompliance, first, one can ignore the actual receipt of the treatment and focus on the causal effects of assignment to the treatment in an intention-to-treat analysis. Second, we can only identify the average effects for sub-populations induced by the instrument to change the endogenous regressors' value. We refer to such sub-populations as compliers and the average treatment effect identified as the local average treatment effect LATE. This terminology stems from the canonical example of a randomized experiment with noncompliance using an instrumental variables method. Where the instrumental variable is the random variable: assignment to the treatment.

3.1.1 Description of Compliers

As highlighted before and in the appendix A the local average treatment effect (LATE) is the average treatment effect for "compliers": those who are induced to use n'kalô after being selected by the experience. In contrast, "always takers" or "never takers" have uses of n'kalô that are unaffected by the experiment. It is not possible to identify the compliers, but it is possible to describe their average observable characteristics. In table 3 we show that compliers are more educated, younger have less credit constraints and live near the village market.

Table 2: Individual Characteristics Sign up VS no sign up to treatment

	(1) $No-sign-up$	(2) $Sign-up$
	275	254
Individual Characteristics		
Age	42.57	40.55
	(11.15)	(10.16)
% Finish his primary school	18.9	56
Life quality		
% Having electricity	82.48	85.31
Geographical situation		
% of people living in region EST	49	51
% of people living in region BOUCLE DU MOUHOUN	53.1	46.9
% of people living in region HAUTS BASSINS	45.6	54.6
% of people living in OTHER REGION	81.5	18.5
Distance to the nearest city	21.2	20
	19.5	17.6
Distance to the nearest marketplace	7.5	7.6
	10.2	12.2
Agricultural information		
Field Area of sesame production	2.3	2.5
	(2.1)	(2.5)
Average years of sesame production	7.1	7.8
	(6.3)	(5.9)
% of sesame as a principal crops revenue	63	65.4
% of cotton producer	48	50.4
% of arachide producer	64.23	68.65
% Of member in a cooperative	64.73	75.1
% Of member of the executive desk in a cooperative	34.46	50
n'kalô Usage		
% of those who know n'kalô	16.36	59.84
% of those who use n'kalô	0	100
% of those who use n'kalô need to translate the SMS	10.55	54.72
% less than two sells	93	90
Commercial		
% of Commercial	8.7	10.7

Notes: Authors' computation based on data 2019 after the survey, *** indicates statistical difference of means significant at ***1%, **5%, *10%. Let $Sign-up$ represent farmers who read n'kalô information. $No-sign-up$ represent farmers who not read n'kalô information.

Table 3: Characteristics of compliers

VARIABLES	(1) Compliers
Read french	1.30
Finished primary school	1.44
living in region of Boucle du Mouhoun	1.25
living in region EST	1.00
aged more than the mean of the population	0.74
Having credit	0.7
having a lot size more than the mean	1.25
history of producing more than the mean of the population	1.13
Producing sesame as the main crops	1.23
Need to translate sms	0.41
Distance to the nearest market more than the mean 7.5	0.84
Distance to the nearest city more than the mean 20.6	1.05
number of sales more than one sell	0.97
Being a member of cooperative	0.8

Note: Authors' computation based on data 2019 after the survey,

4 Empirical strategy

In this section, We are testing the following hypothesis:

- If market price information through mobile phone enables farmers to be strategic during selling campaigns by concentrating their sales during pics prices through a better time arbitrage in the management of crop sales stocks. Therefore, treated farmers should receive a higher price a higher turnover for their crops than uninformed farmers.

- We also investigate through which channel this information could impact farmers' profit. Therefore, we compare farmers' marketing behavior between treated and untreated farmers. n'kalô market price information represents an argument for farmers to negotiate prices with traders better; in this case, farmers could sell their harvest at farm-gate without traveling to the market place.[14] Besides, in the case of a semi-perishable product, farmers could choose the times to sell their harvest, sell in once or several times, and investigate any modifications in the frequency of sales between treated and control groups.

- This experiment also tests what kind of information needs farmers may have. Is it clear information about the current price that they could combine with their knowledge in commercial activities, or they need an

[14]Fafchamps & Minten (2012)do not find an impact on farmers' marketing behaviors, where most sales take place in diversification on market places in a perspective of a spatial arbitrage.

analysis of the current market situation and specific commercial instructions.

We present our empirical strategy to quantify the effect of information received via SMS on various outcome indicators through control and treatment groups, such as farmers' price or turnover. Let $t_{1i} = 1$ if farmer i assigned to the treatment 1 the current market price. $t_{2i} = 1$ if farmer i is assigned to the second treatment the current market price, information in trend and advice about the quantity to sell.

So, we are interested in several outcomes, first the intent to treat, which report being randomly assigned to the treatment. The estimation equation is:

$$Y_{irt} = \theta + \beta_1 * t_{1irt} + \beta_2 * t_{2irt} + \tau_r + time_t + \alpha * X_{irt} + \varepsilon_{irt}, \qquad (1)$$

Where, t_{1irt} is an indicator variable that takes the value 1 for farmer i, in region r assigned to treatment 1(only price information) and 0 otherwise;
t_{2irt} is an indicator variable that takes the value 1 for an individual, i, in region r assigned to treatment 2 (price information, price trend and the advice)
τ_r is a region fixed effect, $time_t$ is a time fixed effect and X_{irt} [15] is a vector of characteristics of the farmers i or the sesame field that could affect the outcomes Y_{irt}.
β_1 is a parameter that report the impact of the price information and β_2 the trend information and the commercial instruction about the quantity to sell.
We expected a positive impact of price information, group t_{1irt} may benefit farmers by improving their bargaining power with traders and sharing commission agents. We may suspect an ambiguous effect of the treatment t_{2irt}, therefore we should investigate if the trend information and the consulting service will help farmers make the best strategy by selling at the best moment or limiting their bargaining capacity immediately.

Next, we look for the direct effect of reading n'kalô SMS on farmers [16]. Let $S_i = 1$ if Dummy variable takes 1 if the farmer signed up for the treatment, and 0 otherwise.

$$Y_{irt} = \theta + \gamma * S_i + \tau_r + time_t + \alpha * X_{irt} + \varepsilon_{irt}, \qquad (2)$$

As explained before, reading n'kalô SMS is not random and can affect the real effect of the outcomes (self-selection effect) where ε_i the error term might be correlated with S_i. We use an instrumental variable approach to deal with

[15] As we show in section 2 the price is higher when the quantity sold is bigger, this case represent farmer who are commercial in the same time who sell their harvest and work also as intermediary between sesame producers and grossest by buying their harvests and reselling it or farmer who produce other crops but play the role of intermediary on sesame.

[16] To estimate the direct impact of n'kalô services, we should consider that (40%) of treated groups declare not to sign up to n'kalô SMS. Other farmers in the control group declare to receive n'kalô SMS because they were subscribed to the initial data by several numbers of their families. As mentioned before, I put this part of the control group in a separate group named $treat_3$; We remove this noise in the control group in our empirical strategy.

the endogeneity problem, using an instrument the assignment to the treatment, t_{1i} and t_{2i} as a random variable where the probability to sign-up is higher among those assigned to the treatment. We can define this IV estimation as the local average treatment effect (LATE) (we explain the approach to estimating the LATE in appendix A). The parameter γ in equation 2 is interpreted as the effect of n'kalô in complier, the farmer who would be induced to sign-up if offered the service for free (In appendix A how could we characterize compliers).

5 Results and discussions

5.1 Price dispersion

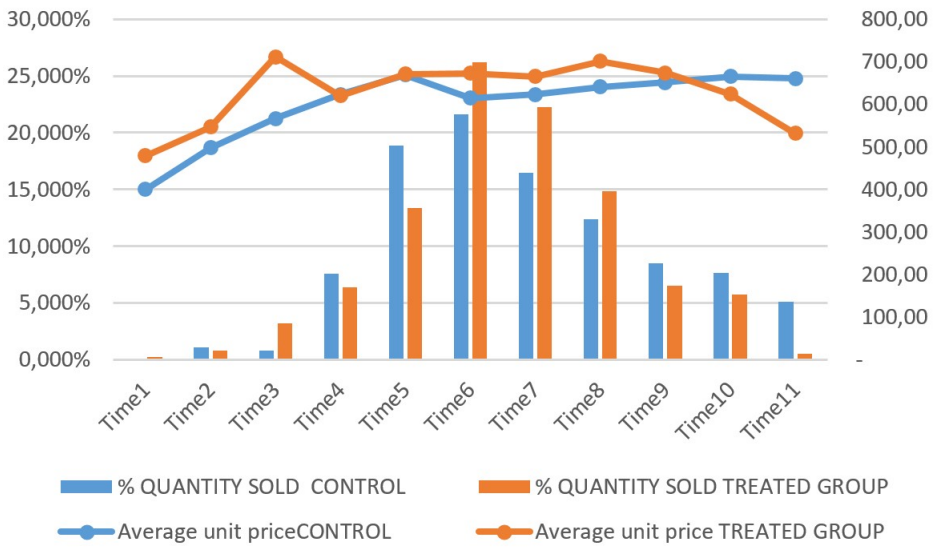
We begin by reporting a holistic view of the n'kalô market information services' impact on price variation during the sesame commercial campaign. We suspect a reduction in price dispersion between markets and treated groups; the information received is a signal that could reduce asymmetric information and enable better market efficiency. We observe that sesame prices do not vary from one region to another on average. The selling price between October and March 2019 in the region of Boucle du Mouhoun is 634 FCFA, an average price higher than that observed in the Eastern region 630; however, the price is more dispersed (the coefficient of variation in Boucle du Mouhoun is 0.19 and region Est 0.15). Price variation within the treated group does not exceed that observed in the control group (0.19 versus 0.18).

In contrast to the role anticipated for information to reduce market price fluctuation, and the results observed by Jensen (2007), he shows that the adoption of mobile phones by fishermen and wholesalers was associated with a dramatic reduction in price dispersion. These results are more accentuated if we focus on the region of Boucle Du Mouhoun (the coefficient of variation is 0.18 control group and 0.21 in the treated group). These results are more clearly observed for t_1 (the coefficient of variation is 0.15 and 0.11 in Boucle du Mouhon and region Est, respectively). In our analysis, we do not have enough information about the locality, and as explained before, the price naturally varies in the different localities in the same region, but what can be a concern is the high dispersion of the prices of the treated group compared to the control group.

These results, such as average prices, do not consider the quantities sold during the sales period, which hides farmers' strategies during profitable mass sales periods. Producers can accept low selling prices to meet their immediate liquidity needs and sell more when the price is higher if we calculate the average unit price within the region by the groups and the percentage of the quantity sold during the sales period, as illustrated in figure 4 where we observed the average unit price for all treated and control groups. In the EST region (figure 5), this price is greater than or equal to the control group's price during the sales period. Furthermore, at the beginning of the period, we see a remarkable price differential between the treated and control groups. This can be

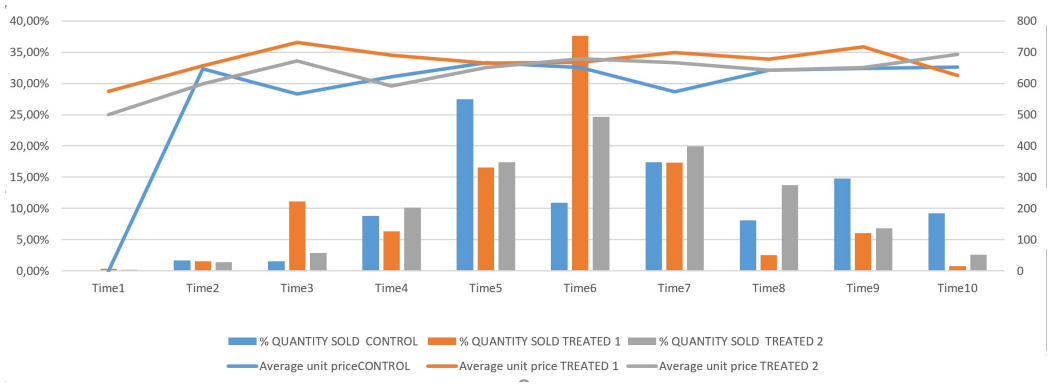
explained by the lack of information circulating in the region, due to an ignorance of the market price position at the beginning of the period intensified by the critical security situation.

Figure 4: Average unit price and quantity sold by groups



Notes: Authors' computation based on data 2019 after the survey, Time1 to time11 represents a period of two weeks for each point starting from October to March.

Figure 5: Average unit price and quantity sold (Region EST)

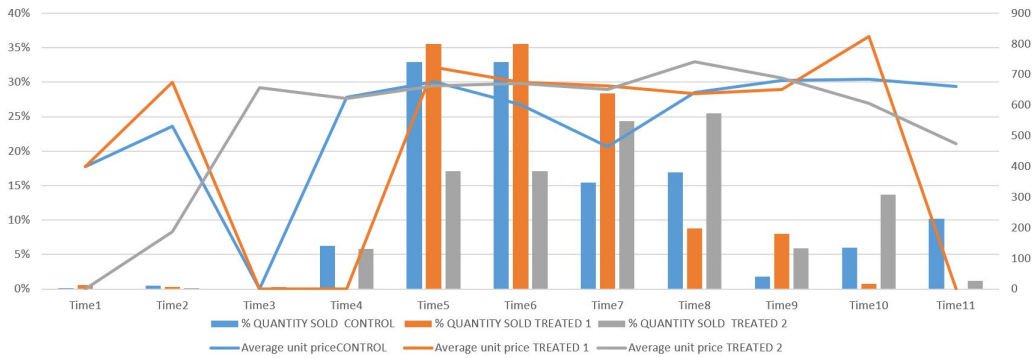


Notes: Authors' computation based on data 2019 after the survey, Time1 to time11 represents a period of two weeks for each point starting from October to March.

In Boucle du Mouhoun region, farmers start selling their harvest effectively six weeks after starting the selling period. The average unit price for the treated group was mostly higher throughout the period (figure 6).

We expect n'kalô information to help farmers make the best profit by receiving the best price on average thanks to their capacity to bargain and to sell at the right moment when the price is higher. As explained before, farmers

Figure 6: Average unit price and quantity sold (Region Boucle du Mouhoun)



Notes: Source : Authors' computation based on data 2019 after the survey, Time1 to time11 represents a period of two weeks for each point starting from October to March.

are constrained to make concessions and may sell a part of their harvest at a lower price because of the liquidity needs. Informed farmers sell more during price peaks, as we can see in figure 4. So, the farmers' strategy is to sell most of their products when the price is high.

5.2 Price received and turnover

Our parameter of interest is the average gain from the n'kalô-based program for the subset of farmers who benefited from the program during the 2018-2019 marketing season. This parameter answers the question: how much informed farmers receive (in terms of price and turnover) compared to what they would have received had they not integrated the program? This is what we investigate in Table 4. The dependent variable is the logarithm of the unit price received by the respondent on average over all the sesame sale transactions during the selling period. Similar results are obtained if we use the price level instead of the log. The unit of observation is the sales transaction. Most farmers report a single sale, but some report more than one, which explains why the number of observations exceeds the number of participating farmers.

In column (column 1 to 4 table 4), all analysis is conducted in terms of intent-to-treat: the treated are offered a free one-year subscription to the n'kalô market information services, whether or not they accepted it. We also report the local average treatment effect (IVLATE) results in which we instrument actual Nklao usage with random treatment assignment. We refer to these results as IV or LATE estimates interchangeably.
We start in table 4 by evaluating the impact of the information received by n'kalô on sesame price and farmer turnover by combining both treatments t_1 and t_2 farmers to improve efficiency. The first and second columns of Table 4 report estimating the impact of treatment on price and turnover respectively

Table 4: Prices received(expressed in log(price/kg) Turnover(expressed in log(quantity*price))

VARIABLES	(1) OLS$_I TT$ log_price	(2) OLS$_I TT$ log_turnover	(3) OLS$_I TT$ log_price	(4) OLS$_I TT$ log_turnover	(5) IV$_L ate$ log_price	(6) IV$_L ate$ log_turnover
Being treated	0.0436*	0.124	0.0448*	0.170		
	(0.0235)	(0.147)	(0.0235)	(0.128)		
Sign in n'kalô					0.106*	0.647**
					(0.0563)	(0.321)
Being in debt			0.0341*	0.155	0.0318*	0.1440
			(0.0196)	(0.107)	(0.0192)	(0.198)
Productivity			0.000237***	0.00359***	0.000205***	0.00295***
			(6.38e-05)	(0.000371)	(4.98e-05)	(0.000572)
Region BM vs EST	-0.0276	-0.170	0.00308	0.0691	0.00902	0.0263
	(0.0196)	(0.129)	(0.0226)	(0.120)	(0.0218)	(0.134)
Constant	6.105***	10.52***	6.037***	9.337***	5.997***	9.158***
	(0.0790)	(0.229)	(0.0800)	(0.268)	(0.103)	(0.342)
Cragg Donald F-stat					29.219	29.219
Stock Yogo critical value (10%)					9.08	9.08
Observations	449	449	438	438	490	490
R-squared	0.076	0.066	0.119	0.310	0.083	0.207

Notes: The additional controls are: dummy variable for reading French and being a member in a cooperative, time fixed effects number of year production. Sign in n'kalô refer to those who received n'kalô SMS. treated are those who were offered a free one-year subscription to the n'kalô service.
*** indicates statistical difference of means significant at ***1%, **5%, *10%.

ITT obtained using a difference between treated and control groups. As expected, we find a beneficial effect of the treatment on selling price and turnover: the treatment effect is positive and statistically significant for selling price but not significant for the turnover.

We can suppose that non-significant results are due to omitted variables, but the treatment assignment was randomly conducted. Despite that, we explore this possible missing in Column 3 and 4. I estimate the impact of treatment (ITT) on price and turnover respectively taking account the capacity to read French and fixed effect on time when the n'kalô services advised farmers to sell, and region fixed effect we add controls variables for farmer financial situation his knowledge on sesame market and the productivity of the farm. The debt constraint approximates the farmer's financial situation. We ask farmers if they have any debt to repay, and the productivity of the farm or is calculated by the ratio of sesame production divided by the farm's size.[17] The number of years of sesame production is used as a proxy to consider farmer knowledge on sesame strategy of marketing. Again we do not find a significant treatment effect on turnover. Besides, not being in debt is positive but not significant for the turnover estimation. In contrast to that supposed before -being in debt may oblige farmers at any price to pay their loan- farmers with a poor financial situation are more strategic to receive the best price and to make the best turnover. The estimated coefficient of the productivity and number of years

[17] As explain before the inputs the sesame production depends only on the land since the farmer often uses last year's seeds for sowing, and plows it as a source of water.

of production are positive as expected. The treatment effect coefficient for the selling price is approximately equal to one estimate without a control variable; this result can reveal a good quality of our randomized procedure.

Next, in columns 5 and 6, we examine whether the lack of effect is due to non-compliance. Indeed, we have seen that many treated farmers did not eventually use the n'kalô service. To investigate whether non-compliance affected our results, we instrument actual n'kalô usage with the intent-to-treat dummy. The estimated coefficient of receiving the n'kalô service is now significant for the turnover. Furthermore, the estimated coefficient of receiving n'kalô service is more significant in IV or LATE estimation than for ITT that is quite obvious because we focus on compliers those who receive the treatment thanks to the experiment.
One of the objectives of this paper was to identify what information we best assimilated by the farmers. Should we inform the farmer about the actual price or give them information about the future price trend and quantity advice? We expect that all additional and pertinent information is useful. If we informed farmers about the price trend, they could sell at the best price by waiting for the expected price to rise and sell when the price decreases. Alternatively, maybe we can dampen sellers' capacities and strategies acquired over several years by a more programmed procedure with less liberty and flexibility of decision-making.

In table 5, we estimate equation 1, where the first term t_1 indicates the effect of the price and t_2 the trend and advice effect. Columns 1 and 2 report the estimation of the impact of treatment on price and turnover, respectively. The effect of treatment one (price) is positive and significant for price and turnover. When we add the information about the trending price, the effect still positive but not significant. We run the same estimation adding control variables to capture any omitted variables in columns (3) and (4). The result is almost the same as t_1, while t_2 is still positive but not significant for the trend information and advice.

What can be drawn from the first estimates is that the effect of the n'kalô information is positive and around 4% from a treatment assignment point of view and 7% for compliers. The treatment effect on turnover is higher than the price; it is 17% for treated assignment and 64% for compliers. Therefore, we can conclude a sales strategy, where the central part of the treated groups' production was sold during the price peaks, which was confirmed in figure 4 where the treated groups sell mostly at peak prices. Therefore, the treated groups' behavior was different from that of the control group than the quantities sold during the sales period and the sales frequencies; we suspect fewer sales of the treated groups. We will come back to these behaviors later in the paper. Otherwise, if they had the same behavior, we would observe the same effect for the sale price and the turnover.

In the following, we will analyze two points; the first is the difference in impact according to the two treatments (information on the price versus information on the price, trend, and advice). To better understand if the trend's effect is not significant if we separate the two treatments and if we look at the impact according to the price received and turnover achieved. The second point is to analyze the channels through which farmers benefit from the n'kalô market information services by analyzing farmers marketing behaviors; we also investigate the reasons for the limited impact of the treatments and specifically the assisting service, we explore the possibility of a heterogeneous distribution of the treatment within treated farmers.

Table 5: Prices received (expressed in log(price/kg)) and Turnover in log(quantity*price)

	(1)	(2)	(3)	(4)
	OLS ITT	OLS ITT	OLS ITT	OLS ITT
VARIABLES	log_price	log_turnover	log_price	log_turnover
t_1	0.0712***	0.214	0.0642**	0.254*
	(0.0254)	(0.162)	(0.0260)	(0.149)
t_2	0.0215	0.0530	0.0244	0.113
	(0.0261)	(0.166)	(0.0260)	(0.142)
Productivity			0.000243***	0.00361***
			(6.29e-05)	(0.000373)
Region BM vs EST	-0.0271	-0.168	0.00274	0.0681
	(0.0194)	(0.129)	(0.0224)	(0.120)
Constant	6.096***	10.49***	6.068***	9.468***
	(0.0799)	(0.217)	(0.0852)	(0.267)
Observations	449	449	438	438
R-squared	0.087	0.069	0.135	0.313

Notes: The additional controls are: dummy variable for reading French, being a member in a cooperative and being in debt, time fixed effects number of year production. t_1 represent the treated group by an unique information on price. t_2 label the treated group by all information (price, trend and advice).
*** indicates statistical difference of means significant at ***1%, **5%, *10%.

5.2.1 Market price information services VS Assisting services

We suspect a difference in the distribution of the treatments impact between farmers; we start by comparing each treatment separately. Table 6 reports a comparison between the group who received treatment t_1 (price information) and the control group. The effect on the price is positive and significant. The

impact on the turnover is positive and significant when we add control variables.
Besides, we run in table 7 to estimate the impact of being informed about (price information, price trend, and being assisted by a consulting service) and the control group. This treatment's impact on price and turnover is positive but not significant, even if we add control variables. Moreover, the magnitude of the effect is different; it is less significant for group t_2 than group t_1, both in price and turnover.

Table 6: Prices received expressed in log(price kg) & Turnover in log(quantity*price) t_1

	(1)	(2)	(3)	(4)
	OLS ITT	OLS ITT	OLS ITT	OLS ITT
VARIABLES	log_price	log_turnover	log_price	log_turnover
t_1	0.0777***	0.200	0.0813***	0.264*
	(0.0257)	(0.166)	(0.0264)	(0.149)
Constant	6.063***	10.66***	5.995***	9.575***
	(0.0991)	(0.290)	(0.0957)	(0.329)
Observations	264	264	257	257
R-squared	0.117	0.078	0.166	0.281

Notes: The additional controls are: dummy variable for reading French, being a member in a cooperative and being in debt, time and regions fixed effects, number of year production and productivity.
t_1 represent the treated group by an unique information on price.
*** indicates statistical difference of means significant at ***1%, **5%, *10%.

5.2.2 Heterogeneous impact within treated group

To analyze this experiment's intervention's limited effect, we suspect a heterogeneous effect between treated farmers. The effect may differ between the different farmers, living far away, the security problems experienced by Burkina Faso can help mitigate the effect of the treatment. Although we have taken into account the fixed region effect, it is not precise enough as given. Living in a village where access is complicated implies lower selling prices because the transaction cost is very high for the farmer who has to travel to the marketplace to sell his harvest and the intermediary if he comes to the farmer to buy his crop. According to the farmers, the price difference at an instant t depends not only on the market information but also on the transaction cost. This explains why we observe dispersed price intervals due to information asymmetry on the one hand and transaction costs (road access and security situation). The treatment effect can further increase the surplus for a part of the population and

Table 7: Prices received expressed in log(price kg) & Turnover in log(quantity*price) t_2

VARIABLES	OLS ITT log_price	OLS ITT log_turnover	OLS ITT log_price	OLS ITT log_turnover
t_2	0.0224	0.0707	0.0227	0.112
	(0.0259)	(0.165)	(0.0258)	(0.143)
Constant	6.099***	10.23***	6.079***	9.204***
	(0.0705)	(0.255)	(0.0972)	(0.216)
Observations	335	335	327	327
R-squared	0.081	0.104	0.134	0.365

Notes: The additional controls are: dummy variable for reading French, being a member in a cooperative and being in debt, time and regions fixed effects, number of year production and productivity.
t_2 represent the treated group by an unique information on price, trend price and advice.
*** indicates statistical difference of means significant at ***1%, **5%, *10%.

not impact another part of the population, making the average effect positive but not significant. Besides, living in remote rural areas may weaken farmers' bargaining power; they must sell their harvest at a lower price. We suspect that the treatment's effect may differ depending on different price ranges accepted by farmers to sell their crops. We proceed by quantile treatment effects to capture this heterogeneous effect. To explain how the intervention of n'kalô services affects the distribution of selling price and turnover. It concerns differences between (statistics of) the distribution of outcomes with the n'kalô services intervention and the distribution of outcomes without it, such as the impact of this intervention on the variance or a specific quantile of the outcome distribution.

Quantile treatment effects are the difference between the quantiles of potential outcomes. In graphical terms, they measure the horizontal distance between outcome distributions Firpo (2007). We formally define quantile treatment effects on the treated (QTT) as:

$$Dif_{Quantile}(\tau) = q_1(\tau) - q_0(\tau) \tag{3}$$

Where $q_1(\tau)$ is the τ -th quantile of the potential outcomes Y for the treated, and $q_0(\tau)$ the counterfactual quantile from untreated observations.
We focus on compliers, since part of the farmers for which the treatment was intended did not receive it. We use the procedure proposed by Frölich & Melly (2013). The idea consists of re-weighting our sample by giving negative weights to the outcomes of non-compliers from the treatment group makes them "cancel out" counterfactual non-compliers in the control group, leaving us with

the distribution of for counterfactual compliers [18]. We proceed by estimating $Dif_{Quantile}(\tau)$ the difference between the quantiles $q_1(\tau)$ and $q_0(\tau)$ of the reweighted sample.

We start by reporting price distribution by quantile for treated and control groups in figures 7 and 8. Price varies between 200 to 900 Franc CFA for the control group and 200 to 1000 Franc CFA. A variation of 700 Franc CFA between the lowest and the highest price. There is a rapid increase in the first and last quantile price, unlike the middle of the distribution.

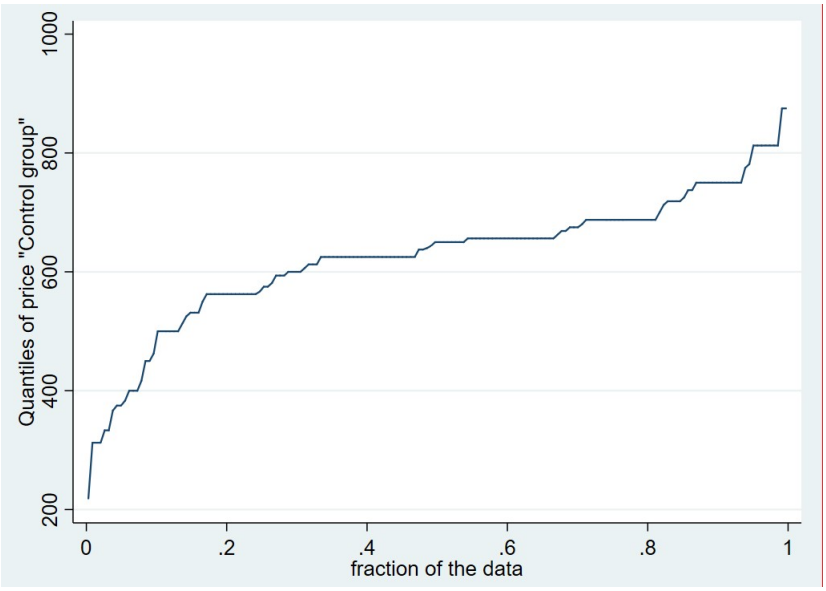
In table 8, I report the quantile treatment effect for compliers in the logarithm of price and turnover for the 25th, 50th, 75th quantiles in the first, the second, the third, fourth, fifth, sixth columns, respectively. On average, receiving n'kalô service increases the selling price, but the impact on turnover is mitigating; it is positive and significant for the first and last quartile but is negative for the 50th quantile. The effect differs from a quartile to another, and the confidence interval of the OLS estimator does not cover some value quantile.

In table 9, and 10 we report the estimation of the quantile treatment effect for the 25th, 50th, 75th quantiles in the logarithm of price and turnover respectively in the third, fourth, fifth, and sixth, column respectively for compliers in the treated group 1 those who receive the first treatment (information about current regional price) in table 9. And the second treated group received the second treatment (information about price, trend, and advice about the quantity to sell) in table 10. We note that on the 25th and 50th, we could increase the sale prices and their turnover, unlike the last quartile, mainly for treatedlevel (price, trend price, and the advice), which was not significant on average. The impact of the treatment on price and turnover is positive and significant for the first three quartiles, refer to farmers who receive low prices and have a reverse impact on farmers who receive high prices.

Another phenomenon that could reduce the treatment's real effect is the spillover effect; farmers in the control group might receive the treatment through farmers in the treated group. Therefore, we ask farmers during the survey if they receive any market information through other farmers related to information services. 14% of the control group declare receiving n'kalô market information through other farmers. Consequently, we consider the following analysis we put those farmers in a separate group to identify the real impact of the treatment. The effect is not significant for price and turnover, as reported by Nakasone *et al.* (2014), who does not find any evidence to support the presence of spillover effects: there are no apparent price benefits to farmers who did not receive the information directly.

[18] For more explication see Frölich & Melly (2013)

Figure 7: Quantile price distribution for control group



Source : Note: Authors' computation based on data 2019 after the survey,

Table 8: Quantile regression; Prices received expressed in log(price kg) & Turnover in log(quantity*price)

	(1) IV LATE	(2) IV LATE	(3) 25th quantile	(4) 25th quantile	(5) 50th quantile	(6) 50th quantile	(7) 75th quantile	(8) 75th quantile
VARIABLES	log_price	log_turnover	log_price	log_turnover	log_price	log_turnover	log_price	log_turnover
Sign in n'kalô	0.0171	-0.0510	0.0187***	0.105***	0.0105***	-0.0547***	0.0104***	0.0413***
	(0.0199)	(0.124)	(0.00317)	(0.0162)	(0.00195)	(0.0140)	(0.00215)	(0.0135)
Constant	6.080***	9.744***	5.956***	9.598***	6.008***	9.716***	6.319***	10.29***
	(0.0834)	(0.272)	(0.0142)	(0.0814)	(0.00791)	(0.0629)	(0.00947)	(0.0598)
Observations	480	480	480	480	480	480	480	480
R-squared	0.124	0.321						

Notes: The additional controls are: dummy variable for reading French, being a member in a cooperative and being in debt, time and regions fixed effects, number of year production and productivity.
Sign in n'kalô refer to those who received n'kalô SMS. .
*** indicates statistical difference of means significant at ***1%, **5%, *10%.

Table 9: Quantile regression t_1; Prices receives expressed in log(price kg) & Turnover in log(quantity*price)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV LATE	IV LATE	25th quantile	25th quantile	50th quantile	50th quantile	75th quantile	75th quantile
VARIABLES	log_price	log_turnover	log_price	log_turnover	log_price	log_turnover	log_price	log_turnover
Sign in n'kalô	0.0779**	0.266	0.0490***	0.416***	0.0350***	0.266***	0.0334***	0.254***
	(0.0311)	(0.176)	(0.00260)	(0.0168)	(0.00144)	(0.0106)	(0.00183)	(0.00908)
Constant	5.974***	9.521***	5.938***	9.327***	5.971***	9.698***	5.982***	9.862***
	(0.103)	(0.338)	(0.0112)	(0.0721)	(0.00618)	(0.0454)	(0.00788)	(0.0390)
Observations	249	249	250	250	250	250	250	250
R-squared	0.164	0.313						

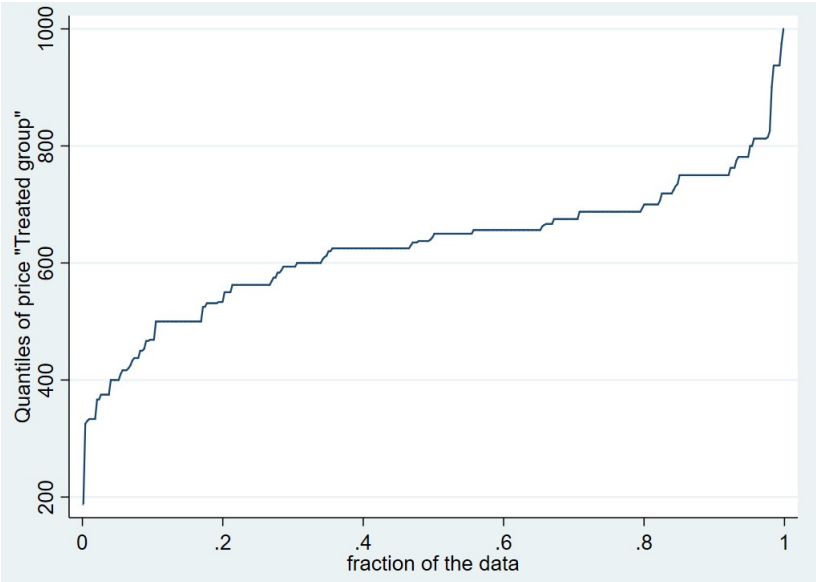
Notes: The additional controls are: dummy variable for reading French, being a member in a cooperative and being in debt, time and regions fixed effects, number of year production and productivity.
Sign in n'kalô refer to those who received n'kalô SMS in t_1. .
*** indicates statistical difference of means significant at ***1%, **5%, *10%.

Table 10: Quantile regression t_2; Prices receives expressed in log(price kg) & Turnover in log(quantity*price)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV LATE	IV LATE	25th quantile	25th quantile	50th quantile	50th quantile	75th quantile	75th quantile
VARIABLES	log_price	log_turnover	log_price	log_turnover	log_price	log_turnover	log_price	log_turnover
Sign in n'kalô	0.0376	0.0131	0.0199***	0.117***	0.0170***	0.0170	0.0173***	-0.0310***
	(0.0281)	(0.157)	(0.00302)	(0.0137)	(0.00151)	(0.0107)	(0.00158)	(0.00974)
Constant	6.075***	9.344***	5.990***	9.338***	6.002***	9.083***	6.329***	9.672***
	(0.0947)	(0.225)	(0.0169)	(0.0767)	(0.00842)	(0.0598)	(0.00881)	(0.0545)
Observations	318	318	318	318	318	318	318	318
R-squared	0.128	0.370						

Notes: The additional controls are: dummy variable for reading French, being a member in a cooperative and being in debt, time and regions fixed effects, number of year production and productivity.
Sign in n'kalô refer to those who received n'kalô SMS in t_2. .
*** indicates statistical difference of means significant at ***1%, **5%, *10%.

Figure 8: Quantile price distribution for treated group



Source : Note: Authors' computation based on data 2019 after the survey,

5.3 Farmers information sources and marketing strategies

To identify channels through which farmers realize the benefit from n'kalô market information, we take advantage of a rich database that allowed us to study the behavior and strategies of farmers treated and untreated to sell their products. At first, we estimated the effect of access to n'kalô information on farmers' strategies where to sell and whom to sell and the frequency of selling. In the rural area in Burkina Faso, farmers can sell their harvest at the farm gate, in the local market, or to sell to a cooperative. Table 15 and 11 report the percentage of farmers' sales in the marketplace to middleman or cooperatives or several buyers for those who cannot specify respectively for the reception and the assignment to the treatment. The groups who received or to whom the information n'kalô was assigned to sell less to the market and sell more to middleman than those who did not receive the n'kalô information or were assigned to receive it.

We use a multinomial Probit for estimating where-to-sell and whom-to-sell to test whether there is a statistical difference between treatment. Table 12 we report results in columns 1 to 3 by combining all treated groups in the first column and looking for each column at the second column (t_2) and (t_1) at the third column. We complete these estimations with a look at the effect of access to n'kalô service on the frequency of transaction (selling) in which the dependent variable takes ordered values (column 4 to 6 in Table 12) as once per sesame campaign, twice per sesame campaign, and more than twice.

We take on account additional control variables to control for observable

Table 11: Source for marketing information

	(1) **All sample**	(2) **control**	(3) t_1	(4) t_2
The important source to consult				
% Using last year price	63.5	58.6	61.8	69.2
% An other nearest producer	20.8	18.5	25	20.3
% Information by n'kalô or other services	30.9	22.2	36.4	31.1
% Cooperative information	13.8	17	12.1	14.7
% Information listen in the nearest local market	34.5	42.2	26.4	33.9
Most important information				
%Assisted by indicating current price, trend and quantity to sell	49	40	45	
% Information about current price level	51	60	55	
Where to sell the harvest				
% In local market	53.3	57.3	47.4	54.3
% To a middleman	33.9	25.8	41	34.5
% To a cooperative	4.9	5.8	6.4	3.1
% Not have precision	7.9	11	5.2	8.1

Note:t_1 represent the treated group by an unique information on price. t_2 label the treated group by all information (price, trend and advice). *control* present the control group.

heterogeneity within the sample.[19] Farmers who receive t_1 (price information) are more likely to sell to Middleman than the local market. Providing price information allows farmers to negotiate the selling price without moving to sell on the local market, as suggested by Fafchamps & Minten (2012). The effect of t_2 (price information, trend, and advice) is positive but not significant.

We have listed in Table 11 the sources of price information that we ask farmers to find out what is essential information to determine the selling price. Over 30% of treated groups consider information received by n'kalô is the most relevant information for their marketing choices. The control group instead believes what he hears directly from the market. However, sesame prices and market conditions (demand) can change quickly. The price disseminated at time t for this market will also not be the same as the next market at t + 1. Indeed, several members of the n'kalô service ask for more than one SMS during the week to be aware of various changes on the market (farmers who consider sesame as a principal source of revenue are more likely to mention n'kalô as their main source of information). The treated and control group uses last year's price as a reference. In table 13, we run different regressions to estimate whether n'kalô is a source of information.

The first column reports the average treatment effect on the treated or ATT is calculated using the nearest neighbor matching methodology described in Abadie *et al.* (2004), where matching is performed by region dummy and other characteristics of farmers. We take on account additional control vari-

[19]These are geographical position (region fixed effect; market access variables such as physical distance from the nearest market; the principal crops providing revenue; and the household financial situation being in dept to take into account their need on liquidity; numbers of years of sesame production to indicate the farmers' experience; the size of land for production sesame) to control for the quantity of sesame produced.

Table 12: To whom is the harvest sold and Number of farmers sales

VARIABLES	(1) 1 Middelman	(2) 1 middelman	(3) 1 middelman	(4) nbr_sells	(5) nbr_sells	(6) nbr_sells
Treated groupe	0.375			-0.146		
	(0.248)			(0.142)		
t_1			0.521		-0.442**	
			(0.321)		(0.184)	
t_2		0.221				0.0695
		(0.291)				(0.156)
Not being in debt	-0.542**	-0.798***	-0.766**	-0.0227	-0.187	0.107
	(0.254)	(0.301)	(0.323)	(0.139)	(0.179)	(0.159)
Region EST vs Region BM	-1.498***	-1.563***	-1.586***	0.279*	0.267	0.241
	(0.253)	(0.299)	(0.325)	(0.155)	(0.206)	(0.175)
Visited by middleman	-0.188	-0.128	-0.434**			
	(0.138)	(0.159)	(0.175)			
Productivity	0.000482	0.000173	0.00104	0.000587*	0.000439	0.000506*
	(0.000679)	(0.000733)	(0.000796)	(0.000317)	(0.000393)	(0.000307)
Distance to the market				-0.0118*	-0.0111	-0.00978
				(0.00673)	(0.00805)	(0.00769)
Production years				0.0256**	0.0294*	0.0181*
				(0.0106)	(0.0172)	(0.0103)
/cut1				0.978***	0.860***	0.988***
				(0.218)	(0.276)	(0.228)
/cut2				1.764***	1.620***	1.765***
				(0.233)	(0.294)	(0.245)
Constant	0.645	0.819*	1.083**			
	(0.417)	(0.464)	(0.495)			
Observations	439	338	272	371	239	276

Notes: t_1 represent the treated group by an unique information on price. t_2 label the treated group by all information (price, trend and advice). *** indicates statistical difference of means significant at ***1%, **5%, *10%. The dependent variable takes ordered values (column 4 to 6) as once per sesame campaign, twice per sesame campaign, and more than twice.

ables to control for observable heterogeneity within the sample.[20] IVLATE estimation is reported in the second column in the third, fourth, and fifth column we look for heterogeneous effects by farmer education and capacity of reading french, knowledge on producing and selling sesame and farm size.

Farmers in the treated group are more likely to mention n'kalô as the source of the sesame price. [21] Educated farmers working on a small farm are more likely to mention the importance of n'kalô as a source of marketing information. This result contrasts with Fafchamps & Minten (2012) where they find that farmers with larger acreages are significantly more likely to mention the RML (a market and production information service) as a source of information. Farmer's age is never significant, found by Fafchamps & Minten (2012) and the number of years of production.

Table 11 (appendix B) explains farmers' information needs and knows their information services expectations; we ask farmers what the most important information to sell at the best price is? Did they need to be 100% assisted by

[20]These are geographical position such as region fixed effect: market access variables such as physical distance from the nearest market, the principal crops providing revenue, being a trader, farmers who declare to look for information before to sell, numbers of years of sesame production to take into account the farmers experience, size of land for production sesame to control for the quantity of sesame produced and the main crops providing revenue.

[21]We take on account other characteristics as age, the capacity to read in french the main source of revenue, region fixed effect, the size of their farm, and commercial farmers.

Table 13: Probability need information like n'kalô (Use of n'kalô)

VARIABLES	(1) Matching	(2) IV Late	(3) Heterogeneous effect (3)	(4) Heterogeneous effect (4)	(5) Heterogeneous effect(5)
treated group			0.359*	0.380**	0.122
			(0.208)	(0.164)	(0.155)
Sign up in n'kalô		0.254*			
		(0.142)			
Not read french		-0.0787	-0.320	-0.472***	-0.511***
		(0.0681)	(0.218)	(0.126)	(0.124)
treated group* Not read french			-0.236		
			(0.266)		
Farmer age		0.000330	-0.000164	-0.000598	
		(0.00202)	(0.00600)	(0.00606)	
production years		-0.00120	0.000398	0.00113	0.00799
		(0.00344)	(0.0110)	(0.0112)	(0.0140)
being a trader		-0.0983	-0.391*	-0.384*	-0.376*
		(0.0689)	(0.231)	(0.231)	(0.220)
Need information		0.0826*	0.215*	0.216*	0.218*
		(0.0428)	(0.126)	(0.127)	(0.125)
Not have electricity		-0.0404	-0.197	-0.195	-0.166
		(0.0576)	(0.182)	(0.183)	(0.179)
Nearest neighor matching	0.0594***				
	(0.00889)				
Treated group*surface				0.186	
				(0.222)	
Treated group* production years					-0.272
					(0.266)
Constant		0.178	-0.654*	-0.623*	-0.492*
		(0.159)	(0.370)	(0.357)	(0.256)
Observations	493	493	493	493	505
R-squared		0.033			

Notes:(1) matching : We take on account other control variable region fixed effect, access to electricity, market access variables such as physical distance from the nearest market, the principal crops providing revenue, being a trader, farmers who declare to look for information before to sell, numbers of years of sesame production, size of land for production sesame and the main crops providing revenue. (2) Sign up in n'kalô to receive n'kalô information, we take on account other control variable the principal crops providing revenue, region fixed effect. (3) To indicate Heterogeneous effect on education, we take on account other control variable the principal crops providing revenue, region fixed effect.
(4) To indicate Heterogeneous effect on farm size, we take on account other control variable the principal crops providing revenue, region fixed effect. (5) To capt Heterogeneous effect on experience of production approximated by number of year of production, we take on account other control variable the principal crops providing revenue, region fixed effect.
*** indicates statistical difference of means significant at ***1%, **5%, *10%.

indicating the price and quantity for sale during the entire agricultural campaign? Or, instead, be directed by the forecast of price developments during this period? More than half of the sample needs asking for more than one market information in a week as what was said before the sesame price fluctuates rapidly. Even the treated t_2 offered information on forecast prices and advice on how much to sell 54% of them consider forecasts on the price is sufficient information.

In table 12, we complete these estimations to look at our experiment's effect on the frequency of farmer's sales[22] -the column 7 treated group to t_1 and t_2 in column 8 and column 9- and -to whom farmers sell their harvest at the farm gate or the closet market (between Middleman or nearest market column 1, 3 and 5). The treated group sells more to intermediaries than market results are positive but not significant. The treated group sells less frequently, confirming a change in the sales strategies of group t_1. They sell 44% than the control group; They took advantage of price peaks for their production. These results coincide with the previous results where, despite a limited impact on the price, the group treated t_1 received higher turnover than the other groups and was due to their strategy of reducing the number of sales during the campaign and focusing on price peaks to sell the majority of their production.

[22]The different modalities of the ordered probit are: "one sell" "two sell", "more than three sell"

6 Conclusion

This paper presents the results from a randomized control trial studying the impact of providing SMS-based agriculture market information in Burkina Faso. This market information service, called n'kalô, sends weekly SMS to farmers with information on prices, trends and gives them advice on the quantity of harvest to sell during the campaign period. The information provided by the service should help farmers to sell their production at the best price by improving their bargaining power with buyers and enable them to better arbitrate in the sale of the campaign (sell the harvest when the price is high). We also study farmers behavior through different information by providing two treatments(treatment1 current price level in the region treatment2 current price in the region, price trend and advice about quantity to sell) in order to understand different farmers strategies according to the different information received, how this impacts the price received, turnover, and marketing behaviors. The crop of interest is sesame, a cash crop production destined for exportation.

The experiment was conducted in collaboration with the NGO Nitidae, supplier of n'kalô, and involved 533 farmers living mainly in this region of Burkina Faso (East and Boucle du Mouhoun). Treatment was randomized across regions; we stratified our sample considering the other crops cultivated by the farmers and the mobile phone operators. Even if our survey suffers from non-response and contaminated control groups, randomized appears good because the control and treated groups are balanced on most relevant variables.

In our experiment, only 60% of the individuals who are offered the treatment (n'kalô information) take it up. That refers to imperfect compliance, that's why we report the intention to treatment where the receipt of treatment is ignored, and outcomes are compared by the assignment to treatment. We also reported IV estimation in which the assignment to the treatment is used to instrument reception of n'kalô SMS.

The impact of n'kalô information on price is about 4%. This impact varies according to the treatments received. Farmers who received only up-to-date price information perform better than those who received price and trend information and advice on how much to sell; the results are not statistically significant for them. n'kalô users, especially those who have received price information, modify their marketing behavior by reducing their sales frequency and selling the majority of the production peaks prices. They were more strategic than those who received the second treatment using n'kalô information to better allocate their sales on time. Distribution of the treatments impact differs through farmers, living far away generate a high transaction cost, the security problems experienced by Burkina Faso can help mitigate the effect of the treatment. That is why we have a high price dispersion that is due to asymmetric information and transaction costs. Using a quantile treatment effect on the treated and focusing on compliers, the impact of the treatment on price and turnover is significantly positive for the first three quartiles, referring to farmers receiving a lower price and having an opposite impact on farmers receiving higher prices.

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AppendixA

Let $z_i \in 0, 1$ a dummy variable denote the randomly assigned treatment by n'kalô(instrument variable). Let $Yi(z)$ denote the potential treatment outcome given assignment Z_i as sales price and the turnover during the sales period, and $t_i \in 0, 1$ a dummy variable denote if the treatment was received(endogenous variable). Define two potential outcomes $t_i(0)$ and $t_i(1)$, representing the value of the status of treatment received given the two values of the instrument z_i. $Yi(z, t)$ denote the potential outcome corresponding to assignment z and treatment received t .

Intention to treat analyses

In an intention-to-treat analysis the receipt of treatment is ignored, and outcomes are compared by the assignment to treatment (Imbens & Rubin (2015)). The intention-to-treat effect is the average effect of the assignment to treatment. In terms of the notation introduced above, the estimation is

$$\mathrm{D}^i tt = \frac{\sum_{i=1}^{N}(Yi(1,t) - Yi(0,t))}{N} \quad (4)$$

Where N is the number of the observations he intention-to-treat principle provides an unbiased assessment of the efficacy of the intervention at the level of adherence observed in the trial. This level of adherence could be similar to that observed in the community, and the results could inform community-based decisions about the effectiveness of the experimental intervention Montori & Guyatt (2001).

Local average treatment effects

An alternative approach that deals directly with the non-compliance is to use instrumental variables methods and related methods based on a set of assumptions. The first one is INDEPENDENCE: $z_i \;\; (Y_i(1), Y_i(0), t_i(1), t_i(0))$ It requires that the instrument is as good as randomly assigned, and that it does not directly affect the outcome. The second assumption requires a Random Assignment $z_i \;\; (Y_i(1,1), Y_i(1,0), Y_i(0,1), Y_i(0,0), t_i(1), t_i(0))$. The third one is Exclusion Restriction It requires that there is no direct effect of the assignment on the outcome without passing through the receipt of treatment. Formally, using the form used in Angrist, Imbens and Rubin (1996).

The last one is is monotonicity (Imbens and Angrist, 1994), or no-defiance, which requires

$t_i(1) \geq t_i(0)$

Table X summarizes the information about compliance behavior from observed treatment status and instrument taking in account this monotonicity assumption. This rules out the presence of defiers, units who always (that is, whether assigned to control or treatment), do the opposite of their assignment.

Table X summarizes the information about compliance behavior from observed treatment status and instrument taking in account this monotonicity assump-

tion.

To estimate the average treatment effect on compliers only or the local average treatment effect LATE. Let denote π_c, π_n and π_a be the population proportions of compliers, never-takers and always-takers respectively. We consider the least squares regression of Y on a constant and Z. The slope coefficient in that regression estimates.

$E[Y_i|z_i = 1] - E[Y_i|z_i = 0]$

Consider the first term:

E[Y$_i|z_i = 1] = E[Y_i|z_i = 1, compliers].Pr(compliers|z_i = 1) + E[Y_i|z_i = 1, never{-}taker].Pr(never{-}taker|z_i = 1) + E[Y_i|z_i = 1, always{-}taker].Pr(always{-}taker|z_i = 1) = E[Y_i(1)|z_i = 1, compliers].\pi_c + E[Y_i(0)|z_i = 1, never - taker].\pi_n + E[Y_i(1)|z_i = 1, always - taker].\pi_a$

(5)

Similarly

E[Y$_i|z_i = 0] = E[Y_i|z_i = 0, compliers].Pr(compliers|z_i = 0) + E[Y_i|z_i = 0, never{-}taker].Pr(never{-}taker|z_i = 0) + E[Y_i|z_i = 0, always{-}taker].Pr(always{-}taker|z_i = 0) = E[Y_i(0)|z_i = 0, compliers].\pi_c + E[Y_i(0)|z_i = 0, never - taker].\pi_n + E[Y_i(1)|z_i = 0, always - taker].\pi_a$

(6)

Hence the difference is $E[Y_i|z_i = 1] - E[Y_i|z_i = 0] = E[Y_i(1) - Y_i(0)|complier].\pi_c$

The same argument can be used to show that the slope coefficient in the regression of W on Z is $E[W_i|z_i = 1] - E[W_i|z_i = 0] = \pi_c$

Hence the instrumental variables estimand, the ratio of these two reduced form estimands, is equal to the local average treatment effect.

Given the monotonicity assumption and the exclusion restriction we can identify the average causal effect of the receipt of treatment on the outcome, what is known as the local average treatment effect (Imbens and Angrist, 1994):

D^{late}=$E[Y_i(1) - Y_i(0)|Complier] = \frac{E[Y_i|z_i=1]-E[Y_i|z_i=0]}{E[t_i|z_i=1]-E[t_i|z_i=0]}$ (7)

Description of Compliers The local average treatment effect (LATE) is the average treatment effect for "compliers": those who are induced to use n'kalô after being selected by the experience. In contrast, "always takers" or

"never takers" have uses of n'kalô that are unaffected by the experiment. It is not possible to identify the compliers, but it is possible to describe their average observable characteristics. $E(X|t_1 = 1, t_0 = 0)$.
For example, define the binary variable t: to be an indicator for the treatment (using n'kalô market information) (e.g. more than 1 night prior to the law change and more than 2 nights after the law change):

$$\begin{cases} 0 & \text{Not using n'kalô information} \\ 1 & \text{Using n'kalô information} \end{cases}$$

Also define t_Z as the value t would take if Z were either 0 or 1. Z is again assumed to be independent of t. Compliers in this context are such that $t_1 = 1$ and $t_0 = 0$.

$E(X|t_1 = 1) = E(X|t = 1, Z = 1)$ represents the characteristics of those who use the treatment (n'kalô information) after being assigned to the treatment and can be estimated by sample means. This can be written as a weighted average of the characteristics of always takers and compliers:
$E(X|t_1 = 1) = E(X|t_1 = 1, t_0 = 1)P(t_0 = 1, t_1 = 1) + E(X|t_1 = 1, t_0 = 0)P(t_0 = 0, t_1 = 1)$
Always takers can be described by the characteristics of individuals who used the treatment (n'kalô information) even without being assigned to the treatment (Z = 0) yet use the treatment (t = 1).
That is, the $E(X|t_1 = 1, t_0 = 1) = E(X|t_0 = 1)$, by the monotonicity condition ($t_1 - t_0 \geq 0$) The last term is $E(X|t_1 = 1, Z = 0)$, which can also be estimated by sample means.
For the probability terms:
$P(t_0 = 1) = P(t_0 = 1, t_1 = 1)P(t_1 = 1) + P(t_0 = 1, t_1 = 0)P(t_1 = 0) = P(t_0 = 1, t_1 = 1)P(t_1 = 1)$
by the monotonicity condition. $P(t_0 = 1)$ and $P(t_1 = 1)$ can be estimated as the sample proportion of those not assigned to the treatment but take it up and the proportion of those assigned to the treatment and using it, respectively. The first is an estimate of the population proportion of always takers π_a by the independence of Z. Similarly, for those assigned to the treatment, and not using it can be used to estimate the population fraction who are never takers, π_n.
The proportion of the population who are compliers is then $\pi_c = 1 - \pi_n - \pi_a$, as "defiers" are assumed away by the monotonicity condition. Among the group assigned to the treatment, the fraction for taking up the treatment,$P(t_1 = 1) = \pi_c + \pi_a$. Thus, $P(t_0 = 1, t_1 = 1) = \frac{\pi_a}{\pi_c + \pi_a}$ and $P(t_0 = 0, t_1 = 1) = \frac{\pi_c}{\pi_c + \pi_a}$. In this case we could estimate characteristics of compliers: $E(X|t_1 = 1, t_0 = 0)$.

The average observable characteristics of compliers $E(X|t_1 = 1, t_0 = 0) = \frac{\pi_c + \pi a}{\pi_c}[E(X = 1, Z = 1) - \frac{\pi a}{\pi_c + \pi_a} E(X|t = 1, Z = 0)$[23]

Appendix B

[23] 9A general method for constructing the mean or other features of the distribution of covariates for compliers uses A Abadie (2003). kappa-weighting scheme.

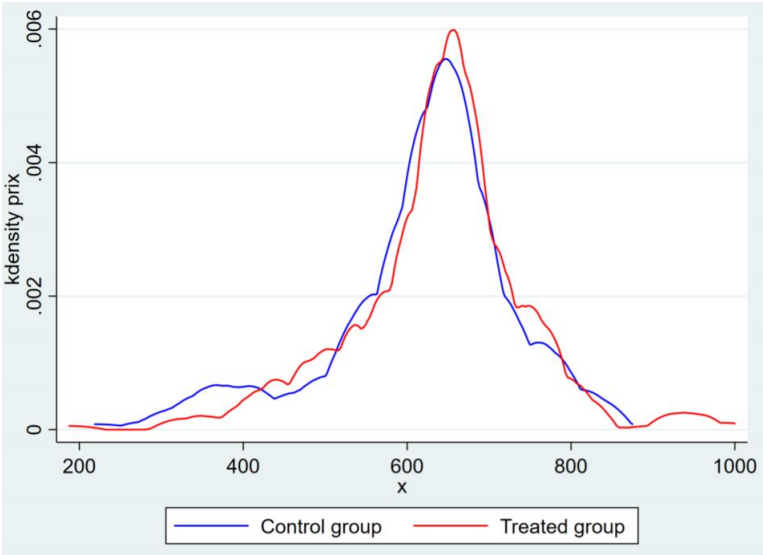
Table 14: Households' characteristics

	(1) **All sample**	(2) **control**	(3) t_1	(4) t_2	(5) $treat_3$
	533	144	148	190	51
Individual Characteristics					
Age	41.2	42.8	40.4	40.3	43.2
	(10.7)	(11.9)	(10.5)	(10.2)	(8.8)
% Mal farmers	95.4	85.7	93.8	97.3	92
% Finish his primary school	37.3	24.8	42.4	41	46.1
Life quality					
% Having electricity	85	79	91.1	84.6	86
% Being in debt	33.6	27.1	39.2	32.8	39.2
Geographical situation					
% of people living in region EST	39	25.4	26.8	38	9.7
% of people living in region BOUCLE DU MOUHOUN	43	31.7	25.2	34.8	8.27
% of people living in region HAUTS BASSINS	13	14.5	36.2	33.3	15.9
% of people living in OTHER REGION	5	33.3	33.3	35.6	9.6
Distance to the nearest city	20.6	20.8	21.4	19.7	20.6
	18.6	18.1	19.6	18	19.1
Distance to the nearest Market place	7.5	7.7	7.6	6.8	9.4
	11.2	11.1		11.7	9 .8
Agricultural information					
Field Area of sesame production	2.4	2.4	2.4	2.6	1.9
	(2.3)	(2.3)	(2.4)	(2.2)	(1.6)
% of sesame as a principal crops revenue	61.7	67.4	56.8	63.2	54.9
% of Cotton producer	49.3	40.3	54.4	50.5	54.9
% of Arachide producer	66.5	66.5	62.6	70.6	62.7
% Of member in a cooperative	69.9	61.1	73.6	69.1	86.3
Average years of sesame production	7.4	7.1	7.8	7.5	
	6.1	6	6.3	6	6.5
Home building					
% of house build by Mud brick	80.1	82.6	80	81	70.6
% of house build by cement brick	8.3	8.3	6.9	8.5	11.8
% of house build by cut stone	9.5	7.6	8.3	10.1	15.7
% of house build by other materials					
n'kalô Usage					
% of those who know n'kalô	37	14	41	45	58
% of those who use n'kalô	48	0	56.2	64	100
% of those who use n'kalô need to translate the SMS	41.3	25	38.7	44.1	44
% Being visited by buyer more than one time on a week	50.3	50.7	54.6	3.7	61.2
% less than two sells	71	72	76	67	65
Commercial					
% of Commercial	9.6	5.6	10.8	12.1	8.2

Table 15: Source for marketing information

	(1) *nonsignup*	(2) *signup*
The important source to consult		
% Using last year price	60	67
% An other nearest producer	22.47	19.55
% Information by n'kalô or other services	25	39
% Cooperative information	17	12
% Information listen in the nearest local market	35	30
Where to sell the harvest		
% In local market	55	50
% To a middleman	33	40
% To a cooperative	5	6

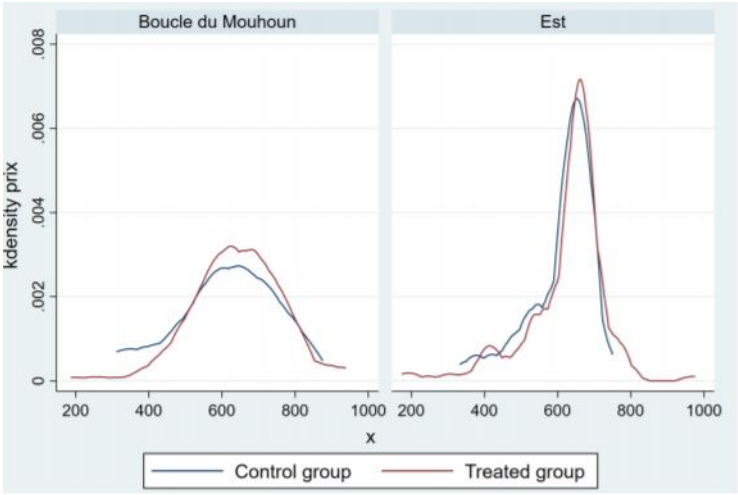
Figure 9: Price distribution treated and control group all population



Source : Note: Authors' computation based on data 2019 after the survey,

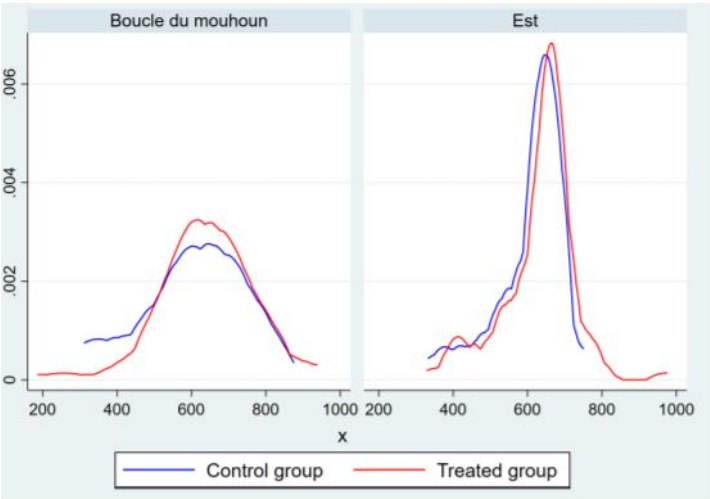
As highlighted before and in the appendix A the local average treatment effect (LATE) is the average treatment effect for "compliers": those who are induced to use n'kalô after being selected by the experience. In contrast, "always takers" or "never takers" have uses of n'kalô that are unaffected by the experiment. It is not possible to identify the compliers, but it is possible to describe their average observable characteristics. E(XjD1 = 1;D0 = 0).

Figure 10: Price distribution treated and control all period by region



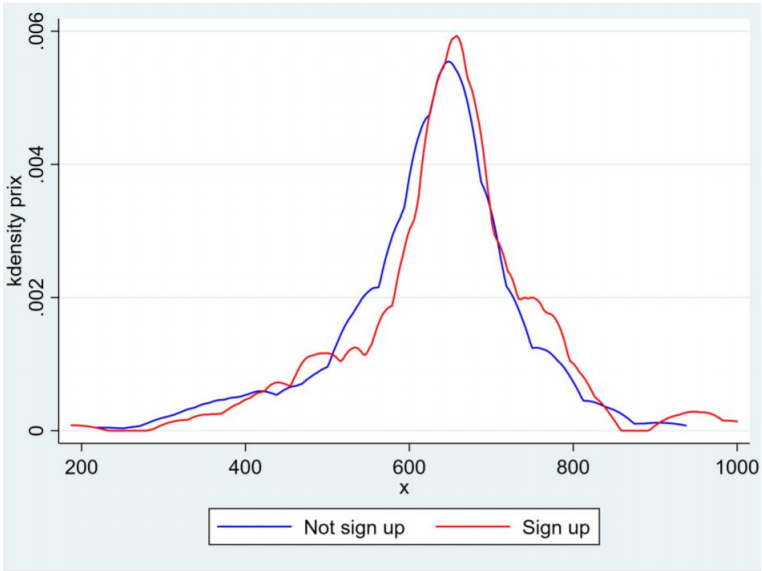
Source : Note: Authors' computation based on data 2019 after the survey,

Figure 11: Price distribution treated and control between time 2 to 6 by region



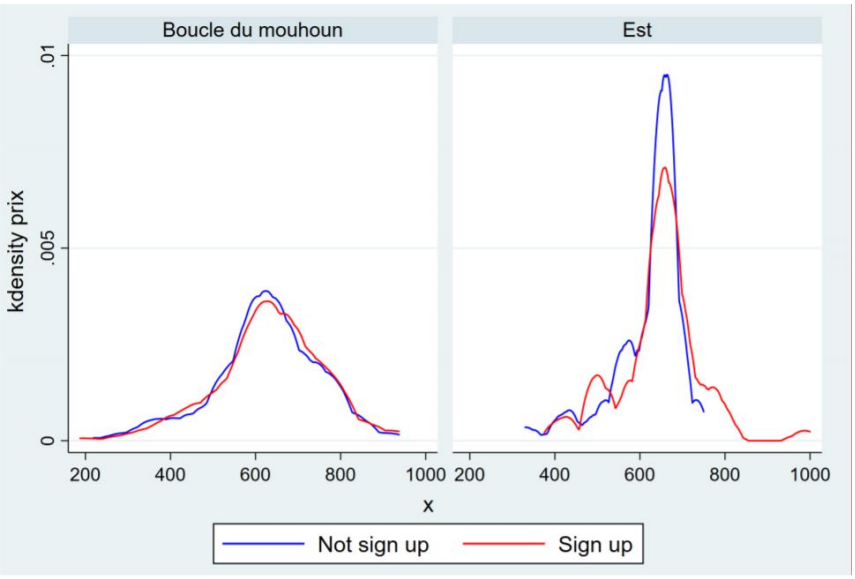
Source : Note: Authors' computation based on data 2019 after the survey,

Figure 12: Price distribution real treatment (sign up to n'kalô)



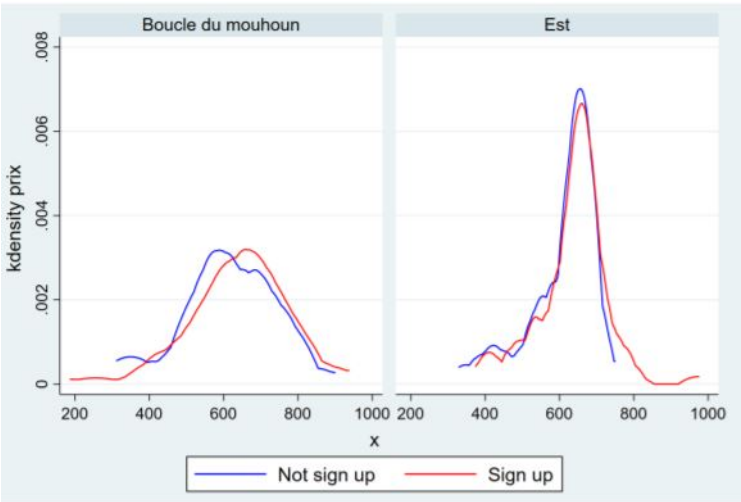
Source :

Figure 13: Price distribution by Region real treatment (sign up to n'kalô)



Source :

Figure 14: Price distribution by Region time 2 to 6



Source :