DECENTRALIZED TARGETING OF AGRICULTURAL CREDIT PROGRAMS: PRIVATE VERSUS POLITICAL INTERMEDIARIES

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Abstract
We conduct a field experiment in India comparing two ways of delegating selection of microcredit clients among smallholder farmers to local intermediaries: a private trader (TRAIL), versus a local-government appointee (GRAIL). Selected beneficiaries in both schemes were equally likely to take up and repay loans, and experienced similar increases in borrowing and farm output. However farm profits increased and unit costs of production decreased significantly only in TRAIL. While there is some evidence of superior selection by ability and landholding in TRAIL, the results are mainly driven by greater reduction of unit production costs for TRAIL treated farmers than GRAIL treated farmers of similar ability or landholding. We develop and test a model where the TRAIL agents' role as middlemen in the agricultural supply chain enabled and motivated them to offer treated farmers business advice, which helped them lower unit costs. (JEL: H42, I38, O13, O16, O17)

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1. Introduction

Across many countries and contexts, microcredit programs have successfully targeted poor women borrowers while at the same time achieving high loan repayment rates. However, multiple field experiments across different settings have failed to find significant impacts on borrowers' project returns, incomes or consumption (Banerjee et al., 2015; AEJ, 2015).[1]

In previous research (Maitra et al., 2017), we reported results of a field experiment in the Indian state of West Bengal comparing the outcomes of traditional group based lending (GBL) with a novel alternative called Trader Agent Intermediated Lending (TRAIL) involving individual liability loans where selection of clients was partially delegated to a local private trader. TRAIL increased production of potato the leading cash crop by 27% and farm incomes by 22%, while GBL had negligible and insignificant effects on these outcomes.

Our analysis showed that the superior outcome of the TRAIL scheme was driven partly by superior borrower selection. Specifically, the beneficiaries that the TRAIL agent recommended were on average more productive than those who self-selected into the group-lending scheme. However as previous

1. Scholars have put forward different explanations for this lack of impact on borrower incomes. These include the high repayment frequency of microloans, borrower heterogeneity, restrictions on risk-taking, high interest rates, and group lending practices which either prevent the most productive borrowers from receiving microcredit, or limit the returns on funded projects (see, for example, Field et al., 2013; Fischer, 2013; Giné and Karlan, 2014; Hussam et al., 2018).

literature has highlighted, a group liability scheme also generates different incentives for borrowers than an individual liability scheme. Hence TRAIL and GBL differed both in the nature of loans offered and the method of selecting clients, making it difficult to disentangle the respective role of these two design elements.

In the current paper we restrict attention to individual loans and compare different ways of delegating client selection to local intermediaries. We compare TRAIL with a scheme called Gram Panchayat Agent Intermediated Lending (GRAIL) where the agent was appointed by the local government (*Gram Panchayat (GP)*). Both TRAIL and GRAIL agents were local members of the village community, equally well connected with farmers though in different ways: the TRAIL agent through economic transactions and the GRAIL agent through social and political connections. Both types of agents were offered identical agency contracts involving carrots (repayment-based commissions) and sticks (upfront deposits forfeited in the event of loan default). However, they had different skills and motivations. As traders, TRAIL agents played an important role in the agricultural supply chain, and had both the related business expertise and motivation to procure larger volumes of harvested crops from local farmers. The GRAIL agent was generally not a trader, but was more likely to be a village-level political operative, motivated instead by social connections and the political objectives of the incumbent local government.

Our field experiment took place in 72 villages in total, with 24 villages randomly assigned to each of the three schemes: TRAIL, GRAIL and GBL. The present paper restricts attention to comparing TRAIL and GRAIL in the

48 villages where they were administered. Each village participated in only one scheme, and had only one agent. Agents recommended a list of potential borrowers from among village residents and a randomly selected subset of each recommended list received loan offers. This design, therefore, allows us to separately estimate selection and treatment effects. Loan take-up rates were high, and slightly higher in TRAIL (94% versus 87%); repayment rates were 93% in both. Moreover, GRAIL and TRAIL borrowers were equally likely to use the loans for productive purposes. We also see similar expansions of acreage, and similar increases in input purchases and harvested quantities of principal crops in the two schemes. However, while TRAIL borrowers' potato and overall farm incomes increased by 20–30%, there was no discernible change in the incomes of GRAIL borrowers. This discrepancy occurs because the unit production costs of TRAIL beneficiaries declined significantly, whereas there was no such change for GRAIL beneficiaries.

We start by examining whether these results are driven by differences in the pattern of beneficiary selection. Although TRAIL and GRAIL agents exhibit different connections with borrowers they recommended, in a comparison of recommended farmers who were not randomly selected to receive the loan (Control 1 households) in the two schemes, we do not find any evidence that the observable farm performance of TRAIL and GRAIL beneficiaries differed significantly (absent the intervention). We then investigate possible differences in selection patterns on unobservable traits, using two different models. The first one (similar to the one in Maitra et al. (2017)) assumes that farmers vary in unobservable ability, that there are no frictions in input markets, and that there are diminishing returns to scale in potato cultivation. This model allows us to back out ability estimates from farmer fixed effects in a panel regression of cultivated area. Using this, we find that TRAIL agents selected more able farmers than GRAIL agents did. An alternative model with frictions in input markets where access to credit and land varies inelastically with wealth yields similar empirical estimates of selection differences.[2] However, a decomposition exercise in to evaluate the quantitative importance of this explanation for our observed findings reveals that these selection differences explain at most 10–15% of the observed difference in ATEs of the two programs. In contrast, within-group differences in treatment effects explain 30% of the ATE difference, indicating that the important explanation goes beyond selection differences, but instead lies in differential effects of the two schemes, *conditional* on beneficiary selection.. An additional problem with both selection models is that neither can explain why unit costs of production declined for TRAIL borrowers but not for GRAIL borrowers. Our finding that selection differences have limited explanatory power for explaining the treatment effects differential is robust to several checks: it continues to hold even when we conduct a finer decomposition exercise (where farmers are classified into many more ability categories), when we allow farmer ability to vary over time, and also when we allow farmers to vary across multiple dimensions such as ability, credit access and business skill, in a model with credit rationing and scale economies.

2. We thank an anonymous referee for suggesting the mechanism that we develop in this alternative model.

We then go on to develop and test a model that explains the larger treatment effects in TRAIL scheme conditional on measured ability; in particular one which explains the greater reduction in unit cost in TRAIL. Our explanation rests on the idea that both types of agents may have the ability and incentive to informally help or monitor borrowers, but these may differ across the two schemes. In particular, given their role as agricultural middlemen, TRAIL agents stand to gain if the borrower produces and sells more output. This motivates them to provide borrowers with useful business advice, for example how to procure cheaper or higher quality inputs. The resulting fall in unit costs motivates farmers to expand production and sales of potato to traders. GRAIL agents are unlikely to have the business knowledge needed to help borrowers reduce costs. Their motivations are also likely to be different. Their social and political reputations are likely tied to the repayment performance of the borrowers they recommended. Moreover, conditional on repayment, they do not earn any additional upside benefits when borrowers produce more output. We hypothesize that this motivates GRAIL agents to monitor treated farmers to reduce the risk of crop failure, e.g., by encouraging them to increase the use of costly risk-reducing inputs such as pesticides. This raises farmers' costs, but conditional on crop success does not affect productivity. In terms of motivation, GRAIL agents can be likened to external loan officers in conventional microcredit programs, who have a mission to lend to poor borrowers while minimizing loan default.

We show that this model can explain the estimated differences in the average treatment effects on the unit cost of production and farm profits. We also successfully test the model's additional predictions for borrowers' acreage, output and loan repayment rates, and the time that agents spend engaging (in conversation) with farmers. However, this does not rule out the possibility of alternative explanations.

In summary, our paper throws light on ways to fruitfully harness local information and connections of local intermediaries in designing microfinance programs. Existing evidence has shown that community based approaches to beneficiary selection can be problematic, particularly when intermediaries are expected to simultaneously satisfy multiple objectives (see, for example Vera-Cossio, 2022). Our results suggest that even when intermediaries' incentives are formally linked to a single criterion, and they are tasked only with *selecting* beneficiaries, their implicit motivations and subsequent informal engagement with these beneficiaries have important consequences. Our findings highlight the importance of considering the context in which delegated agents operate. Specifically, going beyond the explicit incentives built into their reward structure, there is need to pay attention to the implicit personal and professional motivations of those who implement the program. Other work has alluded to this idea when discussing agricultural extension workers (Bandiera et al., 2023) and job referees (Beaman and Magruder, 2012; Heath, 2018), but these lessons are novel in the context of microcredit programs.[3]

3. Following recommendations by experts appointed by the Reserve Bank of India, there has been a move to engage private "business correspondents" to deliver banking services in rural areas (Kishore, 2012; RBI, 2011, 2013). However the literature provides little guidance on how to select or incentivize these correspondents.

The paper is organized as follows. We provide further detail about the two TRAIL and GRAIL schemes in Section 2. In Section 3 we describe the data we collected from sample households in our project sites. These data are then used in Section 4 to provide evidence on the financial performance of the two loan schemes, and in Section 5 to estimate their average treatment effects on borrower outcomes. In Section 6 we evaluate an explanation for these results through a selection-based mechanism. Section 7 discusses our preferred explanation and supporting evidence, while Section 8 concludes.

2. Context and Intervention Design

Our study took place in the districts of Hugli and West Medinipur in West Bengal, where potatoes are an important high-value crop. Of all agricultural crops commonly grown in this area, potatoes generate the highest return (see Maitra et al., 2017, Table 2). However, for many smallholder farmers, the high cultivation costs of potatoes limit cultivation. The subsidized loan interventions we study here were designed to finance the working capital costs of cultivating this crop.

During 2010—2013 we conducted a field experiment across 72 villages, each located at least 8 kilometres away from the nearest other. Each village is governed by an elected village council (GP).[4] Each village was randomly assigned to one of three loan intervention schemes: TRAIL, GRAIL or GBL.

4. Each GP has 8–15 representatives directly elected every five years from a group of villages. In West Bengal village council elections, candidates typically declare an affiliation with a political party. West Bengal has a long history of cadre-based mobilization of voters

To address our research question, we restrict attention to the 48 villages assigned to the TRAIL and GRAIL schemes. As Table 1A shows, in 2007 the average village had about 250—300 households, of which about 60 percent reported planting potatoes. Land was unequally distributed: 47% of households owned less than 1.25 acres of land, and less than 1% owned more than 5 acres.[5] Our program targeted smallholder farmers and only households that owned less than 1.5 acres were eligible to receive the loans. Given the randomized assignment to intervention scheme, we see as expected, that the village characteristics were not statistically different across the two treatment arms (column 3).

The loan schemes were implemented by Shree Sanchari, a microfinance institution headquartered in Kolkata. In order to identify agents for TRAIL scheme, in each of the 24 villages in the TRAIL arm, our field team drew up a list of local traders who had at least 50 clients, or had been operating in the village for longer than 3 years. One randomly selected individual from this list was offered the contract to become the local agent for their village. To identify agents for the GRAIL arm, the field team requested the Gram Panchayat to nominate reputed individuals who had lived in the village for at least 3 years and were personally familiar with farmers in the village. One randomly drawn nominee from this list was offered the position of the GRAIL agent.

through political rallies and campaigns. Local political party workers are often instrumental in identifying beneficiaries for government programs and delivering benefits.

5. These descriptive statistics are based on a house listing exercise we conducted in these villages in 2007.

TABLE 1A. Descriptive Statistics on Village Characteristics

	TRAIL (1)	GRAIL (2)	Difference p-value (3)
Number of Households	284.546	263.455	*0.761*
	(208.611)	(246.204)	
Number of Potato Cultivators	166.318	169.318	*0.949*
	(136.076)	173.336	
Landless	16.182	27.955	*0.502*
	(19.585)	79.136	
Own 0 – 1.25 acres	112.955	100.318	*0.663*
	(107.795)	81.453	
Own 1.25 – 2.50 acres	25.045	26.273	*0.852*
	(16.899)	25.706	
Own 2.50 - 5.00 acres	10.773	13.864	*0.453*
	(7.696)	17.529	
Own 5.00 - 12.50 acres	1.364	1.273	*0.877*
	(1.866)	2.004	
Owns more than 12.50 acres	0.000	0.045	*0.323*
	(0.000)	(0.213)	
Number of Villages	23	23	

The data are from the house listing exercise we carried out in 2007 for 46 of the 48 study villages. We do not have houselisting data for the two villages that replaced villages that had to be dropped due to political violence.
p-values in italics. Standard deviations are in parentheses.

Agents had the same formal role in both schemes: each agent was asked to recommend as potential borrowers 30 village residents who owned no more than 1.5 acres of land. The field team then drew 10 names through a simple lottery conducted in the office of the local government, who were offered the program loans.[6] In what follows we refer to these households as Treatment households.

In the first loan cycle, borrowers were offered loans worth Rupees 2000 (approximately USD 40 at the time). They could choose whether and how

6. The list of recommended individuals was not made public. This was to avoid any spillover effects on informal credit access or other relationships for recommended households that were not randomly assigned to receive the loan.

much they wished to borrow, subject to this maximum. Loans were disbursed during the potato planting season in October–November 2010 and were due in a single lumpsum four months after disbursal, at 6 percent interest. Borrowers were individually liable for repayment. If they successfully repaid the loan, they became eligible for a 33% larger loan in Cycle 2. In this way loan offers became progressively larger in each subsequent cycle, so that in cycle 8 the maximum loan size would have been Rupees8300. Only borrowers who repaid at least 50% of the principal due were allowed to borrow again. To avoid pressuring borrowers to sell their harvest prematurely to repay their loan, in both schemes farmers were given the option of repaying the loan through potato "bonds".[7]

The scheme was designed to incentivise the agent to positively select borrowers and to prevent collusion between the agent and the borrowers. Before the first loans were disbursed, the agent deposited with the scheme an amount of Rupees50 per borrower in his village. This deposit was returned if the borrower survived in the program for two years. At the end of each loan cycle, the agent received a commission equal to 75% of the interest paid by all borrowers in his village. If more than one-half of the recommended borrowers defaulted on their loans, the agent was terminated and did not

7. Although the harvests take place during December–February, farmers can store potatoes in cold storage for up to 11 months. Potato "bonds" are receipts from the cold store facility that can be traded between farmers and traders. If farmers repaid their loans in bonds, the repayment was calculated at the prevailing bond price.

earn any further commissions. All agents who survived the first two years also received a paid holiday to a nearby seaside resort.

In 2010 when our project began, there was very little microfinance available in this area, and our MFI partner had not operated in any of these villages before.[8] The role of the MFI in our interventions was limited to disbursing loans and collecting repayment; they were not required to screen borrowers or monitor their usage of the loans. The loans were funded by an external grant held by the principal investigators of this project.

3. Data and Descriptive Statistics

Every four months during 2010–2013, we conducted detailed crop and credit surveys with 50 sample households in each of the 48 study villages. In each village, all 10 Treatment households were included in our sample. In addition, we surveyed a randomly selected set of 10 of the 20 households that the agent had recommended but did not receive the loan. We refer to these as Control 1 households. We also included 30 additional households randomly chosen from those the agent did not recommend. We call these Control 2 households. The

8. Table B.1 in the Appendix presents selected descriptive statistics about our sample households' credit transactions wprior to our intervention. Two-third of sample households had outstanding loans, and the majority had borrowed for agricultural purposes. Most loans were from traders and money lenders: only 3% were from microfinance institutions. Interest rates varied widely by lending source, from about 11% per annum on bank loans (which are typically collateralized), to 25% on loans from traders and money lenders, and 37% on loans from microfinance institutions. Loans from traders and money lenders were usually of a 4 month duration, which aligns with the typical crop cycle in this region.

same person in each household answered the survey in each round. There was no attrition in the sample over the eight survey cycles. The final sample is a balanced panel of 2050 households across three years.[9]

In Table 1B, we present data on observable characteristics of eligible households (owing no more than 1.5 acres) in the TRAIL (column 1) and GRAIL (column 2) villages.[10]

Nearly all households were male-headed. Between 15 and 21% of households were non-Hindu, and 37-39% belonged to the scheduled castes, scheduled tribes, or other backward castes. As is to be expected in the Indian context, low levels of landholding are correlated with poor socio-economic characteristics. Only a third of households had brick-and-mortar (*pucca*) houses. Education levels were correspondingly low: in only about a third of the households had the oldest male studied beyond primary school. About one half of the oldest males reported cultivation as their main occupation, for one-third of

9. Some households we surveyed are not included in the estimation sample: 319 households that had more than 1.5 acres of land and so would not have qualified for the TRAIL / GRAIL loans, 7 households that did not have any adult males and 7 households that did not report their religion. See Table B.2 in the Appendix.

10. As noted above, our household sample is purposively selected to include fixed proportions of a random subset of the households that the agent recommended and a random subset of those that he did not. To obtain representative survey means, we use household weights. Each Treatment and Control 1 household is assigned a weight of $\frac{30}{N}$ and each Control 2 household is assigned a weight of $\frac{N-30}{N}$, where N denotes the total number of households in the village.

Table 1B. Descriptive Statistics on Household and Agent Characteristics

	Household Sample			Agent Sample		
	TRAIL	GRAIL	Difference p-value	TRAIL	GRAIL	Difference p-value
	(1)	(2)	(3)	(4)	(5)	(6)
Low Caste	0.393	0.372	*0.758*	0.083	0.208	*0.228*
	(0.489)	(0.484)		(0.282)	(0.415)	
General Caste	0.607	0.628	*0.758*	0.833	0.667	*0.190*
	(0.489)	(0.484)		(0.381)	(0.482)	
Non Hindu	0.213	0.150	*0.488*	0.083	0.125	*0.645*
	(0.409)	(0.358)		(0.282)	(0.338)	
Total Land Owned	0.456	0.445	*0.816*	5.042	4.083	*0.016*
	(0.422)	(0.418)		(1.429)	(1.213)	
Has *pucca* house	0.287	0.333	*0.539*	0.458	0.375	*0.568*
	(0.453)	(0.471)		(0.509)	(0.495)	
Male[a]	0.955	0.953	*0.886*	0.958	1.000	*0.322*
	(0.207)	(0.212)		(0.204)	(0.000)	
Age[b]	48.01	47.15	*0.421*			
	(13.65)	(13.17)				
Educated above primary school[b]	0.348	0.360	*0.763*	0.792	0.958	*0.084*
	(0.477)	(0.480)		(0.415)	(0.204)	
Weekly income (Rupees)				1668.75	1102.90	*0.076*
				(1362.687)	(605.822)	
Primary Occupation[b]:						
Cultivation	0.444	0.421	*0.626*	0.042	0.375	*0.004*
	(0.497)	(0.494)		(0.204)	(0.495)	
Shop/Business				0.958	0.292	*0.000*
				(0.204)	(0.464)	
Salaried Employment	0.091	0.127	*0.097*	0.000	0.125	*0.076*
	(0.288)	(0.333)		(0.000)	(0.338)	
Casual Labour	0.342	0.342	*0.999*			
	(0.474)	(0.474)				
Panchayat Member[c]	0.005	0.004	*0.708*	0.000	0.125	*0.076*
	(0.073)	(0.061)		(0.000)	(0.338)	
Party Hierarchy Member[c]	0.072	0.089	*0.688*	0.000	0.167	*0.037*
	(0.258)	(0.285)		(0.000)	(0.381)	
Self/Family ran for village head				0.000	0.083	*0.155*
				(0.000)	(0.282)	
Village Society Member				0.083	0.292	*0.067*
				(0.282)	(0.464)	
Sample Size	1019	1030		24	24	

Treatment and Control 1 households are assigned a weight of $\frac{30}{N}$, where as Control 2 households are assigned a weight of $\frac{N-30}{N}$, where N is the total number of households in the village.

In Columns 1 and 2, the estimation sample includes all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Columns 4 and 5 present descriptive statistics about the agents collected through a separate agent survey.

Low Caste refers to Scheduled Caste, Scheduled Tribe or Other Backward Caste.

(a) refers to the household head in columns 1 and 2; (b) refers to the oldest member of the household in columns 1 and 2. (c) refers to any member of the household in the household sample in Columns 1 and 2, and to the agent in Columns 4 and 5. The occupation category Shop/Business was not offered as a response option in the household survey and the category Labourer was not offered in the agent survey. The household survey did not include questions on whether any member of the household had run for village head or whether they were members of any village societies.

All p-values (in italics) come from a regression of the relevant characteristic on the TRAIL dummy, with standard errors clustered at the village level. Standard deviations are in parentheses.

households the main occupation was casual labour.[11] Between 9 and 13% of households reported they had a salaried job. In line with the random assignment of villages to treatment arms, we do not find any evidence of systematic differences in household characteristics across TRAIL and GRAIL villages (column 3).

Table 2A presents descriptive statistics for households that were recommended (Treatment + Control 1) by the agents in the two schemes. GRAIL recommended households were better off than those recommended in the TRAIL scheme on some dimensions, but not all. They were more likely to reside in *pucca* houses, less likely to be a casual labourer, more likely to be a cultivator, and owed less debt when the intervention began. On the other hand, they were less educated. GRAIL recommended households were also significantly more likely to be a member of the local party hierarchy.

Recall that conditional on recommendation, households were randomly selected to receive the loan offer (treatment). In line with this, Table 2B shows that within each intervention, Treatment and Control 1 households are balanced on most observable characteristics. We are also able to reject the hypothesis that these characteristics jointly predict assignment to treatment (F-statistic = 0.49 for TRAIL and 1.43 for GRAIL).

11. Note however, that the majority of households cultivated agricultural land, regardless of whether it was their primary occupation. There is also an active land tenancy market in the area, so that even those who do not own their own land are able to cultivate crops.

Table 2A. Descriptive Statistics. TRAIL v. GRAIL Recommended Households

	TRAIL (1)	GRAIL (2)	Difference p-value (3)
Male Headed Household	0.989	0.976	*0.122*
	(0.104)	(0.154)	
Low Caste	0.384	0.344	*0.214*
	(0.487)	(0.476)	
Non Hindu	0.167	0.143	*0.327*
	(0.373)	(0.351)	
General Caste Household	0.616	0.656	*0.214*
	(0.487)	(0.476)	
Total Owned Land	0.451	0.491	*0.132*
	(0.394)	(0.408)	
Pucca House	0.226	0.294	*0.019*
	(0.418)	(0.456)	
Non-Program Ag Loans (Rupees)[a]	5701.216	4371.306	*0.001*
	(9559.978)	(7751.828)	
Oldest Male			
Age	46.727	47.967	*0.113*
	(11.607)	(12.012)	
More than Primary Schooling	0.427	0.355	*0.026*
	(0.495)	(0.479)	
Occupation Cultivation	0.460	0.519	*0.075*
	(0.499)	(0.500)	
Occupation Casual Labour	0.377	0.296	*0.009*
	(0.485)	(0.457)	
Occupation Salaried Employment	0.095	0.104	*0.675*
	(0.294)	(0.305)	
Occupation Other	0.067	0.082	*0.406*
	(0.251)	(0.274)	
Any Member of Household			
Member of Party Hierarchy	0.059	0.106	*0.009*
	(0.235)	(0.308)	
Panchayat Member	0.007	0.007	*0.983*
	(0.080)	(0.081)	
Joint F-test			1.86
Sample Size	461	453	

The sample is restricted to TRAIL and GRAIL recommended (Treatment + Control 1) households with at most 1.5 acres of landholding. Low Caste refers to Scheduled Caste, Scheduled Tribe or Other Backward Caste.

(a) refers to loans reported in survey round 1, i.e. obtained before the intervention.

Joint F-statistics are obtained from a regression of treatment assignment on observable characteristics. p-values in italics. Standard deviations are in parentheses.

3.1. Agent and Household Characteristics in TRAIL and GRAIL

In columns 4 and 5 of Table 1B, we describe the characteristics of the TRAIL and GRAIL agents, as reported in a questionnaire we administered at the time

TABLE 2B. Balance of Household Characteristics

	TRAIL			GRAIL		
	Treatment (1)	Control 1 (2)	Difference p-value (3)	Treatment (4)	Control 1 (5)	Difference p-value (6)
Male Headed Household	0.987	0.991	*0.694*	0.982	0.970	*0.522*
	(0.114)	(0.092)		(0.133)	(0.172)	
Low Caste	0.379	0.389	*0.852*	0.327	0.361	*0.378*
	(0.486)	(0.489)		(0.470)	(0.481)	
Non Hindu	0.163	0.171	*0.752*	0.152	0.135	*0.244*
	(0.370)	(0.377)		(0.360)	(0.342)	
General Caste Household	0.621	0.611	*0.852*	0.673	0.639	*0.378*
	(0.486)	(0.489)		(0.470)	(0.481)	
Total Owned Land	0.448	0.454	*0.889*	0.524	0.458	*0.110*
	(0.410)	(0.379)		(0.412)	(0.403)	
Pucca house	0.220	0.231	*0.751*	0.309	0.278	*0.393*
	(0.415)	(0.422)		(0.463)	(0.449)	
Oldest Male:						
Age	46.295	47.145	*0.446*	47.964	47.970	*0.997*
	(11.390)	(11.823)		(12.562)	(11.482)	
More than Primary Schooling	0.427	0.427	*0.999*	0.404	0.309	*0.053*
	(0.496)	(0.496)		(0.492)	(0.463)	
Occupation Cultivator	0.485	0.436	*0.258*	0.565	0.474	*0.061*
	(0.501)	(0.497)		(0.497)	(0.500)	
Occupation Labourer	0.352	0.402	*0.242*	0.238	0.352	*0.008*
	(0.479)	(0.491)		(0.427)	(0.479)	
Occupation Salaried Employment	0.093	0.098	*0.846*	0.103	0.104	*0.963*
	(0.290)	(0.298)		(0.305)	(0.306)	
Occupation Other	0.070	0.064	*0.746*	0.094	0.070	*0.321*
	(0.257)	(0.245)		(0.293)	(0.255)	
Any member of Household:						
Member of Party Hierarchy	0.066	0.051	*0.456*	0.112	0.100	*0.570*
	(0.249)	(0.221)		(0.316)	(0.301)	
Panchayat Member	0.009	0.004	*0.561*	0.013	0.000	*0.085*
	(0.094)	(0.065)		(0.115)	(0.000)	
Joint F-test		0.49			1.43	
Sample Size	227	234		223	230	

The sample includes all households in TRAIL and GRAIL villages with at most 1.5 acres of land. Low Caste refers to households where the head belongs to a Scheduled Caste, Scheduled Tribe or Other Backward Caste.

All p-values, in italics, come from a regression of the relevant characteristic on the Treatment dummy, with standard errors clustered at the village level. Joint F-test statistics are obtained from a regression of treatment assignment on the observable characteristics, run separately for TRAIL and GRAIL schemes. Standard deviations are in parentheses.

they were recruited. In both schemes the agents were predominantly male. Besides this, as might be expected they differed on various dimensions. 96% of TRAIL agents reported that they ran a business or a shop, and only 4% said they were primarily cultivators. In contrast, 37.5% of GRAIL agents reported cultivation as their main occupation. Nearly 13% were salaried employees.

GRAIL agents were more likely to be educated above primary school than TRAIL agents (96% vs. 79%), but on average their earned weekly incomes were 34% lower.

GRAIL agents were significantly more involved in civil society and politics: 30% were members of a village organization, 17% were members of the local political party hierarchy, and 8% had been candidates for the position of village head.

When we compare columns 1 and 2 with columns 4 and 5 it is also clear that agents in both schemes were better off than the population that the program targeted. They owned more land (TRAIL: 5 vs. 0.46 acres; GRAIL: 4 vs. 0.45 acres), and had more education. Notably, GRAIL agents were about as likely to report their occupation as cultivation as the target beneficiary population.

3.2. Pre-Intervention Agent Connections within Villages

In line with the contrasting occupations of TRAIL and GRAIL agents, the nature of their connections with village residents also varied. In Table 2B, we use data from the first round of household surveys to infer sample households' relationships with the agents that existed before the first loans were given out.[12]

The data indicate that the agents were well connected within their respective villages: in both TRAIL and GRAIL villages, more than 90 percent

12. Note, the statistics in Table 2B use the same household weights as described in footnote 10 and so these are representative means for the population of households with less than 1.5 acres of land.

Table 2B. Pre-Intervention Social and Economic Engagement of Sample Households with the Agent

	TRAIL (1)	GRAIL (2)	Difference p-value (3)
Agent and household belong to:			
Same Occupation	0.014	0.287	*0.000*
	(0.120)	(0.452)	
Same Caste Category	0.577	0.654	*0.275*
	(0.494)	(0.476)	
Same Religion	0.797	0.950	*0.025*
	(0.402)	(0.218)	
Agent is one of the two most important:			
Money Lenders	0.169	0.087	*0.252*
	(0.375)	(0.282)	
Input Suppliers	0.184	0.077	*0.095*
	(0.388)	(0.266)	
Output Buyers	0.185	0.024	*0.009*
	(0.389)	(0.153)	
Employers	0.114	0.077	*0.405*
	(0.318)	(0.267)	
In the past 3 years, household has:			
Bought from Agent	0.330	0.047	*0.000*
	(0.471)	(0.212)	
Borrowed from Agent	0.154	0.052	*0.036*
	(0.361)	(0.223)	
Worked for Agent	0.102	0.093	*0.849*
	(0.303)	(0.290)	
Currently:			
Household knows Agent	0.911	0.910	*0.995*
	(0.285)	(0.286)	
Household meets Agent at least once a week[a]	0.979	0.985	*0.926*
	(0.143)	(0.122)	
Household member is invited by Agent on special occasions[a]	0.325	0.298	*0.765*
	(0.469)	(0.458)	
Sample Size	1019	1030	

The TRAIL agent was a randomly selected trader in the village. The GRAIL agent was randomly selected from a list of individuals provided by the local government. The sample is restricted to all households with 1.5 acres of land in TRAIL and GRAIL villages.

(a): The incidence of social interaction with the agent is measured conditional on the household reporting they knew the agent. Treatment and Control 1 households are assigned a weight of $\frac{30}{N}$, where as Control 2 households are assigned a weight of $\frac{N-30}{N}$, where N is the total number of households in the village.

All p-values in italics come from a regression of the relevant characteristic on TRAIL dummy, with standard errors clustered at the village level. Standard deviations are in parentheses.

of sample households reported they knew the agent, and nearly all of them said they saw or met him at least once a week. TRAIL agents had extensive business connections: one-third of the sample households had purchased inputs from the agent, and 15% had borrowed from him in the three years prior to the start of our study. Between 11 and 20% of households reported that the agent was one of the two most important sources of credit, inputs or employment, or one of the two most important buyers of their produce. GRAIL agents were significantly less likely to have transacted with sample households in this way.

4. Loan Performance

In Table 3B, we examine how beneficiaries of the TRAIL and GRAIL schemes responded to the program loan offers. The table presents coefficient estimates from the following regression

$$y_{ivc} = \alpha_0 + \alpha_1 \mathrm{TRAIL}_v + \gamma \mathbf{X}_{iv} + \mathbf{\Gamma_c} + \varepsilon_{ivc} \qquad (1)$$

where the dependent variable y_{ivc} is, in turn, an indicator of loan take-up, the amount borrowed, and a measure of repayment, for household i in village v in loan cycle c. TRAIL_v is a dummy for TRAIL villages. $\mathbf{X}_{iv}$ denotes pre-intervention characteristics such as the household's landholding, religion and caste, and the age and educational attainment of the oldest male in the household. $\mathbf{\Gamma_c}$ indicates loan cycle fixed effects.

In column 1, we investigate the likelihood that a household that eligible to obtain a program loan chose to receive it (take-up). Recall that borrowers were selected before loan cycle 1 through a random draw from the pool of recommended borrowers, and in subsequent cycles they remained eligible to borrow only if they had repaid at least 50% of their previous loan. As we see, take-up rates were high: GRAIL treated households borrowed in 87% of the

Table 3B. Loan Performance

	Take-up (1)	Program Loan Amount (2)	Default (3)
TRAIL ($\hat{\alpha}_1$)	0.066	467.911	-0.003
	(0.011)	(79.754)	(0.010)
	0.000	*0.000*	*0.506*
Mean GRAIL	0.872	4140.864	0.070
R^2	0.06	0.45	0.05
Sample Size	2667	2667	2422

The estimating equation is given by equation (1) in the text. All regressions include controls for landholding, religion and caste of the household and age and educational attainment of the oldest male in the household and loan cycle fixed effects. The estimation sample consists of household-cycle level observations of Treatment households with at most 1.5 acres of landholding in TRAIL and GRAIL villages.

In column 1 take-up is an indicator for whether the household was eligible for the loan as well as took the program loan in that cycle. In column 2 program loan amount is the amount borrowed from the program in the cycle, and takes value 0 if the household did not take a program loan. In column 3 default indicates that the borrowing household failed to fully pay down by the due date their repayment amount on a loan taken that cycle.

Robust standard errors are in parentheses. p-values are in italics.

instances that they were eligible, and the TRAIL treated households' take-up rate was 6.6 percentage points higher. Accordingly, the amount borrowed through the scheme was substantial as well: we see in column 2 that on average across the 8 cycles, GRAIL beneficiaries borrowed Rupees4141 from the program; TRAIL borrowers borrowed Rupees468 (11.3%) more. Finally, in column 3, we see that on average only 7% of loans had not been fully repaid by the due date. Thus the overwhelming majority of borrowers in both schemes successfully repaid their program loans.

5. Estimating Treatment and Selection Effects

To estimate the effects on beneficiaries' outcomes, we aggregate the survey data from multiple rounds into a balanced panel data set of 2050 households across three years: 2010–2011 to 2012–2013. This contains information about sample farmers' annual borrowing for agricultural and non-agricultural purposes, acreage planted with different crops, production, sales, revenues, production costs, value-added and imputed profits.[13] We also have information on non-farm incomes from wage employment and non-farm businesses. Treatment effects are estimated through OLS regressions according to the following specification:

$$\begin{aligned} y_{ivt} = \beta_0 + \beta_1 \text{TRAIL}_v + \beta_2(\text{TRAIL}_v \times \text{Control } 1_{iv}) + \beta_3(\text{TRAIL}_v \times \text{Treatment}_{iv}) \\ + \beta_4(\text{GRAIL}_v \times \text{Control } 1_{iv}) + \beta_5(\text{GRAIL}_v \times \text{Treatment}_{iv}) \\ + \gamma \mathbf{X}_{ivt} + I(\text{Year}_t) + \varepsilon_{ivt} \end{aligned} \tag{2}$$

Here y_{ivt} denotes the outcome variable of interest for household i in village v in year t. The indicator variables TRAIL_v and GRAIL_v take value 1 if the household belongs to a TRAIL or GRAIL village respectively. Treatment_{iv} indicates whether the household was recommended *and* randomly selected to receive a program loan, while Control 1_{iv} indicates recommended but not offered a loan. The omitted category is Control 2 households in GRAIL villages.[14]

13. We track the harvested potatoes over multiple survey rounds to calculate the sales revenues and align them with the costs of production, transport and sales.

14. Since we estimate effects on multiple outcome variables, we also present the FDR sharpened q values, or p-values adjusted for multiple inference (Anderson, 2008).

Since only a random subset of the recommended households were offered the loans, the difference in the outcomes of the Treatment and Control 1 households is an estimate of the average treatment effect of the loan, conditional on being recommended to participate in the scheme. Accordingly, the conditional average treatment effect of the TRAIL scheme is estimated as $\hat{\beta}_3 - \hat{\beta}_2$ and of the GRAIL scheme is estimated as $\hat{\beta}_5 - \hat{\beta}_4$. Since households that were randomly drawn to receive the loan are considered treated regardless of whether they accepted the loan, these are intent-to-treat estimates. As before, $\mathbf{X}_{ivt}$ contains measures of the household's landholding, religion and caste, and the age, education and occupation of the oldest male in the household.[15] $I(\text{Year}_t)$ denotes two year dummies. Standard errors are clustered at the village level.

5.1. Treatment Effects on Agricultural Borrowing

We start by examining whether the program increased beneficiaries' total borrowing. As we see in column 1 of Table 4B, TRAIL Treatment households borrowed Rupees2770 (53%) more than Control 1 households in TRAIL villages, and GRAIL Treatment households borrowed a very similar Rupees2817 (64%) more than Control 1 households in GRAIL villages. The point estimates for treatment effects on non-program agricultural borrowing are small and not statistically significant (column 2), indicating that program

15. Tables B.3–B.6 in the Appendix present results of these same regressions, without controlling for the variables in $\mathbf{X}_{ivt}$. The results are similar to those presented in Tables 4B, 6A, 6B and 8.

TABLE 4B. Average Treatment Effects on Agricultural Borrowing

	All Loans (Rupees) (1)	Non-Program Loans (Rupees) (2)
TRAIL Treatment Effect ($\hat{\beta}_3 - \hat{\beta}_2$)	2770	-533.3
	(721.4)	(591.5)
	0.000	*0.372*
FDR Sharpened q-value	[0.001]	[0.216]
Mean Control 1	5226	5226
GRAIL Treatment Effect ($\hat{\beta}_5 - \hat{\beta}_4$)	2817	-61.59
	(529.9)	(477)
	0.000	*0.898*
FDR Sharpened q-value	[0.001]	[0.945]
Mean Control 1	4422	4422
Difference TRAIL vs GRAIL (($\hat{\beta}_3 - \hat{\beta}_2$) — ($\hat{\beta}_5 - \hat{\beta}_4$))		
p-value	*0.959*	*0.531*
R^2	0.203	0.180
Sample Size	6,150	6,150

Treatment effects ($\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively) are estimated based on a regression following equation (2) in the text. The estimation sample consists of household-year level data for all potato-sowing season survey cycles for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Regressions also control for the religion and caste of the household, age, educational attainment and occupation of the oldest male member of the household, household's landholding, a set of year dummies and an information village dummy. The coefficient estimates are presented in Table **??** in the Appendix.

In column 1, the dependent variable is the total household borrowing, for agricultural use, from all sources. In column 2, the dependent variable is the total non-program agricultural borrowing (loans from sources other than the TRAIL or GRAIL schemes for agricultural use).

Standard errors in parentheses are clustered at the village level. p-values are in italics. The FDR sharpened q-values estimated using the procedure in Anderson (2008) are in square brackets.

loans did not crowd out agricultural loans from other sources. This is possibly explained by farmers not wanting to disrupt their relationships with informal lenders in response to a new program.

5.2. Treatment Effects : Potatoes

Table 6A shows that in both TRAIL and GRAIL villages, the increased borrowing by treated households was associated with greater cultivation of potatoes. TRAIL treated farmers planted an additional 0.09 acres with potatoes (27.5% higher than Control 1 farmers, column 1) and harvested an additional 946 kilograms (26%, column 2). We see similar increases in GRAIL villages: GRAIL treatment households planted an additional 0.07 acres (23%, column 1) and harvested an additional 772 kg of potatoes (24%, column 2). In columns 4–12 of Table 6A we present the treatment effects on the physical quantities of different input categories: own labour, seeds, pesticides, fertiliser (organic and inorganic separately), ploughs/bullocks, power tillers, tractors and water. We find statistically significant treatment effects of the TRAIL scheme on the quantity of seeds and water used, the application of power tillers and the use of household labour. GRAIL borrowers increased their use of household labour by even more: the average GRAIL household increased own labour use by twice the amount that TRAIL households did. We also find positive point estimates for the use of several other inputs for GRAIL treated households, although the estimates are not precise.

Table 6B shows that the increased output translated into higher sales revenue for TRAIL borrowers (Rupees3900, 27% column 2), while increasing the cost of cultivation by less (Rupees1845, 18% column 8), causing value-added to increase by Rupees2060 (36%, column 3). When we subtract the imputed cost of family labor employed in potato farming, this works out to a statistically significant Rupees1906 or 40% increase in profit (column 4).[16]

16. Value-added is computed as the difference between revenue and the total costs of production (which includes both the expenses on variable inputs and the land rent the farmer paid, if any) and costs of selling the harvest. If the farmer did not sell the crop, we impute revenue as the product of the harvested quantity and the median price at which sample farmers in the village sold that crop in that year, and sale cost as the product

Table 6A. Average Treatment Effects for Potatoes: Quantities

	Cultivation			Input Use (Quantity)								
	Acreage (Acres)	Output (Kg)	Yield (Kg/Acres)	Own labour (Hours)	Organic fertilizer (Kg)	Inorganic fertilizer (Kg)	Seeds (Kg)	Pesticides (Lit)	Plough/ bullock (Days)	Tiller (Hours)	Tractor (Hours	Water (Hours)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
TRAIL												
Treatment Effect	0.0925	946	-191.5	6.144	55.710	21.269	35.596	2.951	0.087	0.695	0.029	2.272
$(\hat{\beta}_3 - \hat{\beta}_2)$	(0.0247)	(256.3)	(142.7)	(3.291)	(104.735)	(19.100)	(14.139)	(2.029)	(0.108)	(0.416)	(0.141)	(1.197)
	0.001	*0.001*	*0.186*	*0.062*	*0.595*	*0.266*	*0.012*	*0.147*	*0.422*	*0.095*	*0.839*	*0.058*
FDR Sharpened q-value	[0.004]	[0.004]	[0.122]	[0.062]	[0.304]	[0.172]	[0.025]	[0.121]	[0.238]	[0.091]	[0.344]	[0.062]
Mean Control 1	0.336	3646	10883	39.866	395.955	248.372	212.053	1.441	0.329	2.788	0.645	17.089
GRAIL												
Treatment Effect	0.0689	771.7	10.18	12.727	88.363	20.140	-0.151	-0.294	0.041	0.408	0.036	1.783
$(\hat{\beta}_5 - \hat{\beta}_4)$	(0.0243)	(273.5)	(122.5)	(3.601)	(104.782)	(19.162)	(16.589)	(0.615)	(0.079)	(0.305)	(0.095)	(1.175)
	0.007	*0.007*	*0.934*	*0.000*	*0.399*	*0.294*	*0.993*	*0.633*	*0.603*	*0.182*	*0.705*	*0.130*
FDR Sharpened q-value	[0.025]	[0.025]	[0.945]	[0.001]	[0.741]	[0.602]	[0.987]	[0.796]	[0.796]	[0.425]	[0.799]	[0.352]
Mean Control 1	0.296	3237	10856	37.075	350.729	223.427	206.395	1.853	0.317	2.458	0.522	16.453
Difference TRAIL vs. GRAIL $((\hat{\beta}_3 - \hat{\beta}_2) - (\hat{\beta}_5 - \hat{\beta}_4))$												:
p-value	*0.508*	*0.652*	*0.296*	*0.177*	*0.827*	*0.967*	*0.104*	*0.129*	*0.733*	*0.581*	*0.966*	*0.771*
R^2	0.288	0.276	0.024	0.18	0.09	0.19	0.19	0.01	0.05	0.07	0.10	0.20
Sample Size	6,150	6,150	4,038	6,150	4,049	4,049	4,049	4,049	4,049	4,049	4,049	4,049

Treatment effects are estimated from equation (2) in the text as $\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively. The estimation sample consists of household-year level data for sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Regressions also control for the religion and caste of the household, age, educational attainment and occupation of the oldest male member of the household, household's landholding, a set of year dummies and an information village dummy. The coefficient estimates are presented in Table **??** in the Appendix.

The dependent variables in columns 1 and 2 take the actual value reported by the household if it cultivated potatoes in that year, and 0 otherwise. In columns 3–12, households that did not cultivate potatoes in the year are dropped from the estimation sample.

Standard errors in parentheses are clustered at the village level. p-values are in italics. The FDR sharpened q-values estimated using the procedure in Anderson (2008) are in square brackets.

Table 6B. Average Treatment Effects for Potatoes: Monetary Values

	Price (Rupees) (1)	Revenue (Rupees) (2)	Value Added (Rupees) (3)	Imputed Profit (Rupees) (4)	Paid Labour Cost (Rupees) (5)	Household Labour Cost (Rupees) (6)	Non-Labour Cost (Rupees) (7)	Total Input Cost (Rupees) (8)	Input Cost Per Acre (Rupees) (9)
TRAIL									
Treatment Effect	-0.0301	3897	2059	1906	173.784	1519.992	1359.148	3052.924	-2907.323
$(\hat{\beta}_3 - \hat{\beta}_2)$	(0.0913)	(1099)	(559.9)	(544.4)	(85.692)	(658.517)	(598.662)	(1315.784)	(1016.756)
	0.743	*0.001*	*0.001*	*0.001*	*0.043*	*0.021*	*0.024*	*0.021*	*0.004*
FDR Sharpened q-value	[0.344]	[0.004]	[0.004]	[0.004]	[0.053]	[0.036]	[0.036]	[0.036]	[0.01]
Mean Control 1	4.627	14285	5732	4734	849.688	8144.709	7287.551	16281.949	49064.146
GRAIL									
Treatment Effect	-0.176	2504	493.7	191.4	57.225	1943.498	1875.692	3876.415	546.158
$(\hat{\beta}_5 - \hat{\beta}_4)$	(0.136)	(1060)	(676.8)	(652.8)	(97.891)	(695.047)	(618.881)	(1387.693)	(1097.527)
	0.203	*0.022*	*0.469*	*0.771*	*0.559*	*0.005*	*0.003*	*0.005*	*0.619*
FDR Sharpened q-value	[0.438]	[0.056]	[0.785]	[0.799]	[0.796]	[0.025]	[0.025]	[0.025]	[0.796]
Mean Control 1	4.800	12965	5828	4942	787.001	6728.265	5934.833	13450.099	47489.291
Difference TRAIL vs. GRAIL $((\hat{\beta}_3 - \hat{\beta}_2) - (\hat{\beta}_5 - \hat{\beta}_4))$									:
p-value	*0.370*	*0.377*	*0.085*	*0.052*	*0.373*	*0.660*	*0.551*	*0.668*	*0.022*
R^2	0.252	0.274	0.223	0.210	0.24	0.28	0.27	0.28	0.30
Sample Size	3,818	6,150	6,150	6,150	6,150	6,150	6,150	6,150	4,038

Treatment effects are estimated from equation (2) in the text as $\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively. The estimation sample consists of household-year level data for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Regressions also control for the religion and caste of the household, age, educational attainment and occupation of the oldest male member of the household, household's landholding, a set of year dummies and an information village dummy. The coefficient estimates are presented in Table **??** in the Appendix.

The dependent variables in columns 1–5 take the actual value reported by the household if it cultivated potatoes in that year, and 0 otherwise. In column 9, households that did not cultivate potatoes in a year are dropped from the estimation sample. Imputed profit = Value Added – shadow cost of labour.

Standard errors in parentheses are clustered at the village level. p-values are in italics. The FDR sharpened q-values estimated using the procedure in Anderson (2008) are in square brackets.

Sales revenues also increased for the average GRAIL Treatment household, although the point estimate is smaller at Rupees 2504 (19%).[17] Their cost of production increased by 29 percent, thereby resulting in a negligible effect on value-added or imputed profits (Rupees494 and Rupees191 respectively, not significant). Thus, although both schemes increased beneficiaries' potato acreage and output, only the TRAIL scheme increased farmers' value-added and profits substantially. The p-values for the TRAIL–GRAIL difference in the average treatment effects on value added and imputed profit are 0.085 and 0.052 respectively (columns 3 and 4, Table 6B).

Columns 5–8 of Table 6B present the treatment effects on the cost of production in three broad categories: paid labour, household labour and non-labour inputs. The total input cost is the aggregate of these three. To compute

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of the harvested quantity and the median unit cost of sale (transport, labour charges etc.) for that crop incurred by sample farmers in the village in that year. Imputed profit is calculated (only when the farmer sold the crop) by subtracting from value added the shadow cost of family labour. To calculate the shadow cost of family labour, we price the family labour time for male, female and child labor spent on the crop at the median wage for hired labour of that type paid for that crop in that year, by sample farmers in the village.

17. Column 1 of Table 6B shows that TRAIL Treatment households' sale price for potatoes also decreased (0.6%) less than for GRAIL households (3.6%), although this difference is not statistically significant (p-value = 0.37). We collected quantity and price data for each potato sale by sample households. If farmers held potatoes for self-consumption, we impute the sales revenue by pricing that quantity at the median sale price in the village.

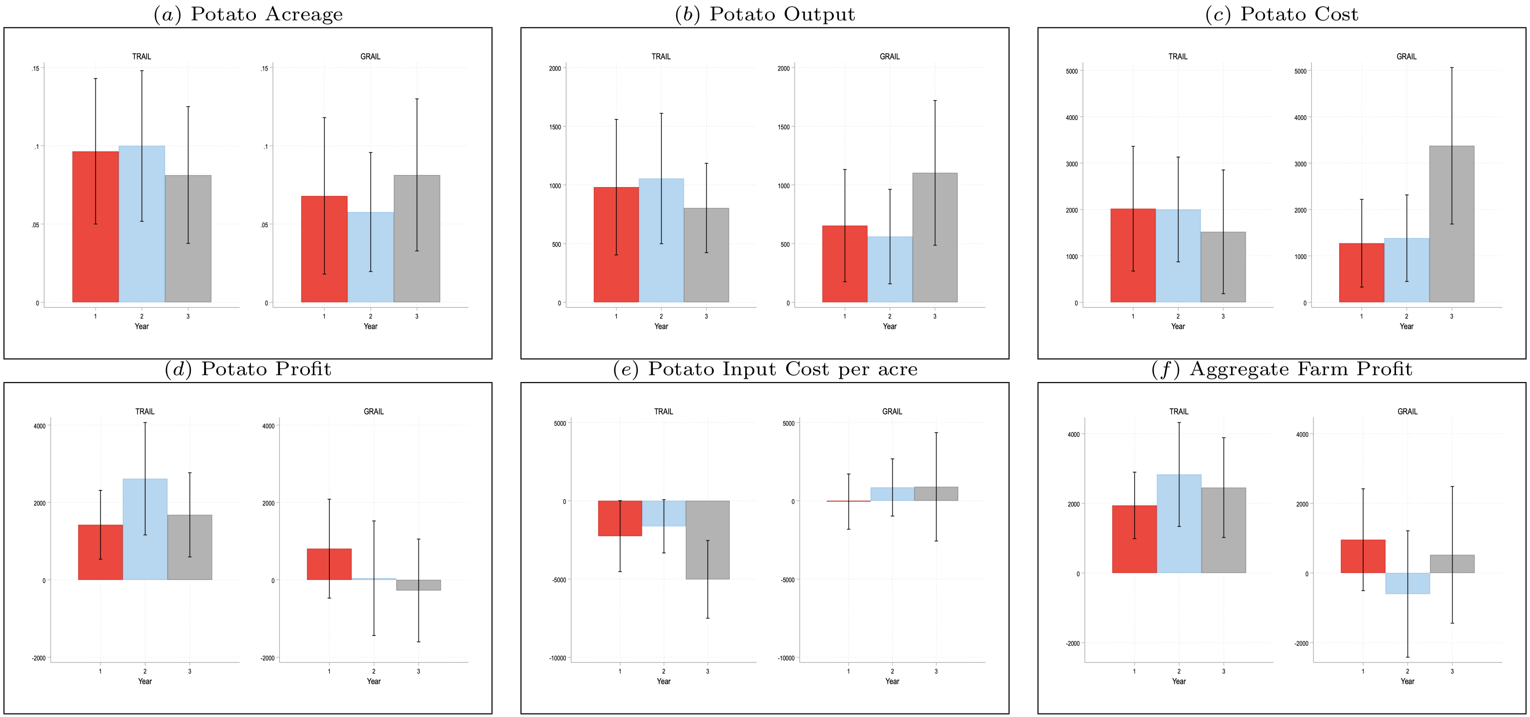
the unit cost of production for a crop we divide the total cost that the farmer paid, by the acreage on which the crop was planted.[18]

The point estimates indicate that the larger treatment effect on imputed profit in TRAIL is accounted for partly by a Rupees 1393 larger treatment effect on revenues and a Rupees 824 smaller treatment effect on total input cost. However, the only indicator of farm performance where the TRAIL–GRAIL difference is precisely estimated is input cost per acre. Column 9 indicates that the TRAIL intervention caused Treatment households' unit costs to fall by a statistically significant 6%, in contrast to a positive but statistically insignificant effect in GRAIL (TRAIL vs. GRAIL difference p-value = 0.022).

Since these estimates are an average effect over 3 years of data, they likely indicate the long term effect of an ongoing loan program. Figure 1 shows that the average treatment effects on potato acreage and output were positive and statistically significant in each of the three years. The TRAIL intervention reduced Treatment households' input costs per acre and increased their profits each year, but the GRAIL intervention had no significant effect in any year. This stability of effects across the three-year period suggests that they are driven by underlying differences in the schemes, rather than

18. For each input used, we asked about the amount of money the farmer paid for the use of this input. By aggregating the costs across all input categories, we are able to arrive at the cost of cultivation (for inputs they hired / paid for). Table B.8 in the Appendix shows that neither intervention affected the input prices of the non-labour inputs. For the sake of completeness, in Table B.9 in the Appendix we present the cost per acre for the different inputs.

Figure 1. **Year Specific Average Treatment Effects for Potatoes**



Average treatment effects and 90% confidence intervals are estimated for each study year separately following the regression specification in equation (2). Acreage, output, cost, profit and input cost per acre all refer to the household's potato crop. Aggregate Profit refers to the sum of imputed profits for the four major crops: potatoes, paddy, sesame and vegetables.

temporal shocks.[19] . There is also no indication of gradual learning: rather than ramping up over time, the point estimates on TRAIL treatment effects on acreage, output and profits are the largest in Year 2.

5.3. Treatment Effects for Other Crops

Although our credit interventions were designed to facilitate the cultivation of potatoes, they could have affected households' cultivation choices for other crops as well. In Table 7 we present the treatment effects on acreage, cost of production, revenue and imputed profit for the three other major crops in this area: sesame, paddy and vegetables.[20] The evidence suggests that TRAIL loans increased farmers' cultivation of and revenue from sesame and paddy, although not from vegetables. The effects of the GRAIL loans are not statistically significant effects for any of the three crop categories.

5.4. Treatment Effects on Aggregate Farm Income

Finally, in Table 8 column 1, we estimate average treatment effects on total farm income, aggregating the profits from the four major crops grown in this area: potatoes, sesame, paddy and vegetables. The farm profits earned by TRAIL treatment households increased by a statistically significant 28%, whereas the point estimate for the GRAIL scheme is a non-significant 3.8%.

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19. Rosenzweig and Udry (2020) have argued that in short-lived RCTs it is difficult to separate the effect of the intervention from temporal shocks.

20. Treatment effects on production, value-added, input cost per acre and yield are presented in Table B.7 in the Appendix.

TABLE 7. Average Treatment Effects for Other crops: Quantities and Monetary Values

	Sesame				Paddy				Vegetables			
	Acreage (Acres)	Cost of Production (Rupees)	Revenue (Rupees)	Imputed Profit (Rupees)	Acreage (Acres)	Cost of Production (Rupees)	Revenue (Rupees)	Imputed Profit (Rupees)	Acreage (Acres)	Cost of Production (Rupees)	Revenue (Rupees)	Imputed Profit (Rupees)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10	(11)	(12)
TRAIL												
Treatment Effect	0.0420	33.28	309.4	186.9	0.0328	286.5	480.5	139.2	0.0104	100.4	128.7	-10.73
$(\hat{\beta}_3 - \hat{\beta}_2)$	(0.0214)	(85.87)	(164.2)	(113.8)	(0.0154)	(253.8)	(212.2)	(139.8)	(0.00644)	(145.1)	(214.1)	(121.8)
	0.0552	*0.700*	*0.0658*	*0.107*	*0.0383*	*0.265*	*0.0282*	*0.324*	*0.113*	*0.492*	*0.551*	*0.930*
Mean Control 1	0.266	829	1957	1081	0.470	5602	5398	93.13	0.0147	589.9	1208	664.5
GRAIL												
Treatment Effect	0.0223	66.08	48.81	-90.68	0.0382	563.7	678.5	285.6	0.00432	127	215.2	94.81
$(\hat{\beta}_5 - \hat{\beta}_4)$	(0.0183)	(67.77)	(147.2)	(118.3)	(0.0323)	(773.5)	(540.7)	(288.3)	(0.00356)	(98.98)	(162.2)	(113.9)
	0.231	*0.334*	*0.742*	*0.447*	*0.243*	*0.470*	*0.216*	*0.327*	*0.231*	*0.206*	*0.191*	*0.409*
Mean Control 1	0.224	667.7	1708	1002	0.561	7949	6985	156.4	0.0175	642.6	1044	482.1
Difference TRAIL vs GRAIL $(\hat{\beta}_3 - \hat{\beta}_2) - (\hat{\beta}_5 - \hat{\beta}_4)$												
p-value	*0.491*	*0.768*	*0.253*	*0.106*	*0.881*	*0.738*	*0.737*	*0.650*	*0.400*	*0.878*	*0.743*	*0.527*
R^2	0.244	0.154	0.184	0.136	0.479	0.344	0.285	0.072	0.025	0.027	0.036	0.031
Sample Size	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150

Treatment effects ($\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively) are estimated from equation (2) in the text. The dependent variables in columns 1, 5 and 9 take the actual value reported by the household if it cultivated the releval in that year, and 0 otherwise. Imputed profit = Value Added – shadow cost of labour. Regressions are run on household-year level data for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Regressions also control for the religion and caste of the household, age, educational attainment and occupation of the oldest male member of the household, household's landholding, a set of year dummies and an information village dummy. Standard errors in parentheses are clustered at the village level. p-values are in italics. Treatment effects of production, value-added, input cost per acre and yield are presented in Table B.7 in the Appendix.

TABLE 8. Average Treatment Effects on Aggregate Farm Profit, Non Agricultural Income and Total Household Income

	Aggregate Farm Profit (1)	Non Agricultural Income (2)	Total Household Income (3)
TRAIL			
Treatment Effect	2406	1436	3843
$(\hat{\beta}_3 - \hat{\beta}_2)$	(597.2)	(3077)	(2872)
	0.000	*0.643*	*0.187*
FDR Sharpened q	[0.001]	[0.318]	[0.122]
Mean Control 1	8564	33618	42182
GRAIL			
Treatment Effect	290.3	-4313	-4023
$(\hat{\beta}_5 - \hat{\beta}_4)$	(768)	(2950)	(3254)
	0.707	*0.150*	*0.222*
FDR Sharpened q-value	[0.799]	[0.37]	[0.444]
Mean Control 1	7580	37171	44751
Difference TRAIL vs. GRAIL $((\hat{\beta}_3 - \hat{\beta}_2) - (\hat{\beta}_5 - \hat{\beta}_4))$:			
p-value	*0.0380*	*0.183*	*0.0735*
R^2	0.269	0.026	0.034
Sample Size	6,150	6,150	6,150

Treatment effects ($\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively) are estimated from equation (2) in the text. Regressions are run on household-year level data for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Regressions also control for the religion and caste of the household, age, educational attainment and occupation of the oldest male member of the household, household's landholding, a set of year dummies and an information village dummy. Standard errors in parentheses are clustered at the village level. p-values are in italics. The FDR sharpened q-values estimated using the procedure in Anderson (2008) are in square brackets. Coefficient estimates are presented in Table **??** in the Appendix.

Looking across Tables 6B and 8, we see that the treatment effects on potato profits account for the 79% of the treatment effects on farm income in the TRAIL scheme, and 66% in the GRAIL scheme.

Column 2 presents treatment effect estimates for non-agricultural income, which is calculated as the sum of rental, sales, labour and business income. The point estimates are imprecise, possibly as a result of measurement error. Column 3 indicates that total incomes increased by 9.1% for TRAIL beneficiaries, but decreased by 9% for GRAIL beneficiaries; this difference is statistically significant at the 10% level.

6. Selection-based Explanations

The empirical findings discussed above indicate that the TRAIL scheme was more successful than the GRAIL scheme at raising borrowers' farm incomes. In what follows, we investigate reasons for this difference in impacts. A natural first avenue to explore is whether TRAIL and GRAIL agents selected borrowers of different types.

We start, in Section 6.1, by showing that in both schemes, selected households were more likely to have prior links with the agent, although the nature of links differed by scheme. Specifically, the households that the TRAIL agents recommended tended to have economic links with the agent, while the households that the GRAIL agent recommended were likely to have a shared political affiliation. Although we do not see significant differences in farm performance between TRAIL and GRAIL recommended households, our semi-parametric estimates in Section 6.2 suggest that TRAIL recommended households had superior unobserved productivity relevant traits. However, as we show in Section 6.3, a decomposition exercise reveals that selection differences can explain less than 15% of the treatment effect difference between the two schemes.

6.1. Links between Agents and Recommended Households

In Table 9 we start by examining the links that recommended (Control 1) households had with the agent prior to our intervention relative to non-recommended (Control 2) households. To this end, we use data only from the first cycle of surveys, conducted in October – December 2010, asking about the relationship the household had with the individual who had just been appointed the agent over the previous three years. The estimation sample does not include Treatment households because the intervention could have changed these households' links with the agent. In regression equation (3) below, the dependent variable $L_{iv} = 1$ if household i in village v reports that they had a particular type of link with the agent. Explanatory variable Recommended_{iv} takes value 1 if the household was recommended (i.e. in the Control 1 group), and 0 otherwise.

$$L_{iv} = \xi_0 + \xi_1 \text{TRAIL}_v + \xi_2 \text{Recommended}_{iv} + \xi_3 (\text{TRAIL}_v \times \text{Recommended}_{iv}) + \xi_4 Z_{iv} + \varepsilon_{iv} \tag{3}$$

Here $\hat{\xi}_1$ measures differences between TRAIL and GRAIL villages in the likelihood that Control 2 farmers had such links with the agents. $\hat{\xi}_2$ measures how the links of Control 1 and Control 2 farmers differ in GRAIL villages. The key parameter of interest is $\hat{\xi}_3$, which measures how the selection pattern differed between TRAIL and GRAIL villages. We can also compute the predicted differences between recommended and non-recommended households in TRAIL and GRAIL villages as $\hat{\xi}_2 + \hat{\xi}_3$ and $\hat{\xi}_2$ respectively.

The coefficient estimates are presented in Panel A, and the corresponding predicted differences are presented in Panel B. It is evident that households the TRAIL agents selected were more likely to have had economic links with them; specifically they were likely to have borrowed from the agent in the past. In contrast, households that the GRAIL agents recommended tended to share political affiliation, and to a lesser extent to belong to the same religion or caste as themselves. Thus the occupational differences among the two different agent types appear to correlate with different criteria for selection.

Any selection based explanation for the difference in the performance of the two schemes relies on productivity differences between the scheme beneficiaries. Although recommended households did not differ statistically between the two schemes in terms of farm outcomes (see Table B.10), the key factor of interest is their underlying productivity-relevant traits. In what follows, we use a semi-parametric approach to examine whether farmers in the two schemes differ in unobservable characteristics.

6.2. Selection on a Single Dimensional Attribute

To begin with, we assume that farmers are heterogeneous in a single trait. Using a model with no input market frictions (Section 6.2.1), a household panel regression allows us to back out estimates of this trait.

6.2.1. Model with No Input Market Frictions. Our model assumes that farmers differ in ability, local input markets are frictionless, and there are diminishing returns to scale in farm production. This is a simplified version of standard models used in the literature on industrial organization to estimate

TABLE 9. Differences between Recommended and Non-Recommended Households

	Economic Links In past 3 years, Household has			Social and Political Links Household and Agent Belong to			
	Bought from Agent (1)	Borrowed from Agent (2)	Worked for Agent (3)	Same Occupation (4)	Same Religion (5)	Same Caste (6)	Same Political Party (7)
Panel A: Coefficient Estimates							
TRAIL ($\hat{\xi}_1$)	0.285	0.108	0.008	-0.277	-0.120	-0.048	
	(0.064)	(0.045)	(0.048)	(0.048)	(0.045)	(0.032)	
Recommended ($\hat{\xi}_2$)	0.024	0.011	0.008	0.066	0.032	0.042	0.081
	(0.019)	(0.015)	(0.013)	(0.041)	(0.014)	(0.029)	(0.033)
TRAIL × Recommended ($\hat{\xi}_3$)	0.034	0.086	0.026	-0.061	-0.004	-0.052	
	(0.044)	(0.030)	(0.035)	(0.043)	(0.036)	(0.036)	
Mean GRAIL Control 2	0.046	0.043	0.090	0.269	0.945	0.641	0.296
Panel B: Predicted Differences Between Recommended and Non-Recommended Households							
TRAIL ($\hat{\xi}_2 + \hat{\xi}_3$)	0.0578	0.0973	0.0338	0.00404	0.0283	-0.0106	
	(0.0396)	(0.0253)	(0.0333)	(0.0106)	(0.0337)	(0.0201)	
	0.151	*0.000*	*0.316*	*0.706*	*0.405*	*0.601*	
GRAIL ($\hat{\xi}_2$)	0.024	0.011	0.008	0.066	0.032	0.042	0.081
	(0.0194)	(0.0154)	(0.0133)	(0.0411)	(0.0144)	(0.0292)	(0.033)
	0.221	*0.477*	*0.539*	*0.117*	*0.0316*	*0.160*	*0.0226*
Sample Size	1,589	1,589	1,589	1,589	1,589	1,589	804
R^2	0.156	0.084	0.049	0.214	0.413	0.577	0.048

Panel A presents regression coefficients from the regression specification given by equation (3) in the text. The estimating sample includes Control 1 (Recommended) and Control 2 (Non-Recommended) households in TRAIL and GRAIL villages with at most 1.5 acres of land. Regressions also include dummies for the religion and caste of the household, age, educational attainment and occupation of the oldest male member of the household, household's landholding and an information village dummy. Panel B presents differences in predicted means between Recommended and Non-Recommended households, derived from the regressions in Panel A. Standard errors in parentheses are clustered at the village level. p-values are in italics.

ability (Olley and Pakes, 1996; Levinsohn and Petrin, 2003; Ackerberg et al., 2015; Shenoy, 2021).[21] Farmers produce a single crop (potatoes) using a single variable scale input (land), according to a Cobb-Douglas function with decreasing returns to scale. This effectively assumes that different inputs are required in fixed proportions to area cultivated. We abstract from price or production risk. Access to program (TRAIL or GRAIL) loans is modelled as the farmer obtaining a supplementary line of credit at a below-market interest rate. Assuming in addition that treated farmers do not find program loan size limits binding, farmers who receive a program loan cultivate on a larger scale, produce more output, and earn more profit. These increases are larger for more able farmers. By plugging in the observed scales of cultivation for Control 1 and Control 2 subjects in each treatment, we can use the model to back out estimates of farmer ability. This allows us to estimate whether selection patterns by ability differ between the two schemes.

Start with farmers in the control group. Farmer i in village v in year t earns revenues given by the production function:

$$R_{ivt} = p_{vt} a_i [\frac{1}{1-\alpha} l_{ivt}^{1-\alpha}] \tag{4}$$

where p_{vt} denotes yield or price, varying at the village-year level, that the farmer knows or expects at the time of planting, l_{ivt} is the farmer's chosen scale of cultivation, and $\alpha \in (0, 1)$. Farmer ability or TFP a_i is exogenous and follows

21. It is also a special case of the model we present in Section 7.1.1. Specifically, it corresponds to the case with no default risk, and no scope for agents to help or monitor borrowers.

a common distribution in GRAIL and TRAIL villages. Ability may depend on the farmer's skill as well as his landholding and other complementary assets. In the baseline model, we assume ability is a farmer-specific, time-invariant characteristic.[22]

Since there are no input market frictions, the cost of production per unit area c is constant and identical across farmers. Each farmer is a price-taker and selects the scale of cultivation that maximizes their profits. Specifically, in village v in year t, a control group farmer borrows from informal lenders at a common cost of capital ρ_{vt}. These lenders compete in Bertrand fashion, so each farmer pays interest cost ρ_{vt}, thus incurring an (interest-inclusive) unit cultivation cost of $c\rho_{vt}$. To cultivate potatoes, the farmer must also pay a fixed cost $F > 0$. Accordingly, he chooses $l = l^c_{ivt}$ to maximize

$$p_{vt} a_i \frac{l^{1-\alpha}}{1-\alpha} - \rho_{vt} c l - F\mathcal{I}_{l>0}$$

where $\mathcal{I}_{l>0}$ denotes an indicator function taking the value 1 if $l > 0$ and 0 if $l = 0$.

If control farmers are sufficiently able, it is optimal for them to select a positive cultivation scale, given by:

$$\log l^c_{ivt} = \frac{1}{\alpha} \log \frac{a_i}{c} + \frac{1}{\alpha}[\log p_{vt} - \log \rho_{vt}] \tag{5}$$

22. In Section 6.3 below we discuss robustness to an extended version where each farmer's ability dynamically evolves across successive years according to a stationary Markov process, as usually assumed in the industrial organization literature on productivity estimation.

Observe that $\frac{1}{\alpha} \log \frac{a_i}{c}$ is monotonically increasing in (and linear in the logarithm of) farmer ability. Accordingly, we estimate the ability of control farmers as the household fixed effect in a household-year level panel regression, where the (log) scale of potato cultivation (acreage or output) is regressed on farmer, village and year dummies.

Farmers whose ability is below some threshold $\underline{a}_{vt}$ would choose not to cultivate potatoes. Our data show that roughly 30 percent of Control 1 and Control 2 group farmers planted potatoes in at most one of the three years in our study period; we cannot estimate household fixed effects for these households. To these "non-cultivator" households, we assign the lower endpoint of the estimated ability distribution among the cultivators; this is an upper bound to their true latent ability. None of the comparisons below are affected if we replace this upper bound with any lower estimate.

This model provides a potential explanation for why more able farmers would obtain larger treatment effects when they obtain subsidized credit.[23] Assuming that program size limits are not binding for any farmer, all farmers expand their scale of cultivation and profits by the same proportion. Since the base levels of these measures of performance are larger for the more able farmers, the reduced input cost also increases their cultivated area and profits by more.[24] In both schemes, agents' bonuses were linked to the scale of

23. See Maitra et al. (2017) for a more general version of this model.

24. We conjecture that farmers do not replace their expensive informal loans with the subsidized program loans but instead expand total borrowing, because they are pre-committed to these informal loans and do not want to disrupt long-term relationships.

borrowing (as well as repayment rates), and so both types of agents would have been motivated to select more able farmers, since they would have borrowed more. That said, TRAIL agents have close economic links with farmers and so they might be better informed about farmer-specific ability and may have selected the more able farmers as program beneficiaries. GRAIL agents may have had less information, and therefore been unable to select as effectively on this dimension.

Before investigating with the data are consistent with this hypothesis, we first examine how estimated ability varies with households' observable characteristics. In Panel A of Table 10 we present results of a regression following the specification:

$$y_i = \eta_0 + \eta_1 \mathbf{X}_i + \varepsilon_i \tag{6}$$

The dependent variable (y_i) is the ability estimate from farmer fixed effects in a regression following equation (5), where cultivation scale is proxied by acreage under potatoes; $\mathbf{X}_i$ includes a set of pre-program household characteristics (landholding, religion and caste of the household, household size, gender of household head and age and educational attainment of the oldest male member of the household). The estimation sample includes Control 1 and Control 2 cultivator households in TRAIL and GRAIL villages with at most 1.5 acres of land. We find that households with more landholding and those with male heads have higher estimated ability. In particular the ability estimate varies almost one-for-one with landholding. As Panel B shows, there is considerable dispersion in the ability distribution. Variation in

Table 10. Variation of Estimated Ability with Observable Household Characteristics

Panel A: Regression Results		Panel B: Descriptives of Estimated Ability Distribution	
Landholding	1.082	Mean	1.694
	(0.165)	SD	1.180
	0.000	Minimum	-2.885
Non Hindu Household	-0.119	First Quartile:	0.845
	(0.161)	Second Quartile:	2.002
	0.464	Third Quartile:	2.629
Low Caste Household	-0.068	Maximum	4.799
	(0.155)		
	0.665		
Age of Oldest Male	-0.004		
	(0.004)		
	0.311		
Oldest Male: Completed Primary School	0.109		
	(0.090)		
	0.233		
Household Size	0.013		
	(0.021)		
	0.541		
Male Head Household	0.482		
	(0.190)		
	0.014		
Constant	0.717		
	(0.249)		
	0.006		
Sample Size	1,001		
R^2	0.154		

OLS regression results presented. Estimating equation is given by equation (6) in the text. The dependent variable is the ability estimate from farmer fixed effects in a regression following equation (5), where cultivation scale is proxied by acreage under potatoes. Control 1 households are assigned a weight of $\frac{20}{N-10}$ and Control 2 households are assigned a weight of $\frac{N-30}{N-10}$, were N is the total number of households in their village. The estimation sample includes Control 1 and Control 2 cultivator households in TRAIL and GRAIL villages with at most 1.5 acres of land. Standard errors in parentheses are clustered at the village level. p-values are presented in italics.

observable characteristics can only explain 15% of this variation, indicating that households' observable characteristics are only incomplete predictors of farmer ability.[25] This underscores one of the principal rationales for hiring community-level agents who may have additional information not easily observable to MFIs.

Recall that our model can predict larger treatment effects of the TRAIL scheme only if TRAIL borrowers were more able than GRAIL borrowers. To examine possible ability differences, we plot cumulative distribution functions of the ability estimates of households in the two schemes. First, we establish that agents selected borrowers positively. Consider Panel A of Figure 2. The figure on the left shows that in TRAIL villages, the cumulative distribution function for Control 1 households first-order stochastically dominates that for non-recommended (Control 2) households.[26] A two-sample Kolmogorov-Smirnov test rejects the null hypothesis that the two distributions are identical (p-value = 0.00). The figure on the right shows a similar pattern in the GRAIL villages: Control 1 households are more able than Control 2 households (K-S test p-value = 0.00).[27] Next, when we compare the two schemes in Panel B, we

25. A LASSO estimator performs only slightly better than the ordinary least squares estimator. Under the Extended Bayesian Information Criterion the selected LASSO model has an R-squared of 0.23.

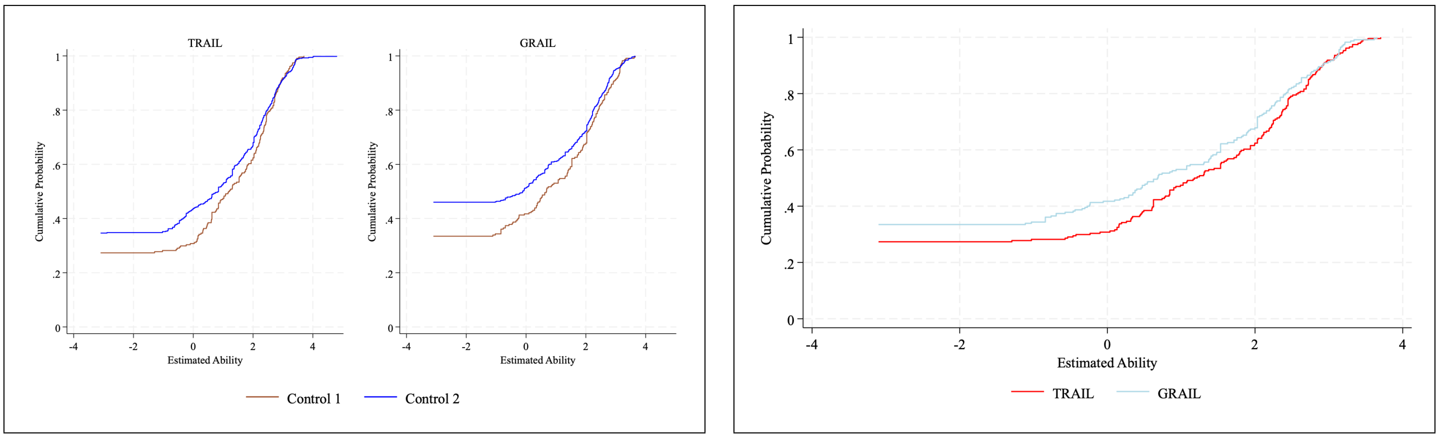
26. The flat segment in the bottom end of the plotted CDFs depicts the upper bound of the estimates for non-cultivators.

27. Since our ability estimates are generated variables, we also simulate 2000 bootstrap samples and run the K-S test for each Control 1 v. Control 2 CDF comparison. We can reject the null hypothesis that the two TRAIL distributions are identical in 99.8% of the simulations. Similarly we can reject the null hypothesis that the two GRAIL distributions are identical in 99.25% of the bootstrap simulations.

FIGURE 2. Borrower Selection on Estimated Ability in TRAIL and GRAIL Schemes

Panel A: Estimated Ability Distribution
Selected v. Non-selected households

Panel B: Estimated Ability Distribution
Selected households: TRAIL vs GRAIL



Ability is estimated following the regression specification in equation (5), proxying scale of cultivation with acreage under potatoes. In Panel A, the sample is restricted to Control 1 and Control 2 households in TRAIL and GRAIL villages. The null hypothesis that Control 1 and Control 2 households follow the same ability distribution is rejected by a two sample Kolmogorov-Smirnov (KS) test (p-value = 0.00) for TRAIL and (p-value = 0.00) for GRAIL. In Panel B, the sample is restricted to Control 1 households in TRAIL and GRAIL villages. The null hypothesis that the estimated ability distributions for TRAIL Control 1 and GRAIL Control 1 households are equal is rejected by a two sample Kolmogorov- Smirnov (KS) test (p-value = 0.00).

see that TRAIL agents were more likely to recommend high-ability borrowers than GRAIL agents were: the distribution for recommended households in the TRAIL scheme first-order stochastically dominates that for recommended households in the GRAIL scheme (K-S test p-value = 0.00).[28] Thus we do find evidence consistent with the selection hypothesis associated with this model.

6.2.2. Selection Model with Credit Rationing and Land Market Frictions. The assumption of no input market frictions could be construed as restrictive. For example, if TRAIL agents selected farmers who were more credit constrained, then their larger treatment effect could simply be the effect of relaxing this constraint. Alternatively, if land markets are thin, then farmers with more land would earn larger returns to program loans. To address such concerns, we now consider an alternative model of selection which incorporates credit rationing, both in the informal credit market as well as in program loans, and also frictions in the land market.[29] Suppose revenues earned by a farmer of type i in village v, year t take the form:

$$R_{ivt} = p_{vt} L_i^{\gamma} [\frac{1}{1-\gamma} l_{ivt}^{1-\gamma}] \tag{7}$$

where $\gamma \in (0,1)$, L_i denotes land area owned by farmer i, p_{vt} denotes output price and l_{ivt} denotes variable inputs purchased by the farmer at constant unit cost c_{vt}. Frictions in the land market prevent any leasing in

28. The Kolmogorov-Smirnov test rejects the null hypothesis that the two distributions are identical in 87.12% of the 2000 bootstrap simulations.

29. We are grateful to an anonymous referee for suggesting this model.

or purchase of additional land, and so area cultivated equals land owned by the farmer. Landholding L_i represents the relevant dimension of heterogeneity in this model, while variable inputs are chosen endogenously. Farmer i faces a credit limit B_i where $\frac{B_i}{L_i}$ is decreasing in L_i, i.e., which expands less than proportionately with landholding. Moreover, the credit limit is binding, i.e., the value of the marginal product (VMP_i) of the variable input l_{ivt} at the corresponding upper bound $\frac{B_i}{c_{vt}}$ exceeds its unit cost:

$$\text{VMP}_i \equiv \frac{p_{vt}}{1-\gamma}[\frac{B_i}{c_{vt}L_i}]^{-\gamma} > c_{vt} \tag{8}$$

The microcredit program is assumed to expand the borrowing limit of all farmers by a uniform amount $dB > 0$, but farmer i is also rationed at the new credit limit (i.e., inequality (8) holds when B_i is replaced by $B_i + dB$). Then farmer i will increase their use of the variable input by $\frac{1}{c_{vt}}dB$, causing output to increase by $\text{VMP}_i \cdot dB$ and profit to increase by $[\text{VM}P_i - c_{vt}]dB$. $\frac{B_i}{L_i}$ is falling in L_i and therefore, VMP_i is increasing in L_i. Since farmers with larger landholding were farming less intensively before the program, diminishing returns to variable inputs ensures they have a larger marginal product of the variable input. Therefore farmers with larger landholding experience larger increases in output and profits.

If TRAIL agents are better informed about farmers' landholdings than GRAIL agents, they are better placed to select farmers who own more land, thereby leading to higher output and profit treatment effects in TRAIL villages. This particular version of the model cannot explain the increase in area cultivated. However, extending it to allow for less extreme frictions on the tenancy market (which allow some leasing) would generate positive treatment effects on area cultivated while still generating similar treatment effects on outputs and profits.

The relevant dimension of heterogeneity in this model is proxied by pre-program cultivation scale (of "comparable" control group farmers). Observe that an estimate of this dimension would deliver the same ability estimate as in the previous exercise in Section 6.2.1. It would therefore generate identical predictions for selection differences between TRAIL and GRAIL, as well as for the pattern of heterogenous treatment effects, viz. that treatment effects should be increasing in landholding (analogous to the ability estimate). By construction, both models predict that farmers with the same trait (pre-program cultivation scale or ability) would achieve the same treatment impacts on area cultivated, output and profits, in both TRAIL and GRAIL schemes, and therefore cannot explain why treatment effects conditional on farmer types would differ between the two schemes. In the same vein, they also cannot predict treatment effects on unit costs.

In Section 6.2.1 we have already seen evidence that TRAIL agents selected farmers of greater ability than GRAIL agents did, and as discussed above, this implies a similar result for selection differences on the relevant landholding trait estimate as per the model in this section. The second model also delivers an additional prediction: among control farmers, those who cultivate on a larger scale farm less intensively. In other words, unit costs are decreasing in area cultivated or farmer landholding. In a regression of unit cost on landholding controlling for year, village and information dummies we find suggestive evidence that unit costs decline with landholding, although the estimates are imprecise (See Table B.11 in the Appendix).

6.3. Heterogenous Treatment Effects and ATE Decomposition

Either of the two models described above can potentially explain why the average treatment effects of the TRAIL loan scheme would be larger than in the GRAIL scheme. The explanation lies in the fact that TRAIL agents would have selected as borrowers farmers who are superior on a particular dimension than the borrowers whom GRAIL agents selected. In this section we check whether the treatment effects do in fact increase in this dimension of borrower heterogeneity, and the extent of variation in ATEs this helps explain.

To estimate heterogenous treatment effects implied by the first model, we need to estimate ability for Treatment households. We cannot estimate this using the same method as for Control 1 and Control 2 farmers described in Section 6.2.1, since Treatment households could have changed their production decisions when they received the program loans. Instead we recover an estimate of their ability under the *order-preserving assumption* that the treatment effect on area cultivated is monotonic in farmer ability. This assumption ensures that all Treatment households remain in the same relative ranking after they received the program loan, as before.[30] Since recommended

30. Athey and Imbens (2006) use a similar assumption to identify treatment effects in non-linear difference-of-difference settings. A theoretical justification for this assumption is provided in Maitra et al. (2017), as well as in Section 7.1.1 (Propositions 1(b) and 2(b)) below.

farmers were randomly assigned to treatment, we assume that ability is distributed identically for Treatment and Control 1 households. As a result, we can rank Treatment farmers within any treatment arm by cultivation scale, and assign to them the counterfactual ability estimate of the farmer at the same rank within the Control 1 distribution.

We can then estimate treatment effects conditional on ability, as the difference in farm outcomes between Treatment households and Control 1 households at the same ability level. For what follows, it is convenient to group all sample households (after pooling TRAIL and GRAIL households together) into three ability classes, or bins. We place all non-cultivator households in the lowest ability class, Bin 1. Among the rest, we use a median split to create Bins 2 and 3.

The heterogenous treatment effects (HTEs) estimates are presented in Tables 12A and 12B. We consider the full range of dependent variables including borrowing, potato cultivation-related choice and outcome variables, as well as aggregate outcomes. The regressions follow the specification:

$$
\begin{aligned}
y_{ivt} = &\sum_{k=1}^{3} \xi_{1k}\ \widehat{\text{Bin}}_{ik} + \sum_{i=1}^{3} \xi_{2k}\ (\text{Control } 1_{iv} \times \widehat{\text{Bin}}_{ik}) + \sum_{k=1}^{3} \xi_{3k}\ (\text{Treatment}_{iv} \times \widehat{\text{Bin}}_{ik}) \\
&+ \sum_{k=1}^{3} \xi_{4k}\ \widehat{\text{Bin}}_{ik} \times \text{GRAIL}_v + \sum_{k=1}^{3} \xi_{5k}\ (\text{Control } 1_{iv} \times \widehat{\text{Bin}}_{ik} \times \text{GRAIL}_v) \\
&+ \sum_{k=1}^{3} \xi_{6k}\ (\text{Treatment}_{iv} \times \widehat{\text{Bin}}_{ik} \times \text{GRAIL}_v) + \gamma \mathbf{X'}_{ivt} + \varepsilon_{ivt}
\end{aligned} \tag{9}
$$

where $\widehat{\text{Bin}}_{ik}$ is an indicator variable for the estimated ability of household i belonging to Bin k. We compute the TRAIL and GRAIL treatment effects for Bin k as $\hat{\xi}_{3k} - \hat{\xi}_{2k};\ k = 1, 2, 3$ and $\hat{\xi}_{6k} - \hat{\xi}_{5k};\ k = 1, 2, 3$ respectively and the corresponding difference in treatment effect as $(\hat{\xi}_{3k} - \hat{\xi}_{2k}) - (\hat{\xi}_{6k} - \hat{\xi}_{5k}); k = 1, 2, 3$.

As we see in Table 12A and columns 1-5 of Table 12B, consistent with the predictions of the first selection model, the heterogenous treatment effects for potato acreage, output, revenue, value added and imputed profits are larger for households in higher ability bins in both treatments (with a few exceptions in GRAIL). For any given ability bin, differences between the estimated treatment effects in the two schemes are not statistically significant. However, we also see in column 8 of Table 12A that contrary to the predictions of either model, in all three ability bins, TRAIL borrowers' unit costs of production declined significantly. The corresponding point estimates for the GRAIL scheme are either positive (in Bin 1) or negative but statistically not distinguishable from zero (Bins 2 and 3). In each bin the point estimate decrease in unit costs is larger in the TRAIL scheme than in the GRAIL scheme, and the difference is statistically significant for the most able farmers (Bin 3). As we know from our discussion in Section 5.2, the differences in unit cost treatment effects also contribute to the observed ATE difference. However, this effect cannot be explained by the selection hypotheses.

This raises the question: how much of the observed ATE difference can be accounted for by differences in selection? Conceptually we have shown above that selection-based models can explain several but not all our empirical

Table 12A. HTEs by Ability Bin. Potato Cultivation

	Acreage (Acres) (1)	Production (Kg) (2)	Cost of Production (Rupees) (3)	Price (Rupees) (4)	Revenue (Rupees) (5)	Value Added (Rupees) (6)	Imputed profit (Rupees) (7)	Input Cost per acre (Rupees) (8)	Yield (Kg/Acres) (9)
Treatment Effects TRAIL									
Bin 1	0.020	189.3	413.8	0.198	834.1	420.1	350.6	-1587.2	-1119.1
$(\hat{\xi}_{31}-\hat{\xi}_{21})$	[-0.01, 0.04]	[-82.01, 406.1]	[-343.7, 1113.3]	[-0.05, 0.49]	[-391.0, 1685.4]	[-113.6, 771.7]	[-141.0, 676.9]	[-8009.5, 8331.3]	[-1946.6, -342.5]
Bin 2	0.075	776.4	1886.9	-0.17	2920.5	1033.5	934.5	-3177.9	181.1
$(\hat{\xi}_{32}-\hat{\xi}_{22})$	[0.03, 0.12]	[391.0, 1174.6]	[988.6, 2703.7]	[-0.39, 0.09]	[1324.3, 4425.3]	[162.9, 1909.0]	[61.3, 1830.8]	[-5894.3, -535.4]	[-562.1, 212.8]
Bin 3	0.128	1297.37	2157.71	0.067	5559.1	3424.5	3244.3	-3088.1	105.5
$(\hat{\xi}_{33}-\hat{\xi}_{23})$	[0.05, 0.21]	[495.0, 2110.6]	[129.3, 4256.9]	[-0.18, 0.26]	[1770.6, 9383.6]	[1179.6, 5488.1]	[1014.9, 5298.5]	[-5557.7, -997.2]	[-428.3, 188.5]
Treatment Effects GRAIL									
Bin 1	0.048	481.6	1278.4	-0.135	1839.4	556.8	227.1	7554.7	45.1
$(\hat{\xi}_{61}-\hat{\xi}_{51})$	[0.02, 0.08]	[156.2, 806.1]	[695.4, 1883.7]	[-0.45, 0.22]	[582.0, 3030.0]	[-182.4, 1224.2]	[-505.9, 866.3]	[2682.6, 12859.5]	[-896.9, 674.2]
Bin 2	0.082	797.8	2445.9	-0.271	2847.1	383.1	140.1	-1422.4	108.9
$(\hat{\xi}_{62}-\hat{\xi}_{52})$	[0.03, 0.13]	[416.3, 1189.5]	[1724.1, 3181.4]	[-0.72, 0.19]	[1074.0, 4618.0]	[-875.1, 1622.0]	[-1053.1, 1329.6]	[-3618.6, 677.0]	[-534.1, 265.4]
Bin 3	0.128	1583.8	3400.6	-0.139	5350.6	1949.0	1591.2	1417.5	253.4
$(\hat{\xi}_{63}-\hat{\xi}_{53})$	[0.04, 0.22]	[640.8, 2540.3]	[1297.1, 5459.3]	[-0.34, 0.04]	[1243.0, 9021.7]	[-1348.9, 4633.3]	[-1728.2, 4324.76]	[-1361.6, 3806.9]	[-119.7, 581.5]
Difference TRAIL vs GRAIL									
Bin 1	[-0.07, 0.01]	[-706.2, 94.6]	[-1830.0, 35.6]	[-0.11, 0.77]	[-2662.1, 513.0]	[-1007.9, 707.4]	[-673.7, 953.5]	[-17832.5, 2003.5]	[-2119.5, 86.0]
Bin 2	[-0.07, 0.05]	[-549.6, 543.4]	[-1780.9, 568.0]	[-0.43, 0.63]	[-2280.5, 2489.8]	[-855.8, 2206.3]	[-675.2, 2284.6]	[-5220.5, 1502.0]	[-593.1, 498.5]
Bin 3	[-0.12, 0.12]	[-1607.4, 940.6]	[-4193.6, 1690.5]	[-0.09, 0.49]	[-5388.6, 5713.4]	[-2094.4, 5242.4]	[-1986.0, 5324.4]	[-8073.1, -1082.4]	[-855.2, 121.8]
Sample Size	6150	6150	6150	6150	6150	6150	6150	6150	6150

Heterogeneous treatment effects are estimated as per regression equation (9) in the text. The estimation sample includes all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. The dependent variables take the actual values reported by the household if it cultivated potatoes in that year, and 0 otherwise. In Columns 8 and 9, households that did not cultivate potatoes are not included. Controls are included for a set of year dummies and an information village dummy. Households are classified into bins based on their household ability estimate (equation (5)), proxying scale of cultivation with potato acreage. Bootstrapped 90% confidence intervals (with 2000 iterations) are in square brackets. interval (2000 iterations) does not include 0.

TABLE 12B. HTEs by Ability Bin. Agricultural Borrowing, Aggregate Incomes and Engagement with Agent

	Agricultural Borrowing			Aggregate Incomes		Engagement
	All Loans	Non-Program Loans	Aggregate Farm Profit	Non Agricultural Income	Total Household Income	with Agent
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment Effects TRAIL						
Bin 1 ($\hat{\xi}_{31} - \hat{\xi}_{21}$)	1255.9	-155.8	217.7	-4656.8	-4439.0	0.032
	[480.1, 2029.9]	[-659.1, 410.6]	[-850.3, 1314.8]	[-12646.2, 3419.9]	[-11864.9, 3341.2]	[-0.03, 0.10]
Bin 2 ($\hat{\xi}_{32} - \hat{\xi}_{22}$)	3489.1	-202.1	956.1	10854.1	11810.2	0.052
	[2424.4, 4389.1]	[-1264.4, 734.8]	[-705.2, 2882.1]	[1203.2, 20492.3]	[1680.7, 21287.8]	[0.00, 0.10]
Bin 3 ($\hat{\xi}_{33} - \hat{\xi}_{23}$)	2770.9	-1417.8	4274.7	-3280.9	993.8	0.415
	[199.5, 5195.4]	[-3809.0, 867.2]	[1578.8, 6728.3]	[-13197.8, 7373.0]	[-8198.7, 10623.6]	[0.10, 0.54]
Treatment Effects GRAIL						
Bin 1 ($\hat{\xi}_{61} - \hat{\xi}_{51}$)	2375.0	675.9	1035.2	-3704.9	-2669.7	1.69
	[1391.0, 3431.5]	[-111.1, 1511.7]	[-352.2, 2261.5]	[-13283.6, 4567.6	[-11972.9, 5099.5]	[0.40, 2.50]
Bin 2($\hat{\xi}_{62} - \hat{\xi}_{52}$)	2062.1	-1169.8	712.0	455.1	1167.2	0.440
	[1129.6, 2877.9]	[-2032.3, -387.9]	[-849.9, 2428.7]	[-10947.1, 10909.1]	[-10288.8, 11718.7]	[-0.24, 0.70]
Bin 3 ($\hat{\xi}_{63} - \hat{\xi}_{53}$)	4940.3	1345.2	1368.1	-8662.7	-7294.5	0.117
	[2795.1, 7133.9]	[-730.3, 3505.8]	[-2142.6, 4401.6]	[-17808.9, -154.6]	[-17783.3, 1808.1]	[0.05, 0.20]
Difference TRAIL vs GRAIL						
Bin 1	[-2408.5, 114.1]	[-1825.5, 90.2]	[-2434.6, 912.8]	[-12417.5, 11541.3]	[-12749.1, 10110.6]	[-2.47, -0.36]
Bin 2	[42.78, 2725.3]	[-332.8, 2252.0]	[-2120.3, 2722.8]	[-3418.0, 25014.9]	[-3389.6, 25436.8]	[-0.65, 0.30]
Bin 3	[-5607.6, 1129.9]	[-6018.1, 281.7]	[-1189.7, 7076.8]	[-7476.0, 19361.2]	[-4600.8, 22384.6]	[-0.04, 0.43]
Sample Size	6,150	6,150	6,150	6,150	6,150	6,150

Heterogeneous treatment effects are estimated as per regression equation (9) in the text. The estimation sample includes all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. In column 1, the dependent variable is the total household borrowing, for agricultural use, from all sources. In column 2, the dependent variable is the total non-program agricultural borrowing (loans from sources other than the TRAIL or GRAIL schemes for agricultural use). In column 6, the estimation sample includes Treatment and Control 1 households in TRAIL and GRAIL villages with at most 1.5 acres of land, and agent-farmer engagement is measured by the average number of times in the year the household reported speaking to the agent about cropping, harvest or sales, averaged over the three surveys per year. The reference period is three days prior to the survey date. Controls are included for a set of year dummies and an information village dummy. Households are classified into bins based on their household ability estimate (equation (5)), proxying scale of cultivation with potato acreage. Bootstrapped 90% confidence intervals (with 2000 iterations) are in square brackets. (2000 iterations) does not include 0.

patterns. To examine the quantitative strength of the selection explanation, in Table 13 we decompose the estimated difference in the ATEs of the two schemes into the *Selection Effect*, and the effect caused by differences in treatment effects conditional on selection *Conditional Treatment Effect*.

The difference in ATEs due to selection is defined as the change in the TRAIL average treatment effect that would occur if the ability distribution of borrowers in the TRAIL scheme was replaced by the actual distribution that we see in the GRAIL scheme, but within each ability bin, borrowers experienced the same treatment effects as we see in the TRAIL scheme. Specifically, the difference in ATEs due to selection is computed as $\sum_{k=1}^{3} \frac{(\sigma_k^T - \sigma_k^G)\times T_k^T}{(\mathrm{ATE})^T - (\mathrm{ATE})^G}$ where σ_k^j, T_k^j and $\mathrm{ATE}^j; j = T, G$ denote the proportion of households in treatment j in Bin k, the HTE in treatment j in the corresponding Bin and the average treatment effect in treatment j respectively and is the sum of the three numbers in column 7 of Table 13 (aggregating over the three bins). In Panel A we see that if instead of the actual 31%, a larger 40% TRAIL borrowers were in Bin 1, then with a bin-specific treatment effect of Rupees350.60 this segment's contribution to the average treatment effect on profits from potatoes would decline by Rupees32.08. If instead of the actual 32%, a smaller 29% of TRAIL borrowers were in Bin 2, then this segment's contribution would increase by Rupees27.10. Finally, if instead of the actual 37%, only 31% of TRAIL borrowers were in Bin 3, then this segment's contribution would increase by Rupees202.77. Thus in total the TRAIL average treatment effect would decrease by Rupees197.79, which is 11.54% of the difference in the actual estimated TRAIL and GRAIL ATEs.

TABLE 13. Decomposition of ATE Differences in Imputed Profit from Potato Cultivation and Aggregate Farm Profit. TRAIL v. GRAIL

Bin (k)	σ_k^T	σ_k^G	$\sigma_k^T - \sigma_k^G$	TRAIL HTEs (T_k^T)	GRAIL HTEs (T_k^G)	TRAIL – GRAIL HTEs ($T_k^T - T_k^G$)	$(\sigma_k^T - \sigma_k^G) \times T_k^T$	$\sigma_k^G \times (T_k^T - T_k^G)$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Potato Profit								
1	0.31	0.40	-0.09	350.60	227.10	123.50	-32.08	49.47
2	0.32	0.29	0.03	934.45	140.07	794.38	27.10	231.88
3	0.37	0.31	0.06	3244.27	1591.17	1653.10	202.77	508.33
ATE				1906	191.4	1714.6		
% of Difference in ATE due to Selection								11.54
% of Difference in ATE due to CTE								46.06
Panel B: Aggregate Farm Profit								
1	0.31	0.40	-0.09	217.74	1035.18	-817.44	-19.92	-327.47
2	0.32	0.29	0.03	956.07	712.04	244.03	27.73	71.23
3	0.37	0.31	0.06	4274.66	1368.14	2906.52	267.17	893.75
ATE				2406	290.3	2115.7		
% of Difference in ATE due to Selection								13.00
% of Difference in ATE due to CTE								30.13

σ_k^T denotes the proportion of TRAIL households in Bin k; σ_k^G denotes the proportion of GRAIL households in Bin k. The difference in ATEs due to selection is computed as $\sum_{k=1}^{3} \frac{((\sigma_k^T - \sigma_k^G) \times T_k^T}{(\text{ATE})^T - (\text{ATE})^G}$, while the difference in ATEs due to conditional treatment effects is computed as $\sum_{k=1}^{3} \frac{\sigma_k^G \times (T_k^T - T_k^G)}{(\text{ATE})^T - (\text{ATE})^G}$. ATE^T and ATE^G denote the average treatment effects of the TRAIL and GRAIL schemes respectively.

The Conditional Treatment Effect (CTE) is the extent to which one could have increased the GRAIL ATE if borrower ability distribution remained the same as in the GRAIL scheme, but borrowers' treatment effects within each bin were increased to the same level as in the TRAIL scheme and is computed as The difference in ATEs due to conditional treatment effects is computed as $\sum_{k=1}^{3} \frac{\sigma_k^G \times (T_k^T - T_k^G)}{(\text{ATE})^T - (\text{ATE})^G}$, i.e., as the sum of the three numbers in column 8 of Table 13. In the first row, we see that if the treatment effects on potato profits for the 40% Bin 1 borrowers in the GRAIL scheme increased from Rupees227.10 to Rupees350.60, then their contribution to the average treatment effect would increase by Rupees49.47. By similar calculations, there would be Rupees231.88 more potato profits in Bin 2, and Rupees508.33 in Bin 3, for a substantially larger total treatment effect of Rupees789.68 (or 46.06% of the difference in estimated TRAIL and GRAIL ATEs). The same calculation in Panel B for aggregate farm profits finds a Selection Effect of 13% and a Conditional Treatment Effect of 30.13% of the difference in TRAIL and GRAIL ATEs.

Hence the differences in conditional treatment effects appear to account for a much larger fraction of the observed difference in average treatment effects, amounting to 46% and 30% for aggregate farm profit and potato profit respectively, compared to 13% and 12% for the selection effect.

6.4. Alternative Specifications and Robustness

The preceding results indicate more generally that as long as we identify farmer types by scale of cultivation (which may reflect characteristics other than ability such as landholding or wealth in a context with credit frictions), differences in selection do not predict large differences in the treatment effects between TRAIL and GRAIL. Below we discuss robustness of this assessment under some specific alternative formulations of borrower types.

6.4.1. Decomposition on Continuous Ability. The decomposition procedure used above ignores variation in borrower ability within each bin. For a more granular decomposition exercise, we first run locally-weighted regressions of potato profits and aggregate farm profits on the ability estimates, separately for Treatment and Control 1 households in TRAIL and GRAIL villages respectively. The predicted values are plotted in Figure B.1 in the Appendix, and they show clear evidence of a positive difference in the profits for Treatment compared to Control 1 households for a large range of the distribution, in the TRAIL but not in the GRAIL scheme. Next, we assign all Treatment and Control 1 households to one of fifty ability bins (using the common support of the TRAIL and GRAIL households). The difference between the mean predicted potato profits (aggregate profits) of the Treatment and Control 1 households is numerically integrated (using weights based on the percentage of households in that bin) to arrive at an estimate of the average treatment effect, separately in TRAIL and GRAIL villages. Next, the total selection effect estimate is computed as

$$\mathrm{TS} = \sum_b [(v^{\mathrm{T}}_{T,b} - v^{\mathrm{T}}_{C1,b}) \times (\Pi^{\mathrm{T}}_b - \Pi^{\mathrm{G}}_b)] \tag{10}$$

where v^{T}_T and v^{T}_{C1} denote the mean predicted value of potato profit (aggregate profit) for TRAIL households in Bin b; and Π^{T}_b and Π^{G}_b denote the proportion of TRAIL and GRAIL treatment households in Bin b respectively. The total CTE estimate is computed as

$$\text{TCTE} = \sum_b [((v^{\text{T}}_{T,b} - v^{\text{T}}_{C1,b}) - (v^{\text{G}}_{T,b} - v^{\text{G}}_{C1,b})) \times \Pi^{\text{G}}_b] \tag{11}$$

We find that selection explains 9.7% of the difference in the average treatment effects of the TRAIL and GRAIL schemes for potato profits, and 12.5% of the difference in ATEs for aggregate farm profit. The corresponding CTEs account for 41.7% and 33.9% of the ATE difference in potato profit and aggregate farm profit respectively. Thus increasing the granularity of the ability estimation does not change our previous conclusion, that selection explains a fairly small proportion of the overall ATE difference.

6.4.2. Allowing Farmer Ability to Vary Over Time. We can also relax the assumption that farmer ability is fixed over time. Instead, we re-estimate each farmer's ability under the assumption that it follows a first order stationary Markov process (Ackerberg et al., 2015). We restrict the sample to Control 1 and Control 2 households and estimate the distribution of household ability in any given year. As Panel A of Figure B.2 in the Appendix shows, in both TRAIL and GRAIL villages, the cumulative distribution function for Control 1 households continues to first-order stochastically dominate that for the Control 2 households. A two-sample Kolmogorov-Smirnov test rejects the null hypothesis that the two distributions are identical ($p - value = 0.000$) in both TRAIL and GRAIL villages. Thus, once again we find that both types of agents recommended the more able borrowers. In Panel B of Figure B.2, we also find again that the distribution for TRAIL Control 1 households first-order stochastically dominate that for GRAIL households (K-S test $p - value = 0.02$).

We can then back out the ability of Treatment households in each year, under a different version of the Order Preserving Assumption, namely that in any given year, treatment status does not change the rank ordering of households. We re-estimate the heterogenous treatment effects using the specification given by equation (9). In Figure B.3, in the Appendix, we present the corresponding ability bin specific HTEs for potato profits (Panel A) and aggregate farm profits (Panel B).

The decomposition results (see Table B.12 in the Appendix) now show that selection explains an even smaller percentage of the TRAIL versus GRAIL difference in average treatment effects (5.6% for potato profits, 7.2% for aggregate farm profits), and conditional treatment effects account for an even larger 88.9% and 72.8% of the difference in ATEs on potato profits and aggregate farm profits respectively. Thus our main findings about the importance of ability selection are robust to this more general approach to estimating farmer ability.

6.4.3. Selection on Multiple Dimensions and Returns to Scale. So far, we have assumed that farmers vary only in a single attribute. However, in addition to different ability or landholding, different farmers may also have different business skills, and these can affect their unit costs of production. For example, farmers with superior procurement skills could pay lower prices for variable inputs. By ignoring other dimensions of farmer heterogeneity, our analysis could have underestimated the role of selection. Section A in the Appendix presents an alternative model where farmers differ on multiple dimensions: ability, wealth (which affects credit limits that are binding), and business skill (affecting factor prices). The model also relaxes our previous assumption of diminishing returns to scale by allowing for technological and pecuniary returns to scale, represented by constant elasticities of potato revenues and unit costs with respect to the scale of cultivation. In particular, revenues are log-linear in farmer ability and scale of cultivation, while unit costs are log-linear in business skill and scale of cultivation, and both are additionally impacted by IID random shocks. Credit limits vary with (exogenous) farmer wealth and village specific shocks, and are binding. They determine each farmer's total expenditure on inputs. The farmers' expenditures together with the revenue and unit cost equations jointly determine the scale of cultivation, revenues and unit costs. The model assumes that the program relaxes credit limits for all treated farmers by an exogenous, uniform amount. The treatment effects of the program can then be expressed as a function of farmer-specific pre-program revenues and costs, given the elasticities of revenue and unit costs. The elasticities can be estimated via an instrumental variable regression on the sample of treated and Control 1 farmers, with the randomized treatment dummy as an instrument for the cultivation scale. Given the observed revenue and unit cost distributions for the set of Control 1 farmers under each treatment, the model generates estimates of predicted average treatment effects of the TRAIL and GRAIL scheme.

In Table **??** we present these predicted ATEs. We find that the predicted ATEs are substantially larger than the ATEs we estimated in Section 5. In addition, we predict a larger ATE in the GRAIL scheme than the TRAIL scheme, which is the opposite of what we find in the data. Thus this extended model cannot satisfactorily account for the observed patterns of average treatment effects in the data.

6.5. Summary

To summarize, the ATE results presented in Section 5 indicate that the TRAIL scheme was more successful than the GRAIL scheme at increasing the farm income of borrowers. Although TRAIL and GRAIL agents leverage different connections to select the farmers they recommend, there is no evidence of significant differences in the recommended farmers' observable farm outcomes. Using two different selection models where farmers vary in a single attribute (ability and landholding respectively), we find evidence that compared to the GRAIL agents, the TRAIL agents recommended more able farmers, and farmers with more landholding. However, these selection differences accounted for less than 15% of the difference in TRAIL and GRAIL ATEs on potato and aggregate farm profits.

Therefore, although there is some evidence of a selection difference, it has only limited power to explain why the TRAIL scheme outperformed the GRAIL. Instead, it appears that the TRAIL scheme had larger treatment effects *conditional* on farmer ability (or landholding). Comparing farmers of the same ability or scale of cultivation in the two schemes, profits increased by more for those in the TRAIL scheme than in the GRAIL. This occurs even though both schemes had the same loan terms, repayment incentives and program-based commissions for the agent. In Section 7.1 below we present a theoretical model where this result is the consequence of the distinctive nature of the TRAIL agent's role in the local agricultural supply chain. In Section 7.2 we then validate the predictions of this model using the experimental data.

7. A Proposed Explanation of Differences in Conditional Treatment Effects

We start with an informal description of the mechanism captured by the model to be developed more formally below. It extends the model in Section 6.2.1 where farmers vary in ability, to explicitly incorporate crop risk and informal contracts between farmers and traders for credit and output sales. Moreover, TRAIL and GRAIL agents can monitor farmers' actions. In addition, the TRAIL agent has the business knowledge to advise them about procuring inputs of better quality or at lower prices, both of which help farmers lower unit production costs. The TRAIL agent is motivated to provide such help because the lower unit costs will induce the farmer to expand cultivation and produce a larger volume of output, thus boosting sales and middleman profits of the agent-trader.

The GRAIL agent on the other hand is not a trader, and therefore has neither the business knowledge nor the profit-oriented motivation to help farmers reduce production costs. Instead, as a political appointee at a time when West Bengal politics was dominated by a strong redistributive ideology, the GRAIL agent is assumed to have a pro-poor motivation. Accordingly, his objective function includes an implicit welfare weight that decreases in farmer ability, since more able farmers own more land, farm assets and earn higher incomes. The GRAIL agent does not personally benefit from farmers' upside crop gains. Instead, he wishes to ensure that GRAIL loans are repaid, since farmer distress reflects unfavorably both on him and the political party that appointed him. He is motivated to monitor treated farmers so that they take action to prevent crop failure. This could include, for instance, selection of hardier crop varieties, increased use of labor engaged in risk-reduction efforts and higher purchase of risk-reducing inputs, all of which raise costs and lower profits conditional on crop success (and also reduce ex ante expected profit). Hence, compared to the TRAIL agent, the GRAIL agent is more focused on reducing downside risk. The TRAIL agent on the other hand, has no incentive to monitor treated TRAIL farmers, since higher unit production costs inhibit (expected) output increases. The result is that GRAIL borrowers are less likely than TRAIL borrowers to default on program loans, but also less likely to lower unit costs, and end up achieving lower profits on average.

The model developed below formalizes this mechanism and generates a number of testable predictions which we subsequently test.

7.1. The Model

7.1.1. Assumptions. Farmers vary only in farm ability (a), as in the model of Section 6.2.1. Farmer productivity θ now depends both on farmer ability a and the extent of monitoring (m) by traders or agents.[31] The crop succeeds with probability $p(a, m)$, where p is increasing both in ability a and in the extent of monitoring m. If successful, the crop output is $\theta(a, m)f(l)$. The production

31. To simplify the analysis, we assume productivity is independent of help. This is reasonable, since by assumption help is in the form of advice about input procurement.

function $(f(\cdot))$ is strictly increasing and strictly concave in the area under cultivation l ($f_l > 0, f_{ll} < 0$). We also assume $-\frac{f''}{f'}$ is non-increasing, and that p_a is bounded above by a sufficiently small positive number, so that farmer ability matters "relatively little" for the probability of crop success.[32] We additionally assume that p exhibits a small but negative slope with respect to m (i.e., the slope is bounded below by a negative number close to 0). These assumptions imply that expected productivity $A(a, m) \equiv p(a, m)\theta(a, m)$ is rising in a and falling in m, in the same way as productivity $\theta(a, m)$. All parties are risk-neutral.

The farmer's unit cost of production $c(h, m)$ depends negatively on help h, and positively on monitoring m. Monitoring has a larger impact on the crop success of less able farmers: $p_{am} < 0$. Finally, higher levels of monitoring have smaller effects ($p_{mm} < 0$). Similarly, there are diminishing returns to help: help lowers unit costs but by less at higher levels ($c_{hh} > 0$). We also assume

32. In Maitra et al. (2017), page 328, we show that these assumptions ensure that TRAIL treatment effects are larger for more able farmers, as observed in the data. Intuitively, consider the limiting case where p is independent of a: then the informal interest rate for control farmers would not vary with ability. Then, since all treated farmers are offered a program loan at the same below-market interest rate, the program loan offers a uniform reduction in interest rate for all farmers regardless of their ability. More able farmers will then expand acreage and output by more, and experience larger increases in profits. However, if p does vary with a, there is a countervailing effect and the informal interest rate would be lower for more able farmers. If so, the program loan would cause a smaller reduction in their interest rates, and so generate a smaller increase in output and profits. It follows from a continuity argument that if p varies relatively little with a, then the countervailing effect is small and so TRAIL treatment effects increase in ability.

no cross-effects of help and monitoring on unit costs ($c_{hm} = 0$); this simplifies the analysis but is not critical. All relevant functions are smooth with well-behaved curvature, ensuring that the optimal allocations are interior. Both help and monitoring are time-consuming activities, imposing a constant per-unit pecuniary cost of γ_T on the TRAIL agent and γ_G on the GRAIL agent.

7.1.2. Control Farmers. A control farmer with ability level a enters into an informal contract with the trader that is denoted by the vector (r, h, m, s, α). The ability of the farmer is common knowledge, so the contract is not subject to any asymmetric information frictions. The trader provides the farmer credit at interest rate r, and chooses levels of help h and monitoring m. Traders have unlimited access to loanable funds at constant cost ρ. The farmer has zero liquid wealth, selects area cultivated a, and repays the loan only if his crop succeeds. In this event, he sells his output $\theta(a, m)f(l)$ to the trader, who resells it in the wholesale market at an exogenous price τ. The trader pays the farmer according to a two part tariff: $s + \alpha q$ where s is a fixed non-negative payment and $\alpha > 0$. Moreover, the farmer has an ex ante outside option payoff denoted by $\underline{U}(a) > 0$, while the trader has an outside option payoff of zero.

The farmer's expected payoff is given by

$$p(a, m)[\theta(a, m)\alpha f(l) - (1 + r)c(h, m)l] + s \tag{12}$$

while the trader's expected payoff is the sum of middleman and lending profit, less the costs of interacting with the farmer:

$$(\tau - \alpha)p(a, m)\theta(a, m)f(l) + [(1 + r)p(a, m) - (1 + \rho)]c(h, m)l - \gamma_T(m + h) - s \tag{13}$$

Their joint surplus therefore equals

$$S \equiv \tau A(a, m)f(l) - (1 + \rho)c(h, m)l - \gamma_T[m + h] \tag{14}$$

Let $(l^*(a), m^*(a), h^*(a))$ denote the value of (l, m, h) that maximizes joint surplus in (14). Let $S(a, \tau)$ denote the resulting maximum value of surplus.

To satisfy the participation constraints of the farmer and trader, there must exist a feasible contract that generates larger payoffs than the farmer's and trader's outside options. We ensure this by assuming that τ is large enough that $S(a, \tau) \geq \underline{U}(a)$ for all values of a.

A feasible contract must also satisfy the incentive constraint for the farmer. In other words, the choice of acreage l must maximize the farmer's payoff in (12) given h, m, r.

The following Lemma shows that the Coase Theorem applies: the outcome of contracting must maximize joint surplus, irrespective of how bargaining power is allocated between the farmer and trader. In particular, outcomes such as area cultivated, help, monitoring, production and profits do not depend on the extent of competition in the market for contracts.

Lemma 1.

(a) The outcome of contracting between a trader and farmer of ability is the surplus-maximizing allocation $(l^*(a), m^*(a), h^*(a))$*, irrespective of their relative bargaining power. This allocation can be achieved via contract* $(r^c(a), h^c(a) = h^*(a), m^c(a) = m^*(a), s^c(a), \alpha^c)$ *where* $m^*(a) = 0$*, or in other words, the trader does not monitor the farmer, and where the trader offers the farmer credit at the interest rate* $r^c(a)$ *such that*

$$1 + r^c(a) = \frac{\delta(a, \tau)}{p(a, 0)}(1 + \rho), \tag{15}$$

and pays him the price $\alpha^c = \delta(a, \tau)\tau$ *per unit of output purchased, where* $\delta(a, \tau)$ *is set equal to* $\frac{\underline{U}(a)}{S(a,\tau)+\gamma_T h^*(a)}$*. The side payment* $s^c(a)$ *depends on the allocation of bargaining power.*

(b) In this allocation, more able farmers receive more help, achieve lower unit costs, plant more area, produce more output and earn larger farm profits.

Part (a) states that the equilibrium allocation is first-best, or maximizes surplus. This result holds despite the presence of moral hazard, in that the farmer chooses the cultivation area in his own self-interest, as well as limited liability constraints. The argument is the following. $S(a, \tau)$ is clearly an upper bound for the joint surplus that can be achieved by a feasible contract. This upper bound can be achieved by a contract of the form described in Lemma 1. To see this, note first that for any given (h, m) and any given $\delta > 0$, if the interest rate r and output price α are set according to

$$(1 + r) = \frac{\delta}{p(a, m)}(1 + \rho); \alpha = \delta\tau \tag{16}$$

then the farmer's payoff (12) reduces to

$$\delta\tau A(a,m)f(l) - \delta(1+\rho)c(h,m)l + s = \delta S + \delta\gamma_T(m+h) + s \tag{17}$$

Then, given (h, m, s), the farmer will choose to plant area l to maximize joint surplus S. Intuitively, in a contract of this form, the farmer receives an output price equal to a (δ) proportion of the market price, and the interest rate is set so that the farmer bears the same (δ) proportion of the (default-risk-inclusive) interest cost. At the margin, the farmer receives a constant (δ) proportion of joint surplus, and thus internalizes the objective of maximizing this surplus. Therefore with h, m set at the levels that maximize joint surplus, the surplus maximizing allocation is incentive compatible: the farmer will select the surplus maximizing area $l^*(a)$.[33]

Part (a) also states that joint surplus maximization is incompatible with monitoring, since monitoring lowers expected productivity $A(a, m)$ and increases both the farmer's production costs and the trader's time costs.

Part (b) shows that more able farmers receive more help, which enables them to lower their unit costs, and in turn induces them to plant a larger area, produce more output, and earn greater farm profit. The proof is presented in the Appendix. Intuitively, since more able farmers plant a larger area *ceteris*

33. This argument holds for any positive δ. If δ is set equal to $\delta(a, \tau)$, and s is set equal to zero, then by construction the farmer's payoff exactly equals his outside option, and the trader receives all of the (positive) joint surplus. If the farmer has bargaining power, then the desired first-best payoff can be achieved by selecting a suitable (positive) side payment s that redistributes surplus to the farmer.

paribus, by helping them traders can decrease unit cultivation costs over a larger cultivation area, and so generate a larger increase in joint surplus.

7.1.3. TRAIL Treatment. Next, consider how the TRAIL scheme would affect this equilibrium. In TRAIL villages, a trader is selected as the agent for the scheme. He then recommends that a farmer of ability a receives a TRAIL loan at interest rate $r_T < \rho$. The farmer now has both the informal loan from the trader, and the TRAIL loan. We assume the farmer is already pre-committed to the acreage $l^*(a)$ he had decided to plant prior to the intervention. Therefore, once the TRAIL loan becomes available, the trader and farmer can decide to expand acreage by $l^t \geq 0$. The trader can also adjust his level of help and monitoring.

The farmer repays the TRAIL loan only if his crop succeeds. The TRAIL agent receives as commission $\psi < 1$ per rupee interest repaid. The trader-farmer pair then modify their contract decisions by choosing $(l^t, m^t, h^t) = (l^t(a), m^t(a), h^t(a))$ to maximize their joint surplus:

$$\tau A(a,m)f(l^c(a)+l^t) - [(1+\rho)l^c(a) + \{1+r_T(1-\psi)\}p(\theta,m)l^t]c(h^t,m^t) - \gamma_T(h^t+m^t) \tag{18}$$

Let the resulting outcomes for TRAIL treated farmer of type a be denoted $l^T(a) \equiv l^c(a) + l^t(a), m^T(a) = m^t(a), h^T(a) = h^t(a)$. We can show that:

PROPOSITION 1. *Conditional Treatment Effects of TRAIL Scheme*

. *(a) Compared to a control farmer of the same ability, a TRAIL treated farmer receives more help, incurs lower unit cost, plants more area,* *produces more output and earns greater farm profit. TRAIL treated farmers continue not to be monitored.*

. *(b) Order Preserving Property) More able TRAIL treated farmers receive more help, incur lower unit cost, plant more area, produce more output and earn greater farm profit.*

As explained previously, our assumption that p varies relatively little with a ensures that at a given level of help from the trader, the treatment effects of the TRAIL loan on acreage, output and profit increase in farmer ability. Participation in the loan program serves to accentuate the monotonicity of acreage and output with respect to ability, for any given level of help. This is reinforced further when the level of help is optimally adjusted, since treated farmers plant larger areas, which increases the marginal (joint surplus) return from increasing help. This explains result (a). Similar to the reasoning for control farmers above, result (b) follows from the complementarity between farmer ability and help among treated farmers.[34]

7.1.4. GRAIL Treatment. In the GRAIL scheme, the agent is a political appointee, not a trader. Therefore, to analyse the effect of the GRAIL intervention, we consider a game between three players: the GRAIL agent, the farmer and the trader whom the farmer contracts with for credit and

34. Thus this model predicts that TRAIL treatment effects preserve order, or in other words, the rank ordering of households by ability is maintained even after the TRAIL intervention. In Proposition 2(b) below we obtain a similar prediction for the GRAIL intervention. This also justifies our use of the order preserving assumption in Section 6.3.

sale of output. Recall also that the GRAIL agent is unable to help, but can monitor the agent. The GRAIL agent selects a level of monitoring which the farmer and trader take as given, and they then respond so as to maximize their joint surplus. As in the TRAIL scheme, the farmer is pre-committed to the acreage financed by his pre-existing contract with the trader. The trader-farmer coalition decides how much to expand the acreage, and the trader adjusts the extent to which he helps and monitors the farmer.

It remains to specify the objective of the GRAIL agent. We assume that as a political appointee, the GRAIL agent is motivated by a combination of redistributive ideology and political opportunism which favors poorer farmers.[35] Therefore his objective is to maximize expected payoff

$$v(a)p(a,m) - \gamma_G m \tag{19}$$

where γ_G denotes the cost of the agent's time spent monitoring the farmer, and $v(a)$ represents the GRAIL agent's welfare weight on a farmer of ability a, which is decreasing in a. This is weighted by the likelihood $p(a,m)$ that the

35. This assumes that the GRAIL agent's incentive to earn the commission is secondary to his political motivation. If instead the commission were more important, he would recommend higher ability farmers and would be disinclined to monitor, since monitoring reduces farmers' expected productivity and therefore cultivation area and amount borrowed, thereby reducing the agents' commissions. Assuming the redistributive motive is strong enough, incorporating these effects would not change the qualitative results.

farmer repays the GRAIL loan, since default would suggest farmer distress and reflect unfavorably on the GRAIL agent and his political party.[36]

We now study the impact of a GRAIL loan given to a farmer of ability level a. The GRAIL agent chooses the monitoring level $m^G(a)$ to maximize the expression in (19), so that the following first order condition is satisfied:

$$p_m(a, m^G(a)) = \frac{\gamma^G}{v(a)} \tag{20}$$

Since $p_{am} < 0$, the returns to monitoring are lower for more able agents, which implies (given $p_{mm} < 0$) that $m^G(a)$ is decreasing. Hence, unlike the TRAIL agent, the GRAIL agent spends more time interacting with less able farmers. Further, this lowers the default rates on GRAIL loans to below the rates for TRAIL loans, and the TRAIL–GRAIL difference in default rates is larger if the farmers are less able.

Turning next to the farmer's acreage decision, and the resulting output and farm profits, observe first that the trader continues to have no incentive to monitor the farmer. Hence, given $m^G(a)$, the revised contract between the farmer and trader will specify the supplementary area cultivated $l^g = l^g(a)$

36. This payoff function could also represent a microfinance loan officer's mission to lend to borrowers who are poor but able to repay. Loan officers generally play no role in the local agricultural supply chain, and so do not directly profit from borrowers' increased crop output. They are generally also unable to offer business advice. However they do monitor borrowers, such as through group meetings that MFIs often conduct even when the borrowers are individually liable for their loans.

and revised help level $h^g = h^g(a)$ that maximizes their joint payoff

$$\tau A(a, m^G(a)) f(l^c(a) + l^g) - [(1+\rho) l^c(a) + p(a,m)(1+r_T)] c(h^g, m^g) l^g - \gamma_T h \tag{21}$$

Let the resulting GRAIL treated outcomes be denoted $(l^G(a) \equiv l^c(a) + l^g(a), m^G(a), h^G(a))$. We can show that:

Proposition 2. *Conditional Treatment Effects of GRAIL Scheme*

. *(a) Compared to a control farmer or a TRAIL treated farmer of the same ability, a GRAIL treated farmer is monitored more, and is less likely to default on loans.*

. *(b) (Order Preserving Property) Among GRAIL treated farmers, the more able are monitored less, incur lower unit costs, plant more area, produce more output and earn larger farm profit.*

As more able farmers are monitored less, their unit costs continue to be lower, and they cultivate more area and produce more output.

However unlike the TRAIL scheme, it is unclear how control and treated farmers differ in terms of unit costs, acreage, output or profit. On the one hand, the monitoring by the GRAIL agent raises the treated farmer's costs. On the other hand, the trader may respond to the loan by helping the treated farmer more, which lowers costs. The net effect is unclear.

Finally we compare conditional treatment effects between TRAIL and GRAIL. Intuitively one would expect that since GRAIL treated farmers are monitored more, their final unit costs are higher than those of TRAIL treated farmers, and so their profits increase by less. We can verify this is the case when the production function $f(l)$ is isoelastic:

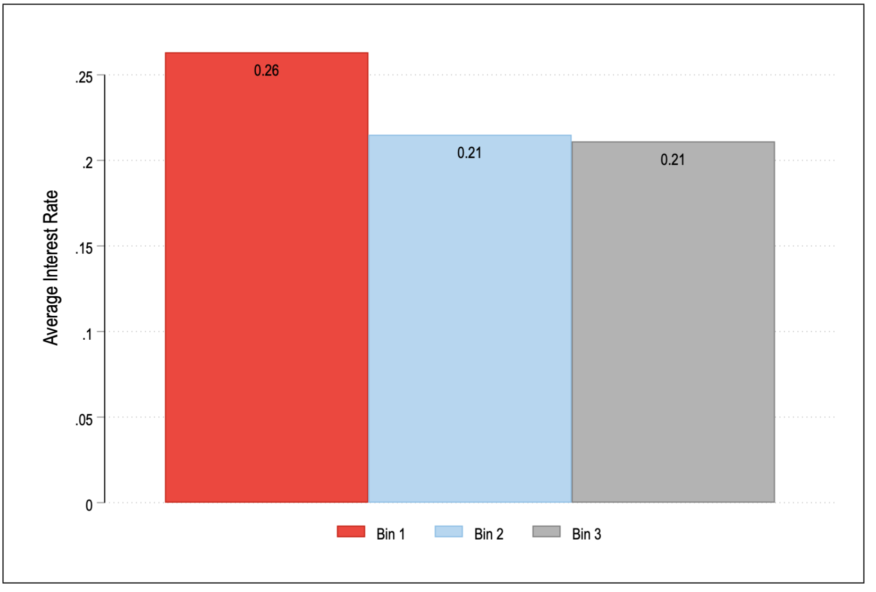
PROPOSITION 3. *Comparing Conditional Treatment Effects between TRAIL and GRAIL Schemes If the production function has constant elasticity, then GRAIL treated farmers cultivate smaller area, receive less help, lower unit costs by less, and increase expected profits by less than TRAIL treated farmers of the same ability.*

Thus, in this model, TRAIL borrowers experience larger treatment effects on cultivation area, output and profits than GRAIL borrowers, even if both sets of borrowers are equally able. This effect is the result of the different non-program objectives of the TRAIL and GRAIL agents. TRAIL agents want treated farmers to produce more, so that they can earn larger middleman profits. To this end, help treated farmers more, which reduces the farmers' unit costs, and in turn induces them to expand acreage and output by more. Also, they help the more able farmers more because help is more effective at raising their crop output than for the less able. On the other hand, the GRAIL agent monitors treated farmers in order to reduce default risk. This raises their unit cost and lowers their productivity, so that treated farmers in the GRAIL scheme produce less and earn smaller profits than those in the TRAIL scheme. These differences are larger if the farmers are less able.

7.2. Testing Predictions of the Model

The model generates a number of testable predictions. The first prediction is that control farmers of different ability levels would pay different informal

Figure 3. Interest Rate on Informal Loans and Estimated Ability among Control Households



Households are placed into three bins based on their ability estimated using equation (5) where cultivation scale is proxied by acreage under potatoes. Average interest rate refers to annual interest rates paid on informal loans, as captured through our household surveys. The sample is restricted to Control 1 and Control 2 households in TRAIL and GRAIL villages with at most 1.5 acres of land. We reject the null hypothesis that the average interest rates for households in Bin 1 and Bin 2 are equal (p-value = 0.06) and the null that the average interest rates in Bin 1 and Bin 3 are equal (p-value = 0.01).

interest rates. This prediction obtains from expression (15) if we assume that $\frac{\underline{U}(a)}{S(a,\tau)}$ is decreasing in a, or in other words, there are larger marginal returns to ability in farming than in the alternative occupation.

Prediction 1. The more able control farmers pay lower interest rates in the informal credit market.

To test this, we consider the average interest rate paid by Control 1 and Control 2 households in the TRAIL and GRAIL schemes. To avoid the concern that the intervention may have changed borrowers' interest rates, we restrict the estimation sample to only include informal loans taken before the

Table 14. Variation of Output and Input Cost per Acre by Estimated Ability. TRAIL and GRAIL Control Households

	Output (Kgs) (1)	Input Cost (per Acre) (2)
Estimated Ability	1,577.6***	–316.4
	[1467.4, 1688.4]	[–825.86, 253.7]
Estimated Ability Squared	594.1	-329.2
	[495.6, 680.6]	[–632.1, –60.0]
Sample Size	4,806	2,991
R^2	0.714	0.259

Coefficients are from ordinary least squares regressions on the ability estimate (from equation (5) with acreage under potatoes proxying for cultivation scale) and its square, for Control 1 and Control 2 households in TRAIL and GRAIL villages with at most 1.5 acres of land. Year dummies are included. Bootstrapped 90% confidence intervals (with 2000 iterations) are presented in square brackets. Control 1 households are assigned a weight of $\frac{20}{N-10}$ and Control 2 households are assigned a weight of $\frac{N-30}{N-10}$, were N is the total number of households in their village.

intervention began. As we show in Figure 3, on average, across both schemes, Control 1 households in ability Bin 1 reported borrowing at 26% interest per annum. This is significantly higher than the 21% that Bin 2 (p-value = 0.06) and Bin 3 households reported (p-value = 0.01).

Prediction 2. The more able control farmers incur lower unit costs and produce more output. This follows from Lemma 1.

Columns 1 and 2 of Table 14 present OLS regression results of potato ouput (in kg) and input cost per acre in potato cultivation (in Rupees) on the ability estimate and its square. The regressions include year dummies to control for annual variation in cultivation choices and outcomes. In column 1 we see that the coefficients on both the ability estimate and its square are positive and statistically significant, indicating that output increases in ability. In column 2 we see that unit costs decrease in the ability estimate.

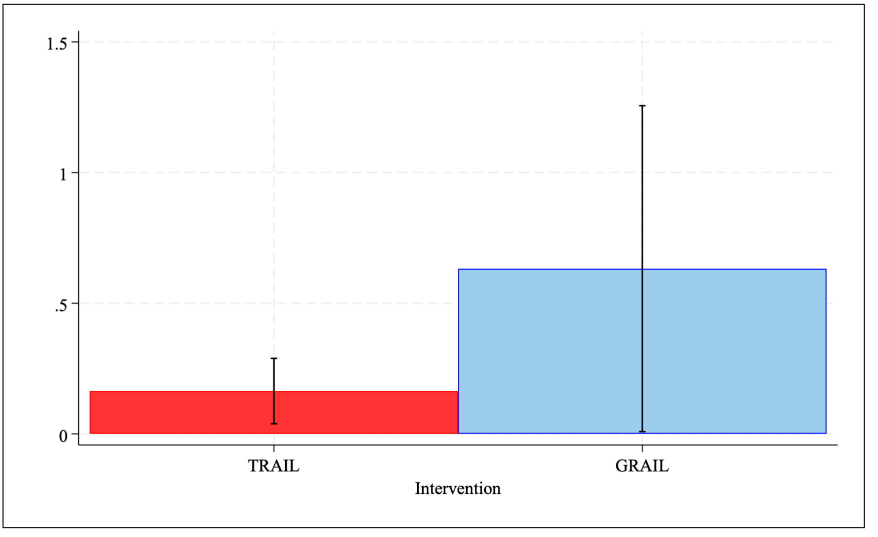
Prediction 3. TRAIL loans increase acreage, output and farm profit, and reduce unit costs of production for treatment farmers at all ability levels. This follows from part (a) of Proposition 1.

Table 12A verifies this prediction within each ability bin. Across columns, we see that the treatment effects of the TRAIL loans are statistically significant both for farmers with ability levels in Bin 2 and in Bin 3, although they are not significant for farmers in Bin 1. The magnitude of the treatment effects is also larger in Bin 3 than in Bin 2 or Bin 1. Together with the corresponding monotonicity properties for control farmers from Lemma 1, this confirms the predictions in part (b) of Proposition 1 that more able TRAIL treated farmers plant more area, produce more output, incur lower input costs per acre and earn more profit.

Prediction 4. Both TRAIL and GRAIL agents respond to the intervention by increasing their engagement with treated farmers. However, in the TRAIL scheme the increase is larger for more able farmers, whereas the opposite is true in the GRAIL scheme. This follows from Propositions 1 and 2.

Our survey data on the farmers' conversations with various individuals in the village community allow us to test this prediction. From each four-monthly survey interview, we have data on how many times the sample households spoke with the local trader or the agent about cultivation, harvest, or output sales, over the three days prior to the interview date. In Figure 4 we present the average treatment effects on the number of times the households had these conversations in the year. The treatment effects are positive and statistically

Figure 4. Average Treatment Effects on Farmers' Engagement with Agents



Average treatment effects and 90% confidence intervals are estimated using a regression following equation (2), where the dependent variable is the number of times households reported they had spoken to the agent about cropping, harvest and sales over the reference period, averaged over the three surveys conducted per year. The reference period was the three days prior to the survey date.

significant for both TRAIL and GRAIL schemes.[37] In column 6 of Table 12B we see that the treatment effects in the GRAIL scheme are always positive and statistically significant in Bins 1 and 3, and the point estimates decline as we move to higher ability bins. In contrast, in the TRAIL scheme the point estimates increase as we move to higher ability bins, although they are

37. It is worth noting that the GRAIL scheme had a larger average treatment effect on the number of conversations between agent and farmer than the TRAIL scheme had. This is consistent with traders (or TRAIL agents) having a higher opportunity cost of time than GRAIL agents. It may also indicate the traders' greater ability to help farmers lower costs, since TRAIL treated households' unit costs fall by more, despite fewer additional conversations with the agent.

statistically significant only for Bin 3 farmers, and not significant for Bins 1 and 2.

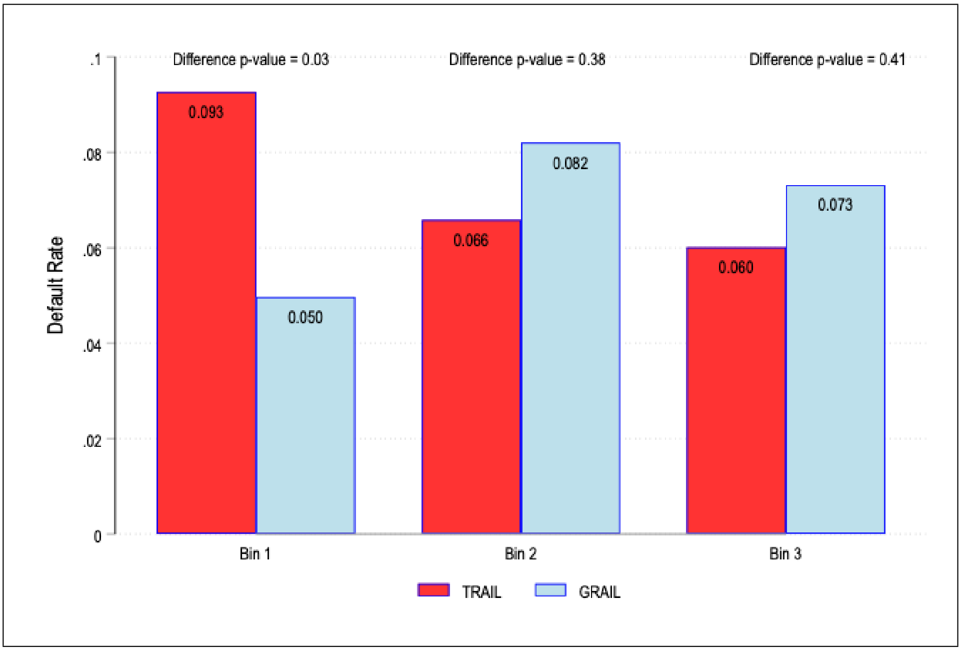
Prediction 5. GRAIL borrowers are less likely to default on program loans than TRAIL borrowers, and this difference is larger among the less able borrowers. This follows from Propositions 1 and 2.

As we see in Figure 5, the probability that a TRAIL Treatment household in ability Bin 1 defaulted on the TRAIL loan was 9.3 percent, significantly larger than the probability that a GRAIL Treatment household in Bin 1 defaulted (5 percent). The difference is statistically significant (p-value = 0.03). The differences are not statistically significant for farmers in the other two bins.

Prediction 6. The conditional treatment effects on acreage, unit cost, output and profit are larger in the TRAIL than the GRAIL scheme. This follows from Proposition 3.

Table 12A shows that holding ability bin constant, the conditional treatment effects of the TRAIL scheme on potato acreage, potato output and input cost per acre in potato cultivation (see columns 1, 2 and 8 respectively) are larger than those of the GRAIL scheme, and the input cost treatment difference is significant in Bin 3.

FIGURE 5. Default Rates on TRAIL and GRAIL Loans, by Estimated Ability Bin



The default rate refers to program loans that were not fully repaid by the due date. The sample is restricted to Treatment households in TRAIL and GRAIL villages with at most 1.5 acres of land. The p-value is for the null hypothesis that the TRAIL and GRAIL default rates are equal. Ability is estimated using equation (5) where cultivation scale is proxied by acreage under potatoes.

8. Concluding Comments

This paper finds evidence that a rural credit program that delegated borrower selection to private traders (TRAIL) significantly increased beneficiaries' production of the major cash crop and total farm income. When instead the local village council appointed the agent (GRAIL), agricultural output increased to a similar extent, but farm incomes did not. The discrepancy between the treatment effects on farmer profits was driven partly by different impacts on unit costs of cultivation.[38]

When we examine underlying mechanisms, we find that although both the TRAIL and the GRAIL agents selectively recommended farmers cultivating on a larger scale (either owing to differences in ability, wealth or credit access), there were differences in the extent to which they did this: borrowers recommended in the TRAIL scheme were cultivating on a larger scale than in the GRAIL scheme. However, a decomposition shows that this difference in selection patterns explains only a small fraction of the observed impacts on farm profits. The bulk of the difference in the impacts comes from the larger treatment effects in TRAIL, conditional on borrower cultivation scale. This can be explained by a model in which the program changed agents' incentives to monitor and advise farmers, but in different ways, depending on the agents' expertise and own professional motivations. Since TRAIL agents were middlemen in the agricultural supply chain, they had the knowledge to help treated farmers, and the incentive to respond to the TRAIL scheme by increasing the help he provided. This enabled TRAIL farmers to lower unit costs and raise farm profits. In contrast the GRAIL agent's redistributive or political motivations meant that he responded to the GRAIL scheme by

38. This paper does not discuss the impacts of the two schemes on the distribution of farm incomes. In a parallel paper (Maitra et al., 2022), we find that the TRAIL scheme increased Atkinson measures of household welfare by significantly more than the GRAIL scheme did, over a wide range of parameters of inequality aversion. Hence the outcomes of the TRAIL scheme appear to be superior to those of the GRAIL scheme, even after accounting for changes in the distribution of farm income.

monitoring treated farmers, which induced reduction in their default risks, but also preventing them to achieve lower unit cost and higher profits on average.

Overall, the paper demonstrates the scope for appointing private agents as intermediaries in the delivery of agricultural development programs, provided they are suitably selected and incentivised. This alignment of agent skill and motivation may be specific to the crop, region and nature of relationships have with farmers. Accordingly, it remains to be seen the extent to which our results extend to other contexts; we hope our paper will inspire future attempts to experiment with similar mechanisms elsewhere.

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Appendix A: Extended Selection Model with Multiple Attributes and Credit Rationing

In Section 6 we assumed that farmers vary only in a single attribute, that we refer to as productivity. In reality, however, farmers could also vary in business skill, which affects unit costs. By ignoring such other dimensions of farmer heterogeneity, our analysis could have underestimated the extent to which selection patterns contributed to the average treatment effects results. That model also cannot explain the negative treatment effect on unit costs in TRAIL. Further, we assumed that input markets functioned perfectly, thereby ruling out credit rationing and scale economies, which many scholars have highlighted as important explanations for poverty traps in developing countries (see, for example, Galor and Zeira, 1993; Banerjee and Newman, 1993; Banerjee et al., 2019; Balboni et al., 2022). If, for instance, the farmers selected by the TRAIL agent faced more acute credit constraints, or were capable of realizing greater scale economies than those selected by the GRAIL agent, then this could explain the larger reductions in their unit costs of production, and their larger increases in profits.

Here we consider an alternative model where farmers differ along three different dimensions: ability a_i, business skill represented by unit cost parameter c_i, and wealth w_i, which proxies for a farmer-level attribute that determines their credit limit. We also allow for technological and pecuniary returns to scale, represented respectively by elasticities μ, ζ of potato revenues and unit costs respectively with respect to scale of cultivation. The magnitude of μ is unrestricted, and ζ is allowed to be negative.

Specifically, the production function determining potato revenues R_{ivt} of farmer i in village v in year t is

$$\log R_{ivt} = \log a_i + \mu \log l_{ivt} + \delta_{vt} \tag{A.1}$$

where l_{ivt} denotes area cultivated and δ_{vt} denotes a village-year yield-cum-price shock. The unit cost function is

$$\log u_{ivt} = \log c_i + \zeta \log l_{ivt} + \log q_{vt} \tag{A.2}$$

where u_{ivt} denotes cost per acre and q_{vt} denotes a village-year cost shock. Hence an expansion in area cultivated will allow unit costs to fall in this model if ζ is negative. Moreover, the extent to which unit costs fall depends on the cost type c_i of the farmer. If farmers selected in TRAIL had a higher cost type c_i on average, a given rate of expansion in area will cause a larger absolute drop in unit costs for treated farmers in TRAIL. So this model could potentially explain a larger TRAIL treatment effect on unit cost reduction.

The farmer's total cultivation cost (C_{ivt}) is determined by his credit access according to the equation:

$$\log C_{ivt} = \log w_i + \log \gamma_{vt} \tag{A.3}$$

where w_i depends on the farmer's wealth, and γ_{vt} is a village-year shock to the supply of credit. As credit constraints are binding, total cultivation costs equal the credit limit:

$$\log C_{ivt} = u_{ivt} l_{ivt}. \tag{A.4}$$

Combining equations (A.3) and (A.4) we obtain

$$\log l_{ivt} = \log w_i - \log u_{ivt} + \log \gamma_{vt} \tag{A.5}$$

Equations (A.2) and (A.5) jointly determine area cultivated and unit costs (where we restrict $\zeta > -1$ in order to ensure the existence of a unique, stable solution):

$$\log l_{ivt} = \frac{1}{1+\zeta}[\log w_i - \log c_i - \log q_{vt} + \log \gamma_{vt}] \tag{A.6}$$

$$\log u_{ivt} = \frac{\zeta}{1+\zeta}[\log w_i + \log c_i + \log q_{vt}] + \frac{1}{1+\zeta}\log \gamma_{vt} \tag{A.7}$$

i.e., by the wealth and cost types of the farmer, in conjunction with village and year shocks in the supply of credit and input prices. Finally, given l_{ivt}, revenues are determined by the production function given by equation (A.1).

Let the proportional change of credit access $d\log C_{ivt}$ resulting from the treatment be denoted Δ. Then the proportional increase in area cultivated equals $d\log l_{ivt} = \frac{1}{1+\zeta}\Delta$, leading to a proportional increase in revenues $d\log R_{ivt} = \mu d\log l_{ivt} = \frac{\mu}{1+\zeta}\Delta$. Hence the increase in potato profit equals

$$d\Pi_{ivt} \equiv dR_{ivt} - dC_{ivt} = [\frac{\mu}{1+\zeta}R_{ivt} - C_{ivt}]\Delta \tag{A.8}$$

Relative to the growth in borrowing, revenues grow at a rate equal to $\frac{\mu}{1+\zeta}$, i.e, on technological and pecuniary scale economy elasticities. If scale economies exist, revenues, and hence profits, expand at a rate faster than costs.

Note that the rate of growth of revenues does not depend on farmer type. The *absolute* change in revenues and costs of course depends on type, since type affects baseline revenues and costs. However, it is apparent that this version of the model will also be unable to explain the larger profit treatment effects in TRAIL, since the baseline (i.e., Control 1 farmers') revenues and costs do not differ significantly between TRAIL and GRAIL (as seen in Table B.10). Given common scale economy elasticities μ, ζ applicable to both sets of selected farmers, as well as similar baseline revenues and costs, equation (A.8) shows that the predicted ATE on potato profits must also be similar.

Instead, it could be argued that farmers differ also in the extent to which they are capable of realizing technological and pecuniary scale economies.

Then μ and ζ could also be farmer-specific. Perhaps farmers selected into the TRAIL scheme had a higher average $\frac{\mu}{1+\zeta}$ resulting in a higher profit ATE despite a similar baseline revenue and cost. To allow for this possibility, we estimate the scale economy elasticities μ and ζ separately for selected TRAIL and GRAIL farmers. For either treatment arm, we restrict the sample to Treated and Control 1 farmers, and use a treatment dummy as an instrument for the area cultivated in regressions corresponding to equations (A.1) and (A.7) respectively to obtain an IV estimate of μ and ζ for selected TRAIL and GRAIL subjects.

These estimates of ζ and μ are presented in the first two rows of Table **??**. We estimate a significant pecuniary scale economy elasticity for TRAIL selected farmers, but not for GRAIL farmers. This reflects the significant difference in ATEs on unit cost we have already seen. On the other hand, we estimate a larger technical scale economy elasticity μ for GRAIL selected farmers (1.69 GRAIL vs. 1.30 TRAIL), and a higher rate of credit access expansion Δ among GRAIL treated farmers (28% GRAIL vs. 22% TRAIL). As a result, we predict a larger ATE on potato profits in the GRAIL scheme. This is true both in terms of absolute and percent changes. Moreover, the predicted ATEs of both schemes are substantially larger (nearly 70% increase for both) than our actual empirical estimates that we saw in Table 6B (40.3% TRAIL; 3.8% GRAIL) respectively. We conclude that this extended model cannot satisfactorily account for the observed patterns in the data.

Appendix B: Model of Agent-Farmer Interactions: Proofs

Proof of Lemma 1: The reasoning for part a) is already explained in the text. To prove (b), observe that given any h, the surplus-maximizing scale of cultivation $l(a;h,0)$ which maximizes

$$\tau A(a,0)f(l) - (1+\rho)c(h,0)l \tag{B.1}$$

is increasing in a and h, because A is increasing in a while c is decreasing in h. Denote the maximized value of the expression in (B.1) by $\Pi(a;h,0)$. Then help $h^*(a)$ maximizes

$$\Pi(a;h,0) - \gamma_T h \tag{B.2}$$

By the Envelope Theorem, Π is a supermodular function: the marginal return to help increases with the farmer's ability.[39] Hence $h^c(a)$ is increasing: higher ability farmers receive more help, and end up with lower unit cost. Surplus maximization then implies they select a higher scale of cultivation, attain greater output and farm profit. ■

Proof of Proposition 1: It is evident that the TRAIL agent continues to find it optimal not to monitor the farmer: $m^T(a) = 0$.

39. This is because Π_h equals $-\rho c_h(h,0)l(a;h,0)$ which is rising in a and h, where $l(a;h,0)$ denotes the surplus maximizing area for a farmer with ability a and receiving help h.

Next, we establish (b). Given help h, the treatment effect on cultivation scale $l^t(a,h)$ maximizes

$$\tau A(a,0)f(l^c(a)+l^t) - [(1+\rho)l^c(a) + p(a,0)\{1+r_T(1-\psi)\}l^t]c(h,m) \quad \text{(B.3)}$$

and therefore it also maximizes

$$\tau\theta(a,0)f(l^c(a)+l^t) - [\{1+r_T(1-\psi)\}l^t]c(h,m) \quad \text{(B.4)}$$

Using the same argument as used in Lemma 2 in Maitra et al. (2017), the cultivation treatment effect $l^t(.,h)$ is increasing in a. The Envelope Theorem implies that the help provided by the agent to the treated farmer $h^T(a)$ must satisfy the first order condition

$$[(1+\rho)l^c(a) + \{1+r_T(1-\psi)\}p(a,0)l^t(a,h^T(a))]c_h(h^T(a),0) + \gamma_T = 0. \quad \text{(B.5)}$$

The corresponding second order condition implies that $h^T(a)$ is increasing. Among treated farmers the more able will receive more help, and thereby attain lower unit costs, cultivate a larger scale, produce higher output and generate higher farm profit.

Finally, to establish (a), we compare agent interactions between treated and control farmers with the same ability a. Help $h^c(a)$ provided to a control farmer with the same ability satisfies the first order condition

$$[(1+\rho)l^c(a)]c_h(h^c(a),0) + \gamma_T = 0. \quad \text{(B.6)}$$

Comparing equations (B.5) and (B.6), it is evident that $h^T(a) \geq h^c(a)$, so treated farmers obtain more help. ■

Proof of Proposition 2: Part (a) has already been established in the text. So turn to (b). Consider a GRAIL treated agent of ability a who is monitored $m^G(a)$ by the agent. The joint surplus of this farmer and the trader he contracts with, is given by

$$\tau A(a, m^G(a) + m))f(l^c(a) + l^g) - [(1+\rho)l^c(a)$$

$$+\{1 + r_T\}p(a, m^G(a) + m)l^g]c(h, m^G(a) + m) - \gamma_T[h + m] \tag{B.7}$$

where l^g denotes the additional area that the GRAIL-treated farmer cultivates, and (h, m) continues to denote help and monitoring activities of the trader.

It is evident that joint surplus of the coalition is decreasing in m, so the trader has no incentive to monitor. Hence the contract involves a treatment effect l^g on area cultivated and help h which maximize

$$\tau A(\theta, m^G(a)))f(l^c(a)+l^g) - [(1+\rho)l^c(a) + \{1+r_T\}p(a, m^G(a))l^g]c(h, m^G(a)) - \gamma_T h \tag{B.8}$$

$l^g(a, h)$ must then maximize

$$\tau\theta(a, m^G(a)))f(l^c(a) + l^g) - [\{1 + r_T\}l^g]c(h, m^G(a)) \tag{B.9}$$

Since $m^G(.)$ is decreasing, it follows that $l^g(, , h)$ is increasing in a.

Now apply the Envelope Theorem to derive the first-order condition for optimal help $h^G(a)$:

$$[(1+\rho)l^c(a) + \{1 + r_T\}p(a, m^G(a))l^g(a, h^G(a))]c_h(h^G(a), m^G(a)) + \gamma_T = 0 \tag{B.10}$$

$c_{hm} = 0$ implies that $c_h(h^G(a), m^G(a)) = c_h(h^G(a), 0)$ and the associated second order conditions implies $h^G(.)$ is increasing.

The rest of (b) then follows, since higher ability GRAIL treated farmers have lower unit costs and higher productivity. ■

Proof of Proposition 3: Observe first that the treatment effect on area cultivated is higher in TRAIL, for any given a and h. This follows from comparing the respective maximization problems (equations (B.4) and (B.9)), and using $\theta(a, m^G(a)) \leq \theta(a, 0)$, $\{1+r_T\} > \{1+r_T(1-\psi)\}$ and $c(h, m^G(a)) \geq c(h, 0)$.

Next, compare the first order conditions in equation (B.5) and (B.10) for help provided by the trader to treated farmers in TRAIL and GRAIL. If

$$p(a, 0)\{1 + r_T(1-\psi)\}l^t(a, h^T(a)) > p(a, m^G(a))\{1 + r_T\}l^g(a, h^G(a)) \tag{B.11}$$

more help will be provided to TRAIL treated farmers, who will then end up with lower unit costs, higher output and profits than GRAIL treated farmers of the same ability.

We show that equation (B.11) holds if the production function has constant elasticity $f(l) = l^\beta$ where $\beta \in (0, 1)$. Since $A(a, m)$ is falling in m and $c(a, m)$

is rising in m, it follows that

$$\frac{A(a, m^G(a))}{c(a, m^G(a))} \leq \frac{A(a, 0)}{c(a, 0)} \tag{B.12}$$

This implies

$$\frac{p(a, m^G(a))}{p(a, 0)} \leq [\frac{\theta(a, 0)c(h, m^G(a))}{\theta(a, m^G(a))c(h, 0)}] \tag{B.13}$$

Since the right-hand-side of equation (B.13) is larger than one:

$$\frac{p(a, m^G(a))}{p(a, 0)} \leq [\frac{\theta(a, 0)c(h, m^G(a))}{\theta(a, m^G(a))c(h, 0)}]^{\frac{1}{1-\beta}} \tag{B.14}$$

From the respective first-order conditions for maximization of equations (B.4) and (B.9), and using $f(l) = l^{\beta}$, we have

$$\frac{\theta(a, 0)c(h, m^G(a))}{\theta(a, m^G(a))c(h, 0)} = [\frac{l^c(a) + l^t(a, 0)}{l^c(a) + l^g(a, m^G(a))}]^{1-\beta} \frac{1 + r_T(1 - \psi)}{1 + r_T} \tag{B.15}$$

The right-hand-side of this is smaller than

$$[\frac{l^c(a) + l^t(a, 0)}{l^c(a) + l^g(a, m^G(a))} \frac{1 + r_T(1 - \psi)}{1 + r_T}]^{1-\beta} \tag{B.16}$$

Therefore

$$[\frac{\theta(a, 0)c(h, m^G(a))}{\theta(a, m^G(a))c(h, 0)}]^{\frac{1}{1-\beta}} < \frac{l^c(a) + l^t(a, 0)}{l^c(a) + l^g(a, m^G(a))} \frac{1 + r_T(1 - \psi)}{1 + r_T} \tag{B.17}$$

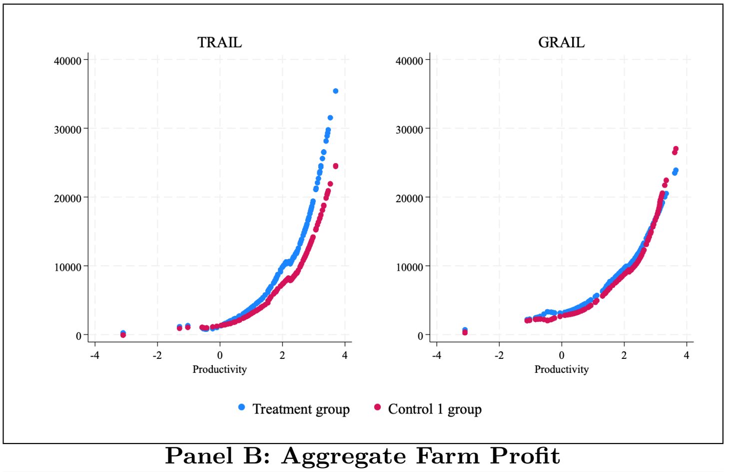
Combining this with equation (B.14) we obtain

$$1 < \frac{p(a, 0)\{1 + r_T(1 - \psi)\}(l^c(a) + l^t(a, 0))}{p(a, m^G(a))\{1 + r_T\}(l^c(a) + l^g(a, m^G(a)))} \tag{B.18}$$

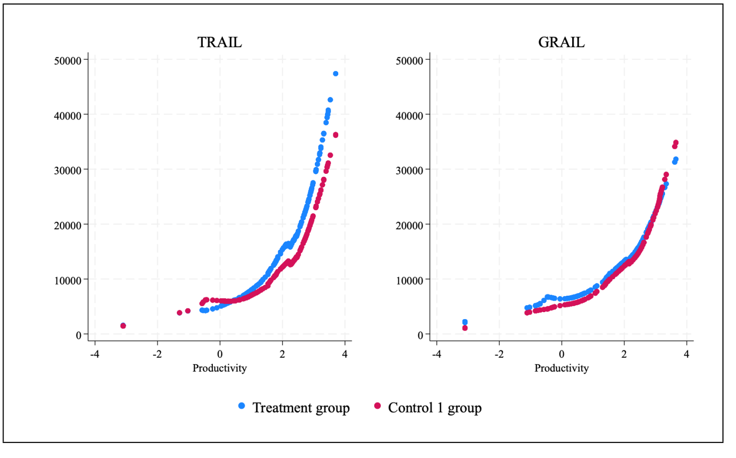
Since $l^g(a, m^G(a)) \leq l^t(a, 0)$ we have $\frac{l^c(a)+l^t(a,0)}{l^c(a)+l^g(a,m^G(a)))} \leq \frac{l^t(a,0)}{l^g(a,m^G(a)))}$. So equation (B.11) holds. ■

Figure B.1. **Variation in Potato Profit and Aggregate Farm Profit for Treatment and Control 1 groups by Estimated Ability**

Panel A: Potato Profit



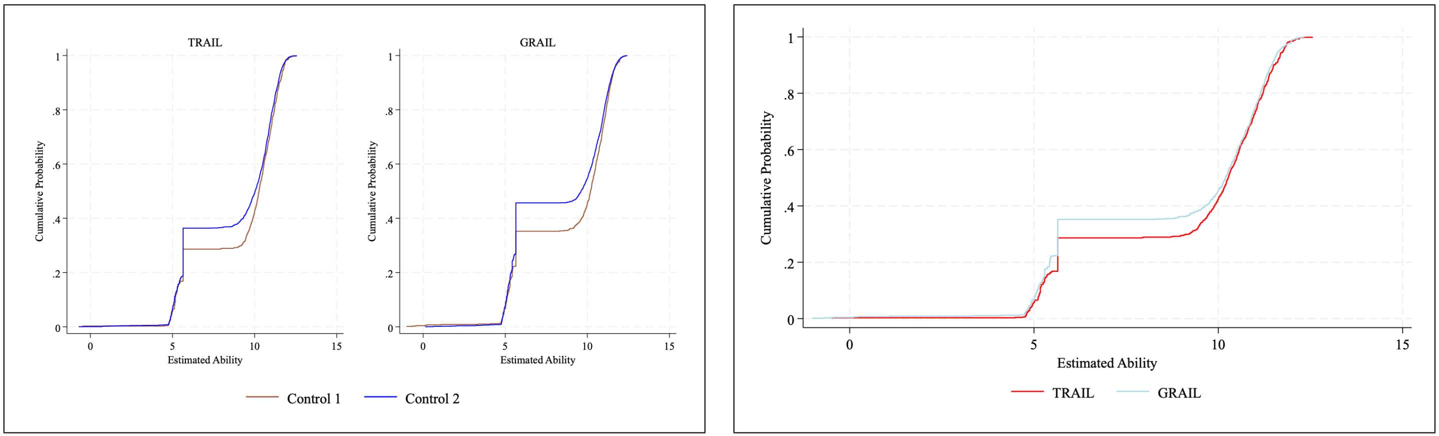
Panel B: Aggregate Farm Profit



Locally weighted smoothed scatterplots of potato profit and aggregate farm profit on the ability estimate are plotted for Treatment and Control 1 households in TRAIL and GRAIL villages.

Figure B.2. **Allowing Farmer Ability to Vary Over Time. TRAIL v. GRAIL.**

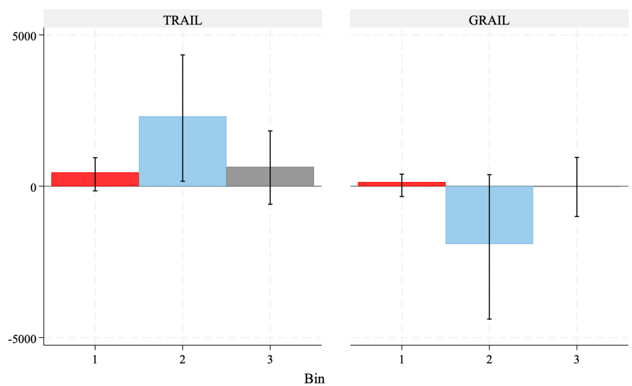
Panel A: Estimated Ability Distribution Selected v. Non-selected households — **Panel B: Estimated Ability Distribution Selected households: TRAIL vs GRAIL**



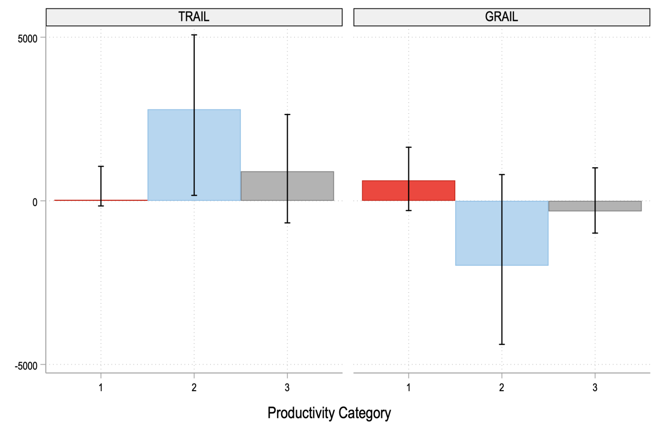
Ability is estimated using the Ackerberg et al. (2015) approach and the *acfest* command in STATA (see Manjón and Mañez, 2016), using the logarithm of acreage under potato cultivation as a proxy for cultivation scale. In Panel A, the sample is restricted to Control 1 and Control 2 households in TRAIL and GRAIL villages. The null hypothesis that the distributions of estimated ability for Control 1 and Control 2 households are equal is rejected by a two sample Kolmogorov-Smirnov (KS) test with p-value = 0.000 for both TRAIL and GRAIL. In Panel B, the sample is restricted to Control 1 households in TRAIL and GRAIL villages. The null hypothesis that the distributions of estimated ability for TRAIL Control 1 and GRAIL Control 1 households are equal is rejected by a two sample Kolmogorov-Smirnov (KS) test with p-value = 0.064.

Figure B.3. **Allowing Farmer Ability to Vary Over Time. HTEs by Ability category. TRAIL v. GRAIL.**

Panel A: Potato Profit



Panel B: Aggregate Farm Profit



Ability estimated using the Ackerberg et al. (2015) approach and the *acfest* command in STATA (see Manjón and Mañez, 2016). Bootstrapped 90% confidence intervals presented. Number of replications = 2000.

Table B.1. Credit Market Characteristics

	All Loans (1)		Agricultural Loans (2)	
Has outstanding loans	0.67		0.59	
Total Borrowing[†]	6352	(10421)	5054	(8776)
Proportion of Loans by Source[‡]				
Traders/Money Lenders	0.63		0.66	
Family and Friends	0.05		0.02	
Cooperatives	0.24		0.25	
Commercial Banks	0.05		0.05	
MFI and Other Sources	0.03		0.02	
Annualized Interest Rate by Source (percent)				
Traders/Money Lenders	24.93	(20.36)	25.19	(21.47)
Family and Friends	21.28	(14.12)	22.66	(16.50)
Cooperatives	15.51	(3.83)	15.70	(2.97)
Commercial Banks	11.33	(4.63)	11.87	(4.57)
MFI and Other Sources	37.26	(21.64)	34.38	(25.79)
Duration by Source (days)				
Traders/Money Lenders	125.08	(34.05)	122.80	(22.43)
Family and Friends	164.08	(97.40)	183.70	(104.25)
Cooperatives	323.34	(90.97)	327.25	(87.74)
Commercial Banks	271.86	(121.04)	324.67	(91.49)
MFI and Other Sources	238.03	(144.12)	272.80	(128.48)
Proportion of Loans Collateralized by Source				
Traders/Money Lenders	0.02		0.01	
Family and Friends	0.04		0.07	
Cooperatives	0.79		0.78	
Commercial Banks	0.81		0.83	
MFI and Other Sources	0.01		0.01	

Descriptive statistics about outstanding loans as of Cycle 1 are reported for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Program loans are not included. Interest rate statistics disregard loans where the reported principal equals the repayment amount. Treatment and Control 1 households are assigned a weight of $\frac{30}{N}$ and Control 2 households are assigned a weight of $\frac{N-30}{N}$, were N is the total number of households in their village. †: Total borrowing = 0 for households that do not borrow. ‡: refers to the value-weighted proportion of loans, computed for households that had outstanding loans in Cycle 1. Standard deviations are in parentheses.

TABLE B.2. Sample Size

Number of Villages (TRAIL/GRAIL intervention)	48
Number of Households in each village (Treatment + Control 1 + Control 2)	50
Total Number of Households	2400
Exclusions:	
Households with landholding > 1.5 acres	319
Households with no adult males	24
Households with missing religion data	7
Total Number of Excluded Households	350
Total Number of Households included in Sample	2050
Number of Years	3
Sample Size (primary regressions)	6150

Table B.3. Average Treatment Effects on Agricultural Borrowing. No Controls

	All Loans (1)	Non-Program Loans† (2)
TRAIL		
Treatment Effect ($\hat{\beta}_3 - \hat{\beta}_2$)	2761	-549.3
	(908.1)	(746.3)
	0.004	*0.465*
Mean Control 1	5226	5226
GRAIL		
Treatment Effect ($\hat{\beta}_5 - \hat{\beta}_4$)	3263	376.9
	(623.6)	(566.5)
	0.000	*0.509*
Mean Control 1	4422	4422
Difference TRAIL vs GRAIL (($\hat{\beta}_3 - \hat{\beta}_2$) — ($\hat{\beta}_5 - \hat{\beta}_4$))		
p-value	0.650	0.327
R^2	0.041	0.016
Sample Size	6,150	6,150

Treatment effects ($\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively) are estimated using equation (2) in the text. In column 1, the dependent variable is the total household borrowing, for agricultural use, from all sources. In column 2, the dependent variable is the total non-program agricultural borrowing (loans from sources other than the TRAIL or GRAIL schemes for agricultural use). Regressions run on household-year level data for all potato-sowing season survey cycles for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Regressions also control for a set of year dummies and an information village dummy. Standard errors in parentheses are clustered at the village level. p-values are in italics. Coefficient Estimates are available on request.

Table B.4. Average Treatment Effects for Potatoes: Quantities. No Controls

	Cultivation			Input Use (Quantity)								
	Acreage (Acres)	Output (Kg)	Yield (Kg/Acres)	Own labour (Hours)	Organic fertilizer (Kg)	Inorganic fertilizer (Kg)	Seeds (Kg)	Pesticides (Lit)	Plough/ bullock (Days)	Tiller (Hours)	Tractor (Hours	Water (Hours)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
TRAIL												
Treatment Effect	0.0921	943.2	-182.5	6.14	65.81	22.20	36.68	2.99	0.09	0.71	0.03	2.39
$(\hat{\beta}_3 - \hat{\beta}_2)$	(0.0373)	(390.2)	(147.2)	(3.21)	(117.93)	(19.55)	(16.40)	(2.72)	(0.12)	(0.42)	(0.14)	(1.44)
	0.017	*0.020*	*0.221*	*0.062*	*0.579*	*0.262*	*0.030*	*0.278*	*0.457*	*0.097*	*0.811*	*0.102*
Mean Control 1	0.336	3646	10883	39.87	395.95	248.37	212.05	1.44	0.33	2.79	0.65	17.09
GRAIL												
Treatment Effect	0.0952	1057	-21.36	13.59	120.44	29.46	6.05	-0.30	0.05	0.40	0.07	2.13
$(\hat{\beta}_5 - \hat{\beta}_4)$	(0.0334)	(368.3)	(117.3)	(3.58)	(73.48)	(21.56)	(16.63)	(0.57)	(0.09)	(0.22)	(0.11)	(1.26)
	0.007	*0.006*	*0.856*	*0.000*	*0.108*	*0.178*	*0.717*	*0.596*	*0.604*	*0.078*	*0.505*	*0.097*
Mean Control 1	0.296	3237	10856	37.87	352.27	224.25	207.15	1.86	0.32	2.46	0.52	16.51
Difference TRAIL vs GRAIL $((\hat{\beta}_3 - \hat{\beta}_2) - (\hat{\beta}_5 - \hat{\beta}_4))$:												
p-value	*0.952*	*0.832*	*0.398*	*0.127*	*0.696*	*0.804*	*0.196*	*0.239*	*0.755*	*0.514*	*0.833*	*0.891*
R^2	0.035	0.034	0.019	0.03	0.04	0.03	0.02	0.01	0.01	0.02	0.05	0.04
Sample Size	6,150	6,150	4,038	6,150	4,049	4,049	4,049	4,049	4,049	4,049	4,049	4,049

Treatment effects ($\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively) are estimated using equation (2) in the text. Regressions run on household-year level data for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Regressions also control a set of year dummies and an information village dummy. In Column 3, households that do not cultivate potatoes are dropped from the estimation sample. Standard errors in parentheses are clustered at the village level. p-values are in italics. Coefficient Estimates are available on request.

TABLE B.5. Average Treatment Effects for Potatoes: Monetary Values. No Controls

	Price (Rs) (1)	Revenue (Rs) (2)	Value Added (Rs) (3)	Imputed Profit (Rs) (4)	Paid Labour Cost (Rs) (5)	Household Labour Cost (Rs) (6)	Non-Labour Cost (Rs) (7)	Total Input Cost (Rs) (8)	Input Cost Per Acre (Rs) (9)
TRAIL									
Treatment Effect	-0.0249	3879	2027	1875	175.05	1524.33	1362.52	3061.90	-2957.75
$(\hat{\beta}_3 - \hat{\beta}_2)$	(0.0987)	(1624)	(758.5)	(734.5)	(124.88)	(877.25)	(767.94)	(1752.55)	(1012.87)
	0.802	*0.021*	*0.010*	*0.014*	*0.168*	*0.089*	*0.082*	*0.087*	*0.005*
Mean Control 1	4.627	14285	5732	4734	849.69	8144.71	7287.55	16281.95	49064.15
GRAIL									
Treatment Effect	-0.181	3754	1140	805	157.40	2585.78	2418.09	5161.27	712.25
$(\hat{\beta}_5 - \hat{\beta}_4)$	(0.143)	(1399)	(793.3)	(757)	(84.15)	(760.49)	(700.97)	(1520.92)	(1002.37)
	0.212	*0.010*	*0.157*	*0.293*	*0.068*	*0.001*	*0.001*	*0.001*	*0.481*
Mean Control 1	4.800	12965	5828	4942	802.94	6869.68	6060.17	13732.78	47452.61
Difference TRAIL vs. GRAIL $((\hat{\beta}_3 - \hat{\beta}_2) - (\hat{\beta}_5 - \hat{\beta}_4))$:									
p-value	*0.373*	*0.954*	*0.423*	*0.315*	*0.907*	*0.364*	*0.314*	*0.369*	*0.013*
R^2	0.239	0.031	0.053	0.056	0.01	0.05	0.05	0.04	0.28
Sample Size	3,818	6,150	6,150	6,150	6,150	6,150	6,150	6,150	4,038

Treatment effects ($\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively) are estimated using equation (2) in the text. The dependent variables in columns 1–5 take the actual value reported by the household if it cultivated potatoes in that year, and 0 otherwise. In column 9, households that did not cultivate potatoes in a year are dropped from the estimation sample. Imputed profit = Value Added – shadow cost of labour. Regressions run on household-year level data for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Regressions also control for a set of year dummies and an information village dummy. Standard errors in parentheses are clustered at the village level. p-values are in italics. Coefficient Estimates are available on request.

Table B.6. Average Treatment Effects on Farm Profit, Non Agricultural Income and Total Household Income. No Controls

	Aggregate Farm Profit (Rs) (1)	Non Agricultural Income (Rs) (2)	Total Household Income (Rs) (3)
TRAIL			
Treatment Effect ($\hat{\beta}_3 - \hat{\beta}_2$)	2339	1063	3402
	(934.5)	(3150)	(2796)
	0.0159	*0.737*	*0.230*
Mean Control 1	8564	33618	42182
GRAIL			
Treatment Effect	1237	-4110	-2873
	(966.8)	(2844)	(3336)
	0.207	*0.155*	*0.393*
Mean Control 1	7580	37171	44751
Difference TRAIL vs GRAIL (($\hat{\beta}_3 - \hat{\beta}_2$) — ($\hat{\beta}_5 - \hat{\beta}_4$))			
p-value	*0.417*	*0.228*	*0.155*
R^2	0.030	0.013	0.015
Sample Size	6,150	6,150	6,150

Treatment effects ($\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively) are estimated using equation (2) in the text. Regressions run on household-year level data for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Regressions also control for a set of year dummies and an information village dummy. Standard errors in parentheses are clustered at the village level. p-values are in italics. Coefficient Estimates are available on request.

	Acreage (Acres) (1)	Production (Kg) (2)	Cost of Production (Rs) (3)	Price (Rs) (4)	Revenue (Rs) (5)	Value-Added (Rs) (6)	Imputed Profit (Rs) (7)	Input Cost per acre (Rs) (8)	Yield (Kg/Acres) (9)
Panel A: Sesame									
TRAIL									
Treatment Effect	0.0420	8.255	33.28	-0.813	309.4	282.1	186.9	-673.5	-11.25
	(0.0214)	(5.155)	(85.87)	(0.697)	(164.2)	(136.6)	(113.8)	(199.2)	(12.69)
	0.0552	*0.116*	*0.700*	*0.249*	*0.0658*	*0.0445*	*0.107*	*0.00146*	*0.380*
Mean Control 1	0.266	57.29	829	31.35	1957	1520	1081	3596	206
GRAIL									
Treatment Effect	0.0223	1.166	66.08	-0.211	48.81	-8.674	-90.68	166.8	5.297
	(0.0183)	(4.542)	(67.77)	(0.230)	(147.2)	(134.4)	(118.3)	(244.7)	(12.09)
	0.231	*0.799*	*0.334*	*0.364*	*0.742*	*0.949*	*0.447*	*0.499*	*0.663*
Mean Control 1	0.224	50.73	667.7	30.41	1708	1365	1002	3327	209.3
Difference TRAIL vs GRAIL									
p-value	*0.491*	*0.316*	*0.768*	*0.443*	*0.253*	*0.144*	*0.106*	*0.0128*	*0.360*
R^2	0.244	0.163	0.154	0.491	0.184	0.164	0.136	0.054	0.024
Sample Size	6,150	6,150	6,150	2,343	6,150	6,150	6,150	3,062	3,062
Panel B: Paddy									
TRAIL									
Treatment Effect	0.0328	13.97	286.5	0.00699	480.5	277.1	139.2	-21.93	-10.52
	(0.0154)	(20)	(253.8)	(0.152)	(212.2)	(206.9)	(139.8)	(674.8)	(31.42)
	0.0383	*0.488*	*0.265*	*0.964*	*0.0282*	*0.187*	*0.324*	*0.974*	*0.739*
Mean Control 1	0.470	189.3	5602	10.07	5398	2557	93.13	13033	281.2
GRAIL									
Treatment Effect	0.0382	25.44	563.7	0.484	678.5	390.5	285.6	598.5	5.454
	(0.0323)	(62.57)	(773.5)	(0.451)	(540.7)	(316)	(288.3)	(457.1)	(38.03)
	0.243	*0.686*	*0.470*	*0.288*	*0.216*	*0.223*	*0.327*	*0.197*	*0.887*
Mean Control 1	0.561	311.8	7949	10.47	6985	3004	156.4	14169	342.9
Difference TRAIL vs GRAIL									
p-value	*0.881*	*0.863*	*0.738*	*0.314*	*0.737*	*0.766*	*0.650*	*0.452*	*0.747*
R^2	0.479	0.216	0.344	0.090	0.285	0.155	0.072	0.057	0.168
Sample Size	6,150	6,150	6,150	1,587	6,150	6,150	6,150	4,351	4,351
Panel C: Vegetables									
TRAIL									
Treatment Effect	0.0104	26.54	100.4	-1.521	128.7	48.52	-10.73	-9442	-108.9
	(0.00644)	(21.41)	(145.1)	(0.650)	(214.1)	(154.9)	(121.8)	(3796)	(1009)
	0.113	*0.221*	*0.492*	*0.0266*	*0.551*	*0.755*	*0.930*	*0.0189*	*0.915*
Mean Control 1	0.0147	128.7	589.9	11.48	1208	889.2	664.5	45477	7765
GRAIL									
Treatment Effect	0.00432	42.44	127	-0.386	215.2	176.5	94.81	-4825	1359
	(0.00356)	(21.81)	(98.98)	(0.858)	(162.2)	(132.2)	(113.9)	(3149)	(1232)
	0.231	*0.0577*	*0.206*	*0.656*	*0.191*	*0.188*	*0.409*	*0.136*	*0.279*
Mean Control 1	0.0175	94.60	642.6	11.92	1044	665.5	482.1	43634	6200
Difference TRAIL vs GRAIL									
p-value	*0.400*	*0.606*	*0.878*	*0.315*	*0.743*	*0.527*	*0.527*	*0.360*	*0.333*
R^2	0.025	0.035	0.027	0.170	0.036	0.036	0.031	0.110	0.193
Sample Size	6,150	6,150	6,150	498	6,150	6,150	6,150	516	516

Treatment effects ($\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively) are estimated using equation (2) in the text. In columns 1–3 and 5–7 the dependent variables take the actual value reported by the household if it cultivated the crop in that year, and take the value zero otherwise. In columns 8

Table B.8. Treatment Effects on Input Prices. Potato Cultivation

	Organic fertilizer (Kg) (1)	Inorganic fertilizer (Kg) (2)	Seeds (Kg) (3)	pesticides (Lit) (4)	Plough/ Bullock (Days) (5)	Tiller (Hours) (6)	Tractor (Hours) (7)	Water (Hours) (8)
TRAIL								
Treatment Effect	4.046	-0.567	-0.468	10.153	-10.983	-7.476	20.383	0.345
	(13.865)	(0.445)	(0.424)	(24.226)	(15.763)	(9.282)	(45.614)	(1.861)
	0.771	*0.203*	*0.270*	*0.675*	*0.488*	*0.421*	*0.655*	*0.853*
Mean Control 1	24.121	15.846	21.637	420.513	110.238	213.995	783.609	68.894
GRAIL								
Treatment Effect	-5.156	0.347	3.291	-27.731	9.994	-4.883	-61.910	-3.458
	(9.048)	(0.454)	(2.729)	(22.790)	(21.004)	(4.838)	(61.479)	(1.917)
	0.569	*0.445*	*0.228*	*0.224*	*0.635*	*0.313*	*0.315*	*0.072*
Mean Control 1	18.580	15.353	21.802	436.900	105.677	207.126	841.119	68.406
Difference: TRAIL vs GRAIL								
p-value	*0.571*	*0.155*	*0.177*	*0.252*	*0.404*	*0.796*	*0.271*	*0.157*
R^2	0.06	0.38	0.09	0.03	0.31	0.14	0.03	0.02
Sample Size	447	3,825	3,897	3,892	213	2,736	1,194	2,864

Treatment effects ($\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively) are estimated using equation (2) in the text. Regressions run on household-year level data for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Households that did not use the relevant input for potato cultivation in that year are dropped from the estimation sample. Regressions also control for the religion and caste of the household, age, educational attainment and occupation of the eldest male member of the household, household's landholding, a set of year dummies and an information village dummy. p-values are in italics. Coefficient Estimates are available on request.

TABLE B.9. Cost of Cultivation per acre. Potato Cultivation

	All Labour (1)	Organic fertilizer (2)	Inorganic fertilizer (3)	Seeds (4)	Pesticides (5)	Plough/Bullock (6)	Tiller (7)	Tractor (8)	Water (9)	Paid labour (10)	Household labour (11)	Non labour (12)
TRAIL Treatment effect	17.237	132.712	-962.364	-307.644	-77.267	-19.208	-45.654	-3.792	-150.532	-5.835	-1467.389	-1434.099
	(156.863)	(71.171)	(286.843)	(274.254)	(62.662)	(13.080)	(110.735)	(128.621)	(136.526)	(155.860)	(509.201)	(472.391)
	0.913	*0.063*	*0.001*	*0.263*	*0.218*	*0.143*	*0.680*	*0.976*	*0.271*	*0.970*	*0.004*	*0.003*
Mean Control 1 TRAIL	2021.395	277.989	8006.210	8748.014	1160.058	35.213	1459.454	704.357	2082.492	2050.457	24539.548	22474.141
GRAIL Treatment effect	-244.374	48.212	129.635	340.138	-67.648	-21.936	178.874	7.264	-58.960	-286.308	276.889	555.578
	(180.912)	(79.900)	(310.449)	(292.372)	(87.829)	(15.021)	(108.324)	(92.400)	(121.104)	(186.902)	(548.826)	(497.152)
	0.177	*0.547*	*0.676*	*0.245*	*0.442*	*0.145*	*0.099*	*0.937*	*0.627*	*0.126*	*0.614*	*0.264*
Mean Control 1 GRAIL	2333.828	363.434	7324.698	8573.095	1232.845	64.452	1338.324	583.019	1870.476	2381.701	23757.248	21350.342
Difference TRAIL vs GRAIL												
p-value	*0.278*	*0.431*	*0.011*	*0.108*	*0.928*	*0.890*	*0.145*	*0.945*	*0.619*	*0.253*	*0.021*	*0.004*
Sample Size	4,038	4,038	4,038	4,038	4,038	4,038	4,038	4,038	4,038	4,038	4,038	4,038
R^2	0.16	0.08	0.26	0.28	0.06	0.01	0.12	0.08	0.08	0.17	0.30	0.33

Treatment effects ($\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_5 - \hat{\beta}_4$ for TRAIL and GRAIL respectively) are estimated using equation (2) in the text. Regressions run on household-year level data for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Regressions also control for the religion and caste of the household, age, educational attainment and occupation of the eldest male member of the household, household's landholding, a set of year dummies and an information village dummy. Standard errors in parentheses are clustered at the village level. p-values are in italics. Coefficient Estimates are available on request.

Table B.10. Farm Outcomes of Control 1 farmers: TRAIL vs GRAIL

	Potato Cultivation								Loans		Aggregates		
	Acreage (Acres)	Production (Kgs)	Cost of Production (Rs)	Price (Rs)	Revenue (Rs)	Value added (Rs)	Imputed Profit (Rs)	Input Cost per Acre (Rs)	All (Rs)	Non Program (Rs)	Aggregate Profit (Rs)	Non-Agricultural Income (Rs)	H
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	
TRAIL ($\hat{\beta}_1$)	0.0377	402.2	1,384	-0.146	1,299	-84.87	-214.0	1,196	915.3	945.5	1,074	-4,246	
	(0.0487)	(559.2)	(1,265)	(0.127)	(2,241)	(1,099)	(996.4)	(1,708)	(979.9)	(976.2)	(1,182)	(3,696)	
	0.442	*0.476*	*0.280*	*0.254*	*0.565*	*0.939*	*0.831*	*0.487*	*0.355*	*0.338*	*0.368*	*0.256*	
Mean GRAIL	0.296	3237	7071	4.800	12965	5828	4942	47511	4330	4330	7580	37471	
R^2	0.251	0.244	0.202	0.221	0.247	0.224	0.220	0.319	0.139	0.140	0.268	0.062	
Sample Size	1,392	1,392	1,392	904	1,392	1,392	1,392	959	1,392	1,392	1,392	1,392	

The regression specification is given by the following equation $y_{ivt} = \beta_0 + \beta_1 \text{TRAIL}_v + \gamma \mathbf{X}_{ivt} + I(\text{Year}_t) + \varepsilon_{ivt}$. y_{ivt} denotes different measures of farm outcomes (cultivation, output, production costs, value added, borrowing, farm incomes etc) for farmer i in village v, year t. $\hat{\beta}_1$ is the predicted difference in the outcome variable between TRAIL and GRAIL Control 1 households. The estimating sample includes Control 1 (recommended but not selected) households with at most 1.5 acres of land in TRAIL and GRAIL villages. The estimation data are at the household-year level. Controls are also included for the religion and caste of the household, age, educational attainment and occupation of the oldest male member of the household, household's landholding, a set of year dummies and an information village dummy. Standard errors, in parentheses, are clustered at the village level and p-values are in italics.

Table B.11. Variation of Output and Input Cost per Acre by Landholding. TRAIL and GRAIL Control Households

	Control 1 and Control 2 Households		Control 1 Households Only	
	Output (Kgs)	Input Cost (per Acre)	Output (Kgs)	Input Cost (per Acre)
	(1)	(2)	(3)	(4)
Landholding	4,061.180	3,241.885	7,993.392	5,070.249
	[2452.67, 5612.56]	[-1925.84, 8361.18]	[5105.62, 12249.70]	[-1493.12, 11185.52]
Landholding Squared	655.375	-3,382.764	-3,354.359	-4,426.053
	[-718.62, 2078.55]	[-7175.06, 272.32]	[-7639.56, -808.39]	[-9122.03, 836.90]
Sample Size	4,806	2,991	1,392	959
R^2	0.222	0.254	0.217	0.363

Coefficients are from ordinary least squares regressions on the Landholding and its square, for Control 1 and Control 2 households (columns 1 and 2) and Control 1 households only (columns 3 and 4) in TRAIL and GRAIL villages with at most 1.5 acres of land. Year dummies are included. Bootstrapped 90% confidence intervals (with 2000 iterations) are presented in square brackets. Control 1 households are assigned a weight of $\frac{20}{N-10}$ and Control 2 households are assigned a weight of $\frac{N-30}{N-10}$, were N is the total number of households in their village.

Table B.12. Allowing Farmer Ability to Vary Over Time. Decomposition of ATE Differences in Imputed Profit from Potato Cultivation and Aggregate Farm Profit. TRAIL v. GRAIL

Bin (k)	σ_k^T (1)	σ_k^G (2)	$\sigma_k^T - \sigma_k^G$ (3)	TRAIL HTE's (T_k^T) (4)	GRAIL HTE's (T_k^G) (5)	TRAIL – GRAIL HTE's ($T_k^T - T_k^G$) (6)	$(\sigma_k^T - \sigma_k^G) \times T_k^T$ (7)	$\sigma_k^G \times (T_k^T - T_k^G)$ (8)
Panel A: Potato Profit								
1	0.32	0.38	-0.06	457.74	138.36	319.38	-27.42	121.11
2	0.34	0.29	0.05	2309.71	-1909.54	4219.24	107.63	1230.33
3	0.34	0.33	0.01	643.16	-14.41	657.57	8.62	216.41
ATE				1906	191.4	1714.6		
% of Difference in ATE due to Selection								5.18
% of Difference in ATE due to CTE								91.44
Panel B: Aggregate Farm Profit								
1	0.32	0.38	-0.06	32.02	580.29	-548.28	-1.92	-207.91
2	0.34	0.29	0.05	2797.10	-1982.36	4779.46	130.34	1393.69
3	0.34	0.33	0.01	985.85	-346.44	1332.29	13.21	438.46
ATE				2406	290.3	2115.7		
% of Difference in ATE due to Selection								6.69
% of Difference in ATE due to CTE								76.77

Ability estimated using the Ackerberg et al. (2015) approach and the *acfest* command in STATA (see Manjón and Mañez, 2016). σ_k^T denotes the proportion of TRAIL households in Bin k; σ_k^G denotes the proportion of GRAIL households in Bin k. The difference in ATEs due to selection is computed as $\sum_{k=1}^{3} \frac{((\sigma_k^T - \sigma_k^G) \times T_k^T}{(\text{ATE})^T - (\text{ATE})^G}$, while the difference in ATEs due to conditional treatment effects is computed as $\sum_{k=1}^{3} \frac{\sigma_k^G \times (T_k^T - T_k^G)}{(\text{ATE})^T - (\text{ATE})^G}$. ATE^T and ATE^G denote the average treatment effects of the TRAIL and GRAIL schemes respectively.