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ARTICLES

Technical Efficiency of Saffron Cultivating Farms in Kashmir Valley: Post National Saffron Mission Implementation

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ABSTRACT

This paper examines saffron growing farmers' performance in the Kashmir Valley's largest saffron producing district Pulwama by estimating the farm level technical efficiency and its determinants. Using cross-sectional data from 390 saffron growing farmers pertaining to the agricultural year 2016, this study employs the Cobb-Douglas stochastic frontier approach with an underlying assumption of the half-normal distribution of the error term. The results confirm wide variations in the sampled farmers' technical efficiency leaving scope to increase production by 41 percent, given the existing resources and technology. An analysis of technical efficiency determinants revealed that farmer experience, education, extension contacts, and family farmworkers are technical efficiency augmenting factors. A higher proportion of saffron land, higher age of the farmer, and access to credit are some of the efficiency retarding factors.

Keywords: Kashmir Valley, Saffron, Cobb-Douglas Production function, Stochastic Frontier Analysis, Technical efficiency.

JEL: C21, Q12, Q16

I

INTRODUCTION

The valley of Kashmir is privileged to produce the world's most expensive spice, popularly known as saffron, with a history dating back to 500 B.C. Kashmir Valley, a part of the union territory of Jammu and Kashmir, is situated in the western part of the Himalayas. In India, almost the entire saffron production comes from Kashmir Valley, and in Kashmir the bulk of this production comes from district Pulwama. India occupied the second place in terms of production and acreage under saffron next to Iran. However in terms of quality India ranked second next to Spain among the top seven saffron producing countries of the world. But this once flourishing sector of the J&K economy, for which Kashmir Valley was famous worldwide, has faced a significant threat of extinction. Consequently, because of its economic and cultural importance, it was declared “Globally Important Agricultural Heritage System” (GIAHS) by the "Food and Agricultural Organization” (FAO). To revive this ancient farming activity, the “National Saffron Mission” (NSM) got implemented in the year 2009-10 spanning over a period of five years during which new

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We are obliged to the farmers of district Pulwama engaged in saffron cultivation for their co-operation in generating the requisite data and feedback given by them regarding the extension agencies.

technology and improved farm management practices were introduced across more than ten thousand saffron growing households in the valley of Kashmir.

According to the data compiled from the unpublished official records of the Financial Commissioner Revenue (J&K Government), area, production and saffron yield in Kashmir division (Pulwama, Budgam, and Srinagar) during 1999 was 3997 hectares, 75.51 quintals, and 1.89 kg per hectare respectively. Since the launch of NSM in 2009, these figures had declined sharply to 2681 hectares, 40.47 quintals, and 1.51 kg respectively. However, up to the year 2013 saffron sector witnessed a continuous recovery in all these areas due to the efforts made under the NSM. The area under saffron expanded by about 20 per cent to 3230 hectares, while production increased by more than 50 per cent to 84 quintals with a consequent improvement in yield per hectare of 2.60 kg. But this momentum seems to have been lost thereafter. During 2016 although the area under this crop increased to 3591 hectares, production nosedived to 51.33 quintals with a drastic fall in the yield to just 1.42 kg per hectare. Pertinently the district Pulwama, our study area, produces more than 70 per cent of saffron alone from Kashmir Valley. According to these official records, the yield estimated was 1.25 kg per hectare during 2016 for Pulwama, which is close to 1.0 kg per hectare estimate of our field survey carried out for the same area during the same year of 2016.

This paper aims to assess the performance of the saffron farmers in the post-NSM era in the study area. The economic performance of an enterprise is a product of allocative and technical efficiency. However, this study is restricted to the measurement of technical efficiency. As stated in the literature, technical efficiency refers to a condition under which a farmer/firm can produce the maximum possible output from a given level of inputs and technology. On the contrary technical inefficiency implies the inability to attain the maximum feasible output from a given a set of inputs and technology (Bravo-Ureta and Pinheiro, 1993). The factors that play a part in determining the efficiency of a producing unit are related to the socio-economic and demographic profile of the households including various farm characteristics. Thus capturing the impact of these attributes on efficiency can go a long way in devising the policies to raise the farm output without any additional costs. The literature on productivity and efficiency analysis point to the fact that if the decision making units are not reasonably efficient in making the best use of technology, then eliminating inefficiencies would be more cost saving than spending resources on upgrading the technology. From this standpoint technical efficiency assessment of the saffron growing farmers in Kashmir Valley would contribute to the existing body of literature, because to the best of our knowledge no such study has been carried out so far. For this reason, wherever necessary, the results of this study would be compared with other studies related to efficiency analysis in agriculture in general and not specifically to the saffron crop.

This study uses cross-section data collected from 390 respondents pertaining to the agricultural year 2016. However, given the perennial nature of the saffron crop, it would have been better to generate data related to the whole crop cycle. This limitation was imposed on account of the memory-based nature of information drawn from the farmers owing to their non-maintenance of book-keeping accounts regarding input usage on their multiple patches of land operating at different stages of crop cycle.

The rest of this paper is organised as follows. Section II discusses the analytical framework describing the stochastic frontier model. Section III gives an account of the methodology used. Interpretation of empirical results is carried out in Section IV. Conclusions with some policy suggestions are presented in Section V.

II

ANALYTICAL FRAMEWORK

The framework of this study is based on the independent works carried out in estimating technical efficiency using cross-section data by Aigner*et al*. (1977) and Meeusen and van den Broeck (1977). They proposed a stochastic frontier production with a composite error term. The principal advantage of this method is that it accounts for the deviations of actual output from the frontier output (technical inefficiency) solely due to the factors under the control of a decision-making unit from those outside its control. This feature makes it more relevant from the policy viewpoint as against the deterministic approach like Data Envelopment Analysis (DEA) in which technical inefficiency is the joint product of both the factors acting simultaneously. The specified model is given below:

$$y_i = f(x_{i,}\beta)\exp(v_i - u_i) \qquad \text{....(1)}$$

where, y_i is the output of the i-th sample farm (i = 1,2,3.........n); x_i is a vector of inputs; β is a vector of unknown parameters to be estimated; $f(x_i, \beta)$ is the stochastic frontier function (e.g., Cobb–Douglas, transcendental-logarithmic form); v_i -u_i is the composite error term in which v_i is the two-sided noise component, and u_i is the one-sided non-negative technical inefficiency component; v_i is assumed to be symmetric random error term distributed independently and identically with zero mean and variance σ^2_v [$N(0, \sigma^2_v)$]and independent of u_i ; and u_i is the one-sided non-negative technical inefficiency component of error term distributed independently and identically and is obtained by truncation (at zero) of the normal distribution [$N(0, \sigma^2_u)$], i.e., half-normal distribution or can be assumed to follow exponential, truncated and gamma distributions (Battese and Coelli, 1995; Coelli *et al*., 2005).The term v_i in the above equation captures the variations in output due to factors beyond the farmer's control like vagaries of weather, disease outbreak, luck, measurement errors, etc. Following Battese and Coelli (1995) and using equation (1) above, the technical efficiency (T.E.) is derived as:

$$TE_i = \exp(-u_i) \quad \text{....(2)}$$

whereas u_i can be expressed as:

$$u_i = z_i\delta + w_i \quad \text{....(3)}$$

where, z_i is a vector of farm/farmer-specific variables associated with technical inefficiency, and δ is a vector of unknown parameters to be estimated; w_i are random variables defined by the truncation of the normal distribution with zero mean and variance σ^2_u. The FRONTIER 4.1 computer program, written by Tim Coelli, was used to provide the maximum likelihood estimates (MLE) of the parameters of the model defined by the equations (1) and (3). The variance parameters generated can be expressed as:

$$\sigma^2 = (\sigma_u^2 + \sigma_v^2) \quad \text{....(4)}$$

and,

$$\gamma = (\sigma_u^2/\sigma_u^2 + \sigma_v^2) = (\sigma_u^2/\sigma^2); 0 \leq \gamma \leq 1 \quad \text{....(5)}$$

In equation (4), the first variance parameter sigma-squared (σ^2) provides an indication of technical inefficiency present in the model only if its value is significantlygreater than zero. The second variance parameter gamma (γ), defined by equation (5), ranges in value between zero and one and explains the percentage of variation of actual output from potential (frontier) output due to technical inefficiency. If γ is not statistically significant from 0, it implies no technical inefficiency effects, and the model reduces to the conventional OLS model (Battese and Coelli, 1995).

III

METHODOLOGY

Study Area and Sampling Procedure

The present study was undertaken in saffron growing areas of district Pulwama of Kashmir Valley. According to the unpublished official records of the Financial Commissioner Revenue (Government of Jammu and Kashmir), the land under this crop in the study area is stretched over 3079 hectares producing 3.86 MT of saffron - constituting 83.49 per cent of the total area and 73.24 per cent of saffron production in Kashmir Valley. Under the NSM scheme, saffron growing areas of district Pulwama have been divided into 17 circles covering 49 villages. For the current study, only 13 circles were selected for data collection. Four circles, namely

Namlabal, Kadlabal, Zantrag, and Khrew, were excluded because of widespread damage caused to the crop either due to the massive floods during the year 2014 or due to the presence of cement factories in some areas. Following a purposive and carefully designed random snowball technique, a sample of 390 farmers was generated by selecting 30 households from each village comprising 315 marginal (less than 1 hectare), 58 small (1-2 hectares), and 17 semi-medium/medium farms (2-5 hectares). The selection of the village was made on the basis of its relative importance and share of land devoted to saffron farming. The survey was conducted during 2017, and the data pertaining to the agricultural year 2016 was obtained through a personal interview method by administering a well structured and pre-tested open-end questionnaire. The year 2016 was, by and large, a normal agricultural year.

Model Specification

The Cobb-Douglas production function has been used to specify stochastic frontier production function, wherein technical inefficiency component $u_i$is assumed to follow half-normal distribution.

$$\ln y_i = \beta_0 + \sum_{k=1}^{6} \beta \ln x_{ki} + (v_i - u_i) \quad \text{....(6)}$$

$$lny = \beta_0 + \beta_1 lnx_1 + \beta_2 lnx_2 + \beta_3 lnx_3 + \beta_4 lnx_4 + \beta_5 lnx_5 + \beta_6 lnx_6 + (v_i - u_i) \quad \text{....(7)}$$

where, y= saffron produced per household (kg) ; x_1= land allocated to saffron in (hectares); x_2= corms planted by a given household in (quintals); x_3= human labour used by a given household (person days); x_4= chemical fertiliser (N+P+K) used per household (kg); x_5=expenditure per household on plant protection measures (rupees); x_6 = farmyard manure (FYM)used per household (kg); v_i = random error term; u_i= one sided inefficiency component; $\beta_{0 \ldots\ldots}$ β_6 = parameters to be estimated.

The efficiency estimates obtained from Cobb- Douglas frontier defined by equation (7) above are regressed with socio-economic and farm characteristics. Since the range of technical efficiency variable is bounded between 0 and 1, it was transformed into log [TE/1-TE], so that the transformed variable ranges between $-\infty$and $+ \infty$, to facilitate the estimation of parameters (Shanmugam and Venkataramani, 2006; Bhende and Kalirajan, 2007). The linear model for each farmer is estimated, as shown below:

$$ln[TE_i/1 - TE_i] = \delta_0 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \delta_4 z_4 + \delta_5 z_5 + \delta_6 z_6 + \delta_7 z_7 + \delta_8 z_8 + \delta_9 z_9 + \delta_{10} z_{10} + \delta_{11} z_{11} + \delta_{12} z_{12} \quad \text{....(8)}$$

where z_1 is the age of the household head farmer, z_2 age-squared, z_3 education of the household head farmer (years of schooling), z_4 number of farm workers in the family, z_5 location of the farm, z_6 corm size, z_7 hired labour used as a proportion of the total labor, z_8 saffron land as a proportion of total land, z_9 level of fragmentation, z_{10} represents total operational landholdings including saffron land, z_{11} is a dummy for extension contacts (1= Yes, 0 = No), z_{12} is a dummy for access to credit (1= credit availed, 0 = otherwise).

Further to study the impact of socio-economic factors on efficiency, each factor was divided into different groups. The means of these groups were compared, and the analysis of variance was carried out to know whether the difference across the groups was significant.

IV

RESULTS AND DISCUSSION

Sample Characteristics

Descriptive statistics of the sample properties regarding the conventional and non-conventional inputs are presented in Table 1. However, there are some major observations to be made. On an average, a household produces 0.601 kg of saffron from 0.60 hectares of land, amounting to per hectare production of 1.0 kg.

TABLE 1. DESCRIPTIVE STATISTICS

Variables (1)	Unit (2)	Mean (3)	Std. Dev. (4)
Saffron yield	kg/farm	0.601	0.72
Saffron yield	kg/ha	1.00	0.56
Saffron landholding	ha	0.600	0.66
Saffron corm	quintal/farm	21.28	24.53
Human labour	man-day/farm	75.74	88.73
Chemical fertiliser	kg/farm	89.02	120.49
Plant protection	INR*/farm	123.18	113.85
Farmyard manure	kg/farm	1003.32	12.31
Age	Year	52.93	11.99
Education	Year	5.88	5.58
Family farm workers	Number	2.86	1.75
Location	Km	0.93	0.47
Corm size	Gm	21.68	9.20
Proportion of hired labour	per cent	0.56	0.15
Proportion of saffron land	per cent	0.57	0.24
Fragmentation level	Number	4.96	3.74
Total operational land	Ha	1.10	1.25
Extension contacts (1=yes; 0 = no)	dummy	0.52	0.50
Access to credit (1=Yes; 0= No)	Dummy	0.21	0.41

Source: Field survey data, 2016. *Stands for Indian Rupee.

It may be noted that saffron farming in the entire valley is rainfed without any irrigation facilities. For this reason the use of irrigation has not been reported in this study, which otherwise is a crucial input in any agricultural operation. The use of bullock power or machine labour is also not reported as the very use of it could damage the crop. An examination of non-conventional inputs reveals that this activity is dominated by relatively old aged farmers having a mean age of 53 years and 6 years of formal education. The proportionate area of saffron land to the extent of 57 per cent, out of total landholdings, indicates the relative importance and commercial significance of this crop in the designated area.

Hypotheses Testing

Using the generalised likelihood ratio test statistic (LR test), a few null hypotheses - concerning the functional form of the model, technical inefficiency, and distribution of error term - were tested. The results are presented in Table 2.

TABLE 2. GENERALISED LOG-LIKELIHOOD TEST

Hypotheses (1)	LR-statistics (λ) (2)	D.F. (3)	Critical Value (α=0.05) $\chi^2_{0.95}$ (4)	Decision (5)
1. $H_0: \gamma = 0$	37.29	1	2.71	Reject:H_0
2. $H_0: \mu = 0$	0.68	1	2.71	Accept:H_0
3. $H_0: \beta_7 = \beta_8 = \ldots = \beta_{27} = 0$	42.80	21	32.671	Reject:H_0
4. $H_0: \beta_7 = \beta_8 = \ldots = \beta_{12} = 0$	15.60	6	12.592	Reject: H_0
5. $H_0: \beta_{13} = \beta_{14} = \ldots = \beta_{27} = 0$	20.42	15	24.996	Accept: H_0

Source: Authors' calculations based on Frontier 4.1 output files.

Note: In the case of the null hypotheses involving the restriction of γ=0 and μ = 0, the critical values are obtained from Kodde and Palm (1986).

(1) Technical inefficiency effects are not stochastic (H_0: γ = 0). (2) Technical inefficiency effects follow a half normal distribution (H_0:μ = 0). (3) Interaction and square terms are equal to zero ($H_0: \beta_7 = \beta_8 = \ldots = \beta_{27} = 0$). (4) Square terms are equal to zero ($H_0: \beta_7 = \beta_8 = \ldots = \beta_{12} = 0$). (5) Interaction terms are equal to zero ($H_0: \beta_{13} = \beta_{14} = \ldots = \beta_{27} = 0$).

The first null hypothesis that technical inefficiency effects are not stochastic is strongly rejected, implying the existence of a one-sided error term, which is also estimated by the Frontier 4.1 and is reported as LR test of one-sided error (Table 3). Accordingly, the Cobb-Douglas OLS model or the average response function cannot be considered an adequate representation of the data.[1] Alternatively, the appropriateness of the stochastic frontier model can also be judged from the fact that the value of the variance parameter γ is reported as 0.914 significant at 1 per cent level (Table 3). The second hypothesis that one-sided error term follows a half-normal distribution is accepted. In other words, it implies that the error term does not follow a truncated normal distribution.

TABLE 3. ESTIMATES OF STOCHASTIC AND OLS PRODUCTION FUNCTION

Variables	ML Estimates Coefficient	t-ratio	OLS Estimates Coefficient	t-ratio
(1)	(2)	(3)	(4)	(5)
Intercept	-0.977*	-1.842	-2.391***	-3.750
Saffron landholding	0.538***	4.149	0.338**	2.144
Saffron corm	0.265**	2.775	0.372***	3.184
Human Labour	0.067	0.800	0.192*	1.984
Chemical Fertilisers	-0.020	-0.521	-0.060	-1.372
Plant protection	0.018	1.188	0.009	0.518
Farmyard manure	0.037***	4.632	0.046***	5.000
log-likelihood function	-286.580		305.228	
σ^2	0.667***	10.069		
γ	0.914***	37.834		
LR test of the one-sided error	37.296			

Source: Frontier 4.1 output file based on field survey data, 2016.
*, **, *** indicate significance levels at 10, 5 and 1 per cent respectively.

Hypotheses 3-5 are related to the functional form of the stochastic production frontier. Here, we test the superiority of a more flexible translog production function over the Cobb-Douglas production function's restrictive nature. On applying the conventional LR test, it was found that all the square and interaction terms are significantly different from zero. However, we found that some of the coefficients generated from the translog production function did not conform to *a priori* expectations in terms of their signs. This necessitated us to conduct a separate test for the square and interaction terms. The LR test suggested that the null hypothesis stating that square terms are not significantly different from zero is rejected, while as the null hypothesis that interaction terms are not significantly different from zero stands accepted.

For analytical purpose, we, therefore, decided to make use of the Cobb-Douglas production function frontier estimates as all the coefficients generated from it had expected signs. However, as stated in the literature, the functional form has little effect on the empirical estimation of efficiency (Ahmad and Bravo-Ureta,1996; Bravo-Ureta and Pinheiro,1997). Furthermore, flexibility advantage of the translog function may actually be counteracted due to the problem of multicollinearity among the regressors resulting in inaccurate and statistically insignificant parameter estimates (Kumbhakar and Lovell, 2003; Coelli *et al*., 2005).[2] The decision to choose the Cobb-Douglas specification in the present case has also received some motivation from other studies facing similar situations like Dey *et al*.(2005).

Estimates of Average and Frontier Production Functions

OLS and ML results of equation (7) are presented in Table 3. The higher MLE intercept in relation to the OLS intercept is a clear indication of higher frontier output. The intercept value improved from -2.391 in OLS to -0.977 in MLE, and so we can infer that this is due to Hicksian neutral shift in the technical progress (Shanmugam, 2003; Shanmugam and Venkataramani, 2006; Bhende and Kalirajan, 2007; Prachitha and Shanmugam, 2012). The value of variance parameter gamma is equal to 0.914 and significant at 1 per cent, which implies that variations in the output among the sampled farmers are dominated by the factors well under the farmers' control. This also means that these factors are capable of explaining the variation of observed output from the frontier output to the extent of 91 per cent, and only about 9 per cent variations from the frontier output are due to random shocks outside their control. This result is consistent with other studies like Kachroo *et al*. (2010) and Sharma *et al. (*2016) relating to maize cultivation in Jammu and Kashmir agricultural sector. The significant values of sigma-squared and gamma are an indication of the goodness of fit with the Cobb-Douglas stochastic frontier model and the correctness of the half-normal distribution assumption of the error term for the current data set (Bhende and Kalirajan, 2007).

The significant values of the land, saffron corm and farmyard manure (FYM) in the frontier production function may be interpreted as the increasing role of these inputs in determining the efficiency of farms. The elasticities of fertiliser (-) and plant protection measures (+) were not significant in both OLS and MLE models suggesting that these variables did not have a significant impact on average or frontier levels of saffron production. While the output is positively responsive to the human effort in the average function at 10 per cent significance level, but the role of this variable becomes insignificant in the frontier model.

Distribution of Technical Efficiency

The distribution of farms based on technical efficiency is presented in Table 4. The sampled farms' technical efficiency ranged between 14 per cent and 93 per cent, with an average value of 59 per cent. This means that with the judicious use of existing resources and technology, it is possible to increase saffron production by more than 40 per cent. The analysis also reveals that in about little less than half of the sampled farms (46.15 per cent), technical efficiency values were below 60 per cent. As such, these farms could reduce their input resources by 40 per cent to produce the same output level through the better practice of technology. These results are more or less similar to the results of Bhatt and Bhat (2014), who reported 48 per cent farm level technical efficiency for the farmers of district Pulwama in Kashmir Valley.

TABLE 4. DISTRIBUTION OF TECHNICAL EFFICIENCY SCORES

T.E. (per cent) (1)	Number of farms (2)	Percentage (3)	Cumulative per cent (4)
Less than 20	09	2.31	2.31
20 - 40	77	19.74	22.05
40 – 60	94	24.10	46.15
60 – 80	155	39.74	85.89
80 and above	55	14.10	100
Total	390	100	
Average	0.59		
Maximum	0.93		
Minimum	0.14		
Average	< 1ha = 0.60	1-2ha = 0.59	2-4ha = 0.47

Source: Computed from Frontier 4.1 output file based on field survey data, 2016.

Furthermore, the farm category-wise distribution of efficiency scores reveals that technical efficiency decreases with the increase in saffron farm size. Although the difference in efficiency levels between marginal and small farms is trivial, it declines by a considerable margin in semi-medium farms (Table 4). This result is different from the findings of Bhatt and Bhat (2014). They reported that technical efficiency in the Jammu and Kashmir agriculture sector initially decreased but eventually increased with the increase in farm size.

Determinants of Technical Efficiency

The regression results of various farm/farmer specific factors and technical efficiency and the influence of these factors on technical efficiency are presented in Tables 5 and 6, respectively.

TABLE 5. DETERMINANTS OF TECHNICAL EFFICIENCY

Variable (1)	Coefficient (2)	S. Error (3)	t Stat (4)
Intercept	-1.6920*	0.7862	-2.1521
Age	0.0618*	0.0293	2.1123
Age-square	-0.0005*	0.0003	-1.7870
Education	0.0424***	0.0090	4.6927
Family farm workers	0.0716**	0.0289	2.4796
Location	0.1065	0.0989	1.0766
Corm size	-0.0108*	0.0050	-2.1601
Proportion of hired labour	0.4950*	0.3263	1.5170
Proportion of saffron land	-0.7895***	0.2054	-3.8444
Fragmentation level	0.0231	0.0156	1.4781
Total operational land	-0.0309	0.0444	-0.6965
Extension contacts (1=Yes; 0 = No)	0.2687***	0.0903	2.9763
Access to credit (1=Yes; 0= No)	-0.2852**	0.1134	-2.5149

Source: Authors' calculations using Frontier 4.1 output file based on field survey data, 2016.
*, **, *** denote significance levels at 10, 5, and 1 per cent respectively.

Age

The age deemed a proxy variable for experience has a positive relationship with a farmer's technical efficiency, as explained by the regression coefficient significant at 5 percent. Further examination of this relationship revealed an inverted U-shaped pattern leveling off at the age of 50-60 years. Thereafter, efficiency actually declines with a further increase in the age. This variation in technical efficiency across the various age groups was significant at 1 per cent level. This is an indication of diminishing returns to human capital and is well supported by the negative coefficient of age-square variable significant at 10 per cent level. This result is similar to the findings of Tzouvelekas *et al*. (1997); Pantzios *et al*. (2002); Reddy and Sen (2004); Sharma *et al*. (2016); Ullah *et al.* (2019).

TABLE 6. INFLUENCE OF SOCIO-ECONOMIC FACTORS

(1)	(2)	(3)	(4)	(5)	(6)
Age	Count	T.E.	Per cent of Saffron land	Count	T.E.
< 40 years	53	0.54	< 33 per cent	57	0.61
40-50	93	0.54	33 – 66	182	0.62
50-60	99	0.68	66 & above	151	0.55
60 & above	145	0.59	Total	390	
Total	390		F = 5.73	P-value = 0.00	F crit = 3.02
F = 10.23	P-value = 0.00	F crit = 2.63	Per cent of Hired Labour	Count	T.E.
Education	Count	T.E.	< 40 per cent	45	0.54
Non-Literate	169	0.56	40 – 60	180	0.59
< 10 years	73	0.60	60 and above	165	0.61
10 – 12	77	0.61	Total	390	
12 – 14	34	0.63	F = 2.26	P-value = 0.11	F crit = 3.02
			Fragmentation		
12 & above	37	0.68	< 4 plots	165	0.60
Total	390		4 - 7	128	0.58
F =3.46	P-value = 0.00	F crit= 2.39	7 & above	97	0.60
Farmworkers	Count	T.E.	Total	390	
< 2 adults	87	0.57	F = 0.263	P-value = 0.77	F crit = 3.02
2 – 4	193	0.59	Total Op. Land	Count	T.E.
4 – 6	81	0.60	< 1 ha	222.00	0.60
6 & Above	29	0.66	1-2 ha	108.00	0.58
Total	390		2-4 ha	50.00	0.58
F = 1.72	P-value = 0.16	F crit = 2.63	4-10 ha	10.00	0.75
Location	Count	T.E.	Total	390	
< 1 km	237	0.58	F = 2.29	P-value=0.08	F. crit =2.63
1 – 2	140	0.60	Extension Contact	Count	T.E.
2 & above	13	0.70	1= Yes	202	0.62
Total	390		0= No	188	0.56
F = 2.17	P-value = 0.12	F crit = 3.02	Total	390	
Corm Size	Count	T.E.	F = 10.14	P value = 0.00	F crit = 3.87
< 20 gm.	118	0.63	Access to credit	Count	T.E.
20 – 30	153	0.58	1= Yes	82	0.57
30 & above	119	0.57	0= No	308	0.60
Total	390		Total	390	
F = 3.56	P-value = 0.03	F crit = 3.02	F = 1.44	P-value = 0.23	F crit = 3.87

Source: Authors' calculations using Frontier 4.1 output file based on field survey data, 2016.

Education

The household head's education measured in terms of years of schooling exhibits a positive and highly significant relationship with technical efficiency. This finding is in conformity with the results of other studies like Kumar *et al*.(2004); Reddy and Sen (2004); Dey *et al.* (2005*);* Sharma *et al*. (2016); Pradhan and Mukherjee (2018); Ullah *et al.* (2019). Moreover, this relationship was found significant across the groups with different education levels demonstrating a linear pattern. As documented in Pantzios *et al*. (2002), education acts as a strong complement in deciding the optimal combination of inputs in the production process, lending support to Welch's (1970) hypothesis about the "worker effect".

Location

The farm location calculated as mean distance from the village and the road facility, is positively but insignificantly related to the technical efficiency. This variable exhibited quite a linear relationship with efficiency across the farms with different locations. However, the difference across the groups was also found insignificant. Although faraway located farms are difficult to manage efficiently, technical efficiency is expected to decline due to the proximity of the farms to the roads and dwellings owing to the sensitivity of this crop to pollutants and contaminants emanating from human activities – *anthropogenic effect*.

Corm Size

In terms of its weight, size of the corm at the time of plantation has a fundamental bearing on the saffron production. Since in our sample we found that the farmers using the corms weighed between 8-40 grams, we divided the farmers into three groups, i.e., farmers who used less than 20 grams (118); 20- 30 grams (153); and 30 grams and above (119). In our regression model the corm size variable depicted a negative coefficient with efficiency, significant at 5 per cent level, indicating that as the size of the corm increases, the efficiency decreases correspondingly demonstrating a linear relationship. The variation across the groups was also found significant at 5 per cent level.

Hired Labour as a Proportion of Total Labour

The hired labour (casual) as a percentage of total labour employed, showing the extent of family-operated farms, was found to have a positive but insignificant coefficient close to 10 per cent level when regressed with the efficiency. It was found that as the proportion of the hired labour increased, the technical efficiency also increased showing a distinct and linear pattern. This variation in efficiency across the groups was too close to the significance level of 10 per cent. These results do not lend support to the notion that family-operated farms are more efficient.

Proportionate Area under Saffron Crop

The percentage area under saffron calculated as the area under saffron land in relation to the total operational landholdings shows an inverse association with efficiency highly significant at 1 per cent level. Moreover, the relation is quite strong as demonstrated by the size of the regression coefficient. This result is in contradiction to the notion that a higher proportion of the crop in the overall crop-mix of a farmer must receive a higher level of attention resulting in higher efficiency (Rao *et al*., 1997 and 2003). To study this relationship in detail, the farmers were categorised into three major groups, viz., farmers having percentage of saffron land below 33 per cent, 33 - 66 per cent, 66 per cent and above. Technical efficiency across the groups followed an inverted U-shaped pattern with the variation across the groups significant at 1 per cent level.

Fragmentation Level

The level of fragmentation and technical efficiency seem to move in the same direction, which is against expectation. However, this relationship is not statistically significant. For a more in-depth examination we categorised the sampled farms into three groups: less than 4 plots, between 4-7 plots and 7 and above. Our further investigation revealed that technical efficiency followed a non-linear U-shaped pattern. However, analysis of variance suggested that this variation in technical efficiency was not significant across the groups. This phenomenon requires further investigation. These results are in contradiction to the studies carried out by Tzouvelekas *et al*. (1997); Pantzios *et al*. (2002); Reddy and Sen (2004), who argue that highly fragmented land inhibits the use of improved technologies.

Total Operational Land

Regression analysis indicates a negative but insignificant relation between efficiency and total operational landholdings, including farmer's saffron land. However, after examining the mean efficiency scores of various farmer categories, analysis of variance revealed that the relation was nonlinear and followed a U-shaped pattern, and variation across the groups was significant at 10 per cent level.

Extension Contacts

The impact of extension contacts on the farmers' efficiency level was found positive and significant at 1 per cent level. In about 52 per cent of the sampled farmers, who had some kind of contacts with extension agencies, efficiency was markedly higher at 62 per cent relative to the rest of 48 per cent farmers. Similar results were obtained in a study conducted by Reddy and Sen (2004), albeit statistically insignificant.

Access to Credit

Access to credit as a determinant of technical efficiency has, unexpectedly, shown a negative and significant relationship in our study. Moreover, the relation is quite strong as indicated by the size elasticity of this variable. However, this finding matches with the result of Ali *et al.* (2014). Further examination of this relation revealed that variation between the two groups was not significant. This can happen in an environment where farmers utilise the funds not for the purpose for which they have actually been obtained owing to uncertainty arising due to low returns from saffron cultivation. Under these circumstances, farmers may be diverting the financial resources towards other productive crops. Such a tendency among the farmers is possible because, under the NSM scheme, farmers are incentivised by providing them various inputs free of cost. However, this phenomenon needs further careful investigation in future research.

V

SUMMARY AND CONCLUDING OBSERVATIONS

One of the major findings of this study is the existence of wide variations in technical efficiency across the farms. So there is scope to increase output sufficiently by about 40 per cent without incurring any additional cost if the farmers are trained to make efficient use of the NSM technology. But the pertinent question to ask is: Is this really sufficient given the current productivity level hovering around 1kg/ha in contrast to the world productivity levels ranging in the vicinity of 4–6 kg/ha for countries like Iran and Spain? The revival of this sector cannot be, and should not be, left at the mercy of the farmers and government agencies. A radical shift in the environment is warranted, and as such, this study recommends a model of contract farming between farmer co-operatives and leading agribusiness firms. Based on this modality, vast tracks of saffron land in district Pulwama could be converted into special saffron zones. Apart from that rest of the observations having policy implications are conventional and are given below.

The practice of indiscriminate application of fertilisers without any knowledge of soil chemistry and lack of irrigation facilities has had harmful effects on crop productivity, as evidenced by the negative coefficient of fertiliser variable. The concerned extension agencies must extend the soil testing facility and encourage the farmers to maintain the proper soil health cards. The plant protection measures do not seem to be working effectively as reported by the farmers, and expectedly, in our model, expenditure incurred on this input did not significantly influence the output of saffron. Since the saffron farming is mostly rain-fed activity and is affected by vagaries of weather, it is essential to install drip irrigation facilities; otherwise any biological package provided under the NSM might become counterproductive. The farmers need to be encouraged to use organic fertilisers like farmyard manure and vermin-compost for better yield, as supported by our model's empirical results.

As noted, saffron farming is predominantly in the hands of old aged farmers associated with a very low level of schooling, resulting in a low level of human capital. This makes a case for strong government intervention in terms of framing appropriate policy for human resource development. As such young, educated, and unemployed youth should be motivated to adopt saffron farming as a fulltime enterprise. The role of the extension agencies in maintaining close contacts, training, and educating the farmers on a regular basis, doubling efforts to get the rest of the 50 per cent of farmers under their ambit, is very crucial. Although already banned under the law, the practice of constructing houses and concrete structures on the saffron land needs to be stopped without delay. It was also found that those farmers who had a higher proportion of saffron land were also less efficient. Being so is fraught with profound implications. Farmers might attempt to diversify resources towards more remunerative crops with a comparative advantage. But this process is impeded by legal restrictions acting against any such change of the status. This has given rise to a structural supply-side shock, a major reason behind declining area and production. After all, any policy which acts as a barrier to exit an inefficient system is debatable. It may be successful in retaining a large structure that is inefficient but cannot help build an efficient and vibrant sector, although small.

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NOTES

1. The relevance of the stochastic frontier models in efficiency analysis lies in the existence of one-sided error term. If evidence for one-sided error term is not established or found statistically insignificant, the model reduces to a simple Cobb- Douglas production function (Battese and Coelli, 1995).

2. Despite its restrictive properties, the Cobb-Douglas functional form has widely been used in frontier applications in agriculture. Its coefficients directly represent the elasticities of output and lend easily to econometric estimation (Abedullah *et al*., 2006; Idiong, 2007; Raphael,2008). For more on this, see Battese and Coelli (1995), and the literature review carried out in Battese (1992); Bravo-Ureta and Pinheiro (1993).

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