Estimation of technical efficiency and determinants of technical inefficiency of dairy farmers in Maharashtra

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ABSTRACT

The present study was undertaken in the Maharashtra state. The estimated mean technical efficiency of the farmers was 80.17 per cent. At the state level, feed cost and capital cost were found to be positively significant to the milk production, whereas, labour cost was found to be negatively significant. It was found that about 19.4 per cent of milk producers were less efficient, 25.7 per cent were moderately efficient, 26.3 per cent were medium efficient and 28.6 per cent were highly efficient realizing more than 90 per cent of technical efficiency. The analysis of determinants of technical inefficiency estimates revealed that education, marketed surplus and distance from milk sale place had negative association with technical inefficiency.

Keywords: Technical efficiency; Technical inefficiency; determinants; dairy farmers

INTRODUCTION

Technical efficiency (TE) measurement is the most studied component of productive efficiency because it can help to generate valuable information for policy formulation and farm level decisions focused on the improvement of farm performance. It is very important from a practical and a policy point of view to study farm efficiency and the potential sources of inefficiency (Solís et al 2009). For the farmers, understanding the factors that affect TE is a helpful tool in improving efficiency and performance of dairy farms. From the policy makers viewpoint, knowing the distribution of TE across dairy farms will help to draft specific and well defined dairy policies which would increase technical efficiencies and the competitiveness of dairy farms. Thus dairy farmers from the state of Maharashtra were evaluated in terms of efficiency of milk production using stochastic frontier production method and to find out the determinants of technical inefficiency (TI).

METHODOLOGY

The study was carried out in five regions of Maharashtra state namely Konkan, western Maharashtra, Khandesh, Marathwada and Vidarbha. One dairy progressive district was selected from each region. From each district two blocks and from each block two villages were selected randomly; thus total ten villages were selected for the study. Primary data were collected from 346 households through personal interview method with the help of well-structured, comprehensive and pre-tested interview schedule.

Stochastic frontier production function analysis was done to find out the technical efficiency of dairy farms in the study area. The frontier production function represents a maximum possible output for any given set of inputs setting a limit or frontier on the observed values of the dependent variable in the sense that no observed value of output is expected to lie above the production function. Any deviation of a farm from the frontier indicates the extent of farm's inability to produce maximum output from its given set of inputs and hence represents the degree of TI.

The TE of an individual farm is defined in terms of the ratio of the observed output to the corresponding frontier output given the available technology. The TE of the farmer, given the specification of the model, is defined by:

$$TE_i = Y_i/Y^*_i = E(-U_i)$$

where Y_i = Observed level of output, Y^*_i = Frontier level of output

Thus the technical efficiency of a farmer is between zero and one and is inversely related to the inefficiency model. The maximum likelihood (ML) estimates of the parameters of the stochastic profit frontier were obtained by using the programme Frontier 4.1 (Coelli 1996).

The TE of a dairy farmer was estimated through the stochastic frontier production analysis as under:

$$\ln Y_i = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + V_i - U_i$$

where Y_i = Milk production per household in rupees, X_1 = Value of feed and fodder per household in rupees, X_2 = Capital cost per household in rupees, X_3 = Labour cost per household in rupees, X_4 = Herd size per household, b's = Parameters to be estimated, Subscript i (I = 1, 2,…..N) = i^{th} sample farm

In the literature, capital variable is mostly defined as user cost of capital equipment which includes depreciation, maintenance, insurance and net interest rate costs for machinery, inventory and building (Kumbhakar and Heshimati 1995). The number of dairy cows is a convenient proxy for herd size (Kumbhakar et al 1989). The error term is farm specific and is composed of two independent components, $e_i = V_i + U_i$. The first element, V_i is a random variable reflecting noise and other stochastic shocks which is assumed to be an independent and identically distributed normal random variable with 0 mean and constant variance. The second component, U_i captures technical inefficiency relative to the stochastic frontier. The inefficiency term U_i is non-negative and it is assumed to follow normal distribution with mean μ and variance σ^2 (Kumbhakar and Lovell 2000), where u_i is defined as:

$$U_i = \delta_0 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \delta_4 z_4 + \delta_5 z_5$$

To indicate the possible effects of farmers characteristics on the inefficiency of milk production, the variables, namely age (Z_1), education level (Z_2), family size (Z_3), marketed surplus (Z_4) and distance from milk sale point (Z_5) were included in the model for technical inefficiency measurement. The variables Z_1,…….. Zi_5 were included in the model for the technical inefficiency effects to indicate the possible effects of the farmer specific characteristics on the efficiency of milk production. The b's and δ's are unknown parameters to be estimated together with the other parameters which are expressed in terms of (Coelli and Battese 1996):

$$\sigma_s^2 = \sigma_v^2 + \sigma_u^2 \text{ and } \gamma = \sigma_u^2/\sigma_s^2$$

where the γ parameter lies between zero and one

Maximum likelihood estimation of explicit Cobb-Douglas stochastic frontier function yields consistent estimators for β, λ, σ^2; where β is a vector of unknown parameter, lambda (λ) is the ratio of the standard error of μ (σ_u) to the standard error of ν(σ_u), that is $\lambda = \sigma_u/\sigma_u$ and $\sigma^2 = \sigma_v^2 + \sigma_u^2$. Based on λ, the value of gamma (γ), which measures the effect of TI in the variation of observed output can be derived as $\gamma = \lambda^2/[1+\lambda^2]$. The value of gamma is bounded between 0 and 1 like TE. A gamma (γ) value which is zero or close indicates that sampled milk producers had no TI. However, a value that is close to one, indicates that variation in observed output is due to the TE of the sampled milk producers rather than uncontrollable factors.

Variables determining technical inefficiency

Age: Age of the farmer was used as proxy for farming experience, because i) generally young farmers are believed to be more efficient than old farmers. The old farmers are likely to be more conservative in adopting the new techniques and practices in dairying, thereby, having more inefficiency and vice versa; ii) farmers having more experience are expected to be more efficient as they possess more experience in managing their enterprises and they are expected to be better crisis managers.

Education: Level of education of the head of the household was considered as the determinant of TI. The farmer who possessesed more formal years of education was expected to be more efficient as he/ she tended to be more open to the new methods and technologies and more innovative as compared to others.

Herd size: The number of dairy cows is a convenient proxy for herd size (Kumbhakar et al 1989). A farmer possessing a larger herd size is hypothesized to be more efficient (provided that he/she possesses adequate resources to manage it).

Family size: It was the proxy for labour force.

Marketed surplus: It is the share of marketed output in total output as a proxy for farm commercialization. This suggests that those farms that had a stronger subsistence character were more efficient. Regarding the share of marketed output, the common expectation was that farmers more integrated in downstream markets were more efficient as this enabled them to acquire knowledge and information and to obtain the cash necessary for investing in high quality inputs. In contrast, subsistence farmers might be more efficient than commercialized farmers by better and more rational use of their limited available resources.

Distance from milk sale place: It was used to capture the impact of farmers access to output markets and infrastructure.

RESULTS and DISCUSSION

The data given in Table 1 show the TE of dairy farmers in Maharashtra. The variance ratio (γ) for the estimated frontier function was 93 for the state. From this value it could be inferred that the farm specific variability contributed to 93 per cent towards the variation in milk yield among the dairy households, which means that the difference between observed and the maximum production frontier was due to difference in farmers' level of TE by adopting different management practices. These factors were under the control of the farm, the influence of which could be reduced to enhance TE of dairy farmers in the study area. The parameter estimates for feed cost and capital investment was found positive and statistically significant at 1 and 5 per cent respectively while labour cost was found to be negative and statistically significant at 1 per cent level of significance. This implies that 1 per cent increase in feed cost and capital investment would increase milk production by 0.53 and 0.27 per cent respectively.

The coefficient for labour cost was with negative sign indicating indirect relationship of this variable with milk production. This implies that 1 per cent increase in this variable would lead to 0.52 per cent decrease in milk production. The parameter estimate for miscellaneous cost and herd size turned out to be statistically insignificant, which might be due to low availability of this input. If the estimated coefficient of the input was positive and significant, it implied that increase in input significantly increase TE of milk production which indirectly indicated that the input was underutilized. In the same fashion if the estimated coefficient of the input was negative and significant, it implied that further increase in input decreased TE of milk production which indirectly shows that the input was either at its optimal level or exceeding the optimal level meaning, thereby, over-utilized.

Frequency distribution of technical efficiency of dairy farmers

The farmer specific technical efficiencies were estimated and the frequency distribution is presented in Table 2. The mean technical efficiency of the state was 80.17 per cent. This suggests that on an average the farmers in all the regions operated 80 per cent below their respective mean level efficiency. Further, it was observed that just 19.4 per cent of milk

Table 1. Maximum likelihood estimates for parameters of the stochastic frontier

Variable	Coefficient	t-value
Constant	0.41**	3.37
Feed cost	0.53**	6.14
Capital investment	0.27*	2.20
Labour cost	–0.52**	6.50
Miscellaneous cost	0.16	–0.03
Herd size	–0.02	–1.05

*Significant at 5% LoS, **Significant at 1% LoS

Table 2. Technical efficiency scores of the sampled milk producers (n = 346)

Per cent efficiency level	Households		
	Number	Percentage	
<70 (least efficient)	67	19.4	-
70-80 (moderately efficient)	89	25.7	-
80-90 (medium efficient)	91	26.3	-
90-100 (highly efficient)	99	28.6	-
Minimum	–	–	39.23
Maximum	–	–	95.26
Mean	–	–	80.17
SD	–	–	13.02

Table 3. Maximum likelihood estimates for parameters of the inefficiency model (n = 346)

Parameter	Likelihood estimate		
Constant	1.01**	6.95	-
Age	–0.03	–2.68	-
Education	–0.06*	2.66	-
Family Size	0.01	0.95	-
Marketed Surplus	0.01**	–6.90	-
Distance from place of milk sale	0.01**	2.90	-
$\sigma^2 = \sigma^2_v + \sigma^2_v$	0.05**	4.96	-
$\gamma = \sigma^2_u/\sigma^2$	0.95**	8.13	-
Log livelihood function	-	-	158.9
LR test	-	-	140.7
Mean efficiency	-	-	80.16

producers had TE below 70 per cent, 25.7 per cent farmers between 70-80 per cent, 26.3 per cent between 80 to 90 per cent and 28.6 per cent farmers had more than 90 per cent.

The heterogeneity in management and production practices employed by these farmers may explain the distribution of TE. The failure of most of the farmers to maximize output while operating in the rational region of production might be due to their failure to adopt appropriate management practices.

Determinants of technical efficiency

It was important to identify the factors which influenced the TE of the dairy farmers to further intervene and increase milk production in the study area. A number of studies have suggested that the TE of farmers is determined by various socio-economic and demographic factors (Kalirajan and Shand 1989, Bravo-Ureta and Rieger 1991) and farm inputs (Manoharan et al 2004, Saha and Jain 2004, Wubeheh and Ehui 2006, Reddy et al 2008).

Table 3 depicts that 1 per cent increase in education would lead to decline in technical inefficiency by 0.06 per cent. Education improves the skill and entrepreneurial ability of the farmers to organize inputs for the maximum efficiency. The coefficient of education turned out to be negative and statistically significant, which reflected that inefficiency tended to decline with the increased years of formal education, as the educated farmers are more innovative and receptive of new technology like crossbreeds etc (Mor and Sharma 2012). Schooling has been shown to provide substantial externality benefits by increasing farm output and shifting the production frontier outwards (Weir and Knight 2005). The present results are in accordance with the findings of Reddy et al (2008) and Nganga et al (2010) who reported that farmers with higher level of education were technically more efficient in producing milk. It was observed that 1 per cent increase in marketed surplus and distance from milk sale point increased TI by 0.01 per cent by both the variables.

CONCLUSION

The picture of Maharashtra state as a whole revealed that the parameter estimates for feed cost and capital investment were found to be positive and statistically significant at 1 and 5 per cent respectively while for labour cost was found to be negative and statistically significant at 1 per cent level of significance. The parameter estimates for miscellaneous cost and herd size turned out to be statistically insignificant. Further, taking Maharashtra state as a whole, it was observed that just 19.4 per cent of milk producers were less efficient, 25.7 per cent were moderately efficient, 26.3 per cent were medium efficient and about 28.6 per cent were highly efficient realizing more than 90 per cent of technical efficiency. The heterogeneity in management and production practices employed by these farmers may explain the distribution of TE. The failure of most of the farmers to maximize output while operating in the rational region of production may be due to their failure to adopt appropriate management practices.

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