Making Markets:

Experiments in Agricultural Input Market Formation

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Abstract: Making markets is central to theories of development, particularly when markets are missing. In our rural Malian study setting, seventy percent of smallholder farmers did not have village-level access to an ag-input dealer in the twelve previous months. We create rural input markets with a 'village input fair' varying market timing (spot market or futures market) when inputs can be ordered, the up-front deposit a farmer pays an ag-input dealer in a futures market, and whether credit is offered during the village input fairs. We estimate the intention to treat effects of differences in these market structures on market volume, consumer demand, and agricultural revenue. The results suggest that futures contracts for inputs substantially raise market sales when deposit amounts are low (10% deposit versus 50% deposit). The credit offers increase sales by USD 63 in the 10% deposit group which increases fertilizer purchased by 140 kg at market prices. Village input fairs led to increases in input utilization at the extensive and intensive margin. We conclude that innovations in market organization resulted in farmer intensification rather than diversification of production with strong effects on farmer yield and minimal changes in crop portfolio choice across all treatment groups.

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1. Introduction

Creating efficient markets are central to theories of development, yet in many rural agricultural contexts markets do not emerge. The technology adoption literature has extensively considered why farmers do not take-up seemingly profitable inputs or technologies (Foster and Rosenzweig 2010, Magruder 2018, de Janvry and Sadoulet 2020, Suri and Udry 2022) with significant attention to demand side constraints. In much of this literature, we assume supply exists should farmers be willing to pay. Demand side experiments assure timely supply for farmers resolving trust issues and reducing transactions costs which often inhibit market formation even if agricultural technologies might be mutually profitable for farmers and ag-input dealers. Despite the idea that farmer constraints inhibit market formation, the supply side of the market is often also constrained. Ag-dealers lack information about existing demand in remote areas, face high transportation and coordination costs in reaching new markets, and are often liquidity constrained (Dar et al. 2021). Markets fail to form due to demand and supply constraints, yet we have few studies on supply side interventions that create agricultural input markets[1] or market-based interventions where we observe behaviors of both demand and supply side actors (Magruder 2018).

Our experimental design is motivated by agricultural input market design problems in rural Mali where alternative contracts could resolve demand and supply side constraints. In our randomized controlled trial, we use exogenous variation in the contracting characteristics of village input fairs[2] to estimate market volume for ag-input dealers and farmer input demand. Village input fairs are commercial events that bring ag-input dealers and farmers together in rural villages to provide market access to agricultural inputs. Organization of these fairs can help disentangle the effects of market structure on farmers, markets and ag input dealers behavior. We think of variations in village input fairs as the set of conditions governing the input market transaction between farmer

[1] We specifically focus on agricultural input markets in this paper. In the recent literature on agricultural output markets, a specific focus on intermediaries and farmer behavior is modeled to estimate welfare effects for farmers and/or price effects. See for example, Bergquist and Dinnerstein (2020) or Casburi and Reed (forthcoming).

[2] Historically, fairs were created to solve the early problems of distribution. They provided an opportunity for the demonstration of skills and crafts, and for the bartering of goods. They concentrated supply and demand in certain places at certain times. Fairs were a fixture of the Roman Empire, and the Romans introduced markets and fairs into northern Europe to encourage trade within their conquered provinces. When the Western Roman Empire disintegrated in the late 5th century, virtually all organized commerce in Europe ceased until the late 7th century. Some literature focuses on the role of fairs in market development. Milgrom et. al (1990) look at how the medieval Champagne fairs filled the gap left open by weak market institutions and provided the right environment for trade growth. Recently, and in the field of marketing and industrial studies, Tafesse and Skallerud (2017) discuss in detail the characteristics of trade fairs and how these events could support industrial development.

and ag-input dealer, or their contractual arrangement. Village input fair contracting characteristics can vary by market timing, the up-front deposit a farmer pays an ag-input dealer, and whether credit is offered during the village input fair.

In rural Kenya, Duflo et al. (2011) compare farmer demand when spot input markets are organized during the planting season in comparison to full prepayment of inputs during the post-harvest period. The rationale for organizing input futures markets is that farmers often have high liquidity during the 'post-harvest season' when crops are sold even if they do not need inputs until the planting season. The market timing characteristics of our village input fairs can be framed as differences in market organization between spot and futures markets for agricultural inputs. Spot markets are organized and clear during the planting season. Whereas the village input fairs organized during the post-harvest season are a futures market where farmers secure delivery of inputs during the planting season by placing an order deposit with an ag-input dealer. Duflo et al. (2011) interpret the behavioral effect of a post-harvest village input fair as a mechanism to induce commitment to a profitable investment. In our experimental design, an ag input futures contract is offered in some village input fair treatment arms, but depend on the deposit amount (10% of the purchase price or 50% of the purchase price) that farmers are required to provide to ag-input dealers in advance of order delivery. Deposit amounts are important to consider in making agricultural input markets because they may facilitate trust between farmers and ag-input dealers. Deposit amounts also determine how much inventory capital ag-input dealers have to finance their stocks relative to how much farmers have to pay in advance, addressing a key supply side constraint of ag-input dealers. Our experimental design provides two additional point estimates for the effect of deposit amount levels on farmer demand. Credit offers are also made during village input fairs through a partnership with a rural microfinance organization in some treatment arms leading to a 3 x 2 experimental design (Table 1). We expect that increased liquidity from credit offers will increase demand for agricultural inputs.

The experimental results suggest that post-harvest commitment mechanisms substantially raise market sales when deposit amounts are low (10% deposit versus 50% deposit). The availability of credit boosts sales by USD 63 in the 10% deposit post-harvest commitment group which increases fertilizer purchased by 140 kg at market prices. The combination of high commitment deposit requirements (50%) and credit offers had strong negative effects on take-up. Take-up in post-harvest commitment groups led to increases in input utilization at the extensive and intensive margin. Innovations in market organization resulted in farmer intensification rather than diversification of production with strong effects on farmer yield across all market treatment groups.

The paper describes the study design in the next section including the Malian input market context and a detailed description of the experimental design. The third section outlines the econometric strategy. The fourth section includes results on the extensive and intensive margins of agricultural inputs, crop choice, and yield effects. The last section concludes.

2. Study Design

2.1 Related Literature

To motivate our experimental design, we first review the related literatures on demand and supply constraints to input market formation, beginning with demand side constraints. The recent technology adoption literature has primarily focused on why farmers do not take-up seemingly profitable technologies. As discussed above, Duflo et al. (2011) provide a theoretical model incorporating time-inconsistent preferences in the context of agricultural input decisions. Offers to purchase inputs using a hard commitment mechanism (full payment at commitment) with guaranteed delivery during the planting season were found to induce much higher take-up of fertilizer than subsidized or market-priced offers of fertilizer purchase during the planting season. The experimental design uses market timing to test the hypothesis that farmers may have time inconsistent preferences leading to suboptimal investment decisions. Duflo et al. (2011) also demonstrate, along with several previous studies (for example, Morris et al. 2007, Duflo et al. 2008, Beaman et al. 2013, Harou et al. 2015) that the return to fertilizer is heterogeneous.

In Burkina Faso, Dillon et al. (2018) build on the experimental design of Duflo et al. (2011) by including a soft 'early' commitment mechanism for sorghum farmers. Farmers commit early by signing a 'purchase order' with an agro-dealer during an input fair, depositing 5% of the total order price. Full payment is made upon delivery of the fertilizer during the planting season. Take-up rates were particularly high among those farmers who received soft commitment offers early (post-harvest) rather than late (at planting), even when the late commitments were subsidized. These take-up rates are similar to those predicted by Duflo et al. (2011) and may be more effective than full-commitment devices (full payment at commitment) as demonstrated in other contexts (Karlan and Linden 2014). Similarly, offering insurance contracts within a contract farming scheme during the post-harvest season increases take-up considerably when compared to a similar offer of the same product at the time of planting (Casaburi et al. 2018).[3]

These models, taken with standard models of credit constraints (Pardhan and Udry 1999), do not provide unambiguous predictions of whether time-inconsistent preferences may most affect agricultural input adoption, particularly when farmers are credit constrained, leaving ambiguity about which constraint (time consistency or credit) would be binding. As the demand for a commitment mechanism may be driven by multiple constraints, our study is motivated by the empirical question of estimating the relative effects of different market structures on consumer demand, household input utilization, and agricultural yields.

A key feature of our study design is treatment arms where offers of agricultural credit are made to reduce credit constraints among farmers. The effect of agricultural credit has well-documented heterogeneous effects on agricultural input decisions (Karlan, 2014). In rural Mali, farmers' total input expense increases substantially when villagers are offered either a grant or unconditional loans at the time of planting (Beaman et al. 2014). Despite widespread expansion of microfinance in low and middle income countries, many microfinance institutions do not conduct agricultural lending. It is generally accepted that the reduction or elimination of agrarian banks in the last decades has also made formal bank credit a rare opportunity for Sub-Saharan African farmers.

On the supply side of input markets, the literature has focused on the effects of asymmetric information in matching ag-input dealers with potential buyers. First, information about potential buyers and sellers is often unavailable, despite the rise of information technology and communication (Aker 2010). Further, there is evidence that agricultural input markets face informational asymmetries regarding the quality of goods, the reputation of agents, and several commitment problems engendered by weak institutions (Michelson et al. 2021, Fafchamps 2020, Aker and Fafchamps 2015, Bird and Fafchamps 2004). Taken together, these factors reduce

[3] Similarly, the take-up of certified hybrid seeds is multiplied when this ag-input is offered at the time when smallholder farmers sell their crops from a previous harvest to a large company (Axmann at al. 2019).

competition and negatively impact the incentive of traders to expand markets to farmers in rural areas. Second, unreliable transport infrastructures affect the marketing costs faced by ag-input dealers. When markets are sparse and population density is low, as is the case in many African countries, transport costs are a barrier to transferring goods from the cities to the farms and vice versa (Aggarwal et al., 2018, Casaburi et al. 2012, Fafchamps and Gabre-Madhin 2006). Third, private-sector agents lack sufficient information about the existing demand in remote areas. Indeed, farmers' input demand varies within and between villages, potentially increasing agro-dealers uncertainty about where to market their products (Macours, 2019, Lybbert, 2018). This demand heterogeneity is exacerbated by how agricultural inputs respond to the characteristics of different soils and by the need to obtain complementary factors like equipment, labor, or water, to ensure a profitable input investment (Harou 2022, Corral et al. 2020, Marenya and Barrett 2009). This related literature motivates our work on agricultural input market development with a particular emphasis on village level interventions that resolve constraints for farmers and ag-input dealers.

2.2 Experimental Design

The context of our experimental design is Mali, a country in the Sahel region of Africa in the semi-arid tropics. Our experiment took place between 2017 and 2019 in four areas of the country, notably Sikasso, Koulikoro, Kangaba and Bananba. These areas are characterized by similar agricultural patterns where agriculture is extensive and characterized by rainfall dependence. One rainy season is available from July to September, with scarce predictability in terms of volume and timing. Agricultural production is labor-intensive, low technology, and low access to infrastructure. Arable land is available. However, other agricultural inputs are not: equipment, water, labor, seeds, fertilizers, and insecticides, among others (USAID, 2018).

In Mali, average fertilizer prices are estimated to be 82% higher than in Thailand, with transport costs accounting for around one-third of the price.[4] The use of mineral fertilizers is concentrated in the cotton sector rather than in subsistence agriculture. Transportation infrastructure is poor and dedicated distribution networks are almost absent. Rural credit is generally unavailable to the

[4] The cost of distributing fertilizer in Mali is estimated at US$ 514 per tonne in 2014 and US$ 569 per tonne in 2016. The cost of urea and the cost of NPK blend were estimated in 2012 at US$ 620 per tonne and US$ 883 per tonne respectively.

average farmer, with lending concentrated on larger agricultural cooperatives. This translates in a fragmented private sector that is mostly formed by small-scale secondary ag input dealers, missing market information on demand, supply and prices, and low control on the quality of the input (especially for fertilizers). Storage facilities for fertilizers and other inputs are inadequate in rural areas, which in turn increases the risk of deterioration of the stocks or imposes transportation costs (USAID, 2018).

To build a market-based randomized controlled trial, we partnered with two agricultural private sector actors. The first is the National Union of the Agro-Input Dealers (UNRIA), which has a network of at least 950 agro-dealers in the targeted regions. The Union seeks to promote the supply of domestic market inputs. It is a national actor promoting access to fertilizer, improved seeds, pesticides, and agricultural equipment. The second major partner is Soro Yiriwaso, a microfinance institution based in Mali that has conducted operations for over 20 years and has been involved in the design since its inception. Both these organizations have collaborated to the organize the study's village input fairs.

The experimental design focuses on the market characteristics of village input fairs. These commercial events are not frequent in rural Mali. When set up by extension services or by the agro-dealers of UNRIA, they are almost exclusively organized at the time of planting and often in secondary towns or cities, rather than in the village context. Village input fairs are efficient market structures that build on the self-interest of three actors: (i) ag input dealers, (ii) farmers and (iii) microfinance institutions. In all village input fairs, ag-input dealers organized a one-day input fair where farmers can purchase inputs after product description and marketing presentations by the ag-input dealers.

Variations in the village input fair treatment are defined by i) the timing at which the input fair is deployed, either during the post-harvest season (ag input futures market with purchase orders) or at planting (a spot input market); ii) the level of deposit required to place an order in a futures market, with a 'soft' 10% or 'hard' 50% deposit (commitment to purchase inputs), and iii) the possibility to obtain credit during the fair. The combination of i) and ii) yields three possible ways of organizing the village input fairs. Either the fair is organized during the post-harvest season (with a 10% or 50% deposit requirement), or the fair is organized at planting season without a deposit amount because farmers pay in full at the spot market. The credit treatment allows the villagers to contract a loan to finance their transactions with partner Soro Yiriwaso. Figure 1 outlines the implementation timeline and the interactions of treatments, which were allocated at the village level.

Table 1 describes the 3 x 2 experimental design including the treatment and the control arms where treatment is assigned at the village level. We selected 140 villages in the defined study area using the National Census available from the Statistical Office in Mali. Each study arm was randomly assigned 20 villages. In Group 1, the microfinance institution facilitated the interaction between farmers and input dealers by accompanying the supplier as they organized the village input fair. This input fair occurred just after the harvest of the previous agricultural season. The opportunity to purchase agricultural inputs was offered to farmers, with the possibility of financing their purchase with a loan. The interested farmer had to place the order and pay a 10% deposit on the day of the fair. The balance of the purchase could be either paid by the farmer or financed by a loan activated upon delivery of the inputs by the dealer at the beginning of the planting season.[5] In Group 2, the same village input fair organization is used without the credit option which was not offered to the farmers.

In Group 3, the input fair took place just after the harvest of the previous agricultural season but, in this case, the farmers placed input orders and paid a 50% deposit on the day of the village input fair. The balance could be either paid by the farmer or financed by a loan. In Group 4, the same village input fair organization is used without the credit option which was not offered to the farmers.[6] Finally, in Group 5 the village input fairs were organized as spot markets at the beginning of the planting season, approximately 4 months after the village input fairs in Groups 1 to 4. The purchase value in the spot market fairs in Group 5 was either directly paid by the farmer or became a loan. In this second case, the microfinance institution made the payment directly to

[5] Please note that the microfinance institution placed the deposit amount in a blocked account. The funds in the blocked account were fully transferred to the input dealer upon delivery, along with the balance payment – is it paid by the farmer or financed by credit. In some cases, when the traders delivered the order at times of sow, the farmer reneged the purchase. The microfinance institution then sanctioned the farmer, by transferring her/his deposit to the ag-input dealer.

[6] We emphasize that the requirement of the deposit is a mandatory feature of the village input fairs organized in the post-harvest season arms (groups 1, 2, 3, and 4). The deposit is not an option. In case the farmers and ag-dealers reach an agreement, the deposit is a necessary condition to conclude the transaction during the post-harvest fairs. This is different from the credit option, which is available in three of the treatment groups (groups 1, 3, and 5), as a possibility that could be voluntarily taken up by the eligible farmers only after the credit screening operated by the microfinance institution.

the ag input dealers after execution of the credit contract with the farmer. In Group 6, the same village input fair organization is used without the credit option which was not offered to the farmers[7].

3. Econometric Strategy

We estimate two intention to treat effects using market and household agricultural data. Data collected during the study included a household baseline pre-treatment, market outcome data collection during the village input fairs, credit information, and a follow-up household survey deployed after the agricultural season that followed the intervention. We observe input allocation decisions for household plots (baseline in 2017 and follow-up in 2018) and we obtain one observation of crop choice and agricultural production (yield) post-treatment, in 2018.

Input fair organization and credit offers are presumed to affect farmers' input allocation decisions depending on their constraints, assets and endowments, beliefs about profitability and weather, and preferences. Farmers could adjust production plans in response to village input fairs, commitments or credit offers at the intensive or extensive margin. In response to market organization, farmers may also adjust other margins of their production plan including their crop choice.

We begin our analysis by comparing the village take-up and market sales from the six different village input fairs. Since no fairs occurred in the control group, we present the outcome mean effect of each group and estimate whether the market outcome is statistically different than zero. What is most interesting is not the statistical significance of market outcome relative to the control arm, but the variation in take-up and mean sales between the different treatment groups.

The market outcomes that we tracked are village participation in input fairs, the percentage of villagers that conclude a transaction conditional on participating in the fair, and the value of the transactions, either at the aggregate level or per transaction. For market outcomes, the

[7] It is not possible, nor necessary, to study a treatment arm where credit is offered but the village input fair is not organized. In Table 1, this is described as not available (e.g. N/A). Our research question is about the impact of the village input fair intervention and thus we are not interested in a treatment arm in which liquidity constraints are relaxed through credit options, but fairs are not organized.

counterfactual is not the control group where no fairs were organized because we can not observe market level transactions without an actual market. We use Group 6, the planting season spot market, as the comparison group, and we compare the performances of the treatment arms with respect to this group.[8]

$$y_m = \alpha + \sum_{k=1}^{6} \beta^k T_{km} + \varepsilon_m \qquad (1)$$

We estimate the market level treatment effect, β^k, in equation 1 on the outcomes of interest y_m - where m defines the markets organized in the village input fairs. The results of this analysis are reported in Table 3.

At the household level, we have four outcomes of interest on agricultural input adoption: i) the extensive margin of input use (e.g. the binary choice on whether the farmer uses input on a plot), ii) the intensive margin of use, measured in quantity of input applied per hectare, iii) crop diversification (an indicator for each crop cultivated by the household), and iv) agricultural yield measured in crop value per hectare. We can then quantify the impact of organizing the village input fairs on the use of inputs, crop diversification, and yields in villages where the fair was organized, with reference to the control arm.

In a pooled difference in difference specification (Bertrand et al. 2004), we estimate the effects on input allocation decisions for household *h* in treatment group *k* in season *t* relative to the control group. Standard errors are clustered at the village level, the unit at which treatment was assigned.

$$y_{ht} = \alpha + \sum_{k=1}^{6} \beta_k T_k + \gamma Year + \sum_{k=1}^{6} \delta_k \left(Year \times T_k\right) + \varepsilon_{ht} \qquad (2)$$

The coefficient δ is the difference in difference estimate, which measures the change in outcomes over time of the farmers receiving the treatment k relative to the change in outcomes of farmers in the control arm. This is an intention-to-treat analysis, which estimates the mean of the outcome variables for the farmers that were assigned to treatment (in our case the opportunity to participate in village input fairs) and compares it to the mean of the outcome variables for the farmers who were assigned to the comparison group (where they had no opportunity to participate in village

[8] In Group 6 the fair is organized in a way that is the nearest to the status quo. Qualitative research reports that when input fairs are established outside of the study, they are usually organized at planting and without the provision of credit options – just like Group 6.

input fairs). In this specification, we estimate year-by-year effects on fertilizer use extensive and intensive margin. The results of this analysis are reported on Tables 4 and 5.

For outcomes including crop choice and agricultural yields, we estimate the intention to treat effects using differences within the same agricultural season as our baseline data did not include detailed plot level agricultural outcomes. Standard errors are clustered at the village level, the unit at which treatment was assigned.

$$y_h = \alpha + \sum_{k=1}^{6} \beta^k T_{kh} + \varepsilon_h \qquad (3)$$

In this case, the coefficient β^k estimates the ex-post difference between the outcome mean in treatment arms with respect to the mean in the control arm. Results from this analysis are reported in Table 6 and 7. All estimates rely on the independence between treatment and household covariates. In particular, equation 3 relies on this assumption as we are estimating treatment effects in levels rather than in differences. To assess the validity of the independence assumption, we use agricultural, household and asset variables collected in the baseline census to assess balance across the six experimental groups and the control. These results are presented in Appendix Tables A1-A3. The market access and credit group in the planting period are imbalanced relative to the control group for the plot area and household size variables. The two treatment groups have smaller land size and household size relative to the control leading to potential underestimation of effect size in this group if land and labor availability are more highly correlated with fertilizer take-up and use. Assets ownership is also less prevalent in several of the treatment groups for beds and video cassette recorders (VCRs) relative to the control group, although bikes are more frequent in the treatment groups. Asset values conditional on ownership are generally similar across the groups. Baseline covariate imbalance likely lead to underestimation of the intention to treat effects.

4. Results

Four sets of intention to treat effects quantify market organization innovations on input market sales and consumer participation, the household's use of agricultural inputs, and crop choice and yield effects. The first set of intention to treat effects allow us to infer market volume, which is essential to understanding ag-input dealer incentives under different village input fair market structures. The last two sets of results allow to infer whether village input fairs have large enough population level effects to affect consumer demand and welfare. The second set looks at the agricultural input decisions that farmers take after the fairs. The third and fourth sets of results estimate whether the village input fairs influence crop diversification at the aggregate level and the value of agricultural production.

4.1 Market

Table 2 shows descriptive statistics of the village input fairs, by treatment arm. These figures give suggestive evidence that there exists little variation in the price of fertilizers among the post-harvest treatment arms for the three major fertilizer categories that are usually traded in village input fairs (e.g. Urea, DAP, and NPK). For these products, Group 5 and Group 6, where fairs were organized as spot markets at planting, show higher prices with higher standard deviations, suggesting more price variation in planting season markets. Table 2 shows that the credit option in Groups 1, 3, and 5 increase the number and volume of the transactions. The impact of credit is plausible given that farmers expand their purchase power by relaxing liquidity constraints. The number of transactions during the spot markets is higher than in the futures markets, but the average value of transaction is generally higher in the futures markets.

Table 3 provides information on the market outcomes for the six treatment arms. Column 1 shows village participation estimates. We report the percentage of villages in which the village input fair resulted in at least one transaction. In the planting season treatment arms (Groups 5 and 6), all villages participated. Village take-up varies among the post-harvest treatment arms (Groups 1, 2, 3, and 4) for futures markets. These markets required more trust between ag input dealers and farmers and were more novel contracts relative to spot markets which frequently occur for other commodities. The soft commitment village input fairs (10% deposit) drove 70% to 80% of villages to take up, while the hard commitment fairs (50% deposit) resulted in a lower 45 to 70% take-up.

After the input fairs, qualitative interviews with agricultural input dealers provided explanations for this. First, there is anecdotal evidence that village leaders who chose not to participate signal hesitancy about the new market structures, especially when organized during the post-harvest season. This may influence the whole village not to participate. Second, as the theory would predict, we see a stronger response to soft commitments, represented by lower deposit amounts

(Karlan and Linden, 2014). Village take-up is consistently higher in the 10% deposit treatment than in the 50% deposit treatment.

Table 3 Column 2 estimates the average value of transactions per village. This is a proxy of the market volume generated by the fairs. Credit availability in Groups 1 and 5 lead to significantly higher market volumes - with the remarkable exception of Group 3 which we will discuss later in more detail. Table 3 Column 3 reports the average value of the transactions that were concluded during the fairs. It appears that Groups 1 and 5 outperform Groups 2 and 6, which correspond to the same market organization with the addition of the credit option. We conclude that credit expands the purchasing power of farmers. For example, average transaction amounts are 25,218 XOF higher (around 45 USD) in Group 1 relative to Group 2. This represents an effect size of 104 pp, equivalent to around 100 more kg of fertilizer, at study period market prices.

Table 3 Column 4 illustrates the participation rate of farmers. It reports the percentage of those farmers that concluded a transaction during the village input fair among the total number of farmers that participated in the fair. Interestingly, we notice that in groups 5 and 6, when fairs are organized as spot markets at planting, more of the participating farmers decide to conclude a transaction. Yet, those transactions are lower in value, as indicated in Column 3. One might conclude that spot markets at planting generate more trading than post-harvest fairs, yet the transaction value is higher in this latter group. With the exception of groups 3 and 4 which have high deposit requirements, the market participation rate of farmers is statistically higher when credit is a feature of the village input fair. We confirm that credit pushes relatively more farmers to conclude transactions. Group 1 show a 16.6 pp increase in the participation rate due to credit inclusion, while group 5 saw an increase of 11.1 pp.

In group three with high commitment and credit offers, the treatment reduces participation, number of transactions, and transaction value. When the deposit commitment is 50% of the order, purchase values are even higher without the credit option. This result seems to contradict the evidence that we provide about the positive effects of relaxing liquidity constraints. There are several potential explanations which we cannot test formally. One might argue that hard commitment depresses demand so much that the additional effect of credit is neutralized. Another plausible explanation is that farmers perceived the combination of high deposits and future credit obligations as severely affecting their liquidity. We also conclude that farmers and ag-input dealers viewed Group 3 and 4 village input fairs as unprofitable given their cost structures. This latter point is corroborated by looking at the distribution of the cumulative value of the transactions in the treatment arms - Table 2, Column 2.

4.2 Input use

We now move to the results on the use of agricultural inputs. One plausible hypothesis is that participation in village input fairs (and the consequent input purchase) might lead to higher fertilizer use, but whether village input fairs increased input use at the population level is an empirical question. Table 4 presents the extensive urea, DAP, and NPK use margin.[9] The coefficients reflect the household decision to use/not use inputs on the plots. For the agricultural season just after the treatment was implemented, we estimate a causal effect of the 'soft' commitment input fairs (Group 2) on the use of urea and DAP, which increase by 14.2 and 17.4 pp, respectively. Adding credit to the 'soft' commitment does not yield statistically significant increases in input use. Groups 5 and 6, when fairs are organized during the planting season also increase the extensive margin of urea utilization with an 8.2 and 14 pp increase, whether the treatment was offered with or without a credit option, respectively.[10]

Table 5 presents the intensive margin of fertilizer use effects. As in the previous table, we use a differences-in-difference specification. Here, we standardize fertilizer value per hectare to address potential heterogeneity in land endowments between households. Table 5 describes the intensity of fertilizer's application. As before, the estimation coefficients prove that the increased access to agricultural inputs improves farmers' agricultural investment. Statistically significant effects on input intensification are found for groups 1, 2, 3, 5, and 6. These effects arise in different groups and with different fertilizer types. We interpret this result as evidence of farmer heterogeneity in demand response. Those farmers who take-up inputs in response to village input fairs are different

[9] The chemical composition and agronomic response of each fertilizer type differ. Urea is used primarily to increase nitrogen availability to improve plant blossoming, aiding photosynthesis. DAP (diammonium phosphate) is used to increase soil pH temporarily. NPK fertilizers contain nitrogen, phosphorous, and potassium.

[10] We also estimate a 12.4 percentage increase among group 3. However, we mentioned that this treatment arm had low take-up and thus we disregard this result.

in demand preferences for inputs than those farmers who intensify production in response to village input fairs.

4.3 Crop Choice and Yield

In Tables 4 and 5, we show that farmers (potentially different types of farmers) respond to both the extensive and intensive margin of fertilizer use. Increases in fertilizer availability especially when accompanied by a longer planning horizon may also allow farmers to adjust crop portfolios or intensify production by moving their production frontier. We test the hypothesis that input market formation leads to either crop diversification or production intensification by estimating intention to treat effects on crop choice.

Table 6 present crop portfolio effects. This specification is the single difference specification as in equation 3, Section 3. We do not find a consistent pattern of crop portfolio substitution among the most frequently planted crops in our sample. These results show that there is no systematic substitution in or out of a particular crop. We cannot conclude that village input fairs influence crop choice.

Table 7 presents the intention to treat agricultural yield effects from the single difference specification as in equation 3. In response to large treatment effects on the intensive and extensive margin of input use, we find strong agricultural yield effects (expressed in crop value per hectare) in mostly all treatment groups. We use crop value per hectare to standardize output measurement across different crop types. These effect sizes vary between 10 and 20 pp of the control group mean. While statistically different from the control group, treatment arms coefficients are not statistically different from each other, based on coefficient tests of mean equality. Our estimate of the effects of increased input use on agricultural yields is consistent with recent descriptive agronomic studies. In particular, a recent study in Mali conducted by Haider et al. (2018) come to the conclusion that the "estimated response rates to nitrogen to be generally in the 10-15 pp range."

5. Conclusion

Market organization has strong effects on market demand, agricultural input utilization and agricultural intensification through increasing yields. In our experiment, we find 'early' commitments during the post-harvest season to have strong effects on these outcomes, while credit augments effect size particularly for market-level outcomes. Farmers are very sensitive to the level of deposit required as a commitment mechanism. Increasing commitment levels to 50% deposits of inputs ordered suppresses demand to unprofitable levels for ag-input dealers. The demand, input utilization outcomes and yield effects in combination with the low cost of organizing village input fairs suggest that encouraging input market development may have higher cost-benefit ratios than alternative input promotion programs.

Our results also illustrate an important consideration about the role of credit in market organization. Credit increases input demand in our experiment but suppresses demand when combined with 'hard' commitment. In principle, the option of credit in the market should not suppress demand, but we emphasize the interlinked nature of commitment and credit in the experiment and the role of risk aversion. It could be the case that our farmers did not trust market actors whose sale conditions were high up-front payment and high future commitments through credit payments. In fact, a high percentage of whole villages opted out of this treatment entirely.

Another explanation for these empirical results is that the simple model of a credit option is not the right theoretical model for the given experiment. The high commitment and credit treatment is an interlinked transaction that requires the farmer to tradeoff risk, liquidity, and investment intertemporally. Deaton (1992) discusses precautionary savings motives that create suboptimal investment when households are liquidity constrained. Basu (1995) demonstrates in the context of share tenancy that high credit obligations and commitment in the form of landowners allocating land to farmers for a fixed season may induce suboptimal effort from farmers. Whether the combination of commitment and credit depresses demand due to social factors such as trust or intertemporal tradeoffs in an important future question to disentangle.

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Figures and Tables

Figure 1: Village Input Fair Implementation Timeline

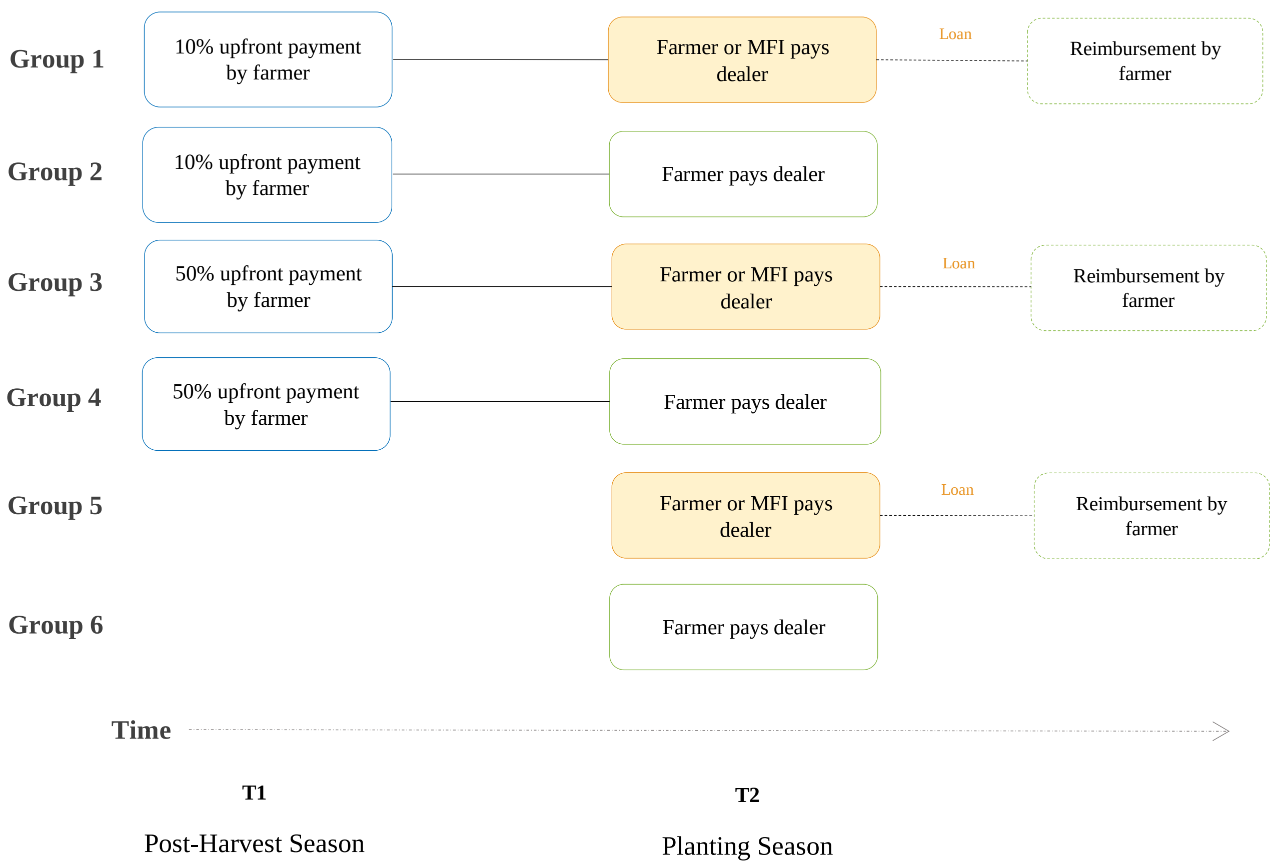

Table 1: Experimental Design

	Input Fairs			
	Post-harvest Season		Planting Season	No input fair
	Soft commitment (10%)	Hard commitment (50%)		
Credit Option	Group 1	Group 3	Group 5	N/A
No Credit Option	Group 2	Group 4	Group 6	Control

Table 2 – Descriptive Statistics of Village Input Fairs by Treatment Arm

	Cumulative number of transactions	Cumulative value of transactions in XOF	Cumulative quantities purchased		Average price of fertilizers per Kilo in XOF	Average price of chemicals per Liter in XOF
			Kilos	Liters		
	1	**2**	**3a**	**3b**	**4**	**5**
Post-Harvest Season						
Group 1	147	7,239,000	20,574	275	240.25	4,350
10% Commitment + Credit Opt.		(91,364)	(187.29)	(2.78)	(46.35)	(2,576)
Group 2	117	2,811,150	4,079	393	230.56	4,293
10% Commitment		(29,709)	(34.07)	(3.57)	(32.60)	(1,802)
Group 3	124	437,700	714	11	220.00	5,667
50% Commitment + Credit Opt.		(6,585)	(9.82)	(0.74)	(0)	(1,722)
Group 4	141	1,571,550	12,437	22	220.00	3,031
50% Commitment		(17,053)	(430.62)	(0.43)	(0)	(427)
Planting Season						
Group 5	397	10,991,600	31,600	1,665	399.56	3,577
Spot Market + Credit Opt.		(54,031)	(832.04)	(8.35)	(89.92)	(5,235)
Group 6	355	3,133,000	3,790	627	277.42	2,529
Spot Market		(13,054)	(24.50)	(3.31)	(120.30)	(2,190)
Number of Observations	1,281	1,281	714	1,057	273	799

Notes:
Symbols: .01 - ***; .05 - **; .1 - *.
Column 1 describe the number of transactions that were negotiated; each transaction could involve the purchase of several products.
Column 3 describes the total quantities purchased, whether in Kilograms or Liters.
Columns 4 and 5 describe average price applied by dealers for three fertilizers type (Urea, Dap and NPK) and for chemicals (pesticides and herbicides).
Columns 2, 3, 4 and 5 report standard deviations in brackets.

Table 3 – Village Input Fairs Market Outcomes

	Percentage of villages with at least one transaction	Average transaction value in XOF (per village)	Average transaction value in XOF (per transaction)	Average farmers' participation rate
	1	**2**	**3**	**4**
Post-Harvest Season				
Group 1	0.70***	517,071	49,244**	45.3%***
10% Commitment + Credit Opt.	(0.105)	(886,881)	(21,391)	(0.070)
Group 2	0.80***	175,696	24,026***	28.7%***
10% Commitment	(0.091)	(192,610)	(4,918)	(0.078)
Group 3	0.45***	48,633	3,529***	26.6%**
50% Commitment + Credit Opt.	(0.114)	(47,424)	(1,106)	(0.103)
Group 4	0.70***	112,253	11,145*	29.6%***
50% Commitment	(0.105)	(291,108)	(6,109)	(0.085)
Planting Season				
Group 5	1.00***	549,580	27,686***	71.1%***
Spot Market + Credit Opt.	(0.000)	(431,332)	(3,753)	(0.092)
Group 6	-	156,650	-	-
Spot Market		(155,674)		
Number of Observations	120		1,281	93
Control Mean	1.00	N/A	8,825	60%
Control Standard Deviation	0	N/A	13,054	

Notes:
Symbols: .01 - ***; .05 - **; .1 - *.
Group 6 is the reference group (e.g. control).
Column 3 is conditional on the individual having made a purchase.
Column 2 and column 4 are conditional on at least one person in the village having made a purchase.

Table 4 – Intention to Treat: Fertilizer Use Extensive Margin Effects

	Urea	DAP	NPK
	1	**2**	**3**
Post-Harvest Season			
Group 1	0.051	0.017	0.088
10% Commitment + Credit Opt.	(0.052)	(0.059)	(0.061)
Group 2	0.142**	0.174**	0.015
10% Commitment	(0.066)	(0.086)	(0.065)
Group 3	0.110	0.124**	0.042
50% Commitment + Credit Opt.	(0.068)	(0.059)	(0.081)
Group 4	0.100	0.110	0.042
50% Commitment	(0.070)	(0.091)	(0.071)
Planting Season			
Group 5	0.082*	-0.022	0.074
Spot Market + Credit Opt.	(0.043)	(0.065)	(0.070)
Group 6	0.140***	0.127	-0.020
Spot Market	(0.051)	(0.076)	(0.061)
Constant	0.802***	0.755***	0.143***
	(0.098)	(0.094)	(0.049)
Number of Observations	7,452	7,452	7,452

Notes:
Symbols: .01 - ***; .05 - **; .1 - *.
Difference in difference specification (2017-2018)
Input use outcomes are defined as follows: input use takes the value 1 when at least one plot managed by the household is using that input and 0 otherwise.
The estimations use robust standard errors clustered at the village level.

Table 5 – Intention to Treat: Fertilizer Use Intensive Margin Effects, Natural Logs

	Ln Urea Value / Ha	Ln DAP Value / Ha	Ln NPK Value / Ha
	1	**2**	**3**
Post-Harvest Season			
Group 1	0.620	0.517	1.007***
10% Commitment + Credit Opt.	(0.518)	(0.531)	(0.377)
Group 2	1.131*	1.710*	0.219
10% Commitment	(0.630)	(0.894)	(0.291)
Group 3	0.110	0.124**	-0.042
50% Commitment + Credit Opt.	(0.068)	(0.059)	(0.081)
Group 4	1.081	1.022	0.612
50% Commitment	(0.671)	(0.891)	(0.558)
Planting Season			
Group 5	0.082*	-0.022	0.074
Spot Market + Credit Opt.	(0.043)	(0.065)	(0.070)
Group 6	1.328**	1.253	0.293
Spot Market	(0.556)	(0.801)	(0.421)
Constant	7.459***	7.283***	0.619***
	(1.028)	(0.994)	(0.187)
Number of Observations	7,075	7,071	7,078

Notes:
Symbols: .01 - ***; .05 - **; .1 - *.
Difference in difference specification (2017-2018)
The estimations use robust standard errors clustered at the village level.

Table 6 - Share of Plots with a Given Crop as Main Crop

		Peanut	Cotton	Fonio	Gumbo	Maize	Millet	Rice	Sesame	Sorghum
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Post-Harvest Season										
	Group 1	0.019	-0.038	-0.005	0.009	-0.001	-0.046	-0.007	0.050	0.029
10% Commitment + Credit Opt.		(0.035)	(0.035)	(0.006)	(0.009)	(0.012)	(0.028)	(0.057)	(0.048)	(0.020)
	Group 2	0.017	0.031	-0.002	0.011	0.007	-0.011	-0.061	0.075**	0.001
10% Commitment		(0.035)	(0.038)	(0.012)	(0.008)	(0.014)	(0.032)	(0.060)	(0.037)	(0.015)
	Group 3	0.074*	0.002	0.003	0.003	0.011	-0.040	0.000	-0.013	0.011
50% Commitment + Credit Opt.		(0.039)	(0.044)	(0.007)	(0.008)	(0.021)	(0.040)	(0.059)	(0.024)	(0.022)
	Group 4	0.070*	-0.024	0.001	0.004	0.010	0.002	-0.054	0.020	0.002
50% Commitment		(0.040)	(0.036)	(0.009)	(0.010)	(0.019)	(0.049)	(0.084)	(0.026)	(0.015)
Planting Season										
	Group 5	-0.015	0.015	-0.008	0.012	-0.011	-0.041	0.050	0.032	0.013
Spot Market + Credit Opt.		(0.038)	(0.040)	(0.006)	(0.009)	(0.012)	(0.034)	(0.076)	(0.026)	(0.019)
	Group 6	0.027	0.042	0.002	-0.001	0.018	0.009	-0.087*	0.023	0.005
Spot Market		(0.037)	(0.033)	(0.007)	(0.007)	(0.013)	(0.031)	(0.052)	(0.023)	(0.019)
	Constant	0.133***	0.192***	0.006	0.004	0.051***	0.229***	0.150***	0.037***	0.022***
		(0.018)	(0.020)	(0.005)	(0.003)	(0.012)	(0.017)	(0.032)	(0.009)	(0.007)
	Number of Observations	2,510	2,510	2,510	2,510	2,510	2,510	2,510	2,510	2,510

Notes:
Symbols: .01 - ***; .05 - **; .1 - *.
Cross-sectional single difference in the 2018 agricultural season specification.
All estimations are at the household level.
The estimations use robust standard errors clustered at the village level.

Table 7: Intention to Treat: Agricultural Yield Effects

	Agricultural Yields (Value per hectare)
Post-Harvest Season	
Group 1	1.377*
10% Commitment + Credit Opt.	(0.709)
Group 2	1.250*
10% Commitment	(0.679)
Group 3	1.518**
50% Commitment + Credit Opt.	(0.755)
Group 4	1.369*
50% Commitment	(0.801)
Planting Season	
Group 5	1.819***
Spot Market + Credit Opt.	(0.690)
Group 6	1.771**
Spot Market	(0.717)
Constant	10.685***
	(0.582)
Number of Observations	2,461

Notes:
Symbols: .01 - ***; .05 - **; .1 - *.
Cross-sectional single difference in the 2018 agricultural season specification.
All estimations are at the household level.
The estimations use robust standard errors clustered at the village level.

APPENDIX TABLES

Household Demographics Descriptive Statistics: Part A				
	Total Plot Area	Average Plot Size	Number of Plots	Household Size
Post-Harvest Season				
Group 1	15.176	2.130	5.429	4.120
10% Commitment + Credit Opt.	[133.013]	[13.323]	[4.027]	[3.364]
Group 2	8.998	1.431	6.766	4.368
10% Commitment	[9.280]	[1.406]	[4.866]	[2.853]
Group 3	8.868	1.577	6.272	4.500
50% Commitment + Credit Opt.	[10.776]	[2.037]	[5.285]	[3.940]
Group 4	9.056	1.312	7.050	5.105
50% Commitment	[10.407]	[1.514]	[5.010]	[4.015]
Planting Season				
Group 5	10.391	1.685	6.589	5.022
Spot Market + Credit Opt.	[10.598]	[1.490]	[5.218]	[3.843]
Group 6	10.959	1.621	7.223	4.851
Spot Market	[11.049]	[1.577]	[6.135]	[3.581]
T-Tests and Mean Differences Relative to the Control Group				
10% Commitment	-0.198	0.296**	-0.747*	0.053
50% Commitment	-0.257	0.415***	-1.031***	-0.684**
10% Commitment + Credit Opt.	-6.376	-0.403	0.590*	0.301
50% Commitment + Credit Opt.	-0.068	0.150	-0.253	-0.078
Spot Market + Credit Opt.	-1.591**	0.042	-0.570	-0.601**
Spot Market	-2.159***	0.106	-1.204***	-0.429*

Household Demographics Descriptive Statistics: Part B – Average Number of a Given Asset Owned by a Household								
		Telephone	Bed	Radio	Bike	TV	VCR	Lounge
Post-Harvest Season								
10% Commitment + Credit Opt.	Group 1	0.868	0.246	0.655	0.728	0.204	0.112	0.022
		[0.339]	[0.432]	[0.476]	[0.445]	[0.404]	[0.316]	[0.148]
10% Commitment	Group 2	0.874	0.158	0.740	0.787	0.240	0.123	0.029
		[0.332]	[0.365]	[0.439]	[0.410]	[0.428]	[0.329]	[0.169]
50% Commitment + Credit Opt.	Group 3	0.883	0.207	0.679	0.691	0.207	0.093	0.028
		[0.322]	[0.406]	[0.468]	[0.463]	[0.406]	[0.290]	[0.165]
50% Commitment	Group 4	0.881	0.199	0.767	0.778	0.277	0.130	0.036
		[0.324]	[0.400]	[0.423]	[0.416]	[0.448]	[0.337]	[0.187]
Planting Season								
Spot Market + Credit Opt.	Group 5	0.891	0.193	0.666	0.755	0.238	0.109	0.012
		[0.312]	[0.395]	[0.472]	[0.431]	[0.426]	[0.312]	[0.111]
Spot Market	Group 6	0.895	0.202	0.758	0.784	0.332	0.191	0.019
		[0.307]	[0.402]	[0.429]	[0.412]	[0.471]	[0.394]	[0.136]
T-Tests and Mean Differences Relative tothe Control Group								
	10% Commitment	0.006	-0.012	-0.027	0.031	-0.023	0.008	-0.007
	50% Commitment	-0.000	-0.054*	-0.055	0.039	-0.061*	0.000	-0.014
	10% Commitment + Credit Opt.	0.012	-0.101***	0.057	0.089***	0.012	0.019	-0.000
	50% Commitment + Credit Opt.	-0.002	-0.061*	0.034	0.126***	0.010	0.038	-0.005
	Spot Market + Credit Opt.	-0.010	-0.048	0.047	0.062*	-0.021	0.022	0.010
	Spot Market	-0.014	-0.056*	-0.046	0.034	-0.116***	-0.061**	0.003

Household Demographics Descriptive Statistics: Part C – Average Value (in CFA) of a Given Asset							
	Telephone	Bed	Radio	Bike	TV	VCR	Lounge
Post-Harvest Season							
Group 1	16403	12443	4179	21519	32877	11500	26688
10% Commitment + Credit Opt.	[11786]	[10227]	[2389]	[14909]	[11362]	[3616]	[23765]
Group 2	15075	13333	4138	22807	34390	10952	9150
10% Commitment	[10326]	[11625]	[2311]	[13123]	[12580]	[2971]	[3214]
Group 3	17701	15336	4377	23705	34925	12000	33889
50% Commitment + Credit Opt.	[12921]	[11034]	[3607]	[21083]	[17784]	[6102]	[25888]
Group 4	18962	18958	5123	27331	37800	12766	14663
50% Commitment	[15218]	[15363]	[3784]	[24989]	[21582]	[7431]	[11421]
Planting Season							
Group 5	17708	13654	4294	25180	34375	10682	21350
Spot Market + Credit Opt.	[13206]	[11450]	[2680]	[17260]	[10643]	[2549]	[12529]
Group 6	17887	13906	4479	24611	35886	11429	12708
Spot Market	[13070]	[9038]	[2589]	[17901]	[13736]	[4101]	[5391]
T-Tests and Mean Differences Relative to the Control Group							
10% Commitment	1291.275	128.205	118.205	1576.870	-1286.796	-380.952	8641.667*
50% Commitment	-2595.739**	-5496.795**	-866.20***	-2947.399	-4696.552	-2194.529*	3128.205
10% Commitment + Credit Opt.	-36.700	1018.357	77.057	2864.331*	226.736	-928.571	-8895.833
50% Commitment + Credit Opt.	-1334.524	-1874.282	-120.728	678.205	-1821.925	-1428.571	-1.61e+04
Spot Market + Credit Opt.	-1341.808	-192.308	-37.136	-796.766	-1271.552	-110.390	-3558.333
Spot Market	-1520.799	-444.712	-222.680	-227.698	-2782.628	-857.143	5083.333