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**Making Markets:
Experiments in Agricultural Input Market Formation**

ANDREW DILLON AND NICOLÓ TOMASELLI

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*DISEI, Università degli Studi di Firenze
Via delle Pandette 9, 50127 Firenze (Italia) www.disei.unifi.it*

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Making Markets: Experiments in Agricultural Input Market Formation

Andrew Dillon
Northwestern University

Nicoló Tomaselli
University of Florence

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Abstract

Making markets is central to theories of development. In a randomized controlled trial, we vary an agricultural input market's organization to test whether time-inconsistent preferences, hard or soft commitments, and liquidity are constraints to market formation. The results show that markets organized earlier raise market sales consistent with farmer's measured time-inconsistent preferences. Liquidity in later spot markets are a substitute for earlier market timing. Farmer's demand is relatively inelastic to deposit levels in forward contracts. The experiment also directly tests the separability hypothesis where we find creating input markets alone does not lead to welfare improvements.

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JEL Codes

Q12 Micro Analysis of Farm Firms, Farm Households, and Farm Input Markets

L10 General, Market Structure, Firm Strategy, and Market Performance

G21 Banks, Depository Institutions, Micro Finance Institutions, Mortgages

1 Introduction

Making markets is central to theories of economic development. A large literature tests for separability of household production and consumption decisions (Benjamin (1992), LaFave and Thomas (2016)) and estimates the consequences of misallocation due to market 'missingness' (Adamopoulos (1992), Gollin and Udry (2021), Dillon and Barrett (2017)). Failure to reject the null hypothesis that markets are complete does not provide predictions on market-making mechanisms. For agricultural markets in low income countries, the technology adoption literature has extensively considered why farmers do not take-up seemingly profitable agricultural inputs or production technologies (Schultz (1964), Foster and Rosenzweig (2010), Magruder (2018), de Janvry and Sadoulet (2020), Suri and Udry (2022)) with significant attention to demand constraints. In much of this literature, a maintained assumption is that supply exists should farmers be willing to pay. Despite the idea that farmer constraints inhibit market formation, the supply side of the market is often also constrained. Input dealers lack information about existing demand in remote areas, face high transportation and coordination costs in reaching new markets, and are often liquidity constrained (Aggarwal et al. (2022), Asante et al. (2021), Macours (2019)). Markets fail to form due to demand and supply constraints, yet we have few empirical studies on supply side interventions that create agricultural input markets¹ or market-based interventions where we observe behaviors of both demand and supply side actors (Magruder (2018)).

Our experimental design addresses how agricultural input markets form in rural Mali by making markets, specifically Village Input Fairs (VIFs). We exogenously vary the input market's organization to better understand which mechanisms inhibit agricultural input market formation, focusing on market timing, deposit levels in forward contracts as a form of farmer commitment and liquidity in the form of credit to farmers. VIFs are one day commercial events that bring ag-input dealers, financial institutions and farmers together to buy and sell agricultural inputs within a village. In our experimental design, VIFs are organized as spot markets during the planting season when farmers apply fertilizer, or during the post-harvest period when the previous agricultural season has closed and farmers have more liquidity from harvest sales. In spot markets during the planting season, markets clear directly after the terms of the transaction are agreed. In post-harvest markets, a forward contract organizes the market transaction, the terms of which are formalized in a purchase order. Post-harvest markets clear during the planting season when inputs are delivered to farmers in their villages and transaction balances are paid. In

¹We specifically focus on agricultural input markets. In the recent literature on agricultural output markets, a focus on intermediaries and farmer behavior is modeled to estimate welfare effects for farmers and/or price effects. See for example, Bergquist and Dinerstein (2020) or Casaburi and Reed (2022).

post-harvest treatment groups, we vary the deposit amounts of forward contracts between 10 or 50 percent of the purchase order. Deposit requirements are, in effect, commitment mechanisms, with a large body of literature focusing on either "hard" or "soft" commitment (Bryan et al. (2010)). The last variation in VIF organization are credit offers made through a partnership with a rural microfinance organization. Variations in market timing, deposit amounts and credit offers allow us to disentangle the effects of behavioural mechanisms, such as time-inconsistent preferences (Duflo et al. (2011)), commitment levels, and liquidity constraints on market demand.

We summarize our results in four parts. First, we present compliance measures from a supply and demand perspective. In experiments such as Duflo et al. (2011) or Liverpool-Tasie et al. (2024), one agricultural input company implements the intervention. In this experiment, a consortium of input dealers organized by the national input dealers association (UNRIA) organized the VIFs. Working with multiple implementers creates potential variation in implementation quality across VIFs, but more closely approximates the real world. We define measures of supply-side compliance that relate to ag-input dealers VIF-organizing effectiveness and village-specific implementation outcomes which are necessary conditions for farmer take-up. We find that ag-input dealers are successful in marketing the VIFs with high levels of farmer awareness, but that village take-up (villages where a VIF was organized, and purchases were made) varies from 45-80 percent in post-harvest market fairs with forward contracts, to 100 percent in spot market fairs organized during the planting season. With respect to demand side compliance, farmer unconditional take-up varied from 18-24 percent of participants in VIFs organized with forward contracts and a 53 percent take-up rate in the spot market VIFs. The higher compliance in spot markets at planting time is associated with lower individual farmer demand. Farmers have lower liquidity during the planting season and a shorter time horizon to make complementary investments in seed, land preparation, water-control, or farm capital acquisition, which may lower demand. Alternatively, the salience of the planting season may also increase market participation, even if transactions are smaller.

Second, we estimate the effect of VIFs on the competitiveness of market prices and farmer trust in the VIF transactions. One potential concern in creating VIFs is that input dealers may price discriminate. We do not find evidence of price differences among the agricultural inputs frequently sold during the VIFs in comparison to the control group. Next, given the novelty of introducing forward contracts in a rural context and offering forward contracts linked to credit, we wanted to assess farmers' trust in VIF markets. Specifically, we ask whether farmers had trust in VIF transactions, namely that transactions would be completed as promised with the products (and quality) promised. We find farmers had high levels of trust in the VIF market

transactions when spot markets were organized with or without credit. Farmer's also had high levels of trust in the forward contract treatments with 10 percent deposits, but we did not observe increased trust in forward contracts with harder commitments of 50 percent.

Third, we estimate the intention-to-treat for input demand. We find that VIFs with forward contracts or spot markets with credit increased farmer total input demand relative to the control group, but more consequentially also relative to simply providing farmers with market access in a planting season spot market. VIFs with forward contracts increased the total value of fertilizer used by farmers by 39,951 - 47,443 FCFA (24 - 28 percent relative to the baseline control mean) relative to the control group. Adding credit options to the commitment contracts increases farmer input demand, but is not statistically different than effect sizes for VIFs organized with only commitment contracts. During the planting season with credit, total fertilizer demand increased by 38,548 FCFA (23 percent relative to the baseline control mean), an effect size which we are not able to reject as different than the post-harvest forward market VIFs. These results suggest that the effect of earlier post-harvest market timing and later planting season liquidity are effectively substitute mechanisms in creating input markets.

Fourth, we estimate the intention-to-treat on interlinked agricultural decisions and sales. Innovations in market organization resulted in increased farmer adoption of inputs and production intensification rather than diversification of production. Forward market VIFs organized in the post-harvest season increase fertilizer use between 9-14 percentage points. A spot market VIF organized at planting with credit increased fertilizer use by 12 percentage points. Despite new farmers' adoption of fertilizer due to VIF treatments and overall increases in farmer input demand, we do not observe changes in the farmers' crop choice portfolio, but do estimate small changes in household and hired labor demand. We do not measure statistically significant effects of VIFs on farmer sales or production value.

Our study contributes to the literature on farmers' constraints and the effect of market organization (contract design) on farmers' input demand, mechanisms explaining farmers' technology adoption and use, and the welfare and substitution effects of market creation on farm households and production.

First, contract design to create agricultural markets is an underappreciated mechanism through which agricultural technologies and farm practices might be promoted. Much of the literature has taken a demand-side approach to relieve farmers constraints, particularly to promote farmer learning through agricultural extension, subsidize inputs, or reduce farmer risk with agricultural

insurance Suri and Udry (2022). Recent attention to scaling has integrated supply side and market perspectives which are often taken as exogenous constraints in a farm household model. By focusing on the experimental variation of contracts in real transactions, the behavior of supply-side actors, such as ag-input dealers, is directly observed, which is necessary for scaling, but also best approximates with whom demand-side actors (farmers) actually interact. Our results illustrate a model where liquidity constraints can be addressed by the timing when markets are organized using forward contracts. Prices are competitive in the VIFs we observe. Taken together with demand and supply side compliance, these results are informative in identifying market-making mechanisms.

Second, we estimate the tradeoffs between commitment and liquidity on market design, illustrating that they are in fact substitutes. ITT effects on farmer input demand are statistically similar whether spot markets are organized during the planting season with credit or commitment contracts without credit are offered to farmers in the post-harvest period. This empirical result underscores a larger literature on farmer seasonal liquidity (Rui Albuquerque (2024)) and how market creation might be tied to seasonal liquidity to improve farmer investment in agricultural inputs.

Third, by directly creating markets with our experimental design, our work provides direct rather than indirect empirical evidence on the effects of incomplete markets on household welfare. Indirect tests of the separability of household production and consumption decisions have provided evidence consistent with this hypothesis (Dillon and Barrett (2017)), but exogenous variation in input markets in our experimental design provides a direct test. We interpret null effects on crop choice, yields and marketed surplus as consistent with the large literature on separability. The experiment provides direct proof of the theoretical hypothesis that resolving one missing market does not improve welfare if households are not able to optimally reallocate labor and capital across time periods and manage risk in labor, capital and insurance markets. This result is also consistent with a broader agricultural literature which finds strong effects on primary outcomes of agricultural investments, but limited or null effects on yields or incomes either due to yield measurement challenges Foster and Rosenzweig (2010) or the inability of farmers to adjust on other margins to maximize the benefits of agricultural innovations (for example, Beaman et al. (2013), Cole and Fernando (2021), Macours (2019), Suri and Udry (2022)).

2 Literature

We motivate the missing market problem with the canonical non-separable agricultural household model. Households maximize utility subject to budget, time and production constraints for a given production technology. The separability literature establishes that an implication of such a model is the non-separability of household consumption and production decisions when markets are incomplete. When markets are complete, households act as price takers and maximize utility recursively. Maximizing profits and taking profits as given in a second stage, the consumption bundle is chosen to maximize utility. The empirical literature has broadly failed to reject the null hypothesis of separability and the existence of complete markets (Benjamin (1992), LaFave and Thomas (2016)).²

Examples from the economic history of markets provide context for the Village Input Fair innovation and economic institutions that have emerged from problems of missing markets (North (1977)). One day fairs, trade shows, farmer’s weekly markets, or annual/harvest festivals are examples of agricultural spot markets. They provide an opportunity for social interaction, the demonstration of skills and crafts, and for the exchange of goods. Fairs were a fixture of the Roman Empire, and the Romans introduced markets and fairs into northern Europe to encourage trade across the Empire. When the Western Roman Empire disintegrated in the late 5th century, virtually all organized commerce in Europe ceased until the late 7th century as these market institutions were abandoned (de Ligt (1994)). Milgrom et al. (1990) assessed how the medieval Champagne County fairs in Northeastern France filled the gap left open by weak market institutions to facilitate trade growth. In Kenya, Ensminger (1996) analyzes the transformation of markets among Orma pastoralists over several decades.

In discussions about missing markets, the empirical literature has focused on the definition of market access. Chamberlain and Jayne (2013) examines correlations in measures of market access and changes over time in market access in rural Kenya. Common definitions of market access have often focused on proximity to roads, but Chamberlain and Jayne (2013) argue that distance to roads are poorly correlated with other more direct measures of farmers market access. They find evidence that supply-side actors behavior is most correlated with changes in more direct measures of market participation.

From a demand side perspective, the technology adoption literature has primarily focused on why farmers do not take-up seemingly profitable technologies. In rural Kenya, Duflo et al.

²Recent work on labor market constraints have also highlighted how rationing (Breza et al. (2021)) or transportation frictions (Bryan et al. (2014)) lead to incomplete labor markets.

(2011) study 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 markets with forward contracts is that farmers often have high liquidity during the post-harvest season when crops are sold even if they do not need inputs until later at planting time. The authors interpret the behavioral effect of a post-harvest market as a mechanism to induce commitment to a profitable investment. Duflo et al. (2011) also 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. These models, taken with standard models of credit constraints (Deaton (1992), Bardhan and Udry (1999)), do not provide unambiguous predictions of whether time-inconsistent preferences may most affect agricultural input demand, 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 farmer input demand.

In Burkina Faso, Dillon et al. (2018) build on the experimental design of Duflo et al. (2011) by including a soft commitment mechanism for sorghum farmers. Farmers commit early, in the post-harvest season, by signing a purchase order with an agricultural input dealer during an input fair, and depositing 5 percent 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 in the post-harvest season, rather than late at planting, even when the transactions in the planting season 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, Casaburi and Willis (2018) documents that offering agricultural insurance contracts during the post-harvest season significantly increases insurance uptake compared to offering the same product at planting time. Axmann et al. (2019) provides evidence for the case of certified hybrid seed whose take-up is highest during the harvest period.

On the supply side of input markets, the literature has focused on the effects of asymmetric information in matching agricultural input sellers with potential buyers. First, information about potential buyers and sellers is often unavailable, despite the rise of information technology

and communication (Aker (2010)). Moreover, there is evidence that agricultural input markets are characterized by information asymmetries regarding the quality of goods, the reputation of agents, and various commitment problems caused by weak institutions (Michelson et al. (2021), Fafchamps (2020), Aker and Fafchamps (2015), Bird and Fafchamps (2004)). Taken together, these factors reduce competition and negatively affect the incentives of traders to expand markets in rural areas.

In addition, unreliable transportation infrastructure affects, not only market access for farmers, but also the marketing costs faced by input dealers. When markets are sparse and population density low, as is the case in many African countries, transportation costs are a barrier to moving goods from cities to farms and vice versa (Aggarwal et al. (2022), Casaburi et al. (2012), Fafchamps and Gabre-Madhin (2006)). Finally, private agents lack sufficient information about demand in remote areas. Farmers’ demand for inputs varies within and between villages, potentially increasing input dealers’ uncertainty about where to market their products (Macours (2019), Lybbert et al. (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 such as equipment, labor, or water to ensure a profitable input investment (Harou et al. (2022), Corral et al. (2020)). This related literature motivates our work on agricultural input market development, with a particular emphasis on village-level interventions that address constraints for farmers and input dealers.

3 Experimental Design

3.1 Input Markets in Mali

Agriculture in Mali is primarily composed of smallholder farmers where the production system is labor-intensive, and farmers have limited access to agricultural inputs like capital, water, labor, seeds, fertilizers, or insecticides. Seventy-two percent of the population cannot afford a healthy diet (Ritchie (2021)), while 62 percent of people work in agriculture — a share that has declined by 10 percentage points in the last twenty years (Roser (2023)).

Our experiment was based in four regions: Sikasso, Koulikoro, Kangaba, and Bananba. Arable land is widely available in these regions, but the nutrient content of the soil is generally very low (Dembele et al. (2016), Vanlauwe et al. (2000)) and agricultural input use, considering improved seeds, fertilizers, and insecticides, is low compared to international standards (Ritchie et al. (2022)). Farmers mainly grow millet, rice, and cotton in these regions. At baseline, households

cultivated 8.3 hectares across six plots. Production is coordinated within the household where all members contribute labor to larger household plots used for cereal production. Most adult household members in rural areas also maintain individual plots with men often producing a cash crop and women producing vegetables and condiments in a secondary season.

Input markets are largely missing in rural areas. 70 percent of farmers in our baseline survey reported that they did not have access to an ag-input dealer in their village in prior agricultural season. Farmers primarily travel to secondary towns to procure fertilizer, but missing markets reduce access for poorer farmers and women who have more limited mobility. These reports are consistent with other Sahelian zones in West Africa such as northern Ghana where 80 percent of farmers travelled to local towns to purchase inputs (Ghana Socioeconomic Panel Survey 2022/23). One barrier to input market formation is the cost of transporting inputs to rural markets, which accounts for around one-third of the total price (USAID (2018)). Storage facilities for fertilizer and other inputs are inadequate, increasing the risk of input quality deterioration and higher coordination costs. A second barrier is the high correlation between weather uncertainty and planting timing. Smallholder farmers without access to water control plant after the first rainfall to ensure seed germination. This creates high seasonal demand which must be satisfied throughout the rural sector in a few weeks. Small-scale ag-input dealers have procurement difficulties working in highly informal supply chains to meet demand. Overall, this environment results in a fragmented private input supply sector, consisting mostly of small-scale secondary input dealers (USAID (2018)) that are connected to a few large dealers in the capital, Bamako.

Ag-input dealers in our rural study areas are local dealers who primarily supply farmers from their shops in secondary towns. These ag-input dealers are at the base of ag-input supply chain. They often employ one or two seasonal employees, and procure their stocks from wholesale ag-input dealers in large cities. Input dealers who participated in VIFs supplied commonly used fertilizers in Mali such as urea, DAP and NPK. These fertilizers are used in the production of cereals, tubers, leafy greens and other vegetables, and cash crops such as cotton. Urea is added to add nitrogen to soils, while DAP is primarily composed of phosphorous with a smaller amount of nitrogen. NPK is composed of lower amounts of nitrogen, phosphorous and potassium. Most mineral fertilizer use in Mali is concentrated in the cotton sector and a national centralized rice irrigation scheme (Office du Niger) rather than in subsistence agriculture (Dissa et al. (2022)). Access to inputs for cotton and irrigated rice farmers is heavily influenced by national agricultural policy and the publicly owned cotton company (CMDT).

For the average smallholder farmer, fertilizer prices in Mali are relatively high compared to other

parts of Africa (Sanga et al. (2021)). In Mali, the average retail prices of urea, DAP, and NPK for the year 2018, when we conducted the experiment, are 0.52 \$/Kg for urea, 0.65 \$/Kg for DAP, 0.47 \$/Kg for NPK.³ The primary data that we collected in the study area during the study period indicate that these commonly used fertilizers were priced between the local currency equivalent of 0.40 and 0.50 \$/Kg, while industrially produced organic fertilizers were priced at \$0.27/Kg. Herbicides and insecticides were priced at \$7.81 and \$8.19/liter, respectively, while commercially improved seeds were priced at \$1.20/Kg.

We highlight two Malian private sector actors which help shape input markets in our study area. The first is UNRIA, which has a network of at least 950 agricultural input dealers in the target regions, represents the main national association of dealers, and plays an active role in agricultural policy. UNRIA mobilized input dealers to supply the VIFs in our experiment. A second private sector actor is Soro Yiriwaso, a microfinance institution based in Mali that has a wide suite of agricultural savings and credit products targeted primarily to rural areas. Although Soro Yiriwaso has been operating in Mali for more than two decades, access to agricultural credit is low due to high demand and relatively few microfinance organizations like Soro Yiriwaso with agricultural lending products.

3.2 Study Design

The experimental design focuses on the market characteristics of Village Input Fairs. These commercial events are not common in rural Mali. When set up by extension services or by the input 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 to sell inputs directly to small-scale farmers or as a technology exposition. In contrast, VIFs are markets created directly in rural villages that build on the self-interest of three actors: input dealers, farmers, and microfinance institutions. In all VIFs, input dealers organize a one-day fair where farmers can purchase inputs after product description and marketing presentations by the input dealers. Farmers are able to purchase any inputs in any quantities they demand, and no pricing policy is enforced. All actors make decisions to sell, purchase or offer credit independently and in their own interest.

Variations in the VIF treatment are defined by i) the timing at which the input fair is organized, either during the post-harvest season organized with a forward contract or at planting time organized as a spot market; ii) the level of deposit required to place an order with a forward

³Data on fertilizer retail prices in eighteen African countries are collected and made publicly available by the Africafertilizers project, powered by IFDC – <https://africafertilizer.org>.

contract, with a ‘soft’ 10 percent or ‘hard’ 50 percent deposit, and iii) the possibility to obtain credit during the fair. The combination of i) and ii) yields three possible ways of organizing the VIFs. Either the VIF is organized during the post-harvest season (with a 10 percent or 50 percent deposit requirement), or the fair is organized at planting season without a deposit amount because farmers pay in full at the spot market. Figure 1 describes the 3 x 2 experimental design where treatment is assigned at the village level. The timing and level of commitment is one level of randomization (post-harvest VIFs with 10 percent deposits, post-harvest VIFs with 50 percent deposits, and planting season VIFs) which are cross randomized with or without credit availability. We selected 140 villages in the defined study area using the National Census available from the Statistical Office in Mali. Each treatment group and a control group were randomly assigned 20 villages.

In the markets where 10 percent deposit forward contracts are offered, the microfinance institution facilitates the interaction between farmers and input dealers by accompanying the supplier in organizing the Village Input Fair. Farmers are offered the opportunity to purchase agricultural inputs with the possibility of financing their purchase with a loan. The interested farmer places the order and pay a 10 percent deposit on the day of the fair. The balance of the purchase could either be paid by the farmer or financed by a loan that would be activated upon delivery of the inputs by the dealer at the beginning of the planting season. The microfinance institution deposits the purchase order in a blocked account. The funds in the blocked account are transferred in full to the input dealer at the time of delivery, along with the balance payment - paid by the farmer or financed by the loan. At the time of delivery, it is possible for a farmer to default on the purchase. In this case, the microfinance institution transfers the order deposit to the input dealer. In reality, we did not observe any farmers who completely reneged. In cases where farmers had difficulty making the final payment at delivery, they often renegotiated their order quantity. The same VIF organization was used in another treatment arm, but without the credit option, which was not offered to farmers in this case.

In the VIFs organized with 50 percent deposit forward contracts, the input fair takes place immediately after the harvest of the previous agricultural season, but in this case the farmer places input orders and pays a higher rate, equal to a 50 percent deposit, on the day of the Village Input Fair. The balance could either be paid by the farmer or financed by a loan. The same VIF organization was used in another treatment arm, but without the credit option, which was not offered to farmers. We emphasize that the deposit requirement is a mandatory feature of the VIFs organized as a market in the post-harvest season (groups 1, 2, 3, and 4 in Figure 1). In contrast, three treatment arms (groups 3, 4, and 5) include the possibility of a credit option

that is entirely voluntary. Farmers can apply for credit, but the microfinance organization treats each farmer as a client and determines eligibility only after credit screening.

In all fairs organized with forward contracts, input delivery occurs on a specified date just before the planting season in bulk for all farmers. Bulk delivery ensures lower costs for ag-input dealers and allows farmers to verify input quality before accepting delivery.

Finally, two VIF treatment arms are organized as spot markets at the beginning of the planting season, in groups 5 and 6. In the spot market VIFs with credit, the purchase value is either paid directly by the farmer or becomes a loan. In the latter case, the microfinance institution makes the payment directly to the input dealer after signing the loan contract with the farmer. The same VIF organization is used in treatment group 6, but without the credit option, which in this case is not offered to farmers. Treatment group 6 is essentially a planting season spot market.

4 Empirical Strategy

4.1 Econometric Analysis

We estimate two intention-to-treat (ITT) 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 household agricultural production, crop choice and labor post-treatment in 2018.

We begin our analysis by comparing demand and supply side compliance, market price, and farmer trust in market transactions conducted during the VIF by treatment group. Since no VIF occurred in the control group, we present comparisons between the treatment arms relative to Group 6 in Figure 1, the spot market VIF without credit organized during the planting season. We interpret differences between the treatment arms and the spot market organized during the planting season as the relative effect of alternative market structures to guaranteed spot market access at planting. 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, market prices and trust levels in the market transaction.

$$y_m = \alpha + \sum_{k=1}^5 \beta^k T_{km} + \epsilon_m \quad (1)$$

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 1.

At the household level, our primary outcome of interest is unconditional input demand. We estimate each of these ITTs relative to the control group, in equation 2. Though most farm households use some type of agricultural input at baseline, we also estimate the effect of VIF market structures on adoption.

In the pooled difference in differences 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.

$$y_{ht} = \alpha + \sum_{k=1}^6 \delta^k T_{kh} + \gamma Year + \sum_{k=1}^6 \beta^k (Year \times T_k) + \epsilon_{ht} \quad (2)$$

The coefficient β^k in equation 2 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. In this specification, we estimate ITT effects on agricultural input extensive and intensive margins. The results of this analysis are reported on Tables 3 and 4.

For outcomes including agricultural production, marketed surplus, crop diversity, and labor, 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.

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

In this case, the coefficient β^k in equation 3 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 Tables 5, 6, and Table 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 a moderate underestimation of the intention to treat effects in our sample.

4.2 Testable Hypotheses

We outline five testable hypotheses from our experimental design and data structure which provide insights on market making mechanisms.

4.2.1 Hypothesis 1: Input markets are competitive.

We test whether the spatial variation in prices faced by households are observationally equivalent between treatment groups and in markets organized during different time periods. Forty-six independent agricultural input dealers participated in our experiment and were assigned to participate in multiple Village Input Fairs. As independent input dealers, they could set prices in their VIF market. We test the null hypothesis that farmer input prices do not vary across treatment and control groups in equation 4:

$$H_o : E(p_h | k = 1) - E(p_h | k = 2) - \dots - E(p_h | k = 7) = 0 \quad (4)$$

Rejection of the null hypotheses indicates that input dealers have market power, while failure to reject the null is consistent with competitiveness in input markets. We test prices in markets organized during the post-harvest and planting seasons, as well as markets organized within these periods.

4.2.2 Hypothesis 2: Farmers input demand is driven by time-inconsistent preferences rather than liquidity.

We measure farmer stated preferences by asking farmers to choose between a current and future monetary transfer similar to elicitation methods described by Cohen et al. (2020) or Falk et al. (2023). Descriptively, we find 87 percent farmers were either impatient or time-inconsistent and 13 percent of farmers were patient.

Given the high proportion of time-inconsistent farmers in our sample, we can test directly whether time-inconsistent preferences or liquidity have stronger effects on farmer input demand. That is, we compare input demand from VIFs organized with a forward contract treatment without credit to the spot market treatment with credit. All else being equal, we can measure the revealed preferences of a farmer faced with a forward contract that includes a commitment mechanism and compare them to input demand expressed in a spot market where liquidity constraints are alleviated by credit offers.

$$H_o : \beta^1 - \beta^5 = 0 \tag{5}$$

$$H_o : \beta^2 - \beta^5 = 0 \tag{6}$$

4.2.3 Hypothesis 3: Within seasonal liquidity affects market demand.

We estimate the marginal effects of forward contract VIFs or spot market VIFs by comparing the demand for 10 percent deposit forward contracts (with and without credit), 50 percent deposit forward contracts (with and without credit), and spot market contracts with and without credit. Testing this hypothesis provides an estimate of the marginal effect of within season liquidity.

$$H_o : \beta^1 - \beta^3 = 0 \tag{7}$$

$$H_o : \beta^2 - \beta^4 = 0 \tag{8}$$

$$H_o : \beta^5 - \beta^6 = 0 \tag{9}$$

4.2.4 Hypothesis 4: 'Soft' commitment increases demand relative to 'hard' commitment mechanisms

The behavioral economics literature recognizes that commitment mechanisms can vary in intensity, leading to differences in behavioral responses Karlan and Linden (2014). In our experimental design, we vary the level of commitment in forward contracts based on the amount of deposit a farmer must pay up front to secure the order. Harder commitments reduce future liquidity

which may reduce input demand in the current period. Farmers may value this commitment mechanism if they have time inconsistent preferences. Whether the value of the commitment mechanism depends on the deposit amount or the option to order inputs and be committed to paying for them in the future period is an empirical question. This is a directly testable hypothesis in our experimental design by comparing demand levels between VIFs with 10 percent deposits and VIFs with 50 percent deposits.

$$H_o : \beta^1 - \beta^2 = 0 \tag{10}$$

4.2.5 Hypothesis 5: Resolving one missing market does not improve welfare if other markets are incomplete.

We highlight two implications of complete markets that are relevant to our results. First, in a separable agricultural household model, complete markets imply not only the existence of land, labor, credit, or insurance markets, but that these markets exist in all current and future periods in this state-contingent model. Second, direct tests for complete markets are quite difficult to formulate, even with rich panel data that control for other potential sources of endogeneity, precisely because evidence against complete markets would be predicated on finding a missing market.

Given our first stage results on input demand, we can estimate secondary effects of intention to treat effects on household production value and marketed surplus. Creating input markets when other markets are complete should lead to increased production value and marketed surplus conditional on first stage input demand effect sizes.

As a second set of tests for complete markets, we can test whether VIF treatments have indirect effects on household input adoption, crop choice and labor demand by repeating the above hypotheses tests with these outcome variables to explore how households adjust to the creation of input markets. Missing markets could restrict the farmer’s ability to adjust their production plan optimally.

5 Results

We report five sets of results on: supply and demand side compliance, the ITT effects on market outcomes, the ITT effects on household input demand, the ITT effects on adoption, and the ITT on effects on production and marketed surplus, crop choice and labor.

5.1 Compliance

Table 1 presents compliance statistics for the Village Input Fairs by treatment group. One concern with supply-side interventions implemented by private actors is the possibility that low compliance *on the supply side* may affect farmer uptake. Because we work with a consortium of ag-input dealers, implementation quality might vary by site independent of farmer’s willingness to purchase inputs in VIFs. To quantify this supply side dimension of compliance, we identify several variables directly tied to supply-side implementation quality. We find that households in treatment villages were aware of the input fair (Table 1, column 1), but not all villages participated in the fairs. We characterize village take-up heterogeneity as supply-side compliance as the ag-input dealers primary responsibility was to market and organize the VIFs.

Village-level take-up rates are 100 percent in the planting season when markets are organized as spot markets, but range from 45 percent to 80 percent in the post-harvest season when markets are organized in the post-harvest period with forward contracts. In villages where the VIF was organized with a 50 percent commitment and credit offered, several village leaders unilaterally declared their unwillingness to engage the entire village on such terms, which they considered too high and risky for their farmers. In qualitative work in treatment villages and with agricultural input dealers, farmers reported some reluctance to use commitment contracts. These markets required more trust between input dealers and farmers and were more novel contracts compared to spot markets. We observe higher compliance with soft commitments (10 percent deposit requirements) than harder commitments (50 percent deposit requirements). Despite differences in village take-up across treatments, unconditional farmer compliance ranged from 18 to 24 percent of farmers participating in the post-harvest season markets with forward contracts and 53 percent in the planting season, spot market VIFs.

Among farmers who ordered agricultural inputs with forward contracts, an open compliance question was whether farmers would pay their order balances upon delivery. Farmers rarely reneged on their commitment contracts, but did renegotiate quantity ordered, particularly when financing with credit was not possible. Table 1, column 4, shows the percentage of the farmer’s final order value paid to the ag-input dealer. In spot markets, there is no concern about revising or reneging on orders with a 100 percent order fulfillment rate. In the 10 and 50 percent commitment groups without credit, 70 and 82 percent of the order value was actually purchased. In the same groups with credit, 95 and 98 percent of the order value was actually purchased at delivery.

5.2 Market

Table 2 presents results on market prices and farmer self-reported trust in their VIF market transactions. In the bottom panel of Table 2 and each subsequent table, we formally test for differences between treatment groups. We report the groups for which we reject the null hypothesis that the treatment effects between groups i and j are equal. All p-values for the joint tests are reported in the Appendix.

A primary supply side concern is whether organizing VIFs with only a few (on average 2-3 input dealers) creates an opportunity for price discrimination as stated in Hypothesis 1. There are several reasons why VIF prices may vary from prices in other fertilizer markets. We test whether VIF prices in the post-harvest or planting seasons differ from input prices found in the control group. We find little variation in the price of fertilizers among the post-harvest treatment groups for the three major fertilizer categories that are usually traded in Village Input Fairs (e.g. Urea, DAP, and NPK). For NPK, where fairs were organized as spot markets at the planting period, we find higher prices with higher standard deviations than the control group, suggesting more price variation in planting season markets. We do not find a statistically significant difference in VIF prices relative to the control group. We also do not find systematic differences between VIF treatments in market prices. The integration of credit into VIF markets could have caused input dealers to offer higher prices, but we do not find evidence of this behavioral response by input dealers. Broadly, we conclude from this analysis that prices were competitive in VIF markets.

We also asked farmers about their trust in input market transactions in their respective groups. Anecdotally, both farmers and ag-input dealers can be skeptical of the trustworthiness of the other, particularly in bilateral transactions where contract enforcement is weak. In treatments with the highest participation, we find higher reported levels of trust which are statistically different than the control group, ranging between a 4 and 6 percentage point increase in trust levels. While these effect sizes are not large, a common concern among farmers and donors is the quality of agricultural inputs. While we can not independently validate the quality of inputs as in Harou et al. (2022), we find that farmers self-report high levels of trust in treatment villages indicative of comparable input quality in VIFs as in other input markets. VIFs introduce third-party verification when inputs are delivered and community observability of transactions in VIF marketplaces which may also have reinforced trust in VIF transactions.

5.3 Input demand

Table 3 presents the effects of VIF treatments on unconditional input demand, our main outcome of interest, which we estimate using a difference-in-differences specification. We specify input demand as the total input value of fertilizer and pesticide used during the agricultural season (Column 1). We also provide ITT estimates for disaggregated effects on fertilizers and pesticides as independent categories (Columns 2 and 3) as well as specific fertilizers: urea, DAP and NPK (Columns 4, 5, and 6). A few input demand patterns emerge from the table. First, by comparing Columns 1 and 2, total input value and total fertilizer value, treatment effects are primarily driven by farmer fertilizer demand rather than pesticide demand. Second, providing market access through a spot market in the planting season (treatment Group 6) has no statistically significant effect on input demand relative to the control group. This result is consistent with Aggarwal et al. (2024) who created spot markets during the planting season and similarly found no effects. We are also able to reject the hypothesis that total input demand in treatments 2-5 are statistically similar to the market access group (Column 1). We conclude from these results that commitment and liquidity are important market organization mechanisms independent of creating the market itself. Third, total fertilizer demand (Column 2) is primarily driven by DAP input demand for all treatments. The effect sizes range from 23 to 28 percent of baseline mean total fertilizer demand (USD 66 - 81). Farmers demand larger values of DAP relative to Urea and NPK, likely because farmers perceive soil nutrient deficiencies to primarily be driven by phosphorous rather than nitrogen. For treatments where credit is offered during the VIF, farmers demand for urea increases significantly. The effect sizes range from 20 to 28 percent of the baseline mean urea demand (USD 20 - 29). We do not find effects of market organization on NPK demand.

Given these results, we focus on the effects of commitment and liquidity to make input markets. We test three hypotheses described above: whether farmer input demand is driven by time-inconsistent preferences (Hypothesis 2), the effect of within season liquidity on market demand (Hypothesis 3), and whether 'soft' commitment increases demand relative to 'hard' commitment mechanisms in forward contracts (Hypothesis 4).

A hypothesis tested by Duflo et al. (2011) is that time-inconsistent preferences drive farmer demand for commitment contracts. Their conclusion is driven by comparing farmer demand with a commitment mechanism relative to subsidized fertilizer in the planting season. Our hypothesis test compares soft commitment contracts in the form of 10 or 50 percent deposit requirements with credit availability rather than price discounts. We can not reject the hypothesis that commitment treatment effects are equal to treatment effects of markets organized with credit. Focusing on total fertilizer demand (Column 2), treatment effects for the 10 percent commitment (Group 1) and credit (Group 5) treatment groups are statistically similar. The pairwise

t-test between coefficients of the 50 percent commitment (Group 2) and credit (Group 5) also are statistically similar. We interpret these effects as consistent with Duflo et al. (2011) findings that commitment mechanisms drive farmer demand. These results do provide a broader test of the relative effects of commitment and liquidity by using an alternative treatment to test reducing liquidity constraints. Credit availability might be a better intervention to reduce liquidity constraints rather than price subsidies, particularly in our Malian context where farmers are poorer and have lower welfare levels compared to many other small holder farmers. By reducing liquidity constraints, the results clearly demonstrate that softer commitment mechanisms are substitutes for planting season agricultural credit.

Given that commitment and liquidity are substitutes, our results also test the effect of within seasonal liquidity on market demand (Hypothesis 3). Whether we focus on total input demand or fertilizer demand (Columns 1 and 2), we can not reject the hypothesis that treatments organized in the post-harvest season with commitment contracts are similar to those treatments with commitment contracts and credit. Though treatment effects are slightly larger in treatments organized with credit (group 1 vs group 3; group 2 vs group 4), effects on total input demand or total fertilizer demand are not statistically different. Credit offers with the commitment treatments did change the composition of fertilizer demand with statistically significant effects on urea demand as noted above.

Within the post-harvest treatments, we are also able to test whether 'soft' commitment increases demand relative to 'hard' commitment mechanisms (Hypothesis 4). If we think of commitment contracts from the perspective of a two period model of input demand, increases in commitment deposit amounts in period 1 might reduce demand, particularly if farmers have time inconsistent preferences. However, we do not find evidence that input demand is statistically different in the 10 or 50 percent commitment treatments. We are not able to reject the null hypothesis in pairwise t-tests between groups 1 and 2; and groups 3 and 4.

5.4 Adoption

In our unconditional demand analysis, treatment effects could be driven by either farm households that had not used agricultural inputs previously or those who are increasing the intensive margin of input demand. Table 4 presents the extensive margin of demand use, the binary variable if the household uses inputs or not. At baseline, fertilizer and pesticide use at the household level is relatively high. The baseline average household input use is 91 percent, with 85 percent of households using fertilizer and 87 percent using a pesticide. Despite relative high baseline mean adoption, we find significant treatment effects on adoption for fertilizer use, consistent with the patterns of treatment effects for unconditional fertilizer demand. This result shows that making

village markets supplies the marginal farmers that would otherwise be denied market access. In this sense, village input fairs represent an opportunity to address the 'last-mile problem' in household input adoption.

We find statistically significant effects of commitment contract VIFs and spot markets organized with credit on input use. Fertilizer effect sizes range from 9.6 percentage points to 13.7 percentage points and are driven primarily by urea adoption rather than DAP or NPK adoption. We cannot reject the hypothesis that any of the treatment groups are different from each other. The adoption results are broadly consistent with the hypotheses testing whether time inconsistent drive farmer demand, the effect of within season liquidity on demand and the relative effect of "soft" versus "hard" commitment mechanisms.

5.5 Production and Marketed Surplus, Crop Choice, and Labor

Observed changes in input demand could affect household output or other input margins such as the household crop portfolio or agricultural labor demand. These specifications are cross-sectional as in equation 3. Table 5 presents ITT estimates of VIFs on household production value and marketed surplus. Changes in input demand associated with the VIFs organized either as a commitment contracts or as a spot market lead to increases in the total value of household agricultural production, but these effect sizes are not statistically significant. We also do not find evidence that these treatment effects are statistically different from each other.

Table 6 presents the ITT estimates of VIFs on household crop choice. Despite the potential for VIFs with commitment contracts to increase a farmer's seasonal planning horizon, we do not find a consistent pattern of crop portfolio substitution among the most commonly grown crops in our sample. These results show that there is no systematic substitution into or out of a particular crop. We cannot conclude that VIFs influence crop choice, or that changes in the value of agricultural production are due in part to changes in crop portfolio rather than input intensification.

We also estimate agricultural labor supply effects that may result from increased input utilization. In Table 7, we report ITT estimates for agricultural household labor days and agricultural hired labor days. Household labor supply increased in the VIF treatments relative to the control, primarily for planting (25-34 labor days) and weeding (30-36 labor days). We do not estimate significant treatment effects on household labor supply response during the harvest period. On hired labor demand, we largely do not see an effect on hired labor in response to the VIF treatments. For the 10 percent commitment group, we observe a 7 day or 116 percent increase in hired

labor for the weeding season. There is not an increase in hired labor during the weeding period for the VIF treated households, but overall hired labor demand is very low in these households as most planting and weeding is conducted by household members. Though agricultural labor supply data is often noisy, these results do suggest that increased labor demand resulted from VIF treatments where we found first-order input demand effects.

Taken together, these results provide a direct test of the welfare effects of incomplete markets. A main theoretical prediction from the nonseparability literature is that resolving one missing market does not improve welfare if other markets are incomplete. A related agricultural technology adoption literature also often finds increased adoption without yield or profitability (Beaman et al. (2013) Cole and Fernando (2021), Udry and Kolavalli (2019)). While much of the nonseparability literature has focused on indirect tests, the VIF treatments directly create markets in rural villages for agricultural inputs. Our results provide additional evidence for the theoretical prediction that creating markets may not increase yields or household welfare if other markets remain incomplete. In our rural Malian context, farmers also face missing markets for insurance, land or water-control technologies which may prevent increased productivity.

6 Conclusion

A central feature of low-income countries is the absence of markets for goods and services. In Mali, farmers demand fertilizer but often can not purchase it. Ag-input dealers would like to increase their fertilizer profits, but do not service rural communities. We focus on market organization mechanisms to better understand how to make markets, estimating the relative effects of timing, the deposit rate (commitment levels) used in forward contracts, and the availability of credit offers. Markets organized in the post-harvest period and with credit access had strong effects on farmer demand, input adoption, and household agricultural labor supply. The creation of spot markets during the planting season did not have an effect on agricultural input demand suggesting that timing and liquidity are market making mechanisms. We also find these market making mechanisms can be substitutes: forward contracts in the post-harvest period are substitutes for agricultural credit interventions organized during the planting season.

The results suggest several reflections on the potential behavioral implications of forward contracts which we are not able to fully disentangle in the present design. While the demand for forward contracts is consistent with time-inconsistent farmer preferences and higher liquidity in the post-harvest period, an alternative explanation is that farmers value forward contracts to protect them from market volatility that can occur later at planting time. At planting, farmers

often face supply shortages, generating the risk of not having access to their agricultural input of choice. The timing of when inputs are available is a risk for rain-dependent farmers because input application depends on the uncertainty of when the rainy season begins, a period of a few weeks. Farmers often wait for subsidized fertilizer which does not come. Input quality is another risk factor perceived by the farmers which may encourage ordering inputs from trusted ag-input dealers earlier, although farmer beliefs are not generally a good proxy for true input quality (Michelson et al. (2021), Michelson et al. (2023)). Lastly, input prices can be volatile as high prices resulting from the Ukrainian war illustrated in 2022.

These are all factors that the literature has shown to be crucial in farmers' investment decisions (Suri and Udry (2022)) and consistent with prospect theory (Kahneman and Tversky (1979), Prietzel (2020)) interpretations. In their study of index insurance products, Shin et al. (2022) provide evidence for a *certainty effect* which occurs when agents give greater weight to outcomes that are perceived as certain as opposed to those that are only possible. Although we cannot test it formally, our results are also consistent with the certainty effect. Entering into a forward contract with an input dealer who commits to provide quality inputs at a future date generates certainty, as opposed to the alternative of waiting until planting, when market conditions may or may not hold.

The experiment also distinguishes the effects of forward contracts with soft or hard commitment levels. Village compliance was much lower with harder commitments, even though farmer input demand effects were similar across both types of commitment deposit levels. From an ag-input dealers perspective, hard commitment contracts would not be profitable as the fixed costs of organizing the fair would be lost if whole villages are not willing to participate. From a scaling perspective, an open question would be whether effective marketing might change village compliance rates with higher commitment. Ag-input dealers do prefer higher deposit rates as it increases their liquidity at a period of time when they are financing their stocks with larger suppliers in the supply chain.

We also highlight the potential importance of trust in market creation, but are unable to identify the effect of trust in this experiment. In all treatment groups, a microfinance organization was present to collect deposits, even when their role during the fair was not to provide access to credit. By integrating a third-party financial intermediary, the microfinance organization provide some assurance to farmers and ag-input dealers that transactions are being monitored. VIFs were organized in public, so transactions were also more publicly observable by farmers and ag-input dealers, potentially increasing social pressure to respect the transaction terms. While we are not

able to estimate these effects directly and they do not bias our results, they are informative of potential market making mechanisms and other avenues for future research.

Though VIFs did not have strong effects on household agricultural productivity, VIFs are a promising policy response to missing agricultural input markets and the promotion of last-mile adoption extension efforts. During the experiment, we estimated VIF costs at USD 100 per fair, suggesting that promoting input market development with VIFs is cost effective. We also highlight that the VIF model leverages private sector actors by providing ag-input dealers access to new potential markets, building the private sector rather than competing directly with local ag-input dealers. We hope in future work to better understand these supply-side effects on ag-input dealer profitability and business growth.

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Figures and Tables

Figure 1: Experimental Design and Timeline

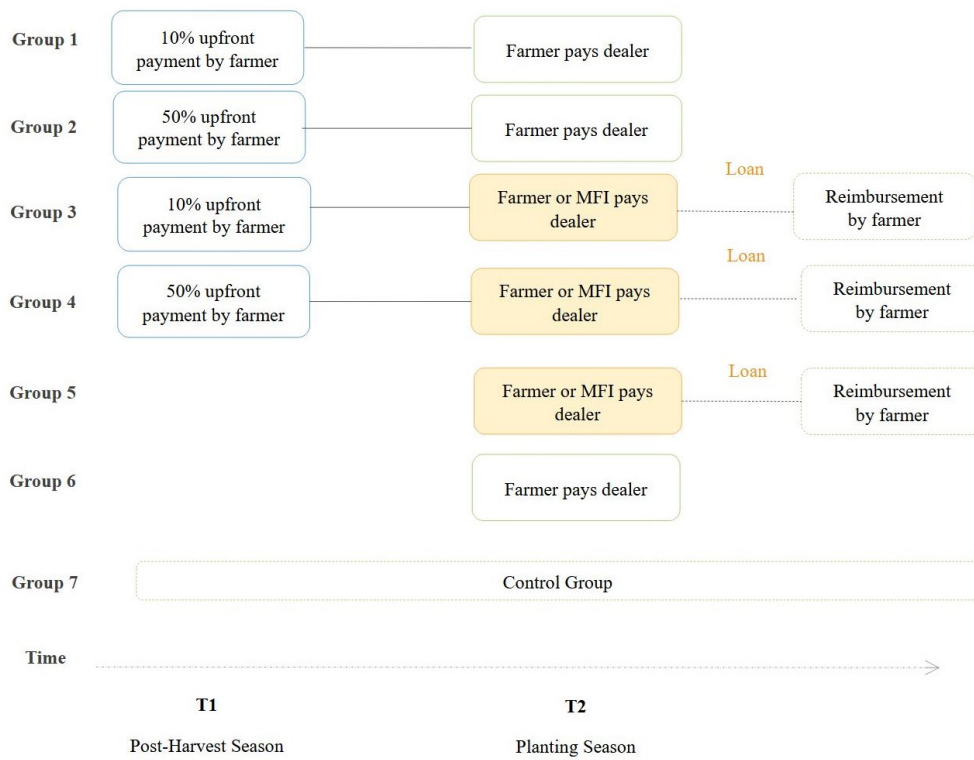


Table 1: Supply and Demand-side Compliance

	Village is aware of the input fair	Percentage of villages with at least one purchase	Proportion of participants who have ordered inputs (unconditional)	Percentage of delivery value
Post-Harvest Season				
10% Commitment	100.0%	80%	18.2%	70%
50% Commitment	95.0%	70%	23.0%	82%
10% Commitment + Credit	90.0%	70%	23.9%	95%
50% Commitment + Credit	90.0%	45%	21.9%	98%
Planting season				
Credit	100.0%	100%	53.2%	100%
Market Access	95.0%	100%	52.9%	100%
Total	95.0%	78%	33.2%	94%

Notes: The third column shows the proportion of participants who ordered inputs out of the total number of participants, regardless of village take-up.

Table 2: ITT Estimates on Market-level Outcomes

	Urea price	DAP price	NPK price	Pesticide price	Trust in transaction
	1	2	3	4	5
Post-Harvest Season					
<i>Group 1</i>	-0	-3*	25	87	0.054**
10% Commitment	(2)	(2)	(18)	(325)	(0.023)
<i>Group 2</i>	0	-3	7	-201	0.004
50% Commitment	(2)	(3)	(19)	(253)	(0.025)
<i>Group 3</i>	0	0	18	-433	0.059**
10% Commitment + Credit	(3)	(2)	(13)	(276)	(0.024)
<i>Group 4</i>	-0	-4**	-4	-212	0.018
50% Commitment + Credit	(2)	(2)	(21)	(250)	(0.029)
Planting Season					
<i>Group 5</i>	2	-2	15	65	0.047**
Credit	(1)	(2)	(21)	(257)	(0.022)
<i>Group 6</i>	-3	-2	12	-32	0.040*
Market Access	(2)	(2)	(13)	(245)	(0.023)
Cons	230***	230***	257***	3,862***	0.899***
	(1)	(1)	(11)	(136)	(0.020)
Number of observations	254	254	254	254	2,543
i	$H_0 : \beta^i = \beta^j$				
1	2				
2	3, 5, 6				
3	5				
4					
5	6				

Notes: Symbols ***, **, * denote significance at 1, 5, and 10 percent level, respectively. i: group number. Prices are in XOF by kilogram. Average exchange rate in 2017: 1000 XOF= \$1.7126

Table 3: ITT Estimates on (Unconditional) Input Demand

	Total input value	Total fertilizer value	Total pesticide value	Total urea value	Total DAP value	Total NPK value
	1	2	3	4	5	6
Post-Harvest Season						
<i>Group 1</i>	42,220	39,948*	7,738	12,530	31,782**	-2,625
10% Commitment	(25,935)	(22,237)	(9,406)	(8,105)	(15,362)	(5,349)
<i>Group 2</i>	47,266*	41,441*	7,264	10,558	31,331**	-3,406
50% Commitment	(25,210)	(21,046)	(8,662)	(7,556)	(14,649)	(4,701)
<i>Group 3</i>	56,425**	47,470**	16,470*	16,740**	27,019*	2,406
10% Commitment + Credit	(28,447)	(22,844)	(9,543)	(7,565)	(15,396)	(5,450)
<i>Group 4</i>	50,219**	45,969**	8,806	14,849**	34,371**	-1,739
50% Commitment + Credit	(23,603)	(20,175)	(7,987)	(6,758)	(14,144)	(5,115)
Planting Season						
<i>Group 5</i>	49,211**	38,577**	11,736	11,772*	25,643*	-2,536
Credit	(23,552)	(19,314)	(8,804)	(6,532)	(15,154)	(5,303)
<i>Group 6</i>	1,051	5,822	-3,487	2,912	11,318	-6,322
Market Access	(24,405)	(21,052)	(8,534)	(7,239)	(14,959)	(4,700)
Baseline control mean	216,016	167,750	55,990	59,844	97,502	2,483
	(210,039)	(173,646)	(61,129)	(59,984)	(107,691)	(10,876)
Number of observations	4,961	4,794	4,667	4,753	4,749	4,912
i	$H_0 : \beta^i = \beta^j$					
1						
2	6					
3	6					6
4	6	6				
5	6				6	

Notes: Difference in difference specification (2017-2018). Fertilizer: Urea, DAP, NPK, other chemical. Pesticide: Insecticide, fungicide, herbicide. Input: fertilizer + pesticide. The estimations used robust standard errors clustered at the village level and added these controls: household land size quartiles, median prices of DAP, pesticides, NPK, and other chemicals at the village level. All outcome variable values in XOF. Average exchange rate in 2017: 1000 XOF= \$1.7126. Symbols ***,**,* denote significance at 1, 5 and 10 percent level, respectively. i: group number

Table 4: ITT Estimates on Input Adoption

		Input use	Fertilizer use	Pesticide use	Urea use	DAP use	NPK use
		1	2	3	4	5	6
Post-Harvest Season							
	<i>Group 1</i>	0.107	0.137**	0.135*	0.139*	0.066	0.108
10% Commitment		(0.065)	(0.068)	(0.077)	(0.077)	(0.049)	(0.092)
	<i>Group 2</i>	0.054	0.099	0.083	0.089	0.012	0.079
50% Commitment		(0.068)	(0.061)	(0.086)	(0.069)	(0.050)	(0.081)
	<i>Group 3</i>	0.122	0.126*	0.138	0.152**	0.078	0.097
10% Commitment + Credit		(0.077)	(0.073)	(0.090)	(0.075)	(0.057)	(0.085)
	<i>Group 4</i>	0.093	0.096*	0.138*	0.144**	-0.020	0.099
50% Commitment + Credit		(0.057)	(0.053)	(0.071)	(0.059)	(0.058)	(0.067)
Planting Season							
	<i>Group 5</i>	0.137*	0.117*	0.164*	0.128**	0.036	0.062
Credit		(0.071)	(0.062)	(0.085)	(0.064)	(0.051)	(0.079)
	<i>Group 6</i>	0.057	0.047	0.090	0.057	-0.039	0.042
Market Access		(0.061)	(0.057)	(0.076)	(0.067)	(0.050)	(0.079)
Baseline control mean		0.910	0.851	0.866	0.821	0.123	0.746
		(0.286)	(0.357)	(0.342)	(0.384)	(0.329)	(0.436)
Number of observations		4,961	4,961	4,961	4,961	4,961	4,961
i		$H_0 : \beta^i = \beta^j$					
1		6					
2							
3		6					
4							
5							

Notes: Diffence in difference specification (2017-2018). Fertilizer: Urea, DAP, NPK, other chemical. Pesticide: Insecticide, fungicide, herbicide. Input: fertilizer, pesticide. Input use, Fertilizer use and Pesticide use outcomes are defined as follows: they takes the value 1 when at least one plot managed by the household is using respectively an input, a fertilizer and a pesticide and 0 otherwise. The estimations used robust standard errors clustered at the village level and added these controls: household land size quartiles, median prices of DAP, pesticides, NPK and other chemical at the village level. Symbols ***, **, * denote significance at 1, 5 and 10 percent level, respectively. i: group number

Table 5: ITT Estimates on Production Value and Marketed Surplus

	Total value of agricultural production	Marketed surplus
	1	2
Post-Harvest Season		
<i>Group 1</i>	36,634	79
10% Commitment	(42,556)	(139)
<i>Group 2</i>	52,068	203
50% Commitment	(48,882)	(140)
<i>Group 3</i>	61,794	179*
10% Commitment + Credit	(37,490)	(106)
<i>Group 4</i>	39,715	145
50% Commitment + Credit	(39,608)	(129)
Planting Season		
<i>Group 5</i>	20,905	52
Credit	(36,893)	(124)
<i>Group 6</i>	-2,118	67
Market Access	(40,068)	(126)
Midline control mean	353,125	983
	(278,868)	(1,104)
Number of observations	2,332	2,325
i	$H_0 : \beta^i = \beta^j$	
1		
2		
3		
4		
5		

Notes: Cross-sectional analysis in 2018. Symbols ***, **, * denote significance at 1, 5 and 10 percent level, respectively. i: group number. The estimations used robust standard errors clustered at the village level and added these controls: household land size quartiles, median prices of DAP, pesticides, NPK and other chemical at the village level. All outcome variables in XOF. Average exchange rate in 2017: 1000 XOF= \$1.7126

Table 6: ITT Estimates on Crop Choice: Share of Plots with a Given Crop Listed as a Main

Crop		Peanut	Cotton	Fonio	Gombo	Maize	Millet	Rice	Sesame	Sorghum
		1	2	3	4	5	6	7	8	9
Post-Harvest Season										
	<i>Group 1</i>	0.069	-0.128**	0.054	-0.089***	-0.033	0.118	-0.062	0.036	0.032
10% Commitment		(0.072)	(0.063)	(0.036)	(0.029)	(0.046)	(0.090)	(0.085)	(0.024)	(0.035)
	<i>Group 2</i>	-0.013	-0.011	0.002	-0.044	0.006	0.081	0.011	0.002	-0.008
50% Commitment		(0.073)	(0.059)	(0.020)	(0.034)	(0.070)	(0.133)	(0.073)	(0.021)	(0.040)
	<i>Group 3</i>	0.031	-0.031	0.026	-0.059*	0.025	0.084	-0.086	0.056	-0.043
10% Commitment + Credit		(0.060)	(0.055)	(0.030)	(0.034)	(0.045)	(0.086)	(0.090)	(0.043)	(0.048)
	<i>Group 4</i>	-0.032	-0.053	-0.006	-0.036	0.042	0.029	-0.015	0.011	0.022
50% Commitment + Credit		(0.057)	(0.069)	(0.021)	(0.027)	(0.056)	(0.095)	(0.070)	(0.031)	(0.042)
Planting Season										
	<i>Group 5</i>	0.114*	-0.066	0.010	-0.064**	0.033	-0.009	-0.049	0.024	-0.008
Credit		(0.058)	(0.060)	(0.020)	(0.031)	(0.045)	(0.102)	(0.073)	(0.033)	(0.040)
	<i>Group 6</i>	-0.012	-0.108*	0.019	-0.039	-0.017	0.125	0.030	0.052	0.009
Market Access		(0.053)	(0.055)	(0.023)	(0.039)	(0.049)	(0.086)	(0.063)	(0.033)	(0.038)
Baseline control mean		0.760	0.574	0.081	0.151	0.647	0.380	0.496	0.116	0.388
		(0.428)	(0.496)	(0.274)	(0.359)	(0.479)	(0.486)	(0.501)	(0.321)	(0.488)
Number of observations		2,537	2,537	2,537	2,537	2,537	2,537	2,537	2,537	2,537

Notes: Cross-sectional analysis in 2018 with interaction between treatment and gender. All estimations are at the household level. The estimations use robust standard errors clustered at the village level. Symbols ***, **, * denote significance at 1, 5 and 10 percent level, respectively

Table 7: ITT estimation on labor demand

	Household labor (days)			Hired labor (days)		
	Planting	Weeding	Harvest	Planting	Weeding	Harvest
	1	2	3	4	5	6
Post-Harvest Season						
<i>Group 1</i>	25**	36**	16	1	7***	-1
10% Commitment	(11)	(15)	(12)	(1)	(2)	(3)
<i>Group 2</i>	34***	13	8	-1	3	-0
50% Commitment	(13)	(13)	(14)	(1)	(2)	(4)
<i>Group 3</i>	23	30*	7	0	3	-1
Credit + 10% Commitment	(14)	(18)	(11)	(1)	(3)	(3)
<i>Group 4</i>	22	23	6	-0	1	-1
Credit + 50% Commitment	(13)	(20)	(14)	(1)	(2)	(3)
Planting Season						
<i>Group 5</i>	30**	33**	22*	-0	3	-1
Credit	(13)	(15)	(12)	(1)	(3)	(3)
<i>Group 6</i>	17	10	8	1	3	0
Market Access	(11)	(15)	(12)	(1)	(2)	(3)
Midline control mean	94	121	106	3	6	15
	(85)	(120)	(114)	(9)	(14)	(32)
Number of observations	2,543	2,543	2,543	2,543	2,543	2,543
i	$H_0 : \beta^i = \beta^j$					
1				2	4	
2						
3						
4						
5						

Notes: Cross sectional specification (2018). Symbols ***, **, * denote significance at 1, 5 and 10 percent level, respectively

A Appendix 1: P-values of tests for difference between treatment coefficients for tables 2-5

Table A1: P-values of tests for difference between treatment coefficients table 2

	Urea price	DAP price	NPK price	Pesticide price	Trust in trade
	1	2	3	4	5
$\beta^1 = \beta^2$	0.963	0.990	0.376	0.336	0.005
$\beta^1 = \beta^3$	0.879	0.134	0.661	0.105	0.758
$\beta^1 = \beta^4$	0.984	0.578	0.200	0.315	0.133
$\beta^1 = \beta^5$	0.242	0.746	0.660	0.943	0.626
$\beta^1 = \beta^6$	0.188	0.753	0.393	0.684	0.366
$\beta^2 = \beta^3$	0.899	0.335	0.504	0.345	0.003
$\beta^2 = \beta^4$	0.956	0.710	0.649	0.960	0.580
$\beta^2 = \beta^5$	0.196	0.822	0.726	0.233	0.011
$\beta^2 = \beta^6$	0.143	0.851	0.784	0.420	0.045
$\beta^3 = \beta^4$	0.884	0.081	0.254	0.363	0.096
$\beta^3 = \beta^5$	0.585	0.425	0.876	0.047	0.435
$\beta^3 = \beta^6$	0.275	0.293	0.537	0.093	0.250
$\beta^4 = \beta^5$	0.414	0.490	0.455	0.209	0.210
$\beta^4 = \beta^6$	0.314	0.452	0.428	0.384	0.360
$\beta^5 = \beta^6$	0.009	0.942	0.854	0.650	0.619

Table A2: P-values of tests for difference between treatment coefficients for table 3

	Total input value	Total fertilizer value	Total pesticide value	Total urea value	Total DAP value	Total NPK value
	1	2	3	4	5	6
$\beta^1 = \beta^2$	0.842	0.946	0.957	0.819	0.975	0.869
$\beta^1 = \beta^3$	0.615	0.752	0.355	0.618	0.759	0.379
$\beta^1 = \beta^4$	0.724	0.768	0.893	0.756	0.850	0.864
$\beta^1 = \beta^5$	0.754	0.944	0.640	0.918	0.671	0.987
$\beta^1 = \beta^6$	0.085	0.113	0.184	0.227	0.169	0.433
$\beta^2 = \beta^3$	0.704	0.757	0.249	0.359	0.741	0.242
$\beta^2 = \beta^4$	0.888	0.803	0.819	0.526	0.806	0.711
$\beta^2 = \beta^5$	0.923	0.864	0.549	0.845	0.665	0.853
$\beta^2 = \beta^6$	0.041	0.076	0.151	0.298	0.145	0.478
$\beta^3 = \beta^4$	0.791	0.937	0.309	0.767	0.571	0.433
$\beta^3 = \beta^5$	0.740	0.599	0.557	0.364	0.918	0.367
$\beta^3 = \beta^6$	0.029	0.052	0.016	0.053	0.268	0.085
$\beta^4 = \beta^5$	0.954	0.619	0.656	0.546	0.486	0.874
$\beta^4 = \beta^6$	0.019	0.036	0.069	0.068	0.081	0.316
$\beta^5 = \beta^6$	0.016	0.065	0.041	0.148	0.302	0.430

Table A3: P-values of tests for difference between treatment coefficients for table 4

	Input use	Fertilizer use	Pesticide use	Urea use	NPK use	DAP use
	1	2	3	4	5	6
$\beta^1 = \beta^2$	0.426	0.583	0.532	0.537	0.197	0.749
$\beta^1 = \beta^3$	0.845	0.892	0.970	0.877	0.814	0.906
$\beta^1 = \beta^4$	0.787	0.485	0.957	0.940	0.101	0.908
$\beta^1 = \beta^5$	0.634	0.757	0.701	0.875	0.504	0.593
$\beta^1 = \beta^6$	0.373	0.164	0.514	0.279	0.013	0.456
$\beta^2 = \beta^3$	0.318	0.700	0.490	0.347	0.209	0.811
$\beta^2 = \beta^4$	0.468	0.953	0.436	0.362	0.537	0.741
$\beta^2 = \beta^5$	0.191	0.764	0.308	0.518	0.597	0.815
$\beta^2 = \beta^6$	0.949	0.356	0.918	0.625	0.250	0.627
$\beta^3 = \beta^4$	0.665	0.653	0.999	0.899	0.100	0.970
$\beta^3 = \beta^5$	0.821	0.891	0.754	0.696	0.433	0.618
$\beta^3 = \beta^6$	0.323	0.243	0.533	0.176	0.029	0.481
$\beta^4 = \beta^5$	0.420	0.675	0.704	0.740	0.295	0.505
$\beta^4 = \beta^6$	0.431	0.308	0.416	0.121	0.728	0.341
$\beta^5 = \beta^6$	0.162	0.200	0.299	0.227	0.109	0.782

Table A4: P-values of tests for difference between treatment coefficients for table 5

	Total value of agricultural production	Agricultural sales
	1	2
$\beta^1 = \beta^2$	0.747	0.376
$\beta^1 = \beta^3$	0.535	0.375
$\beta^1 = \beta^4$	0.935	0.597
$\beta^1 = \beta^5$	0.664	0.827
$\beta^1 = \beta^6$	0.313	0.924
$\beta^2 = \beta^3$	0.826	0.842
$\beta^2 = \beta^4$	0.791	0.673
$\beta^2 = \beta^5$	0.478	0.265
$\beta^2 = \beta^6$	0.240	0.313
$\beta^3 = \beta^4$	0.534	0.741
$\beta^3 = \beta^5$	0.191	0.205
$\beta^3 = \beta^6$	0.075	0.277
$\beta^4 = \beta^5$	0.568	0.411
$\beta^4 = \beta^6$	0.256	0.497
$\beta^5 = \beta^6$	0.510	0.893

B Appendix 2: Balance tables

Table B1: Household Demographics Descriptive Statistics

		Total Plot Area	Average Plot Size	Number of Plots	Household Size
Post-Harvest Season					
	<i>Group 1</i>	7.03	1.36	6	4
10% Commitment		(7.29)	(1.29)	(5)	(3)
	<i>Group 2</i>	7.88	1.20	7	5
50% Commitment		(7.56)	(1.02)	(5)	(4)
	<i>Group 3</i>	6.74	1.30	5	4
10% Commitment + Credit		(6.90)	(1.11)	(4)	(3)
	<i>Group 4</i>	6.57	1.26	5	4
50% Commitment + Credit		(6.78)	(1.15)	(4)	(3)
Planting Season					
	<i>Group 5</i>	8.03	1.61	5	4
Credit		(8.33)	(1.42)	(5)	(3)
	<i>Group 6</i>	7.70	1.41	6	4
Market Access		(7.54)	(1.15)	(5)	(3)
<i>T-Tests and Mean Differences Relative to the Control Group</i>					
10% Commitment		-1.385***	-0.014	-0.737***	-0.249*
50% Commitment		-0.539	-0.167***	0.067	0.429***
10% Commitment + Credit		-1.677***	-0.071	-1.410***	-0.135
50% Commitment + Credit		-1.843***	-0.113**	-1.201***	-0.200
Credit		-0.387	0.236***	-1.035***	0.073
Market Access		-0.718*	0.036	-0.773***	-0.027

Notes: Symbols ***, **, * denote significance at 1, 5 and 10 percent level, respectively

Table B2: Average Value (in CFA) of a Given Asset

	Telephone	Bed	Radio	Bike	TV	VCR	Lounge
Post-Harvest Season							
<i>Group 1</i>	12,662	1,718	2,737	16,858	6,962	1,160	502
10% Commitment	(10,597)	(5,394)	(2,739)	(15,091)	(14,618)	(3,498)	(3,787)
<i>Group 2</i>	14,637	2,800	3,378	17,679	8,083	1,342	362
50% Commitment	(13,309)	(7,884)	(3,479)	(19,710)	(16,924)	(4,084)	(3,347)
<i>Group 3</i>	14,109	2,640	2,585	17,846	6,103	1,120	505
10% Commitment + Credit	(12,915)	(7,074)	(2,643)	(17,609)	(14,126)	(3,564)	(4,096)
<i>Group 4</i>	14,154	2,977	2,761	14,737	6,158	914	519
50% Commitment + Credit	(12,221)	(7,423)	(2,986)	(18,295)	(13,875)	(3,294)	(4,941)
Planting Season							
<i>Group 5</i>	13,062	1,938	2,307	14,050	5,914	909	312
Credit	(12,594)	(6,122)	(2,595)	(16,266)	(14,064)	(3,516)	(3,049)
<i>Group 6</i>	13,603	2,127	2,807	15,369	9,102	1,616	180
Market Access	(11,979)	(5,674)	(2,755)	(16,490)	(16,236)	(4,165)	(1,491)
<i>T-Tests and Mean Differences Relative to the Control Group</i>							
10% Commitment	-1,538***	-766***	-199	-1,752**	-334	-105	190
50% Commitment	437	316	442***	-931	787	77	49
10% Commitment + Credit	-91	156	-352***	-765	-1,192*	-146	193
50% Commitment + Credit	-46	492	-176	-3,873***	-1,138*	-351**	207
Credit	-1,138*	-546*	-629***	-4,560***	-1,381**	-356**	-1
Market Access	-596	-358	-130	-3,242***	1,807**	351*	-132

Notes: Symbols ***, **, * denote significance at 1, 5 and 10 percent level, respectively

C Appendix 3: Pooled regressions tables

Table C1: Labor

	Household labor			Hire labor		
	Planting	Weeding	Harvest	Planting	Weeding	Harvest
	1	2	3	4	5	6
10% + 50% commitment	30*** (10)	24** (12)	12 (11)	0 (1)	5*** (2)	-0 (3)
10% + 50% commitment and credit	22** (11)	27* (15)	7 (10)	0 (1)	2 (2)	-1 (3)
Credit	30** (13)	33** (15)	22* (12)	-0 (1)	3 (3)	-1 (3)
Market access	17 (11)	10 (15)	8 (12)	1 (1)	3 (2)	0 (3)
Midline control mean	94 (85)	121 (120)	106 (114)	3 (9)	6 (14)	15 (32)
Number of observations	2,543	2,543	2,543	2,543	2,543	2,543
i	$H_0 : \beta^i = \beta^j$					
1						
2						
3						

Notes: Symbols ***,**,* denote significance at 1, 5 and 10 percent level, respectively

Table C2: Labor

	Household labor			Hire labor		
	Planting	Weeding	Harvest	Planting	Weeding	Harvest
	1	2	3	4	5	6
Early treatments	26*** (8)	25** (11)	10 (9)	0 (1)	4** (2)	-1 (3)
Planting treatments	23** (10)	21* (12)	14 (10)	0 (1)	3 (2)	-0 (3)
Midline control mean	94 (85)	121 (120)	106 (114)	3 (9)	6 (14)	15 (32)
Number of observations	2,543	2,543	2,543	2,543	2,543	2,543
i	$H_0 : \beta^i = \beta^j$					
1						

Notes: Symbols ***, **, * denote significance at 1, 5 and 10 percent level, respectively