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RESEARCH ARTICLE

The Effect of Adoption of Better Farm Management Practices in the Technical Efficiency of Dairy Farms in Punjab, Pakistan

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ABSTRACT

Pakistan dairy sector is moving toward modern technological adoptions. These adoptions will significantly affect farm efficiency, profitability and long-term sustainability of dairy sector. Realizing the significance of the sector in terms of contribution to GDP, employment and importance to serve as a vehicle to alleviate poverty especially among the rural population, government also paying due attention to this sector. The goal of this study was to examine the impact of better farm management practices in the efficiency of dairy farms. For this purpose, a stochastic production function and a technical inefficiency model was used. Data collected randomly by a field survey in the selected region, district Toba Tek Singh and Jhang. The results show that technical efficiency is positively related to the better management practices in the sample area. The average technical efficiency of Better Management Practices (BMPs) dairy farms was estimated about 95.27 percent while it was 87.68 percent in the case of traditional practices dairy farms. The value of γ is significantly different from one which shows that random error is playing a significant role to explain the variation in dairy production.

INTRODUCTION

The dairy sector in Pakistan has gone through a gradual transformation from rural subsistence small holdings production system into rural market oriented and peri-urban commercial dairy production system. Rapid urbanization trend coupled with increased per capita income resulted in significant increase in the demand for milk and its by-products in the urban areas. The projected rapid economic development in the future is expected to exert more pressure on dairy sector to increase its output, thus commercial dairy production and processing activities are expected to expand in the country (Afzal, 2007).

Pakistan Dairy Development Company (PDDC) is established in 2005 it is a Public-Private sector joint initiative to bring about structural long term changes in the dairy industry of Pakistan. Along with other objectives, one of its main objective is to increase the profitability of dairying sector. PDDC has started a Model Farming Programme (MFP) in dairy farming sector. Under this programme PDDC provides technical assistance to the existing dairy farmers and they introduced better management practices (BMP) in dairying sector of Pakistan[1]. PDDC is claiming that its recently introduced strategy of best management practices has significantly increased the profitability of the dairying sector. The main emphasis of the study is to investigate that either these practices are achieving their goals and are in a position to bring about the desired changes in dairy farming sector. Hence, it is important to evaluate the contribution of BMP introduced by PDDC to improve the productivity of different inputs in dairy farming sector and impact of these changes on technical efficiency. None of the study has estimated these impacts which are required to determine the future direction of sector specific

[1]Better Management Practices are animal identification for record keeping, free water supply, fencing for free animal movements, mastitis control, shed cooling and feed preparation at farm.

investment. Studying farm efficiency and the potential sources of inefficiency are important from a practical as well as from a policy point of view. On one hand, farmers could use this information to improve their performance and on the other hand, policymakers could use this knowledge to identify and target public interventions to improve farm productivity and farm income (Solis *et al*., 2009)

The existing literature can be divided into two groups. The first group estimates technical efficiency (**TE**) among dairy farms by employing production function and using either a non-parametric method (Charnes *et al*., 2000) or an econometric approach (Kumbhakar and Lovell, 2000). The studies employ non-parametric approach include: Jaforullah and Whiteman (1999) examine the relationship between farm size and technical efficiency; and, Stokes *et al*., (2007) calculate the efficiency of a small group of Pennsylvania dairy farms. The studies using econometric approach include Ahmad and Bravo-Ureta, (1996); and Cuesta, (2000) evaluate the evolution of TE in panel data; and Alvarez *et al*., (2005) compute TE levels using genetic indices as an additional input. However, second group of studies is analyzing the sources of inefficiencies. Among this group, Tauer (2001) and Tauer and Mishra (2006) evaluate the efficiency and competitiveness of small scale dairy farms; and Cabrera *et al*., (2010) study the effect of traditional practices in the efficiency of dairy farms in Wisconsin.

In addition, in case of Pakistan Burki and Khan (2011) show that the technical inefficiency of the smallholder dairy producers is significantly reduced when they formally participate in a milk supply chain. They also detected the strong impact of supply chain in reducing technical inefficiency of farms that are located in remote areas and on those that have larger herd size. Sadaf and Riaz (2012) show that access to modern marketing channels improve efficiency of dairy enterprises. Further, they find that efficiency is positively affected by the size of dairy operations, and negatively by the size of operational land area. Moreover, dairy enterprises with smaller herds tend to operate at a suboptimal scale, possibly due to credit and/or land constraints.Our study aims in investigating the impact of changing practices in dairy farming system on productivity and technical efficiency in mixed cropping zone in Punjab, Pakistan. The paper is organized as follows: Section 2 presents the empirical framework; Section 3 discusses the empirical results; while Section 4 presents conclusions.

MATERIALS AND METHODS

Empirical methodology

Conceptual framework

This study is employing a stochastic production frontier approach introduced by Aigner *et al.* (1977). Following their specification, the stochastic production frontier can be written as:

$$y_i = F\left(x_i, \beta\right)e^{\varepsilon_i} \qquad i = 1,2,............N \qquad (1)$$

Where, y_i is output for the *i*-th farm, x_i is a vector of k inputs, β is a vector of k unknown parameters, ε_i is an error term. The stochastic frontier is also called "composed error" model, because it postulates that the error term ε_i is decomposed into two components: a stochastic random error component and a technical inefficiency component as follow,

$$\varepsilon_i = v_i - u_i \qquad (2)$$

where, v_i is a symmetrical two sided normally distributed random error that captures the stochastic effects outside the farmer's control (e.g. weather, natural disaster, and luck), measurement errors, and other statistical noise. It is assumed to be independently and identically distributed $N\left(0, \sigma_v^2\right)$. Thus, v_i allows the frontier to vary across farms, or over time for the same farm, and therefore the frontier is stochastic. The term u_i is one sided ($u_i \geq 0$) efficiency component that captures the technical efficiency of the *i*-th farmer. The variance parameters of the model are parameterized as:

$$\sigma_s^2 = \sigma_v^2 + \sigma_u^2 \; ; \quad \gamma = \frac{\sigma_u^2}{\sigma_s^2} \quad and \quad 0 \leq \gamma \leq 1 \qquad (3)$$

The parameter γ must lie between 0 and 1. The maximum likelihood estimation of equation (1) provides consistent estimators for β, γ, v_i, u_i and σ_s^2 parameters. Multiplying by e^{-v_i} of both sides of equation (1) and replacing β's with maximum likelihood estimates yields stochastic production frontier as:

$$y_i^{\bullet} = F\left(x_i, \beta^{\otimes}\right)e^{-u_i} = y_i e^{-v_i} \qquad (4)$$

Where, $y_i^{\bullet}$ is the observed output of the *i*-th farm adjusted for the statistical random noise captured by v_i (Bravo-Ureta, and Rieger, 1991). All other variables are as explained earlier and $\overset{\otimes}{\beta}$ is the vector of parameters estimated by maximum likelihood estimation technique. The technical efficiency (TE) relative to the stochastic production frontier is captured by the one-sided error components $u_i \geq 0$, i.e.

$$TE = e^{-u_i} = \left[\frac{y_i}{F\left(x_i, \beta^{\otimes}\right)e^{v_i}}\right] \qquad (5)$$

Technical efficiency index in equation (5) can be defined as the ratio of observed to maximum feasible output and it is estimated by employing traditional stochastic production frontier approach. The function determining the technical inefficiency effect is defined in general form as a linear function of socio-economic and management factors.

$$TIE = F(z_i) \quad (6)$$

Where TIE stands for technical efficiency and z is a vector of socio-economic and management factors. It should be noted that stochastic frontier production function and inefficiency model is estimated in one step as proposed by Kumbhakar *et al.,* (1991); Huang and Liu (1994) by using Frontier 4.1. developed by Coelli (1994).

Empirical model

Different type of production function exists to estimate technical efficiency but we employ Cobb- Douglas type of production function because of having limited observations in our sample. Moreover, its coefficient is easy to interpret. The Cobb-Douglas production is defined as:

$$\text{Ln } Y= \beta_0+\beta_1 LnX_1++\beta_2 LnX_2+\beta_3 LnX_3+\beta_4 LnX_4+\beta_5 LnX_5 ++\beta_6 D_{1+}€ \quad (7)$$

Where Y is milk production per animal per lactation period in liters, X_1 is the amount of fodder used (kg)/animal/lactation period, X_2 is amount of concentrate used (kg)/animal/ lactation period, X_3 is the amount of wheat straw (kg)/animal/lactation period, X_4 is the labor hours/animal/lactation period, X_5 is the total veterinary cost (Rs.)/animal/lactation period, D_1 is the dummy if BMPs then 1 otherwise 0, βs are parameters to be estimated and ε is error term.

Technical inefficiency (TIE) can be estimated by subtracting technical efficiency from one. The function determining the technical inefficiency can be written as:

$$TIE = \alpha_0 + \alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 z_3 + \alpha_4 z_4 + \alpha_5 z_5 + \alpha_6 z_6 \quad (8)$$

Where αs are the coefficients of explanatory variables, $z_1$is education i.e. No. of schooling years of the farmer, z_2 is the experience of the farmers (years), z_3 is market distance from the farm (km), z_4, z_5, and z_6 are the dummy variables for road condition, extension services, and credit.

Data collection procedure

The present study involves economic analysis of two groups of farmers, i.e. one who adopted better management practices and second those with traditional practices. A well designed and pre tested questionnaire was used for the collection of relevant information regarding various farm-specific characteristic and different farm-level practices for the year 2009.Two districts i.e. two major districts Jhang and Toba Tek Singh of mixed cropping zone of Punjab were purposively selected for data collection. The 40 farmers who have adopted the best management practices were interviewed and these farmers were spread unevenly in different villages of these two districts. The farmers who have adopted best management practices are limited in numbers because PDDC is striving hard to increase the number of farmers under this category. However, 80 farmers with traditional practices by selecting 40 from each district were interviewed. Hence, our sample is consists of 120 respondents.

RESULTS AND DISCUSSION

The results of Maximum Likelihood Estimates (MLE) for stochastic frontier production function are reported in Table 1. We can test the null hypothesis that no technical inefficiency exists in the sample dairy farms. It is observed that the log-likelihood value for the stochastic frontier model is 132.37 while for OLS it is 110.52, which is less than that of frontier model. The likelihood-ratio statistic is used as, LR = -2*(110.52-132.37) = 43.70 to test the absence of technical efficiency in the model. The value of likelihood-ratio LR=43.70, exceeds the critical value of 10.37 obtained from Kodde and Palm (1986) for the degree of freedom equal to 5 at five percent level of significance. The log-likelihood ratio test suggests that inefficiency exits in the data and hence the null hypothesis of no technical inefficiency in dairy farming system is rejected.

Table 1 presents the maximum likelihood parameter estimates for the estimated frontier production function. Because all inputs and output are used in logarithmic form, hence, the coefficient of frontier production function can be interpreted as partial output elasticities. The estimated elasticity coefficient for green fodder shows that a 1 percent increase in the amount of green fodder there is 0.017 percent increase in milk production per lactation period. As the green fodder is the basic requirement for each animal, its intake surely increases the milk production capacity of milking animal. Green fodders are mostly rich in protein, which are essential for milk production. The coefficient of concentrate per animal for a farm is 0.059, which is positive and statistically significant. It suggests that 1 percent increase in concentrate contributes in milk production by 0.059 percent during the lactation period. The results are according to our priori expectation; it is commonly observed that change in the amount of concentrate immediately effect the milk production. The recommended amount of concentrate for each animal is 1 kg for each 3 liters of milk. The coefficient of wheat straw is 0.151 with negative sign; implying wheat straw is effecting milk production negatively. It is because; farmers are using wheat straw as dry fodder in abundant amount especially during the green fodder shortage period i.e. April-May. At this stage farmers have fewer options to feed their animals with nutritious food. . So, our results suggest that amount of wheat straw should be decreased in order to make a balanced diet. The coefficient of labor is positive but statistically insignificant, implying that family labor is being over utilized in diary sector which is making its marginal contribution to zero. This can lead to conclude that livestock sector is not a labor intensive entrepreneur. The coefficient of veterinary cost is 0.098, which is negative and statistically significant. The veterinary cost included the diseases, medicines and other related expenses. Its sign is consistent with the economic theory[1].

The coefficient of dummy for better management practices is 0.208, which is positive and highly significant. This indicates that increase in better management practices increases the milk production. As mentioned above, better practices include animals are un-tie, free water access, proper shed construction and ventilation for heat control and better feed management. Surely these practices have a positive impact on milk production of a milking animal. In the case of traditional practices dairy farming these practices are not adopted where animals are tied and cannot have free water access at all the times. The traditional practices dairy farmers can take to animals at water only once or twice in a day. The water requirement for a milking animal is about 75 liters per day but if it is tied and drink water only two times, it can drink a maximum of 40-50 liters per day. So the deficiency of water reduced the milk production. Similarly if the hygienic conditions are poor and shed is not properly constructed, the increase in temperature can negatively impact milk production.

It is observed that MLE for γ is 0.809 and it is highly significant. It is consistent with the theory that true γ value should be greater than zero. The value of γ is significantly different from one which shows that random error is playing a significant role to explain the variation in dairy production as commonly observed for agricultural and dairy production process. Our results suggest that 80.9 percent of the variation in yield is due to technical inefficiency and only 11.1 percent is due to the stochastic random error, implying that technical inefficiency is playing a significant role in explaining the variation.

The results of technical inefficiency effect model shows that the coefficient of education is negative and statistically significant. This implies that education contributes significantly in reducing inefficiency in the milk production. The results are similar with the findings of Philips and Marbel (1986); and Flinn and Ali (1986). Although the coefficient of experience carries negative sign but it is statistically non-significant and these findings are similar with Kalirajan (1981) and Amoloza (1983). The coefficient of farm distance is positive and significant, implying that inefficiency increases as distance of the farm increases from the market and these results are consistent with the economic theory. It is generally hypothesized that if a dairy farm is away from market, then its efficiency is affected because it becomes difficult for him to transfer all inputs and outputs efficiently by covering large distances and our results also confirms this. The coefficient of dummy variable for road condition is negative but insignificant i.e., if the road condition is good, the inefficiency in milk production reduces. This implies that development of physical infrastructure can significantly contribute in improving the efficiency of

[1]Dairy farming has always been considered as a by-product of cropping in Pakistan i.e., mixed farming. The benefits of mixed farming include: the waste or farm residue of agri-farms is utilized in dairy farms; likewise, dairy farm residue is utilized in agri-farms thus minimizing losses to farmers. However, the weakness is that in the absence of enhanced management techniques for dairying, its profitability relative to other farms has been overshadowed. This has hampered the growth of a specialized sector with specific dairy innovative techniques.

Table 1: OLS and maximum likelihood estimates of cobb douglas stochastic frontier function and inefficiency effect model

Variable	OLS estimates	MLE coefficients
Constant	*9.278*	*8.979**
	(2.67)	(2.052)
Ln (Amount of fodder)(Kg)	0.022	0.017*
	(2.56)	(1.622)
Ln (Amount of concentrate)	0.068	0.059**
(Kg)	(3.92)	(2.554)
Ln (Amount of wheat straw)	-0.236	-0.151**
(Kg)	(4.22)	(-3.939)
Ln (Labor)	0.281	0.261$^{n.s}$
(Hours)	(0.937)	(0.691)
Ln (Vetnory cost)	-0.151	-0.098*
(Rs)	(2.13)	(-1.51)
Dummy	0.260	0.208**
(BMP=1)	(11.44)	(9.63)
Sigma-square	0.039	0.057**
		(2.58)
Gamma (γ)		0.809**
		(7.51)
Log Likelihood	110.52	132.37
Inefficiency effect model		
Variables	MLE coefficients	t-ratio
Constant	0.141*	2.28
Education	-0.026**	2.42
Experience	-0.002$^{n.s}$	-0.784
Farm distance	0.017*	1.22
Road condition	-0.029$^{n.s}$	-0.447
Extension	-0.043*	-1.697
Credit	-0.183*	-1.646

Figures in parenthesis are t-ratio; *and** indicates significance at 10 and 1 percent probability levels respectively; n.s = Non-Significant.

Table 2: Comparison of technical efficiency of better management practices and traditional dairy farms (percent)

Efficiency interval	BMPs dairy farms	Traditional practices farms
0.900< TE <1.00	65	40
0.900< TE <0.800	27.5	33.75
0.800< TE <0.700	7.5	20
0.700< TE <0.600	0	6.25
Average	95.27	87.68
Maximum	98.18	97.40
Minimum	73.09	67.55

milk production. The coefficient of dummy for extension services and credit is negative and statistically significant. This implies that investment in improving extension services and increasing the credit facility could significantly increase milk production.

Table 2 shows the comparison between technical efficiency of both groups i.e. traditional and better management practices of dairy farms. Our results reveal that average technical efficiency of BMPs dairy farms is significantly higher (95.27 percent) than conventional farms(87.68 percent), indicating that changes in management practices introduced by PDDC are contributing in improving milk production in the region. Our conclusion also coincides with findings of Ball (2009) and Cabrera *et al.,* (2010). The reason is that BMPs dairy farms not only have less per unit of milk production cost but also more milk production per animal, making them technically more efficient.

Conclusions

This study intended to examine the impact of better management practices on the technical efficiency of dairy farms using the stochastic production frontier approach. The data was collected from 120 dairy farms in Punjab, Pakistan. The empirical results of production frontier indicate that better management practices are significantly contributing in increasing milk production. The results of technical inefficiency model demonstrate that credit availability to the farmer has the highest impact in reducing inefficiency. It is generally assumed that farmers having better financial resources first adopt the innovations introduced at the farm level; credit availability strengthens the financial position of a farmer which motivates him to take risk of adopting new technology or management practices. Hence, the role of financial institutions needs to reformulate and they should tie up the credit availability with adopting best management practices by the dairy farmers. The education and extension services also has significant role in reducing inefficiency in dairy production, implying that Government need to strengthen the availability of these facilities to the farmers.

The average technical efficiency of BMPs dairy farms is found to be significantly higher than conventional farms. These results suggest that dairy farms can improve their productivity and efficiency if they take advantage of more efficient farm management practices. Our results suggest that investment in farmers' education, extension services and physical infrastructure can make the dairy farmers technically more efficient. The results also suggest that by augmenting financial resources technical efficiency in dairy production can further be improved.

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