Does Credit Access Improve Firm Output and Technical Efficiency? Evidence from a Field Experiment in Bangladesh

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ABSTRACT

Recent empirical evidence shows that expanding credit access for firms in developing countries results in output improvements. However, relaxing credit constraints could also influence how firms use production inputs and how efficiently they transform them into output. Using a field experiment in Bangladesh, we estimate the causal impact of expanding credit access on microenterprise productivity and farmer technical efficiency for rice farmers in Bangladesh. We find that expanding access to credit results, on average, in 12.25 percent increase in farm efficiency. We also find that within the treatment group, households with more diversified production system- involvement in poultry and livestock activity- gain more (4.86 percent) from credit access whereas small farm size has negative effect on efficiency.

Keywords: field experiment, microfinance, credit, output, efficiency, productivity

JEL Codes: E22, H81, Q12, D2, O12, O16

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1. Introduction

Market imperfections and credit constraints are pervasive in informal financial markets in developing countries (Kirkpatrick, Clarke and Podiano 2002; Stiglitz, Emran and Morshed 2006; Bruhn, Karlan and Schoar 2010;). The rapid increase in microfinance funding in the last two decades has relaxed some of these constraints (Yunus 1989; Buttari 1995; Morduch 1999; Schreiner and Woller 2003; Yunus 2007; Sengupta and Aubuchon 2008; Armendariz and Morduch 2010). Recent empirical evidence based on microfinance interventions with informal microenterprises demonstrate positive marginal returns to capital and positive impacts on investment, business size, and profits (de Mel, McKenzie and Woodruff 2008; McKenzie and Woodruff 2008; Banerjee 2013; Banerjee and Duflo 2014; Banerjee et al. 2015; Karlan et al. 2013; Karlan, Knight and Udry 2015; Dodlova et al. 2015; Siba 2015; Crepon 2015; Grimm, Knorringa and Lay 2012; Grimm, Kruger and Lay 2011).[4] However, access to more credit influences the environment in which small farm households make production and investment decisions (Shah, Mullainathan and Shafir 2012). Expanding credit access can influence the interplay between the context of informal markets and a firm's capacity to transform inputs into output. Although credit expansion has positive impacts on a number of microenterprise outcomes (Banerjee et al. 2015) no previous credible evidence examines the effect of credit expansion on firm efficiency.

In this paper we use a natural field experiment[5] to identify the causal effects of credit access on the productivity and technical efficiency of farm enterprises. We exploit random assignment of credit services by BRAC, one of the largest microfinance NGOS in Bangladesh, on the village level. Random assignment of credit services occurred at the village level: out of 7563 villages, 4,228 villages were randomized and enrolled into eligibility for credit services. Households in the treatment eligible units were provided with credit access of up 30,000 Takas (≈ 382USD); average credit take-up was 6194 (≈ 73USD). Out of the village sampling frame, microenterprises residing in treatment and control villages were randomly surveyed (*i.e.,* 2,164 treatment households, 2,167 control households). The baseline survey on various farm inputs and output for rice farmers was conducted in 2012 and the endline survey was carried out in 2014. In

[4] See Karlan and Morduch (2009) for a pre-2009 review of empirical studies.
[5] As per the taxonomy put forth in Harrison and List (2004).

addition to identifying the causal effects of credit access on the productivity and technical efficiency of farm enterprises, we also examine how these two outcomes vary by farm characteristics.

Conceptually, relaxing liquidity and credit constraints has an ambiguous effect on the technical efficiency of farm microenterprises (Hadley et al., 2001; Davidova and Latruffe, 2003). On one hand, less credit-constrained farms could procure farm inputs more easily and finance operating expenses more easily in the short run (Singh, Squire, and Strauss 1986) and they could make microenterprise-related investments in the long run.[6] Liu and Zhuang (2000) and Easwaran and Kotwal (1989) posit an argument in which credit can mitigate consumption risk and encourage investment by risk-averse small farmers, promoting technical efficiency. On the other hand, Sena (2006) reviews several broad mechanisms (e.g., operational expenditures, internal organization inefficiencies, organizational value slack) that tie the positive influence of credit constraints on higher technical efficiency. Relaxing credit constraints could influence less farm effort level and stir complacency in managing various inputs through behavioral channels (Mullainathan and Shafir 2013).

Focusing on microenterprise technical efficiency – a measure of how well an organization transforms inputs into a set of outputs based on a given set of technology and economic factors – is essential for understanding microenterprise capacity for competitiveness and profitability. If credit is at the fulcrum of the relationship between credit constraints and output and profit has several policy implications. First, not accounting for potential efficiency improvements due to credit constraints may be causing us to miscalculate the benefits of credit programs. Second, existence of inefficiencies imply that firms do not allocate optimally resources. Therefore, public welfare can be substantially improved. Empirical estimates of expanding credit access on firm efficiency, largely based on observational studies, are mixed (Battese 1992). Battese and Broca (1997), using parametric efficiency analysis, find a negative relation between credit constraints and efficiency. Liu (2005) and Hazarika and Alwang (2003) find no significant relation. Among female-led microenterprises in Paraguay, microenterprises that had access to credit services were, on average, 11 percent more efficient (Fletschner 2007).

[6] Credit has been shown to affect risk behavior of producers (Guirkinger and Boucher, 2005; Eswaran and Kotwal, 1990), thereby affecting technology choice and adoption by farmers.

This paper contributes to the existing empirical literature by isolating more credible causal impacts of credit expansion on output and efficiency among small scale enterprises in a low-income country context. We exploit random assignment of credit services among microenterprise clients of BRAC International, one of the largest microfinance NGOs, in Bangladesh. In addition to identifying the causal impacts on technical efficiency by exploiting the random assignment of credit services, we also contribute to previous field experiments examining the impact of credit on productivity (Banerjee et al. 2015) as exploring whether previous results replicate in Bangladesh.

2. Credit Constraints and Microenterprise Productivity

This project contributes to two strands of the empirical literature on the effects of microcredit. We first contribute to an older strand of observational studies using non-parametric and parametric approaches examining the effect of credit on technical efficiency. In this set of studies, the effect depends on the method the study choses. Generally, credit has a bigger effect on technical efficiency if the chosen method is non-parametric. This is due to the fact that stochastic frontier models generate lower mean TE (MTE) estimates than non-parametric deterministic models, while parametric deterministic frontier models yield lower estimates than the stochastic approach (Bravo-Ureta 2007). In these empirical studies, frontier models on technical efficiency based on cross-sectional data produce lower estimates than those based on panel data whereas.

Based on previous observational studies, estimates of the impact of microcredit on farmer efficiency are mixed. In the Philippines, West Bengal, Pakistan and Bangladesh, relaxing credit constraints was an important determinant of farm efficiency (Martey et al. 2015; Arindam 2013; Zahidul 2011). In Brazil and Latin American subsidized credit programs did not improve farm efficiency (Taylor et al. 1986). In Ghana and Philippine credit was a determinant of farm efficiency but far less effective for farm efficiency than land ownership and access to tenure system (Donkor 2014; Koirala et al. 2015). Unlike, these previous studies, we rely on random assignment of credit service so our estimates are arguably more credible estimates of true causal effects of credit on microenterprise technical efficiency.

This paper also relates to recent field experiments that examine the effect of credit on various outcomes (de Mel, McKenzie and Woodruff 2008; Banerjee et al. 2015). Unlike previous observational studies de Mel, McKenzie and Woodruff (2008) and Banerjee et al. (2015) rely on field experiments that disentangle more carefully causation from correlation. Banerjee et al. (2015) summarizes the impacts of microcredit expansions by seven different lenders in six different countries.[7] Combined with two previously published field experiments from other settings (Karlan and Zinman 2010, 2011), Banerjee et al. (2015) add to the empirical base for evaluating the impact of microcredit out a variety of microenterprise and social outcomes. Although Karlan and Zinman (2010, 2011) and Banerjee et al. (2015) rely on random assignment of credit, the studies focus exclusively on micro-entrepreneurial activity, investment, business size, profits, consumption, income composition and social indicators. Unlike these previous experimental studies, our experimental estimates contribute to the array of outcomes by our focus on productivity and microenterprise efficiency.

3. Project Background

3.1 The BCUP Credit Program

BRAC, one of the largest NGOs in Bangladesh, introduced in 2009 the 'Tenant Farmers Development Project' (called Borga Chashi Unnayan Prakalpa). The project was initiated with Tk. 5,000 million (USD 70 million) as a revolving loan fund from the Bangladesh Bank (Central Bank of Bangladesh) with an interest rate of 5 per cent per month (the rate at which commercial banks can borrow funding from the Central Bank). Funding was initially given for three years with a target of reaching 300,000 farmers for credit provision within this period. Subsequently, in 2012, Bangladesh Bank approved extension of the project for another three years.

The main objective of BCUP program was to reduce the dependence of tenant farmers on high-cost informal markets for financing their working capital needs. Tenant farmers do not typically have access to formal financial institutions. By reducing credit constraints, the BCUP program aimed at improving farm productivity and livelihoods of rural small-scale farm households of Bangladesh significantly.

[7] The six studies cover Bosnia, Ethiopia, India, Mexico, Morocco, and Mongolia—from 2003– 2012

Borga Chashi Unnayan Prakalpa (BCUP) provides a customized credit services to farmers who cultivate land owned by themselves (owner farms) and by others either fully or partially (pure tenant, tenant-owner etc.). Loans are provided at subsided interest rate - a flat rate of 10 per cent per year (See Figure 2). The effective rate of interest is 15 to 20 per cent on declining balance depending on the mode of repayment of the principal and interest due. The credit limit is $62 to $375 (*i.e.,* taka 5,000-30,000); duration is 6-10 months; grace period is 1 month and the instalment is monthly. BCUP was targeted to reach all 484 *Upazilas* (sub-districts) of Bangladesh in successive phases. By September 2012, the program reached 212 *Upazilas.*

Households are selected for a loan disbursement based on a few stages of verification. The first stage entails initial selection of members. Members are selected by matching each household against the BCUP eligibility criteria and orienting the farmers with the BCUP program and its terms and conditions.[8] The second stage is the formation of the Village Organization (VO). After initial verification of information, if members agree to the terms and conditions of the BCUP, a small group of five farmers are formed informally. Stage three entails collection of member information. In the final fourth stage, the members list is finalized through verification by Branch Manager on the eligibility of the selected members.

After this selection process, new members get a formal admission and attend an orientation meeting. An important feature of the BCUP is the formation of Village Organization (VO) and its use as a platform for service delivery. In the VO, members are grouped in teams of five members, and four to eight teams consisting of 20 to 40 members forming the village level informal tenant farmer association. The VO meets once every month on a fixed day and time which is attended by the BCUP Program Organizer and an agricultural technician. Apart from the discussion of loan proposal and collection of repayment of the instalment dues and the deposit of savings, farmers can get agricultural information and advice from the Agriculture Development Officer. Table 1 presents the summary statistics of baseline household composition for program participants on various inputs used and on output of rice production.

[2] The selection criteria were: 1) The farmer has National ID card, 2) Age of the farmer is between18 and 60 years, 3) Education of the farmer is at the most SSC pass or below, 4) Permanent resident of the concerned area for at least 3 years, 5) Has at least 3 years of prior experience in farming activities, 6) Maximum land holding limits 33 decimal- 200 decimal, 7) Not an MFI (Micro Finance Institution) member, 8) Willing to take credit from BCUP.

3.2 Random Assignment of Credit Services

The BCUP program relies on clustered randomized control trial (RCT) design. The program first identified 40 potential branch offices for program scale-up in 2012. Branches were randomized into a treatment group (20 branches), which was being offered credit services. For each treatment and control branch, from the universe of all villages within an 8-kilometer radius branch catchment area six villages were selected at random for each of the two groups. The resultant sample was 240 villages which comprise the study sample for this project.

In each of the 240 villages, we conducted a census survey spanning 61,322 eligible households. Using household census information and based on the program eligibility criteria, 7,563 households were identified as eligible for the BCUP program -- 4,228 and 3,335 made up the treatment and control areas, respectively. Program take-up rate was 20%. Figure 2 outlines the complete experimental study design. Figure 3 provides the spatial overview of treatment and control areas.

Under random assignment to one of the two groups, the baseline survey characteristics should be the same on average across the groups except for variation due to sampling. Table 2 shows the means of baseline variables by treatment assignment. We test the equality of means by random assignment and Table 2 presents the p-values. We find that only three (*i.e.,* being a female-headed household, using a pesticide or having access to an informal loan) of the 22 differences between the control group and the two treatment groups have a p-value of less than .05; this pattern is quite consistent with a successful implementation of random assignment.

3.3 Survey Data

We use administrative data at the farm-household level from the BCUP program. Among study households a total of 4,331 households were randomly selected for a quantitative baseline survey (2,155 in treatment areas and 2,146 in control areas). The baseline survey was conducted on 2012 and end-line survey was conducted in 2014. Data comprises economic, demographic variables of farm households, production inputs and production output.

4. Identification Strategy

Our general objective is to estimate the causal impact of credit expansion to households on output and on their technical efficiency[9] for rice production.

4.1 The effect of credit on output

To formalize our analysis, let D_i be an indicator variable for use of BCUP credit services, or treatment take-up (1 if the farm household took credit from BCUP and 0 otherwise). Let Z_i be an indicator variable for being eligible for credit services under the BCUP program, or treatment group assignment.

The difference in outcomes between the treatment and control group are known as "Intent-to-Treat" (ITT) effect, and is captured by the ordinary least squares (OLS) estimate of the coefficient in a regression of the outcome (Y) on an indicator for assignment (Z) to a treatment or control group as in the following specification:

$$Y_i = \gamma_0 + \gamma_1 Z_i + \sum_{j=1}^{m} \gamma_{ji} X_{ji} + \vartheta_i \qquad (1)$$

Y_i is output and $X_{ji}'s$ are baseline covariates j of household i. γ_1 captures the ITT effect and is an average of the causal effects for those who are eligible to receive credit service and those who do not. From the perspective of a policy maker designing a policy that would offer a similar credit program to a similar population, this parameter is directly of interest.

Let η be the other determinants of the credit program, which is determined as in equation (2):

$$D_i = Z_i \pi_2 + \eta_i \qquad (2)$$

Because not all farms who were assigned to credit took up the credit and because intent-to-treat effects could obscure heterogeneity in effects on different types of farms, we also

[9] Technical efficiency is the effectiveness with which a given set of inputs is used to produce an output. A firm is said to be technically efficient if a firm is producing the maximum output from the minimum quantity of inputs, such as labor, capital, land etc.

examine the effect of credit of rice production for farm households that actually took up credit. It desirable to have an estimate of the impact of households who actually took up credit services, rather than simply of being offered the credit service.

We can use treatment assignment as an instrumental variable to estimate the parameter commonly known as "the effect of Treatment-on-Treated" (TOT). The TOT parameter measures the average effect of the treatment on those in the treatment group who actually received credit. One estimate of the TOT for credit on rice output is γ_1/π_2 following the notation above.

We use an alternative estimate of TOT that employs an instrumental variable (IV) approach (the two approaches are asymptotically equivalent). We use treatment assignment Z_i as an instrument for credit take-up (D_i) in:

$$Y_i = \gamma_0' + \gamma_1' D_i + \sum_{j=1}^{m} \gamma_{ji}' X_{ji} + \vartheta_i' \qquad (3)$$

The TOT estimate of the effect of credit expansion on rice output in the specification above is γ_1' and is a regression-adjusted estimate of TOT.

The TOT is the estimated difference in rice output between those households who actually used the credit services in the BCUP program and the households in the control group who would have used the credit services if they had been offered to them (the group that generates the TOT estimate is the so-called "complier" population, the households who decide take up the offered credit only if they are offered credit access). Figure 3 provides a summary on the relationship between the "complier" population and treatment assignment.

4.2 The effect of credit on technical efficiency

We also want to capture the causal effect of credit expansion on technical efficiency. We do this through a two-step estimation process. In the first step, we estimate the relationship between firm output and inputs with the following specification:

$$y_i = \beta_0 + \beta_1 N_i + \beta_2 L_i + \beta_3 P_i + \beta_4 S_i + \beta_5 I_i + \beta_6 F_i + \beta_7 H_i + \epsilon_i \qquad (4)$$

i denotes the household i. y_i is rice output (kilogram). Variables $N_i, L_i, P_i, S_i, I_i, F_i, H_i$ represent land (decimals), labor (days), plough for land preparation (number of times), seed (kilogram), irrigation (hours), fertilizer (kilogram) and pesticide (number of times) respectively. All variables are measured on an annual basis from the end-line survey data conducted in 2014. They can be either in level or log form reflecting a simple linear or constant elasticity of substitution (CES) production function, respectively. We focus on an estimation structure with level form of the input and output variables.[10] From equation (4), we obtain the predicted value of rice output $\widehat{y_i}$. We obtain the residual- the difference between actual and predicted rice output -- $(y_i - \widehat{y_i})$ and calculate $\widehat{\epsilon_i} = \left[\frac{y_i - \widehat{y_i}}{\widehat{y_i}}\right] * 100$.

We then estimate the impact of treatment assignment (i.e., random assignment of credit) on technical efficiency of rice production with the following[11]:

$$\widehat{\epsilon_i} = \gamma_0 + \gamma_1 Z_i + \sum_{j=1}^{m} \gamma_{ji} X_{ji} + \vartheta_i \qquad (5)$$

where Z_i be an indicator for treatment assignment of household i. $X_{ji}{}'s$ are baseline covariates j of household i. We focus on γ_1, which captures the average causal effect on technical efficiency among farms being assigned to credit access. Analogously to the discussion above, γ_1 is the ITT estimate of assignment to credit services (regardless of whether they obtained credit) on technical efficiency.

We also examine the technical efficiency of rice production among households that actually took up credit, analogous to TOT estimation approach above. We use treatment assignment Z_i as an instrument for credit take-up (D_i) via a two-stage least squares estimation (2SLS). After estimating (4) to obtain $\widehat{\epsilon_i}$, we estimate the following equation via 2SLS to capture the impact of credit on technical efficiency of rice production:

$$\widehat{\epsilon_i} = \gamma_0' + \gamma_1' D_i + \sum_{j=1}^{m} \gamma_{ji}' X_{ji} + \vartheta_i' \qquad (6)$$

[10] See appendix for treatment effect measured in log form.

[11] In log form we simply take the difference between actual and predicted output after estimating equation 1, $\widehat{\epsilon_i} = (y_i - \widehat{y_i})$. Then, we estimate (2) to estimate the impact of credit access on efficiency.

X_{ji} is a vector of baseline covariates j of household i. D_i is an indicator variable (1 if the farm household took credit from BCUP and 0 otherwise). γ_1' is our parameter of interest which captures the treatment on the treated estimate (TOT) of credit on technical efficiency of rice production. The 2SLS estimate of γ_1' in (5) is a regression-adjusted estimate of TOT, using the information in X_{ji} to obtain additional statistical precision.

We estimate equations (5) and (6) for each of the two major rice producing seasons of Bangladesh - Boro and Aman[12] separately as well as for the total rice production which we denote by "All Seasons". We cluster standard errors at the branch level.

4.3 Heterogeneous Treatment Effects

We explore whether treatment effects of credit access on the outcomes are uniform across various household economic and farm characteristics. In particular, we focus on gender of the household head, household's ownership of livestock, microenterprise size, status of remittances received, size of farming land, familiarity with agricultural extension services.

To estimate the heterogeneous impact, we augment specifications (1) and (5) (respectively for the output and efficiency outcomes). To capture heterogonous effects for output, we estimate:

$$Y_i = \gamma_0 + \gamma_1 Z_i + \sum_{j=1}^{m} \theta_{ji} X_{ji} + \sum_{j=1}^{m} \delta_{ji} X_{ji} * Z_i + v_i \qquad (7)$$

X_{ij} is a vector of economic and demographic variables j for farm household i. We interact X_{ij} with household's treatment assignment status (Z_i). The coefficient of the interaction term, δ_{ji} in (7) captures the heterogeneous treatment effect.

Similarly, to capture heterogonous effects for efficiency, we estimate:

[12]Boro and Aman are major rice growing seasons in Bangladesh. December-February is the plantation time of Boro and April–May is the harvesting time. Boro production is heavily dependent on irrigation as it covers the dry seasons. Boro production, including the high-yield varieties, expanded rapidly until the mid-1980s with the green revolution and rapid increase in use of irrigation. Aman season has plantation time of April- May and harvesting time of November-December. Some rice for this season harvest is sown in the spring through the broadcast method, matures during the summer rains, and is harvested in the fall

$$\widehat{\epsilon_i} = \gamma_0 + \gamma_1 Z_i + \sum_{j=1}^{m} \theta_{ji} X_{ji} + \sum_{j=1}^{m} \delta_{ji} X_{ji} * Z_i + v_i \qquad (8)$$

The coefficient of the interaction term in (8) captures the heterogeneous treatment effect.[13]

4.3.1 Treatment effects by gender of enterprise head

A number of studies (Ongaro 1990; Saito 1994; Udry et al. 1995; Udry 1996; Deininger and Olinto 2000; Tiruneh et al. 2001; Ouma et al 2006; Wanjiku et al 2007) point to gender differences in take up of credit, fertilizers, capital use and technological adoption. Belanger and Li (2009) find that females have less control over assets, credit access and influence in decision-making regarding extension services and inputs – a difference that results in lower microenterprise productivity.

4.3.2 Treatment effects by livestock ownership

Household farm diversification can help to spread risk and buffer shocks. The gain can come from complementarity effects across farm outputs or economies of scope and risk (Kim, Chavas and Barham 2012; Asante, et al. 2016). We examine whether poultry and livestock ownership influences impacts.

4.3.3 Treatment effects for farms with rice production only versus farms with non-farm activity

Non-farm activities and self-employment are two important sources of income in informal markets. Participation in non-farm activities increases income and therefore can provide buffer for shocks in household farm production. Non-farm activities serve as a form of insurance against the risks of farming, and thus enabling farm microenterprises to adopt new production methods that have the potential to raise output. On the other hand, involvement in non-farm

[13] We estimate the specifications above for all seasons as well as for Boro and Aman season separately. In each case, we control for the baseline covariates and standard errors are clustered at branch level.

activities can crowd out labor in the agricultural activities, therefore potentially dampening productivity.

4.3.4 Treatment effects by farm size

Previous empirical studies document an inverse relationship between farm size and output per hectare in agriculture. Some studies posit that this relationship is an artefact of measurement error in soil quality and land size (Bhalla and Roy, 1988; Newell et al., 1997; Fan and Chan-Kang, 2003; Bellemare 2012) and other studies show that this inverse relationship disappears at high levels of technology adoption (Cornia, 1985; Deolalikar, 1981).

4.3.5 Treatment effects by remittance status

Remittances can influence the relationship between credit access and output. On one hand, remittances provide more income buffer and farmers can take on high-value commercial crops and adopt new technologies (Gonzalez-Velosa 2011; Benjamin and Brandt, 1998). On the other hand, remittances can induce higher levels of migration and subsequent labor exodus from the agricultural sector (Tuladhar, Sapkota and Adhikari 2014; Rozelle, Brauw and Taylor 1999).

4.3.6 Treatment effects by extension services status

Agricultural extension services link farmers with institutional support thought better information dissemination for agricultural practices. Extension and advisory services can provide information on better seed varieties or better fertilizer practices (Hasan, Imai and Sato, 2013; Ragasa, Berhain and Taffesse, 2013). Extension services can provide farmers with more knowledge on better practices for farming.

5. Results

Table 3 presents the ITT estimates of credit expansion on technical efficiency. Column 1 of Panel A shows that small-scale farms with access to subsidized credit are on average 12.25% more efficient than farm households with no access. Producers of modern rice varieties-

HYV and Hybrid, experienced this efficiency gain from access to credit (on average, 10% and 14% respectively). However, for traditional variety producers access to credit shows no positive impact on efficiency. Column 1 of Panel B and C presents the results for two major rice producing seasons- Boro and Aman respectively- of the country. Results are positive for both seasons though the impact is larger for the Aman season.

Table 3 (Column 2) presents the TOT estimates of credit expansion on technical efficiency. The impact of credit is positive and significant for total rice production as well as for each of the major rice producing seasons. Compared to others, hybrid rice producers of Aman season exhibit the highest efficiency gain due to credit.

We also examine the heterogeneity in the effect of access to credit along several socio-economic characteristics of the rice farm households. The variables include gender of household head, household's involvement in poultry and livestock activity, presence of small business, remittance earning, size of rice farming land, familiarity with agricultural extension service provider and associated institutions etc. The coefficient on the interaction term is significant for female headed household, marginal farming size and poultry and livestock activity. This statistically significant interaction term implies that within the treatment group, the average effect of credit access on technical efficiency is not uniform across these subgroups of rural farming households. Farm household with female head and poultry and livestock activity have higher efficiency gain in rice production from access to credit compare to other treatment households. On the contrary, effect of credit access is significantly negative when farm size is small, i.e. less than 50 decimals which supports the idea that large farming size promotes efficiency. The coefficient on the interaction terms of variables indicating household head’s familiarity with extension service provider and institutional training are negative and insignificant.

6. Discussion

Access to subsidized credit can aid small farm households in their capacity to reallocate their production inputs and invest in modern technology. Changes in production behavior might also cause change in the efficiency of output production. In this paper, we estimate the impact of credit on small farm output and efficiency. Using survey data of the BCUP program evaluation study of Bangladesh, we show that relaxing the credit constraint has sizable positive impact on technical efficiency of rice production. On an average, small-scale rice farms with access to subsidized credit are approximately 12.25% more productive than farms with no credit access. Within the treatment group, the average effect of access to credit on technical efficiency of rice production is higher in female headed households and in households with poultry and livestock activity. However, the average effect of credit access on efficiency is around 7.8% lower for the treatment households with very small farm size.

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Figures and Tables

Figures

Figure 1: Design of Field Experiment and Treatment Assignment

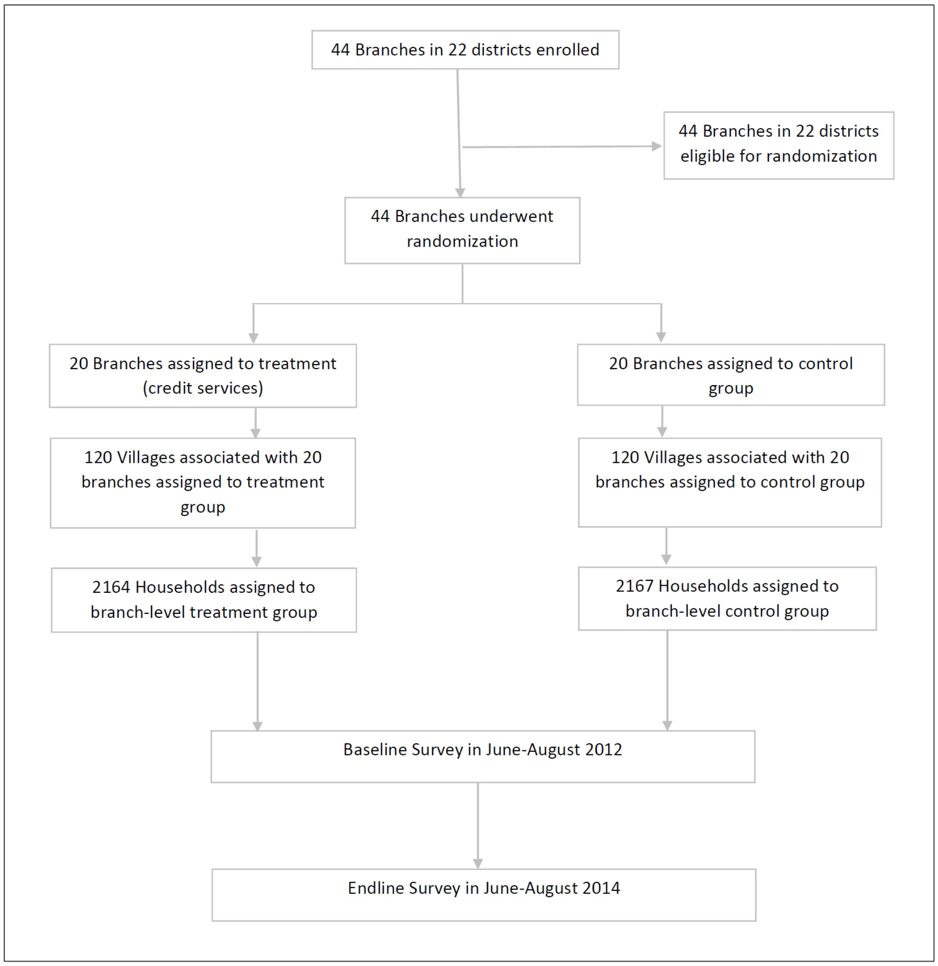

Figure 2: BCUP Program Features

Treatment Groups	Program Features
Treatment Group	• Credit limit: Taka 5,000-50,000 (~ \$60 - \$600); • Duration: 12 months • Grace period: 1 month • Instalment: Monthly • Interest rate: 18% (declining)
Control Group	None

Figure 3: Map of Treatment and Control Areas

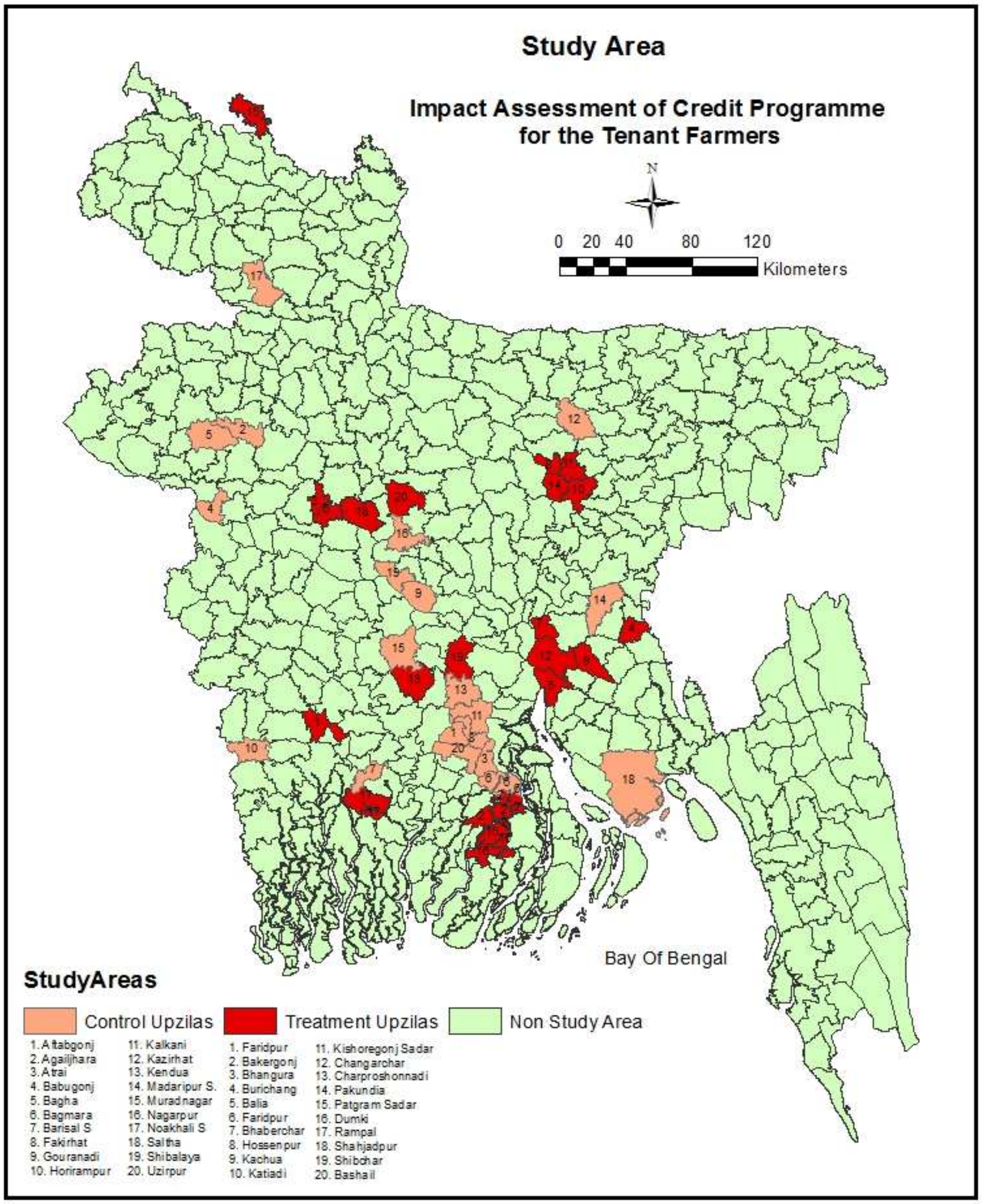

Figure 4: Definitions of Compliers and Never Takers

	All	Complier (C=1)	Never Taker (C=0)
Offered Treatment (Z=1)	"Treatment Group" $E[Y\|Z=1]$ Sample mean observed. In BCUP Program, offered credit in random assignment.	"Treatment Compliers" $E[Y\|C=1, Z=1]$ Sample mean observed. In BCUP Program, offered credit and used it.	"Treatment Never Takers" $E[Y\|C=0, Z=1]$ Sample mean observed. In BCUP Program, offered credit but did not use it.
Not Offered Treatment (Z=0)	"Treatment Group" $E[Y\|Z=0]$ Sample mean observed. In BCUP Program, not offered credit in random assignment.	"Control Compliers" $E[Y\|C=1, Z=0]$ Sample mean not observed. In BCUP Program, not offered credit but would have used it if offered.	"Control Never Takers" $E[Y\|C=0, Z=0]$ Sample mean not observed. In BCUP Program, not offered credit and would not have used it if offered.

Tables

Table 1: Descriptive Statistics and Baseline Characteristics

Variables	N	Mean	Std. Dev.
Household Composition			
Female Headed household (percentage)	4301	0.07	0.25
Age of household head (in years)	4301	44.74	11.53
Household size (number of members)	4301	4.84	1.76
Number of child (<16 years)	4301	3.10	1.34
Number of adult members (>16 years)	4301	1.74	1.24
Household head with no education (percentage)	4301	0.44	0.50
Amount of Land and credit			
Own cultivated land (in decimal†)	4301	38.12	51.41
Rented in land (in decimal)	4301	51.23	89.36
Rented out land (in decimal)	4301	8.05	28.32
Total cultivated land (in decimal)	4301	89.34	98.03
Any formal and informal loan (yes=1)	4301	0.14	0.35
Output and Input for Rice Production (yearly)			
Total rice production (kilogram††)	3752	1994	1694.41
Total High Yielding Variety rice (kilogram)	3752	1576.76	1531.38
Total Hybrid rice (kilogram)	3752	88.36	499.82
Total Traditional Variety rice (kilogram)	3752	328.88	783.81
Total Land (in decimal)	3752	116.73	102.12
Total Labor days (own as well as hired labor)	3752	53.43	47.71
Total Plough (number of times)	3752	7.53	7.15
Total Seed (kilogram)	3752	21.13	22.81
Total Irrigation (hours)	3752	44.4	55.61
Total Fertilizer (kilogram)	3752	177.9	175.71
Total Pesticide (number of times)	3752	4.77	8.71

Notes: †A **decimal** (also spelled **decimel**) is a unit of area in India and Bangladesh approximately equal to 1/100 acre (40.46 m²); 247 decimal=1 hectares. ††**kilogram** (1 kilogram=2.204 pounds).

Unit of observation: Household. Sample includes all households surveyed at baseline (2012); for input output section, only rice producing farm households are considered. Informal lenders include moneylenders, loans from friends/family, and buying goods/services on credit from sellers. **Own land** refers to the cultivated crop land owned by the farm household. **Rented in** land means the land rented in from others for crop cultivation. **Rented out** land means the land rented to other farmers for crop cultivation.

High Yielding Varieties (HYV) rice seeds are land substituting, water economizing, more labor using, and employment generating innovation. HYVs significantly outperform traditional varieties in the presence of an efficient management of irrigation, pesticides, and fertilizers. However, in the absence of these inputs, traditional varieties may outperform HYVs.

Hybrid rice is any genealogy of rice produced by crossbreeding different kinds of rice. It typically displays heterosis or hybrid vigor such that when it is grown under the same conditions as comparable high yielding inbred rice varieties it can produce up to 30% more rice. However, the heterosis effect disappears after the first (F1) generation, so the farmers cannot save seeds produced from a hybrid crop and need to purchase new F1 seeds every season to get the heterosis effect each time.

Table 2: Baseline Characteristics and Balancing

	Means by treatment		
	Control (1)	Treatment (2)	P-value (3)
Variables			
Household Composition			
Female Headed household (percentage)	0 .05	0.09	0.09
	(0.00)	(0.01)	
Age of household head (in years)	44.45	45.07	0.33
	(0.26)	(0.25)	
Household size (number of members)	4.75	4.93	0.3
	(0.04)	(0.04)	
Number of adult members (>16 years)	3.10	3.10	0.97
	(0.03)	(0.03)	
Number of child (<16 years)	1.65	1.83	0.13
	(0.03)	(0.03)	
Household head with no education (percentage)	0.45	0.42	0.57
	(0.01)	(0.01)	
Amount of Land and credit			
Own cultivated land (in decimal†)	38.83	37.38	0.66
	(1.15)	(1.06)	
Rented in land (in decimal)	51.31	51.12	0.98
	(1.71)	(2.12)	
Rented out land (in decimal)	7.78	8.39	0.67
	(0.57)	(0.65)	
Total cultivated land (in decimal)	90.14	88.51	0.86
	(1.96)	(2.26)	
Any formal and informal loan (yes=1)	0.17	0.11	0.004
	(0.01)	(0.01)	

Notes: †A **decimal** (also spelled **decimel**) is a unit of area in India and Bangladesh approximately equal to 1/100 acre (40.46 m^2); 247 decimal=1 hectares. ††**kilogram** (1 kilogram=2.204 pounds). Column 3 shows the P value of mean difference column 3=column1- column2.

Unit of observation: Household. Sample includes all households surveyed at baseline (2012); for input output section, only rice producing farm households are considered. Standard error in parenthesis. Informal lenders include moneylenders, loans from friends/family, and buying goods/services on credit from sellers. **Own land** refers to the cultivated crop land owned by the farm household. **Rented in** land means the land rented in from others for crop cultivation. **Rented out** land means the land rented to other farmers for crop cultivation.

Table 2 (contd.): Baseline Characteristics and Balancing

	Means by treatment		
	Control (1)	Treatment (2)	P-value (3)
Variables			
Output and Input for Rice Production (yearly)			
Total rice production (kilogram[††])	1987.76	1999.32	0.95
	(39.86)	(38.40)	
Total High Yielding Variety rice (kilogram)	1549.25	1602.95	0.85
	(33.81)	(36.78)	
Total Hybrid rice (kilogram)	97.28	79.50	0.72
	(12.65)	(10.35)	
Total Traditional Variety rice (kilogram)	341.22	316.87	0.89
	(18.97)	(17.22)	
Total Land (in decimal)	115.41	117.98	0.85
	(2.51)	(2.21)	
Total Labor (days)	51.93	54.87	0.53
	(1.09)	(1.11)	
Total Plough (number of times)	7.44	7.61	0.82
	(0.17)	(0.16)	
Total Seed (kilogram)	21.31	20.93	0.87
	(0.56)	(0.49)	
Total Irrigation (hours)	48.56	40.30	0.42
	(1.36)	(1.20)	
Total Fertilizer (kilogram)	183.08	172.75	0.66
	(4.27)	(3.83)	
Total Pesticide (number of times)	5.52	4.04	0.06
	(0.21)	(0.19)	
Joint significance test		F (17, 39) =	2.22
		Prob > F =	0.02

Notes: [†]A **decimal** (also spelled **decimel**) is a unit of area in India and Bangladesh approximately equal to 1/100 acre (40.46 m²); 247 decimal=1 hectares. [††]**kilogram** (1 kilogram=2.204 pounds). Column 3 shows the P value of mean difference column 3=column1- column2.

Unit of observation: Household. Sample includes all households surveyed at baseline (2012); for input output section, only rice producing farm households are considered. Standard error in parenthesis.

High Yielding Varieties (HYV) rice seeds are land substituting, water economizing, more labor using, and employment generating innovation. HYVs significantly outperform traditional varieties in the presence of an efficient management of irrigation, pesticides, and fertilizers. However, in the absence of these inputs, traditional varieties may outperform HYVs.

Hybrid rice is any genealogy of rice produced by crossbreeding different kinds of rice. It typically displays heterosis or hybrid vigor such that when it is grown under the same conditions as comparable high yielding inbred rice varieties it can produce up to 30% more rice. However, the heterosis effect disappears after the first (F1) generation, so the farmers cannot save seeds produced from a hybrid crop and need to purchase new F1 seeds every season to get the heterosis effect each time.

Table 3: Impact of Access to Credit on Efficiency of Rice Production (percentage effect)

	Intent to Treat Effect (ITT)		N
	(1)	(2)	
Panel A: All Season†			
Total Rice production	11.29**	11.92***	3,171
	(4.45)	(4.30)	
High Yielding Varieties Rice	9.33***	9.58***	2,830
	(2.70)	(2.67)	
Hybrid Rice	14.94***	14.64***	412
	(5.42)	(5.31)	
Traditional Rice Variety	-2.79	-1.98	842
	(8.16)	(8.16)	
Panel B: Boro Season††			
Total Rice production	9.45**	9.72**	2,570
	(3.80)	(3.80)	
High Yielding Varieties Rice	6.02*	6.23**	2,475
	(3.08)	(3.07)	
Hybrid Rice	6.4	6.72	301
	(5.97)	(5.72)	
Panel C: Aman Season†††			
Total Rice production	16.34*	19.49**	1,671
	(8.063)	(8.53)	
High Yielding Varieties Rice	11.81**	10.46*	1,196
	(5.433)	(5.80)	
Hybrid Rice	32.12**	41.66***	111
	(14.41)	(12.77)	
Control for Baseline covariates	No	Yes	

Notes: *** p<0.01, ** p<0.05, * p<0.1.

Results show the percentage effect of credit on rice production efficiency. Column (1) and (2) shows the intent to treat (ITT) effect of the treatment on outcome of interest. Column (3) and (4) shows the impact of credit (Treatment on the Treated or TOT) on outcome of interest where credit is instrumented by the treatment assignment. Sample includes only rice producing farm households. Standard errors (in parentheses) are clustered at Branch level.

†We refer to both Boro and Aman production by All Season. These are two major rice seasons and covers most of the rice cultivation in the country.

††Boro is a rice growing season in Bangladesh. December-February is the plantation time of Boro; April–May is the harvesting time. Boro production is heavily dependent on irrigation as it covers the dry seasons. Boro production, including the high-yield varieties, expanded rapidly until the mid-1980s with the green revolution and rapid increase in use of irrigation.

†††Aman is a rice growing season in Bangladesh with plantation time April- May and harvesting time November to December. Some rice for this season harvest is sown in the spring through the broadcast method, matures during the summer rains, and is harvested in the fall.

High Yielding Varieties Rice (HYV) refers to the households producing HYV rice in the end line. HYV seeds are land substituting, water economizing, more labor using, and employment generating innovation. HYVs significantly outperform traditional varieties in the presence of an efficient management of irrigation, pesticides, and fertilizers. However, in the absence of these inputs, traditional varieties may outperform HYVs. Hybrid rice refers to the households producing Hybrid rice in the end line. Hybrid rice is any genealogy of rice produced by crossbreeding different kinds of rice. It typically displays heterosis or hybrid vigor such that when it is grown under the same conditions as comparable high yielding inbred rice varieties it can produce up to 30% more rice. However, the heterosis effect disappears after the first (F1) generation, so the farmers cannot save seeds produced from a hybrid crop and need to purchase new F1 seeds every season to get the heterosis effect each time.

Table 4: Impact of Credit on Efficiency of Rice Production (percentage effect)

	Treatment on Treated Effect (TOT)		N
	(3)	(4)	
Panel A: All Season†			
Total Rice production	77.65***	80.38***	3,171
	(25.11)	(23.82)	
High Yielding Varieties Rice	56.55***	57.22***	2,830
	(16.18)	(15.86)	
Hybrid Rice	60.67**	55.16**	412
	(23.79)	(21.47)	
Traditional Rice Variety	-46.33	-30.03	842
	(137.9)	(123.8)	
Panel B: Boro Season††			
Total Rice production	49.57***	50.36***	2,570
	(18.87)	(18.68)	
High Yielding Varieties Rice	33.15**	33.85**	2,475
	(15.97)	(15.78)	
Hybrid Rice	27.01	26.41	301
	(24.88)	(22.62)	
Panel C: Aman Season†††			
Total Rice production	92.06**	101.51**	1,671
	(45.89)	(45.55)	
High Yielding Varieties Rice	61.74*	66.27**	1,196
	(31.99)	(32.92)	
Hybrid Rice	93.89*	93.60**	111
	(49.35)	(42.87)	
Control for Baseline covariates	No	Yes	

Notes: *** p<0.01, ** p<0.05, * p<0.1.
Results show the percentage effect of credit on rice production efficiency. Column (1) and (2) shows the intent to treat (ITT) effect of the treatment on outcome of interest. Column (3) and (4) shows the impact of credit (Treatment on the Treated or TOT) on outcome of interest where credit is instrumented by the treatment assignment. Sample includes only rice producing farm households. Standard errors (in parentheses) are clustered at Branch level.

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Table 5: Heterogeneous Impact of Access to Credit on Rice Production (percentage effect)

Dependent Variable: Efficiency in Total Rice Production

Sample	All household	All household	All household	All household	All household	All household	All household	All household
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Access to credit (Treatment dummy)	10.86**	11.42**	8.95*	9.69**	11.51**	11.98***	12.53**	13.06**
	(4.57)	(4.39)	(4.82)	(4.65)	(4.35)	(4.22)	(5.19)	(5.05)
Female Headed Household (dummy)	-8.54**	-3.97						
	(3.33)	(4.55)						
Access to credit*Female Headed Household	11.52**	12.09**						
	(5.06)	(4.79)						
Poultry and livestock activity (dummy)			-0.64	-0.47				
			(1.89)	(1.85)				
Access to credit*Poultry and livestock activity			6.00**	5.66*				
			(2.90)	(2.86)				
Small business activity (dummy)			0.93	0.48				
			(1.69)	(1.62)				
Access to credit*Small business activity			3.02	3.17				
			(2.55)	(2.48)				
Received Remittance (dummy)			0.93	0.10				
			(1.90)	(1.91)				
Access to credit*Received Remittance			1.41	0.88				
			(3.97)	(3.70)				

Notes: *** p<0.01, ** p<0.05, * p<0.1.
Sample includes all rice producing farm households. Rice is measured in kilogram. Results show the percentage effect of access to credit on rice production efficiency by different farm household characteristics. Total rice production is the yearly rice production. Poultry and livestock activity refers to whether household in involved in production either for own consumption or sell or both. Small business activity includes small local shop, vegetable and livestock business, tea stall, machinery repairing etc. Received remittance is a dummy variable taking value 1 if the migrant members of household sent remittance last year. Marginal farm size takes a value 1 if total rice producing farm land is less than 50 decimals. Familiarity with agriculture extension service provider implies that farmers are acquainted with the persons/institution from whom they can seek information or advice on crop selection, crop rotation, modern cropping technology, appropriate use of fertilizer, pesticide etc. Institutional training is a dummy that takes a value 1 if the farmer had training on proper use of fertilizer, pesticide, irrigation, animal husbandry, modern cropping technology etc. from the extension service providing institutions. Standard errors (in parentheses) are clustered at Branch level. For all the regression we control for baseline covariates.

Table 5 (contd.): Heterogeneous Impact of Access to Credit on Rice Production (percentage effect)

Dependent Variable: Efficiency in Total Rice Production

Sample	All household	All household	All household	All household	All household	All household	All household	All household
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Marginal Farm size (1 = < 50 decimal)					-18.16***	-17.56***		
					(2.48)	(2.42)		
Access to credit*Marginal Farm size					-6.19	-6.28*		
					(3.69)	(3.65)		
Familiar with Agriculture Extension Service provider (dummy)							9.54***	9.12***
							(3.06)	(2.85)
Access to credit*Familiar with Agriculture Extension Service provider							-4.99	-4.91
							(4.67)	(4.48)
Had Institutional training (dummy)							-4.51	-5.18
							(3.97)	(3.61)
Access to credit*Had Institutional training							-1.69	-0.69
							(6.50)	(6.18)
Constant	-9.47***	-16.34***	-9.86***	-12.43***	-6.23***	-7.14**	-12.67***	-14.44***
Control for Baseline covariates	No	Yes	No	Yes	No	Yes	No	yes
Observations	3,199	3,199	3,199	3,199	3,199	3,199	3,199	3,199

Notes: *** p<0.01, ** p<0.05, * p<0.1.
Sample includes all rice producing farm households. Rice is measured in kilogram. Results show the percentage effect of access to credit on rice production efficiency by different farm household characteristics. Total rice production is the yearly rice production. Poultry and livestock activity refers to whether household in involved in production either for own consumption or sell or both. Small business activity includes small local shop, vegetable and livestock business, tea stall, machinery repairing etc. Received remittance is a dummy variable taking value 1 if the migrant members of household sent remittance last year. Marginal farm size takes a value 1 if total rice producing farm land is less than 50 decimals. Familiarity with agriculture extension service provider implies that farmers are acquainted with the persons/institution from whom they can seek information or advice on crop selection, crop rotation, modern cropping technology, appropriate use of fertilizer, pesticide etc. Institutional training is a dummy that takes a value 1 if the farmer had training on proper use of fertilizer, pesticide, irrigation, animal husbandry, modern cropping technology etc. from the extension service providing institutions. Standard errors (in parentheses) are clustered at Branch level. For all the regression we control for baseline covariates.

Appendix

Table A.1: Effect of Credit on Efficiency of Rice Production (variables in log form)

	Intent to Treat Effect (ITT)	Treatment on Treated Effect (TOT)	N
Panel A: All Season†			
Total Rice production	0.13***	0.72***	1,936
	(0.03)	(0.16)	
High Yielding Varieties Rice	0.10***	0.58***	1,864
	(0.02)	(0.15)	
Hybrid Rice	0.10*	0.38*	235
	(0.06)	(0.22)	
Panel B: Boro Season††			
Total Rice production	0.07**	0.37**	1,886
	(0.03)	(0.15)	
High Yielding Varieties Rice	0.06**	0.34**	1,818
	(0.03)	(0.15)	
Hybrid Rice	0.09	0.34	225
	(0.06)	(0.22)	
Panel C: Aman Season†††			
Total Rice production	0.16*	1.85	124
	(0.07)	(1.48)	
High Yielding Varieties Rice	0.42***	2.49	116
	(0.06)	(1.60)	
Control for baseline covariates	Yes	Yes	

Notes: *** p<0.01, ** p<0.05, * p<0.1.

Results show the percentage effect of credit on rice production efficiency. Column (1) shows the intent to treat (ITT) effect of the treatment on outcome of interest. Column (2) shows the impact of credit (Treatment on the Treated or TOT) on outcome of interest where credit is instrumented by the treatment assignment. Sample includes only rice producing farm households. Standard errors (in parentheses) are clustered at Branch level.

†We refer to both Boro and Aman production by All Season. These are two major rice seasons and covers most of the rice cultivation in the country.

††Boro is a rice growing season in Bangladesh. December-February is the plantation time of Boro; April–May is the harvesting time. Boro production is heavily dependent on irrigation as it covers the dry seasons. Boro production, including the high-yield varieties, expanded rapidly until the mid-1980s with the green revolution and rapid increase in use of irrigation.

†††Aman is a rice growing season in Bangladesh with plantation time April- May and harvesting time November to December. Some rice for this season harvest is sown in the spring through the broadcast method, matures during the summer rains, and is harvested in the fall.

High Yielding Varieties Rice (HYV) refers to the households producing HYV rice in the endline. HYV seeds are land substituting, water economizing, more labor using, and employment generating innovation. HYVs significantly outperform traditional varieties in the presence of an efficient management of irrigation, pesticides, and fertilizers. However, in the absence of these inputs, traditional varieties may outperform HYVs.

Hybrid rice refers to the households producing Hybrid rice in the endline. Hybrid rice is any genealogy of rice produced by crossbreeding different kinds of rice. It typically displays heterosis or hybrid vigor such that when it is grown under the same conditions as comparable high yielding inbred rice varieties it can produce up to 30% more rice. However, the heterosis effect disappears after the first (F1) generation, so the farmers cannot save seeds produced from a hybrid crop and need to purchase new F1 seeds every season to get the heterosis effect each time.

Table A.2: Effect of Credit on Efficiency of Rice Production (percentage effect) for All farm households vs. Owner farm households

	Intent to Treat Effect (ITT) All farms		N	Intent to Treat Effect (ITT) Owner farms		N
	(1)	(2)		(3)	(4)	
All Season†						
Total Rice production	11.29**	11.92***	3,171	2.87	3.14	2,147
	(4.45)	(4.30)		(6.531)	(6.68)	
High Yielding Varieties Rice	9.33***	9.58***	2,830	-26.04	-27.76	1,853
	(2.70)	(2.67)		(32.28)	(33.12)	
Hybrid Rice	14.94***	14.64***	412	18.11**	16.31***	152
	(5.42)	(5.31)		(6.83)	(5.67)	
Traditional Rice Variety	-2.79	-1.98	842	-10.15	-9.17	563
	(8.16)	(8.16)		(8.453)	(8.29)	
Control for Baseline covariates	No	Yes		No	yes	

Notes: *** p<0.01, ** p<0.05, * p<0.1.

Results show the percentage effect of credit on rice production efficiency. Column (1) and (2) shows the impact of credit (Treatment on the Treated or TOT) on outcome of interest where credit is instrumented by the treatment assignment for all farm households. All farms include farm households who cultivate their own land, farmers who rented cultivating land from others or produced rice under sharecropping arrangement. Column (3) and (4) shows the impact of credit (Treatment on the Treated or TOT) on outcome of interest where credit is instrumented by the treatment assignment for land owner farm households. Sample includes only rice producing farm households. Standard errors (in parentheses) are clustered at Branch level.

†We refer to both Boro and Aman production by All Season. These are two major rice seasons and covers most of the rice cultivation in the country.

High Yielding Varieties Rice (HYV) refers to the households producing HYV rice in the endline. HYV seeds are land substituting, water economizing, more labor using, and employment generating innovation. HYVs significantly outperform traditional varieties in the presence of an efficient management of irrigation, pesticides, and fertilizers. However, in the absence of these inputs, traditional varieties may outperform HYVs.

Hybrid rice refers to the households producing Hybrid rice in the endline. Hybrid rice is any genealogy of rice produced by crossbreeding different kinds of rice. It typically displays heterosis or hybrid vigor such that when it is grown under the same conditions as comparable high yielding inbred rice varieties it can produce up to 30% more rice. However, the heterosis effect disappears after the first (F1) generation, so the farmers cannot save seeds produced from a hybrid crop and need to purchase new F1 seeds every season to get the heterosis effect each time.

Table A.3: Effect of Credit on Efficiency of Rice Production (percentage effect) for All farm households vs. Owner farm households

	Treatment on Treated Effect (All farms)		N	Treatment on Treated Effect (Owner farms)		N
	(1)	(2)		(3)	(4)	
All Season†						
Total Rice production	77.65***	80.38***	3,171	23.99	26.57	2,147
	(25.11)	(23.82)		(50.75)	(52.20)	
High Yielding Varieties Rice	56.55***	57.22***	2,830	-178.30	-194.50	1,853
	(16.18)	(15.86)		(213.9)	(224.3)	
Hybrid Rice	60.67**	55.16**	412	75.14***	68.35***	152
	(23.79)	(21.47)		(26.69)	(20.03)	
Traditional Rice Variety	-46.33	-30.03	842	-345.90	-292.10	563
	(137.9)	(123.8)		(391.5)	(341.3)	
Control for Baseline covariates	No	Yes		No	yes	

Notes: *** p<0.01, ** p<0.05, * p<0.1.

Results show the percentage effect of credit on rice production efficiency. Column (1) and (2) shows the intent to treat (ITT) effect of the treatment on outcome of interest for all farmers. All farms include farm households who cultivate own land, farmers who rented cultivating land from others or produced rice under sharecropping arrangement. Column (3) and (4) shows the intent to treat (ITT) effect of the treatment on outcome of interest for land owner farm households. Sample includes only rice producing farm households. Standard errors (in parentheses) are clustered at Branch level.

†We refer to both Boro and Aman production by All Season. These are two major rice seasons and covers most of the rice cultivation in the country.

High Yielding Varieties Rice (HYV) refers to the households producing HYV rice in the endline. HYV seeds are land substituting, water economizing, more labor using, and employment generating innovation. HYVs significantly outperform traditional varieties in the presence of an efficient management of irrigation, pesticides, and fertilizers. However, in the absence of these inputs, traditional varieties may outperform HYVs.

Hybrid rice refers to the households producing Hybrid rice in the endline. Hybrid rice is any genealogy of rice produced by crossbreeding different kinds of rice. It typically displays heterosis or hybrid vigor such that when it is grown under the same conditions as comparable high yielding inbred rice varieties it can produce up to 30% more rice. However, the heterosis effect disappears after the first (F1) generation, so the farmers cannot save seeds produced from a hybrid crop and need to purchase new F1 seeds every season to get the heterosis effect each time.

Table 6: Amount of Credit Taken by Households

	Mean	Std. Dev.	N
Treatment Assigned Households (Access to Credit)			
Amount of Credit Taken (in taka†)	5701.882	13988.14	2072
Credit Taken Households			
Amount of Credit Taken (in taka†)	29027.76	17869.91	407

Note: †78taka=1dollar. Treatment assigned households are the ones who are eligible to receive the credit service. Credit taken households are the households in the treatment group who actually took credit.

Figure 5: Distribution of the Amount of Credit (Credit Taken Households)

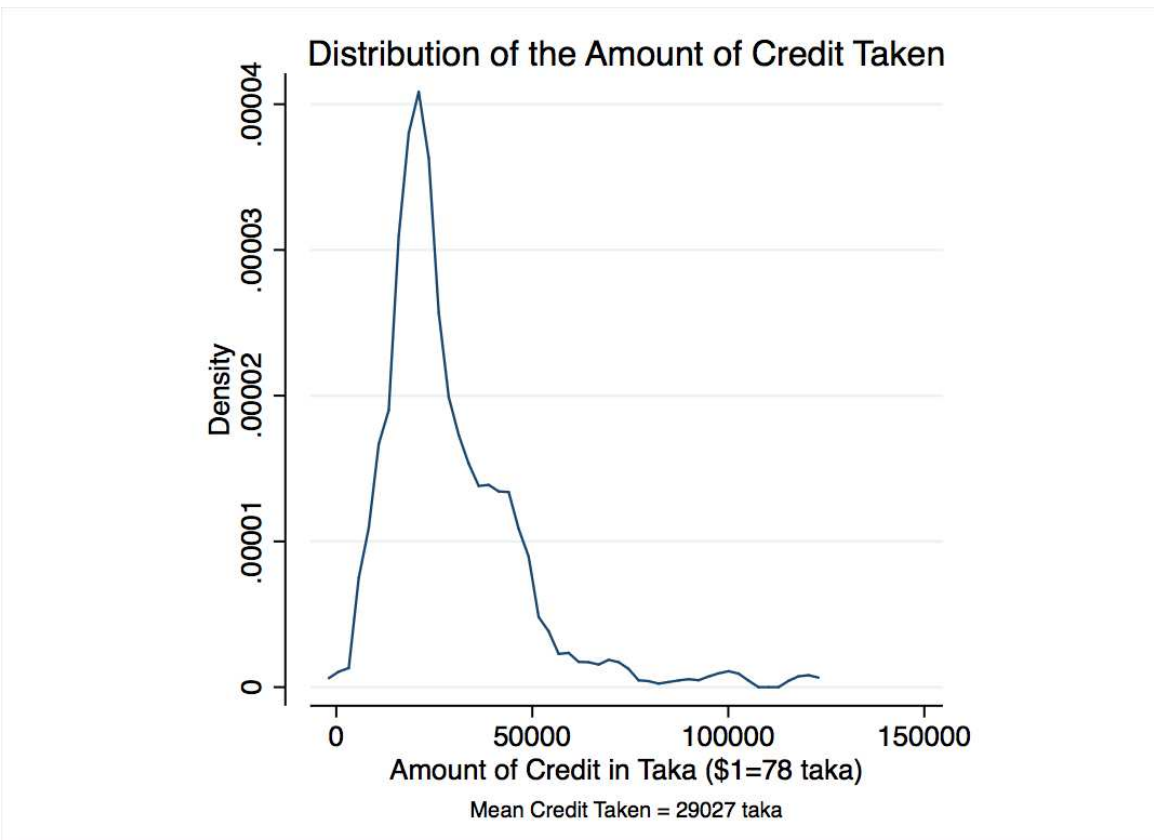

Table 7: Change in Production Inputs over Study Period by Household's Credit Status

	Change in Input Use Over Study Period (2012-2014)						
Variables	Land	Labor	Seed	Irrigation	Fertilizer	Pesticides	Plough
Households with Credit Access (Treatment assigned)	1.78	29.44***	5.99***	9.07*	35.72***	2.78***	2.29***
	[5.23]	[4.54]	[1.88]	[4.62]	[10.09]	[0.63]	[0.42]
Number of observations	3,535	3,535	3,535	3,535	3,535	3,535	3,535
Households with No Credit Access (Control)	1.09	29.03***	2.56	10.19***	16.31	-0.17	1.48***
	[4.68]	[4.86]	[2.57]	[3.45]	[11.41]	[0.58]	[0.35]
Number of observations	3,395	3,395	3,395	3,395	3,395	3,395	3,395
Credit Taken Households (Treatment assigned & took credit)	-3.24	22.98***	4.78**	4.48	34.89***	2.60***	1.63**
	[8.01]	[2.85]	[1.77]	[4.76]	[10.32]	[0.63]	[0.68]
Number of observations	660	660	660	660	660	660	660

Notes: *** p<0.01, ** p<0.05, * p<0.1. Land is measured in decimal (also spelled **decimel**) which is a unit of area in India and Bangladesh approximately equal to 1/100 acre (40.46 m²); 247 decimal=1 hectares. Labor is measured in days and consists of both family labor and hired labor. Seed is measured in kilogram (1 kilogram=2.204 pounds). Irrigation is measured in number of hours. Fertilizer measured in kilogram. Pesticides are in number of times applied. Ploughed refers to number of time the land is ploughed to prepare it for cultivation. Sample includes only rice producing farm households. Standard errors (in parentheses) are clustered at Branch level.

Table 8: Change in Production Inputs over Study Period by Household's Credit Status

	Change in Input Use Over Study Period (2012-2014)						
Variables	Land	Labor	Seed	Irrigation	Fertilizer	Pesticides	Plough
Households with Credit<20000	-7.92	24.18***	6.77*	1.48	14.22	1.57**	1.56**
	[9.81]	[4.12]	[3.35]	[6.78]	[11.50]	[0.60]	[0.54]
Number of observations	138	138	138	138	138	138	138
Households with Credit>=20000	-2.44	22.52***	4.27*	4.93	39.46***	2.84***	1.61*
	[9.00]	[3.57]	[2.03]	[4.79]	[13.10]	[0.76]	[0.82]
Number of observations	522	522	522	522	522	522	522

Notes: *** p<0.01, ** p<0.05, * p<0.1. Land is measured in decimal (also spelled **decimel**) which is a unit of area in India and Bangladesh approximately equal to 1/100 acre (40.46 m^2); 247 decimal=1 hectares. Labor is measured in days and consists of both family labor and hired labor. Seed is measured in kilogram (1 kilogram=2.204 pounds). Irrigation is measured in number of hours. Fertilizer measured in kilogram. Pesticides are in number of times applied. Ploughed refers to number of time the land is ploughed to prepare it for cultivation. Sample includes only rice producing farm households. Standard errors (in parentheses) are clustered at Branch level.