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Total Factor Productivity in Milk Production in Haryana

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Abstract

The study estimates total factor productivity (TFP) in milk production and identifies factors influencing it in Sirsa district of Haryana. The TFP has been found highest in large herds (0.2202) and for crossbred cows (0.2346), which imply that increase in herd size and adoption of high-yielding animals (crossbred or buffalo) would positively contribute to TFP. However, the overall TFP is low across herd sizes; hence, transfer of technology and infrastructural support related with milk production are of paramount importance. Creation of dairy assets on farms and balanced feeding are the significant determinants of TFP.

Key words: Dairy cooperatives, total factor productivity, milk production, Haryana

JEL Classification: D21, D24, O32, O33

Introduction

In India, the growth in milk production has been driven primarily by the animal numbers than their yields (Ohlan, 2013). The milk yield of dairy animals is very low in India as compared to other countries. Consequently, the country has to maintain a much larger stock to produce the required quantity of milk. In 2012-13, the average annual yield per dairy cow was estimated to be 1,284 kg of liquid milk in India, whereas it was 6,212 kg in the European Union and 9,117 kg in the United States (FAOSTAT database, 2012). The efforts made by the cooperatives coupled with research and extension inputs toward improving milk production and productivity, have started showing results. The average milk productivity has increased marginally of buffaloes from 4.51 kg/day in 2009-10 to 5.15 kg/day in 2014-15 and of crossbred cows from 6.87 kg/day to 7.15 kg/day. The improvement in productivity of indigenous cows from 2.14 kg/day in 2009-10 to 2.54 kg/day (about 18.69% increase) in 2014-15 reveals the potential of higher milk production

from indigenous breeds, if managed properly. As per the latest estimates, the contribution of local cows, crossbred cows and buffaloes to total milk production in the country is 20.15 per cent, 25.24 per cent, and 51.06 per cent, respectively (GoI, 2015).

The pathways to enhance animal productivity are the adoption of improved technologies and improvement in technical efficiency (Karanja *et al.*, 2012). The technological developments require a substantial capital investment and have a lagged effect. In a developing country like India, it is important to weigh the strategies for productivity enhancement against the alternatives before investing resources on technological development (Saha and Jain, 2004). The analysis of factor productivity in milk production assumes more significance in low-input and low-output production environments having poor infrastructure and policy supports. In view of the above, the present study has been conducted to estimate the TFP of milk production on dairy farms in Sirsa district of Haryana. It has also attempted to capture the contributions of factors like infrastructure, skill, institutions and technology in milk production and productivity.

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Data and Methodology

The study was conducted in the Sirsa district of Haryana keeping in view the conducive environment available for crops as well as milk production. The Sirsa Cooperative Milk Union has a milk plant in Sirsa town and four chilling plants in Jiwan Nagar, Patli Dabar, Gusiana and Gori Wala. From each of these chilling plants, two cooperative societies having highest number of member suppliers were taken to select 140 dairy farmers at random to collect data on milk production and inputs used. These dairy farmers are allocated across societies according to probability proportional allocation. The selected dairy farmers were post-stratified into three herd-size categories on the basis of standard animal units (SAUs), namely small (1-4 SAUs), medium (5-6 SAUs) and large (≥ 7 SAUs) using cumulative square root frequency method. The conversion factor used to calculate SAUs was taken from the reference (Sirohi *et al.*, 2015)

In this study, farm and animal level cross-sectional household data have been used for estimating total factor productivity (TFP), similar to the studies by Fleisher and Yunhua (1992), Piesse *et al.* (1996), Akcay and Esengun (1999) and Alemdar and Oren (2006). The input-output relationship in dairying is assumed to be linearly homogeneous exhibiting Hicks-neutral technological change that equilibrates TFP to shift in the intercept or the inverse of average cost. Assuming conventional double log production function (Cobb-Douglas functional form) relationship between output and inputs, TFP is estimated as antilog of the efficiency parameter (b_{0j}).

$$Y_j = b_{0j} \prod_{i=1}^n X_{ij}^{b_{ij}} \quad \dots(1)$$

where,

Y_j = Fat corrected milk (FCM) production per animal per day of the j th household

X_{ij} = Value of the i^{th} inputs used per animal per day (only variable cost inputs) by the j th household, where $i=1$ to 6 and inputs included in the function were green fodder, dry fodder, concentrate, labour, veterinary expenses and miscellaneous expenses.

All input variables are taken in value terms to take care of quality variation. The data were converted as per animal basis to ensure constant

returns to scale in double log function form setting.

$b_{ij} = e_p$ = Factor coefficients corresponding to the elasticity of production of i^{th} input for the j th household

From Equation (1), we have

$$\ln(b_{0j}) = \ln(Y_j) - \sum_{i=1}^6 b_{ij} \ln(X_{ij}) \quad \dots(2)$$

where, TFP of milk production in the j^{th} household is equal to $\text{Exp}(b_{0j})$

In the econometric estimation, equation (2) gives only the average value of coefficients for all herd-size categories and not at individual farm level. Secondly, the negative coefficient of an input has a positive effect of TFP which is not correct theoretically. In order to overcome these limitations, b_{ij} 's are estimated indirectly as the factor share of the i^{th} input in total cost on j th farm assuming cost minimization objective function. In this way, the value of b_{ij} varies household-wise for a single input. Thus, b_{ij} for the i^{th} input on the j^{th} farm is taken as:

$$P_{xi} * X_{ij} / P_{xi} * X_{ij}$$

The TFP so calculated for individual farm is averaged to have herd-size category estimates. The frequency distribution of the farms has been studied with relation to TFP parameter.

Determinants of Total Factor Productivity

The factors affecting TFP at a farm level have been determined through log linear regression. In this context, many factors were tried in the step down regression, but the followings are retained in the final regression keeping in view their level of significance, expected relationship and the value of coefficient of multiple determination.

TFP = f (Herd size, Fixed cost, Family size, Concentrate-Productivity ratio)

Herd size is used to separate out the effect of scale. It is taken as the number of milch animals at a farm. The fixed cost in rupees per animal per day is another variable used to capture the effect of infrastructure at farm level. The effect of management practices has been approximated by concentrate-productivity (C-P) ratio in quantity terms. It is the ratio of quantity of concentrate fed to a lactating animal in kilograms to

Table 1. Total factor productivity in milk production

Particulars	Average TFP	Standard deviation	Frequency of households		Total households
			< Average	≥ Average	
Herd- size category-wise					
Small	0.1916	0.0879	42 (56.00)	33 (44.00)	75 (100.00)
Medium	0.2195	0.0825	23 (51.11)	22 (48.89)	45 (100.00)
Large	0.2202	0.0981	12 (60.00)	8 (40.00)	20 (100.00)
Overall	0.2046	0.0882	72 (51.43)	68 (48.57)	140 (100.00)
Dairy animal-wise					
Crossbred cow	0.2346	0.1001	56 (55.45)	45 (44.55)	101 (100.00)
Buffalo	0.1842	0.0736	57 (48.72)	60 (51.28)	117 (100.00)
Local cow	0.1013	0.0440	8 (53.33)	7 (46.67)	15 (100.00)

Note: Figures within the parentheses indicate the percentages of their respective totals

the milk productivity of animal in the same units. The ideal C-P ratio is considered to be 0.50 by the nutritionists which explains that to be efficient, the amount of concentrate fed to animal should be half of its milk productivity.

Results and Discussion

TFP in Milk Production

Two major approaches cited in literature (Pender *et al.*, 2003; Dietrich *et al.*, 2012) to augment production and productivity are the factor intensification and management or technological improvements. But, there are limits to factor intensification; hence the need to rely on TFP. This section discusses TFP in milk production across herd sizes and animal types. The mean values of TFP with their standard deviation are given in Table 1.

A perusal of Table 1 reveals highest TFP in large herds (0.2202) and in crossbred cows (0.2346), implying a greater role of factors other than inputs in these categories of farms. Yet we find TFP to increase with increase in herd-size (Figure 1). The results clearly indicate that the benefits realized from technology, infrastructure, skill and institution are more at the

higher level of productivity, and the economics of scale are obvious in larger herds where the probability of following a scientific approach to dairy production is quite high. The crossbred cows have high genetic potential and better feeding practices can result in realization of genetic potential. All these factors together make greater use of infrastructure like veterinary services, institutions like cooperative dairy processing and also of trainings and skill improvement. The same reasons explain the lower values of TFP in case of buffaloes and local cows vis-a-vis crossbred cows.

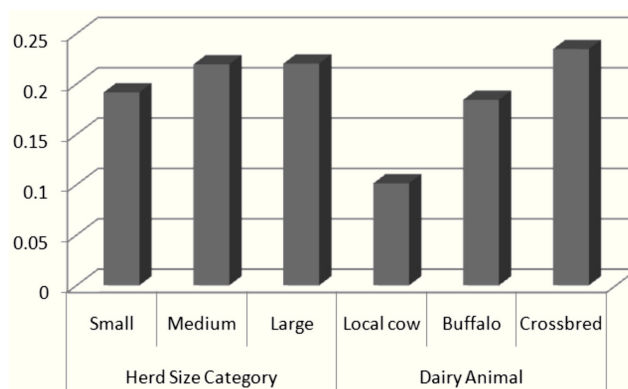


Figure 1. Bar diagram showing TFP according to herd-size and dairy animal species in Sirsa

The category-wise and animal-wise standard deviations in the Table 1 explain the consistency of TFP within a group. The value of standard deviation shows presence of significant variation in TFP across herd-size categories as well as animal type. The variability coefficient is the lowest (37.58%) i.e., 0.2195 ± 0.0825 in medium herds and the highest (45.88%) i.e. 0.1916 ± 0.0879 in small herds. Among the types of animals, the variability coefficient is estimated the lowest (39.96%) i.e. 0.1842 ± 0.0736 in buffaloes and the highest (43.43%) i.e. 0.1013 ± 0.0440 in local cows.

The frequency distribution of all households by TFP values given in Table 2 depicts that the majority of the farms are at a low level of TFP. The proportion of households having less than average TFP is the highest (60%) on large herds, followed by small herds (56%) which means that the average TFP values in these categories are influenced more by the lower values, otherwise, the TFP values for rest of the herds are substantially higher than the average. It reveals that there exists a large variation in TFP which could be minimized by capacity building of farmers to adopt better technologies and management practices.

The cumulative frequency column in Table 2 shows a skewness in the distribution of dairy farm households towards the lower value of TFP (Figure 2). About 88 per cent of the farms have TFP value less than 0.30. In the other way, only 12 per cent of the farms have TFP values greater than or equal to 0.30. It varies from a minimum of 0.0516 to a maximum of 0.5820 with mean value of 0.2046 ± 0.0882 .

Table 2. Frequency distribution of farm households according to TFP in milk production

TFP index range	Frequency of farms (No.)	Percentage distribution	Cumulative percentage distribution
<0.10	13	9.29	9.29
0.10-0.20	57	40.71	50.00
0.20-0.30	53	37.86	87.86
0.30-0.40	14	10.00	97.86
0.40-0.59	1	0.71	98.57
0.50-0.60	2	1.43	100.00
No. of observations	140		
Mean	0.2046		
Standard deviation	0.0882		
Maximum	0.5820		
Minimum	0.0516		

Determinants of Total Factor Productivity

In this section we identify correlates of TFP. The multiple regression technique was followed using power function where TFP in milk production is regressed on the factors assumed to cause variation in it.

The partial regression coefficients of TFP per animal per household are presented in Table 3 for different herd-size categories. The R^2 value is less than 0.60 in all herd-size categories, except in the medium category. Overall, 55 per cent of the variations in TFP is explained by the factors included in the regression. It can be observed from Table 3 that the herd-size is

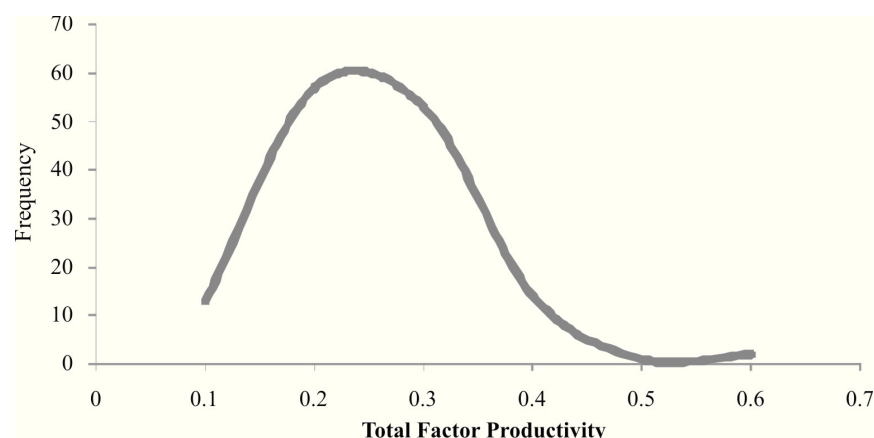


Figure 2. Frequency distribution of sample households as per total factor productivity in milk production

Table 3. Partial regression coefficients of total factor productivity for different herd-size categories

Variables	Herd-size categories							
	Small		Medium		Large		Overall	
	Regression coefficients	Standard error	Regression coefficients	Standard error	Regression coefficients	Standard error	Regression coefficients	Standard error
Constant	-3.2721**	0.4336	-2.6212**	0.4106	-2.0570**	0.6477**	-3.0818**	0.2397
Herd-size (X_1) (No. of milch animals)	0.3824*	0.1479	-0.1927	0.2560	0.1356	0.2162	0.3770**	0.1080
Fixed cost (X_2) (₹/Animal)	0.0914	0.0767	0.1538**	0.0531	-0.0426	0.1216	0.0910*	0.0462
Family Size (X_3) (No./household)	0.0562	0.1112	-0.0192	0.0681	-0.0549	0.2395	-0.0194	0.0691
Concentrate-productivity ratio (X_4)	-0.6589**	0.0887	-0.8870**	0.0916	-0.4660*	0.1770*	-0.6875**	0.0623
R ²	0.4865		0.8128		0.4957		0.5500	
Sample size (No.)	71		39		18		128	

Note: * Significant ($p < 0.05$), ** significant ($p < 0.01$)

positive and significant at less than 5 per cent level for the overall sample and for small herds. This indicates a direct relationship between the herd-size and TFP.

In all the cases, the only non-significant coefficient is family size, indicating that labour does not influence TFP. At the same time, the coefficient for concentrate-productivity ratio is significant in all herd-size categories, but it is a negative suggesting that the feeding of more concentrates has a negative effect on TFP. The coefficient of C-P ratio is highest in the case of medium herd-size category (-0.8870). The proportionate decrease in TFP will increase in C-P ratio is found lowest in large herd-size category (-0.4660) and significant at five per cent level. This finding indicates that farmers feed more concentrates to their animals the incremental benefits from which are lower than the incremental cost of feeding and therefore they need to be educated on balanced feeding practices to improve factor productivity and profitability.

The fixed cost, a proxy for on-farm infrastructure, has a positive effect on TFP, but is found significant in the case of medium category where TFP increases by 0.15 per cent with one per cent increase in fixed cost. The improvements in TFP due to improvements in on-farm infrastructure is less.

Conclusions

The study has estimated total factor productivity (TFP) in dairying. The results show higher TFP on larger dairy farms and for high-yielding animals, viz. crossbreds and buffaloes, and implies that increased scale of production and adoption of high-yielding animals (crossbred or buffalo) will enhance the TFP. These factors together would enable the farmers to make greater use of infrastructure, technology, institutions and skill.

The herd-size, fixed cost and concentrate-productivity ratio are identified as major determinants of TFP with herd-size and fixed cost having a positive effect and the C-P ratio a negative effect on TFP. Thus, it could be concluded that increase in herd-size and private investment at dairy farms on housing and equipment along with educating the farmers about balanced rationing and appropriate concentrate-productivity ratio would improve the factor productivity at farm level.

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