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Increasing Boro rice productivity through credit: Evidence from Bangladesh

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Abstract: Rice productivity needs to be increased to feed Bangladesh's growing population. Productivity can be increased by adopting improved varieties and management practices, which require additional capital inputs. In this article, we aim to estimate the effect of formal and semiformal credit on rice productivity in Bangladesh. We surveyed 500 rice farmers to achieve these objectives. We used descriptive statistics, propensity score matching and Heckman's endogenous treatment effect model to analyse the data. The findings indicate that literacy, television ownership and training positively influenced access to formal credit. In general, credit recipients achieved higher productivity than did non-recipients. In the situation of credit source-specific effect, we found mixed results. Given the estimated difference of 438 kg/ha to 495 kg/ha, the results indicated that formal credit recipients had significantly higher productivity than did formal credit non-recipients. In contrast, endogenous treatment effect model results suggested that both formal and semiformal sources of credit had a significant effect on rice productivity. Increased agricultural loan disbursement through formal and semiformal credit institutions is strongly advocated. Farmers' decision-making abilities regarding the most effective source of credit can be improved through training in financial literacy. The central bank of Bangladesh, along with the credit regulatory authorities of non-governmental organisations, can implement appropriate agricultural credit programmes for farmers.

Keywords: agricultural loan; formal credit; Heckman's endogenous treatment effect; propensity score matching; semiformal

In developing countries, the agricultural sector serves as the primary catalyst for economic growth (Haryanto et al. 2023). The modernisation of agriculture, being a venture that requires a significant amount of capital, necessitates substantial investment. Hence, the presence of sufficient capital is essential for enhancing farm productivity, as it enables farmers to acquire necessary inputs and technology. In the present era, the agriculture industry relies significantly on credit as a result of the fluctuating income of farmers caused by seasonal variations and the shift from subsistence farming to commercial farming (Deb et al. 2020a). The credit al-

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located to agriculture in 2022 amounted to USD 1 099 billion, representing growth of 13%, compared with the 2013 amount of USD 972 billion (FAO 2023).

Agriculture in Bangladesh is dominated by crop cultivation, particularly rice production. Rice, the main course of approximately 165 million Bangladeshis, accounts for nearly two-thirds and one-half of an average person's total calorie supply and protein intake, respectively (Akter et al. 2019). Bangladesh has done very well in terms of expanding rice production. Rice production in 1971 was 10.59 million tonnes, and it has increased to 36.6 million tonnes in 2020 (BBS 2020). The increase in rice production is primarily attributable to the modernisation of rice farming techniques, such as introducing modern rice varieties and improved management practices. However, Bangladesh's population continues to increase by two million people each year, and farmers in Bangladesh are losing croplands at a pace of 1% per year (Shelley et al. 2016). As a result, increasing total rice production is necessary to feed the growing population. Bangladesh intends to double its rice yield by 2050 to feed this expanding population (Kabir et al. 2020). Boosting rice production requires replacing local varieties with modern varieties, which necessitates the use of better input management technologies, quality seeds and mechanisation of rice-growing operations, all of which require more capital supply. However, Bangladeshi farmers have generally been small land-holders with little financial means to adopt new and improved agricultural technology (Bidisha et al. 2017). Small farmers are frequently unable to cover the costs of crop production from their own resources, resulting in the application of inputs being postponed (Deb et al. 2020a). Previous researchers have identified a shortage of funds as one of the primary causes for the limited adoption of improved agricultural technology (Rashid et al. 2004; Porgo et al. 2018). Credit constraints can have a negative influence on the adoption of improved management methods, which has an effect on agricultural productivity (Ouattara et al. 2020). Therefore, securing a steady supply of cash through credit can be critical to increasing rice output.

In Bangladesh, the financial market is classified into three categories: formal, semiformal and informal. The formal market is made up of state-owned specialised and commercial banks, as well as private commercial banks. Non-governmental organisations (NGOs) are semiformal sources, whereas friends, family, dealers and moneylenders are informal sources (Deb et al. 2020b). Because of Bangladesh's underdeveloped credit market, credit-constrained households have been forced to seek credit from informal sources at unfavourable terms and conditions (Bidisha et al. 2015). Access to credit from formal and semiformal sources might be critical in overcoming this circumstance. Credit provided by formal and semiformal financial institutions might assist in meeting the surplus demand for capital. In light of this situation, in this study, we seek to assess the effect of formal and semiformal credit on rice productivity, which will aid in the formulation of suitable policies to meet the credit needs of credit-constrained farmers.

Researchers in several studies conducted all over the world have found that having access to credit boosts the rate of adoption and use of improved inputs (Tadesse 2014; Abate et al. 2016; Ouattara et al. 2020). Deb et al. (2020b) stated that receivers of formal credit in Bangladesh reaped higher profits from rice production than did non-recipients. Access to credit enhanced borrowers' income in Ghana (Abdallah et al. 2019). However, the investigators in these studies did not take into account semiformal sources of financing and also ignored crop productivity, which is vital for farmers. A few researchers examined the effect of credit on productivity. According to Bidisha et al. (2015), credit had a major influence on household agricultural output in Bangladesh. Other researchers found a substantial difference in cassava productivity between farmers with and those without access to financing in Nigeria (Awotide et al. 2015). Formal credits considerably boosted overall expenditure and spending on health care and education, but informal and semiformal credits had a minimal effect on consumption in Vietnam (Truong et al. 2020). Investigators in several other studies (Chandio et al. 2018; Agbodji and Johnson 2021) found that relaxing credit constraints increased crop productivity. Approximately 11% of the increase in productivity came from the adoption of technological improvements, which necessitates capital supply (Jimi et al. 2019). However, none of the study investigators distinguished between formal and semiformal credit. The current study adds to the literature through estimation of the productivity effect of access to credit through formal and semiformal channels, which will help develop important guidelines for funding smallholder farmers.

MATERIAL AND METHODS

Study site, sampling technique and data collection

We collected the data from a sample of credit recipients and non-recipients in five districts (admin-

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istrative units) in Bangladesh: Dinajpur, Naogaon, Lalmonirhat, Faridpur and Mymensingh. We selected these districts on the basis of their extensive land suitable for Boro rice cultivation and the presence of farmers who had received credit from banks and NGOs (Rayhan et al. 2023).

For this study, we used a multistage sampling procedure. In the first stage, we purposively selected five districts from 64 districts (the geographical region used for administration). Second, we randomly selected one upazila (subdistrict) from each district. Third, we drew the sample from 10 villages in five upazilas of Bangladesh (two villages from each upazila). We conducted sampling by considering two groups: treatment and control. The treatment group consisted of farmers who were obtaining credit from banks and NGOs. We compiled a list of individuals who were granted credit between July 2018 and June 2019 for the treatment group, encompassing the selected upazilas, in collaboration with bank managers (formal source) and NGOs (semiformal source). The formal sources were Rajshahi Krishi Unnayan Bank and Bangladesh Krishi Bank, and the semiformal source was Association for Social Advancement (ASA), which is an NGO operating in the study areas. The rationale for this selection was that both the selected formal and semiformal sources were the biggest providers of agricultural credit in Bangladesh. The list generated consisted of 1 984 farmers who received credit in five upazilas: Dinajpur (n = 387), Naogaon (n = 395), Lalmonirhat (n = 405), Faridpur (n = 389) and Mymensingh (n = 408). Among the 1 984 farmers who received credit, 695 obtained it from formal sources, and the remaining obtained it from semiformal sources. We randomly selected 250 credit recipients from the list for a face-to-face interview. Out of a total of 250 farmers, we classified 125 as formal credit recipients, and we classified the remaining farmers as semiformal credit recipients. We created a control group in each selected village, consisting of a list of farmers who did not receive any credit from any source. From that list, we selected a total of 250 farmers as control farmers (non-recipient of credit). Therefore, the total sample size for this study was 500.

We used a semi-structured interview schedule to conduct face-to-face interviews between September and December 2019 to obtain the relevant data. We chose the Boro season (December to June) because most rice is produced during this time. For implementation, we pretested the interview schedule before finalising it. We performed the final survey by using a paper interview schedule written in English. The enumerators asked questions in the local language, and the enumerators wrote the farmers' answers in English. Our interview schedule included rice farmers' demographic and socio-economic characteristics, rural credit information, credit recipient and non-recipient status, institutional service and lending information, agricultural input and technology-related information and rice production-related questions. Table 1 shows the distribution of respondents.

Variable definition and measurement

Outcome variable. The outcome variable for this study was rice productivity in kilograms per hectare.

Explanatory variables. Access to credit is influenced by different factors, such as sociodemographic characteristics and economic factors. For this study, the choice of explanatory variables was guided by previous literature, a priori expectations and theoretical and empirical works on determinants of access to rural credit and its effect (Li et al. 2011; Bhandari 2013; Muhongayire et al. 2013; Mazumder and Lu 2015; Abate et al. 2016; Luan and Bauer 2016; Moahid and Maharjan 2020). A description of the explanatory variables used in the models is given in Table 2.

Analytical techniques

We used descriptive statistics and a set of econometric models to achieve the objectives of the study. In this study, we used propensity score matching (PSM) to assess the effect of access to credit on rice productivity. In addition to PSM, we used Heckman's endogenous treatment effect model to assess the effect on rice productivity. The primary concern in assessing the effect of credit on productivity is the presence of selection bias. To measure effects accurately, we had to mitigate sample selection bias by randomly assigning in-

Table 1. Distribution of farmers interviewed in the study areas

Location	Credit recipient		Credit non-recipient	Total
	bank	NGO		
Dinajpur	25	25	50	100
Naogan	25	25	50	100
Lalmonirhat	25	25	50	100
Faridpur	25	25	50	100
Mymensingh	25	25	50	100
Total	250		250	500

NGO –non-governmental organisation
Source: Authors' own elaboration

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Table 2. Definition of variables and measurements

Variable	Type	Definition and measurement
Family size	continuous	total number of members in the household.
Earning member in family	continuous	number of household members that earn in the family
Literacy	dummy	1 if household head went to school, otherwise 0
Distance to bank	continuous	distance from home to the nearest commercial bank (in km)
Distance to NGO	continuous	distance from home to the nearest NGO or rural credit institute (in km)
Rice farming experience	continuous	experience of rice farming of the household head (in years)
Farm size	continuous	farm size in decimal
Off-farm income	dummy	1 if the household generated off-farm income, otherwise 0
Television ownership	dummy	1 if the household had television, otherwise 0
Safety net	dummy	1 if the household participated in a safety net programme, otherwise 0
Training	dummy	1 if the farmer received training in rice cultivation, otherwise 0
Dinajpur	dummy	1 if located in Dinajpur, otherwise 0
Naogaon	dummy	1 if located in Naogaon, otherwise 0
Mymensingh	dummy	1 if located in Mymensingh, otherwise 0
Lalmonirhat	dummy	1 if located in Lalmonirhat, otherwise 0
Productivity	continuous	yield of rice per ha

NGO –non-governmental organisation
Source: Authors' own elaboration

dividuals to different treatments. Both parametric and nonparametric estimation approaches can be used to address issues related to non-randomised data and selection bias. In this study, we used both approaches.

We used the PSM method as a nonparametric technique to ascertain the causal effects. PSM can effectively decrease the number of covariates, thereby facilitating the attainment of balance between credit recipients (treatment group) and credit non-recipients (control group) among farmers. PSM compares the mean outcome of the treatment group (credit recipient) with that of the control group (credit non-recipient) on the basis of observed characteristics. In observational studies, no farmers can both participate in the credit programme and concurrently not take part in it. Thus, we considered farmers who did not take any credit as the control group (Luan and Bauer 2016). We used two steps for PSM. In the first step, we used a binary probit model to analyse factors affecting farmers' decision to take credit. We assumed that, given the socioeconomic and technological characteristics, farmers would prefer to receive credit if the utility gain from credit received was higher than it would be without receiving it. For the binary probit model, we considered a farmer to be a credit recipient if he or she received credit from any of the financial institutions and assigned a score of 1; otherwise, the score was 0. The second step of PSM was to estimate the effect denoted by the average treatment effects on the treated (*ATT*), expressed formally as follows:

$$ATT = (Y1 - Y0|T = 1) = (Y1|T = 1) - (Y0|T = 1) \quad (1)$$

where: $(Y1|T = 1)$ – outcomes for credit recipients; $(Y0|T = 1)$ – hypothetical outcome that would have resulted if the recipient farmers had not taken credit.

However, the validity depended on the conditional independence and common support assumption in propensity scores across the credit recipient and credit non-recipient farmers. In this study, we tested the validity of assumptions by using a balancing property test. We used three matching algorithms – nearest neighbour, kernel and radius matching – to estimate the effect on rice productivity. However, one drawback of PSM is that it may fail to account for unobserved differences between credit recipients and non-recipients because the propensity scores are calculated based on observed characteristics. Therefore, we used Heckman's endogenous treatment effect model to capture the effect of unobserved differences.

For the parametric approach, one can use either instrumental variable regression or Heckman's endogenous treatment effect model (Vella and Verbeek 1999).

https://doi.org/10.17221/341/2023-AGRICECON

Both models yield comparable results (Vella and Verbeck 1999). However, we used Heckman's endogenous treatment effect model to determine effectively whether unobservable characteristics had an effect on the outcome variable through the Wald test. Following random utility theory, we estimated access to credit by using the following equation:

$$Z_i^* = \beta_i X_i + U_i \quad (2)$$

where: Z_i^* – latent variable representing the difference between utility gain from access to credit; β_i – coefficient to be estimated; X_i – independent variable which influences access to credit; U_i – error term.

If a farmer applied for credit and received credit either from a formal source (bank) or from an informal source (NGO), we considered that farmer a credit recipient. We estimated the effect of access to credit on rice productivity by using the following equation (Rabbi et al. 2019):

$$Y_i = \beta i X_i + \gamma D_i + V_i \quad (3)$$

where: Y_i – productivity of rice; D_i – dummy variable representing access to credit (1 = credit recipient, 0 = credit non-recipient); V_i – error term.

We expected access to credit and productivity to be interdependent, which can be estimated through Equations (2) and (3). However, the problem of selection bias may occur if latent variables affect the error term of both equations. Selection bias results in correlation between the error terms of Equations (2) and (3). Therefore, estimating the effect of using Equation (3) by ordinary least squares (OLS) will produce a biased result. Selection bias could result from the selection on observables or unobservables. Selection on observables could be controlled by including some set of variables in the model (Danso-Abbeam et al. 2018). Selection on the unobservables, however, is typically difficult to control by introducing variables. Therefore, estimating the effect by using Equation (3) by OLS will produce a biased result. To overcome this issue, we used Heckman's endogenous treatment effect model (Heckman 1976, 1978). Heckman's endogenous treatment effect model is an extension of the Heckman two-stage model (Danso-Abbeam et al. 2018). The main difference is that in Heckman's endogenous treatment effect model, the dependent variable in the selection equation becomes one of the explanatory variables in the outcome equation. Heckman's endogenous treatment effect model can be used only when the correlation between the two error terms (represented by the Wald test) is greater than zero (Heckman 1979; Hoq et al. 2021). The first stage of Heckman's endogenous treatment effect model is a probit model, and the second stage is OLS regression used to estimate the effect of adoption.

The endogenous treatment effect model is estimated by specifying an equation for the endogenous treatment (T_i) (in this study, access to credit) followed by specification of an outcome equation (Y_i) (in this study, rice productivity). Following Nyaaba et al. (2019), we specified the endogenous treatment-regression model as follows:

$$Y_i = \beta X_i + \gamma T_i + \nu_i \quad (4)$$

where: $T_i = \begin{cases} 1, & Z\delta + u_i > 0 \\ 0, & \text{Otherwise} \end{cases}$; Y_i – outcome variable (rice productivity); T_i – treatment variable representing access to credit; X_i, Z_j – independent variables affecting outcome and treatment status, respectively; ν_i, u_i – error terms.

We diagnosed the model for its suitability by checking possible multicollinearity problems by using the variance inflation factor). A variance inflation factor value less than the critical value of 10 confirms that multicollinearity is not a major problem (Gujarati and Porter 2009). The significant Wald test results suggested suitability of this model for our data.

RESULTS AND DISCUSSION

Descriptive statistics. Table 3 shows the test of the mean differences of the variables used in the models. The findings revealed that there were significant differences between credit recipients and non-recipients in terms of a few selected characteristics. Farmers who had access to credit had significantly higher literacy, income and productivity than did non-recipients of credit. Conversely, non-recipients tended to have larger family sizes and a greater proportion of participation in safety net programmes. Repayment behaviour plays a vital role in obtaining credit from any financial institution. A higher number of family members and lower income can adversely affect the repayment behaviour of the farmers, which may restrict financial institutions in terms of providing credit.

Factors affecting access to credit. The findings indicated that family size negatively influenced access

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Table 3. Summary statistics of selected variables

Variable	Credit recipient		Credit non-recipient		*t*–test
	mean	SD	mean	SD	
Family size	5.09	1.67	5.68	2.31	–0.58***
Earning member in family	1.47	0.68	1.55	0.91	–0.08
Literacy	0.64	0.48	0.44	0.50	0.19***
Distance to bank	3.24	2.12	3.29	1.82	–0.05
Distance to NGO	2.90	1.89	2.86	1.54	–0.04
Rice farming experience	27.66	10.84	28.67	11.08	–1.00
Farm size	227.72	162.74	237.07	176.89	–9.35
Off–farm income	0.69	0.46	0.69	0.46	0.00
Television ownership	0.70	0.46	0.65	0.48	0.05
Safety net	0.02	0.14	0.06	0.23	–0.04**
Training	0.48	0.50	0.46	0.49	0.02
Productivity (kg/ha)	6 989.00	842.00	6 493.00	776.00	496.00***

,* significant at 5% and 1% level, respectively; NGO –non-governmental organisation
Source: Authors' calculation

to credit (Table 4). Investigators in prior studies argued that larger households are unable to save funds for capital because they place stress on the household's financial resources, increasing their credit demand (Salima et al. 2023). However, in this study, we found the likelihood of credit accessibility decreased with higher family size. Descriptive statistics in our study suggested that credit non-recipients had a larger family size than did credit recipients (Table 3). A larger family size necessitates additional funds for their sustenance, potentially exerting a negative effect on their repayment behaviour, thus reducing the likelihood of credit accessibility.

Education positively influenced access to all sources of credit. Education helped respondents learn about new production technologies. Adoption of production technologies can augment productivity but at the same time required extra investment which may influence farmers to obtain credit. Farmers with lower levels of education are commonly seen as inflexible and unhelpful when it comes to supporting their efforts to obtain credit. Education enhances an individual's capacity to make informed decisions in life (Ewoi et al. 2023). Farmers with a higher level of education were more likely to have stable incomes and a greater likelihood of obtaining credit from both formal and semi-formal institutions. The likelihood of credit accessibility decreased with farmers who participated in safety net programmes. Farmers in Bangladesh are mostly smallholders and have limited resources. A major portion of their cultivated rice is used for consumption. Assistance provided to farmers through safety net programmes may have reduced their motivation to work in the field. Consequently, the probability of receiving credit decreased.

Our study results also indicated that the likelihood of obtaining formal credit was higher among individuals who owned a television and had received training on rice farming. The positive coefficient of television ownership, used as a proxy for social status and information sources, implies that owning a television indicated a favourable social position and consequently facilitated convenient access to formal credit. The formal banking sector in Bangladesh engages in alternative and diverse promotional activities, which may serve as an incentive for individuals to obtain credit from formal banks. Farmers in Bangladesh received various kinds of agricultural training focused on crop cultivation. Financing sources that could potentially incentivise farmers to obtain credits from the formal sector were also discussed during the trainings. However, selecting the appropriate credit sources is not a simple or uncomplicated decision. Both sources possess certain benefits and drawbacks. For instance, the procedure of obtaining credit from conventional banks is intricate and time-consuming (Deb et al. 2020b). The completion of all formalities may require several months, whereas obtaining credit from an NGO can be accomplished within a couple of weeks. Conversely, the interest rate for NGO credit is significantly greater

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Table 4. Factors affecting credit accessibility

Variable	Whole sample		Bank		NGO	
	coefficient	SE	coefficient	SE	coefficient	SE
Family size	–0.122***	0.040	–0.048	0.042	–0.116**	0.046
Earning member in family	0.096	0.094	0.055	0.102	0.071	0.105
Literacy	0.555***	0.121	0.421***	0.133	0.283**	0.131
Distance to bank	–0.040	0.053	–0.062	0.058	0.012	0.060
Distance to NGO	0.065	0.063	0.156	0.169	–0.089	0.071
Rice farming experience	0.001	0.006	–0.001	0.006	0.003	0.006
Farm size	0.000	0.000	0.000	0.000	0.000	0.000
Off–farm income	0.047	0.132	–0.107	0.141	0.182	0.146
Television Ownership	0.191	0.129	0.267*	0.143	–0.018	0.140
Safety net	–0.632**	0.318	–0.637	0.412	–0.340	0.370
Training	0.092	0.121	0.325**	0.131	–0.229*	0.131
Dinajpur	–0.028	0.191	–0.070	0.208	0.019	0.205
Naogaon	–0.166	0.196	–0.291	0.214	0.075	0.210
Mymensingh	–0.017	0.192	0.101	0.208	–0.130	0.210
Lalmonirhat	0.022	0.190	0.092	0.206	–0.089	0.208
Constant	0.024	0.331	–1.215***	0.363	–0.082	0.363

*, **, *** significant at 10%, 5% and 1% level, respectively; NGO –non-governmental organisation
Source: Authors' calculation

than that for formal bank credit. Consequently, it is imperative to offer farmers training in financial literacy to enhance their decision-making abilities.

Effect on Boro rice productivity. Table 5 shows the result of the PSM analysis. Non-significant mean difference of propensity scores in each block indicates that there was no significant difference between propensity scores of adopters and those of non-adopters [Table S1 in the Electronic Supplementary Material (ESM)]. Figure S1 in the ESM indicates that there was adequate overlap between credit recipients and non-recipients. The PSM analysis findings indicate that credit recipients achieved higher productivity than did non-recipients. Per hectare yields of rice were 521 kg, 465 kg and 467 kg higher for credit recipients than for non-recipients of credit on the basis of nearest neighbour, kernel and radius matching, respectively (Table 5). The *ATT* values of different matching algorithms are similar, confirming the robustness of the findings. Nordjo and Adjasi (2020) suggested that farmers with access to credit increased productivity through investment in farm inputs. Awotide et al. (2015) also suggested that access to credit had a significant positive effect on cassava productivity in Nigeria. Results from

Table 5. Impact of access to credit on productivity via PSM

Outcome variable	Number of observations		Average treatment effect on treated (*ATT*)	SE	*t*-value
	recipients	non-recipients			
Productivity					
NN matching	250	126	521***	113	4.58
Kernel matching	250	247	465***	75	6.21
Radius matching	250	247	467***	74	6.29
Balancing property satisfied			yes		
Common support			0.12–0.78		

*** significant at 1% level; PSM – propensity score matching; NN – nearest neighbour
Source: Authors' calculation

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a study conducted by Miah et al. (2006) in Bangladesh also suggested that credit recipients achieved a rice yield 1.21 times higher than that of non-recipients. In contrast to households without access to credit, the provision of credit gave farmers a liquidity cushion that enabled them to adopt contemporary crop varieties and apply and manage supplementary inputs in a more effective and timely manner, thus increasing productivity. Supply of capital is vital to purchase different essential production inputs in time. Timely and regular application of production inputs may play a crucial role in increasing productivity.

Furthermore, to estimate the effect of formal and semiformal credit on rice productivity, we used two separate models: PSM and Heckman's endogenous treatment effect model. The *ATT* values from PSM indicate that recipients of formal credit had significantly higher productivity (324–516 kg/ha) than did non-recipients of formal credit (Table 6). However, access to semiformal credit did not have any significant effect on rice productivity (Table 7), which indicates that formal credit was more effective than semiformal credit in terms of rice farming. This finding is in line with the findings of Truong et al. (2020). Nevertheless, with use of Heckman's endogenous treatment effect model, we observed a substantial influence of both credit sources on rice productivity (Table 8). However, the *ATT* value was higher for formal credit than for semiformal credit. Semiformal credit provided a smaller amount of money than formal credit did, which may limit farmers' ability to purchase required agricultural inputs in sufficient quantities. Furthermore, the interest rate on semiformal loans was higher than that on formal credit loans, which may persuade farmers to divert money from other sources to repay the interest rather than using it for rice farming. However, results from previous studies suggested that semiformal institutions like NGOs are demonstrating superior performance in effectively handling defaults in agricultural credit by using field agents to collect repayments and oversee the activities of farmers (Rayhan et al. 2023). Furthermore, the credit demands of farmers are typically urgent, necessitating prompt fulfilment. For instance, a farmer might require a loan to cover the expenses of purchasing seeds and fertilisers in the initial phases of cultivation. However, the individual cannot

Table 6. Impact of access to formal credit on productivity via PSM

Outcome variable	Number of observations		Average treatment effect on treated (*ATT*)	SE	*t*-value
	recipients	non-recipients			
Productivity					
NN matching	125	93	324**	128	2.52
Kernel matching	125	371	483***	894	5.75
Radius matching	125	371	516***	89	5.80
Balancing property satisfied			yes		
Common support			0.04–0.63		

, * significant at 5% and 1% level, respectively; PSM – propensity score matching; NN – nearest neighbour
Source: Authors' calculation

Table 7. Impact of access to semi-formal credit on productivity via PSM

Outcome variable	Number of observations		Average treatment effect on treated (*ATT*)	SE	*t*-value
	recipients	non-recipients			
Productivity					
NN matching	125	94	145	117	1.23
Kernel matching	125	370	107	88	1.22
Radius matching	125	369	140	87	1.60
Balancing property satisfied			yes		
Common support			0.06–0.55		

*, **, *** significant at 10%, 5% and 1% level, respectively; PSM – propensity score matching; NN – nearest neighbour
Source: Authors' calculation

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Table 8. Impact on productivity via endogenous treatment effect model

Variable	Bank		NGO	
	ATT	SE	*ATT*	SE
Access to credit	1 170.00***	267.00	1 083.00***	220.00
Control variable	yes		yes	
Rho	–0.62***	0.17	–0.58***	0.09
Sigma	746.00***	48.00	873.00***	62.00
Lambda	–390.00***	153.00	–681.00***	121.00
Wald test	5.75**	–	21.00***	–

, * significant at 5%, and 1% level, respectively; NGO – non-governmental organisation; *ATT* – average treatment on treated; the second stage of the endogenous treatment effect model incorporates all of the independent variables used in earlier model; because our primary goal is to assess the impact of credit access, we only reported on the credit variable.
Source: Authors' calculation

afford to wait for an extended time to secure a loan from the formal banking system. As a result, farmers may opt for NGOs that offer loans with high interest rates. Both the formal and semiformal sectors play crucial roles in increasing credit availability for farmers. Public banks could implement mobile financial services for loan disbursement and repayment to decrease the time needed. NGOs should consider lowering their interest rates to facilitate financial inclusion for all farmers.

CONCLUSION

In this study, we used cross-sectional data to estimate the effect of access to credit on rice productivity in Bangladesh. The findings show that farmers who received credit were more productive than farmers who did not. This finding implies that credit availability has a positive effect on production. Because of the favourable relationship between formal credit and rice productivity, an argument is made for increasing agricultural credit disbursement. The likelihood of credit accessibility increased with education. Therefore, farmers and household members can be trained by financial institutions in family financial management so that they can use credit responsibly and consistently. Both formal and semiformal sources were important and had a positive effect on rice productivity. Efforts should be made to minimise the paperwork and time needed to access credit from formal sources, while also facilitating the establishment of appropriate agricultural credit programmes for farmers by NGOs. Semiformal credit sources can suitably cut interest rates on agricultural credits and implement a special interest rate subsidy policy for rice farming, as rice is the people's staple food. Because access to credit is an essential component in the drive to enhance productivity, this study's results suggest that access to credit should be incorporated in agricultural development initiatives.

Although this study generated useful information, it is not without its constraints. We examined the effect of credit in the formal and semiformal sectors, while disregarding the informal sector of credit, which serves as a significant source of credit for rural people. Subsequent researchers could conduct a comparative analysis of the three credit sources to assess and compare their effect on crop productivity. In this study, we used single-period cross-sectional data collected from a limited number of areas in Bangladesh to accomplish our objectives. A larger survey encompassing a greater number of areas and using multi-period panel data may provide a more comprehensive picture.

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