

DOES AGRICULTURE CREDIT AFFECT PRODUCTION EFFICIENCY? Frontier Production Function Approach

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Abstract. In the present study, the economic efficiency of credit and non-credit users in agriculture farms was estimated through frontier production function approach. In total, 152 farmers were selected through simple random sampling from District Sargodha of Punjab Province. The results of the study revealed that mean technical efficiency in the region was 0.90 and 0.79 percent of the credit and non-credit users, respectively. The high technical efficiency of credit users was safely attributed to credit availability through which they have a timely access to farm inputs. But still farmers were mis-allocating their resources means inputs at farm level. In this regard farmers need extension services along with credit use to make them economically efficient.

Keywords: Agricultural credit, Economic efficiency, Marginal value product, Frontier production function

JEL classification: O13, O16

I. INTRODUCTION

There are many studies which are supporting the hypothesis the access to credit increased the productivity and profit of the farm households (Diagne

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and Zeller, 2001; Adesina and Djato, 1996; Hazarika and Alwang; 2003; Foltz, 2004). Formal credit has a positive impact on household welfare outcomes. It was also found that formal credit increased rural income and productivity and that overall benefits exceeded the costs of the formal credit system by about 13 percent in India (Binswanger and Khandker, 1995; Khandker and Faruque, 2003). In examining sources of efficiency differentials among basmati rice producers in the Punjab province of Pakistan, Ali and Flinn (1989) found significant effects of farmers' access to credit. Significant difference in productivities of credit-constrained and unconstrained households was observed in China (Feder *et al.*, 1989; 1990). In Bangladesh, Pitt and Khandker (1996) examined the impact of credit from the Grameen Bank and other two targeted credit programmes and found significant effects on household welfare, including education, labour supply and asset holding. Freeman *et al.* (1998) found that the marginal contribution of credit to milk productivity was different among credit-constrained and non-constrained farmers in East Africa.

Guirkingner and Boucher (2005; 2007) found that productivity of credit-constrained households depended on their endowments of productive assets and the credit they obtained from informal lenders. Similarly, Holden and Bekele¹ (2004) observed that households with access to credit compensated for increasing risk of drought by reallocating their production in such a way that crop sales were lower in good years to reduce the need to buy the crops in bad years, and they argued that the households would be less able to do so without access to credit.

Agriculture credit supply is complex in nature in Pakistan. It is mainly comprised of formal and informal sector. If a household was constrained in the formal market, then, credit being fungible, it must be constrained overall. Therefore, the present study focused on the market of institutional credit (Malik, 1999).

This study only analyses the farmers who have the access to credit from the formal sources which is mainly Zarai Taraqiati Bank Limited (ZTBL). Agriculture credit supply soared high due to the regulations by the central bank. In total all banks are supplying Rs. 300 billion credit to farmers (GoP, 2012). The institutional agriculture credit has a positive impact on the agriculture farm productivity in Pakistan (Iqbal *et al.*, 2003; Okurut *et al.*, 2004; Olagunju, 2007).

¹Cited by Komicha and Öhlmer (2008), Influence of credit constraints on production efficiency: The case of farm households in Southeastern Ethiopia.

In addition to this, lack of access to institutional credit is considered a main constraint to agriculture production. This constraint becomes more severe due the seasonality of agriculture. For the welfare of the small farmers it is important that they utilize all the available resource (fertilizers, plant protection measures and other inputs in a judicious manner. Small farmers are having less than 12.5 acres of land holding, thus it is important to develop the agriculture sector to bring prosperity and welfare in the agricultural community, and especially small farmers (Khan, 2000).

The difference in the production capacity of credit borrowers and non-borrowers is due to use of credit and pre-existing inherent characteristics of small-scale farmers. The mean difference was 40 percent of which 2 percent is due to credit. The credit can increase the output up to 21 percent. The major constraint to the farmers is to access an affordable credit which can affect the output capacity and level. There is positive linkage between the technical efficiency of farm businesses and their financial structure. The farmers with greater financial control put forth more industrious efforts to meet their debt obligations, although lenders also may be certifying greater credit value associated with more efficient production (Spio, 2002).

In the context of the above discussion, it is comprehensible that, farmers farm productivity is different with and without credit. Present study attempt to answer the following questions:

1. How does credit affect the farm production efficiency of small farmers?
2. How do farmers efficiently allocate their resources during the availability of credit?

II. ANALYTICAL FRAMEWORK

This paper will provide an analytical framework for efficiency measurement along with empirical analysis of credit users and non-credit users. Basically, the economic efficiency can be estimated by measuring technical and allocative efficiency. Technical efficiency (TE) is the ability of a firm to obtain maximum output from a given set of inputs, and allocative efficiency (AE), which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices. The concept of technical, allocative and economic efficiency can be illustrated by using input/input space (input-oriented measures) or output/output space (output-oriented measures) (Coelli, 1996) or input-output space (Ali and Chaudhry, 1990). These concepts were explained by employing input-oriented measures.

Farmers are generally believed to maximize their profit. However, it should be noted, efficiency (allocative and technical) and profit maximization are two sides of the same coin in that at the level of individual production unit you cannot have one without the other (Ellis, 1993).

There are two approaches; stochastic frontier (parametric approach) and data envelop analysis (DEA), also named as non-parametric approach mostly used to measure technical, allocative and economic efficiency. The present study employed a stochastic production frontier approach introduced by Aigner *et al.* (1977) and Meeusen and van den Broeck (1977). The weaknesses and advantages have been discussed by Coelli (1996) and Coelli and Perelman (1999). The maximum likelihood estimates provided consistent estimators for coefficients, technical inefficiency measures and variance for details (see Jondrow *et al.* (1982; Bravo-Ureta and Rieger, 1991).

III. MODEL SPECIFICATION

The Cobb-Douglas form is linear in logarithms and can be conveniently analyzed with standard linear regression. The function form fitted to the data is as follows:

$$Y = aW^{b_1} NP^{b_2} C^{b_3} L^{b_4}$$

$$\ln Y = \ln a + b_1 \ln W + b_2 \ln NP + b_3 \ln C + b_4 \ln L + e \quad (1)$$

Where:

- ln = Logarithm;
- Y = Gross value of the crop products (Rupees);
- W = Irrigation water in acre inches;
- NP = Nutrient kg/acre;
- C = Cash inputs (Rs.)/acre;
- L = Labour input in man days/acre; and
- e = error term.

DERIVATION OF MARGINAL VALUE PRODUCTS AND OPPORTUNITY COSTS

Where Y represents farm revenue, X_i represents the level of input of the i^{th} resource, and b_i is the regression coefficient of the i^{th} input in a Cobb-Douglas model, it can be shown that (Heady and Dillon, 1969): Marginal value product (MVP) of $X_i = dY/dX_i = b_i (Y/X_i)$.

Following customary practice, one can obtain a point estimate of MVP by evaluating above equation at the mean value of each input, in this case irrigation water. The example for derivation of MVP and its associated statistics is given below: In this paper, individual farm budget of representative categories, *i.e.* credit users and non-credit users were developed for production function analysis.

SAMPLE AND DATA

The study was undertaken in the mixed cropping zone district Sargodha. This comprised of five tehsils: Sargodha, Bhalwal, Sahiwal, Shahpur and Sillanwali. Out of which two tahsils were purposively selected as the concentration of borrowers was high in two tahsils. From each tehsil two villages were again purposively selected. In total 80 farmers were randomly selected who owned the land less than 12.5 acres. Non-borrowers were also randomly selected from the same villages, a list was made with the help of Chowkedar of the villages. Of the total sample, 77 respondents were non-credit users and 75 were credit users for final analysis.

A structured questionnaire was used to collect information on farmer-household socioeconomic characteristics, farm management practices and income patterns. The characteristics include amongst others the following: size of arable land in acres; farmers' age in years; number of years of formal education; gender, marital status; membership of farmers' associations; farming experience in years; inputs used in production process like irrigation water in acre inches; Nutrients kg per acre; Cash inputs (land preparation cost (tillage, ploughing, planking, pesticide and hoeing cost, seed cost (Rs. per acre); L: Labour input in man days per acre.

IV. RESULTS AND DISCUSSION

The following section presents the results and discusses them in detail.

TECHNICAL EFFICIENCY OF CREDIT/NON-USERS

The maximum-likelihood estimates of Cobb-Douglas stochastic production frontier and parameters explaining inefficiency of credit users were obtained in Table 1 for the study area. The estimated coefficients of the input variables of frontier production function have a positive sign and consistent with economic theory. All coefficients were highly significant ($p = 0.01$) except labour input. In the Cobb-Douglas production function, the parameters were the respective elasticities of input which provides the important direction in production decision. The elasticity for some inputs was smaller as their sum was equal to one showing a constant return to scale.

The mean technical efficiency of credit users was 90 and that of non-credit users were 79 percent, respectively (Table 2). The results were consistent with Desai and Mellor (1993). The efficiency of credit users was higher than their counterparts.

TABLE 1
Maximum Likelihood Estimates of the Cobb Douglas
Stochastic Frontier Function of Credit Users

Variables	Coefficients	t-statistics
Constant	1.945***	3.045
Irrigation Water	0.233***	2.502
Fertilizer cost	0.405***	3.543
Cash Inputs	0.346***	2.795
Labour Cost	0.058	0.736
Technical Inefficiency Model		
Constant	0.021	0.031
Farm Size	-0.006	0.287
Experience	0.001	0.133
Education	-0.008	-0.396
sigma-squared	0.043*	1.625
Gamma	0.557*	1.673
Mean Efficiency	0.90	

* indicate that the coefficient is significantly different from zero 0.10 percent probability level; ** indicate that the coefficient is significantly different from zero 0.05 percent probability level; and *** indicate that the coefficient is significantly different from zero 0.01 percent probability level.

The high technical efficiency of credit users was their more motivation towards credit. They utilize all available information regarding credit. In order to test this hypothesis preferably we would have incorporated the new technology (which is not available) in the inefficiency model to study the impact of new technology on technical inefficiency. However, scale variables farm size and education played a major role in lowering the inefficiency. The low level of technical efficiency of non-credit users as compared to credit users implied that the potential for improvement exists.

The inefficiency parameters, *i.e.* farm size, experience and education could play a major role in improving the efficiency of non-credit users.

TABLE 2

Maximum Likelihood Estimates of the Cobb Douglas
Stochastic Frontier Function of Non-Credit

Variables	Coefficients	t-statistics
Constant	3.781***	15.7
Irrigation Water	0.668***	7.259
Fertilizer cost	0.044	0.977
Cash Inputs	0.003	0.068
Labour Cost	0.003	0.055
Technical Inefficiency Model		
Constant	0.400***	5.915
Farm Size	-0.017	0.842
Experience	-0.0008	-0.724
Education	-0.013*	-1.857
sigma-squared	0.017***	4.901
Gamma	0.999	0.269
Mean Efficiency	0.79	

* indicate that the coefficient is significantly different from zero 0.10 percent probability level; ** indicate that the coefficient is significantly different from zero 0.05 percent probability level; *** indicate that the coefficient is significantly different from zero 0.01 percent probability level.

The value of γ -estimate for credit users was significantly ($p = 0.10$) different from one, indicates that random error was dominant and playing a significant role to explain the variation in the dependent variable and this was normal especially in the case of agriculture where risk was assumed to be a main source of variation (Table 3 and 4). Similar was the case for the non-credit users where the value of γ -estimate was significantly ($p = 0.01$) from zero. The results were consistent with Olomola (1997). The credit was contributing significantly in reducing risk and access to all the resources on which farmer is dependent in the production process.

TABLE 3
Marginal Value Product of Selected Inputs
for Credit Users, Sargodha, Punjab

Variables	Unit	Mean	Production Elasticity	MVP (Rs.)	OC (Rs.)	MVP/OC
Irrigation Water	Acres Inches	333	0.318	500	300	1.66
Fertilizer	N/Kgs	3070	0.342	57.73	20	2.88
Labour	M/Days	178	0.057	175.59	150	1.17
Cash Inputs	Rupees	122598	0.376	1.57	1	1.57
Gross Revenue	Rupees	521306	–	–	–	–

OC: opportunity cost

ALLOCATIVE EFFICIENCY OF CREDIT USERS AND NON-CREDIT USERS

The intent here was to show estimates of the marginal value product of inputs. Farm survey data were used to estimate the economic value of selected input and to measure the allocative efficiency of these inputs, the Cobb-Douglas (C-D) form provided the best fit to the survey data (as measured by the coefficient of determination (R^2) and t-tests on the regression coefficients). The C-D function is probably the most widely used forms for fitting agricultural production data, because of its parsimony in parameters, ease of interpretation, and computational simplicity.

TABLE 4
Marginal Value Product of Selected Inputs for
Non-Credit Users, Sargodha, Punjab

Variables	Unit	Mean	Production Elasticity	MVP (Rs)	OC (Rs.)	MVP/OC
Irrigation Water	Acres inches	130	0.775	906	300	3.02
Fertilizer	N/Kgs	1025	0.074	10.763	20	0.5
Labour	M/Days	164	0.004	3.828	150	0.02
Cash Inputs	Rupees	27467	0.056	0.321	1	0.32
Gross Revenue	Rupees	157702	–	–	–	–

OC: Opportunity cost

The results (Table 3 and Table 4) revealed that credit users and non credit users were allocatively inefficient; especially in water use (custom hiring rates of tube well water were used as an opportunity cost). The ratio of MVP/OC was greater than one showing scarcity of the most of the inputs. However, the ratio of fertilizer, cash inputs and labour were low but the coefficients of these inputs were not significant and magnitudes of the parameters were also small. The results were consistent with Olagunju (2007) and Udayanganie *et al.* (2006). The resource-use efficiency of fertilizer and capital were higher than the non-credit users.

V. CONCLUSION AND SUGGESTIONS

The farm enterprises were predominantly small and constitute the majority of the farming community in Sargodha Division. The Division represents the mixed cropping zone where most of the crops are grown. Mostly the farmers were resource poor and often facing constraints in obtaining agricultural credit from the institutional sources. The agricultural credit schemes introduced time to time by the government did not yield desired results. There was a dearth of empirical literature to support or refute the argument for or against the agricultural credit programmes. In this paper the economic efficiency of the credit users and non-credit users was estimated through the frontier production function.

The mean technical efficiency in the region was 0.90 and 0.79 percent, for credit and non-credit users respectively. The high technical efficiency of credit users was safely attributed to credit availability through which they have an access to inputs. The results of the allocative efficiency showed that farmers were inefficient (MVP/OC) >1) in their input use at the farm level. Thus, both categories of farm were found economically inefficient.

In the light of this study's results, the following suggestions are proposed for the improvement of the production efficiency of the farmers:

- The farmers should be provided technical know how, how to utilize the credit for the enhancement of farm productivity judicious use of inputs.
- The motivation required at institutional level to target the most vulnerable group especially small farmers.

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