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Role of Agricultural Credit on Production Efficiency of Farming Sector in Pakistan- A Data Envelopment Analysis

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Abstract

The study identified the sources of production inefficiency of the farming sector in district Faisalabad in the Punjab province of Pakistan. Data Envelopment Analysis (DEA) technique was utilized at farm level survey data of 300 farmers for the year 2009. The overall mean efficiency score was 0.78 indicating 22 percent inefficiency of the sample farmers. Computed efficiency scores were then regressed on farm specific variables using Tobit regression analysis. Farming experience, education, access to farming credit, herd size and number of cultivation practices showed constructive and significant effect on the farmer's technical efficiency.

Key words: Agricultural credit, DEA, Technical efficiency, Tobit analysis

Introduction

Farming credit is provided for the purpose of production and development. Production loan is specified for agriculture inputs consisting of seeds, fertilizer, plant protection measures, poultry/animal feeds and medicines, water charges, labor etc. The development loans were supplied for purchase of agriculture equipments i.e. tractors, cutter binders, threshers, trolley, spray machinery and installation of tube wells, etc. To help out small farmers by extending loans to them on easy terms, government made agricultural credit policies (Hanif et. al., 2004).
Easy availability and access to credit resulted in rapid development of farming sector. It provides ability to the farmers and entrepreneurs to diversify agriculture sector by undertaking new investment or adopt new technology. Rural credit market comprising of formal and informal sector, play a significant and an active role in rural economy (Adams and Fitchett, 1992; Aleem, 1990). The institutional agricultural credit has shown a considerable affirmative influence on agricultural productivity in Pakistan (Iqbal et al., 2003).

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The formal agricultural credit accessible to the farmer before independence was "taccavi" loans and loans from co-operative societies. Farmers having no land or small farmers particularly depended upon these sources to fulfill their credit needs. Government of Pakistan has extensively used the subsidized agricultural credit policies to achieve higher agricultural growth through relaxing monetary limitation. Since the 1950s the provision of agricultural credit in Pakistan is a significant component to improve the rural economy (Zubairi, 1989; Malik etal., 1991). In 1950s, two credit institutes i.e. Agricultural Development Finance Corporation (ADFC) and the Agricultural Bank were originated to overcome this credit shortage. In 1961, these credit institutes were merged and appeared as Agricultural Development Bank of Pakistan (ADBP), now Zarai Taraqiati Bank Limited (ZTBL). By the end of 1972, the Commercial Banks (CBs) and Domestic Private Banks were specified targets to provide the facility of agricultural credit. Commercial banks were mostly charging high interest rate as compared to ZTBL (Bashir and Azeem, 2008). Presently in Pakistan, the formal agricultural credit institutions include ZTBL, a principal source of formal agricultural lending, Commercial Banks, Federal Bank for Cooperatives and also some non-governmental organizations (NGOs).
The government practices the credit policy to protect the interest of small and medium farmers by providing them loans on easy terms; to facilitate them in case of any natural hazards and disaster. Ministry of Food, Agriculture and Livestock is playing an active role to monitor agricultural credit distribution and take significant steps to remove the hurdles in credit disbursement (Iqbal et al., 2003). According to Zubairi (1989) the impact of institutional credit comes through financing of seed and fertilizer. Qureshi and Shah (1992) opined that formal loans positively affect agricultural output through financing of capital investment and it is more beneficial than financing of seed and fertilizers.
Informal credit sector consists of professional moneylenders, friends, relatives, and commission agents, etc. Though the informal sector is charging high interest rate but still its contribution is larger

than the formal sector owing to low transaction cost, easy access and procedures. Moreover, informal credit is also available for consumption, social ceremonies and for non-productive purposes. Non-institutional credit is more costly and not adequately large to promote growth and investment. Thus it has no helpful contribution in agricultural production.

Various viewpoints are expressed about the economic impact, equality and adequacy of credit for the recipients. The true empirical estimation of the credit impact was difficult due to the fungible nature of credit and as it was ambiguous if the estimated impact of credit explains the borrowing restraints or the indistinguishable borrower's characteristics (David and Mayer, 1980).

The efficiency of farming credit system and shadow price of capital in Pakistani Punjab was calculated by Sial and Carter (1996). Through endogenous switching regression method it was found that the borrowers produced 48 percent more output than the non-borrowers. Farmers having no loans could make Rs. 3.05 additional income for one rupee loan; an indicator of inefficiency of capital market. If shadow price is greater than the opportunity cost of capital, the provision of subsidized credit has no economic rationale to improve the small farmer's access to credit.

The technical and allocative efficiency are the two elements of efficiency of production units. The technical efficiency describes the potential of production units to attain maximum level of output holding input level fixed. The allocative efficiency (AE) illustrates the capacity of production units to use optimal proportion of inputs (factors) for same level of output. To estimate the total economic efficiency (EE), the technical and allocative efficiency estimates are combined.

The technical efficiency estimation of creditors and non creditors in Pakistan was the main objective of this study. The technical efficiency estimation was carried out through Data Envelopment Analysis (DEA) method while sources of inefficiency were examined through Tobit model.

Efficiency Analysis

The production efficiency estimation had imperative implications for both economic theory and policies. Such analysis allowed the assessment of probable increase in output together with the efficiency enhancement (Farrell, 1957).

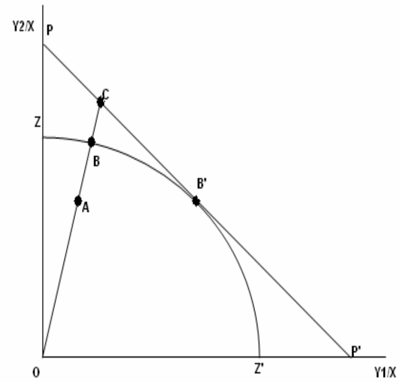
To estimate technical efficiency, there are two commonly used approaches, the Data Envelopment Analysis (DEA) a nonparametric technique and Stochastic Frontier Analysis (SFA), a parametric approach. Under Data Envelopment Analysis the functional form was not specified for the production technology and it also did not include the error terms, whereas in SFA, a specified functional form was used for the efficiency estimation and the error terms were also included for inefficiency measurement (Farrell, 1957; Färe et al., 1990).

Data Envelopment Analysis (DEA)

DEA was used as an apparatus for evaluating and improving the performance of production units. The DEA efficiency estimation technique generates an efficiency boundary from the given sample of production units (farming households in this study). The constructed efficiency boundary line shows the practices of the efficient farms and the farmers below that line are called inefficient production units. The estimation of technical efficiency (TE) through DEA can be either input or output oriented under constant as well as variable returns to scale (CRS and VRS). The TE scores obtained through input oriented and output oriented methods possess the similar values under constant returns but differ under variable returns to scale technology (Coelli, 1996).

Output-Oriented DEA

The present study estimated technical efficiency of farming households under output-oriented technique explaining that how much feasible output is maximized for given level of inputs. According to Farrell (1957) output-oriented efficiency measure could be described through the following diagram:



Source: Coelli, 1998

In above figure distance **AB** is technical inefficiency which is the quantity through which production could be raised with no input increase. Consequently the technical efficiency scores under output-oriented method is **TE=OA/OB.** If information about price is available then price line could be drawn. As **PP′** in above figure and allocative efficiency is **AE=OB/OC.** And thus economic efficiency would be **EE=TE*AE=OA/OC.** The obtained efficiency scores of all these types were always surrounded with the closed interval 0 and 1.

To estimate the technical efficiency of the sample production units, the subsequent mathematical model of linear programming was considered:

$$\max_{y, \lambda_1, \ldots, \lambda_k} y$$

S.T.

$$\sum_{i=1}^{n} y_i \lambda_i \geq y_i$$

$$\sum_{i=1}^{n} x_i^n \lambda_i \leq x_i^0$$

$$\lambda_i \geq 0$$

Where:

y = maximum production level,

y_i = the production of the i^th^ production unit,

x_i^n = the n^th^ factor of production used on i^th^ production unit,

x_i^0 = the n^th^ factor of production used on the production unit being tested, and

λ_i = the weight assigned to i^th^ production unit.

The consequential technical efficiency was estimated in the form of a fraction between the examined production points of the production unit being analyzed (y_i) and the maximum output point (y). The production units having 1 efficiency point were said to be technically efficient while the production units that were technically inefficient having score strictly lower than one. The estimated efficiency scores of the production units are bounded by 0 and 1. The efficiency estimates through DEA are the radial efficiency measures showing unit indifference i.e. the estimated efficiency points do not vary with the transformation of estimation entries (Coelli et al., 1998).

Two weaknesses were observed of DEA approach: it is only an investigative approach and does not prescribe any helpful technique to reduce inefficiency and calculated measures of inefficiency are confused with measurement error (Lovell, 1993; Ray, 2004).

Tobit Regression Analysis

The efficiency analysis also need to determine that why efficiency differs among the farmers practicing the same farming operations. To examine the factors affecting the technical efficiency or inefficiency otherwise, the technical efficiency index acquired from DEA were further regressed with the farm specific variables by utilizing Tobit regression technique.

The Tobit model was estimated with the help of computer software SAS version 9.1. Instead of common regression arrangement, the restricted dependent variable was used as estimated efficiency scores bounded between 0 and 1.

The management of socio economic and environmental characteristic of farmer could affect the efficiency and productivity of the farmers. It was often argued by Ureta & Pinheiro (1997) that it is difficult to assess all the factors affecting efficiency of the farmer but the variables considered most important influencing factors were measured.

In present study, the DEA scores of efficiency obtained in the output oriented CRS model were regressed on various explanatory variables. The explanatory variables included in this study were: operational area, farming experience, education, household size, herd size, dummy of credit, cultivation practices number and plant protection measures.

To measure the impact of farm specific and socio economic characteristics on the inefficiency of farm, the following form of Tobit model was used:

$$Eff = \alpha_0 + \alpha_1 X_{1i} + \alpha_2 X_{2i} + \alpha_3 X_{3i} + \alpha_4 X_{4i} + \alpha_5 X_{5i} + \alpha_6 X_{6i} + \alpha_7 X_{7i} + \alpha_8 X_{8i} + \mu_i$$

Where:

Eff = Efficiency Scores (from first stage DEA)
X_{1i} = Operational land holding of the i^th^ farm in acres.
X_{2i} = farming experience of the i^th^ farm's operator in years.
X_{3i} = education level of the i^th^ farmer in years.
X_{4i} = number of family members of i^th^ farmer,
X_{5i} = Herd size of the i^th^ farmer in animal units.
X_{6i} = Dummy of credit of i^th^ farm (1, if farmer was obtaining loan , zero otherwise)
X_{7i} = number of cultivation practices s of i^th^ farm, (hoeing and weeding etc)
X_{8i} = No of sprays for Plant protection of the i^th^ farm,
α's = the unidentified parameter to be estimated.
μi = the error term.

Data

The primary data was collected through well-structured comprehensive questionnaire. The sample of 300 farmers was collected from two tehsils of Faisalabad district; namely Faisalabad and Jaranwala. In each tehsil 150 farm households were interviewed, which were further divided into two categories, credit and non-credit users. The questionnaire contained information about socio-economic profile of respondent, operational land, production of various crops, cost of production, livestock information and value of farm implements. Data on farming inputs included use of seed, fertilizer, irrigation, labor and machinery. The interviewing schedule covered information about use of credit, sources of credit, loaning amount, purpose of loan, time lag between loans applied for and loan disbursement, cost of obtaining loan and repayment schedule.

Result and Discussion

The descriptive statistics of farms provided in Table 1 showed farmer's annual output and pattern of input use and farm specific variables of total sample of 300 farms. The average annual gross farm output value was Rs. 55,497. The highest reported value of output was Rs. 98,000 and the lowest value was Rs. 28,460. The average gross income from sale of milk was Rs. 38,012 per year.

The labor input expressed in man days, includes family labor and permanent hired labor. The mean value of labor was only 111.38 days per acre for a year, which translates to 2 days per week ranging from only 3 hours to 9 days per week. The average annual use of fertilizer nutrients was 112.66 kg per acre whereas average irrigation level was 56.87 acre inches per acre. The table 1 showed that average expenditures on cash inputs were Rs. 6,135.28 per acre and average annual expenditure on livestock was Rs. 12,234 per animal.

Adding years of schooling not only improves the efficiency of farmers but also enhanced their capability to understand and adopt new methods and techniques of farming (Olagunju and Adeyemo, 2007). Table 2 presented frequency distribution of education level for creditors and non creditors included in study. The table showed that 36 creditors (24 percent) had 8 years of education. And the majority of the non creditors (30 percent) had 10 years of education. The mean education level of creditors was 7.78 years and 8.28 years for non creditors. These results are somewhat contradictory to the study of (Bashir and Azeem ,2009). According to them education level of loanee was more than non creditors. Despite of the fact that sample area was almost the same i.e. Faisalabad, the only possible reason might be source of credit as UBL creditors were included there.

Based upon the farming experience, the practical knowledge and skills which a farmer ascertain through the number of years spent in farming activities, progress and improvement in the production activities of a farmer could easily be observed. Generally it was believed that farmer who had more farming experience might be more efficient and productive through trial and error (Olagunju and Adeyemo, 2007). Table 3 showed that 40 percent of non creditors had 11 to 20 years of farming experience, whereas 27 percent creditors belonged to this category. More years of experience were noted for creditors (43 percent) than non creditors (33 percent) excess to 20 years.

Table 1 Descriptive Statistics of the physical inputs and output

Variable	Mean	Std. Dev.	Minimum	Maximum
Output and Inputs				
Gross farm output/year (Rs./acre)	55497.28	13481.93	28460	98000
Gross income/year from sale of milk (Rs./animal)	38012.5	18705.25	0	72000
Labor days/year (man days/acre)	111.38	82.66	16.25	472.5
Fertilizer Nutrients/year (Kg./acre)	112.66	39.91	23	266
Irrigation/year (per acre inch)	56.87	20.95	18.2	160.65
Cash inputs/year (Rs./acre)	6135.28	1586.14	3030.96	12851.88
Expenditures on livestock/year (Rs./animal)	12234.07	7715.92	0	40200

Source: Field Survey 2009

Table 2 Distribution of Educational Attainment of Respondents

	creditors		non creditors	
Years of education	**Frequency**	**Percent**	**Frequency**	**Percent**
No education	23	15	16	11
Primary education	27	18	27	18
Middle	36	24	26	17
Metric	32	21	45	30
Secondary education	16	11	21	14
Higher secondary education	11	7	14	9
Graduate	5	3	1	1
Total	150	100	150	100

Source: Field Survey 2009

Table 3 Distribution of Farming Experience of Respondents

	Creditors		Non Creditors	
Farming Experience	**Frequency**	**%**	**Frequency**	**%**
up to 10	23	15	28	19
11 to 20	41	27	60	40
21 to 30	41	27	23	15
31 to 40	33	22	27	18
41 to 50	12	8	12	8
Total	150	100	150	100

Source: Field Survey 2009

Table 4 Distribution of Household Size of Respondents

	Creditors		Non Creditors	
Household Size	**Frequency**	**%**	**Frequency**	**%**
Less than 5	10	7	16	11
5 to 9	85	57	81	54
10 to 14	32	21	34	23
15 to 19	16	11	12	8
20 to 24	3	2	2	1
25 and above	4	3	5	3
Total	150	100	150	100

Source: Field Survey 2009

Table 5 Distribution of Technical Efficiency of Borrowers and non-Borrowers (DEA)

Efficiency score	Farms using credit (percent)	Farms not using credit (percent)
≤ 0.60	14	20
0.61-0.80	36	34
0.80-1.00	50	45
Total	150	150
Minimum	0.42	0.23
Maximum	1	1

Table 4 showed the frequency distribution of household size of borrowers and non borrowers included in the study. Majority of the respondents in both categories, had large family size as 85 borrowers (57%) and 81 non borrowers (54 %) falling within the range of 5 to 9 family members. These results are in line with Bashir and Azeem (2009).According to them 80% and 82 % loanee and non loanee farmers were having 5-9 family members.

Efficiency Estimates through Data Envelopment Analysis (DEA)

The technical efficiency of farmers in district Faisalabad was estimated by applying output oriented Data Envelopment Analysis (DEA) under constant returns to scale. The estimated mean efficiency of 300 sample farmers was 78 percent. The output oriented technical efficiency explained that how much feasible output is maximized for a given level of input. There is scope for the farmers to improve their efficiency about 22 percent. The resultant efficiency scores from DEA were further divided into two categories: namely borrowers and non-borrowers. The different levels of technical efficiency and percentage of farmers showed that more percentage of farmers using credit were at high efficiency level (Table 5). The results also indicated a technical efficiency range from 0.23 to 1.00 for non-borrowers and from 0.42 to 1.00 for borrowers. The efficiency distribution had shown that, 20 percent of non-borrower farmers and 14 percent of borrowing farmers are below 60 percent level of efficiency. This level of efficiency showed that 6 percent farmers not using credit are at low efficiency level. The table also explained that 50 percent of borrowers are above 80 percent efficiency level while the percentage of non-borrowers was 45.

Technical Inefficiency sources

The technical efficiency scores from first stage Data Envelopment Analysis examined that there existed 22 percent inefficiency of respondent farms. Thus to investigate the factors affecting technical efficiency of sample, Tobit model was applied. In Tobit model, the efficiency scores from DEA were regressed on operated area, farming experience, education of household head, dummy of credit (1=borrower, 0=non-borrower), household size, herd size (animal

Table 6 Regression Results through Tobit Model

Parameter	Parameter Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	0.667	0.036	18.78*	<.001
Operational area	-0.0006	0.001	-0.54	0.5871
Farming experience	0.002	0.002	3.04*	0.0024
Education years	0.008	0.002	3.36*	0.0008
Credit dummy	0.039	0.018	2.11**	0.0351
Household size	-0.004	0.002	-2.07**	0.0387
Herd size	0.002	0.001	1.75***	0.0801
Total cultivation practice number	0.025	0.008	3.28*	0.0010
Total plant protection numbers	-0.009	0.004	-2.25**	0.0247

Note: * Indicates that the coefficient was significantly different from zero at 0.01 probability level; **Indicates that the coefficient was significantly different from zero at 0.05 Probability level; *** Indicates that the coefficient was significantly different from zero at 0.10 Probability level

units), cultivation practice, and numbers of plant protection measures. Table 6 described the parameters estimated through Tobit regression model which illustrated the extent of factors affecting technical efficiency of farms. Six of the 9 parameters were statistically significant at 0.05 probability level, which suggests a fairly good fit of the model. The positive sign statistically significant at 0.05 probability level of the credit dummy indicated that access to credit would result a decrease in inefficiency of the farms. For a one percent increase in the access to credit; technical efficiency of farmers will increase by 0.04 percent. The small value of credit coefficient was may be due to the fungible nature of credit as it was also argued by Von and Adam (1980) that fungibility had considerably declined the expected effect of all the ten observed credit projects in Latin America. Access to agricultural credit allows farmer's timely use of farm inputs and application of new and modern technology which ultimately increase output of the farms. The credit dummy showed the highest coefficient value than all other factors determining technical efficiency. Various studies like Sial and Carter (1996), Feder, et. al. (1990), Zubairi (1989) and Qureshi and Shah (1992), confirmed these results through different estimation techniques. Operational area showed negative sign; large farm size increased inefficiency of farms but insignificantly. The household size also exhibited negative relationship with technical efficiency and was significant at 0.05 probability level. The large family size increased inefficiency of farms by 0.004 percent. The total number of plant protection measures was statistically significant at 0.05 probability level but had negative correlation with technical efficiency with the coefficient value of 0.008. More number of sprays (pesticides and weedicides) is not solely responsible for pest control but also indicated the heavy pest attack further deteriorating the productivity.

Conclusion

The study employed a two stage estimation technique to examine the impact of agricultural credit on technical efficiency and its determinants for rural farmers in Faisalabad. In first stage the technical efficiency was calculated using output oriented DEA. In the second stage the farm specific characteristics were used in Tobit regression model to examine the factors effecting farming efficiency. The results indicated that o.78 average efficiency score with minimum value 0.42 for credit user and minimum value 0.23 for non-credit users. Tobit regression results provided the indication that farming experience, education, access to farming credit, herd size and number of cultivation practices had positive and significant correlation with efficiency of the farmer.

Recommendation

The agriculture sector of Pakistan still suffers from low productivity, expensive financial support to the farmers, inefficient market structure and improper research. Thus to develop farming sector and to increase the farming efficiency it was recommended to enhance the accessibility of small and marginal farmer to formal agricultural credit.

Loan for the livestock should be enhanced and this would definitely enhance farmer's income and ultimately would reduce poverty.

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