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Impact of agricultural credit on sugarcane production

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Abstract
An attempt has been made in this paper to highlight the impact of agricultural credit on sugarcane production in Erode district of Tamil Nadu. Resource use efficiency and stochastic frontier model was employed to assess the impact of agricultural credit on sugarcane production between borrower-and non-borrower farmers. Results revealed that borrower sugarcane farmers are using more quantity of inputs (setts, machine hours, irrigation hours, manure and human labour) compared to non-borrower sugarcane farmers. MVP to MIC ratio indicates that human labour usage and irrigation hours are underutilised by both the sugarcane farmers. Stochastic frontier results revealed that Borrowers are more technically efficient in sugarcane production compared to non-borrower. Based on the results appropriate policy were suggested.

Keywords: Credit, Resource use efficiency, Frontier, Sugarcane

Introduction
Agriculture and allied sector contribute 14.39 percent to gross domestic product of Indian economy in 2017-18 (MoSPI, 2018) [8]. The sugar industry is the second largest agro-based industry in India next to textiles. It plays a vital role in the development of the country since it influences on both agricultural and industrial economy. Though sugarcane and sugar beet are the main sources of sugar in the world. Most of the sugar in India is only from sugarcane. More than 80 percent of the world's share in sugarcane production and area cultivated is contributed by Brazil, China-mainland, Colombia, Cuba, India, Mexico, Pakistan, Philippines, Thailand and the United States of America (FAOSTAT, 2017) [5]. Brazil ranks first in area (10.18 million ha with a share of 39.21percent) and production (759 million tons with a share of 41.19 percent) of sugarcane. India occupies a second major share in the area as well as in production with a share of 16.90 percent (4.39 million ha) and 16.62 percent (306.06 million tons) respectively. In the case of productivity, Peru has the highest productivity with a yield of 121.24 tons per hectare. The productivity of India's sugarcane (69.74 tons per hectare) is lesser than the world's productivity (70.89 tons per hectare), though it ranks second in area and production. Sugarcane accounts for 3 percent of net sown area, 95.3 percent of irrigated area and 5.40 percent of total fertilizer consumption. On the other hand, India's sugar consumption has been growing at a steady rate of 3% and is currently at 23 Mt. Because of this high domestic demand and occasional fluctuation in production, India has a minimal share in sugar export (Solomon, 2011) [13]. The sugar demand of the country is growing consistently with population growth. Without the contribution of efficient sugarcane production, meeting such a huge domestic demand for sugar is impossible and would have warranted massive sugar import. Production of sugarcane depends on quantity of input use and combinations of inputs. Input use depends on the availability of credit to the farmers who are credit starved. In the case of India most of the farmers are small and marginal farmers and the credit gap was high among the small and marginal farmers (Das, A., Senapati, M., & John, J., 2009) [4]. Accessing institutional credit is also considered as an criterion influencing use of Technology. The variations in accessing institutional credit also affect the sugarcane yield. Many studies confirmed that there is a gap between potential and realized yield of sugarcane in India (Surendran, *et al*., 2016; Felix, K. T *et al*., 2018; Rao, I. V. Y., 2012; Shanthy, T. R., 2011) [14, 6, 9, 12]. Particularly in developing countries like India, inefficiency in production due to non-availability of credit which is one of the core factors hindering the exploitation of the full potential (Sekhon, M. K., *et al*., 2010; Kalirajan and Shand, 1989; Banik, 1994; Thomas and Sundaresan, 2000) [11, 7, 1, 15]. With this scenario, the core objective of this study is to assess the impact of institutional credit on production in terms of the resource use efficiency and technical efficiency of borrowers and non-borrowers of sugarcane farmers.

2. Methodology

Erode district of Tamil Nadu was purposively selected for this study taking into account the area under sugarcane, production and productivity of the crop. The district ranked first in productivity among various districts of Tamil Nadu with an average production of 121 tonnes per hectare during the year 2017-18. Though the district occupies 5.08 percent of the total area under the crop, it contributes 6.16 per cent of the total production of the state. Hence the district was selected for the study. A multistage random sampling technique was adopted for the selection of blocks, villages and sample respondents in the villages. The Primary data were collected for 60 samples (30 borrowers and 30 non-borrowers) through personal interview method with the help of Interview schedule.

2.1. Resource use efficiency:

Production function analysis is used to study the Resource Productivity and Resource use Efficiency. There are different types of production function from which Cobb-Douglas type of production function was used to analyse the effect of various input on output of sugarcane and justify its wide application in analysing production relations. The estimated regression co-efficient represents the production elasticity. In the process of production, the efficiency of various resources was analysed using cobb-Douglas production function. It indicates Marginal Value products at geometric mean level of inputs.

The Cobb- Douglas production function is expressed in the following as

$$y = aX1^{b1}X2^{b2}X3^{b3}X4^{b4}X5^{b5} \dots\dots\dots e^{u}$$

Y= yield (Kilogram/Hectare); X_1= Fertilizer (Kilogram/ Hectare); X_2= Human labour (in hours); X_3= Animal labour (in hours); X_4= Machine labour (in hours); X_5= Sett (Kilogram/ Hectare); X_6= Manure (Tons/ Hectare); X_7= Irrigation(Machine hours/Hectare); α = intercept; β_1 to β_7= regression co-efficient; µ= error term.

Cobb-Douglas production function can be converted into log linear form by Ordinary Least Square technique is given as

$$\ln y = \ln \alpha + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + \beta_6 lnX_6 + \beta_7 lnX_7 + \mu$$

2.1.2. Marginal value product

The marginal value product is used to assess the Resource use efficiency from the regression co-efficient which is derived using Cobb-Douglas production function

$$MPP\ of\ Xi\ input = bi\ \frac{\bar{Y}}{\overline{Xi}}$$

Where, MPP = Marginal Physical Product of i^{th} input; bi= Regression co-efficient of i^{th} input; $\bar{Y}$ = Output of the crop at its geometric mean level; $\overline{Xi}$ = i^{th} independent variable at its geometric mean level.

The Marginal value product of each input is calculated by multiplying the marginal physical product with unit price of dependent variable.

$$MVP = MPP \times P_y$$

When, MVP = MFC, Efficient utilization; MVP < MFC, Over utilization; MVP > MFC, under utilization

2.2. Technical Efficiency analysis

"It is hypothesized that technology adoption increases technical efficiency and thus leads to higher yield (due to direct and indirect effects), higher productivity, and ultimately higher income. The level and determinants of technical efficiency (TE) were estimated to identify the causes of efficiency (or inefficiency) and to analyze whether technology adaptation leads to higher efficiency. A stochastic function approach proposed by Battese and Coelli (1995) [3] was used in the study in which the technical inefficiency effects in a stochastic frontier are an explicit function of other farm-specific explanatory variables, and all parameters are estimated in a single-stage maximum likelihood (ML) procedure. The stochastic production frontier is defined as

$$LnY_i = \beta_0 + \sum_{j=1}^{n} \beta_j Ln(X_{ij}) + (v_i - u_i)$$

where subscript i refers to the i^{th} farmer; Ln represents the natural logarithm; Y is that the ascertained farm yield (Kg/ha); X_1= Fertilizer (Kilogram/ Hectare); X_2= Human labour (in hours); X_3= Animal labour (in Pair hours); X_4= Machine labour (in hours); X_5= Setts (Quintal/ Hectare); X_6= Manure (Quintal/ Hectare); X_7= Irrigation (Machine hours/Hectare).

The above equation has two error terms: one (v_i) to account for random shocks (weather conditions, disease, measurement errors in the output variable, etc. and the combined effects of unobserved/uncontrollable inputs on production) and the other (u_i) to account for technical inefficiency in production. The $v_i$is a random error that is assumed to be independently and identically distributed N (0, σ_v^2) and independent of the u_i;$u_i$is a non-negative random variable. The model, defined by in the above equation, is a stochastic frontier function because the random error (v_i) can be positive or negative and the output values are bounded above by the stochastic (random) variable, exp ($X_i\,\beta$+v_i).

The farm-specific technical efficiencies (TE_i) are computed by taking the exponentiation of the negative of u_i, that is

$$TE_i = \exp(-u_i)$$

The estimation of technical efficiencies is based on the conditional expectation of exp (*-u)*, given the model specification (Battese, G. E., &Broca, S. S., 1997) [2]

3. Results and Discussion

The descriptive statistics of input usage and output of sugarcane farmers (non-borrower) are presented in the Table 1. The results show that on an average,421.25kg/ha of chemical fertilizer,1783.31hrs/ha of human labour, 14.56Pair.hrs/ha of animal labour, 8.94 hrs/ha of machine labour, 22.81t/ha of setts, 67.62Qtl/ha of manure, 646.70 hrs/ha of irrigation machine hours were used to produce an average output of 81.836 t /ha. Maximum yield has been recorded as 105.714 t/ha and minimum yield as 49.939 t/hafor non-borrower sugarcane farmers in the study area.

Table 1: Descriptive statistics of Non-Borrower Sugarcane farmers

Variable	Obs	Mean	Std. Dev.	Min	Max	Geometric mean
Yield Kg/ Ha	30	81836.61	12775.24	43939.41	105714.40	80717.82
Fertilizer Kg/Ha	30	421.25	75.15	295.00	606.67	415.03
Labour hrs/Ha	30	1783.31	483.07	1104.55	3512.50	1728.43
Animal Phrs/ Ha	30	14.56	31.18	0.00	105.00	52.16
Machine hrs/Ha	30	8.94	12.55	0.00	56.67	11.30
Setts Qtl /Ha	30	22.81	41.56	0.00	125.00	78.26
Manure Qtl /Ha	30	67.62	85.29	0.00	306.45	99.37
Irrigation hrs/Ha	30	646.70	323.36	0.00	1437.50	584.04
Yield Rs/Kg.	30	262.23	25.67	230.00	335.00	261.05
Fertilizer Rs/Kg	30	25.02	3.18	18.67	31.43	24.83
Labour Rs/Hr	30	52.86	7.12	37.60	64.13	52.38
Animal Rs/Hr	7	60.40	11.88	50.00	85.00	59.52
Machine Rs/Hr	18	293.76	253.95	32.14	1000.00	188.20
Setts Rs/ Qtl	8	252.92	25.75	210.00	285.00	251.72
Manure Rs/ Qtl	17	72.68	76.00	6.75	200.00	38.31
Irrigation Rs/Hr	17	72.68	76.00	6.75	200.00	38.31

The descriptive statistics of input usage and output of sugarcane farmers (borrower) are presented in the Table 2. The results show that on an average, 412.83kg/ha of chemical fertilizer, 1800.73 hrs/ha of human labour, 10.03P.hrs/ha of animal labour, 11.19 hrs/ha of machine labour, 34.04Qtl/ha of setts, 69.60Qtl/ha of manure, 713.83 hrs/ha of irrigation machine hours were used to produce an average output of 110.334 t /ha. Maximum yield has been recorded as 175 t/ha and minimum yield as 66.265 t/ha for non-borrower sugarcane farmers in the study area.

Table 2: Descriptive statistics of Borrower Sugarcane farmers

Variable	Obs	Mean	Std. Dev.	Min	Max	Geometric mean
Yield Kg/ Ha	30	110334.30	23250.37	66265.06	175000	108062.10
Fertilizer Kg/Ha	30	412.83	99.41	236.25	671.00	401.85
Labour hrs/Ha	30	1800.73	685.85	560.78	3113.34	1642.99
Animal Phrs/ Ha	30	10.03	26.94	0.00	127.00	16.60
Machine hrs/Ha	30	11.19	13.20	0.00	39.34	10.75
SettsQtl/Ha	30	34.04	47.44	0.00	120.83	88.73
Manure Qtl/Ha	30	69.60	107.01	0.00	393.94	97.52
Irrigation hrs/Ha	30	713.83	476.58	0.00	2213.33	650.21
Yield Rs/Kg.	30	251.87	16.69	230.00	285.00	251.35
Fertilizer Rs/Kg	30	25.87	4.32	18.38	35.41	25.52
Labour Rs/Hr	30	59.09	8.47	45.78	76.75	58.51
Animal Rs/Hr	9	100.16	65.06	50.00	220.00	85.51
Machine Rs/Hr	21	4440.24	8464.99	64.00	22111.30	761.83
Setts Rs/Qtl	11	248.56	23.58	210.00	275.00	247.50
Manure Rs/Qtl	15	53.10	50.49	3.00	161.10	31.30
Irrigation Rs/Hr	15	53.10	50.49	3.00	161.10	31.30

The results of descriptive statistics of sugarcane farmers (borrower and non-borrower) revealed that there was a huge difference exists in input usage and yield between borrower and non-borrower sugarcane farmer. An average of 35 per cent higher yield was obtained by borrower sugarcane farmers compared to non-borrowers. Similarly, in the case of inputs use like setts (49 per cent), machine hours (25 per cent), irrigation hours (10 per cent), manure (3 per cent) and human labour (1 per cent) borrower sugarcane farmers are using more. Hence, it is witnessed that, non-borrower sugarcane farmers are using lesser inputs which results in lesser yield. The results are in line the results of Venu *et al.*, 2014 [16].

3.1. Resource use efficiency

Resource use efficiency implies that the inputs used in production process are optimally allocated while minimizing waste and inefficiency. Cobb-Douglas production function was employed to compute the production elasticity of different inputs and Ordinary Least Squares procedure was used for estimation. The estimated regression co-efficient of the inputs are represented in Table 3.

Table 3: Cobb-Douglas production function estimates for Borrower and Non-Borrower

Particulars	Non-Borrower			Borrower		
	Coef.	Std. Err.	P>t	Coef.	Std. Err.	P>t
ln_Fertilizer Kg/Ha	0.302***	0.050	0.000	0.000^{NS}	0.002	0.383
ln_Labour hrs/Ha	1.169***	0.489	0.003	0.039***	0.009	0.000
Ln Animal Phrs/ Ha	0.013^{NS}	0.018	0.485	0.006^{NS}	0.025	0.797
ln_Machine hrs/Ha	0.448***	0.090	0.000	-0.020***	0.006	0.000
ln_Sett Qtl/Ha	0.000^{NS}	0.019	0.993	-0.045**	0.019	0.025
ln_Manure Qtl/Ha	-0.004^{NS}	0.016	0.814	0.009^{NS}	0.017	0.612
ln_Irrigation hrs/Ha	0.019***	0.007	0.000	0.077***	0.021	0.002
Constant	8.034***	1.371	0.000	10.023***	1.083	0.000

Note: *** indicates 1% significant, NS indicates Not Significant

It is noted from table 3 that the co-efficient of multiple determination (R^2) value is found to be 0.72 for non-borrower and 0.80 for borrower. In log linear production, the co-efficient of input variables is representing the production elasticity of the resources used. The regression co-efficient for chemical fertiliser, human labour, machine usage and irrigation are positive and significantly influence the non-borrower's sugarcane yield with the value of 0.302, 1.169, 0.448 and 0.019respectively. In the case of borrower's sugarcane yield, the variable human labour and irrigation has a positive impact with the value of 0.039 and 0.077 respectively. But machine hour and sett usage has had a significant and negative impact on yield with the negative value of 0.020 and 0.045 respectively. This shows that, human labour hour and irrigation machine hour usage has a positive impact on sugarcane yield in both farmer group. Increase in human labour usage has more production elasticity to increase the non-borrower sugarcane farmers yield.

In estimating the Resource use efficiency, the marginal value products of the explanatory variables were calculated and compared with the unit cost of the corresponding inputs. The efficient utilization of resources is obtained when the Marginal value product and the Marginal input cost are equal. The Results are analysed and compared for non-borrower and borrower in Table 4 and 5 respectively.

Table 4: Resource use efficiency Non-Borrower

	Cost & Price	APP	MPP	MVP	MVP/MIC	Decision
Yield Kg/ Ha	261.051					
Fertilizer Kg/Ha	24.830	194.486	58.751	15336.952	617.670	>1 (UU)
Labour hrs/Ha	52.380	46.700	54.600	14253.359	272.114	>1 (UU)
Animal Phrs/ Ha	59.521	1547.51	19.741	5153.290	86.580	>1 (UU)
Machine hrs/Ha	188.197	7146.27	3203.4	836266.3	4443.581	>1 (UU)
Sett Qtl/Ha	251.719	1031.373	0.184	48.006	0.191	<1 (OU)
Manure Qtl/Ha	38.312	812.329	-3.003	-784.046	-20.465	<1 (OU)
Irrigation hrs/Ha	38.312	138.206	2.590	676.181	17.649	>1 (UU)

Note: UU-Under Utilised and OU-Over Utilised

From the table 4, MVP to MIC ratio is less than unity for setts (0.191) and manure (-20.465) indicates the over utilization of these resources, whereas MVP to MIC ratio was more than unity for chemical fertilizer (617.670), human labour (272.114), Animal labour (86.580), machine (4443.581) and irrigation (17.649) indicates that the resource are under-utilized.

Table 5: Resource use efficiency Borrower

	Cost & Price	APP	MPP	MVP	MVP/MIC	Decision
Yield Kg/ Ha	251.347					
Fertilizer Kg/Ha	25.517	268.912	0.040	10.125	0.397	<1 (OU)
Labour hrs/Ha	58.509	65.772	2.540	638.465	10.912	>1 (UU)
Animal Phrs/ Ha	85.508	6508.20	42.179	10601.57	123.983	>1 (UU)
Machine hrs/Ha	761.829	10050.1	-197.5	-49654.0	-65.177	<1 (OU)
Sett Qtl/Ha	247.499	1217.88	-55.34	-13911.11	-56.207	<1 (OU)
Manure Qtl/Ha	31.297	1108.102	9.477	2382.140	76.113	>1 (UU)
Irrigation hrs/Ha	31.297	166.196	12.787	3214.075	102.695	>1 (UU)

Note: UU-Under Utilised and OU-Over Utilised

From the table 5, MVP to MIC ratio is less than unity for fertilizer (0.397) and machine (-65.177) indicates the over utilization of these resources, whereas MVP to MIC ratio was more than unity for human labour (10.912), Animal labour (123.983), machine (76.113) and irrigation (102.695) indicates that the resource are under-utilized. It is evident that human labour usage and irrigation hours are under utilised by both the sugarcane farmers.

Table 6: Estimated coefficients of frontier model

Yield Kg/ Ha	Coef.	Std. Err.	z	P>z
Fertilizer Kg/Ha	0.201***	0.049	4.096	0.000
Labour hrs/Ha	0.013**	0.006	2.161	0.023
Animal Phrs/ Ha	0.007 ^{NS}	0.020	0.361	0.718
Machine hrs/Ha	0.015***	0.005	2.859	0.000
Sett Qtl/Ha	-0.019 ^{NS}	0.019	-0.990	0.322
Manure Qtl/Ha	-0.003 ^{NS}	0.015	-0.212	0.832
Irrigation hrs/Ha	0.047***	0.010	4.747	0.000
Constant	10.050***	0.974	10.319	0.000
/lnsig^{2}v	-3.497***	0.600	-5.820	0.000
/lnsig^{2}u	-2.870***	0.960	-2.990	0.003
sigma_v	0.174	0.052		
sigma_u	0.238	0.114		
sigma^2	0.087	0.040		
lambda	1.368	0.162		

Note: *** indicates 1% significant, ** indicates 5% significant, NS indicates Not Significant

The estimated lamda (λ) parameter is 1.368, which means that the total error variance is mainly due to inefficiency, whereas random errors are less important. The percentage of total variation due to variation in efficiency is 87.097 per cent. The estimated variance for the variation in efficiency is sigma^{2}u value is equal to-2.870is considerably larger than variation due to random errors sigma^{2}v value is equal to -3.497. It shows that presence of error due to technical inefficiency. Results of co-efficient reveals that chemical fertilizer, human labour, machine and irrigation machine hour usage have a significant impact on sugarcane yield.

Table 7: Technical efficiency of Borrower and Non-Borrower

Variable	Obs	Mean	Std. Dev.	Min	Max
Non-Borrower	30	0.789	0.067	0.541	0.852
Borrower	30	0.883	0.044	0.711	0.940

The results of mean technical efficiency of borrower and non-borrower are presented in Table 7. It shows that Borrowers (0.883) are more technically efficient in sugarcane production compared to non-borrower (0.789). Saima, A., & Zakir, H. (2011) [10] study yields the same results.

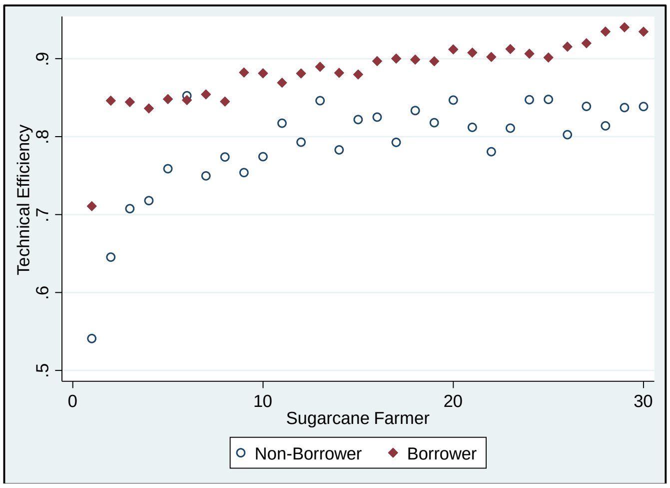

Fig 1: Sugarcane Production Technical Efficiency of Borrower and Non-Borrower farmers

The maximum and minimum production technical efficiency of borrower is 0.940 and 0.711. In the case of non-borrower, it was 0.852 and 0.541. The graphical representation of technical efficiency distribution of both sugarcane farmers is presented in Figure 1.

4. Conclusion and policy implications

The findings of the study confirmed that the borrower sugarcane farmers enjoyed edge over the non-borrowers in terms of production. It was observed that a drastic production gap between borrower and non-borrower sugarcane farms. Results of higher production of borrower sugarcane farmers are using more quantity of inputs (setts, machine hours, irrigation hours, manure and human labour) compared to non-borrower sugarcane farmers. This may be a reason for higher sugarcane production. Results also indicates that Borrowers are more technically efficient in sugarcane production compared to non-borrower. Although many factors influence the yield of sugarcane, here the institutional credit provides a greater result to loan availed sugarcane farmers. Hence, it is important that the interest rate charged on institutional credit should be reduced up to the extent that the farming community is willing to access it. Although human labour usage and irrigation hours are used comparatively high in borrower group, it was underutilised by both the sugarcane farmers. Hence procedure of advancing loan should be made simple and timely availability of credit to farmers will be more helpful for timely purchase of the required inputs.

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