An Economic Analysis of Milk Production in Hardoi District of Uttar Pradesh

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Abstract
The present study has been conducted in Hardoi district of western Uttar Pradesh. Primary data have been collected from 100 milk producing households. The objective of the study is to estimate the resource-use efficiency in respect of the use of principal inputs in the study area. The findings show that resources are being used inefficiently in the study area and it is suggested that the milk producers must be educated on feeding balanced ration to their animals to improve resource-use efficiency of different feed inputs and economic returns from milk production.

Key Words: Cobb-Douglas Production Function, Linear Production Function, Marginal Value Product, Milk Production, Resource-Use Efficiency

Introduction
Dairy sector in India has acquired substantial growth momentum from 9th Plan onwards as a result of which we now rank first among the world's milk producing nations, achieving an annual output of about 146.3 million tonnes of milk during 2014-15 compared to 17 million tonnes in 1950-51 and 78.3 million tonnes in 1999-2000. This represents sustained growth in the availability of milk and milk products for our growing population. Dairying has become an important secondary source of income for millions of rural families and had assumed the most important role in providing employment and income generating opportunities particularly for marginal and women farmers. Most of the milk is produced by small, marginal farmers and landless labourers. Government of India is making efforts for strengthening the dairy sector through various development schemes.

The dairy sub sector occupies a very important place in agricultural economy of India as milk is the second largest contributor to GDP, next only to rice, as far as agricultural commodities are concerned. It is said that crop husbandry is a land resource based enterprise and provides almost seasonal income and employment to the farmers, whereas dairy provides not only employment to the farmer's family during the off season but also a regular flow of income throughout the year. So, dairy development is recognized as an important activity
suitable for employment generation and value addition in agricultural sector in Indian economy in general and of rural families especially the small and marginal farmers and landless agricultural labourers in particular.

But despite the fact that India occupies the status of largest milk producing country in the world, the per capita availability of the milk is low as compared to some developed countries. In fact India achieved a per capita availability of milk (250 grams/day) for consumption - the level recommended by the United Nations' Food and Agricultural Organisation (FAO) as late as 2010. Although the per capita availability of milk has reached a level of 322 grams per day during the year 2014-15, which is more than the world average of 294 grams per day during 2013, it has, as the ASSOCHAM's "Unlocking growth potential of Indian Dairy Industry" report observes, got a long way to go before matching the standards set by other countries. Therefore, the estimation of cost, return and profitability of milk production is essential for the dairy farmers for introducing desirable changes in the production, productivity and value addition in its operation at the micro level and for policy makers in formulating plans for improvements in dairy cattle productivity and value addition based on sound economic principles at the macro level. As the country has a limited availability of feed and fodder resources, it becomes imperative to analyse the efficiency with which these resources are being used in the dairy sector. The present study is an attempt in this direction in the state of Uttar Pradesh, India's largest milk producing state.

**Objective of the Study**

The present study attempts to gain insight into the economics of milk production in Uttar Pradesh so as to gauge the potential of dairy farmers for improvement with the specific objective of estimating the resource-use efficiency in respect of the use of principal inputs in the study area. It may guide and encourage the most efficient and economic use of available resources and serves the base for future improvements in dairy practices.

**Hypotheses for the Study**

Hypotheses taken for this present study are as follows:

- All inputs affect milk production significantly.
  
  \[ H_0 : \text{The output elasticities of all inputs are insignificant.} \]
  
  \[ H_1 : \text{The output elasticities of all inputs are significant.} \]
• Inputs are used efficiently for all types of milch animals, i.e., local cow, crossbred cow and buffalo.

H₀: There is no significant difference between the marginal value product of an input and its unit price for all types of milch animals.

H₁: There is significant difference between the marginal value product of an input and its unit price for all type of milch animals.

Research Methodology and Research Design

(a) Sampling Design

The study has been conducted in the Hardoi district of western Uttar Pradesh. Selection of Uttar Pradesh as the study area was a case of purposive sampling. Uttar Pradesh is the biggest milk producing state in India; this is why it was selected. Hardoi was selected randomly by lottery method. Hardoi has 19 development blocks. Out of these 19 development blocks 2 were selected randomly, viz., Pihani and Bavan. 2 villages were selected randomly from each of these 2 blocks. Sample size for the present study is 100; 25 dairy farmers were selected randomly from each of these villages. From each dairy farmer feeding information regarding one dairy animal was collected. The primary data were collected through a structured questionnaire which was developed for this purpose.

(b) Research Design

The research design followed for the present study is Complex Factorial Design because there are three or more independent variables with one experimental / dependent variable. Factorial design has been used mainly because of the two advantages - (i) it is a source of economy as it provides equivalent accuracy with less labour and (ii) it permits various other comparisons of interest. For example, it gives information about such effects which cannot be obtained by treating one single factor at a time. The determination of interaction effects is possible in case of factorial design.

(c) Estimation of Production Function and Resource-Use Efficiency

Functional Analysis
The production function for milk is a highly complex function which includes several genetic and non-genetic and environmental factors. Though it is not possible either to identify all the factors affecting milk production or to take into account all of them in a single production function framework (Dixit, 1999)\(^1\). In the present study the focus is on estimating the resource-use efficiency for principal inputs. The regression equations have been fitted for different categories of lactating animals. Some of the important variables such as order of lactation of milch animals and stage of lactation of milch animals have been purposively eliminated due to difficulty in incorporating this information at an aggregated milk production function. Hence, it has been assumed that the eliminated variables are not significantly varying between farm households in the study areas. (Saha and Jain, 2004)\(^2\).

**Specification of Milk Production Function**

The production function for milk used for the present study has been specified as follows:

\[ Y = f( X_1, X_2, X_3, X_4, X_5) \]

\[ Y = \text{Income from milk per animal per day (in Rs.)} \]

\[ X_1 = \text{Expenditure on green fodder per animal per day (in Rs.)} \]

\[ X_2 = \text{Expenditure on dry fodder per animal per day (in Rs.)} \]

\[ X_3 = \text{Expenditure on concentrates per animal per day (in Rs.)} \]

\[ X_4 = \text{Value of labour used per animal per day (in Rs.)} \]

\[ X_5 = \text{Miscellaneous expenses per animal per day (in Rs.)} \]

Ideally, the output \((Y)\) and inputs \((X_i)\) in the defined production function has been measured in monetary values rather than their physical quantities. The protein content of milk, which decides the value of the output, varies

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considerably and the quality of feeds and fodders differs from one respondent to the other and can be more appreciably reflected in value terms.

**Choice of a Specific Functional Form**

Sign and statistical significance of estimated parameters and co-efficient of multiple determination (R²) have been used as criteria for choosing a specific functional form. Mainly two functional forms, viz. Linear and Cobb-Douglas were tried.

Linear Production Function in its stochastic form may be expressed as:

\[ Y_i = \alpha + \sum_{i=1}^{n} \beta_i X_i + u_i \]

i.e.,

\[ Y_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + u_i \]

where, \( u \) is the stochastic disturbance term, distributed normally with zero mean and constant variance

and \( X_1, X_2, X_3, X_4 \) and \( X_5 \) are as defined above

\( \alpha \) is the constant or intercept term.

This model is a linear regression model. It is linear in parameters as well as in explanatory variables.

The Cobb-Douglas Production Function, in its stochastic form, may be expressed as:

\[ Y_i = \alpha \prod_{i=1}^{n} X_i^{b_i} e^{ui} \]

i.e.,

\[ Y_i = \alpha X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} e^{ui} \]

where 'e' is the base of natural logarithm

other symbols have the same meaning as defined above.

Here the relationship between output and the inputs is non-linear. However if we log-transform this model, we obtain:
\[ \ln Y_i = \ln \alpha + \beta_1 \ln X_{i1} + \beta_2 \ln X_{i2} + \beta_3 \ln X_{i3} + \beta_4 \ln X_{i4} + \beta_5 \ln X_{i5} + u_i \]

where \( \beta_0 = \ln \alpha \)

This transformed model is linear in the parameters \( \beta_0, \beta_1, \beta_2, \beta_3, \beta_4 \) and \( \beta_5 \) and is, therefore, a linear regression model. Though it is nonlinear in the variables \( Y \) and \( X_i \)'s but linear in the logs of these variables. In short, it is a log-log, double log, or log-linear model.

By applying Ordinary Least Square method regression coefficients are estimated.

**Test of Significance of Regression Coefficients**

The customary of applied econometrics to test the hypothesis that the true population parameter is zero has been followed. That is, the typical form of the null hypothesis in is

\[ H_0 : \beta_i = 0 \]

and it is tested against the alternative hypothesis

\[ H_1 : \beta_i \neq 0 \]

If we reject the null hypothesis, we may conclude that the coefficient \( \beta_i \) is statistically significant, or, it is significantly different from zero. If we accept the null hypothesis, then \( \beta_i \) is not significant and there is probably no linear relation between the dependent and the explanatory variable.

To carry out the test of the above null hypothesis we set \( \beta_i = 0 \) in the Z transformation formula

\[ Z_{\text{calculated}} = (\beta_i - \beta_i) / \text{S.E.}(\beta_i) = (\beta_i - 0) / \text{S.E.}(\beta_i) = \beta_i / \text{S.E.}(\beta_i) \]

Then we compare \( Z_{\text{calculated}} \) with the theoretical value of \( Z \), which define the critical region for our test. For the 5 percent level of significance or the 95 percent confidence level the critical value of \( Z \) is 1.96; and for the 1 percent level of significance or the 99 percent confidence level the critical value of \( Z \) is 2.58. If \( Z_{\text{calculated}} \) is
greater than these critical values of $Z$ we reject the null hypothesis at that level of significance. If $Z_{\text{calculated}}$ is less than these critical values of $Z$ we fail to reject the null hypothesis on the basis of our sample statistics.

Marginal Value Product (MVP)

In linear function, the regression coefficients($b_i$'s) of the explanatory variables, estimated at their geometric mean level, indicate the Marginal Value Product of the explanatory variables measured in monetary terms, i.e.,

$$\text{MVP}_{X_i} = \beta_{X_i} \left(\text{G.M. of } Y / \text{G.M. of } X_i\right)$$

where,

$\text{MVP}_{X_i} =$ Marginal Value Product of $X_i$ input

$\beta_{X_i} =$ Regression Coefficient associated with $X_i$ input

$\text{G.M. of } Y =$ Geometric Mean of output

$\text{G.M. of } X_i =$ Geometric Mean of input $X_i$

The elasticity is variable, depending on the value taken by the dependent variable (output) or a explanatory variable (input) or both. When no dependent variable and explanatory variable values are specified, in practice, very often these elasticities are measured at the mean values of the variables, namely $\overline{X_i}$ and $\overline{Y}$. Geometric Mean, instead of Arithmetic Mean, has been used because geometric mean measures the typical value of a set of numbers that change over a period of time.

In the case of log-linear regression model (i.e. log-transformed Cobb-Douglas production function), the coefficient of each of the explanatory variables measures the partial elasticity/ output elasticity of the concerned explanatory variable, holding other inputs constant. Thus, the regression coefficient of each explanatory variable estimated at its geometric mean level gives the Marginal Value Product of the concerned explanatory variable.
MVP_{Xi} = \beta_{Xi} \left( \text{G.M. of } Y / \text{G.M. of } X_i \right)

In the present study, both linear and Cobb-Douglas production functions were applied. The Cobb Douglas production function was found best fit by applying the criteria of signs and statistical significance of regression coefficients and the value of the Coefficient of Multiple Regression (R^2).

**Resource-Use Efficiency**

Inputs are used efficiently if the MVP of the input is equal to its unit price, i.e.,

\[ MVP_{Xi} = P_{Xi} \]

where, \( P_{Xi} \) is the unit price of the input.

In order to examine the resource-use efficiency, the Marginal Value Products of various inputs were worked out from the significant regression coefficients in the estimated production function. Any deviation of MVP of an input from its unit price may be termed as resource-use inefficiency. The higher the difference between MVP of an input and its price, the higher is the resource-use inefficiency and vice versa.

Further, the z-statistic (as the sample was large, i.e., \( n > 30 \)) was used to test the statistical significance of the difference between the MVP of an input and its unit price. If the difference between the MVP of an input and its unit price is statistically non-significant, it indicates that the input is being utilised efficiently or optimally. A significant higher MVP of an input than its unit price shows that the input can be used further to increase productivity, while a significantly lower MVP of an input than its unit price indicates that the input is being used in excess and hence needs reduction.

\[ Z_{\text{calculated}} = \frac{(MVP_{Xi} - P_{Xi})}{\text{S.E.} (MVP_{Xi})} \]

where, \( \text{S.E.} \) = Standard Error; it is the standard deviation of the distribution of a sample statistic.

Standard Error of MVP_{Xi} = Standard Error \{ \beta_{Xi} \left( \text{G.M. of } Y / \text{G.M. of } X_i \right) \}
Marginal Value Products have been calculated for the different inputs, viz., green fodder, dry fodder and concentrates for Local Cow, Crossbred Cow and Buffalo and also for different categories of dairy farmers, viz., marginal, small, medium and large farmers. z-Statistics has been applied to test the significance.

Before going for regression analysis for establishing production function, data have been tested for normality, multicollinearity and autocorrelation. Normality of data has been established by Q-Q plots, measures of skewness and kurtosis and Shapiro-Wilk test. Many parametric statistical methods require that the dependent variable is approximately normally distributed. Multicollinearity has been tested by the value of Variable Inflation Factor (VIF). Durbin-Watson test has been used to test the phenomenon of autocorrelation. Regression analysis and all these tests have been done on SPSS software.

Results and Discussions
The estimated parameters of the production function along with their standard errors and function's R²-value for different types of milch animals have been presented in Table 1.
Table 1: Estimated Parameters of Milk Production Function

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Local Cow</th>
<th>Crossbred Cow</th>
<th>Buffalo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant term</td>
<td>-3.47</td>
<td>-1.68</td>
<td>-2.43</td>
</tr>
<tr>
<td>Green Fodder</td>
<td>0.26</td>
<td>0.41</td>
<td>0.29</td>
</tr>
<tr>
<td>(0.057)</td>
<td></td>
<td>(0.106)</td>
<td>(0.065)</td>
</tr>
<tr>
<td>Dry Fodder</td>
<td>0.02</td>
<td>0.11</td>
<td>0.41</td>
</tr>
<tr>
<td>(0.082)</td>
<td></td>
<td>(0.129)</td>
<td>(0.263)</td>
</tr>
<tr>
<td>Concentrate</td>
<td>0.32</td>
<td>0.67</td>
<td>0.52</td>
</tr>
<tr>
<td>(0.049)</td>
<td></td>
<td>(0.076)</td>
<td>(0.063)</td>
</tr>
<tr>
<td>Labour</td>
<td>0.12</td>
<td>0.23</td>
<td>0.01</td>
</tr>
<tr>
<td>(0.079)</td>
<td></td>
<td>(0.138)</td>
<td>(0.071)</td>
</tr>
<tr>
<td>Miscellaneous Expenses</td>
<td>0.12</td>
<td>0.09</td>
<td>0.06</td>
</tr>
<tr>
<td>(0.064)</td>
<td></td>
<td>(0.083)</td>
<td>(0.069)</td>
</tr>
<tr>
<td>No. of Observations</td>
<td>30</td>
<td>32</td>
<td>38</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.73</td>
<td>0.81</td>
<td>0.69</td>
</tr>
</tbody>
</table>

(Figures in parentheses indicate the Standard Error of regression coefficients)

These Regression Coefficients have been tested for their significance. Results have been presented in Table 2.
Table 2: Test of Significance of Estimated Parameters of Milk Production Function

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Type of Animal</th>
<th>Reg. Coefficient</th>
<th>S.E.</th>
<th>Z-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Fodder</td>
<td>Local Cow</td>
<td>0.26</td>
<td>0.057</td>
<td>4.561**</td>
</tr>
<tr>
<td></td>
<td>Crossbred Cow</td>
<td>0.41</td>
<td>0.106</td>
<td>3.868**</td>
</tr>
<tr>
<td></td>
<td>Buffalo</td>
<td>0.29</td>
<td>0.065</td>
<td>4.462**</td>
</tr>
<tr>
<td>Dry Fodder</td>
<td>Local Cow</td>
<td>0.02</td>
<td>0.082</td>
<td>0.244</td>
</tr>
<tr>
<td></td>
<td>Crossbred Cow</td>
<td>0.11</td>
<td>0.129</td>
<td>0.853</td>
</tr>
<tr>
<td></td>
<td>Buffalo</td>
<td>0.41</td>
<td>0.263</td>
<td>1.559</td>
</tr>
<tr>
<td>Concentrate</td>
<td>Local Cow</td>
<td>0.32</td>
<td>0.049</td>
<td>6.531**</td>
</tr>
<tr>
<td></td>
<td>Crossbred Cow</td>
<td>0.67</td>
<td>0.076</td>
<td>8.816**</td>
</tr>
<tr>
<td></td>
<td>Buffalo</td>
<td>0.52</td>
<td>0.063</td>
<td>8.254**</td>
</tr>
<tr>
<td>Labour</td>
<td>Local Cow</td>
<td>0.12</td>
<td>0.079</td>
<td>1.518</td>
</tr>
<tr>
<td></td>
<td>Crossbred Cow</td>
<td>0.23</td>
<td>0.138</td>
<td>1.667</td>
</tr>
<tr>
<td></td>
<td>Buffalo</td>
<td>0.01</td>
<td>0.071</td>
<td>0.141</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Local Cow</td>
<td>0.12</td>
<td>0.064</td>
<td>1.875</td>
</tr>
<tr>
<td></td>
<td>Crossbred Cow</td>
<td>0.09</td>
<td>0.083</td>
<td>1.084</td>
</tr>
<tr>
<td></td>
<td>Buffalo</td>
<td>0.06</td>
<td>0.069</td>
<td>0.869</td>
</tr>
</tbody>
</table>

** Significant at 1 percent level of significance

Partial Regression Coefficients of green fodder and concentrates were found positive and significant for all types of milch animals, viz., local cow, crossbred cow and buffalo.

It indicates that milk production can be increased through effective feeding of green fodder and concentrates for all kinds of milch animals.
Partial Regression Coefficients of dry fodder, labour, and miscellaneous expenses were positive but non-significant for all kinds of milch animals.

In the light of these findings the first hypothesis for the study that all inputs affect milk production significantly is rejected.

In order to examine the resource-use efficiency, the MVP's of inputs whose regression coefficients were found statistically significant in estimated production function were compared with the unit price. To test the significance of deviation of MVP of an input from the unit price, Z-statistics was calculated. Results have been shown in Table 3.

**Table 3: Resource-Use Efficiency in Milk Production**

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Type of Animal</th>
<th>MVP</th>
<th>Diff.</th>
<th>S.E.</th>
<th>Z-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Fodder</td>
<td>Local Cow</td>
<td>0.364</td>
<td>-0.636</td>
<td>0.079</td>
<td>-8.051**</td>
</tr>
<tr>
<td></td>
<td>Crossbred Cow</td>
<td>0.529</td>
<td>-0.471</td>
<td>0.137</td>
<td>-3.438**</td>
</tr>
<tr>
<td></td>
<td>Buffalo</td>
<td>0.372</td>
<td>-0.628</td>
<td>0.083</td>
<td>-7.566**</td>
</tr>
<tr>
<td>Concentrate</td>
<td>Local Cow</td>
<td>2.798</td>
<td>1.798</td>
<td>0.428</td>
<td>4.201**</td>
</tr>
<tr>
<td></td>
<td>Crossbred Cow</td>
<td>0.878</td>
<td>-0.122</td>
<td>0.099</td>
<td>-1.232</td>
</tr>
<tr>
<td></td>
<td>Buffalo</td>
<td>0.609</td>
<td>-0.391</td>
<td>0.074</td>
<td>-5.284**</td>
</tr>
</tbody>
</table>

** Significant at 1 percent level of Significance

The resource-use efficiencies of green fodder for local cow, crossbred cow and buffalo were found to be negative and significant. It indicates over-utilisation of this input. Reduction in green fodder will not affect production adversely.
The difference between MVP and unit price of concentrates was found to be positive and significant for local cows. It indicates under-utilisation of concentrates in case of local cows. This input may increase milk production further.

In case of buffalo, this difference was negative and significant, indicating over-utilisation of concentrates. Therefore, feeding of concentrates can be reduced without affecting milk production.

In case of crossbred cows, concentrates were being fed efficiently and optimally as revealed by the insignificant deviation of MVP from the unit price.

In the light of these findings the second hypothesis that inputs are used efficiently for all types of milch animals, i.e., local cow, crossbred cow and buffalo is rejected.

**Conclusions**

The study concludes that green fodder and concentrates are contributing significantly to milk production in the case of all three types on dairy animals. Effective feeding of green fodder and concentrates will increase milk production in the study area. On the other hand, the contributions of inputs like dry fodder, labour and miscellaneous expenditures to milk production are not statistically significant in the study area. The resource-use efficiency of green fodder for all types of dairy animals has been found to be negative and statistically significant, indicating over-utilisation of green fodder in the study area. Reduction in green fodder feeding will not affect production adversely. Concentrates are being under-utilised in the case of local cows, and being over-utilised in the case of buffalo. However, it is being fed optimally in the case of crossbred cows in the study area.

It must be underlined that data have been collected in the winter season; it might have a bearing on the findings. In the light of these findings it is suggested that the milk producers must be educated on feeding balanced ration to their animals. It has potential to improve resource-use efficiency of different feed inputs and economic returns from milk production.

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