Decentralized Targeting of Agricultural Credit Programs: Private versus Political Intermediaries *

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Abstract

We report on a field experiment in rural West Bengal, India comparing two approaches to delegating beneficiary selection for an agricultural credit program. A local agent recommended borrowers for individual liability loans, and was incentivized by repayment-linked commissions. In the TRAIL treatment arm, the agent was a randomly chosen trader, whereas in the GRAIL treatment arm, he was appointed by the elected village council. Beneficiaries in the TRAIL scheme took up loans more, repaid at similar rates, and earned larger increases in farm incomes than in the GRAIL scheme. Borrowers recommended by the TRAIL agents were more productive than borrowers recommended by the GRAIL agents. However we find that the bulk of the observed difference in average treatment effects occurs because TRAIL borrowers outperformed GRAIL borrowers of equal productivity. We explain this through a theoretical model where TRAIL agents are incentivized by middleman margins to help lower borrowers' unit costs of cultivation, whereas GRAIL agents are motivated by political objectives to monitor poorer borrowers and lower their default rates. The data support the predictions of this model.

Key Words: Targeting, Intermediation, Decentralization, Community Driven Development, Agricultural Credit, Networks.

JEL Codes: H42, I38, O13, O16, O17

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1 Introduction

Public programs in developing countries are increasingly being implemented at the local level. Communities are monitoring teachers and health professionals, and budgets for local public goods are being devolved to local governments. The aim of such devolution is to leverage the local community's superior information about potential beneficiaries, and its greater ability to monitor service providers. However a large literature now questions whether these programs have succeeded (see, for example World Development Report 2004; Mansuri and Rao 2013). There is also growing evidence that local governments' target their vote bank, rather than those who stand to benefit the most (Stokes 2005; Robinson and Verdier 2013; Bardhan et al. 2015; Bardhan and Mookherjee 2016; Devarajan and Khemani 2016; Dey and Sen 2016).

In this paper we present evidence on a new alternative. Our context is an agricultural credit program in West Bengal, India. Beneficiaries are smallholder farmers who are individually liable for their loans, and thus a standard credit scheme would be subject to the well-known problems of information asymmetry. In our program, beneficiary selection is delegated to a local intermediary, or "agent". In one treatment, the Trader Agent Intermediated Lending (TRAIL) treatment, the agent is a local private trader, with a track record of lending to and selling and buying from farmers in the village. In the other, Gram Panchayat Agent Intermediated Lending (GRAIL) treatment, the elected village council was asked to appoint the agent. Agents recommend farmers for the scheme, who are then offered a subsidized loan designed to finance the cultivation of the local cash crop, potatoes. The agent earns a commission that is linked to the repayment behavior of the borrowers they recommended.

Given their different backgrounds we expect the TRAIL and GRAIL agents to be informed about and motivated to influence different aspects of the borrowers' behavior. First, given his economic role, the TRAIL agent is likely to observe the loan repayments, crop production and sales of individual farmers. In contrast the GRAIL agent may be better informed about borrowers' social and political connections. Second, the two agents would likely differ in their motivations. In our context private traders usually buy crops from farmers and resell them to wholesale buyers for a profit.[1] This suggests the TRAIL agent might wish to direct credit towards, and provide useful business advice to their most important farmer-clients. The GRAIL agent is unlikely to have such trade-related motivations; instead he might select beneficiaries in line with the priorities of the incumbent political party. Given the predominant redistributive ideology and intense political competition between the two competing political parties in West Bengal during this period, it is plausible that both parties would target poor and ideologically "swing" voters. In addition, not being a business person, the GRAIL agent may not be able to offer business advice on par with the TRAIL agent.

Our experiment involved 48 villages in two potato-growing districts. Starting in October 2010 we implemented both schemes over nine 4-month loan cycles, thus the experiment ended in August 2013. A microfinance institution based in the state capital Kolkata implemented the credit program. Our survey teams conducted detailed farm surveys with a sample of 50 households in each village three times a year.[2]

The formal role of the agent was to recommend 30 village residents who owned less than 1.5 acres of cultivable land, as potential borrowers for the subsidized crop loans. Agents stood to earn commissions set at 75% of the interest paid by the loan recipients, and if the borrower defaulted, they stood to forfeit the deposits they had posted at the beginning of the scheme. Borrowers were individually liable to repay the loans. In both schemes, loans were offered at the same below-market interest rate, were offered in the planting season for important crops and were repayable in a single lumpsum at the end of four months. In the first cycle the loan size was Rs.2000 (or US $30), but it increased by 33% in each subsequent lending cycle. This created dynamic repayment incentives.

[1] The potato value chain in this region is characterized by large middlemen margins: Mitra et al. (2018) estimate that in 2008 farmgate prices were 45% of wholesale prices, with middlemen earning at least 50—70% of this gap.

[2] In a different set of 24 randomly chosen villages in the same districts, we implemented a group-based lending (GBL) approach, where borrowers self-selected into joint liability groups. Our previous research (Maitra et al. 2017) compares TRAIL with GBL. In the current paper we focus on a comparison of the TRAIL and GRAIL schemes.

Only 10 randomly chosen individuals from the 30 recommended were offered the loan. This creates two control groups in our sample. Control 1 households are those that were recommended by the agent but were not randomly chosen to receive the loan treatment. Control 2 households are village residents who were not recommended. This design allows us to estimate loan treatment effects in the two schemes conditional on selection by comparing Treatment and Control 1 subjects, and to examine selection patterns by comparing the Control 1 and Control 2 groups.

We find that TRAIL loans had higher take-up rates, and were repaid at the same high rate (93%) as GRAIL loans. In both interventions, Treatment households had borrowed more and cultivated greater areas under potatoes than Control 1 households. In both schemes there was a similar 25% increase in potato output. However, TRAIL Treatment farmers lowered their per-acre production costs and consequently increased potato profit by 40%. GRAIL Treatment farmers' profits increased by a statistically insignificant 4%. Aggregate farm income increased by 21% for TRAIL Treatment farmers, compared to 1.4% for GRAIL Treatment farmers.

The rest of the paper seeks to explore the underlying reasons for these differences. We start by building on a model of one-dimensional heterogeneity across farmers, to estimate the respective contributions of selection and incentives to the average treatment effects.[3] We assume a Cobb-Douglas form for the farm production function and develop a procedure to estimate the total factor productivity (TFP) of control subjects from farmer fixed-effects in a panel regression of area cultivated or potato output, after controlling for village and year dummies. We can then assess and compare how recommended (selected) farmers' productivity levels differ in the two schemes. We find that TRAIL agents selected more productive farmers: the distribution of productivity among recommended farmers in the TRAIL scheme first-order stochastically dominates the corresponding distribution in the GRAIL scheme. In particular, the GRAIL agent was more likely than the TRAIL agent to select low productivity borrowers who did not cultivate potatoes frequently

[3] This extends the model in (Maitra et al. 2017).

However, when we decompose the difference in average treatment effects, we find that less than 10% can be explained by differences in borrower productivity. Instead, approximately 75% is due to differences in treatment effects conditional on productivity (conditional treatment effects, or CTEs). In other words, borrowers of the same productivity level achieved very different outcomes in the two interventions. Within a given productivity class, the average TRAIL and GRAIL Treatment household had similar increases in area cultivated and potato output. However, the TRAIL Treatment household realized higher crop prices and lower unit costs, thereby earning substantially larger increases in profits. Under the maintained assumption of one-dimensional heterogeneity, the only difference between a TRAIL and GRAIL borrower with the same productivity is the nature of the agent involved. This leads us to hypothesize that the two agents engaged differentially with the Treatment households, and this drove the differences in outcomes.

Accordingly, we develop a theoretical model of agent-borrower interactions in the two schemes. We hypothesize that the respective agents were motivated differently to alter the nature and scale of their interactions with treated farmers, with consequent effects on risk and unit costs. Private traders are primarily motivated by the large middleman margins they earn on potatoes purchased from farmers, so are motivated to help them with business advice that lowers unit costs, thereby motivating farmers to grow and sell more potatoes. Most GRAIL agents do not have a trading relationship with farmers. Instead, their political objectives and the scheme commissions motivate them to lower default rates, especially for the poorer farmers. Hence GRAIL agents may monitor, rather than help borrowers and may pressurize them to apply more pesticides or use more water to reduce the risks of crop failure in the (low probability) event of pest attacks or droughts. This raises production costs. The model generates detailed predictions about the variation in default rates, CTEs on production, incomes, and frequency of interactions with the agent and the local trader, across farmer productivity types. These predictions match the patterns in the data. In particular, GRAIL agents interact more frequently with lower-productivity Treatment households, who in turn have lower default rates than TRAIL Treatment households in the same productivity class. In contrast, the TRAIL agent, interacts more frequently with higher-productivity Treatment households, whose units costs decrease by more, and farm incomes increase by more than for GRAIL Treatment households.

We leave open the possibility of alternative explanations based on other dimensions of heterogeneity such as wealth differences generating differences in credit constraints. It is possible that some part of the superior performance of the TRAIL scheme could also be due to the TRAIL agents' superior selection on these other dimensions. This is left as a question for future research.

Our paper contributes to the recent literature on the use of community knowledge to target development interventions. Several recent papers find that it is cost-effective to leverage information within the community, particular that of central individuals in the network, to select beneficiaries, diffuse information and increase program take-up (Bandiera and Rasul 2006; Alatas et al. 2012, 2016; Fisman et al. 2017; Hussam et al. 2018; Berg et al. 2018; Beaman and Magruder 2012; Debnath and Jain 2018; Beaman et al. 2018; Banerjee et al. 2013; Chandrasekhar et al. 2018). However others have argued that groups of influential community members may capture programs instead (Vera-Cossio 2018; Deserranno et al. 2018; Mansuri and Rao 2013). Our research focuses on particular members of local networks: either private traders who are important nodes in the economic network, or political intermediaries involved in voter mobilization and distribution of government benefits. These specific individuals might play very different roles in village society and economy, and we develop specific hypotheses about their motivations with respect to the credit intervention that is the focus of our paper. We thus move one step further than the literature in identifying the different roles that different networks play, and highlighting the particular network that might be most useful for agricultural credit targeting.

Not much is known either about the precise role of program intermediaries.[4] Is their role

[4] For example, Beaman and Magruder (2012) argue that members of social networks can be incentivized to help select and refer high ability workers to jobs. On the other hand, Heath (2018) finds evidence that firms mitigate shirking by workers referred by employees that interact with them socially, relying on these interactions

primarily to select recipients, or do they subsequently engage with them, and how do their incentives to do so differ? We provide evidence on interactions between the beneficiary and program intermediary; moreover we quantify its role vis-a-vis selection in explaining observed outcomes. The patterns of our agents' conversations and engagement with beneficiaries suggest they may have helped them with or monitored their production choices. The data suggest that this contribution can explain a large part of the observed increase in farm incomes.[5]

The paper is organized as follows. In Section 2 we describe the two loan intervention schemes that we will analyse in this paper. Section 3 describes our data and Section 4 presents the estimates of the average treatment effects of the two schemes on borrower outcomes; in Section 5 we present statistics on the financial performance of the schemes: take-up and repayment rates. Next, we attempt to explain our empirical findings. We start in Section 6 by estimating the farm productivity of borrowers, examining how the distribution of borrower productivity differed across the two schemes, and then decomposing the difference in average treatment effects into the part that can be explained by these selection differences, and the part that is due to differences in treatment effects, conditional on productivity. Since we find that this latter part is substantial, in Section 7 we develop the aforementioned model of agent incentives and engagement. The predictions of this model are validated in Section 8. Section 9 concludes.

to help weaken the effect of limited liability constraints.

[5]In our previous research (Maitra et al. 2017), we compared TRAIL with traditional group-based micro-lending (GBL) whose average treatment effects on borrower farm incomes turned out to be statistically indistinguishable from zero. That paper focused only on selection differences and found they accounted for at least 30-40% of the difference in average treatment effects. This paper differs as we compare TRAIL with GRAIL, and find that selection differences are less important in explaining this; accordingly we focus instead on the role of interactions between agent and farmers. In another related paper (Maitra et al. 2019) we compare distributive effects of TRAIL, GRAIL and GBL, by assessing their impacts on an Atkinson (Atkinson 1970) welfare function corresponding to different parameters of inequality aversion. It finds that the average treatment effects of TRAIL on welfare were significantly positive and higher than the corresponding average treatment effects of GRAIL and GBL, irrespective of the parameter of inequality aversion.

2 Empirical Context and Intervention Design

Our interventions were conducted across 48 randomly-chosen villages in the Hugli and West Medinipur districts of the Indian state of West Bengal.[6] These districts are among the largest producers of potatoes in West Bengal and India. Potatoes are a high-reward but relatively costly crop to plant. During the years of our study, our data suggest that potatoes had significantly larger working capital requirements than the other major crops grown in this region. However they generated about three times as much value-added per acre as paddy, sesame or vegetables (see Maitra et al. 2017, Table 2). Our interventions were therefore designed to facilitate the cultivation of potatoes.

In both treatment arms, each village was assigned a single agent, who was tasked with recommending borrowers for the loan scheme. In the TRAIL treatment arm, the agent was a randomly selected trader based in the local community. The structure of the potato markets in this region led us to believe that traders would have considerable information about the farmers in their clientele. Unlike other settings where farmers might transport their harvests and sell to traders located at the market, in West Bengal traders visit farmers in their fields and homes to purchase their potatoes. They may also visit them during the planting season and sell inputs or provide them information on credit availability and loan repayment. They thus have ample opportunity to engage with village farmers, and other village residents. We drew up a list of local traders who had at least 50 clients in the village or had been operating for longer than 3 years, and then randomly drew one name and offered the agent contract to him.[7]

In the GRAIL treatment arm the agent was selected by the village council (or *Gram Panchayat*, hence forth GP). Gram panchayats are village councils of between 8 and 15 members, formed through direct elections once every five years. In the West Bengal village councils, candidates

[6]This is a subset of the random sample of villages where Mitra et al. (2018) conducted a potato price information intervention experiment in 2007–08.

[7]If this person had refused to participate, we would have offered the position to a second randomly chosen trader from the list. In practice the first trader approached always accepted the contract.

tend to be affiliated with the state-level political parties. From 1977 to 2011, the Communist Party of India (Marxist) led a left-wing coalition government in West Bengal state, and held the majority of the village councils seats. This long dominance ended when the Trinamool Congress captured the majority of state assembly seats in the 2011 state elections. The subsequent village council elections in 2013 mirrored this pattern, so that most village councils now have a Trinamool Congress majority. West Bengal has a long history of cadre-based mass mobilization of voters through political rallies and campaigns. In addition, since many government schemes are implemented locally by village councils, political party workers in village councils are often involved in identifying beneficiaries for these programs and delivering benefits to them.[8] Thus it was reasonable to expect that the village council could appoint a political affiliate with extensive local information as a GRAIL agent. We approached the village council and asked them to suggest the name of a potential GRAIL agent who had lived in the village for at least 3 years, was personally familiar with farmers in the village and had a good local reputation. We then offered this individual the GRAIL agent contract.

In each intervention arm, the agent was required to recommend 30 potential borrowers, from among the village residents who owned less than 1.5 acres of land. This landholding restriction helped to ensure that the scheme benefited poor farmers. Ten of these 30 recommended individuals were randomly chosen in a lottery that we conducted in the office of the local government.[9] Individuals who were selected in the lottery were then approached and offered the loans.

The first loan cycle began with loan disbursals in October-November 2010, to coincide with the planting season for potatoes. Borrowers were individually liable for the repayment of their loans. The scheme featured "progressive lending" to generate dynamic repayment incentives. In cycle 1 the loan size was capped at Rs.2000 (equivalent to US $30), repayable as a single

[8] There is considerable evidence that local governments in West Bengal direct benefits towards swing voters (Bardhan et al. 2015; Dey and Sen 2016).

[9] The pool of recommended borrower names was kept confidential so as to avoid any spillover effects on informal credit access or other relationships for households that had been recommended but did not end up being chosen to receive the loan.

lumpsum at the end of four months at 6 percent interest. The loan size in the next cycle was 133% of the principal amount repaid. Borrowers who repaid less than 50% of principal, in any cycle, were terminated. To avoid creating pressure for borrowers to sell their harvest prematurely in order to repay the loan, we also accepted repayment in the form of potato "bonds". In this case the repaid amount was calculated at the prevailing price of potato bonds.[10] Although the stated purpose of the loans was agricultural, we did not ask households for any evidence of their agricultural investment. However our household surveys asked detailed questions about farm cultivation, input use, harvest and crop sales.

The 48 villages in our sample were randomly assigned to two treatment arms. We implemented the TRAIL scheme in all the 24 villages in one treatment arm, and the GRAIL scheme in all the 24 villages in the other. Our sample villages were at least 8 kilometres apart from each other; this helped to avoid information and other spillovers across the treatment arms. Each village belonged to the jurisdiction of a different village council (also known as the *gram panchayat* or GP). Panel A of Table 1 shows that there are no significant differences in village size, number of potato cultivators in the village or the number of potato cultivators in the different landholding categories across the two treatment groups. Our partner MFI had not operated in any of these villages before. There was very little MFI penetration in this area in 2010. The MFI was limited to conducting loan transactions with the Treatment households. They did not select borrowers or monitor them subsequently. The loans were funded through an external grant held by the principal investigators of this project.

Agents had both monetary and non-monetary incentives to participate in the scheme. At the end of each loan cycle, they stood to earn a commission equal to 75% of the interest paid by all borrowers whom they had recommended. This high commission rate was meant to incentivize the agent to select productive borrowers who would repay the loan and benefit from it, and to discourage collusion between the agent and potential applicants. In addition, the agent put down a deposit of Rs.50 per borrower, which was returned to him if his borrower survived

[10] Farmers can store their harvested crop in cold storages for a maximum of 11 months. Potato "bonds" are receipts from the cold store facility that are often traded between farmers and traders.

in the program for two years. If more than one-half of the borrowers that this agent had recommended defaulted on their loans, the agent was expelled from the scheme and earned no further commissions. At the end of two years, the deposit was returned to all surviving agents. These agents also received a paid holiday to a seaside resort. In conversations during our field visits, some TRAIL agents remarked that they expected the scheme to increase their prominence in the village, or to boost their business. GRAIL agents may also have viewed the scheme as an extension of government anti-poverty programs, or as a means to increase the popularity of their political party.

3 Data and Selected Descriptive Statistics

We conducted surveys with 50 households per village. These households were selected as follows. In each village, all 10 households assigned to receive the loan (Treatment households) were included in the sample. Of the 20 households that the agent recommended but did not receive the loan, we included in our sample a random subset of 10 households (Control 1). We also included 30 households randomly chosen from the pool of the non-recommended. We refer to these as Control 2 households.

In Panel B of Table 1 we present summary statistics of selected household-level characteristics for this sample. These household characteristics do not jointly explain assignment to treatment ($p - value = 0.996$).

The first round of surveys was conducted in December 2010, two months after the Cycle 1 loans were disbursed. Surveys were repeated every four months. This high frequency of data collection helped minimize measurement error. In each sample household, the same person answered the survey in each round. There was no attrition in the sample over the eight survey cycles.

Table 2 compares the characteristics of the TRAIL and GRAIL agents. Over 95% of the TRAIL agents were business persons and reported owning a shop or business. GRAIL agents either worked in farming or had a salaried government job. TRAIL agents were also more wealthy and had higher incomes, but were less likely to have studied beyond primary school. On the other hand GRAIL agents were more involved in civil society and politics; 30% were members of a village organization, 17% were political party workers, and 13% had been members of the local government. None of the TRAIL agents were directly involved in politics in this way.

Table 3 shows that the different agent characteristics also correlate with different types of engagement with village residents. First, both types of agents were well-known by village residents and appeared in public quite often. Even among the households that they did not recommend (Control 2), more than 90% said they knew the agent, and 98% of this group said they met him at least once a week. Closer social ties with the agent were less common: about 45% of Control 2 households in TRAIL villages, and 61% of Control 2 households in GRAIL villages belonged to the same caste or religious category as the agent, and a smaller fraction reported being invited over by the agent on special occasions.

Important distinctions can be seen in the economic links between sample households and the agents. Nearly a fifth of Control 2 households and a quarter of Recommended households in TRAIL villages reported that the agent was an important source of credit or inputs, or an important buyer of their output. The GRAIL agent was significantly less likely to fill these roles.[11] The differences across agent types are significant. In survey cycle 1, we also asked households whether they had engaged in product, credit or labour market transactions with the agent in the previous three years. A third or more of TRAIL households had bought from the agent, and a tenth to a quarter had borrowed or worked for the agent. Once again, households in GRAIL villages were less likely to have engaged with their agent in this way. This underscores our hypothesis that the TRAIL and GRAIL agents might have had different information about and different motivations to engage with village residents.

[11] We note however that both types of agents had about a ten percent chance of being an important employer for the sample households.

In Table 4 we summarize the characteristics of the loans that sample households already held at the time that our intervention began, to describe the prevailing credit market in these villages. Two-thirds of the households reported that they had an outstanding loan; the majority of these were used for agricultural purposes. Of the agricultural loans, nearly two-thirds had been taken from traders or moneylenders for a mean duration was 4 months and an average annual interest rate of 25%. Credit cooperatives accounted for nearly one quarter of the loans, but loans from commercial banks and from microfinance institutions were rare. The average annual interest rate on loans from traders and moneylenders was 25 percent. Cooperatives and commercial banks charged much lower interest rates, but as the last panel shows, more than three-quarters of these loans were collateralized. This suggests that smallholder households may have been unable to access these loans.

4 Average Treatment Effects of the Schemes

We start the empirical analysis by examining the impacts of the two loan schemes on borrower outcomes. Recall that only a random subset of the recommended household were offered the loans. Therefore, the difference in the outcomes of households that were recommended as well as offered the loan (Treatment households) and those that were recommended but were not offered the loan (Control 1) is an estimate of the treatment effect of the loan, conditional on the household being selected into the scheme. Our regression specification therefore takes the following form:

$$\begin{aligned} y_{hvt} = \beta_0 &+ \beta_1 \text{TRAIL}_v + \beta_2(\text{TRAIL}_v \times \text{Control } 1_{hv}) + \beta_3(\text{TRAIL}_v \times \text{Treatment}_{hv}) \\ &+ \beta_4 \text{GRAIL}_v + \beta_5(\text{GRAIL}_v \times \text{Control } 1_{hv}) + \beta_6(\text{GRAIL}_v \times \text{Treatment}_{hv}) \\ &+ \gamma \mathbf{X}_{hvt} + I(\text{Year}_t) + \varepsilon_{hvt} \end{aligned} \tag{1}$$

Here y_{hvt} denotes the outcome variable of interest for household h in village v at time t. The omitted category is the Control 2 households in GBL villages. The average treatment effects of the TRAIL and GRAIL schemes are estimated by $\hat{\beta}_3 - \hat{\beta}_2$ and $\hat{\beta}_6 - \hat{\beta}_5$ respectively.[12] The coefficient $\hat{\beta}_2$ is the difference in outcomes of Control 1 and Control 2 borrowers in TRAIL villages, so represents the TRAIL selection effect; analogously, $\hat{\beta}_5$ measures the GRAIL selection effect. The set $\mathbf{X}_{hvt}$ contains measures of the household's landholding, religion and caste, and the age, education and occupation of the oldest male in the household. $I(\text{Year}_t)$ denotes two year dummies to control for secular changes over time.[13] Standard errors are clustered at the hamlet level.[14]

4.1 Treatment Effects on Agricultural Borrowing

Table 5 presents the treatment effects on agricultural borrowing. Column 1 shows that the TRAIL scheme increased the total agricultural borrowing of selected households by Rs.7517 (or 134%) over the three-year study period, significant at the 1% level. The GRAIL scheme caused a similar increase of Rs.7341. In column 2 the point estimates on non-program agricultural borrowing are small and statistically insignificant, suggesting that the TRAIL and GRAIL loans did not crowd out agricultural loans from other sources. We conjecture that farmers are reluctant to disrupt their traditional informal credit relationships within the village for the sake of a new intervention.

[12] All treatment effects are intent-to-treat estimates because they compare the outcomes of households *assigned* to the Treatment and Control 1 groups, regardless of whether the Treatment households actually took the loan.

[13] In columns 1–2 of Table A2, Panel A of Table A3 and columns 1–3 of Table A4 we present results of running (1) but without including the set of controls $\mathbf{X_{hvt}}$. The key effects are less precise but are qualitatively similar.

[14] In our study the administrative definition of a village corresponds to a collection of hamlets or *paras*. Households within the same hamlet tend to be more homogenous, are more likely to interact with each other, and arguably experience correlated shocks to cultivation and market prices. The results are robust to clustering at the village-level instead. See columns 3–4 of Table A2, Panel B of Table A3 and columns 4–6 of Table A4.

4.2 Treatment Effects on Potato Cultivation and Farm Incomes

Table 6 presents the average treatment effects on potato cultivation.[15] The TRAIL loans led to large and statistically significant increases in potato cultivation. The effect is concentrated on the intensive: although the TRAIL scheme did not increase the likelihood that recommended households cultivated potatoes (column 1), it increased potato acreage by 0.09 acres (or 27%, column 2), increased potato output by 950 kg (or 26%, column 3) and the implied potato sales revenue by Rs.3900 (or 27%, column 5).[16] The cost of production increased by Rs.1846 (or 22%, column 4), so that on net, value-added increaesd by Rs.2060 (or 36%, column 6). When we subtract the imputed cost of family labor employed in potato farming, this works out to a statistically significant Rs.1907 or 40% increase in profit (column 7).[17]

The GRAIL scheme also appears to have increased potato cultivation. Control 1 households recommended to participate in the GRAIL scheme were less likely than TRAIL households to plant potatoes (64% versus 72%), but the GRAIL scheme increased this probability by 13 percentage points (or 20%, p¡0.01, column 1). Average acreage (column 2) and output (column 3) also increased significantly. Although the point estimates for the GRAIL scheme are smaller than for the TRAIL scheme, the difference between the TRAIL and GRAIL treatment effects is not statistically significant. Revenue increased by 19% (column 5), but the cost of production increased by a larger 28% (column 4). The result is that unlike the TRAIL scheme, the GRAIL scheme had a non-significant effect on value-added and imputed profit.[18] The difference in the

[15] We aggregate the data from the four-monthly surveys into a household-year level dataset including the amount of land planted with potatoes, potato output, sales, revenues, production costs, value-added and imputed profits. This allows us to align the costs of cultivation with the revenues, since harvested potatoes can be stored and sold at different points in the year.

[16] We have data about the quantity and price of each individual potato sales transaction. For amounts that farmers held for self-consumption, we impute the sales revenue by pricing the potatoes at the median sale price in the village.

[17] To calculate the shadow cost of family labour, we price the reported family labor time (male, female and child labor separately) spent on the crop at the median wage reported for hired labor of that type in that village in that year for that crop.

[18] Since we analyse a large number of dependent variables, we correct for the increased chance of finding statistically significant results. Following Hochberg (1988), we report a conservative p-value for an index of variables in a family of outcomes taken together (see Kling et al. 2007). The variables are normalized by subtracting the mean in the control group and dividing by the standard deviation in the control group; the index is the simple average of the normalized variables. To adjust the p-value of the treatment effect for an

TRAIL and GRAIL treatment effects on imputed profits (column 7) is statistically significant at 10%. In sum therefore, both schemes led borrowers to increase potato cultivation, but only TRAIL borrowers did this profitably. This appears to be partly because GRAIL borrowers faced substantially larger increases in production costs, and a greater decline in potato price realized.

Table 7 presents ATEs on aggregate farm and non-farm incomes of the household. In column 1, farm value-added is computed as the sum of value-added for all four major crops grown by our sample farmers: potatoes, paddy, sesame and vegetables.[19] The TRAIL scheme resulted in a statistically significant 21% increase in average farm value-added, compared to a non-significant 1.3% increase in GRAIL. Non-agricultural income in column 2 is calculated as the sum of rental, sales, labour and business income. We are unable to obtain precise estimates of ATEs on non-agricultural income, possibly due to higher measurement error for these income sources. Nevertheless, column 2 indicates that neither loan scheme increased non-agricultural incomes significantly. Column 3 shows that aggregate income increased by 11.3% in the TRAIL scheme, and decreased by 10% in the GRAIL scheme; this difference is significant at the 10% level.

5 Loan Performance

In Table 8 we examine the loan take-up and repayment rates. Column 1 presents results on the likelihood that a household eligible to take the loan in any given cycle actually took the loan. After cycle 1, in each subsequent loan cycle, eligibility of a Treatment household depended on past repayment. A borrower needed to repay at least 50% of the amount due to become eligible to receive a new program loan. The sample means in Panel A show that eligible TRAIL Treatment households accepted the program loan 94% of the time, whereas eligible GRAIL

index, the p-values for all indices are ranked in increasing order, and then each original p-value is multiplied by $m-k+1$, where m is the number of indices and k is the rank of the original p-value. If the resulting value is greater than 1, we assign an adjusted p-value of > 0.999.

[19] The separate results for each of the other three major crops are available on request.

Treatment households took it 87% of the time (column 1). The difference of 6.5% points is statistically significant at the 1% level. These results holds even in Panel B when we control for household characteristics according to the following regression[20]:

$$y_{hvt} = \alpha_0 + \alpha_1 \text{GRAIL}_v + \gamma \mathbf{X}_t + \varepsilon_{hvt} \tag{2}$$

As column 1 shows, the difference in loan acceptance rates is statistically significant even after we control for cycle fixed effects and other household characteristics (landholding, religion, caste, age and educational attainment of the oldest male member of the household) through $\mathbf{X}_t$ to account for seasonal variation.

We define a loan to be in default if the amount due was not fully repaid by the due date. The average default rate over the three-year intervention period is an identically low 7% in both schemes (Panel A, column 2). The regression result in Panel B of Table 8 confirms that there is no difference in default rates in the two schemes. Despite the fact that the scheme did not increase their incomes significantly, GRAIL Treatment households repaid their loans at the same high rates as TRAIL Treatment households.

6 Explanations

The differential effects of the TRAIL and GRAIL schemes could be caused by two factors: TRAIL and GRAIL agents may have recommended households with different characteristics (the selection effect); in addition selected households of the same type may have behaved differently in the two schemes (the conditional treatment effects). In this section, we decompose the difference in average treatment effects on potato value-added into the relative contributions of these two effects.

[20] Since the data are organized at the household-cycle level, we also include cycle dummies to control for changes over time.

This exercise requires us to represent and estimate a measure of the underlying heterogeneity among farmers. Throughout this paper we assume that farmers vary in a single dimension, their ability. More able farmers produce greater output given the same inputs, and incur lower costs of production per acre cultivated. We rule out other sources of heterogeneity. For example, farmers are not credit-rationed in the informal market, and all farmers within any village face the same cost of borrowing. The program loans provide them an extra line of credit at a rate below the prevailing market interest rate, and induce them to expand borrowing and scale of cultivation.

6.1 Estimation of Control Households' Ability

Consider farmer i in village v in year t.[21] The production function takes the Cobb-Douglas form and can be written as follows:

$$Y_{ivt} = P_{vt} A_i \frac{1}{1-\alpha} l_{ivt}^{1-\alpha} \tag{3}$$

where P_{vt} denotes a village-level yield or price shock, A_i is the farmer's total factor productivity and an increasing function of farmer ability θ_i, l_{ivt} is the farmer's chosen scale of cultivation, and the parameter $\alpha \in (0, 1)$. Farmer ability θ_i follows a common, given, distribution in both GRAIL and TRAIL villages. As stated above, the cost of production per unit area c_i is decreasing in farmer ability.[22]

The farmer who does not receive a program loan (henceforth, the control farmer) borrows from informal lenders at the interest rate ρ_{vt}. We assume that traders and lenders observe the ability of each farmer.[23] To cultivate potatoes, the farmer must incur a fixed cost $F > 0$.

[21] Unlike the model in Section 7, the current model assumes that farmer productivity and costs are correlated with a measure of exogenous ability. Thus it abstracts from agent engagement through endogenous help and monitoring, which in turn affect farmer productivity and costs. This is the same model as in our previous paper (Maitra et al. 2017) and is a special case of the more general model.

[22] In this section, we take A_i and c_i as given for each farmer; in Section 7 we allow the trader and agent to endogenously determine the extent to which they help and monitor the farmers, and these in turn affect the values of A_i and c_i.

[23] One specific version of this model involves Bertrand competition among lenders, all of whom have cost of

Then, the control farmer chooses $l = l^c_{ivt}$ to maximize

$$P_{vt}A_i\frac{l^{1-\alpha}}{1-\alpha} - \rho_{vt}c_i l - F$$

For control farmers with a sufficiently high ability, this yields

$$\log l^c_{ivt} = \frac{1}{\alpha}\log\frac{A_i}{c_i} + \frac{1}{\alpha}[P_{vt} - \rho_{vt}] \tag{4}$$

A similar expression obtains for the logarithm of output produced.

Observe that $\log \frac{A_i}{c_i}$ is increasing in ability. This serves as a suitable exogenous measure of productivity. It follows from equation (4) that this productivity measure can be estimated 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.Observe also that there is no credit rationing or mis-allocation in the informal credit market: marginal revenue products are equalized across farmers of different productivity.[24]

Equation (4) applies only to farmers with ability above the threshold $\underline{\theta}_{vt}$. These farmers end up earning profits that cover the fixed cost F. Farmers of lower ability would choose not to cultivate potatoes. Roughly 30 percent of Control 1 and Control 2 group farmers in our sample planted potatoes in at most one of the three years in our study period, and hence we cannot estimate household fixed effects for them. We call these households non-cultivators, and assign to them the lower endpoint of the estimated productivity distribution among the cultivators. This is an upper bound to their true latent productivity. None of the comparisons below are affected if we replace this upper bound with any lower estimate. Recall, from above, that productivity (A_i) is an increasing function of ability (θ_i). In all our empirical analysis, we will use our estimate of productivity as a proxy for the underlying, unobserved ability.

capital ρ'_{vt} in village v in year t. Alternatively, we can assume that lenders charge a mark-up over the cost of capital. If the probability that a farmer defaults on his loan depends on his ability, then the default risk is incorporated into this mark-up. In the general model to be presented later, we will allow for interlinked credit-cum-marketing contracts between farmers and traders, and will find similar results.

[24]However the diminishing returns to scale ensure that average products differ across farmers.

In Table 9 we regress our household productivity estimate obtained from the household fixed effects regression, on household characteristics. The sample is restricted to cultivator Control 1 and Control 2 households with at most 1.5 acres of land in TRAIL and GRAIL villages. The results indicate the extent to which formal lenders, government bodies or NGOs could assess farmer productivity from household characteristics that could be measured through surveys. We find significant correlations with socio-economic characteristics: households with greater landholding and male-headed households had higher farm productivity. However the low R-squared statistic suggests that observable characteristics can only explain 16% of the variation in household productivity. This justifies the working hypothesis in our study that these community-based agents had other local information about farmers that an outsider would be unable to observe.[25]

6.2 Differences in Selection

We can now examine whether the TRAIL and GRAIL agents systematically recommended households of different productivity levels. We focus only on Control 1 households, since they were recommended by the agent but did not receive any program loans. This helps avoid the concern that productivity estimate may be influenced by the receipt of the loan.

In Figure 1, we compare the distributions of the productivity estimates for Control 1 and Control 2 households. We pool non-cultivators at the bottom end at their estimated upper bound. This corresponds to the flat segment in each of the plotted cumulative distribution functions at the bottom end. The left panel shows the distributions in TRAIL villages. The CDF for Control 1 households first-order stochastically dominates the CDF for Control 2 households. A two-sample Kolmogorov-Smirnov test rejects the null hypothesis that the two distributions

[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. Table A1 presents the differences in demographic characteristics between the cultivators and non-cultivators. Cultivators own more land, are more likely to be upper caste Hindus, have larger households, are more likely to be male-headed, and the oldest male in the household is likely to be older and is more likely to have completed primary school.

are identical ($p - value = 0.005$).[26] This indicates that TRAIL Control 1 farmers had higher productivity estimates than TRAIL Control 2 farmers did, subject to the qualification that the estimates for non-cultivators cannot be compared.

The right panel also suggests that GRAIL Control 1 farmers were more productive than GRAIL Control 2 farmers. The two-sample Kolmogorov-Smirnov test rejects the hypothesis of equality of distributions ($p - value = 0.011$).[27] Thus it appears that both TRAIL and GRAIL agents selected borrowers positively, and recommended the more productive households within their villages.

Next we examine how the productivity of recommended households compares across the two schemes. Table 10 presents descriptive statistics on household productivity for TRAIL and GRAIL Control 1 households. Seventy-three percent of TRAIL Control 1 households were cultivators, whereas only 66% of GRAIL Control 1 households were. Among the cultivators, TRAIL households had higher mean and maximum productivity estimates; the 25^{th}, 50^{th} and 75^{th} percentiles or the distribution of productivity were also higher for TRAIL Control 1 households. Figure 2 plots the cumulative distribution functions for Control 1 households in TRAIL and GRAIL villages. The CDF for GRAIL Control 1 households first-order stochastically dominates the CDF for TRAIL Control 1 households. A two-sample Kolmogorov-Smirnov test rejects the null hypothesis that the two distributions are identical ($p - value = 0.06$).[28] Since villages were randomly assigned to TRAIL or GRAIL treatment arm, and village and household characteristics are balanced across treatment arm, any differences in the productivity levels of recommended households in the two schemes cannot be due to inherent differences across villages. Instead, the results indicate that TRAIL agents selected borrowers of higher productivity more often than GRAIL agents did.

[26] Since our productivity estimates are generated variables, we also simulate 2000 bootstrap samples and run the Kolmogorov-Smirnov test for each Control 1 vs Control 2 CDF comparison. In 87 percent of the simulations, we can reject the null hypothesis that the two distributions are identical.

[27] The Kolmogorov-Smirnov test rejects the null hypothesis that the two distributions are identical in 83 percent of our bootstrap simulations.

[28] The Kolmogorov-Smirnov test rejects the null hypothesis that the two distributions are identical in 74 percent of our 2000 bootstrap simulations.

6.3 Differences in Conditional Treatment Effects

Even after they had completed their formally assigned task of selecting borrowers, the TRAIL and GRAIL agents may have played other informal roles in the scheme, for example by interacting with the Treatment households and influencing their farming practices and input choices. If the two types of agents engaged differently with the borrowers, this could have led to different treatment effects for households of equal productivity.

In order to examine whether the treatment effects vary in the two schemes even after we control for borrower productivity, we need to estimate the productivity of Treatment households. These cannot be estimated with the same procedure as we used in Section 6.1 for Control 1 and Control 2 group households. This is because the program loan itself would have directly changed Treatment households' scale of cultivation. In addition, households' engagement with the agent could also have responded to their treatment status.

Instead, we make an *Order-Preserving Assumption (OPA)*. This assumes that the receipt of the program loans did not change households' rank order in the distribution of cultivation scale. In Section 8 we will provide theoretical justification for this assumption.[29] Under this assumption, in each treatment arm, we can rank Treatment farmers by cultivation scale, and assign to them the counterfactual productivity estimate A_i of the farmer in the Control 1 distribution (as estimated in Section 6.1 at the same rank). This gives us the latent counterfactual productivity of this farmer had he not received the program loan.

Now that we can assign a productivity estimate to each household in both the Treatment and Control 1 groups, we can estimate conditional treatment effects at every productivity level in the continuous support of the estimated distribution. However, we increase the power of this exercise by grouping subjects into three "productivity bins". All non-cultivator households are placed in Bin 1. Among the rest, we use a median split to create Bins 2 and 3.[30] We then

[29] Athey and Imbens (2006) use a similar assumption in order to identify treatment effects in non-linear difference-of-difference settings.

[30] Figure A1 presents the fraction of Treatment (T) and Control 1 (C1) households in each productivity bin,

estimate bin-specific conditional treatment effects using the following specification:

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

From equation (5), the conditional treatment effect of the TRAIL scheme on non-cultivators (Bin 1) is given by $\hat{\xi}_{31} - \hat{\xi}_{21}$. The conditional treatment effect for Bin 2 is given by $\hat{\xi}_{32} - \hat{\xi}_{22}$ and for Bin 3 is given by $\hat{\xi}_{33} - \hat{\xi}_{23}$. The corresponding conditional treatment effects for the GRAIL scheme are given by $\hat{\xi}_{61} - \hat{\xi}_{51}$, $\hat{\xi}_{62} - \hat{\xi}_{52}$ and $\hat{\xi}_{63} - \hat{\xi}_{53}$.[31]

Results from equation (5) are presented in Table 11. Since household productivity is an estimated regressor, we bootstrap standard errors with 2000 iterations. In Panel A, we see positive, significant TRAIL CTEs on potato output (column 3), value-added (column 7) and imputed profit (in column 8) in Bins 2 and 3, with larger point estimates in Bin 3. In Panel B, we see significant and positive CTEs of the GRAIL scheme only for potato output and revenues for Bins 2 and 3, but not for value-added or profit. This is because the corresponding GRAIL CTEs on costs were also large, so that the increase in revenue is negated by this increase in costs. We also see that Treatment households in Bin 1 in the TRAIL scheme faced a smaller decrease in potatoes prices than in the GRAIL scheme, and those in Bin 3 in the TRAIL scheme decreased their unit costs while in the GRAIL scheme their unit costs remained constant. The TRAIL scheme caused value-added to increase by more for all three bins than the GRAIL scheme did, although the difference between the two schemes is not statistically

separately in the TRAIL and GRAIL villages. These results are consistent with those presented in Figure 2 and are indicative of superior selection by TRAIL agents, relative to GRAIL agents.

[31]In this process we are abstracting from any heterogeneity of treatment effects within productivity bins. However, the decomposition results we report in Section 6.4 are robust with respect to using finer partitions of the productivity range (see also footnote # 32). For households that did not cultivate potatoes in any study year, we replace the value of potato area cultivated, output produced or profits earned with zero, thus we continue to include these households in the estimating sample. However the treatment effects on unit costs are only estimated from the subset of observations where potatoes were cultivated.

significant.

Figure 3 presents the smoothed values of households' farm value-added against their productivity estimate. At any productivity level, the vertical difference in value-added between Treatment and Control 1 households gives us a visual estimate of the treatment effect at that productivity level. As we see in the left panel, in the TRAIL scheme the value-added plot lies above that for hte Control 1 households at nearly all productivity levels above the very lowest. This suggests that the positive treatment effects of the TRAIL scheme are not limited to households at any particular productivity level. The panel on the right shows that the GRAIL treatment effects are nearly always zero.

6.4 Decomposition

The results so far suggest that TRAIL agents selected more productive households than the GRAIL agents did, and that households of equivalent productivity earned larger farm incomes under the TRAIL scheme than the GRAIL scheme. What are the relative contributions of these two mechanisms? The following decomposition exercise allows us to ascertain this.

If $\sigma^R(\zeta)$ denotes the proportion of borrowers of productivity ζ that were recommended in loan scheme $R \in \{T, G\}$, the average treatment effect of loan scheme R can be written as:

$$\text{ATE}^R = \int_\zeta \sigma^R(\zeta) T^R(\zeta) d\zeta \tag{6}$$

Therefore the difference in the average treatment effects of the two schemes is

$$\text{ATE}^T - \text{ATE}^G = \int_\zeta [\sigma^T(\zeta) - \sigma^G(\zeta)] T^T(\zeta) d\zeta + \int_\zeta \sigma^G(\zeta)[T^T(\zeta) - T^G(\zeta)] d\zeta \tag{7}$$

The first term on the right-hand-side of equation (7) ($\int_\zeta [\sigma^T(\zeta) - \sigma^G(\zeta)] T^T(\zeta) d\zeta$) can be interpreted as the contribution of the superior selection by the TRAIL agent. It measures the extent to which the TRAIL average treatment effect would have decreased if the TRAIL agent had instead selected borrowers of the productivity levels that the GRAIL agent did, but the TRAIL conditional treatment effects had applied to them. The second term ($\int_\zeta \sigma^G(\zeta)[T^T(\zeta) - T^G(\zeta)]d\zeta$) represents the "agent engagement effect", or the counterfactual average treatment effect of the GRAIL scheme if the actual GRAIL borrowers had been selected but they had earned the conditional treatment effects of the TRAIL scheme.

We modify equation (7) to use a discrete partitioning of borrowers into the three productivity bins described above, and present the results in Table 12. In columns 1 and 2 we compute the proportion of the TRAIL and GRAIL pools of Control 1 households that belong to each productivity bin ($\sigma^R(\zeta)$). In column 3, we compute the TRAIL v. GRAIL difference in these proportions, i.e., measure the difference in the likelihood of finding a household of this productivity bin in the TRAIL as opposed to the GRAIL recommended household pool. As suggested by our discussion of Figure 1, compared to the GRAIL pool, a smaller proportion of the TRAIL pool lies in Bin 1, but a larger proportion lies in Bin 2 and Bin 3. We use the differences from column 3 to compute a weighted average of the TRAIL conditional treatment effects in column 7. This average is Rs.131.20 and represents the difference in the TRAIL v. GRAIL average treatment effects we might have seen, if superior borrower selection alone were driving the differential effects. This accounts for only 8.4% of the actual estimated difference in average treatment effects of Rs.1566.84.

Next, for each productivity bin, we compute the difference in the estimated conditional treatment effects between the TRAIL and GRAIL schemes (see column 6). We weight these by the proportion of GRAIL Control 1 households that belong to this productivity bin ($\sigma^G(\zeta)$). The weighted average, seen in column 8, indicates that conditional on productivity, differences in the TRAIL and GRAIL treatment effects cause the average treatment effects of the two schemes to differ by Rs. 1182.30. In other words, 75.4% of the estimated ATE difference can be attributed to differences in treatment effects conditional on borrower productivity.[32]

[32] When we use a continuous measure of productivity we estimate that 17.5% of the estimated ATE difference can be explained by selection differences, and 82.5% is due to differences in conditional treatment effects.

Clearly then, the superior performance of the TRAIL scheme is not mainly caused by the fact that TRAIL loans were given to more able borrowers. Instead, our results indicate that farmers of similar productivity levels increased their farm incomes by more in TRAIL. Since the two schemes differ only in the characteristics of the agent, this suggests that TRAIL agents played a differential role from GRAIL agents that went beyond borrower selection.

7 A Model Of Agent-Farmer Engagement

We hypothesize that this additional role took the form of engagement with the farmers. Accordingly, we formulate a model of interactions between the agent and the farmers. These interactions could be conversations about the weather, market prices, cultivation practices and techniques and harvesting times. They could be used to provide technical or marketing assistance, or monitor and regulate farmers' actions, which would affect productivity and cultivation costs.

As explained in the Introduction and in Section 2, besides the commissions, TRAIL agents stand to earn middleman profits from purchasing and then re-selling farmers' crops. They incur costs of providing credit to the farmer and the time costs of engaging with them. Accordingly, they share both downside and upside risk with the farmers: when the farmer's crop fails the TRAIL agent earns smaller middleman profits, and if the farmer defaults on this loan then the TRAIL agent loses both the informal loan he may have given out and the TRAIL commission. Conversely, when the farmer plants more potatoes and harvests a larger crop, he both repays his loans and generates the TRAIL commission for the agent, and increases the agent's middleman profits. The GRAIL agent earns the same commissions as the TRAIL agent but does not have the additional business motive. Instead, we hypothesize that he benefits from furthering the political objectives or mission of the incumbent political party. Accordingly, he is likely to target poorer farmers of lower productivity, and then attempt to ensure that they do not default. The GRAIL agent's incentives would then resemble that of a classic banker, sharing mainly the downside risk but not the corresponding upside risk. If there is a trade-off between lowering default risk and raising mean returns, the TRAIL agent would be inclined to favor higher average returns, while the GRAIL agent would want to minimize default risk. Our model below incorporates this trade-off.

7.1 Assumptions

Farmers vary in intrinsic ability, denoted by θ. Less able farmers are less likely to grow a successful crop. Farmers can be monitored by local intermediaries such as traders or agents. When monitored, farmers choose less risky production techniques, and do more to prevent pest attacks. Therefore the crop success rate increases in monitoring. Formally, the probability of crop success $p = p(\theta, m)$, $p_\theta > 0$, $p_m > 0$, $p_{mm} < 0$. Moreover $p_{\theta m} < 0$, i.e, monitoring is more effective for less able farmers who are higher default risks.

Conditional on crop success, the farmer's output depends on his total factor productivity (TFP) $a(\theta, m)$, and a concave production function f that depends on the scale of cultivation l. Monitoring lowers productivity by discouraging adoption of high return but risky crop varieties or production methods. Hence expected TFP $A(\theta, m) \equiv p(\theta, m)a(\theta, m)$ decreases in monitoring: at any given scale of cultivation, monitoring has a negative effect on TFP that outweighs the positive effect on the crop success rate. Monitoring also raises unit production costs, because it causes farmers to use expensive inputs such as pesticides and water to increase the chance that their crop will succeed.

On the other hand, traders can also help farmers by providing advice about the types or sources of inputs, and the timing of transactions. This lowers farmers' unit costs. The unit cost of production $c(h, m)$ is thus decreasing in help h and increasing in m.

Monitoring and help are assumed to be time-consuming activities, so are measured in units of time. Traders have an opportunity cost of γ_T per unit time, while GRAIL agents' opportunity cost is γ_G. These may differ owing to differences in their occupation and wealth; we impose no restriction on this.

A specific parametric example involves constant elasticity (CE) success, production, productivity and cost functions: $p(\theta, m) = 1-(1-\pi(\theta))(1+m)^{-\mu_0}$, where π is increasing and $\mu_0 > 0$; $f = \frac{l^{1-\alpha}}{1-\alpha}$ with $1 > \alpha > 0$; $a(\theta, m) = z(\theta)(1+m)^{-\mu_1}$ and $c(h, m) = (1+h)^{-\nu}(1+m)^{\mu_2}$ where z is increasing, $\mu_1, \mu_2 > 0, 1 > \nu > 0$. We also impose the conditions (i) $\nu < \frac{\alpha}{1-\alpha}$, to ensure diminishing returns to help, and (ii) $1 + \frac{\mu_0}{\mu_1} < \frac{1}{1-\pi(\underline{\theta})}$ where $\underline{\theta}$ is a lower bound to θ, which implies expected TFP is falling in m.

All inputs are purchased upfront, so the farmer incurs cultivation cost $c(h, m)l$ when he plants the crop, and earns revenue $a(\theta, m)f(l)$ at harvest time conditional on avoiding a crop failure.[33] The farmer has no wealth to self-finance production, and thus needs to borrow $c(h, m)l$ upfront. Borrowers have limited liability, so they repay loans only if the crop is successful. We also assume that there is no strategic default, owing to the dynamic repayment incentives created for borrowers.

Traders in the village face a constant cost of capital ρ. They enter into "interlinked" contracts with farmers; these contracts specify the scale of cultivation, extent of help and monitoring. In turn these determine the farmers' borrowing and output levels. Farmers and traders are risk-neutral. The farmer sells the output to a trader who earns a middleman margin of τ per unit transacted. Each farmer enters into a contract with a representative village trader. Traders have perfect information about farmers' types, and there are no frictions, so the interlinked contract maximizes joint expected payoff of trader and farmer. The division of payoffs between the two depends on the degree of competition in the market for contracts, represented by a suitable lumpsum side-payment, which will have no productive consequences.[34]

[33] The product price is treated as exogenous and normalized to unity. We abstract from the possible role of help and monitoring in determining the product price, since that would give us qualitatively similar results as for their effect on unit cost.

[34] An implicit assumption here is that the limited liability constraint does not bind. This will be true if farmers are on the short side of the market and therefore have all the bargaining power.

7.2 Control Farmers

A contract between farmer F of ability θ and trader T is represented by a scale of cultivation l, help h, monitoring m, an interest rate r and a side-payment s. The first three determine the size of the loan $c(h,m)l$. The farmer repays the loan if his crop succeeds. Hence the farmer's expected payoff (excluding fixed cost F) is

$$p(\theta,m)[a(\theta,m)f(l) - rc(h,m)l] + s \tag{8}$$

while the trader's payoff is

$$\tau p(\theta,m)a(\theta,m)f(l) + [rp(\theta,m) - \rho]c(h,m)l - \gamma_T(m+h) - s \tag{9}$$

where τ represents the product of the share of output sold to the trader, and middleman margin earned by the trader per unit output. We take τ to be exogenous. An efficient contract maximizes the joint payoff given by

$$(1+\tau)A(\theta,m)f(l) - \rho c(h,m)l - \gamma_T[m+h] \tag{10}$$

To start with, note that it is optimal for the trader to not monitor the farmer at all ($m^c(\theta) = 0$), since monitoring lowers expected productivity A, imposes a monitoring cost, and increases the production cost. Next, observe that given a certain level of help h, the optimal scale of cultivation $l^c(\theta,h)$ which maximizes

$$(1+\tau)A(\theta,0)f(l) - \rho c(h,0)l \tag{11}$$

is increasing in θ and h. Let the maximized value of the expression in equation (11) be denoted by $\Pi(h,\theta)$. Then help $h^c(\theta)$ is chosen to maximize

$$\Pi(h,\theta) - \gamma_T h \tag{12}$$

By the Envelope Theorem, Π is a supermodular function: the marginal return to help increases with the farmer's ability.[35] Hence $h^c(\theta)$ is increasing: higher ability farmers receive more help, and end up with higher scale of cultivation, productivity, and lower unit cost. This rationalizes our use of scale of cultivation as a proxy for ability and for productivity among control farmers.

Observe also that the choice of scale of cultivation can be delegated to the farmer, if the interest rate is set at

$$r^c(\theta) = \frac{\rho}{(1+\tau)p(\theta, 0)} \tag{13}$$

This interest rate equals the cost of capital ρ adjusted upwards for default risk, and then subsidized by the trader so as to induce the farmer to internalize the effect of cultivation scale on T's profits. This gives us our first proposition.

Proposition 1 *Among control farmers, unit costs and interest rates are decreasing in ability, while TFP, scale of cultivation and output are increasing in ability.*

In the constant elasticity (CE) case, we can derive closed form expressions for the efficient contract:

$$l^c(\theta, h) = [\frac{(1+\tau)A(\theta, 0)(1+h^c(\theta))^\nu}{\rho}]^{\frac{1}{\alpha}} \tag{14}$$

$$1 + h^c(\theta) = [\frac{(1+\tau)A(\theta, 0)}{\rho^{1-\alpha}}\{\frac{\nu}{\gamma_T}\}^\alpha]^{\frac{\alpha}{\alpha-\nu(1-\alpha)}} \tag{15}$$

while $m^c(\theta) = 0$ and $r^c(\theta)$ is given by equation (13).

7.3 TRAIL Treatment Effects

In TRAIL, a trader is appointed the agent, and recommends borrowers for TRAIL loans. These loans are offered at interest rate r_T, which is lower than the informal cost of capital for traders ρ. Agents earn a commission of $\psi \in (0, 1)$ per rupee interest paid by the borrowers

[35] This is because Π_h equals $-\rho c_h(h, 0)l^c(\theta, h)$ which is rising in θ.

they recommended. We assume that any farmer whom the agent selects is already committed to cultivating l^c, financed by informal loans taken before the TRAIL loan was offered to him/her.[36] As a result the TRAIL loan finances an increase in the cultivation scale.[37] This applies to farmers in productivity Bins 2 and 3; for those in Bin 1 there are no pre-existing plans for cultivating potatoes. In what follows, we present calculations for farmers in Bins 2 and 3; for those in Bin 1 we set the pre-existing cultivation scale $L^c(\theta)$ to zero.

The efficient contract between T and F will now involve a supplementary cultivation scale of l^t, resulting in total scale of $l^T \equiv l^c + l^t$. The levels of monitoring and help will be adjusted to m^T, h^T. Then the joint payoff of T and F is

$$(1+\tau)A(\theta,m)f(L^c(\theta)+l^t) - [\rho L^c(\theta) + p(\theta,m)r_T(1-\psi)l^t]c(h,m) - \gamma_T[h+m] \tag{16}$$

where $L^c(\theta) \equiv l^c(\theta, h^c(\theta))$.

The TRAIL agent continues to find it optimal not to monitor the farmer: $m^T(\theta) = 0$. Given help h, the treatment effect on cultivation scale $l^t(\theta, h)$ maximizes

$$(1+\tau)A(\theta,0)f(L^c(\theta)+l^t) - [\rho L^c(\theta) + p(\theta,0)r_T(1-\psi)l^t]c(h,m) \tag{17}$$

Using the same argument as used in Lemma 2 in Maitra et al. (2017), the cultivation treatment effect $l^t(.,h)$ is increasing in θ provided a regularity condition RC is satisfied, which requires: (i) $\frac{-f"}{f'}$ is non-increasing, which is satisfied by any constant elasticity or exponential function, and (ii) $p(\theta,h)$ varies relatively 'little' with ability θ, compared to the variation in productivity $a(\theta,h)$. In what follows, we assume this condition is satisfied. The Envelope Theorem implies that the help provided by the agent to the treated farmer $h^T(\theta)$ must minimize

$$[\rho L^c(\theta) + p(\theta,0)r_T(1-\psi)L^T(\theta)]c(h,0) + \gamma_T h \tag{18}$$

[36]This is in order to explain the lack of treatment effects on informal borrowing.
[37]Recall that in Table 5 we did not see any evidence that the TRAIL loans crowded out informal loans.

where $L^T(\theta)$ denotes $l^t(\theta, h^T(\theta))$. It is then evident that $h^T(\theta)$ is increasing: among treated farmers the more able will receive more help, and thereby attain lower unit costs, cultivate a larger scale, and produce higher output. This validates our use of the Order Preserving Assumption to estimate ability among treated farmers.

We can also compare agent engagement between treated and control farmers with the same ability θ. Help $h^c(\theta)$ provided to a control farmer with the same ability minimizes

$$[\rho L^c(\theta)]c(h, 0) + \gamma_T h \tag{19}$$

Comparing (18) and (19), it is evident that $h^T(\theta) \geq h^c(\theta)$, so treated farmers obtain more help. Intuitively they cultivate a larger area compared to control farmers with the same ability, so the gains from unit cost reductions generate a larger reduction in total cost, thereby motivating the agent to provide more help. Since $r_T < \rho$, it follows that TRAIL treated farmers have a lower expected marginal cultivation cost than corresponding control farmers in Bins 2 and 3: $c(h^T(\theta), 0)p(\theta, 0)r_T < c(h^c(\theta, 0))\rho$. Hence the TRAIL treatment effect on scale of cultivation and expected output will be positive. This is the result of both the lower marginal borrowing costs and the induced increase in the TRAIL agent's help, which lower unit production costs. This is true for Bins 2 and 3; for Bin 1 the result is obvious since control farmers in Bin 1 do not cultivate potatoes.[38]

Proposition 2 *In TRAIL:*

(a) *Treated farmers of higher ability cultivate larger area, receive more help, have lower unit costs, and produce higher output, so the Order Preserving Assumption is valid;*

(b) *Compared to control farmers with the same ability, treated farmers cultivate larger area, receive more help, have lower unit costs, and produce higher output.*

[38] Unfortunately, closed form expressions for the TRAIL treatment effects in the CE case can no longer be obtained for farmers in Bins 2 and 3, so we are unable to provide theoretical results showing how TRAIL treatment effects vary with θ.

7.4 GRAIL Treatment Effects

In the GRAIL scheme, the political incumbent appoints an agent who is not a trader. This agent does not lend, or trade in inputs or crop output, and so does not have the same business-related incentives as a TRAIL agent. Instead, his objectives are political or ideological, represented by welfare weight $v(\theta)$. In the context of West Bengal, it is natural to suppose that v is decreasing in θ, representing a redistributive ideology or a motivation to garner support from low-ability farmers for the incumbent political party. In addition, this agent would earn commissions that depended on the interest payments by the borrowers he recommended. Both the political and non-political payoffs of the GRAIL agents depend on whether Treatment farmers successfully repay their loans. Hence the objective of the GRAIL agent, conditional on selecting a farmer of ability θ, is to maximize

$$[\chi + v(\theta)]p(\theta, m) - \gamma_G m \tag{20}$$

where χ denotes the agent's return from the repayment based commission. We abstract here from loan size and its effect on the agent's commission, which complicates the analysis considerably is likely to be of second order importance relative to political or ideological motives. The results derived below would hold in an extended model where loan size is incorporated, if the commissions are small relative to the political weight $v(\theta)$.

In contrast to the TRAIL agent, the GRAIL agent is motivated to minimize default risk, so has no incentive to help Treatment farmers, but instead seeks to monitor them. The optimal level of monitoring (positive if γ_G is small enough) satisfies

$$[\chi + v(\theta)]p_m(\theta, m^G(\theta)) = \gamma_G \tag{21}$$

Since monitoring is more effective when farmers are less able, and the welfare weights are decreasing in ability, $m^G(\theta)$ is decreasing in ability.

Monitoring by the GRAIL agent affects the payoffs of treated farmers and the trader they contract with. Their joint payoff is given by

$$(1+\tau)A(\theta, m^G(\theta)+m))f(L^c(\theta)+l^g)-[\rho L^c(\theta)+p(\theta, m^G(\theta)+m)r_T(1-\psi)l^g]c(h, m^G(\theta)+m)-\gamma_T[h+m] \tag{22}$$

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. The trader continues to have no incentive to monitor. Hence the contract involves a treatment effect l^g on area cultivated and help h which maximize

$$(1+\tau)A(\theta, m^G(\theta)))f(L^c(\theta)+l^g) - [\rho L^c(\theta) + p(\theta, m^G(\theta))r_T(1-\psi)l^g]c(h, m^G(\theta)) - \gamma_T h \tag{23}$$

Arguments similar to those used for TRAIL treated subjects imply that under the regularity condition RC, higher ability farmers receive more help, under the additional assumption that $c_{hm} = 0$. To see this, note that if $l^G(\theta; h)$ denotes the area treatment effect in GRAIL for any given help h, the same argument (combined with $m^G(.)$ decreasing) implies $l^G(, , h)$ is increasing in θ. Hence $h^G(\theta)$ minimizes

$$c(h, m^G(\theta))[\rho L^c(\theta) + p(\theta, m^G(\theta))r_T(1-\psi)L^G(\theta)] + \gamma_T h \tag{24}$$

(where $L^G(\theta) \equiv l^G(\theta, h^G(\theta))$) and then $c_{hm} = 0$ implies that $h^G(.)$ is increasing. Under these assumptions, the Order Preserving Assumption is also satisfied in GRAIL, and GRAIL treated farmers of higher ability have lower unit cost, cultivate larger area and produce more output.

Observe that for any given level of help h from the trader, a GRAIL treated borrower will cultivate at a smaller scale than a TRAIL treated borrower with the same ability ($l^G(\theta; h) \leq l^T(\theta, h)$), owing to the monitoring of the GRAIL agent which lowers the former's productivity and raises unit costs. Comparing (24) with the corresponding expression (18) in TRAIL, it follows that the TRAIL treated subjects will receive more help than GRAIL treated subjects, if $c_{hm} = 0$. This assumption, however, does not hold in the CE case, for which we can obtain the following result.[39]

Proposition 3 **(a)** *If $c_{hm} = 0$, GRAIL treatment effects (conditional on ability) on help from the trader, unit cost reduction, area cultivated and output are smaller than in TRAIL.*

(b) *In the constant elasticity case, TRAIL treated farmers in Bin 1 have smaller unit costs, cultivate larger area, produce more output and earn higher value added/profit than GRAIL farmers of the same ability in Bin 1. TRAIL treated farmers in Bins 2 and 3, have lower unit costs, produce more output and earn higher value added/profit if the TRAIL treatment effects on area cultivated (weighted by repayment rate) are at least as large as the GRAIL treatment effects:*

$$p(\theta, m^G(\theta))l^g(\theta) \leq p(\theta, 0)l^t(\theta) \tag{25}$$

In the CE case, unit costs end up being smaller for TRAIL farmers in Bin 1. This is because the TRAIL agent does not monitor, and monitoring raises unit costs directly, which outweighs the induced indirect effects on help, even if they happen to be larger in the GRAIL scheme. For Bins 2 and 3, the same result obtains if the additional condition in equation (25) holds. This condition involves endogenous variables, but can be checked empirically. It ensures that the benefits of unit cost reductions are spread over a larger base in TRAIL, which motivates the trader to push unit costs lower in TRAIL.

Next, we derive predictions for loan default rates. Since the GRAIL agent monitors the farmer but the TRAIL agent does not, GRAIL treated farmers are less likely to default on their loans than GRAIL control farmers of the same ability. The GRAIL control farmers' default rates equal the default rates of both control and treated farmers in the TRAIL scheme, since as we saw above, the TRAIL agent does not monitor in equilibrium. Finally the ratio of interest rates $\frac{r_1}{r_2}$ paid on informal loans by borrowers of ability θ_1, θ_2 where $\theta_1 < \theta_2$, equals $\frac{R_2^I}{R_1^I}$, where R_i^I

[39] The proof is presented in Section A1.

denotes the repayment rate by θ_i on informal loans. This relative repayment rate on informal loans will be higher than on GRAIL loans, since repayment rates for lower ability borrowers increase by more owing to the more intensive monitoring by the GRAIL agent. Hence $\frac{r_1}{r_2}$ will be higher than $\frac{R_2^G}{R_1^G}$, where R_i^G denotes the repayment rate on GRAIL loans. On the other hand, $\frac{r_1}{r_2}$ will equal $\frac{R_2^T}{R_1^T}$, since there is no monitoring of treated or control farmers by the TRAIL agent, so their default risks are unaffected by the treatment.

Proposition 4 **(a)** *GRAIL Treatment effects on agent engagement are decreasing in ability.*

(b) *At any given ability level, default rates on program loans are lower in the GRAIL scheme than in the TRAIL scheme.*

(c) $\frac{r_1}{r_2} > \frac{R_2^G}{R_1^G}$*, where* r_i, R_i^G *denote the informal interest rate and GRAIL repayment rates of borrowers of ability* θ_i*, if* $\theta_1 < \theta_2$*.*

Finally, we compare effects of the two schemes on political support for the incumbent party. In TRAIL the agent has a business profit motivation rather than a political one, so we expect no treatment effects on political support for the incumbent. In GRAIL we expect recipients to either be grateful for being selected for a low interest loan by the local incumbent party, or reciprocate the benefit in a clientelistic arrangement.[40] The incumbent is likely to target low ability borrowers because they are poorer on average, and both welfarist and clientelistic missions would be expected to target the poor more since the welfare impacts would be larger. So we expect:

Proposition 5 *Treatment effects on the likelihood of voting for the political incumbent in GRAIL are positive on average, and decreasing in borrower ability. Corresponding treatment effects in TRAIL are zero.*

[40] This is a standard feature of the literature on political clientelism (see, for example, Stokes 2005; Kitschelt and Wilkinson 2007): poorer voters are likely to sell their vote for a lower price, so parties tend to target swing voters among the poor in their efforts to mobilize vote share.

8 Testing Predictions of the Model

We now test the predictions of the model, made in Propositions 1—5.

Test of Proposition 1

Column 1 of Table 13 presents the OLS regression results of interest rates paid by Control 1 and Control 1 households on informal loans. We pool both TRAIL and GRAIL households together. To avoid the concern that the intervention itself might have changed the interest rate they were charged, we only consider informal loans taken before our intervention began.[41] The coefficient estimate of productivity is negative ($p - value = 0.11$) indicating that for control households, there is a decline in interest rate as productivity increases.[42] The average control household in Bin 1 reported taking loans at 21% interest per annum. This is significantly greater than the 15% that Bin 2 households reported ($p - value = 0.03$) and the 16% that Bin 3 households reported ($p - value = 0.04$).[43] This supports the prediction in Proposition 1 that more able farmers pay lower interest rates.

Columns 2 and 3 of Table 13 present the OLS regression results of potato cultivated (in Kgs) and input cost per acre in potato cultivation (in Rs.) on productivity. The regressions also control for a set of year dummies. Again, the sample is restricted to Control 1 and Control 2 households in TRAIL and GRAIL villages, with at most 1.5 acres of land holding. Consistent with Proposition 1, we see, in column 2, that among control farmers output is increasing in productivity, while in column 3 we see that unit costs are decreasing in productivity. ■

[41] However, since only 10 households in each village received the program loans, we do not believe there were any spillover or general equilibrium effects.

[42] Recall, from Section 6.1, that productivity (A_i) is an increasing function of ability (θ_i). In all our empirical analysis, we use our estimate of productivity (given by the household fixed effect) as a proxy for the underlying, unobserved ability.

[43] These averages are presented in the left panel of Figure A2. The right panel of this Figure takes into account the variation in productivity. Recall that we do not have a continuous measure of productivity for those who did not cultivate potatoes; for this group we compute the mean informal interest rate and plot it as a single point in the right panel of Figure A2. For Bins 2 and 3, we run a locally-weighted polynomial regression of the mean interest rate on farmer productivity.

Test of Proposition 2

At each four-monthly survey interview, we asked sample households whether in the previous three days they had specifically spoken with the local trader about cultivation, about the harvest, or about sales. We interpret conversations about any of these three topics as an indicator that the trader helped the farmer. A separate set of questions asks if they had spoken to the agent about these topics. Since in the TRAIL scheme the agent is also a trader, we include engagement with the trader as well as the agent in the measure of help from the trader. Column 4 of Table 13 presents the OLS regression results of help from traders received by TRAIL treatment households with at most 1.5 acres of landholding. Consistent with part (a) Proposition 2 we see that help from trader is increasing in productivity. Columns 5 and 6 of Table 13 present the OLS regressions of quantity of potato cultivated and input cost per acre in potato cultivation on productivity for TRAIL treated households. Again, consistent with part (a) of Proposition 2, more productive farmers produce more potatoes, at a lower input cost per acre.

Figure 4 provides evidence on part (b) of Proposition 2. Panel A presents the conditional heterogeneous treatment effects on trader help for TRAIL households, estimated using equation (5). The treatment effect is large and statistically significant in Bin 3. Thus, among the most able farmers, Treatment households received more help than Control 1 group farmers. However, the treatment effects are not significantly different from zero for less productive farmers, and indeed in Bin 1 the sign is negative.

Panels B, C and D present the conditional treatment effects of the TRAIL scheme on potato acreage, potato output and input cost per acre in potato cultivation. TRAIL loans caused farmers in all three bins to significantly increase the acreage that they devoted to potatoes (Panel B) and significantly increase potato output (Panel C). The point estimates of the TRAIL treatment effects on potato input costs per acre (Panel D) are negative, suggesting that the intervention caused input costs per acre to fall. They are statistically significant in Bins 2 and

3. ∎

Test of Proposition 3

Table 11 presents estimates of the conditional treatment effects of the TRAIL and GRAIL schemes. While the differences are not statistically significant, the results in the last panel of Table 11 show that for all three Bins, the GRAIL treatment effects on area planted (column 2), potato cultivation (column 3), value added (column 7) and imputed profit (column 8) are lower than the corresponding TRAIL treatment effects. These results are consistent with those of part (a) of Proposition 3.

These results are also consistent with the part (b) of Proposition 3 relating to Bin 1. For Bins 2 and 3, part (b) of Proposition 3 predicts that TRAIL treated farmers would have smaller unit costs and would produce more output if treatment effects on area cultivated (weighted by repayment rate) in the TRAIL scheme are at least as larger as in the GRAIL scheme. This condition is satisfied in the data. Figure 6 shows the rate at which borrowers in each productivity bin defaulted on the program loans. The repayment rates in Bins 2 and 3 are respectively 93.4% and 94% in TRAIL villages and 91.8% and 92.7% in the GRAIL villages.[44] As a result, for households in Bins 2 and 3, the repayment-rate-weighted treatment effects on area cultivated are always larger in the TRAIL scheme (0.084 and 0.1034 for Bins 2 and 3 respectively) than in the GRAIL scheme (0.0734 and 0.1019). Consistent with the predictions of part (b) of Proposition 3, Panel C of Table 11 shows, the TRAIL treated farmers have smaller unit costs; the difference is statistically significant for Bin 3. TRAIL treatment effects on output, value added and profits exceed GRAIL treatment effects, although the differences are not statistically significant. ∎

[44] If a borrower did not repay the entire amount due on the pre-arranged repayment date, we record this as a default.

Test of Proposition 4

The right hand panel of Figure 5 presents estimates of conditional treatment effects of the GRAIL scheme on agent engagement. Consistent with part (a) of Proposition 4, the GRAIL agent increased his engagement with the more productive Treatment households by less.

To examine part (b) of Proposition 4, consider the rate at which borrowers in each productivity bin defaulted on the program loans (Figure 6). TRAIL Treatment households in productivity Bin 1 defaulted on 9.3 percent of their loans, whereas GRAIL Bin 1 Treatment households defaulted at a significantly lower 5 percent ($p - value = 0.03$). In Bins 2 and 3 the differences in default rates across TRAIL and GRAIL go the other way, although they are not statistically significant.

Finally, we check that part (c) holds by comparing Bin 1 with either Bin 2 or 3, since GRAIL loan default rates are lower in Bin 1, while the corresponding informal interest rates are higher in Bin 1. Default and interest rates do not vary much between Bins 2 and 3, so it is not meaningful to compare across these. ■

Test of Proposition 5

In our final survey round in 2013, all sample households were asked to participate in a straw poll. On a sheet of paper resembling a ballot, the respondent was asked to mark the symbol of their preferred political party and then fold and place the paper in a box. We use the response to this question as our indicator of the political party they support.[45] Our working assumption is that the GRAIL agents were affiliated with the party that held the majority of seats in the local village council in 2010. A straw poll vote cast in favor of this incumbent party then

[45] Although our surveyors did not look at the respondents' choice at the time the ballot was cast, respondents may have realised that they would look at the choice later and record it. However, surveyors made it clear that the response would only be used for research purposes and would be kept confidential. Less than 1% of households refused to participate, so we have responses from 1194 TRAIL and 1188 GRAIL households.

indicates that the voter supports the incumbent. We use data from the West Bengal State Election Commission to identify this incumbent political party in each local village council. This allows us to run the regression

$$I_{hv} = \xi_0 + \xi_1 \text{Treatment }_{hv} + \xi_2 \text{Control } 1_{hv} + \gamma \mathbf{X}_{hv} + \varepsilon_{hv} \tag{26}$$

The dependent variable I_{hv} takes the value 1 if the respondent h in village v voted for the incumbent party in the straw poll. $\mathbf{X}_{hv}$ includes the same set of additional controls that were included in previous regressions and discussed in Section 5. We run the regression separately for TRAIL and GRAIL villages. The estimated treatment effect $\hat{\xi}_1 - \hat{\xi}_2$ indicates whether, conditional on being recommended by the agent, Treatment households demonstrated differential support for the incumbent than Control 1 households did.

As column 2 of Table 14 shows, the treatment effect is positive and statistically significant in GRAIL villages. Thus, compared to the recommended households that did not receive the loan, those that did were more likely to support the incumbent. This is consistent with the hypothesis that GRAIL agents were clientelistic and recommended borrowers who would repay the favor by voting for them. However it is also consistent with the hypothesis that the political incumbent selected more low-productivity, poor households from minority communities, and that among these households, those that received the GRAIL loans reciprocated by increasing their support for this party. Both explanations are also consistent with the finding in Column 4: a Bin 1 borrower who received a GRAIL loan was 13 percentage points more likely to vote for the incumbent party than a Bin 1 borrower who was also recommended, but did not receive the loan. In contrast the loan had small and non-significant treatment effects on Bin 2 and Bin 3 borrowers.

Columns 1 and 3 show that the loans did not change voting patterns in TRAIL villages. This is consistent with the idea that TRAIL agents were less likely to be involved in politics and perhaps did not select households on the basis of voting patterns or propensities. ■

9 Conclusion

We briefly summarize our results. First, the TRAIL scheme increased potato profits and aggregate farm incomes for selected households by more than the GRAIL scheme did. Only a small portion of this difference is due to differences in the composition of borrowers. Instead, we find that farmers of similar productivity levels increased their farm incomes by more in the TRAIL scheme than in the GRAIL scheme.

To explain this, we focused on the non-scheme incentives of the two agent types. TRAIL agents are traders who earn profits by buying and reselling farmers' crop output. We hypothesize that this gives them an incentive to help farmers lower their unit costs and thereby produce more. In contrast, the GRAIL agent's interests are aligned with the locally dominant political party, which causes him to target the loan scheme to poor, low-productivity farmers. This could be in order to fulfill the poverty alleviation mission of his government, or because households that benefit from the scheme may reciprocate by voting for his political party in the subsequent election. The GRAIL agent may then choose to monitor these low-productivity households to ensure that they repay the loans and succeed in the program. Such monitoring prevents these households from lowering unit costs. At the same time, since the GRAIL agent is not a trader, he may be unable or uninterested in helping farmers lower their costs of production. We successfully tested the predictions of a theoretical model that incorporated these ideas.

Ours is of course one possible interpretation of the results. We leave open the possibility of alternative explanations. However, irrespective of the precise explanation, our paper indicates the potential value of enlarging the set of potential intermediaries for agricultural development interventions to include private traders. Their specialized information about the productivity and reliability of farmers in these communities, and their incentives to help farmers take advantage of these interventions make them potentially valuable partners in development interventions.

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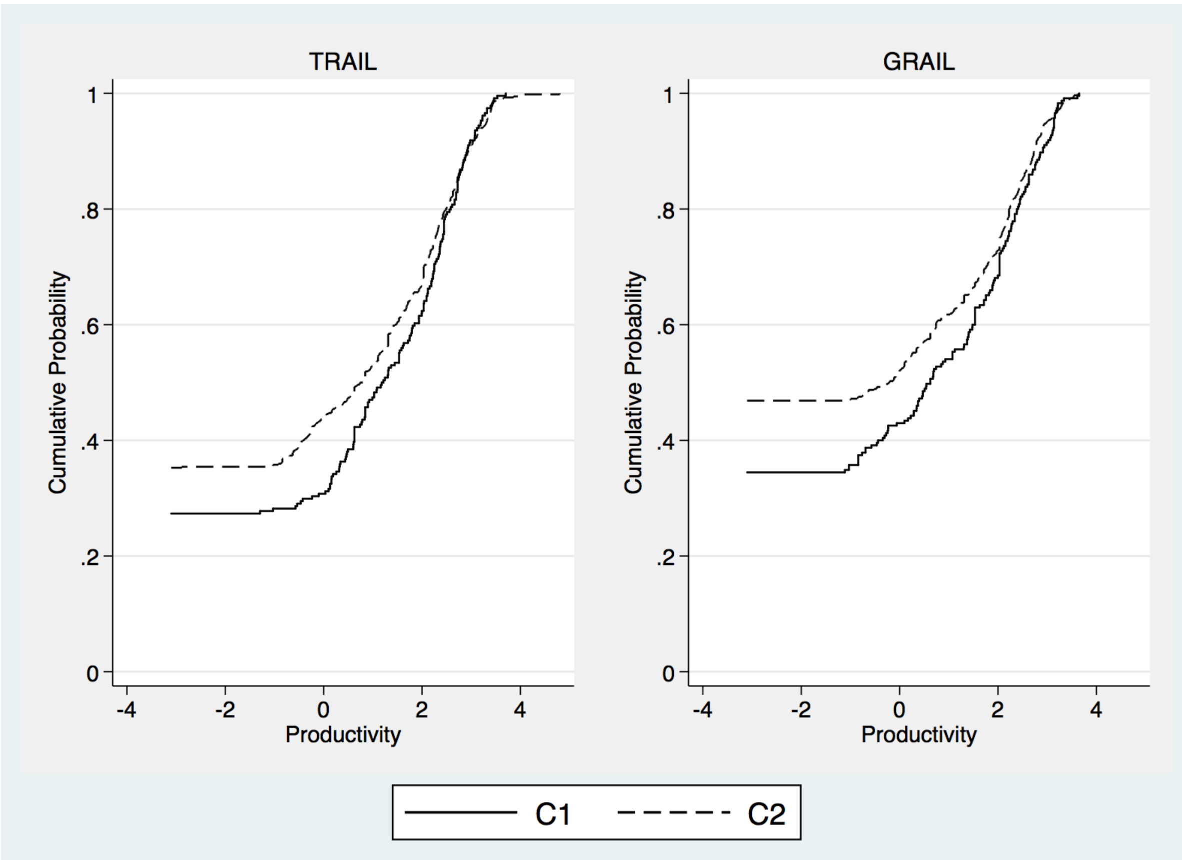
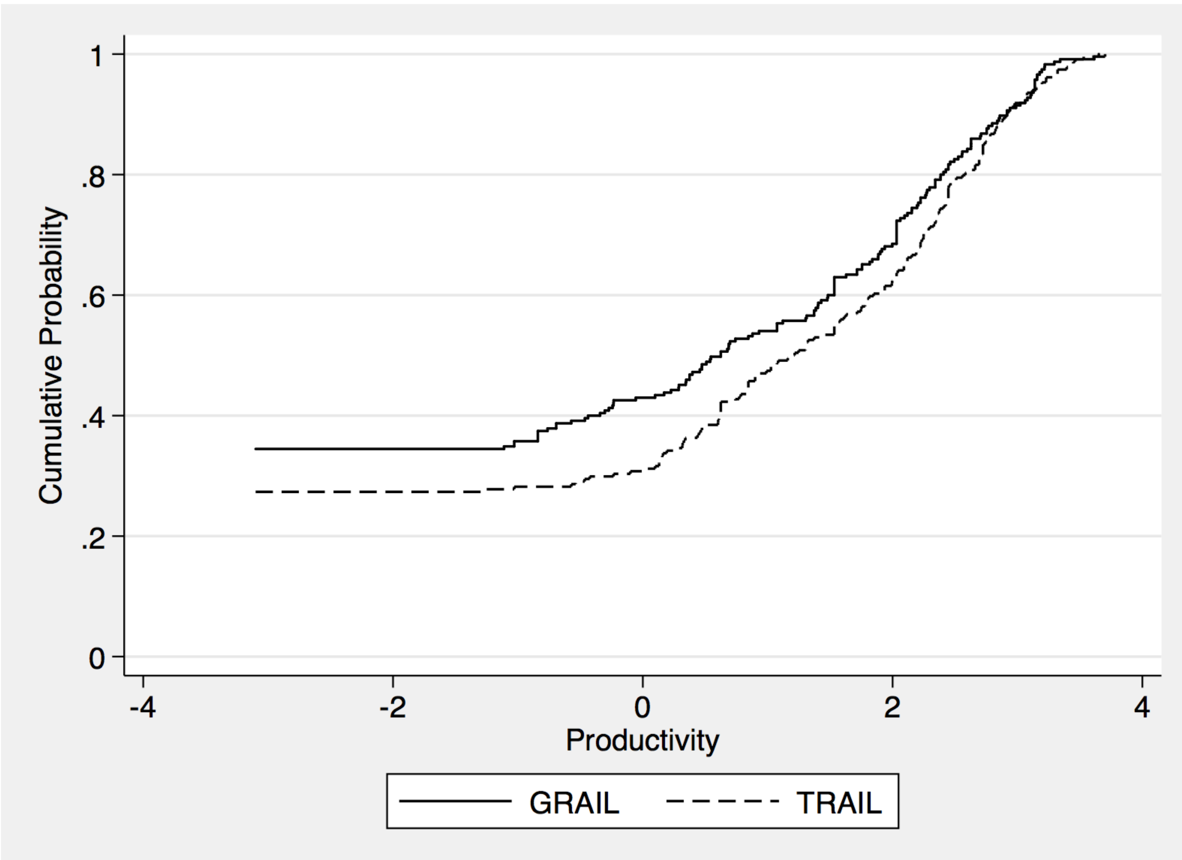
Figure 1: Productivity estimates for Selected v. Non-selected households in TRAIL and GRAIL villages



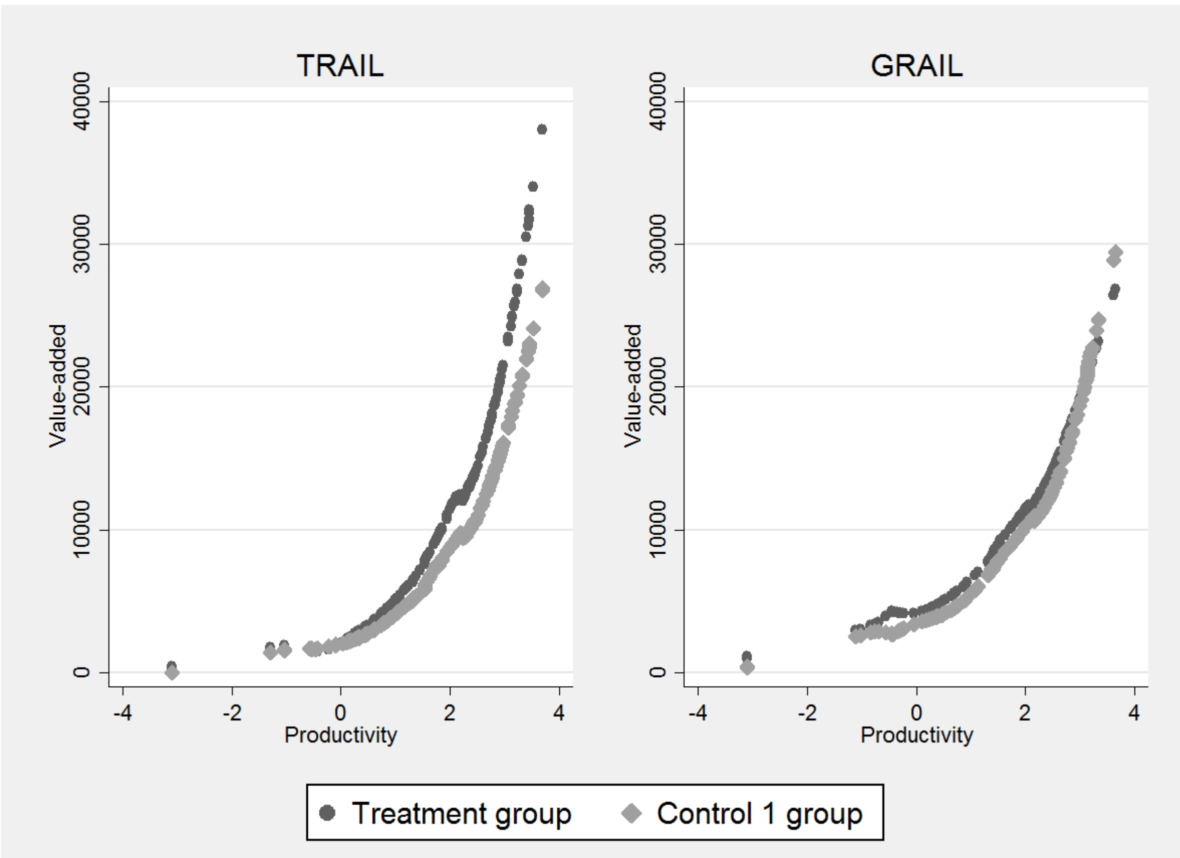
Notes: The sample is restricted to Control 1 and Control 2 households in TRAIL and GRAIL villages. Productivity is computed using the logarithm of acreage under potato cultivation. The null hypothesis that the distributions of estimated productivity for Control 1 and Control 2 households are equal is rejected by a two sample Kolmogorov-Smirnov (KS) test with $p - value = 0.005$ for TRAIL and 0.011 for GRAIL.

Figure 2: Productivity estimates for Selected households in TRAIL and GRAIL villages



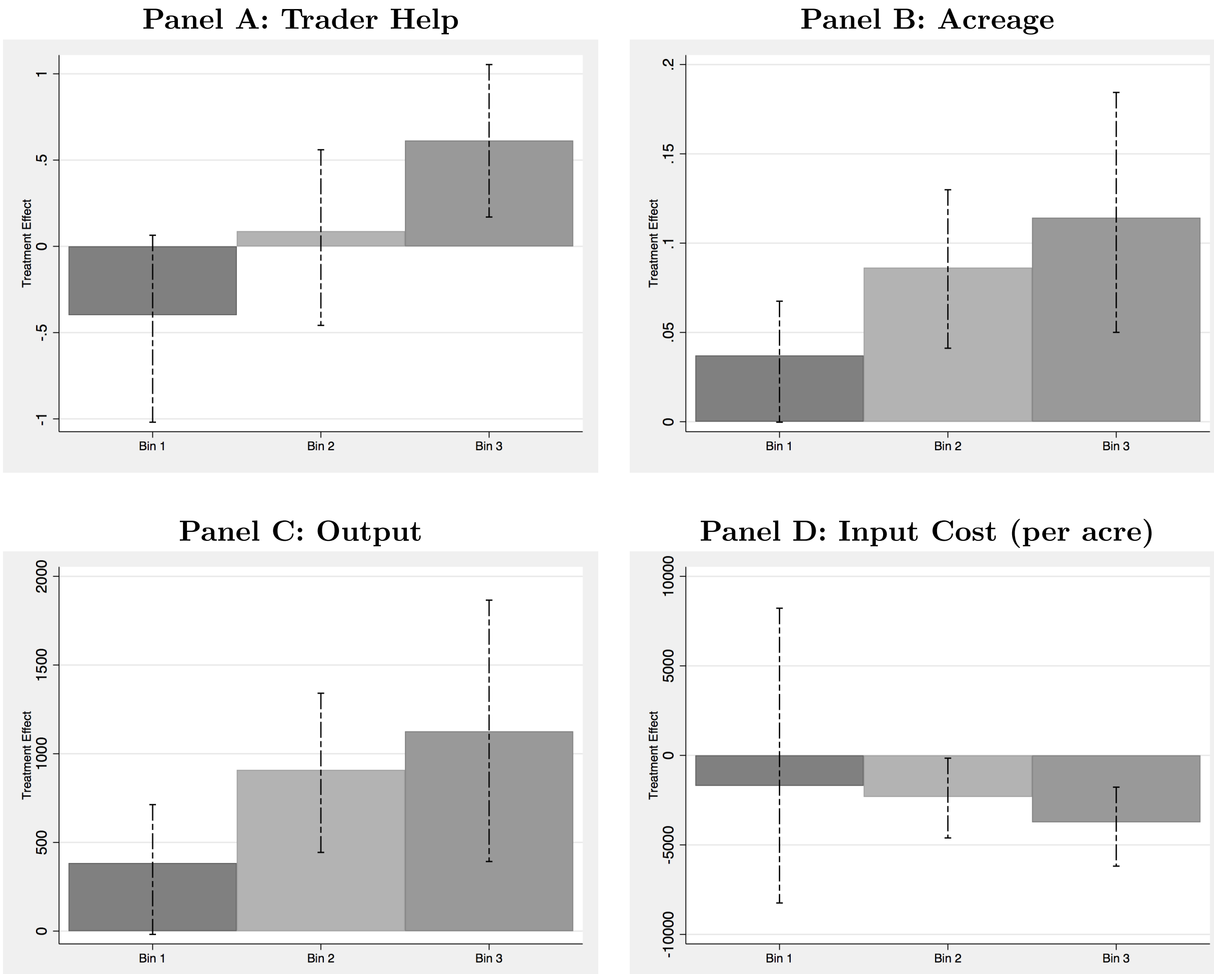
Notes: The sample is restricted to Control 1 households in TRAIL and GRAIL villages. Productivity is computed using the logarithm of acreage under potato cultivation. The null hypothesis that the distributions of estimated productivity for TRAIL Control 1 and GRAIL Control 1 households are equal is rejected by a two sample Kolmogorov-Smirnov (KS) test with $p - value = 0.06$.

Figure 3: Variation in Farm Value Added for Treatment and Control 1 groups by Productivity



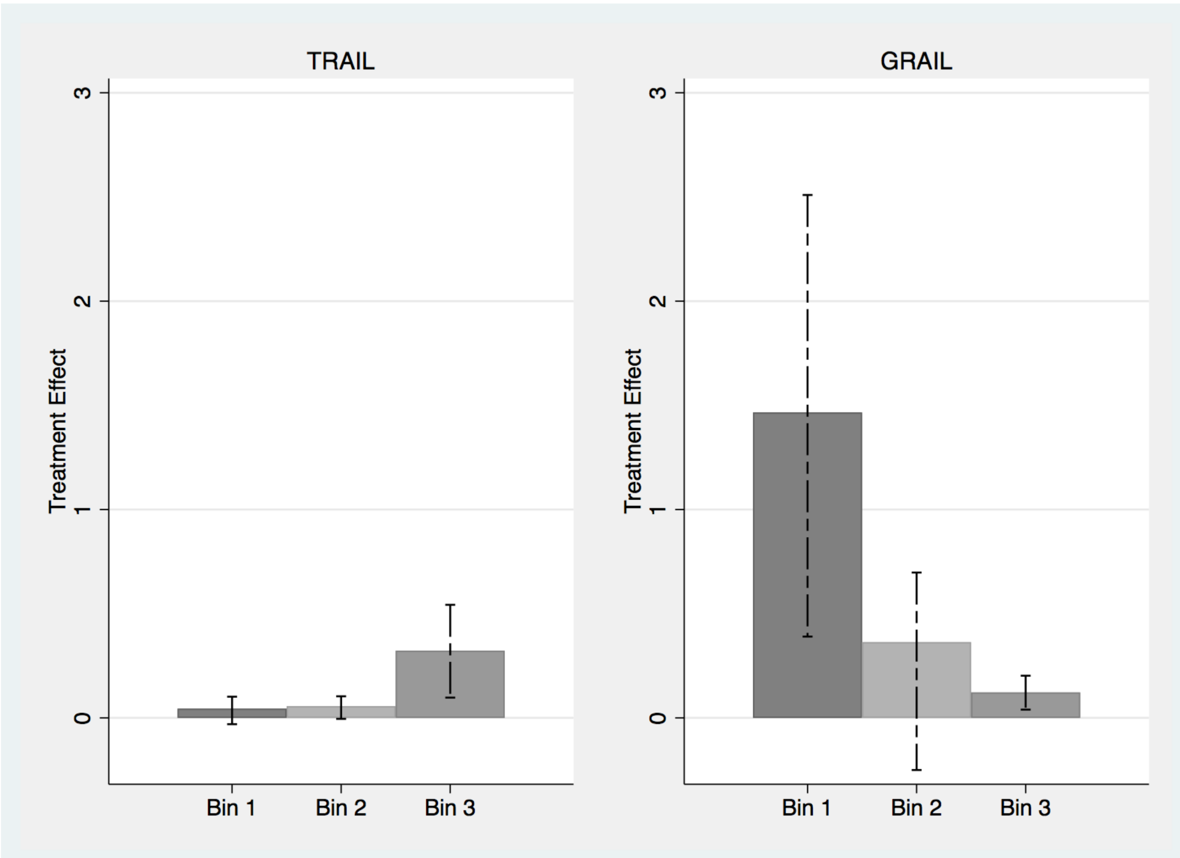
Notes: Lowess plot of farm value added from potato cultivation on productivity presented. Separate lowess plots presented for Treatment and Control1 households in TRAIL and GRAIL villages.

Figure 4: Conditional Heterogeneous TRAIL Treatment Effects on Trader Help, Acreage, Output and Input Cost per acre (Potato)



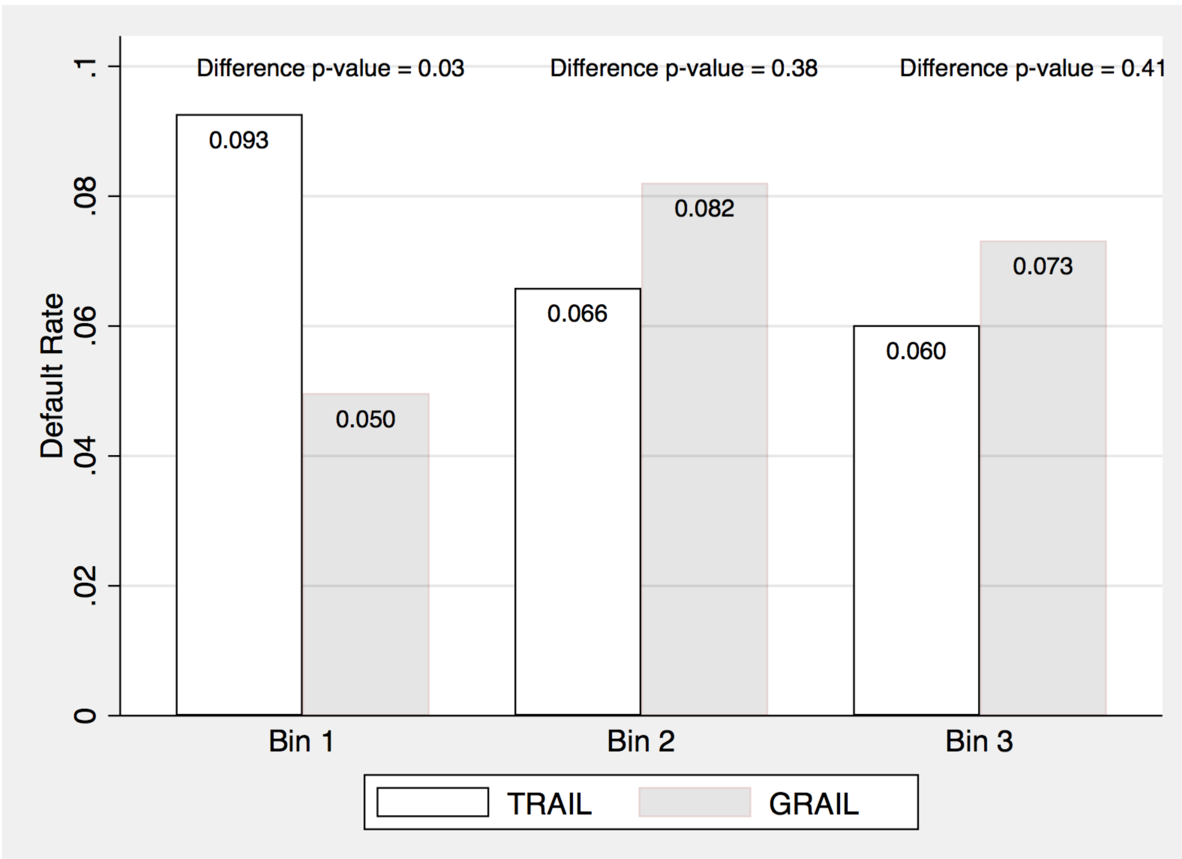
Notes: Conditional Heterogeneous TRAIL treatment effects of trader help, potato acreage, potato output and input cost per acre in potato cultivation by productivity bin presented. The estimating equation follows equation (5) in the text. In Panel A, Trader Help measured by the number of times in the past year the responder talked to local trader or agent about agricultural cultivation related matters. The bars denote the conditional heterogeneous treatment effects by productivity bin. The lines denote the bootstrapped 95% confidence interval (2000 iterations). Estimating sample includes Treatment and Control1 households.

Figure 5: Conditional Heterogeneous Treatment Effects on Agent Engagement (TRAIL vs GRAIL)



Notes: Agent Engagement measured by the number of times in the past year the responder talked to the agent about agricultural cultivation related matters. The bars denote the conditional heterogeneous treatment effects by productivity bin. The lines denote the bootstrapped 95% confidence interval (2000 iterations). Estimating sample includes Treatment and Control1 households.

Figure 6: Default Rates on TRAIL and GRAIL Loans, by Productivity Bin



Notes: The height of each bar measures the fraction of program loans that were not repaid fully by the due date. The sample is restricted to Treatment households in TRAIL and GRAIL villages with at most 1.5 acres of land. p-value of difference between default rate between TRAIL and GRAIL for each Bin presented. Productivity is computed using the logarithm of the acreage under potato cultivation.

Table 1: Randomization

	TRAIL (1)	GRAIL (2)	TRAIL — GRAIL (3)
Panel A: Village level characteristics			
Number of Households	276.04	252.21	23.83
	(201.59)	(238.36)	
Number of Potato Cultivators	164.63	160.75	3.88
	(130.30)	(168.39)	
Of which:			
Landless	15.96	27.96	-12.00
	(18.98)	(75.63)	
Own $0 - 1.25$ acres	113.88	99.67	14.21
	(103.22)	(78.00)	
Own $1.25 - 2.50$ acres	25.58	24.63	0.96
	(16.27)	(25.20)	
Own $2.50 - 5.00$ acres	10.88	12.83	-1.96
	(7.39)	(17.11)	
Own $5.00 - 12.50$ acres	1.38	1.17	0.21
	(1.79)	(1.95)	
Own more than 12.50 acres	0.00	0.04	-0.04
	(0.00)	(0.20)	
Panel B: Household level characteristics			
Head: More than Primary School	0.407	0.420	-0.013
	(0.015)	(0.015)	
Head: Cultivator	0.441	0.415	0.026
	(0.015)	(0.015)	
Head: Labourer	0.340	0.343	-0.003
	(0.015)	(0.015)	
Landholding (Acres)	0.456	0.443	0.013
	(0.013)	(0.013)	
Area of house and homestead (Acres)	0.052	0.052	0.000
	(0.001)	(0.002)	
Separate toilet in house	0.564	0.608	-0.044
	(0.015)	(0.015)	
Own a motorized vehicle	0.124	0.126	-0.002
	(0.010)	(0.010)	
Own a Savings Bank Account	0.447	0.475	-0.028
	(0.015)	(0.015)	

Notes: Panel A uses data from the houselisting exercise we carried out in 2007. Since 2 of the villages from the 2007 sample had to be replaced due to Maoist violence, Panel A uses a sample of only 46 villages. Panel B uses household survey data from 2010 for all 48 villages for sample households that owned no more than 1.5 acres of land. Standard errors in parentheses. $^{***}: p < 0.01; ^{**}: p < 0.05; ^{*}: p < 0.1$.

Table 2: Agent Characteristics

	GRAIL (1)	**TRAIL** (2)	**Difference** (3)
Male	1.00	0.958	0.042
	(0.00)	(0.042)	(0.042)
SC/ST	0.208	0.083	0.125
	(0.085)	(0.058)	(0.102)
Non-Hindu	0.125	0.083	0.042
	(0.069)	(0.058)	(0.090)
General caste	0.667	0.833	-0.167
	(0.098)	(0.078)	(0.125)
Primary Occupation: Cultivator	0.375	0.042	0.33***
	(0.101)	(0.042)	(0.109)
Primary Occupation: Shop/business	0.208	0.958	-0.667***
	(0.095)	(0.042)	(0.104)
Primary Occupation: Other	0.417	0.000	0.125*
	(0.690)	(0.000)	(0.690)
Owns agricultural land	2.63	3.29	-0.667**
	(0.198)	(0.244)	(0.314)
Total owned land	4.08	5.04	-0.958**
	(0.248)	(0.292)	(0.383)
Has *pucca* house	0.375	0.458	-0.083
	(0.101)	(0.104)	(0.145)
Educated above primary school	0.958	0.792	0.167*
	(0.042)	(0.085)	(0.094)
Weekly income (Rupees)	1102.895	1668.75	-565.855
	(138.99)	(278.16)	(336.78)
Village society member	0.292	0.083	0.208*
	(0.095)	(0.058)	(0.111)
Party hierarchy member	0.167	0.000	0.167**
	(0.078)	(0.00)	(0.079)
Panchayat member	0.125	0.000	0.125*
	(0.069)	(0.00)	(0.069)
Self/family ran for village head	0.083	0.000	0.083
	(0.058)	(0.00)	(0.058)

Notes: Sample consists of 24 agents in TRAIL villages and 24 agents in GRAIL villages. Standard errors in parenthesis. $^{***}: p < 0.01; ^{**}: p < 0.05; ^{*}: p < 0.1$.

Table 3: Pre-Intervention Social and Economic Engagement with the Agent

	TRAIL		**GRAIL**		**Difference (TRAIL–GRAIL)**†	
	Non-recommended	Recommended	Non-recommended	Recommended	Non-recommended	Recommended
	(1)	(2)	(3)	(4)	(5)	(6)
Agent and Household belong to same caste/religion category‡	0.45	0.53	0.61	0.68	-0.16***	-0.15***
	(0.021)	(0.023)	(0.020)	(0.022)	(0.03)	(0.03)
Respondent knows Agent	0.90	0.96	0.91	0.97	-0.01	-0.01
	(0.013)	(0.009)	(0.012)	(0.008)	(0.02)	(0.02)
Respondent meets Agent at least once a week*	0.98	1.00	0.98	1.00	-0.01	0.00
	(0.007)	(0.002)	(0.006)	(0.003)	(0.01)	(0.00)
Household member invited by Agent on special occasions	0.31	0.45	0.27	0.39	0.04	0.06***
	(0.020)	(0.024)	(0.019)	(0.023)	(0.03)	(0.03)
Agent is one of the two most important						
Moneylenders	0.17	0.21	0.08	0.10	0.08***	0.11***
	(0.016)	(0.019)	(0.012)	(0.014)	(0.12)	(0.02)
Input suppliers	0.18	0.24	0.08	0.09	0.10***	0.14***
	(0.016)	(0.020)	(0.011)	(0.014)	(0.02)	(0.02)
Output buyers	0.18	0.25	0.02	0.04	0.16***	0.21***
	(0.016)	(0.020)	(0.006)	(0.009)	(0.02)	(0.02)
Employers	0.12	0.10	0.08	0.07	0.04**	0.03*
	(0.013)	(0.014)	(0.011)	(0.012)	(0.02)	(0.02)
In the last 3 years household has						
Bought from Agent	0.33	0.41	0.05	0.07	0.28 ***	0.34***
	(0.020)	(0.023)	(0.009)	(0.012)	(0.02)	(0.03)
Borrowed from Agent	0.14	0.25	0.04	0.09	0.10***	0.16***
	(0.015)	(0.020)	(0.008)	(0.013)	(0.01)	(0.02)
Worked for Agent	0.10	0.13	0.09	0.11	0.01	0.02
	(0.012)	(0.016)	(0.012)	(0.014)	(0.02)	(0.02)
Household Sold Potatoes to Agent (% of Transactions)	0.109	0.171	0.020	0.027	0.089***	0.143***
	(0.312)	(0.377)	(0.142)	(0.163)	(0.02)	(0.02)
Household has been selling Potatoes to Agent for longer than one year♣	0.870	0.877	0.556	0.615	0.315*	0.261**
	(0.339)	(0.331)	(0.527)	(0.506)	(0.133)	(0.107)

Notes: The TRAIL agent was a randomly selected trader in the village. The GRAIL agent was selected by the local government. Recommended households include Treatment and Control 1 households. Non-recommended households include Control 2 households. Sample restricted to all households with 1.5 acres of land in TRAIL and GRAIL villages.‡: The farmer belongs to same the religion category (Hindu/Non-Hindu) or caste category (Scheduled caste/Scheduled tribe, or General) as the agent. ♣: Conditional on selling to the agent. *: Conditional on knowing the agent. †: The differences in columns 5 and 6 denote TRAIL—GRAIL for the specific sub-group (Non-recommended or Recommended) households.

Table 4: Baseline Credit Market characteristics

	All Loans (1)		Agricultural Loans (2)	
Household had borrowed	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	
Government 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)
Government 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)
Government 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	
Government Banks	0.81		0.83	
MFI and Other Sources	0.01		0.01	

Notes:
Statistics are reported for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. All characteristics are for loans taken by the households in Cycle 1. Program loans are not included. For the interest rate summary statistics loans where the principal amount is reported equal to the repayment amount are not included. To arrive at representative estimates for the study area, 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. ‡: Proportion of loans in terms of value of loans at the household level. All proportions are computed only over households that borrowed. Standard deviations are in parentheses.

Table 5: Average Treatment Effects on Agricultural Borrowing

	All Agricultural Loans (Rs.) (1)	Non Program Agricultural Loans† (Rs.) (2)
TRAIL Treatment	7517***	-385.9
	(817.6)	(653.8)
Mean TRAIL C1	5590	5590
% Effect TRAIL	134.472	-6.903
GRAIL Treatment	7341***	-250.7
	(816.3)	(570.4)
Mean GRAIL C1	5016	5016
% Effect GRAIL	146.352	-4.998
TRAIL v. GRAIL Treatment	176.5	-135.2
	(1162)	(869.5)
Sample Size	6,156	6,156

Notes: Treatment effects are computed from regressions that follow equation (1) in the text and 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 eldest male member of the household, household's landholding, a set of year dummies and an information village dummy. % Effect: Treatment effect as a percentage of the mean of the relevant Control 1 group. †: Non-Program loans refer to loans from sources other than the TRAIL or GRAIL schemes. Standard errors in parentheses are clustered at the hamlet level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 6: Average Treatment Effects in Potato Cultivation

	Cultivate	Acreage (Acres)	Production (Kgs)	Cost of Production (Rs.)	Price (Rs./Kgs)	Revenue (Rs.)	Value Added (Rs.)	Imputed Profit (Rs.)	Input Cost (Rs.)	Input Cost Per acre (Rs./Acres)	Index Variable
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
TRAIL Treatment	0.040	0.093***	946.368***	1846.025**	-0.030	3898.401***	2059.235***	1906.696***	3049.126**	-2908.838***	0.180***
	(0.028)	(0.028)	(302.239)	(722.561)	(0.099)	(1204.271)	(631.241)	(600.595)	(1316.601)	(1015.032)	(0.054)
Mean TRAIL C1	0.715	0.336	3646.124	8481.751	4.627	14285.467	5732.357	4733.770	16288.501	49076.876	
% Effect TRAIL	5.63	27.58	25.96	21.76	-0.650	27.29	35.92	40.28	18.719	-5.927	
GRAIL Treatment	0.130***	0.069**	770.916**	2007.117**	-0.176	2500.996*	492.395	190.292	3886.833***	554.147	0.142**
	(0.029)	(0.029)	(340.084)	(779.852)	(0.110)	(1377.891)	(744.349)	(720.068)	(1389.776)	(1098.176)	(0.062)
Mean GRAIL C1	0.641	0.296	3236.730	7070.653	4.800	12964.776	5827.663	4941.511	13454.993	47510.733	
% Effect GRAIL	20.33	23.25	23.82	28.39	-3.665	19.29	8.45	3.85	28.888	1.166	
TRAIL v. GRAIL	-0.090**	0.024	175.452	-161.092	0.146	1397.405	1566.839	1716.404*	-837.707	-3462.985**	0.038
Treatment	(0.040)	(0.041)	(457.836)	(1067.944)	(0.145)	(1838.410)	(979.876)	(941.279)	(1923.972)	(1499.369)	(0.083)
Sample Size	6,150	6,150	6,150	6,150	3,820	6,150	6,150	6,150	6150	4038	6150

Notes: Treatment effects are computed from regressions that follow equation (1) in the text and are run on household-year level data for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. The dependent variable in column 1 takes the value of 1 if the household cultivated potato in that year, 0 otherwise. The dependent variables in columns 2—9 take the actual value reported by the household if it did, or take the value zero if it did not cultivate potatoes in that year. In column 10, households that did not cultivate potatoes in a year are dropped from the estimating 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. % Effect: Treatment effect as a percentage of the mean of the relevant Control 1 group. Imputed profit = Value Added – shadow cost of labour. In column 11, the dependent variable is an index of z-scores of the outcome variables in the panel; the p-values for treatment effects in this column are computed according to Hochberg (1988)'s step-up method to control for the family-weighted error rate across all index outcomes. Standard errors in parentheses are clustered at the hamlet level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 7: Average Treatment Effects on Farm Value Added, Non Agricultural Income and Total Household Income

	Farm Value Added (Rs.)	Non Agricultural Income (Rs.)	Household Income (Rs.)
	(1)	(2)	(3)
TRAIL Treatment	2147.874***	1506.785	5612.479
	(723.935)	(3655.543)	(4125.591)
Mean TRAIL C1	10336.511	33617.764	49765.238
% Effect TRAIL	20.779	4.482	11.278
GRAIL Treatment	138.905	-4326.522	-5434.789
	(929.675)	(3225.654)	(4496.421)
Mean GRAIL C1	10501.064	37170.751	56082.489
% Effect GRAIL	1.323	-11.640	-9.691
TRAIL v. GRAIL Treatment	2008.969*	5833.307	11047.268*
	(1183.349)	(4879.593)	(6110.838)
Sample Size	6,156	6,159	6,156

Notes: Treatment effects are computed from regressions that follow equation (1) in the text and 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 eldest male member of the household, household's landholding, a set of year dummies and an information village dummy. % Effect: Treatment effect as a percentage of the mean of the relevant Control 1 group. Standard errors in parentheses are clustered at the hamlet level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 8: Loan Performance

	Take-up (1)	**Default** (2)
Panel A: Sample Means		
TRAIL	0.937	0.070
	(0.006)	(0.007)
GRAIL	0.872	0.070
	(0.009)	(0.008)
Difference (TRAIL–GRAIL)	0.065***	0.000
	(0.011)	(0.010)
Panel B: Regression Results		
GRAIL	-0.066 ***	0.005
	(0.011)	(0.010)
R^2	0.08	0.05
Sample Size	2667	2422

Notes: The sample consists of household-cycle level observations of Treatment households in TRAIL and GRAIL villages with at most 1.5 acres of landholding. The dependent variable in column 1 takes value 1 if the household took the program loan in the particular cycle, provided the household was eligible for the loan in that cycle. The dependent variable in column 2 takes value 1 if a borrowing household fails to fully repay the amount due on the loan taken in that cycle on the due date. The regression specification In Panel B is given by equation (2). Regressions also control for landholding, religion and caste of the household and age and educational attainment of the oldest male in the household. Robust standard errors. Significance $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 9: Variation of Productivity with Observable Household Characteristics

Regression Results	
Landholding	1.103***
	(0.115)
Non Hindu	-0.157
	(0.147)
Low Caste	-0.110
	(0.120)
Household Size	0.019
	(0.021)
Female-headed Household	-0.457**
	(0.217)
Age of Oldest Male	-0.004
	(0.003)
Oldest Male: Completed Primary School	0.080
	(0.084)
Constant	1.212***
	(0.188)
Sample Size	1,000
R-squared	0.163
Descriptives on farm productivity	
Mean of Productivity	1.707
SD of Productivity	1.148
Minimum Productivity	-1.294
Productivity Quartile 25%	0.811
Productivity Quartile 50%	2.014
Productivity Quartile 75%	2.638
Maximum Productivity	3.702

Notes: The dependent variable is the household productivity estimate. Standard errors in parentheses are clustered at the hamlet level. The etimating sample includes cultivator Control 1 and Control 2 households in TRAIL and GRAIL villages with at most 1.5 acres of land. Significance $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 10: Comparing selection in TRAIL and GRAIL villages. Descriptive Statistics on Productivity.

	TRAIL (1)	GRAIL (2)
% Cultivators	72.65	65.53
Mean of Productivity	1.787	1.618
SD of Productivity	1.082	1.214
Minimum Productivity	-1.294	-1.111
Productivity Quartile 25%	0.845	0.677
Productivity Quartile 50%	2.037	1.908
Productivity Quartile 75%	2.693	2.559
Maximum Productivity	3.702	3.651

Notes: Sample restricted to cultivator Control 1 households TRAIL and GRAIL villages with at most 1.5 acres of land.

Table 11: Conditional Treatment Effects by Productivity Bin. Potato Cultivation only

	Cultivate (0/1) (1)	Acreage (Acres) (2)	Output (Kgs) (3)	Cost (Total) (Rs.) (4)	Price (Rs./Kgs) (5)	Revenue (Rs.) (6)	Value Added (Rs.) (7)	Imputed Profit (Rs.) (8)	Input Cost (Rs.) (9)	Input Cost (Per acre) (Rs./Acres) (10)
Panel A: TRAIL										
Bin 1	0.08†	0.04†	383.82	696.46	0.27	1740.24	1040.43	930.02	1404.31	-1701.34
	(0.03)	(0.02)	(179.66)	(444.71)	(0.19)	(799.82)	(461.01)	(439.59)	(867.58)	(5217.85)
Bin 2	0.01	0.09†	909.28†	2132.54†	-0.13	3701.22†	1561.19†	1458.58†	3629.66†	-2320.53
	(0.02)	(0.03)	(274.25)	(638.20)	(0.11)	(1116.50)	(616.88)	(590.20)	(1380.78)	(1624.29)
Bin 3	0.00	0.11†	1126.38†	1814.68	0.03	4617.76†	2834.05†	2668.16†	2614.40	-3737.34†
	(0.00)	(0.04)	(488.62)	(1252.25)	(0.16)	(2127.12)	(1296.70)	(1268.49)	(2162.73)	(1334.26)
Panel B: GRAIL										
Bin 1	0.26†	0.03†	287.04	892.40†	-0.21	923.13	30.37	-265.08	1882.20†	6768.55†
	(0.04)	(0.02)	(191.71)	(392.02)	(0.16)	(754.42)	(436.82)	(419.17)	(782.34)	(2949.59)
Bin 2	0.12†	0.08†	844.40†	2461.04†	-0.27	3022.03†	551.22	301.55	4002.05†	-1881.26
	(0.02)	(0.03)	(277.39)	(622.18)	(0.22)	(1214.53)	(776.04)	(752.09)	(1350.70)	(1708.23)
Bin 3	0.00	0.11†	1418.74†	3210.20†	-0.12	4499.38†	1291.41	900.73	6777.32†	1552.87
	(0.00)	(0.05)	(570.73)	(1254.91)	(0.10)	(2438.55)	(1705.78)	(1713.97)	(2271.26)	(1561.18)
Panel C: TRAIL - GRAIL Difference										
Bin 1	-0.18†	0.01	96.79	-195.94	0.47†	817.11	1010.06	1195.10	-477.89	-8469.90
	(0.05)	(0.02)	(269.90)	(608.30)	(0.25)	(1135.25)	(652.15)	(622.94)	(1197.94)	(5981.13)
Bin 2	-0.11†	0.00	64.88	-328.49	0.14	679.19	1009.97	1157.03	-372.38	-439.27
	(0.03)	(0.04)	(388.58)	(887.63)	(0.24)	(1650.43)	(997.51)	(962.31)	(1921.03)	(2374.94)
Bin 3	0.00	0.00	-292.36	-1395.52	0.16	118.38	1542.63	1767.44	-4162.92	-5290.21†
	(0.00)	(0.06)	(751.62)	(1773.03)	(0.19)	(3235.01)	(2147.61)	(2137.38)	(3134.61)	(2061.19)
Sample Size	6,150	6,150	6,150	6,150	3,820	6,150	6,150	6,150	6,150	4,038

Notes: The estimating equation follows equation (5) in the text. The estimating sample includes all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. The dependent variable in column 1 takes the value of 1 if the household cultivated potato in that year, 0 otherwise. The dependent variables in columns 2—9 take the actual value reported by the household if it did, or take the value zero if it did not cultivate potatoes in that year. In column 10, households that did not cultivate potatoes in a year are dropped from the estimating sample. The 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. Productivity is computed using the logarithm of the acreage under potato cultivation. Standard errors in parentheses are clustered at the hamlet level. †: Bootstrapped 90% confidence interval (2000 iterations) does not include 0.

Table 12: Decomposition of ATE Differences in Value-added from Potato Cultivation; TRAIL v. GRAIL

	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 = (3) × (4))	(8 = (2) × (6))
Bin 1	0.27	0.34	-0.07	1040.4	30.4	1010.1	-74.1	348.2
Bin 2	0.33	0.33	0.00	1561.2	551.2	1010.0	-4.5	335.2
Bin 3	0.40	0.32	0.07	2834.1	1291.4	1542.6	209.8	498.9
ATE				2059.2	492.4	1566.8		
% of ATE due to Selection								8.38
% of ATE due to CTE								75.46

Notes: σ_k^T denotes the proportion of TRAIL households in Bin k; σ_k^G denotes the proportion of GRAIL households in Bin k. % of ATE due to selection computed as $\sum_{k=1}^{3} \frac{((\sigma_k^T - \sigma_k^G) \times T_k^T}{\text{ATE}}$.

Table 13: Variation of Informal Interest Rate, Trader Help, Output and Input Cost per acre by Productivity

	TRAIL and GRAIL Control Households			TRAIL Treatment Households		
	Interest Rate	Output	Input Cost (per acre)	Trader Help	Output	Input Cost (per acre)
	(1)	(2)	(3)	(4)	(5)	(6)
Productivity	-0.007	907.774***	-182.203	0.368***	1,219.652***	-1,042.832***
	(0.004)	(40.407)	(194.776)	(0.068)	(133.88)	(375.664)
Productivity squared	0.001	679.859***	-352.578***	-0.033	685.131***	-101.632
	(0.002)	(23.831)	(89.164)	(0.044)	(48.367)	(168.138)
Constant	0.196***	486.300***	42,641.482***	3.100***	697.368***	41,291.774***
	(0.012)	(139.244)	(705.384)	(0.430)	(255.379)	(1090.398)
Sample Size	524	2,876	2,876	681	500	500

Notes: OLS regression results presented. In column 1, the dependent variable is average interest rate paid on informal loans by households prior to the intervention. In columns 2 and 5, the dependent variable is the quantity of potato produced (in Kgs). In columns 3 and 6, the dependent variable is input cost per acre in potato cultivation (in Rs.). In column 4, the dependent variable is Help from trader, measured as the of times in the year the household reported engaging with the local trader on agricultural matters. Sample in columns 1–3 restricted to Control 1 and Control 2 households in TRAIL and GRAIL villages with at most 1.5 acres of land. Sample in columns 4–6 restricted to Treatment households in TRAIL villages with at most 1.5 acres of land. In columns 2–6, the regressions also control for year dummies. Standard errors in parentheses are cluster-bootstrapped at the hamlet-level with 2000 iterations. Productivity is computed using the logarithm of the acreage under potato cultivation. Significance $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 14: Effect of Treatment on Voting Patterns in Straw Poll

	Average Treatment Effect		Heterogeneous Treatment Effect	
	TRAIL	GRAIL	TRAIL	GRAIL
	(1)	(2)	(3)	(4)
Treatment Effect	0.0241	0.0782**		
	(0.0496)	(0.0340)		
Treatment Effect: Bin 1			0.0915	0.130†
			(0.0868)	(0.0697)
Treatment Effect: Bin 2			-0.0741	0.0309
			(0.0805)	(0.0702)
Treatment Effect: Bin 3			0.0568	0.0135
			(0.0564)	(0.0743)
Selection Effect	-0.0649	0.0825**		
	(0.0447)	(0.0369)		
Selection Effect: Bin 1			-0.133	0.0217
			(0.0610)	(0.0580)
Selection Effect: Bin 2			-0.0291	0.117†
			(0.0738)	(0.0664)
Selection Effect: Bin 3			-0.0343	0.105†
			(0.0594)	(0.0718)
Sample Size	1,011	1,026	1,021	1,044

Notes: Estimating sample includes all sample households in TRAIL and GRAIL villages with at-most 1.5 acres of land. OLS regression results presented. Standard errors in parenthesis clustered at the hamlet level. Estimating sample includes all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. Productivity computed using logarithm of acreage under potato cultivation. Significance $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$. † : Bootstrapped confidence interval with 2000 iterations does not include 0.

A1 Appendix: Proof of Proposition 3

In the CE case, we can obtain closed form expressions for area cultivated, help and unit costs of Bin 1 farmers, as a function of agent monitoring ($m(\theta) = m^G(\theta)$ in GRAIL, zero in TRAIL):

$$\begin{aligned} l(\theta) =& [\{(1+\tau)A(\theta, m(\theta))\}^{1+\nu}\{\frac{\nu}{c_T}\}^{\nu}\{(1-\psi)p(\theta, m(\theta))r_T\}^{-1} \\ & (1+m(\theta))^{-\mu_2(1-\nu)}]^{\frac{1}{\alpha-\nu(1-\alpha)}} \quad \text{(A1)} \\ [1+h(\theta)]^{1+\nu} =& [\{(1+\tau)A(\theta, m(\theta))\}^{1+\nu}\{\frac{\nu}{c_T}\}^{\alpha(1+\nu)}\{(1-\psi)p(\theta, m(\theta))r_T\}^{-(1-\alpha)(1+\nu)} \\ & (1+m(\theta))^{\mu_2[\alpha(1+\nu)-1]}]^{\frac{1}{\alpha-\nu(1-\alpha)}} \quad \text{(A2)} \\ c(\theta) =& (1+m(\theta))^{\mu_2 \frac{\alpha-\nu(\nu-\alpha)}{(\nu+1)[\alpha-\nu(1-\alpha)]}} K^{\frac{1}{(\nu+1)[\alpha-\nu(1-\alpha)]}} \quad \text{(A3)} \end{aligned}$$

where

$$K \equiv [\frac{\nu}{c_T}]^{\frac{\alpha\nu}{1+\nu}}[(1-\psi)p(\theta, m(\theta)r_T]^{(1-\alpha)(1+\nu)\nu}[(1+\tau)A(\theta, m(\theta))]^{-(1+\nu)\nu}$$

The result concerning area cultivated and unit cost comparisons follow from observing that (A1) is falling and (A3) is rising in $m(\theta)$ (the latter holds since $\alpha-\nu(\nu-\alpha) > \alpha-\nu(1-\alpha) > 0$).

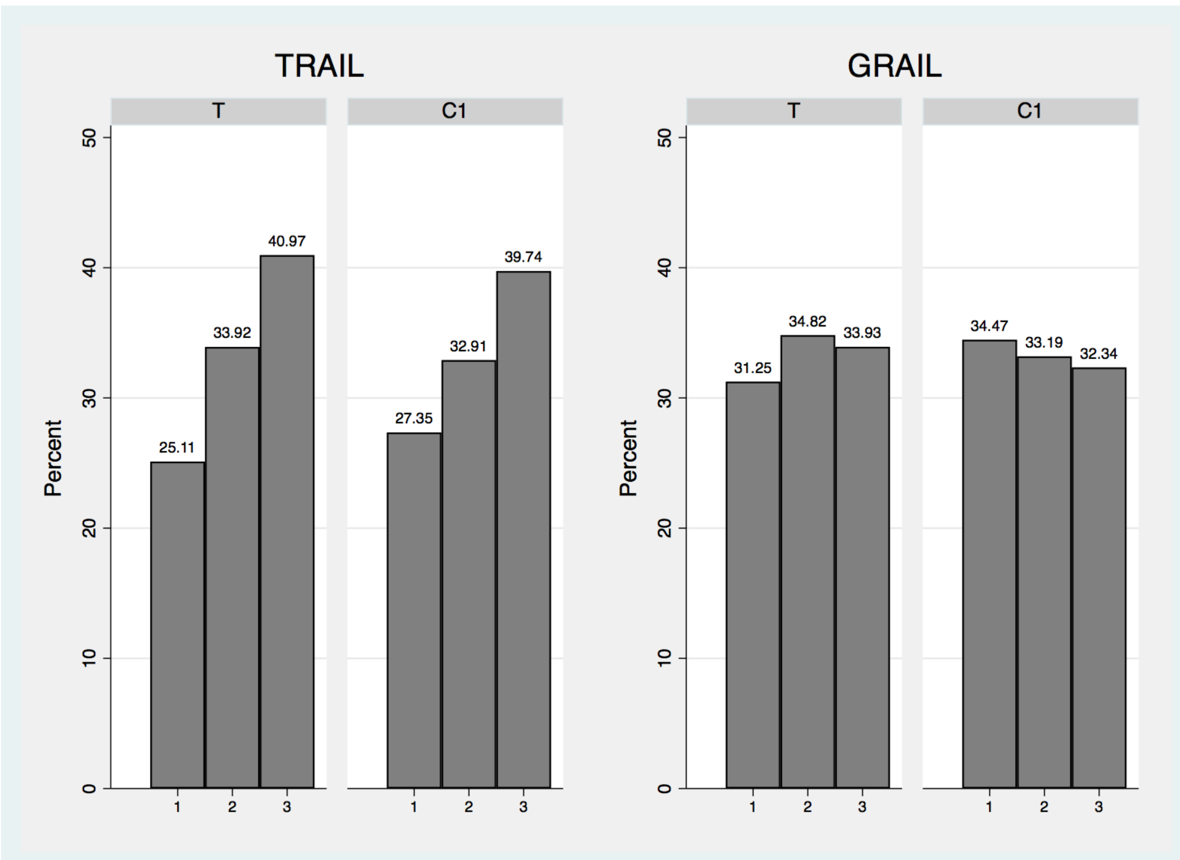
For Bins 2 and 3 the comparison of unit cost is more complicated, owing to the absence of closed-form expressions. Comparing equations (18) and (24) and using equation (25), we obtain $(1+h^G)^{-\nu-1}(1+m^G)^{\mu_2} \geq (1+h^T)^{-\nu-1}$, where we suppress the notation for dependence on θ. Hence unit cost of a GRAIL treated farmer $c^G = (1+h^G)^{-\nu}(1+m^G)^{\mu_2} > (1+h^G)^{-\nu}(1+m^G)^{\frac{\mu_2\nu}{1+\nu}} \geq (1+h^T)^{-\nu} = c^T$. ■

Finally, the comparison of value added follows from the result that unit cost is lower and productivity is higher in TRAIL (owing to less monitoring) for any given type, since value added for any given type is the result of choosing scale l to maximize

$$A^i f(L^C + l) - [\rho L^C + p^i r_T(1-\psi)l]c^i \quad \text{(A4)}$$

where A^i, p^i, c^i denote expected productivity, repayment rate and unit cost in intervention $i = T, G$ and L^C denotes pre-program scale for the given type, and we have $A^T > A^G, p^T < p^G, c^T < c^G$.

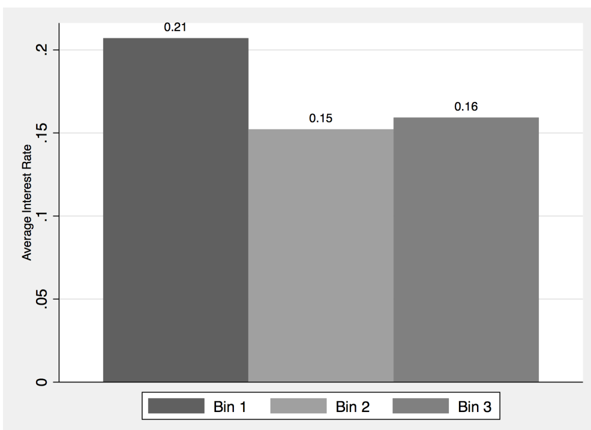
Figure A1: Percentage of households in each Productivity Bin



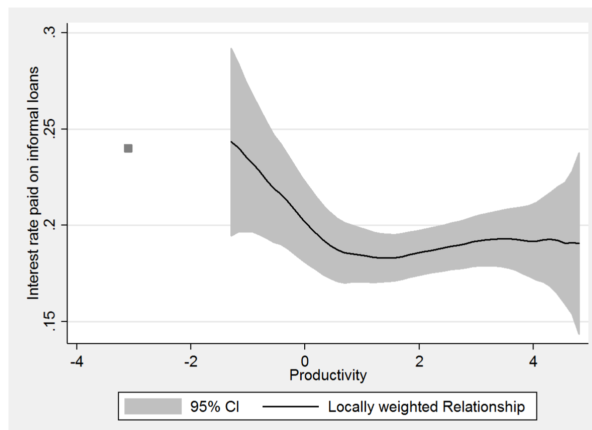
Notes: The height of the bars denote the fraction of households in each productivity Bin. Productivity is computed using the logarithm of acreage under potato cultivation.

Figure A2: Interest Rate on Informal Loans and Productivity. Control Households Only

Panel A: Average Informal Interest Rates



Panel B: Variation in Informal Interest Rates



Notes: The vertical axis measures the average interest rate paid on informal loans by households. The horizontal axis shows the productivity estimate. In the left panel, we compute the average interest rate for households in each productivity bin. The average interest rate paid on informal loans by households in productivity Bin 1 is significantly higher than that paid by households in productivity Bin 2 ($p-value=0.03$) and productivity Bin 3 ($p-value = 0.04$). In the right panel we present the locally weighted regressions in of interest paid on informal loans on productivity. The average interest rate paid by households in productivity Bin 1 is shown as a single point. The sample is restricted to Control 1 and Control 2 households in TRAIL and GRAIL villages with at most 1.5 acres of land. Productivity is computed using the logarithm of the acreage under potato cultivation.

Table A1: Cultivators and Non-cultivators. Differences in Demographic Characteristics

	Non Cultivators (1)	Cultivators (2)
Landholding	0.267	0.561
Non Hindu	0.239	0.139
Low Caste	0.419	0.261
Household Size	4.440	4.806
Female Headed Household	0.101	0.031
Age of Oldest Male	45.280	49.007
Oldest Male: Completed Primary School	0.348	0.457

Notes: Households that cultivate potato at least 2 of the 3 survey years are categorized as cultivators.

Table A2: Robustness. Average Treatment Effects on Borrowing.

	Excluding Additional Controls		Village Level Clustering	
	All Agricultural Loans	Non Program Agricultural Loans	All Agricultural Loans	Non Program Agricultural Loans
	(1)	(2)	(3)	(4)
TRAIL Treatment	7538***	-377.3	7517***	-386.2
	(926.5)	(744.5)	(1124)	(599.6)
Mean TRAIL C1	5590	5590	5590	5590
% Effect TRAIL	134.848	-6.750	134.472	-6.909
GRAIL Treatment	8001***	371.2	7341***	-250.5
	(876)	(614.4)	(913.7)	(502.8)
Mean GRAIL C1	5016	5016	5016	5016
% Effect GRAIL	159.510	7.400	146.352	-4.994
TRAIL vs GRAIL Treatment	-462.9	-748.4	175.9	-135.8
	(1275)	(964.8)	(1453)	(769.5)
Sample Size	6,243	6,243	6,159	6,159

Notes: Treatment effects are computed from regressions that follow equation (1) in the text and 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 in columns 3 and 4 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. % Effect: Treatment effect as a percentage of the mean of the relevant Control 1 group. †: Non-Program loans refer to loans from sources other than the TRAIL or GRAIL schemes. In columns 1 and 2, standard errors in parentheses are clustered at the hamlet level. In columns 3 and 4, standard errors in parentheses are clustered at the village level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table A3: Panel A. Robustness. Average Treatment Effects in Potato Cultivation. Regressions with no Additional Controls

	Cultivate	Acreage (Acres)	Production (Kg)	Cost of Production (Rs)	Price (Rs/Kg)	Revenue (Rs)	Value Added (Rs)	Imputed profit (Rs)	Input Cost (Rs)	Input Cost per acre (Rs/acre)	Index Variables
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
TRAIL Treatment	0.04	0.09**	934.37**	1842.19**	-0.03	3839.97**	2005.47***	1852.20**	3027.82*	-2904.30***	0.18***
	(0.03)	(0.04)	(376.71)	(865.79)	(0.10)	(1495.02)	(752.46)	(716.06)	(1660.52)	(1072.87)	(0.07)
Mean TRAIL C1	0.72	0.34	3646.12	8481.75	4.63	14285.47	5732.36	4733.77	16288.50	49076.88	0.05
% Effect TRAIL	6.25	27.21	25.63	21.72	-0.68	26.88	34.99	39.13	18.59	-5.92	362.36
GRAIL Treatment	0.15***	0.10***	1127.11***	2755.10***	-0.18	4033.85**	1267.60	913.02	5459.37***	700.20	0.21***
	(0.03)	(0.03)	(378.38)	(824.74)	(0.12)	(1554.91)	(857.83)	(826.72)	(1522.90)	(1048.81)	(0.07)
Mean GRAIL C1	0.64	0.30	3236.73	7070.65	4.80	12964.78	5827.66	4941.51	13454.99	47510.73	-0.02
% Effect GRAIL	23.79	34.29	34.82	38.97	-3.83	31.11	21.75	18.48	40.58	1.47	-869.23
TRAIL v. GRAIL Treatment	-0.11**	-0.01	-192.74	-912.91	0.15	-193.88	737.87	939.18	-2431.54	-3604.50**	-0.03
	(0.05)	(0.05)	(533.63)	(1195.00)	(0.15)	(2155.41)	(1140.18)	(1092.87)	(2251.67)	(1500.80)	(0.10)
Sample Size	6,237	6,237	6,237	6,237	3,843	6,237	6,237	6,237	6,237	4,061	6,237

Notes: Treatment effects are computed from regressions that follow a restricted version of equation (1) in the text and are run on household-year level data for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. The dependent variable in column 1 takes the value of 1 if the household cultivated potato in that year, 0 otherwise. The dependent variables in columns 2—9 take the actual value reported by the household if it did, or take the value zero if it did not cultivate potatoes in that year. In column 10, households that did not cultivate potatoes in a year are dropped from the estimating sample. Regressions also control for a set of year dummies and an information village dummy. % Effect: Treatment effect as a percentage of the mean of the relevant Control 1 group. Standard errors in parentheses are clustered at the hamlet level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table A3: Panel B. Robustness. Average Treatment Effects in Potato Cultivation. Regressions with SEs clustered at the village level

	Cultivate	Acreage (Acres)	Production (Kg)	Cost of Production (Rs)	Price (Rs/Kg)	Revenue (Rs)	Value Added (Rs)	Imputed profit (Rs)	Input Cost (Rs)	Input Cost per acre (Rs/acre)	Index Variables
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
TRAIL Treatment	0.04	0.09***	946.10***	1845.43***	-0.03	3897.28***	2058.71***	1906.18***	3047.95***	-2910.32***	0.18***
	(0.03)	(0.02)	(256.12)	(648.20)	(0.09)	(1098.41)	(559.84)	(544.32)	(1189.33)	(900.72)	(0.05)
Mean TRAIL C1	0.72	0.34	3646.12	8481.75	4.63	14285.47	5732.36	4733.77	16288.50	49076.88	0.05
% Effect TRAIL	5.63	27.58	25.95	21.76	-0.65	27.28	35.91	40.27	18.71	-5.93	365.12
GRAIL Treatment	0.13***	0.07***	770.95***	2007.20***	-0.18	2501.15**	492.47	190.36	3886.99***	550.94	0.14***
	(0.03)	(0.02)	(273.22)	(624.02)	(0.14)	(1059.90)	(676.98)	(652.96)	(1174.36)	(1091.80)	(0.05)
Mean GRAIL C1	0.64	0.30	3236.73	7070.65	4.80	12964.78	5827.66	4941.51	13454.99	47510.73	-0.02
% Effect GRAIL	20.33	23.25	23.82	28.39	-3.66	19.29	8.45	3.85	28.89	1.16	-581.15
TRAIL v. GRAIL Treatment	-0.09**	0.02	175.14	-161.77	0.15	1396.12	1566.24*	1715.82**	-839.04	-3461.26**	0.04
	(0.04)	(0.04)	(383.88)	(913.29)	(0.16)	(1561.45)	(890.85)	(861.55)	(1695.62)	(1420.65)	(0.07)
Sample Size	6,153	6,153	6,153	6,153	3,821	6,153	6,153	6,153	6,153	4,041	6,153

Notes: Treatment effects are computed from regressions that follow equation (1) in the text and are run on household-year level data for all sample households in TRAIL and GRAIL villages with at most 1.5 acres of land. The dependent variable in column 1 takes the value of 1 if the household cultivated potato in that year, 0 otherwise. The dependent variables in columns 2—9 take the actual value reported by the household if it did, or take the value zero if it did not cultivate potatoes in that year. In column 10, households that did not cultivate potatoes in a year are dropped from the estimating 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. % Effect: Treatment effect as a percentage of the mean of the relevant Control 1 group. Standard errors in parentheses are clustered at the village level. $^{***}: p < 0.01$, $^{**}: p < 0.05$, $^{*}: p < 0.1$.

Table A4: Robustness. Average Treatment Effects on Farm Value Added, Non Agricultural Income and Total Household Income.

	Excluding Additional Controls			Village Level Clustering		
	Farm Value Added (Rs)	Non Agricultural Income (Rs)	Household Income (Rs)	Farm Value Added (Rs)	Non Agricultural Income (Rs)	Household Income (Rs)
	(1)	(2)	(3)	(4)	(5)	(6)
TRAIL Treatment	2116.89**	1192.26	5460.31	2147.32***	1507.26	5612.18
	(959.03)	(3669.52)	(4135.26)	(642.86)	(3062.63)	(3467.44)
Mean TRAIL C1	10336.51	33617.76	49765.24	10336.51	33617.76	49765.24
% Effect TRAIL	20.48	3.55	10.97	20.77	4.48	11.28
GRAIL Treatment	1369.59	-4015.76	-2557.88	139.29	-4326.85	-5434.58
	(1148.30)	(3198.67)	(4640.83)	(895.42)	(2945.70)	(3573.66)
Mean GRAIL C1	10501.06	37170.75	56082.49	10501.06	37170.75	56082.49
% Effect GRAIL	13.04	-10.80	-4.56	1.33	-11.64	-9.69
TRAIL v. GRAIL Treatment	747.30	5208.02	8018.19	2008.03*	5834.11	11046.76**
	(1496.27)	(4869.25)	(6226.41)	(1118.82)	(4243.60)	(4970.22)
Sample Size	6,243	6,246	6,243	6,159	6,162	6,159

Notes: Treatment effects are computed from regressions that follow a restricted version of equation (1) in the text and 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 in columns 4—6 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. % Effect: Treatment effect as a percentage of the mean of the relevant Control 1 group. †: Non-Program loans refer to loans from sources other than the TRAIL or GRAIL schemes. In columns 1—3, standard errors in parentheses are clustered at the hamlet level. In columns 4—6, standard errors in parentheses are clustered at the village level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.