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Identifying Technical Efficiency of Dairy Cattle Management in Rural Areas Through a Non-Parametric Method: A Case Study for the East Mediterranean in Turkey

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Abstract: There are many aspects regarding the success of dairy cattle management and productivity. In this study, amount and kinds of feed, costs of veterinary consultancy, herd size, labor and capital were utilized to estimate technical efficiency of dairy cattle management in small scale farms in the east Mediterranean region of Turkey. A non-parametric efficiency analysis was used for the data obtained through face-to-face interviews in 100 small scale farms. We used tobit regression analysis to determine the effectiveness of possible factors affecting production performances of the farms. The results suggested that the average technical efficiency is unsatisfactory since Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) values are relatively <1 (0.59 and 0.83, respectively). Only 13 and 46% of the farms were found to be efficient in terms of CRS and VRS, respectively. Data Envelopment Analysis (DEA) showed that the farms had excess input usage ranging from 10-22%. To increase efficiency scores in subsidiary profit farms in semi-arid east Mediterranean conditions, farmers should adopt new methodologies, which decrease the costs and excess input usage in such semi-pasture management systems.

Key words: Dairy cattle management, technical efficiency, rural development, data envelopment analysis, tobit regression, Turkey

INTRODUCTION

The dairy cow has long been proclaimed as the most efficient among farm animals. Animal husbandry constitutes 60-70% of the total agricultural income in the most developed countries, while it was as low as 25% in Turkey (Anonymous, 2006). Rural population and agricultural employment are about 30% of total Turkish population or employment and per capita income in rural areas was ¼ of the average income (Anonymous, 2006). Cattle management is a major animal husbandry practice and dairy cattle production forms 40% of the total cattle production in Turkey. Turkey is one of the bigger cattle producing countries and it is ranked 8th in the world and 3rd in the OECD countries in terms of cattle numbers. However, dairy production and yield are not in the desired levels and urgent cautions should be taken especially to increase the dairy yield. Instead of local lineages, increasing the ratio of high yielding hybrid cattle number in the populations is one of the solutions to elevate the milk yield (Hoglund, 2006). In Tanzania conditions, mixing herd with crossbred and grade cattle, farmers increased the benefit/cost ratio by 20% by just using farm leftovers (Mdoe and Wiggins, 1998). In another mediterranean environment, technical efficiency scores of dairy farms were analyzed by DEA with input oriented model approach and only few farms were found to be efficient in Azores, Portugal (Silva *et al*., 2004). High input usage efficiency and adopting new technologies in dairy farms should increase the international competition for dairy

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products (Tauer *et al*., 2006). Efficiency improvement of dairy farming has also been in the European Union's (EU) agenda and it requires several issues for the integration to EU that rural areas develop themselves on their own and agricultural employment and animal production should be increased. For this aim, World Bank introduced the project of social support for rural areas in 2003 for developing countries. One of the aim of this project, was to organize people in rural areas and to constitute an economic model in terms of cooperatives. To observe the changes, at least 2 pregnant cows were delivered to member farmers through cooperatives. Therefore, dairy cattle production improvements will be achieved and a better income return will be provided compared to sole plant productions. Another purpose of the project, was to increase the income in rural areas therefore, decreasing the poverty and irregular migration to urban areas.

The objective of this study, was to identify a technical efficiency of the dairy cattle management, supported by project of World Bank, in rural areas of the east Mediterranean which is of great potential to improve dairy cattle management. For this aim, 2 provinces, Adana and Hatay representing typical east Mediterranean conditions, were chosen and of the total dairy cattle, 11% were high yielding varieties, 68% were hybrids and 21% were local lineages. Although, the region is suitable for range and forage plant production, livestock production and management were not satisfactory. We especially, chose this region since it has adequate labor, suitable climate and production patterns founding great potential for improving dairy production despite very uneven income distribution (Dagistan *et al*., 2005). This study will also, be the most recent evidence to review the input usage efficiency in dairy cattle management in small scale farms in Turkey.

MATERIALS AND METHODS

Data envelopment analysis is a nonparametric method broadly used in efficiency measurement studies (Battese, 1992). In this method, each production unit is given an efficiency score based on its distance to a production frontier constructed through linear programming model (Battese, 1992). One advantage of DEA is that there is no need for specifying a distributional form for the production function and the inefficiency term. That is, no explicit functional form is assumed for the basic production technology in DEA (Hansen *et al*., 2002).

An input oriented BCC (Banker-Charnes-Cooper) model is given below for N Decision Making Units (DMU), each producing M outputs by using K different inputs (Coelli *et al*., 2005):

$$\text{Min}_{\theta,\lambda} \quad \theta$$

subject to

$$-y_i + Y\lambda \geq 0$$
$$\theta x_i - X\lambda \geq 0$$
$$N1'\lambda = 1$$
$$\lambda \geq 0$$

where:

θ = A scalar
N1' = Convexity constraint
λ = A vector of N×1 constants

The input and output matrices are represented by Y and X, respectively. The value of θ is the efficiency score for the ith farm. This linear programming problem must be solved N times, once for each farm in the sample. A θ value of one indicates that the farm is technically efficient according to the Farrell (1957) definition.

The technical efficiency score ratio measures the Scale Efficiency (SE), which is obtained from DEA under CRS (Constant Return to Scale) and VRS (Variable Return to Scale) assumptions. For very inefficient and very efficient farms, the value of SE is close to 0 and 1, respectively (Coelli, 1996, 1997).

To standardize the number of animals in each farm, Animal Unit Equivalent (AUE) for cattle was calculated based on metabolic weight (Manske, 1998). Following formula used for calculation of AUE:

$$((\text{Live animal weight})^{0.75})\ 1000^{-0.75} = \text{Animal Unit Equivalent}$$

Data are obtained from the families who were provided with milk cows by rural support project in Turkey. Inquiries are done through random sampling method through face-to-face interviews on 100 farmers in the rural areas of Adana and Hatay provinces. Information about land size, number of farmers and cows were obtained from State Institute of Statistics (SIS). Detailed socio-economic profile of the farms was depicted in Table 1. Each farmer was provided with at least 2 pregnant cows. Data Envelopment Analysis (DEA) was used in subsidiary production activities of farms. In this analysis, output was milk production (L), inputs are forage and concentrate feed (kg), veterinarian and medicine costs (US dollars; \$), cow number (i.e., AUE), manpower (h) and capital (U.S. Dollars). Data Envelopment Analysis 2.1 DEAP version was used (Coelli, 1997; Jaforullah and Premachandra, 2004). Investigated farms under rural development project were similar to each other in terms of ages and lineages of animals, duration of animal stay and feed quality. The average technical efficiency scores were

Table 1: Socio-economic characteristics of farms

Variables	Mean
Average population in farm (person)	4.10
Male	51.60
Female	48.40
Farmer's education (year)	5.67
Farmer's cow growing experience (year)	16.80
Farmer age (year)	43.20
Average planting area (ha)	2.20
Farm out agricultural income ($)	254.00
Non-agricultural income ($)	439.00

assessed by Constant Returns to Scale (CRS) or Variable Returns to Scale (VRS) values and the more they are close to one, the higher technical efficiency is. Tobit regression analysis was used to determine the influence of probable factors affection production performances of the farms.

RESULTS AND DISCUSSION

There were differences among farms in production, size, inputs and capitals. As shown in Table 2 total milk production could be as much as 56 folds between the smallest and largest farm under investigation. The least difference (8 folds) was obtained on labor (Table 2). The summary statistics on Table 2 showed that as the farm got larger, it became more input use (especially labor) efficient. For example, the smallest farm produced 960 kg milk cow^{-1}, while the largest one produced 3085 kg of milk cow^{-1}. The former needed 1 h labor to produce 1.6 kg milk while, the latter produced 10.7 kg. There also, seemed big differences in income distribution since the difference in the capital between smallest and largest farm was 1000 folds. However, when considering the factors such as high labor and veterinary costs, larger farms could be inefficient compared to medium size farms, thus, a more comprehensive analysis was needed in order to assess feasibility of dairy farming in small scale farms. Therefore, we investigated input-output relationship in all farms and found that out of 100, only 15 farms were technically efficient in terms of input usage (Table 3). We obtained relatively lower mean scale efficiency (72%, Table 3) compared to previous reports in Australia (88%) and Scotland (84%) (Kompas and Che, 2004; Barnes, 2006). About 30% of the farms in Scotland, doubling the farms in our region, were technically efficient. Probably, more developed infrastructure, pasture areas and improved management could be the cause of such difference. Frequency distribution of technical efficiency scores also showed that 13 and 46 farms were efficient in terms of CRS and VRS values, respectively.This may indicate that as the farmers increased their inputs to an optimum level they had more milk and used their sources efficiently (Table 3). Namely, looking at the mean value of CRS (0.59), which was well below 1 and not technically efficient,

Table 2: Summary statistics for variables used in the efficiency analysis

Variables	Min.	Max.	Mean	SD
Output				
Milk production (kg)	960	54000	11033	10135
Inputs				
Purchased feedstuff (kg)	2280	103780	14407	16607
Farm produced feedstuff (kg)	667	41000	8754	8024
Veterinary cost ($)	8.1	1620	262	300
Herd size (AUE)	1.0	17.5	3.8	3.2
Labor (h)	600	5025	2102	1059
Capital ($)	12.2	11907	2650	2452

Table 3: Frequency distributions of technical efficiency scores obtained with DEA model

Efficiency scores	DEA CRS	VRS	SE
1.00	13	46	15
0.90-1.00	4	7	19
0.80-0.90	6	8	10
0.70-0.80	6	10	4
0.60-0.50	14	12	16
0.50-0.60	14	8	15
0.40-0.50	21	5	14
0.30-.040	8	4	4
<0.30	14	0	3
Minimum	0.14	0.35	0.14
Maximum	1.00	1.00	1.00
Mean	0.59	0.83	0.72
SD	0.24	0.20	0.23

Table 4: Excess input usage

Input	No. farms	Mean input waste	Mean input use	Excess input use (%)
Purchased feedstuff (kg)	39	1380	14407	9.58
Farm produced feedstuff (kg)	27	614	8754	7.02
Veteniary cost ($)	35	58	262	22.21
Herd size (AUE)	26	0.2	3.8	5.46
Labour (h)	28	185	2102	8.80
Capital ($)	39	544	2650	20.52

farmers need to use their sources optimally. Variable returns to scale mean supported such idea since, addition of inputs to some extend increased the efficiency. However, more inputs did not mean more milk production or that sources were efficiently used. Excess input usage tended to decrease the efficiency of many farms. For example, excess use of forage and concentrate feed in 27 and 39 farms decreased the efficiency by 7-10%, respectively (Table 4). In about 40% of the farms, higher input misuses were on veterinary costs (22.18%) and capital (22.52%) (Table 4). The reason for excess veterinary costs was that animals were delivered to farmers through the project and they are required to be under insurance, therefore, farmers did not want to risk the animals' lives and consulted the veterinarian in any case. Namely, more money was spent than it was required to provide better conditions to have the animals from the project. Excess labor usage (8.8%) could be attributed to unemployed people in the farm. Consultancy or extension services could be provided by Ministry of Agriculture for

Table 5: Characteristics of farms with respect to returns to scale scores

Variables	No. farms	Cow number (AUE)	Mean herd size (AUE)	Mean production (kg cow^{-1})
Sub-optimal	79	2.38	3.42	3351
Optimal	16	4.19	5.31	5544
Super-optimal	5	7.00	10.42	4066

Table 6: Results of Tobit Regression Analysis

Variable	Coefficient	SE	Significance (p<F)
C	0.92430	0.09140	0.0000
Experience	0.00120	0.00150	0.4001
Education Level	0.00450	0.00750	0.5482
Benefit/cost ratio	0.09580	0.03410	0.0050
Farm out agricultural revenue	-0.00005	0.00002	0.0055
Population	-0.00790	0.00950	0.4086
Cowl number	-0.02640	0.00490	0.0000
Total land	-0.00070	0.00040	0.1090
Farmer age	-0.00120	0.00150	0.4320

optimum feeding conditions, animal health and management systems. Therefore, we also classified the farms as sub-optimal, optimal and super-optimal with respect to return scale scores and identified that most of the farms (79%) had Increasing Returns to Scale (IRS) scores and only 21% seemed to be profitable for dairy farming (Table 5). This indicated that profitability, in small scale farms, was strictly dependent upon increased investment for dairy farming while avoiding excess input usage. However, decreasing returns to scale in 5% of the farms indicated that such farms should reduce the input usage to come to a profitable level (Table 5).

We also, performed tobit regression analysis to find the influence of other factors on technical efficiency of the farms (Table 6). Analysis showed that benefit/cost ratio, agricultural revenue and animal number are the significant factors ($p<0.01$) affecting the technical efficiency (Table 6). Each 1% increase in benefit/cost ratio will result in 2.5% increase in scale efficiency (Table 6). This was expected since animal number increased while cost decreased the profitability and efficiency of the farms increased. However, increased number of animals in the farms per se makes crop based farms compete with dairy production. Therefore, resource allocations could not be easily arranged. Increased, agricultural revenue negatively affected the technical efficiency (Table 6). This was probably, due to that the farms with higher agricultural income had tendency towards intensive crop production and neglected the dairy cattle production. Although marginally significant ($p<0.11$), land size negatively affected the technical efficiency of the dairy farming for similar reason (Table 6). This may be the result of high numbers of low yielding cattle in the herds and insufficient areas allocated for feed crops.

CONCLUSION

This study is carried out in the east Mediterranean Area to determine the effectiveness of the resource allocation in milking cows in small scale farms through social support project in rural areas. Our results suggested that dual-purpose dairy cattle system is a profitable way for the development of rural areas although, efficiency level was below desired levels. The technical efficiency scores we obtained from the analyses could be improved by increasing pasture areas and providing more feed crops to farmers. Additionally, enhanced agricultural extension and supervising systems could increase the farmers knowledge about the dairy production. Increasing the high yielding hybrids and grade cattle numbers in herds could also increase the subsidiary revenue for such dual purpose farming systems. Minimizing the input cost, benefit/cost ratio would be increased as with technical efficiency, therefore, policy interventions encouraging to minimize the input costs could be implemented. Our study suggested, solutions to several problems to increase the dairy production efficiency as well as income of the people in small scale farm in the presented.

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