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

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Abstract: Poor financial environment of rural developing economy leads to underinvestment and inefficiency of marginal and small-scale farm households. Development interventions for providing improved market access and credit at subsidized interest rate to small farm households are therefore considered as the preconditions in the transformation process of rural agrarian economy. Hence, the question of whether access to resources influences farm households' production decisions, performance and efficiency is very important. In this paper, we attempt to estimate the impact of a subsidized credit on farm output and efficiency of small and marginal rice farmers of Bangladesh. Using survey data of a field experimental study, we show that relaxing the credit constraint has significant positive impact on farm output and efficiency. On an average, small-scale rice farms with access to subsidized credit are found to be 13% more efficient than farms with no credit access. The increase is 76% on average when we use the randomized access to credit as instrument for farm credit. We also examine the impact heterogeneity of access to credit by rice variety. We find that cultivation of modern Hybrid rice variety is significantly higher (on average 17%) for treatment farm households compare to the control group. However, we do not find much evidence of heterogeneous productivity impact of access to credit by HYV vs. Hybrid rice. Combining the results, we conclude that access to credit is effective in improving the overall output and efficiency of marginal and small-scale rice farm households. Thus, policies enhancing the credit access of marginal farmers are important for sustainable agricultural development of rural developing economy.

Introduction

Small and informal firms are central source of employment for half or more of the labor force in most developing countries (World Bank, 2004). However, marginal and small-scale farm households in rural developing economy face imperfect financial markets as well as limited resources. This poor financial environment shapes the investment pattern of small farm households and might lead to underinvestment and inefficiency (Townsend 1994, Morduch 1993, D Karlan et. all 2013). Recent causal evidence on microcredit impacts confirms the existence of severe credit

constraints of marginal firms in developing economies. Marginal rate of return to capital of small marginal farms is very high compare to the market interest rate. Thus, relaxing the liquidity constraint induces these farms to finance their production and affects farm sales and profit. (McKenzie, Woodruff 2008; Banerjee, Duflo 2013). However, capital or credit constraints alone are not the problem especially in the context of rural agrarian economy. Risk matters and it influences the investment decision and farm income even after relaxing the credit constraint (D Karlan et.all 2013).

Therefore, development interventions for providing resource constrained farm households with credit at subsidized interest rate, inputs, improved financial instruments, market access etc. are considered as preconditions for the transformation process of rural developing economy. Given this context, the question of whether small-scale farms allocate limited resources to their best use, whether access to credit and resources influences small farm household's performance and efficiency etc. are very important. This paper, using survey data of a field experimental study in Bangladesh, aims to estimate the impact of a subsidized credit on farm output and efficiency of small and marginal rice farmers of Bangladesh.

Measuring the efficiency of marginal and small-scale farmers and attempts to identifying credit as one of the possible determinants of efficiency has long been the research interest among agricultural economists. Lots of empirical papers attempt to test the effectiveness of subsidized agricultural microcredit on income and efficiency of subsistence and marginal farmers. However, the findings are not conclusive. Also, most of the studies rely exclusively on observational studies,

plagued by endogeneity concerns. Thus, there exists a lack of credible estimates of the impact of credit expansion on farm households' efficiency.

This paper attempts to address this gap. We add to the existing literature by using data from a natural field experiment to estimate the causal effect of credit expansion on output and efficiency of small-scale farm households. In particular, we attempt to address two questions: (1) Does credit expansion improve small firms' output and technical efficiency of small and subsistence level agricultural farm households? (2) Whether there is any heterogeneity in the effect of credit on farm household efficiency (e.g. by adoption of modern rice variety, land size etc.)?

To answer the questions, we begin by estimating a simple log linearized Cobb- Douglas production function of rice and get the predicted rice output. Next, we take the difference between actual and predicted output (i.e. the residuals). Then we regress the actual and predicted output difference on treatment variable to estimate the impact of access to credit on efficiency of rice farms. However, as the program take-up rate was around 20%, this estimate gives us the intent-to-treat effect of the credit expansion program- i.e. how access to credit, on average, affects outcome variable of interest. To estimate the impact of credit on efficiency of rice production, we follow the IV approach. We instrument credit by the treatment assignment and get the treatment on the treated effect.

We also examine the impact of access to credit on the technology choice or adoption of modern rice variety by farm households and then test the impact heterogeneity of access to credit by rice variety. Specifically, we estimate whether impact of credit access on rice productivity is different for HYV (high yielding variety) vs. modern Hybrid rice. To answer this question, we create an

interaction term of modern rice variety (Hybrid dummy) and treatment assignment and check whether the coefficient estimate of this interaction term is statistically significant or not. We control for baseline covariates for all the regressions and the standard errors are clustered at the branch level.

Our findings are as follows. Small-scale rice farm households with access to subsidized credit are, on average, significantly more efficient (by 13%) than farms with no credit access. The increase is 76% on average when we use the randomized access to credit as instrument for farm credit. We also find that cultivation of modern Hybrid rice variety is significantly higher (on average 17%) for treatment farm households compare to the control group. However, we do not find evidence of heterogeneous productivity impact of access to credit by HYV vs. Hybrid rice. Combining the results, we conclude that access to credit is effective in improving the overall output and efficiency of marginal and small rice farm households.

Credit and firm output Literature

The rapid increase in development funding being channeled to microfinance organizations highlights the nexus between credit access and small farm efficiency. Channelizing credit in the resource utilization may not automatically ensure the full potential of output in agriculture and thus the notion of 'technical efficiency in production' arises (Taylor et al, 1986a, p.111). Schultz's "poor but efficient" hypothesis argues that in context of rural developing economy, merely a provision of agricultural credit at subsidized rate may not be effective in achieving higher technical efficiency due to limited investment opportunities.

Therefore, attempts to test the effectiveness of subsidized agricultural microcredit on income and efficiency of subsistence and marginal farmers is not new. Economic efficiency at the micro level focuses on the ability of farms to utilize the best available technology and to allocate resources productively. Measurement of technical efficiency of farmers and identifying credit as a possible determinant of efficiency has long been the research interest among agricultural economists. The question is also important from policy perspective as governments of developing countries, with their limited resources and urge to ensure the food security and well-being of poor people, aim to find out the effective ways to improve the productivity and efficiency of the small and subsistence farm households.

Findings of empirical studies on the effectiveness of subsidized credit are mixed. Studies in Brazil and Latin American did not find subsidized credit programs as useful for improving traditional farm efficiency (Taylor et. al 1986; Adams 2001). On the other hand, studies in Philippine, West Bengal, Pakistan, Bangladesh, using stochastic frontier analysis, identified credit as an important determinant of farm efficiency and suggest that access to credit has the potential to increase the production and cost efficiency (Edward Martey et. al 2015; Laha Arindam 2013; Zahidul 2011). Some recent studies in Ghana and Philippine have found land ownership and tenure system to be more important for farm efficiency and argue that only credit is not effective in improving farm efficiency (Donkor, 2014; Koirala et. al 2015).

Also, most of these studies rely exclusively on observational studies and thus plagued by endogeneity concerns. Although recent causal evidence on microcredit impacts informs economic theory and policy debates about its effectiveness as a development tool, none of the recent evidence

addresses credit impacts on firm efficiency (Banerjee, Karlan, Zinman, 2015). Therefore, no credible estimates exist of the impact of credit expansion on firm efficiency and there is gap in the existing literature and we attempt to address this gap in this paper.

Rest of the paper proceeds as follows. In Section 1, we describe the credit program and the experimental design. Section 2 presents our estimation approach. Sections 3 discuss the results and Section 4 concludes.

1. Project Background

1.1. BCUP Credit Program

Ineffectiveness of conventional microcredit and formal banking systems for the farming community especially the tenant farmers in Bangladesh is prevalent. In this context, BRAC[1] introduced the 'Tenant Farmers Development Project' (*Borga Chashi Unnayan Prakalpa* (BCUP)), with a low-interest revolving fund from the Bangladesh Bank (Central Bank of Bangladesh) under its financial inclusion strategy. The project was initiated in December 2009 (*Boro* season of 2010) with Tk. 5,000 million (USD 70 million) as revolving loan fund with an interest rate of 5 per cent per month (the rate at which commercial banks can borrow fund from the Central Bank). The fund was given initially for three years with a target of reaching 300,000 farmers with credit within this period. In 2012, Bangladesh Bank approved extension of the project for another three years.

[1] BRAC is the largest NGO in Bangladesh and the world.

The BCUP program 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 rate of interest which is a flat rate of 10 per cent per year. The effective rate of interest comes to about 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 (taka 5,000-30,000); duration is 6-10 months; grace period is 1 month and the Instalment is monthly. An important feature of BCUP program is the formation of Village Organization (VO) as the platform for the delivery of services. 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, advice from the Agriculture Development Officer (ADO).

Households are selected for loan disbursement by few stages of verification. After screening and verification of information, members are formed into small groups. A Village organization (VO) is formed by combining at least three small groups. BCUP is targeted to reach all 484 *Upazilas* (sub-districts) of Bangladesh in successive phases. By September 2012, it reached to 212 *Upazilas.* The main objective of the program was to reduce the dependence of tenant farmers on high-cost informal markets for financing their working capital needs, since they do not have access to formal financial institutions for various reasons. By reducing the credit constraints, BCUP program aimed at improving farm productivity and livelihoods of rural small-scale farm households of Bangladesh significantly.

1.2. Experimental Design

For the purpose of the evaluation of the BCUP program, a clustered randomized control trial (RCT) design was adopted. Initially, the program identified the potential 40 branch offices to scale up the program in the year 2012. The research team then randomly drew twenty (20) treatment branches for intervention and the rest twenty (20) branches were designated as control branch offices. Six villages were selected randomly from each treatment and control branch among all the villages within the 8 kilometer radius of the branch catchment area. Thus, 240 villages were selected for this study. Then, a census was conducted in 240 villages covering 61,322 households for detecting eligible households. Using this household census information and based on the program eligibility criteria- willing to take loan, maximum land holding limits 33 decimal- 200 decimal etc. 7,563 households were identified as eligible to participate in the BCUP program- 4,228 and 3,335 in the treatment and control areas, respectively. Finally, among these eligible households, a total of 4,331 households were selected randomly for the 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. The program take-up rate was around 20%.

2. Empirical Strategy

2.1 Data

This study uses data from a randomized control evaluation design adopted to evaluate the BCUP (Barga Chashi Unnayan Prakalpa) program in Bangladesh. The level of analysis is

farm household. Baseline and end line information on economic, demographic variables of farm households; input, output, price and other variables of rice farm land etc. are used.

2.2 Empirical Strategy

Our aim is to estimate the impact of credit on technical efficiency[2] of rice production. We begin by estimating a simple log linearized Cobb- Douglas production function of rice.

$$y_i = \beta_0 + \beta_1 N_i + \beta_2 L_i + \beta_3 M_i + \beta_4 K_i + \epsilon_i \qquad (1)$$

$y_i =$ Value of rice output of household i

$N_i =$ Labor cost of household i

$L_i =$ Land cost of household i

$M_i =$ Seed, Fertilizer and Pesticide cost of household i

$K_i =$ Irrigation, Land preparation and other cost of household i

$\epsilon_i =$ Error term

i $= 1\ to\ n$

All the variables are from the end line survey data of 2014 and measured in log form. Estimation of the rice production function (equation 1) gives us the $\widehat{y_i}$ - predicted value of rice output. We take the difference between actual and predicted output i.e. the residuals,

[2]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.

$\widehat{\epsilon_i} = y_i - \widehat{y_i}$. Then we run the regression of the actual and predicted output difference $\widehat{\epsilon_i}$on treatment variable Z_i

$$\widehat{\epsilon_i} = \gamma_0 + \gamma_1 Z_i + \sum_{j=2}^{m} \gamma_{ji} X_{ji} + \vartheta_i \qquad i = 1 \; to \; n \qquad (2)$$

$Z_i = 1$ if treatment household (Access to credit) and 0 otherwise. $X_{ji}{}'s$ are baseline covariates j of household i. Our parameter of interest is $\hat{\gamma}_1$ which shows the impact of access to credit (treatment assignment) on efficiency of rice farms. However, as the program take-up rate was around 20%, this estimate gives us the intent-to-treat effect of the credit expansion program- i.e. how access to credit, on average, affects outcome variable of interest.

To estimate the impact of credit on efficiency of rice production, we follow the IV approach and run the following version of regression (2)

$$\widehat{\epsilon_i} = \gamma_0' + \gamma_1' D_i + \sum_{j=2}^{m} \gamma_{ji}' X_{ji} + \vartheta_i' \qquad i = 1 \; to \; n \qquad (2')$$

$D_i = 1$ if the household took credit from BCUP and 0 otherwise. We instrument D_i by Z_i. Thus, $\widehat{\gamma_1'}$ gives the impact of credit on efficiency- treatment on the treated effect. Standard errors are clustered at the branch level. There are two major rice producing seasons in Bangladesh – Boro and Aman[3]. We refer to both Boro and Aman production by All Season.

[3]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

We estimate equation (2) and (2′) for All season as well as for each of the seasons separately.

2.3 Heterogeneous Treatment Effects

Relaxing credit constraint induces small-scale farms to finance more in production. (McKenzie, Woodruff 2008; Bnaerjee, Duflo 2013). However, capital or credit constraints alone are not the problem especially in the context of uncertainty of rural agrarian economy. Risk matters and it influences the investment decision of farm and farm income even after relaxing the credit constraint (D Karlan et.all 2013).

We expect that BCUP credit enables the resource constrained marginal farms to buy fertilizer, seeds and do irrigation at proper time and hence increase their output and productivity. Credit can also induce the small farms to adopt/ produce more Hybrid rice variety which is comparatively more costly (requires more complementary inputs) but also has higher yield on average than HYV rice. Thus credit might have differential impact on the technical efficiency of different rice varieties.

To test these hypotheses, at first, we examine the impact of access to credit on adoption of modern rice variety by the following equation

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.

$$Y_i = \beta_0 + \beta_1 Z_i + \sum_{j=2}^{m} \gamma_{ji} X_{ji} + \epsilon_i \qquad i = 1\ to\ n \qquad (3)$$

$Y_i = 1$ if the farm *i* produces Hybrid rice, 0 otherwise. Z_i if is the treatment dummy (Access to credit). $X_{ji}s$ are baseline covariates *j* of household *i*. Our parameter of interest is $\hat{\beta}_1$. We also estimate impact of credit on Hybrid rice adoption by instrumenting credit D_i by treatment assignmentZ_i in equation (3).

We then test the impact heterogeneity of access to credit by rice variety by creating an interaction term of modern rice variety (Hybrid dummy) and treatment assignment and run the following version of equation 2

$$\widehat{\epsilon_i} = \gamma_0^* + \gamma_1^* Z_i + \delta_1^* Hybrid_i + \delta_2^* Hybrid_i * Z_i + \sum_{j=2}^{m} \gamma'_{ji} X_{ji} + \vartheta_i^* \qquad (2'')$$

$\widehat{\delta_2^*}$ is our parameter of interest. Again we estimate equation (3) and $(2'')$ for All season as well as for each of the Boro and Aman season separately. We control for baseline covariates and standard errors are clustered at the branch level.

3. Results and Discussion

We use data from RCT study for evaluating the BCUP (Barga Chashi Unnayan rakalpa) program in Bangladesh. Sample size of the study is 4301 households. For this paper, we only consider the rice producing farm households. Our sample size is 3752 households. Table 1 shows the baseline characteristics and balancing between treatment and control

households. Treatment and control households had significant difference in terms of credit access to other NGO and informal sources. We also did the join significance test and we could not reject the Null hypotheses of no joint significance. For all our regression analysis, we control for Baseline covariates.

At first, we estimate the impact of credit access on farms input allocation and adoption of modern Rice varieties. Table 2 summarizes the result. We find that Hybird rice production was on average 17% higher for the treatment rice farms compare to the control farm households. Treatment farm households significantly reduced their input investment for HYV rice and increased input allocation for modern Hybrid rice. The finding was consistent for each of the rice producing seasons.

Then, we estimate the impact of access to credit on efficiency of rice farms. Table 3 presents both the ITT and IV estimates. We find that small-scale rice farms with access to subsidized credit are on average 13% more efficient than farms with no credit access. The increase is 76% on average when we use the randomized access to credit as instrument for farm credit.

Finally, we examine the impact heterogeneity of access to credit by rice variety (Table 4). However, we only find heterogeneous productivity impact of access to credit for Aman season. Treatment farm households who produced Hybrid rice are found to be 37% more efficient than HYV rice producers. Combining all the results, we conclude that access to

credit is effective in improving the overall output and efficiency of marginal and small-scale rice farm households.

4. Conclusion

Using survey data of a BCUP program evaluation study of Bangladesh, we estimate the impact of a subsidized credit on farm output and efficiency of small and marginal rice farmers. We show that relaxing the credit constraint has significant positive impact on farm output and efficiency. On an average, small-scale rice farms with access to subsidized credit are more productive than farms with no credit access. We also find that removing credit constraints helps small and marginal farms to reallocate their production inputs and invest more in modern rice variety. Cultivation of modern Hybrid rice variety is significantly higher for treatment farm households compare to the control group. However, there is not much evidence of heterogeneous impact of access to credit by rice variety except the Aman season produciton. Combining the results, we conclude that access to credit is effective in improving the overall output and efficiency of marginal and small-scale rice farm households. Thus appropriate policies targeting at enhancing the credit access of small farms are important for the sustainable agricultural growth and improved efficiency of rural agrarian economy.

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Table 1: Baseline Characteristics and Balancing

	(1) Control	(2) Treatment	(2)-(1) t value
Variables			
Household Composition			
Sex of household head (male=1)	0.95	0.91	-1.68
Age of household head	44.45	45.07	0.911
Household size	4.75	4.93	1.044
Number of adult members (>16)	3.1	3.1	0.0324
Number of child (<16)	1.65	1.83	1.544
Household head no education	0.45	0.42	-0.565
Amount of Land			
Own cultivated land (decimal[†])	38.83	37.38	-0.442
Rented in land (decimal)	51.31	51.12	-0.0252
Rented out land (decimal)	7.78	8.39	0.517
Total cultivated land (decimal)	90.14	88.5	-0.177
Access to credit			
Loan from other NGO (dummy)	0.07	0.05	-1.91
Any formal and informal loan (dummy)	0.17	0.11	-3.059
Output and Input for Rice Production (yearly)			
All Season production (kilogram)	1988.56	1999.32	0.0531
HYV rice (kilogram)	1550.05	1602.95	0.19
Hybrid rice (kilogram)	97.39	79.5	-0.353
Land (decimal[†])	115.44	117.98	0.189
Labor days	51.96	54.87	0.627
Seed, Fertilizer and Pesticide (taka[††])	5654.67	5134.75	-0.842
Irrigation, Land preparation and other cost (taka[††])	6819.5	6311.16	-0.539
Price of Inputs			
Price of rice[§] (kilogram)	15.34	16.11	1.282
Price of land (decimal[†])	9250.09	11731.28	1.428
Labor Wage[§§] (taka[††])	229.9	276.42	2.387
Joint significance test			*F* statistic = 45.10

Notes to table 1: [†]247 decimal=1 hectare. [††]$1=80 taka. [§]village level rice price. [§§]Village level wage per day. Unit of observation: household. Standard errors (in parentheses) are clustered at Branch level. Sample includes all households surveyed at baseline (2012); for input output section, only rice producing farm households are considered. Informal lenders includes moneylenders, loans from friends/family, and buying goods/services on credit from sellers.

Table 2: Effect on Inputs of Rice and Adoption of Modern Rice varieties

	All Season[#]		Boro season Rice[##]		Aman Season Rice[###]	
	(1)	(2)	(3)	(4)	(5)	(6)
Adoption of Rice varieties						
HYV rice (dummy)	-0.10	-0.09	-0.047*	-0.276**	0.01	0.039
	[0.07]	[0.06]	[0.02]	[0.11]	[0.12]	[0.66]
Hybrid rice (dummy)	0.17***	1.18***	0.16***	0.95***	0.09***	0.51***
	[0.03]	[0.18]	[0.04]	[0.20]	[0.028]	[0.172]
Total Rice Production Inputs (yearly)						
Land (decimal)	-5.40	-62.47	-12.32**	-72.22**	-7.09	-39.12
	[10.47]	[65.69]	[5.64]	[33.54]	[10.45]	[57.02]
Labor days	-8.17	-27.32	-8.69	-50.87*	-4.64	-25.61
	[7.20]	[47.72]	[5.40]	[28.74]	[4.28]	[23.69]
Seed, Fertilizer and Pesticide (taka[††])	-1,466**	-5,973*	-1,050***	-6,156***	-932.2**	-5,146*
	[613.6]	[3,531]	[317.8]	[2,06]	[366.4]	[2,878]
Irrigation, Land preparation and other cost (taka[††])	542.60	-247.10	-2829.00	-16581.00	-540.40	-2,983
	[492.1]	[660.9]	[1,945]	[11,50]	[703.7]	[3,780]
HYV Rice Production Inputs (yearly)						
Land (decimal[†])	-23.97*	-93.67	-19.85**	-116.4**	-13.37	-73.79
	[12.73]	[66.21]	[5.72]	[31.78]	[11.18]	[71.25]
Labor days	-14.25	-47.81	-12.41**	-72.71***	-5.92	-32.67
	[8.49]	[47.05]	[5.39]	[26.99]	[5.769]	[34.25]
Seed, Fertilizer and Pesticide (taka[†])	-1,891**	-8,553**	-1,480**	-8,675**	-848.00	-4,681
	[699.1]	[3,435]	[331.9]	[1,922]	[532.2]	[3,626]
Irrigation, Land preparation and other cost (taka[††])	-4,473**	-25,167**	-3,768**	-22,086**	-1,164**	-6,423**
	[1,892]	[11,075]	[1,840]	[10,826]	[447.3]	[3,268]
Hybrid Rice Production Inputs (yearly)						
Land (decimal[†])	8.46***	53.70***	7.78***	45.61***	4.05**	22.38*
	[2.23]	[9.20]	[2.22]	[9.64]	[1.94]	[12.15]
Labor days	3.77***	25.82***	3.78***	22.14***	1.65**	9.10**
	[1.08]	[5.59]	[1.14]	[5.76]	[0.63]	[4.033]
Seed, Fertilizer and Pesticide (taka[††])	371.8***	2,820***	434.3***	2,546***	113.9**	629.0***
	[130.8]	[682.0]	[155.6]	[668.6]	[43.84]	[226.0]

Irrigation, Land preparation, other cost (taka††)	791.4***	5,799***	943.0***	5,527***	167.0*	922.1
	[225.6]	[1,347]	[291.5]	[1,366]	[91.29]	[574.1]
Observations	3,062	2498.00	2439.00	2439.00	1671.00	1671.00

Notes to table 2: †247 decimal=1 hectare. ††$1=80 taka. *** p<0.01, ** p<0.05, * p<0.1.
Sample includes only rice producing farm households. Column (1), (3) and (5) shows the intent to treat (ITT) effect of the treatment on outcome of interest. Column (2), (4) and (6) shows the impact of credit (Treatment on the Treated) on outcome of interest where credit is instrumented by the treatment assignment. Standard errors (in parentheses) are clustered at Branch level. For all the regression we control for baseline covariates.
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.

Table 3: Effect of Credit on Efficiency of Rice Production

	(1)	(2)	Observation
All Season#			
Total Rice production	0.13***	0.76***	2,474
	[0.05]	[0.27]	
Total HYV	0.14***	0.77***	2,289
	[0.05]	[0.28]	
Total Hybrid	0.11	0.37*	365
	[0.07]	[0.23]	
Total Traditional Variety	-0.08	-0.55	441
	[0.083]	[0.66]	
Boro Season##			
Total Rice production	0.089**	0.57**	2,197
	[0.04]	[0.24]	
Total HYV	0.08*	0.52**	2,141
	[0.041]	[0.25]	
Total Hybrid	0.03	0.116	278
	[0.08]	[0.33]	
Aman Season###			
Total Rice production	0.22*	1.18*	1,635
	[0.11]	[0.61]	
Total HYV	0.26**	1.21*	1,176
	[0.12]	[0.64]	

Total Hybrid	0.49**	1.15	110
	[0.18]	[0.71]	
Total Traditional Variety	-0.0004	-0.00312	636
	[0.08]	[0.64]	

Notes to table 3: *** p<0.01, ** p<0.05, * p<0.1.
Sample includes only rice producing farm households. 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) on outcome of interest where credit is instrumented by the treatment assignment. Standard errors (in parentheses) are clustered at Branch level. For all the regression we control for baseline covariates.
[#] 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.

Table 4: Heterogeneous Effect of Credit on Efficiency Rice Production (HYV vs. Hybrid rice)

Variables	All season[#]		Boro Season[##]		Aman Season[###]	
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment (access to credit)	0.134***	0.160***	0.0897**	0.077**	0.221*	0.286**
	[0.047]	[0.049]	[0.0405]	[0.038]	[0.109]	[0.128]
Hybrid rice production (dummy)		0.141**		0.19**		-0.125
		[0.065]		[0.074]		[0.128]
Access to credit x Hybrid Dummy		-0.08		-0.075		0.369**
		[0.068]		[0.079]		[0.140]
Control for Baseline covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,474	2,038	2,196	2,182	1,635	999

Notes to table 4: *** p<0.01, ** p<0.05, * p<0.1.
Sample includes only rice producing farm households. **R**esults show the intent to treat (ITT) effect of the treatment on outcome of interest. Standard errors (in parentheses) are clustered at Branch level. For all the regression we control for baseline covariates.
[#] 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.

Appendix

Table A.1: Descriptive Statistics and Baseline Characteristics

Variables	N	Mean	Std. Dev.	Min	Max
Household Composition					
Sex of household head (male=1)	4301	0.93	0.25	0.00	1.00
Age of household head	4301	44.76	11.64	7.00	99.00
Household size	4,301	4.84	1.76	1.00	20.00
Number of adult members (>16)	4301	3.10	1.34	1.00	12.00
Number of child (<16)	4,301	1.74	1.24	0.00	11.00
Household head no education	4301	0.44	0.50	0.00	1.00
Amount of Land					
Own cultivated land (decimal†)	4301	38.10	51.39	0.00	1003.00
Rented in land (decimal)	4301	51.20	89.30	0.00	2610.00
Rented out land (decimal)	4301	8.09	28.42	0.00	426.00
Total cultivated land (decimal)	4,301	89.30	97.96	0.00	2610.00
Access to credit					
Loan from other NGO (dummy)	4301	0.06	0.23	0.00	1.00
Any formal and informal loan (dummy)	4,301	0.14	0.35	0.00	1.00
Output and Input for Rice Production (yearly)					
All Season production (kilogram)	3752	1994.00	1694.41	30.00	23325.00
HYV rice (kilogram)	3752	1576.76	1531.38	0.00	23325.00
Hybrid rice (kilogram)	3752	88.36	499.82	0.00	9126.00
Land (decimal†)	3752	116.73	102.12	4.00	1320.00
Labor days	3,752	53.43	47.71	0.00	575.86
Seed, Fertilizer, Pesticide Cost (taka††)	3752	5392.21	4972.32	0.00	53153.00
Irrigation, Land preparation, other cost (taka††)	3,752	6562.89	6329.18	0.00	67201.00
Price of Inputs					
Price of rice§ (kilogram)	3752	15.73	2.53	9.38	30.81
Price of land (decimal†)	3752	10502.59	18081.30	1.00	500000.00
Labor Wage§§ (taka††)	3752	253.38	66.29	100.00	450.00

Notes to table A1: †247 decimal=1 hectare. ††$1=80 taka. §village level rice price. §§Village level wage per day. 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 includes moneylenders, loans from friends/family, and buying goods/services on credit from sellers.