Role of Credit on Production Efficiency of Farming Sector in Pakistan (A Data Envelopment Analysis)

Saima Ayaz, Zakir Hussain, Maqbool Hussain Sial

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.

Keywords**—**Agricultural credit, DEA, Technical efficiency, Tobit analysis

I. Introduction

FARMING sector is the leading sector of economy of Pakistan. Out of total gross domestic product almost 21 percent was produced by farming sector and this sector also engaged 44 percent of total labor force. Agriculture adds to economic development since it provides raw material to manufacturing sector and it significantly contributes to country's exports. The 66 percent of the rural population of Pakistan is directly or indirectly related by farming sector for their income. In the presence of an ever increasing population, a rise in agricultural growth is crucial to support the growing food needs of the people. A strong and an efficient farming sector would enable a country to feed its growing population, earn foreign exchange, generate employment and provide raw materials for expanding industries. Due to the multifunctional nature of agriculture sector, it has a multiplier effect on any nation's socio-economic and manufacturing framework [14].

Enhanced agricultural inputs use, new technologies adoption and technical efficiency achievement are the key determinants for rapid growth of farming sector. To use better inputs and to implement new technology the farmers require finances, which come either from their own savings or from obtaining loans. In developing economies like Pakistan, savings among the small farmers are of negligible amount and agricultural credit appears as an essential input for investment in agriculture [10]. Credit plays an enormous function to make farming sector more productive and efficient all over the world. Shortage of credit availability or capital constraint faced by the farmers is one of the major problem in the adoption of modern technologies and efficiency improvement in the agriculture sector. The lack of resource constraints was not only the possibilities to realize opportunities for increase in productivity but also the ability to smooth consumption [12].

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 loan supplied for agriculture equipments i.e. purchase of tractors, cutter binders, threshers, trolley, and installation of tube wells, spray machinery etc. To help out small farmers by extending loans to them on easy terms, government made agricultural credit policies. Ministry of Food, Agriculture and Livestock (MINFAL) play a vital role in Pakistan to remove obstacles in credit disbursement and to check the state of disbursement [9].

Agriculture credit played a significant role in the adoption of modern technologies in the farming sector. The credit used as working capital to input purchase as well as for consumption. Farmers immediately need funds after the harvesting period for the next cropping season because of cash scarcity and non payment of new crop. Modern agriculture is comprised of high-yielding seeds, fertilizers, and plant protection measures (PPM). Most of which purchased through cash or on credit, thus more and more farm households' depends upon credit markets. Efficient credit market provided an opportunity to the farmers meet the consumption requirements and balanced input use, which resulted in betterment of the farmers [7].

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 is comprised of formal and informal sector, which play a significant, and an active role in rural economy [1] and [2].

Presently in Pakistan, the formal agricultural credit institutions are comprises of Zarai Taraqiati Bank Limited (ZTBL), Commercial Banks, Federal Bank for Cooperatives and also some non-governmental organizations (NGOs). The institutional agricultural credit was positively affecting the agricultural productivity in Pakistan [10].

The informal sector consists of professional moneylenders, friends, relatives, and commission agents, etc. Though the

Saima Ayaz was graduate student at university of Sargodha, Sargodha, Pakistan (phone: 0333-9794860; fax: 048-9230817; e-mail: mishal_uos@ yahoo.com.

Zakir Hussain, Jr., was professor and chairman, department of Economics, University of Sargodha, Pakistan (e-mail: zakir_rana@yahoo.com.)

Maqbool Hussain Sial was Professor of Economics, University of Sargodha, Sargodha, Pakistan.

informal sector is charging high interest rate but still its contribution is larger than the formal sector. The reason is low transaction cost due to 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, which is utilized for non-agricultural expenses most of the time and also is not adequately large to promote growth and investment. Thus it has no helpful contribution in agricultural production.

The easy availability of funds directs to increased use of input and then to increased output that consequently shows growth in net income that raises welfare gains. It also helps to enhance the capability of farming household to face the risks which consequently directed to new technology implementation and diversification of crop mix and income sources.

Various viewpoints were there about the economic impact, equality and adequacy of credit for the recipients. The true empirical estimation of the impact of credit 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 [5].

The efficiency of farming credit system and shadow price of capital in Pakistani Punjab was calculated by reference [18]. By using endogenous switching regression method it was investigated that the individuals who obtained average size loans produced 48 percent more output than the non-borrowers. The study also examined that farmers having no loans could make Rs. 3.05 additional income by taking one rupee loan. The estimated shadow price of capital showed inefficiency of capital market. The results revealed that if shadow price is greater than the opportunity cost of capital, the provision of subsidized credit have no economic rationale to improve the small farmer's access to credit.

Government of Pakistan has been extensively used the subsidized agricultural credit policies to achieve higher agricultural growth through relaxing monetary limitation. Reference [19] investigated that the impact of institutional credit comes through financing of seed and fertilizer. Reference [16] observed that formal loans positively affect agricultural output through financing of capital investment. They found that financing capital investment is more beneficial than that of financing of seed and fertilizers.

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 input for same level of output. To estimate the total economic efficiency (EE), the technical and allocative efficiency estimates are combined.

To explore the effect of farming credit on technical efficiency of farming household in Pakistan was the main objective of this study. The technical efficiency estimation was carried out through Data Envelopment Analysis (DEA) method. The study also examined sources of inefficiency through Tobit regression model.

II. 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 [6].

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 included the error terms, whereas in SFA, a specified functional form was used for the efficiency estimation and the error terms were described for inefficiency measurement [6].

Data Envelopment Analysis (DEA)

DEA was used as an apparatus for evaluating and improving the performance of production units. It is a nonparametric mathematical programming approach. 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 through DEA can be either input or output oriented. It could also be described under constant as well as variable returns to scale (CRS and VRS). The technical efficiency scores obtained through input oriented method and through output oriented methods possess the similar values under constant returns but the values are different under variable returns to scale technology [4]. The DEA technique has plus point that the functional form is not pre specified, hence specification error does not arise.

The present study estimated technical efficiency of farming households under output-oriented technique.

Output-Oriented DEA

The technical efficiency could be estimated that how much feasible output is maximized for given level of input.

According to reference [6] output-oriented efficiency measure could be described through the following diagram:

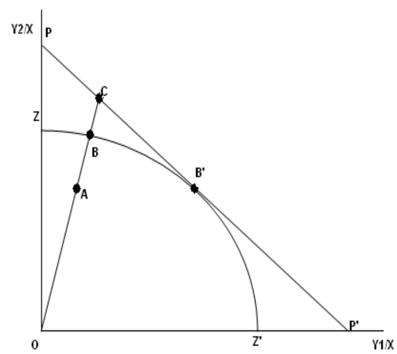

Fig. 1 efficiency and productivity analysis
Source: [4]

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 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 have efficiency 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 so they are unit indifference i.e. the estimated efficiency points do not vary with the transformation of estimation entries [4].

There were observed two weaknesses 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 [11] and [17].

III. Tobit Regression Analysis

The efficiency analysis also had a significant need to know 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 were bounded by 0 and 1.

The management, socio economic and environmental characteristic of farmer could affect the efficiency and productivity of the farmers. It was argued that to assess all the factors affecting efficiency of the farm was not possible but the variables which were considered as most important influencing factors were measured [3].

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:

X_{1i} = Operational land holding of the i[th] farm in acres.
X_{2i} = the farming experience of the i[th] farm's operator in years.
X_{3i} = the education level of the i[th] farmer in schooling years.
X_{4i} = the household size of i[th] farmer, here number of family members.
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} = Cultivation practices numbers of i[th] farm, including hoeing and weeding numbers.
X_{8i} = Plant protection of the i[th] farm, including spray numbers of pesticides, insecticides and weedicides
ß's = the unidentified parameter to be estimated.
µi = the error term.

IV. Data

The primary data was collected through well-structured comprehensive questionnaire. The sample of 300 farmers was collected from two tehsils of Faisalabad district: tehsil Faisalabad and tehsil Jaranwala. In each tehsil 150 farming households were interviewed, which were further divided into two categories, credit users and non-users of credit. The questionnaire contained information about socio-economic profile, 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.

V. RESULT AND DISCUSSION

The descriptive statistics of farms was provided in Table 1. The table showed farmer's annual output and pattern of input use and farm specific variables of total sample of 300 farms. The average value of total farm output per year was Rs. 137732.25 per year. The highest value of output was Rs. 244475 and the lowest value was Rs. 29250. The value of farm output included both annual crop income and annual income from livestock.

The labor input includes family labor and permanent hired labor and was expressed in man days. The mean value of labor shows that farmers work only 110 days per acre within a year, which translate to 2 days per week ranging from only 3 hours to 9 days per week. The average annual use of fertilizer nutrients was 112.95 kg per acre whereas average irrigation level was 57 acre inches per acre. The table showed that average expenditures on cash inputs were Rs. 6181.64 per acre and mean value of annual expenditures on livestock was Rs. 12282.39 per animal.

TABLE I DESCRIPTIVE STATISTICS OF THE PHYSICAL INPUTS AND OUTPUT

Variables	Mean	Standard deviation	Minimum	Maximum
Farm output/year (Rs./acre)	137732	44996.28	29250.00	244475
Inputs				
Labor days/year (Man days/acre)	110.49	82.72	14.11	472.50
Fertilizer Nutrients/year (Kg./acre)	112.95	39.85	23.00	266.00
Irrigation/year (Per acre inch)	57.00	20.89	18.20	160.65
Cash inputs/year (Rs./acre)	6181.64	1645.74	3030.96	12851.88
Expenditures on livestock/year (Rs./animal)	12282	7702.58	1.00	40200.00

Source: Field Survey 2009

Adding years of schooling not only improves the efficiency of farmers but also enhanced their capability to understand and adopt new method and techniques of farming [15]. Table 2 presented frequency distribution of education level for all respondents included in study. The table showed that the sample farmers generally had 8 (21 percent of total sample) to10 (26 percent of total sample) years of education.

TABLE II DISTRIBUTION OF EDUCATIONAL ATTAINMENT OF RESPONDENTS

Years of education	Frequency	Percent
No education	39	13
Primary education	54	18
Middle	62	21
Metric	77	26
Secondary education	37	12
Higher secondary education	25	8
Graduate	6	2
Total	300	100

Source: Field Survey 2009

The practical knowledge and skills which a farmer attains ascertained through the number of years a farmer had spent in farming activities. Based upon the farming experience, 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 [15]. Table 3 showed that 34 percent of the farmers included in the study had 11 to 20 years of farming experience.

TABLE III DISTRIBUTION OF FARMING EXPERIENCE OF RESPONDENTS

Farming experience	Frequency	Percent
≥ 10	51	17
11 - 20	101	34
21 - 30	64	21
31 - 40	60	20
41 - 50	16	5
≤ 51	8	3
Total	300	100

Source: Field Survey 2009

Table 4 showed the frequency distribution of household size of the respondents. The study revealed that majority of the respondents had large family size as 167 farmers (59 percent of the sample) falling within the range of 5 to 9 persons per household. Table also showed that 22 percent of the farmers had 15 to 19 family members, probably 2 to 3 times more than the national average.

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 or in other words 22 percent farmers were inefficient. The output oriented technical efficiency explained that how much feasible output is maximized for a given level of input. Thus the results depicted that there is scope for the farmers to improve their efficiency by about 22 percent.

TABLE IV DISTRIBUTION OF HOUSEHOLD SIZE OF RESPONDENTS

Household size	Frequency	Percent
> 5	26	9
5 - 9	167	56
10 - 14	66	22
15 - 19	28	9
20 - 24	5	2
≤ 25	9	3
Total	300	100

Source: Field Survey 2009

TABLE V DESCRIPTIVE STATISTICS OF EFFICIENCY SCORES (DEA)

Mean efficiency	0.78
Standard deviation	0.16
Minimum	0.23
Maximum	1

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 were explained in Table 3. The results clearly showed that more percentage of farmers using credit were at high efficiency level. The results presented in Table 3, 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 while 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.

TABLE VI 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

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 regression technique 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 units), cultivation practice, and numbers of plant protection measures. Table 4 described the parameters estimated through Tobit regression model which illustrated the extent of factors affecting technical efficiency of farms. Six of 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 farms will increase by 0.04 percent. 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 for example reference [6], [16], [18], and [19] 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 0.4 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.

TABLE VII 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

The years of schooling and farming experience and total number of cultivation practices showed positive sign, significant at 0.01 probability level. An increase in schooling by one year increased efficiency level 0.008 percent. While one more year of farming experience increase technical efficiency by 0.002. Farming experience is directly correlated with the age of farmers. Farmers having more experience are generally considered having more knowledge of farming practices, but also more hesitant in adoption of modern technologies. But here the estimated coefficient value of experience explained the overriding effect of former point of view. Education level more strongly affected the farming efficiency as compared to experience. Similarly a one more cultivation practice increased 0.025 percent technical efficiency. Farmers having more stock of animals were more efficient.

VI. Conclusion

The study employed a two stage estimation technique to examine the technical efficiency and its determinants of 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. These results of Tobit regression 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. The coefficient value of credit dummy indicated that a one percent increase in the access to credit would increase 0.039 percent technical efficiency of farms. This confirmed the expectations that agricultural credit access increases farming efficiency, as it allows farmers timely use of farm inputs and application of new and modern technology which ultimately increase output of the farms.

References

[1] Adams, D. W. & Delbert A. F. (1992). Edited by Informal Finance in Low-income Countries, Westview Press, Colorado, 1992
[2] Aleem, I., (1990). Imperfect information, screening, and the costs of informal lending: A study of rural credit market in Pakistan. World Bank Economic Review, 4(3), 329-349.
[3] Bravo-Ureta, B. E. & Pinheiro. A. E., (1997). Technical, economic and allocative efficiency in peasant farming: Evidence from the Dominican Republic. The Developing Economies, 35, 48–67.
[4] Coelli T. D. S., Rao P. & Battese, G. E. (1998). An introduction to efficiency and productivity analysis. Boston MA: Kluwar Academic Publishers
[5] David, C. & Mayer, L. R. (1980). Measuring the farm level impact of agricultural loans, in borrowers and lenders: rural financial Markets and Institutions in Developing Countries. London: Overseas Development Institute, 201-234.
[6] Farrell, M.J. (1957). The measurement of productive efficiency. Journal of the Royal Statistical Society (A, general), 120, 253-281.
[7] Feder, G., Lawrence J., Lau, J., Lin, Y., & Luo, X., (1990). The relationship between credit and productivity in Chinese agriculture: A microeconomic model equilibrium. American Journal of Agricultural Economics, 72(5), 1151-1157.
[8] GOP (2008) Economic Survey of Pakistan, Government of Pakistan, Finance Division, Islamabad.
[9] Hanif, M., Khan, S. & Nauman, F., (2004). Agricultural perspective and policy. ISBN 969-8581-06-5 Ministry of Food, Agriculture and Livestock (MINFAL), Islamabad.
[10] Iqbal, M., Ahmad, M. & Abbas, K. (2003). The impact of institutional credit on agricultural production in Pakistan. The Pakistan Development Review, 42 (4), 469-485.
[11] Lovell, C. A. K. (1993). Production frontier and productive efficiency. The Measurement of Productive Efficiency, Oxford University Press, New York, 3-67.
[12] Malik, S. J. (1999). Poverty and rural credit: the case of Pakistan. Pakistan Institute of Development Economics Islamabad.
[13] Meeusen, W. and Broeck, J. V. (1977). Efficiency estimation from cobb-douglas production functions with composed errors. International Economic Review, 18, 435-444.
[14] Ogen, O. (2007). The agricultural sector and Nigeria's development: comparative perspectives from the Brazilian agro industrial economy, 1960-1995. Nebula Journal Australia, 4(1), 184-194.
[15] Olagunju, F.I. & Adeyemo, R. (2007). Agricultural credit and production efficiency of small-scale farmers in south-eastern Nigeria. Agricultural Journal 2(3), 426-433.
[16] Qureshi, S. K & Shah, A. (1992). A critical review of rural credit policy in Pakistan. The Pakistan Development Review, 31(4), 781-801.
[17] Ray, S. C. (2004). Data envelopment analysis: theory and techniques for economics and operations research. The University of Cambridge Press, U K.
[18] Sial, H. M. & Carter, M. R. (1996). Financial market efficiency in an agrarian economy: micro econometric analysis of the Pakistan Punjab. The Journal of Development Studies, 32(5), 771-798.
[19] Zuberi, H. A. (1989). Production function, Institutional credit and agricultural development in Pakistan. The Pakistan Development Review, 28(1), 43-56.