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FARM LEVEL IMPACTS OF CREDIT CONSTRAINTS ON AGRICULTURAL INVESTMENT AND INCOME

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Pakistan is an agriculture based economy and the main economic activity in Sindh province is farming, which is a capital intensive business. For diversified and efficient agricultural production, agricultural investment is important. Despite the importance of the modern technological practices, most farmers are still practicing subsistence agriculture. The lack of capital is the one of the major constraints in increasing investment in farming. The main focus of this article is to examine rice farmer's investment and the income under credit constraints in rural Sindh, Pakistan. For this research an endogenous switching regression model was employed to conclude the problem of selection bias and endogeneity of credit constraints. In order to achieve the results from visible and invisible factors average treatment effect was utilized. The results revealed that more than half of farmers (65.0 percent) from the total sample are hampered by supply-side (34.0 percent) and demand-side (31.0 percent) credit constraints. Importantly, the results have significant implications that agricultural investment and income can be increased up to 7.3 and 5.1 percent, if there are no credit constraints. Therefore, it is suggested that investment in agriculture can be increased if there is no or minimized credit constraints, which can ultimately increase the farmers' income in the country.
Keywords: Credit access, endogenous switching regression, agricultural investment, income.

INTRODUCTION

Pakistan is an agrarian economy, where the agricultural products, like rice, cotton, and wheat are leading the country's export. The share of this sector in the GDP of Pakistan is 19.8 percent and, providing 80.0 percent of combined total export income. Additionally, this sector provides 43.7 percent of rural employment (GoP, 2018). The economic growth of Sindh depends largely on agriculture sector after Punjab. Sindh province contributes in the national agriculture productivity through various major crop, i.e. rice 32.0 percent, sugarcane 24.0 percent, wheat 21.0 percent and 12.0 percent cotton. The rice is main food crop and key source of export after cotton in Pakistan (GoP, 2018).

The significant assignment of rural credit has been broadly acknowledged. The efficient-working of credit organizations promote country's development, household income expansion and contribute to poverty reduction. Previous literature has suggested that credit constraint affects the agricultural productivity of farmers (Kochar, 1997; Foltz, 2004). Furthermore, Chandio *et al.* (2017) as well as Guirkinger and Boucher (2008) have also expressed that productivity of credit-constrained farmers was comparatively lower than the unconstrained farmers. Especially, negative impacts on farm production and production efficiency (Zhao and Berry, 2014), farm investments (O'Toole *et al.*, 2014), farm profit (Sabasi and Kompaniyets, 2015; Tran *et al.*, 2018), and food consumption (Zhao *et al.*, 2014; Li *et al.*, 2016).

Adequate access to formal credit markets is essential for farmers in several emerging nations, and especially important for poor farmers in Sindh, in order to increase their agricultural investment, income and livelihood. Consequently, the inadequate credit access depresses farmers in agricultural investment to purchase high-quality seed, pesticide and fertilizer. The agricultural output can be increased if inputs are utilized properly in farming business. It will be possible if farmers have more capital, and that can be obtained if credit markets are free from credit constraints.

Few studies have been conducted to estimate the relationship between the credit constraints and agricultural income in the country (Sial and Carter, 2003; Chandio *et al.*, 2017; Mehmood *et al.*, 2017; Elahi *et al.*, 2018), while no specific study has been carried out to determine the effect of credit constraints on the farmer's agricultural investment in Sindh province of Pakistan. Accordingly, this study estimates the effects of credit constraints and discovers which type of credit constraints (supply-side or demand-side) hampers farmers to acquire adequate credit, and also to find the credit constraints which create obstacles for farmers in getting agricultural credit and increasing agricultural investment as well as income. Therefore, the key objectives of this study are (i) To determine the impact of credit constraints on farm-

level agricultural investment of rice farmers (ii) to compare the credit constrained and unconstrained rice farmers' income.

***Theoretical model for categorizing credit constraints using direct elicitation*:** To identify that whether farm households are credit constrained from using formal credit institutions, we followed the direct elicitation method as proposed by Jappelli (1990) and adapted by Boucher *et al.* (2009) and Li *et al.* (2016). The theoretical framework presented in Figure 1 is utilized to identify credit constraints through a sequence of questions.

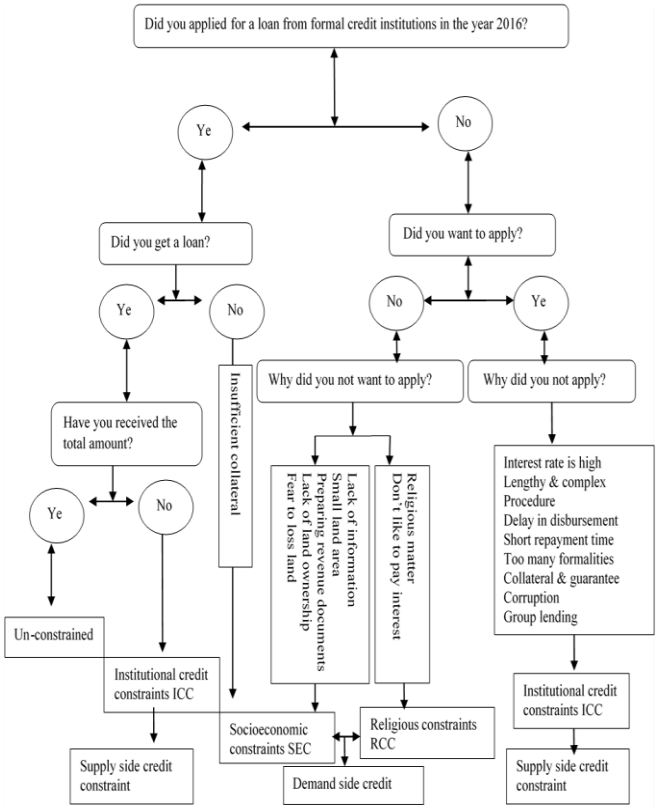

Figure 1. Theoretical model for identifying credit constraints using direct elicitation method.

In Figure 1, if the answer to the question; "did you apply for a loan from formal credit institutions in the year 2016"? and "did you receive the total amount?" are "Yes", we grouped these farmers as credit unconstrained farm household (CUFH). The farmers were again divided in two different types: credit constrained supply-side and credit constrained demand-side. Furthermore, we categorized supply side constraints into institutional credit constraints (ICC), and demand side categorized into two categories as; socioeconomic credit constraints (SCC) and religious credit constraints (RCC). First, if farmers did not want to apply: second, if they did not get a loan, and third, if did not receive the full amount due to low land area and other reasons. These are referred as being socio-economical credit constrained (SCC), and the second, if the farmers did not want to apply for religious reasons, categorized as religious credit constraints (RCC) (Figure 1). Similarly, the farmers did not apply because of the cumbersome procedure, high interest rate and other reasons relating to formal credit institutions, which are categorized as institutional credit constraints (ICC). Additionally, the empirical specification was used to identify farmer's status either credit constrained from formal credit or not. It is supposed that when farmers are relaxed from credit constraints and obtained credit for purchasing high-quality inputs and bore all agricultural expenditures, to enhance income from rice production were regarded as the unconstrained group $Y_{iUnconst}$ and other farmers as to constrained group (Y_{iConst}). The changes between the income and investment of constrained and unconstrained farmers are explained as CR_i^*, that is $CR_i^* = CR_{Unconst}^* - CR_{const}^*$ Then whether rice grower decided to obtain credit from formal credit institution if $CR_i^* > 0$. However, CR_i^* may not be determined, then, may be stated as a utility of distinction factors in subsequent advanced variable model;

$$CR_i^* = \gamma Z_i + \mu_i$$
$$CR_i = 1 \text{ if } CR_i^* > 0$$
$$otherwise\ CR_i = 0 \qquad (1)$$

Where, CR_i is a binary variable that equals to 1 for farmer *i*, in condition of credit-constrained and 0 for unconstrained; Z_i is vector of socioeconomic and institutional characteristics, for example age, education, family size, off-farm income, value of land, access to formal credit, collateral, saving, land ownership, agricultural investment and agricultural income; γ is vector of parameter to be expected; and μ_i is an error term supposed to be generally distributed with zero mean. The possibility of being credit constrained from credit institutions can be referred as:

$$Pr(CR_i = 1) = Pr(CR_i^* > 0)$$
$$= Pr(\mu_i > -\alpha X_i) = 1 - F(-\alpha X_i) \qquad (2)$$

Where *F* is the accumulative probability function of μ_i.

To elaborate, the perspective of a result with credit constraints: we supposed that intellectual growers make the best use of inputs to increase the agricultural income (Y) from rice productivity. It can be stated as:

$$Y_{max} = PQ(T, Z) - TS \qquad (3)$$

Here P indicates the value of rice yield, and Q is the total yield obtained from rice; T is total price of inputs, and S is the vector of production variables such as (labor, fertilizer, pesticide and weedicide application), as mentioned earlier in eq.1 Z is a vector of explanatory variables. Yield Q is defined in production function in which $\partial Q/\partial T > 0$ and $\partial^2 Q/\partial^2 T < 0$ the net agricultural income is described as a utility of output value and input value, the farmer suffers credit constraints from formal credit CR_i, and rice farmers and farm characteristic are as under:

$$Y = Y(P, T, CR_i, Z) \quad (4)$$

The maximization equation of net agricultural income (3) produces a reduced-form rice yield function:

$$Q = Q(P, T, CR_i, Z) \quad (5)$$

The detailed description in Eq. (4) and (5) indicated that net agricultural income of (Y) and rice production (Q) are ascertained by output and input values, the influence of credit constraints on farm-level and household-level characteristics.

***Model specification*:** According to Dong and Featherstone (2012) when estimating the effect of credit constraints on income and investment, issue of endogeneity will arise from discreet factors, which affects the farmer's participation in credit access and their credit constraints status. For example, all farmers are not homogenous that is why some have additional funds or did not need a credit. In this condition, the effect of credit constraints possibly will be biased for that reason. The literature on credit access emphasizes on a variety of clarifications for diminutive usage of formal credit market funds in emerging countries, categorizing institutional and socioeconomic constraints, information barriers, religious limitations, risk perceptions, and various geographical and ago-ecological situations. Taking an account the vector outcome variable (agricultural income and agricultural investment) is a linear function of independent variable's X_i, we specify the outcome equation as:

$$Y_i = \beta X_i + \eta\, CR_i + \varepsilon_i \quad (6)$$

Where Y_i is the vector of outcome variables; X_i is the vector of independent socioeconomic and institutional variables, such as (age, family size, education, farm size, access to credit and distance); CR_i is sign of credit constraints binary variable; β and η are parameters to be estimated and ε_i is error term.

In equation (6) the credit constraint conditions of growers are exogenously determined. Furthermore, the credit needs of all the farmers are not similar, such as some credit-constrained and unconstrained farmers cultivate crops on different land sizes (small, medium and/or large). For instance, some farmer's do not need to borrow credit whereas others need credit, but all of the needy could not obtain due to constraints. Thus, Average Treatment Effects (ATT) was used to evaluate the biased elements. Additionally, the invisible elements possibly affect the error term μ_i in selection equation (1) and error ε_i in the equation (6) concomitantly, resulting in correlation between the two errors, i.e. corr $(\mu_i, \varepsilon_i) \neq 0$. The selection bias may result in contradictory estimates. The farmers possibly will display some discrete uniqueness, if farmers have low income than average output like agricultural income and agricultural investment. However, farmers achieve higher income and agricultural investment, which possibly belongs to credit unconstrained group. Possibly it provides negative selection bias and miscalculated the control effects. Hence, if the farmers have greater yield than average productivity may be relaxed from credit constraints and credit access is affected by occupation status, this overestimated control effect possibly give the outcome as positive selection bias.

Furthermore, the economists opined that the endogeneity is a form of sample selection as well as self-selection and suggested that the most potential and suitable solution is the endogenous treatment problems associated with credit constraints variable (Clougherty *et al.*, 2016). These techniques of controlling the endogeneity problems are connected to self-selection and sample-selection (endogenous treatment and endogenous switching). There are different approaches proposed in the literature to control the endogeneity of a binary variable in restricted explanatory variations. The literature has utilized two methods one is full information likelihood method and second is limited information maximum likelihood method (Heckman, 1979). In addition, Wooldridge (2014) suggested two common approaches to resolve the issue of endogeneity by using instrumental variable and control function techniques. Accordingly, we employed instrumental variable techniques, which remove the exogenous factors of credit constraints by employing instrument, which only influences selection equation during farmer's credit access.

It can be presumed that the influence of credit access contained inconsistency effects on farmer income and agricultural investment, whereas considering issue of endogeneity, both outcomes equations for credit-constrained and unconstrained need to be accurate. However, scientists (Hausman, 1978; Heckman, 1979) concluded that two statistical issues will come up in the endogeneity and sample selection. Moreover, the recent studies (Ma and Abdulai, 2016; Hao *et al.*, 2018) recommended that the endogenous switching regression model (ESRM) is best to utilize and to control the dual dilemma of sample selection and endogeneity. Considering these issues, the endogenous switching regression model is also applied in this research study. Moreover, this model also utilizes the full information maximum likelihood approach to evaluate the one choice and two effects of equations at the same time.

Research Methodology

***Study area and Sampling method*:** Four rice growing districts namely; Jacobabad, Shikarpur, Larkana and Dadu of Sindh province, Pakistan were purposely selected for this study. A survey was conducted to collect the data in year 2017. A well designed and pretested questionnaire was employed to a sample taken from the population of the major villages of these preselected four districts. By employing proportional allocation technique 14, 11, 15 and 14 villages were selected from Dadu, Larkana, Shikarpur and Jacobabad respectively (Figure 2). Furthermore, among these 54 villages 7 rice growers were randomly selected from each village, which makes 400 respondents. After screening and removing inconsistent and incomplete

questionnaires, a total of 353 respondents (with response rate 85.2 percent) were available for analysis.

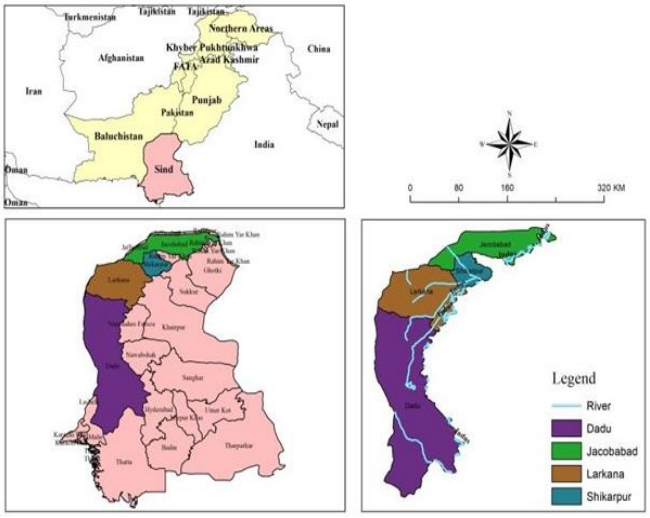

Figure 2. Districts chosen for study.

The explanations of the parameters employed in the study are specified in Table 1. The dependent variable utilized in the selection equation is binary variable, which is equal to 1, where farmers are credit-constrained from formal credit institution, otherwise 0. In the outcome equation, the first dependent variable is the log of total quantity of rice yield kg ha^{-1}. The second is log of the total amount (Rupees ha^{-1}) invested on farm inputs. The agricultural investment of rice crop includes amount invested on labor, canal water, plowing, seed, fertilizer, inter-culturing harvesting, threshing and loading.

The independent variables consist of both binary and continuous variables, which contain the demographic characters such as age, education, family size and farm size. The farm household financial and economic variables are characterized by total income earned, which includes gross agricultural income, net agricultural income, and total investment on agricultural inputs. The credit variables included the amount of credit received, interest rate, and terms of loan, purpose, and source of the credit. Furthermore, whether they actually received the loan and how much amount was received from formal credit institution.

***An endogenous switching regression model (ESRM)*:** The ESR model is comprised of two steps. The first step is the selection of equation, which is related with selection function for the income and agricultural investment of credit constrained group that is explained in Eq. (1). In the second stage, two group functions for credit constrained and unconstrained can be expressed for the result of objectives. Following Lokshin and Sajaia (2004), we designed following equations, which are:

$$\text{Regime 1: } Y_{iConst} = \gamma_{Const} Z_i + \varepsilon_{iConst} \quad \text{if } CR_i = 1 \qquad (7)$$

$$\text{Regime 2: } Y_{iUnconst} = \gamma_{Unonst} Z_i + \varepsilon_{iUnconst} \quad \text{if } CR_i = 0 \qquad (8)$$

The Y_{iConst} and $Y_{iUnconst}$ are the results determined for credit-constrained and credit unconstrained farmers such as agricultural income and investment, that one equation will be used for two purposes (assessment of agricultural income and agricultural investment) correspondingly; Z_i is a vector of exogenous elements that possibly influence the outcomes of being credit constrained; $\varepsilon_i$is a random interruption term connected with the result of factors.

Table 1. Description of variables used in the research study.

Name of variable	Description
Age	Age of farm household head in years
Education	Years of schooling of a farm household
Family size	Number of family members
Family health status	Health condition of family members (1= healthy otherwise 0)
Off-farm income	Income earned from other activities in Rs. 1000/month
Log of consumption Expense	Total food and consumption expense in Rs. 1000/month
Education expense	Amount spend on children education in Rs. 1000/month
Health care expense	Amount spend on family health care in Rs. 1000/month
Saving	Farmer saving in Rs. 1000/season
Log of agricultural income	Total income earned from rice in Rs. 1000/season
Gross Agricultural income	Gross amount earned from rice in Rs. 1000/season
Log of agricultural investment	Log of total agricultural investment in Rs. 1000/season
Total agricultural investment	Total investment of agricultural in Rs. 1000/season
Harvesting investment	Total harvesting investment in Rs. 1000/season
Fertilizer investment	Quantity of fertilizers in bags Rs. 1000/season
Farm size	Farm size in ha^{-1}
Log value of agricultural land	Total value of agricultural land Rs ha^{-1}
Landownership	If farmers owned land =1 otherwise=0
Access to credit	If farmer obtained credit =1 otherwise=0
Larkana	If farmer settled in Larkana district=1 otherwise=0
Dadu	If farmer settled in Dadu district=1 otherwise=0
Shikarpur	If farmer settled in Shikarpur district=1 otherwise=0
Jacobabad	If farmer settled in Jacobabad district=1 otherwise=0
Distance	The distance between the financial institutions and farmers residence measured in kilo meters (Km)
Collateral	Credit institutions required collateral=1 otherwise 0
constraints	If farmer is constrained from formal credit institution =1 otherwise=0

Whereas, the Z_i variable in eq. (1) and (7-8) are intended to cover up, at least one absolute variable need to be recognized in eq. (1) which does not emerge in (7-8). So, the equation (1) is estimated depend upon all independent variables expressed in outcome equations added single or additional instrument variables. The efficient instrument variable is needed to affect the credit-constraint condition of a farmer, which shows no influence on the agricultural income and investment. We utilized two instruments for finding the impact of credit constraints on agricultural investment and income of credit-constrained and unconstrained farmers. However, previous literature (Dong and Featherstone, 2012; Li *et al.*, 2016) explained that credit constraints condition of farmers is significantly influenced by distance and collateral. Therefore, we used these two variables as an instrument, distance which measures the minimum distance between formal credit institutions and farmer's residence, and collateral measures the loan repayment ability of farmers. These instruments are associated with the farmers credit constraints status, and influence the transaction costs of a loan and the risk bearing ability of the farmers and formal credit institutions. We employed two instruments in the income outcome equation, while in the investment outcome equation, only distance was employed. However, for the validity check of the instrument, we used the probit model for selection equation and OLS regression for outcome of income and investment equation individually. We obtained results which show that two instruments were insignificant in both outcome equations. Whereas, in selection equation only distance was significant. The equation (7-8) shows Z_i variable is considered for visible characteristics to overcome the problem of selection bias. However, discrete characteristics possibly will produce connection between the error term in the outcome and selection equation. For example, $corr\ (\mu_i, \varepsilon_i) \neq 0$. An endogenous switching regression model explains the problem of selection bias, which arises from the invisible elements and absent variable's issue. The inverse Mills ratios γ_{Unonst} and γ_{Const} as well as covariance term $\sigma_{\mu\text{Unconst}} = \text{cov}(\mu_i, \varepsilon_{\text{Unconst}})$ and $\sigma_{\mu\text{Const}} = \text{cov}(\mu_i, \varepsilon_{\text{Const}})$ are measured and fixed in equation (7-8) after evaluating the selection equation.

$$Y_{\text{iConst}} = \gamma_{\text{Const}} Z_i + \sigma_{\mu\text{Const}}\gamma_{\text{iConst}} + \lambda_{\text{iConst}} \quad \text{if } CR_i = 1 \qquad (9)$$

$$Y_{\text{iUnconst}} = \gamma_{\text{Unconst}} Z_i + \sigma_{\mu\text{Unconst}}\gamma_{\text{iUnconst}} + \lambda_{\text{iUnconst}} \quad \text{if } CR_i = 0 \qquad (10)$$

Where γ_{Unonst} and γ_{Const} control for selection bias ensuing from unobservable factors; the error terms λ_{Unonst} and λ_{Const} have conditional zero means. Following Lokshin and Sajaia (2004), we use FIML method to evaluate the outcome and selection equation. In endogenous switching regression evaluation, the correlation coefficients

$$\rho_{\mu\text{Unconst}}(\sigma_{\mu\text{Unconst}}/\sigma_{\mu}\sigma_{\text{iUnconst}})$$

and

$$\rho_{\mu\text{Const}}(\sigma_{\mu\text{Const}}/\sigma_{\mu}\sigma_{\text{iConst}})$$

of the covariance terms between the error terms in selection Eq. (1) and outcome Eq. (7-8) have statistically explanations. First, if $\rho_{\mu\text{Unconst}}$ or $\rho_{\mu\text{Const}}$ is significant, possibly it implies the proximity of selection bias resulting from discreet elements. For this reason, we consider that both visible and invisible elements are inevitable for obtaining neutral evaluation of controlling consequences. Second, if $\rho_{\mu\text{Unconst}}$ and $\rho_{\mu\text{Const}}$ have different symbols, it indicates that farmers are related to the unconstrained group on the basis of their income enhancement, while the unchanged symbol entails ''hierarchical sorting", i.e., farmers have exceeding standard incomes, contrast to constrained farmers, self-sufficient of credit access outcome. Third, $\rho_{\mu\text{Unconst}} > 0$ shows negative selection bias, signifying that farmers, who have below than standard outcome belongs to unconstrained farmers. Moreover, if $\rho_{\mu\text{Unconst}} < 0$, that possibly indicate the positive selection bias.

***The estimation of treatment effect*:** The previous study performed by Lokshin and Sajaia (2004) established that to find the average treatment effect on treated variables by utilizing the coefficient of variables, which is obtained from the endogenous switching regression model. Predominantly, the observable and unobservable effect from constrained and unconstrained farmers can be considered as under;

Constrained free farmers (observed)

$$E|Y_{iUnconst}|CR_i = 1/= \gamma_{Unconst}\, Z_i + \sigma_{\mu Unconst}\lambda_{iUnconst} \qquad (11)$$

Constrained farmers (invisible)

$$E|Y_{iConst}|CR_i = 1/= \gamma_{Const}\, Z_{i+}\sigma_{\mu Const}\lambda_{iConst} \qquad (12)$$

Accordingly, the expected results in Eq. (11) and (12) are subsequent to develop impartial treatment effects.

$$ATT = E(Y_{iUnconst}|CR_i = 1) = E(Y_{iConst}|CR_i = 1) = Z_i\ (\gamma_{Const} - \gamma_{Unconst})\lambda_{iConst}(\sigma_{\mu Unconst} - \sigma_{\mu Const}) \qquad (13)$$

RESULTS AND DISCUSSION

Table 2 explains the mean difference of the variables between the both groups of farmers. The results revealed that the agricultural income of credit unconstrained farmer is higher than constrained with the average of 99,657 Rs ha^{-1} ($819.85) and 86,231 Rs ha^{-1} ($709.40), respectively. Whereas, agricultural investment of unconstrained and constrained farmers are 25,946.65 Rs ha^{-1} ($213.46) and 24,642.72 Rs ha^{-1} ($202.73). The income and investment per-hectare on agricultural inputs were also significantly lower for the both groups of farmers. The results revealed that the credit constraints had a huge effect on income and investment. According to Table 2, the unconstrained farmers are older, large farm sizes, more credit access and owned more land than constrained farmers. Furthermore, the

Table 2. The sample means and standard errors (in parenthesis) of credit constrained and credit unconstrained farmers.

Variables	Unconstrained Mean (Std. Err.) (N=124)	Constrained Mean (Std. Err.) (N=229)	Mean Difference	Full sample Mean (Std. Err.) (N=353)
Age	46.99 (-1.13)	45.24 (0.76)	1.75§	45.85 (0.63)
Education	2.37 (0.15)	2.65 (0.10)	-0.28	2.55 (0.08)
Family size	10.22 (0.43)	10.55 (0.34)	-0.34	10.43 (.26)
Family health status	0.911 (0.25)	0.95 (0.14)	-0.04	0.93 (0.012)
Off-farm income	.241 (.038)	.227 (.027)	.014	.232 (.022)
Log of consumption expense	13.03 (.069)	13.01 (.049)	0.02	13.02 (.040)
Education expense	42272 (6803)	50036 (5211)	-7764	47309 (4139)
Health care expense	56510 (5575)	62132 (4393)	-5622	60157 (3456)
Savings	.080 (.24)	.069 (.016)	.010	.073 (.013)
Log of agricultural income	12.59 (0.08)	12.54 (0.05)	0.05	12.55 (0.04)
Gross agricultural income	636625 (191026)	384420 (23469)	252204‡	473013 (68933)
Net agricultural income	406789 (176474)	241762 (11653)	165027	299731 (62429)
Net income ha^{-1}	99657 (14139)	86231 (1843)	13426	90947 (5107)
Log of agricultural investment	11.28 (0.11)	11.24 (0.07)	0.04	11.25 (0.059)
Total agricultural investment	231509 (73591)	142188 (15867)	89321‡	173564 (27851)
Agricultural investment ha^{-1}	25946 (1484)	24642 (754)	1303	25100 (714)
Harvesting investment	42068 (4165)	41048 (2646)	1020	41406 (2252)
Fertilizer investment	82818 (7963)	77425 (4373)	5392	79319 (3980)
Farm size	5.15 (0.64)	4.57 (0.26)	0.58	4.77 (0.28)
Value of agricultural land	1656802 (185734)	1472549 (88454)	184252	1537272 (86857)
Log value of agricultural land	13.97 (0.07)	13.90 (0.05)	0.07	13.92 (0.04)
Landownership	0.93 (0.02)	0.89 (0.01)	0.03§	0.91 (0.015)
Access to credit	0.50 (0.045)	0.49 (0.03)	0.01	0.50 (0.02)
Larkana	0.17 (0.03)	0.25 (0.02)	-0.07	0.22 (0.02)
Dadu	0.25 (0.03)	0.23 (0.02)	0.02	0.24 (0.02)
Jacobabad	0.37 (0.04)	0.21 (0.02)	0.15†	0.27 (0.02)
Shikarpur	0.19 (0.03)	0.29 (0.03)	-0.10	0.26 (0.02)
distance	15 (0.87)	11.93 (0.57)	3.24†	13.07 (0.48)
Collateral	0.387 (0.043)	0.379 (0.032)	0.0071	0.382 (.025)
Credit constraint	---	---		0.6487 (.025)
Observation	124	229	--	353

† Shows the mean values for credit unconstrained farmers are significantly different from credit constrained farmers at 1% levels; ‡ Shows the mean values for credit unconstrained farmers are significantly different from credit constrained farmers at 5% levels; § Shows the mean values for credit unconstrained farmers are significantly different from credit constrained farmers at 10% levels.

Table 3. Credit rationing technique in the formal credit institution.

Regions	Credit constrained				Unconstrained		
	Supply side	Demand side		Total	Full amount	No need	Total
	Institutional CC	Religious CC	Socioeconomic CC				
Dadu	35	5	13	53 (62.4%)	25	7	32
Larkana	21	13	24	58 (72.5%)	16	6	22
Jacobabad	30	6	14	50 (52.0%)	38	8	46
Shikarpur	35	16	17	68 (73.0%)	13	11	24
Total	121	40	68	229	92	32	124
	34.28%	11.33%	19.26%	64.90%	74%	25%	(35.13)

unconstrained have more expertise in rice production than constrained farmers which shows that senior farmers are experienced, and are easily getting loans from formal credit institutions.

Table 3 provides the detail result of regularity of the credit rationing in a formal credit institutions from four different

locations on the basis of the theoretical model of categorizing credit constraints (Figure 2). The result shows that most of the farmers are hampered by supply side, which arises from credit institutions. Moreover, the outcome also indicates that 34.2 percent of the rice farmers were institutionally credit constrained for the reasons, such as the high-interest rate charged by formal sources, lengthy and complex procedure, delay in disbursement, corruption short repayment time, too much formalities and the staff of formal sources are not cooperative. Table 3 also demonstrates that 11.3 percent of farmers were religiously credit constrained from formal credit institutions. During the interview the first reason presented by the farmers was that "Interest is prohibited in Islam". The second reason specified by farmers was that formal sources charged high-interest and that takes long time to repay credit. Moreover, farmers apprehended about the drawback of interest, the formal sources charged extra amount on credit as a penalty, if credit is not paid on time. So, farmers were unable repaid the loan on time with high interest. As reported by (Akram *et al.*, 2008) also revealed that 29.0 percent of the farmer's do not get loan due to religious reason.

The finding also explains that 19.2 percent of the farmers were socio economically credit constrained as the reasons like as lack of information, lack of land ownership, insufficient collateral and credit demand did not meet due to small land area. Between the two groups (i.e., supply and demand side) 34.2 percent of farmers suffer from supply side credit constraints, whereas, the 30.5 percent of farmers suffered by demand-side credit constraints. Moreover, the Table 3 explicates that majority of 64.8 percent rice growers are credit constrained. However, the result from this study is in line with (Li *et al.*, 2016) established that the more than half of a total sample size of the farmer are credit constrained. In conclusion, 50.0 percent of farmers received loan from credit institutions, whereas 92 farmers obtained credit easily, and 32 farmers did not need credit.

According to LR test of independence equations, the estimated model is universally statistically significant (Prob > chi2 = 0.000). The endogeneity of both outcome equations (agricultural income and investment) was tested by using the 2SLS-IV command to find Durbin and Wu-Hausman test score. The Durbin and Wu-Hausman results revealed that agricultural income equation score is 2.24 with *p* value 0.1339 and 2.13 with *p* value 0.1445 respectively, while for agricultural investment equation it is 0.77 with *p* value 0.377 and 0.74 with *p* value 0.3891 both are insignificant. This result implies that the variable for credit constraints was found exogenous in estimation and that there was no issue of endogeneity. However, it provides biased and incoherent estimation (Table 4-5). Therefore, average treatment effect was utilized to correct the selection bias in the model. The evaluation of the factors that influence farmers being a credit-constrained and the effects of credit constraints on agricultural income and investment are mentioned in Table 4-5. As the ESRM evaluates selection and outcome equations collectively. The selection equation that signify the determinants of credit constraints are specified in first column of Table 4-5.

Table 4. Shows maximum likelihood estimated result of endogenous switching regression model for Agricultural income.

Variable name	Agricultural Income		
	Selection	Credit-constrained	Credit unconstrained
Age	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)
	0.0005 (0.0069)	-0.0066‡ (0.003)	0.0021 (0.0046)
Education	0.036 (0.050)	0.038 (0.051)	-0.037 (0.034)
Family size	0.0044 (0.117)	-0.088 (0.123)	0.140§ (0.080)
Family health status	0.275 (0.333)	-0.171 (0.136)	-0.122 (0.208)
Off-farm income	-0.164 (0.245)	-0.162‡ (0.087)	-0.237 (0.162)
Log of consumption expense	0.062 (0.164)	0.387† (0.059)	0.321‡ (0.108)
Log of education expense	0.104† (0.048)	-0.053† (0.018)	-0.104† (0.032)
Log of health care expense	-0.069 (0.110)	-0.0055 (0.043)	-0.049 (0.067)
Saving	-0.292 (0.281)	-0.100 (0.106)	-0.085 (0.184)
Farm size	-0.0049 (0.019)	0.069† (0.011)	0.037† (0.011)
Log value of Land	-0.1430 (0.143)	0.371† (0.062)	0.625† (0.090)
Landownership	-0.182 (0.272)	0.133 (0.095)	0.157 (0.197)
Access to credit	0.072 (0.193)	-0.052 (0.053)	0.014 (0.092)
Larkana	0.461‡ (0.243)	-0.016 (0.083)	0.036 (0.149)
Shikarpur	0.480‡ (0.215)	0.223‡ (0.080)	0.327‡ (0.130)
Dadu	0.149 (0.240)	0.304† (0.089)	0.238§ (0.141)
Distance	-0.0153‡ (0.007)	--	--
Collateral	0.0031 (0.171)	--	--
_cons	1.540 (2.423)	2.918† (0.980)	-0.927 (1.517)
$Ln\sigma_{\mu unconst}$			-0.517† (0.106)
$Ln\sigma_{\mu const}$		-0.861† (0.079)	
$\rho_{\mu unconst}$			-0.911† (0.042)
$\rho_{\mu const}$		-0.881† (0.064)	
Observation	353	229	124
LR test of independence equations	X^2=20.65	Prob > Chi^2 = 0.0000	

In the selection equation, the dependent variable of credit constraints is equal=1, otherwise=0. In the outcome equation, the dependent variable is a log of Income. We used occupation, and Distance as the instrumental variables in selection equation. P values are reported as. †, ‡and §denotes †1, ‡5 and§ 10 statistically significant levels respectively.

***Determinants of credit constraints*:** The first column of Table 4-5 shows the estimated results of switching regression model of full sample. The result of the determinant of the rice farmers being constrained in the rural credit market of Sindh, Pakistan entails that the variable for log education expense is positive and significant (0.104 with *p* value 0.030); further it explains that those farmers who spent more money on the children's education indicated that

the probability of credit constraints increases. However, the survey finding reveals that the education expenses and healthcare expenses are higher for constrained farmers than unconstrained farmers. There might be two reasons; first, the farmers think that they will not be capable of repaying the loan with interest and may be farmers did not apply for a loan due to high expenses. Second, the loan will not be sanctioned if the applicant found less creditworthiness and/or threat to be defaulter. The result of this finding is similar with Li and Zhu (2010); however, their study indicated that the educational expenditure influences farmers being a credit constrained.

Table 5. Shows maximum likelihood estimated result of endogenous switching regression model for agricultural expenditure.

Variable name	Agricultural Expenditure		
	Selection	Credit-constrained	Credit unconstrained
	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)
Age^2	-0.00021 (0.00052)	0.00008 (0.00023)	(-0.00009) (0.00036)
Age	0.0124 (0.046)	-0.012 (0.021)	0.0074 (0.0326)
Education	0.044 (0.048)	-0.0095 (0.019)	-0.020 (0.027)
Family size	0.0307 (0.111)	-0.0074 (0.045)	-0.021 (0.059)
Family health status	0.0573 (0.354)	-0.269‡ (0.147)	0.191 (0.173)
Log of consumption expense	-0.021 (0.124)	0.088‡ (0.048)	0.044 (0.071)
Harvesting investment	-5.5e-6 (5.9e-6)	2.59e-6 (2.3e-6)	2.2e-7 (2.96e-6)
Fertilizer investment	3.8e-6 (3.9e-6)	7.3e-6† (1.7e-6)	6.9e-6†(1.9e-6)
Farm size	-0.0016 (0.028)	0.0427§ (0.017)	-0.0059 (0.011)
Log value of Land	-0.172 (0.138)	0.442† (0.065)	0.746† (0.074)
Landownership	-0.121 (0.255)	0.091 (0.098)	-0.039 (0.164)
Access to credit	0.165 (0.137)	-0.034 (0.055)	-0.0032 (0.078)
Larkana	0.441‡ (0.225)	-0.171‡ (0.085)	0.154 (0.153)
Shikarpur	0.555‡ (0.247)	-0.149 (0.099)	0.363§ (0.173)
Dadu	0.167 (0.231)	0.121 (0.089)	0.290§ (0.117)
Distance	-0.0092 (0.006)	--	--
_cons	2.742 (2.268)	3.620† (1.024)	-0.889 (1.356)
$Ln\sigma_{\mu unconst}$			-0.968† (0.179)
$Ln\sigma_{\mu const}$		-0.809† (0.064)	
$\rho_{\mu unconst}$			0.329 (0.681)
$\rho_{\mu const}$		-0.971§ (0.019)	
Observation	353	229	124
LR test of independence equations	X^2=21.74	Prob > chi2 = 0.0000	

In the selection equation, the dependent variable of credit constraints is equal=1, otherwise =0. In the outcome equation, the dependent variable is a log of agricultural investment. We used occupation, and Distance as the instrumental variables in selection equation. P values are reported as. †, ‡and §denotes †1, ‡5 and§ 10 statistically significant levels respectively.

The dummy covariate in Larkana (0.461 with *p* value 0.058 0.441 with *p* value 0.050) and Shikarpur (0.480 with *p* value 0.026 and 0.555 with *p* value 0.025) both are positive and significant which indicated that credit constraints had the highest effect on agricultural income and investment of farmers in these two regions. Furthermore, it explains the significant impact of geological variation and difference of local resources and use of particular credit sources. The instrument variables i.e. distance (-0.015 with *p* value 0.024) is negative and statistically significant in income equation indicating the highest influence of credit constraints condition; while in the agricultural investment, it is insignificant. Moreover, agricultural income and investment are influenced bluntly by these two instruments since agricultural income is based on utilization of high-quality and optimum quantity inputs in the cultivation of rice crop.

***Agricultural income effects*:** The impact of credit constraints on agricultural income of two groups, utilizing the assessment result are mentioned in Table 4. The variable for age had significant (-0.0066 with *p* value 0.012) impact on the constrained rice farmer's income. Possibly the significance of age shows that younger farmers may have low farming and credit experience. Moreover, significance indicates that young farmers who are constrained must be targeted by credit access to increase their incomes. Our results are consistent with Simtowe *et al.* (2009) who observed that young farmers were more constrained and need more attention. The coefficient of variable off-farm income is negative and significant (-0.162 with *p* value 0.064) implying that credit constraints influence the off-farm income of constrained farmers.

The variable log of consumption expense is positive and significant (0.387 with *p* value 0.000 and 0.321 with *p* value 0.003) for both groups signifying, the consumption expense is the key factor to increase the agricultural income. The variable for education expense is negative and statistically significant for both groups (-0.053 with *p* value 0.003 and -0.104 with *p* value 0.001) indicating that spending more amounts on children education increases the income. It might be due to the education children work as family labor and help farmers to adopt modern technology to increase income. The outcome of these two variables is consistent with the results of Li and Zhu (2010). The farm size variable (0.069 with *p* value 0.000 and 0.037 with *p* value 0.001) is positive and statistically significant, showing the highest impact of both groups on the income. It implies that as farm size increases the resulting income also increases. The coefficient of the log value of land (0.371 with *p* value 0.000 and 0.625 with *p* value 0.000) is positive and significant for both groups showing that high agricultural income increases the value of land. However, we utilized the value of agricultural land as physical asset because in the rural credit market of Pakistan, formal credit organizations supply credit to farmers on its value of physical assets. The dummy covariates for districts Dadu (0.304 with *p* value 0.001 and 0.238 with *p* value 0.092) and Shikarpur (0.223 with *p* value 0.006 and 0.327 with *p* value 0.012) are significant for both groups of farmers. It indicates that both regions Dadu and

Table 6. Impact of credit constraints on agricultural income and investment.

	Mean outcome		ATT	t-Value	Change (%)
Output	**Unconstrained**	**Constrained**			
Agricultural income	13.18(0.079)	12.53(0.04)	0.64	7.41†	5.13
Agricultural investment	12.046(0.12)	11.22(0.06)	0.81	6.33†	7.28

Note: The average treatment effect of the treated (As per outcome equation mean outcome is mentioned in logs forms)

Shikarpur have the highest income than Larkana and Jacobabad farmers.

The correlation coefficient of $\rho_{\mu unconst}$ and $\rho_{\mu const}$ is significant (-0.911 with *p* value 0.000 and -0.881 with *p* value 0.000) in the agricultural income. Table 4 shows that indicating selection bias. The outcome recommends that observable and unobservable element's impact farmers being a credit constrained. As a result, it may present biased results of coefficient and did not solve the issue of selection bias. Moreover, the symbol of $\rho_{\mu unconst}$ and $\rho_{\mu const}$ are negative in Table 4, indicating positive selection bias. For the correction of selection bias, we have used average treatment effect to get the outcome from unobservable and observable factors (Table 6). The results suggest that farmers with low income are additionally related to credit constraints than average income of farmers. It is important to state that the positive selection bias. However, the credit organizations are established to increase the welfare and income of farming community. But, the farmers are reluctant to access formal credit.

***Agricultural investment effects*:** Table 5 indicates the impact of credit constraints on agricultural investment of rice farmers. The variables family health status (-0.269 with *p* value 0.069) is negative and significantly influences the credit constraints status of farmers. Possibly the constrained farmers expend more amount on the treatment of the family members hence farmers family expenditure increased. Such increase in family expenses will depresses the farmers to utilize certified and quality inputs. The variable for log of consumption expense is positive and significant (0.088 with *p* value 0.064), which influences on the consumption expense of the credit constrained farmers. It reflects that consumption expense is important element in the agricultural outflow to utilize improved and quality seeds and other inputs. The variable fertilizer cost is statistically significant (7.3×10^{-6} with *p* value 0.000 and 6.9×10^{-6} with *p* value 0.000) and implies that use of fertilizer application is essential in agriculture. The variable for farm size is positive and significant (0.042 with *p* value 0.013) in constrained farmers. It indicates that as the farm size increases investment will also increase. Furthermore, it implies that farm size has the highest impact on investment of the constrained farmers. The coefficient of the log value of land (0.442 with *p* value 0.000 and 0.746, with *p* value 0.000) is positive and significant for both groups showing that high-quality cultivated lands need high-quality inputs. The dummy variable for Larkana (-0.171 with *p* value 0.045) is negative and significant suggesting that Larkana region farmers have highest impact of credit constraints whereas other two regions have lower effect on agricultural investment.

Table 5 reveals that the correlation coefficient $\rho_{\mu const}$ for credit constrained is statistically significant (-0.971 with *p* value 0.000) while correlation coefficient $\rho_{\mu unconst}$ of unconstrained is nonsignificant (0.329 with *p* value 0.655) in the agricultural investment. This entails that the farmers who are constrained had low agricultural investment than a random unconstrained farmer in the sample. Moreover, the nonsignificant value of correlation coefficient $\rho_{\mu unconst}$ signifies that farmers who are credit unconstrained had higher agricultural income than random constrained farmers (Dong and Featherstone, 2012) which might results in high agricultural investment.

***The evaluation of treatment effects*:** Table 6 presents the average treatment effects on the treated and illustrates the effect of credit constraints on agricultural income and investment (Table 6). The Table 2 and 6 explains the mean difference, which is not same. After correcting the selection bias, we got exact mean difference from Average Treatment Effect (ATT). Furthermore, the ATT gives us the outcome from the both observable and unobservable distinctiveness. The outcome shows that farmers that have not faced credit constraints can increase their income up to 5.1 percent. Regarding the agricultural investments, the outcome implies that constrained farmers can increase investment by 7.2 percent, if the credit constraints are removed. these findings are consistent with those established in China (Li and Zhu, 2010; Dong and Featherstone, 2012) and suggest that credit access of farmers will result in significant increase in agricultural income and investment by 12-13 percent and 23.2 percent respectively, if the credit constraints are removed from the rural credit market.

***Conclusion and suggestions*:** In order to obtain the exact outcome, the present study employed endogenous switching regression model that considered the two econometric issues which are selection bias, and observable and unobservable elements. Furthermore, there is employed the Average Treatment Effect (ATT) to correct the selection bias. Direct Elicitation Method (DEM) was used to identify the credit constraint's status of rice farmers in the rural areas of Sindh province, Pakistan. The results revealed that more than half of farmers from the total sample are hampered by supply-side and demand-side credit constrained (34.2%) and

(30.5%), respectively. The credit constraints have significant effect on the agricultural income and investment.

The result indicated significant relationship between unconstrained farmer's agricultural income and investment. However, the rural farmer's income and investment are estimated to be enhanced by 7.2 and 5.1 percent, respectively, with the elimination of credit constraints. Furthermore, this study intimates that the formal credit access delivery plays very important role for the development of agricultural income and investment. We have found that those farmers who are dampened by credit constraints had lower income and investment than a random farmer in the sample. However, those farmers who had no credit constraints had greater investment and income than a random farmer from the sample. Similarly, the result shows that the factors affecting farmers access to credit, including consumption expense; education expense and farm size have positive and significant.

The credit institutions must revise the revise their policies related to interest rates, recovery schedule, loan application procedure and unnecessary delays in disbursement of the loans/credits and to make the application process more convenient, to enable maximum number of farmers to access formal credit. Moreover, to get rid from the credit constraints, government should establish Zarai Taraqiati Islamic Banking, because in Pakistan, there are some Islamic Banks but there is no specialized Agricultural Islamic Bank in Pakistan. As a result, there is a need to establish Islamic Banking Window at Zarai Taraqiati Bank Limited (ZTBL), in order to catch more Muslim credit seekers. The new branch network will trim down the cost of credit, and improve access to formal institutes by rural farm households in Sindh Pakistan.

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