Analysis of ınput usage efficiency in dairy cattle enterprises: a case study of Turkey

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Ahmet Duran Çelik
Asst.Prof.Dr.
Institution: Hatay Mustafa Kemal University
Address: Faculty of Agriculture, Department of Agricultural Economics, P.O.Box: 31060. Hatay, Turkey.
E-mail: **ahmetdurancelik01@hotmail.com**

Abstract

This study aimed at analyzing the factors which affect the milk production amount in the Hatay province by means of the functional analysis. Within the study, data from 141 dairy cattle enterprises in the Hatay province were used as the main material, which were chosen by the Stratified Sampling Method. According to the research results; the number of cattle average per enterprise was 11,04, the dairy cattle average per enterprise was 4,87, the annual milk production amount average per enterprise was 27 tons, and milk production per dairy cattle was 18,7 lt. According to analysis results based on the Cobb-Douglas production function; roughage, concentrate feed, cereal grains, labor force usage, and veterinary and medicinal expenses were found to affect the milk production amount during the lactation period positively. The production elasticity total of the variables in the estimating equation was found as (Σbi) 1,225, which indicates increasing returns to scale. Among the variables of the equation, roughage was found to have the highest efficiency coefficient with 3,18. According to the values obtained from the ratio of technical substitution levels of the production factors to the price levels, input combinations used in production were found economically improper. In other words, resource utilization of the factors in milk production in the research area was not at a rational level. In order to carry out more profitable milk production activities in the research area; the enterprises could concentrate on growing more forage plants on their fields, and using their own cereal grains in forage rations. Additionally, it's important for the enterprises to increase the level of the pure breed/pure breed cross ratio in the herd population.

Keywords: Dairy cattle. Cobb-Douglas. Efficiency coefficient. Technical substitution level. Turkey.

1. Introduction

Agricultural production is an important part of countries' economies when considered with development aspects. Agricultural production is an organic unity, and in this unity, livestock breeding has an indispensable importance in terms of enterprise profitability. Livestock breeding contributes to agricultural enterprises in many ways such as; utilization of other main or waste products (manure, hay, etc.) which are produced in the enterprise, balanced labor force usage, providing cash-flow throughout the year, helping to spread risks, providing food products to farmers' families such as meat, milk, cheese and yogurt, and providing social benefits by helping to decrease rural immigration. Besides, livestock breeding contributes to the national economy by providing raw material to agricultural industries and accordingly contributes to agricultural foreign trade. In other words, livestock breeding has important contributions to the national economy at the macro and micro economic levels (Aslan, 2000; Öztürk ve Karkacıer, 2008).

According to FAO data of 2017; the number of cattle in the world was 675,621,017 and Turkey's ratio in this number was 0.94%, the number of milk cow in the world was 278,014,136 and Turkey was 13th with a 2.15% proportion. The global milk production in 2017 was 1,491,687,239 tons and Turkey was 9th in the world with a 2,78% proportion (FAO, 2019).

Milk production is one of the agricultural activities in Turkey that provides high added value to the national economy. In 2018, 44.25% of Turkey's total livestock production value (79.1 billion TL) consisted of milk production (TSI, 2019a,b). In the same year, Turkey's milk production amount was around 22.1 million tons of which; 90,58% was cow milk, 6.45% was sheep milk, 2.54% was goat milk, and 0.34% was water buffalo milk (USK, 2019). The number of Turkey's cattle existence in 2017 was around 17 million; 49.40% was pure breed, 41.25% was pure breed cross, and 9.35% consisted of native breed (TSI, 2019c). According to both FAO and Turkish Statistical Institute (TSI) data, dairy cattle breeding activities in Turkey have developed significantly. However, the milk yield level has not increased as desired. Thus, according to FAO data, between 2003 and 2017 Turkey's cattle existence increased by 44%, and milk production increased by 97%. However, in terms of milk yield, Turkey is 57th in the world with 3.1 tons. According to TSI data, the increase ratio of milk yield between 2004 and 2018 was only 27% (Semerci et al., 2020).

Efficient input usage and productivity have significant importance in terms of national, economic, and rural wealth. It is possible to decrease production costs, and to increase productivity and producer income by determining the optimal factor combinations which are used in production (Akçay and Uzunöz, 1999) .

2. Literature Review

In literature there are different studies in the world and Turkey about milk production cost, and analyses of the factors that may affect the gross output value (GOV).

Kopecek (2002) carried out a study in Czechia on 135 agricultural enterprises about economic and technical analyses of milk production.

Poldaru et al. (2005) analyzed milk cost in Estonia by using the SVM regression method, and suggested that SVM regression methods should be used widely in agricultural research.

Bayramoğlu and Direk (2006) aimed at finding the milk production cost, and rationality level of resource usage in agricultural enterprises that were members of the agricultural development cooperative in the Konya province.

Wieck and Heckelei (2007) carried out a study to examine marginal cost differences in dairy cattle enterprises in selected regions of the EU. Within the study, affects of regional differences on input and output prices, and the affects of stable factors on marginal costs were presented.

Gonçalves et al. (2008) analyzed the technical and scale efficiencies of milk production at different stages in dairy cattle enterprises in the Minas Gerais region of Brasil.

Gündüz and Dağdeviren (2011) carried out a study in the Samsun province of Turkey. The Cobb-Douglas production function analysis results indicated that the number of dairy cattle and concentrate feed usage significantly affect the milk production amount, and among the factors, the number of dairy cattle had the highest marginal efficiency. Also, increasing return to scale was another finding of the study.

Venkatesh and Sangeetha (2011) aimed to research the cost structure and resource usage efficiency of dairy cattle enterprises in the Tamil Nadu state of India.

Pandian ve ark. (2013a) also carried out a study in the Tamil Nadu state of India to analyze resource usage efficiency in dairy cattle enterprises by using the Cobb-Douglas method.

In addition to the studies mentioned above, in recent years there were studies that focused on the technical efficiency in dairy cattle breeding (Alvarez et al., 2014; Gül et al., 2018; Torres-Inga et al., 2019).

This study aimed at examining dairy cattle enterprises in the Hatay province in terms of factors which affect milk production such as roughage, concentrate feed, cereal grains, labor force usage, veterinary and medicinal expenses, and milk yield per lactation period. In order to achieve that purpose, besides the analysis of inputs at the functional level; the marginal yield, marginal income, marginal efficiency coefficients, marginal technical substitution ratios of factor combinations, and price ratios were comparatively analyzed with the previous studies' results.

3. Materials and Methods

3.1. Materials

The main material of the study consists of primary data which were collected from 141 dairy cattle enterprises in the Hatay province with a 3,5% margin of error, and at a 95% confidence interval. Also within the study are secondary data used from statistical institutions' (FAO, TSI) reports, as well as previous studies related to the topic. The data were analyzed by electronic calculation tables, and proper statistical softwares. The findings of the research were comparatively analyzed with previous studies.

3.2. Methods

3.2.1. Sampling Method

In order to determine sample size, information about the enterprises in the province were gathered from the cattle database of The Hatay Directorate of Provincial Agriculture and Forestry. Within the study, the Neyman Method which is one of the "Stratified Layered Sampling Methods", was used in order to determine the sampling frame and sample size (Yamane, 1967). The formula of the method is given below:

$$n = \frac{\Sigma(NhSh)^2}{N^2 D^2 + \Sigma Nh(Sh)^2}$$

n= Sample size

Nh= Number of enterprises at hth layer

Sh= Standard deviation at hth layer

Sh^2= Variation of data at hth layer

t= "t value" at a certain confidence limit

N= Total enterprise number that belongs to the sampling frame

D= d/z

d=Deviation ratio from average

The formula below was used in order to distribute the sample size to the layers;

$$n = [(Nh * Sh) * n] / \Sigma(Nh * Sh)$$

The enterprises in the research area were divided into 3 groups based on the number of dairy cattle that they have. The distribution of the groups were; 1st group: 3 to 5 cattle, 2nd group: 6 to 10 cattle, and 3rd group: 11 or more cattle. The research was carried out in 24 villages from 12 districts considering the number of dairy cattle and the amount of milk produced. Distribution of the 141 surveys into the groups were as follows; 27 surveys in the 1st group, 32 surveys in the 2nd group, and 82 surveys in the 3rd group.

3.2.2. Functional Analysis Method

Production functions have been increasingly used in recent years in order to utilize scarce resources more efficiently. Therefore, the Cobb-Douglas production function is one of the functions that is being used widely in agricultural economic studies (Debertin, 2012). The Cobb-Douglas production function is a differentiable and two way logarithmic function which is used in industry and economics. In the equation, each **X** variable coefficient gives partial elasticity of the **Y** dependent variable. The equation is given below (Gujarati ve Porter, 2014):

$$Y = aX1^{b1}X2^{b2}X3^{b3}\dots Xn^{bn}$$

In the equation; **Y** is output, $\mathbf{X_i}$ is each production factor, and $\boldsymbol{\beta_i}$ is elasticity coefficients of production functions. The linear formula of the Cobb-Douglas function is as follows:

$$\log Y = \log \alpha + \beta 1 logx1 + \beta 2 logx2 + \dots + \beta k logxk + e^u$$

The significance level of the elasticity is tested by the formula below:

$$t\,\beta i = \beta i / se(\beta i)$$

In the regression equation of milk production; multiple regression (R) and coefficient of determination (R^2), elasticity coefficients of independent variables (β_i), standard errors ($s_e\beta i$) and significance levels ($t\beta_i$), geometric averages of the variables (X_iG, YG), simple correlation coefficients (ri_j) with standard deviation (S) of the equation and it's significance level (F) were analyzed by the proper statistical analysis software. Within the study in relation to the estimation equation; coefficient of determination (R^2), significance tests of partial correlation coefficients (b_i), and autocorrelation and multicollinearity tests were also carried out.

The formula that was used to calculate the Marginal Physical Productivity (MPP) of any input in milk production is given below (Singh et al., 2004; Mobtaker et al., 2010; Rafiee et al., 2010). In the equation; *MPPxj* is the marginal physical productivity of an input, *αj* is the regression coefficient of an input, *GM(Y)* is the geometric average of the dependent variable, and *GM (Xj)* is the geometric average of inputs.

$$\mathbf{MPPXij} = \boldsymbol{\beta}\mathbf{ij} * GM(Y)/GM(Xi)$$

Geometric averages are used in the Cobb-Douglas model. Marginal Revenue (MR) of any input (X_i) was calculated by the formula below (Singh et al., 2004; Mobtaker et al., 2010; Rafiee et al., 2010):

$$MjRxj = \beta j * \frac{GM(Y)}{GM(Xij)} * Fy$$

Marginal Efficiency Coefficients (MEC) indicate whether or not each factor is being used efficiently. The equation that was used in the calculation of the Marginal Efficiency Coefficient is given below (Singh et al., 2004; Mobtaker et al., 2010; Rafiee et al., 2010):

$$MEC = \frac{Marginal\ Factor\ Revenue}{Marginal\ Factor\ Cost\ (Factor\ Price\ or\ Opportunity\ Cost)}$$

EC = 1 indicates efficient factor usage (MR=MC).

EC > 1 indicates underuse of a factor, and it should be increased (MR>MC),

EC < 1 indicates overuse of a factor, and it should be decreased (MR<MC)

In order to find the optimum factor combinations, besides the rate of substitution ($MRS_{X1}/_{X2}$), price rates of the factors should be taken into consideration (P_{X1}/P_{X2}). Thus, within the study, the equation below was used (Heady and Dillon, 1961; Doll and Orazem, 1984).

$$MRS_{x_1,x_2} = \frac{\partial X_2}{\partial X_1} = \frac{MP_{X_1}}{MP_{X_2}} = \frac{b_1 X_2}{b_2 X_1} = \frac{P_{X_1}}{P_{X_2}}$$

In the equation, the case of $MRS_{(x1/x2)} > (P_{X1}/P_{X2})$ indicates overuse of the X_1 factor in proportion to the X_2 factor, and in order to equalize the rate of substitution $MRS_{(x1/x2)}$ with the factor price rate (P_{X1}/P_{X2}), the factor combination should be adjusted in favor of the X_2 factor.

In the study, the Cobb-Douglas production function was used to define relationships between milk production amount (Y) and inputs (X) (Heady and Dillon, 1961). The variables of the model are as follows:

Log Y: Milk production amount per enterprise (lt).

Log X_1: Roughage amount per enterprise (kg).

Log X_2: Concentrate feed amount per enterprise (kg).

Log X_3: Cereal grain amount per enterprise (kg).

Log X_4: Labor force usage per enterprise (hour).

Log X_5: Veterinary and medicinal expenses per enterprise (USD).

Log X_6: Milk yield per dairy cattle (lt $year^{-1}$).

4. Results and Discussion

4.1. Animal Existence in the Research Area

Changes in animal existence between a year's beginning and a year's end is an important subject in dairy cattle breeding. Thus, generational change in a herd also makes a change in the fixture value of animal existence. The herd composition of the research area is given in Table 1.

Table 1: Animal Existence in the Research Area (Herd Composition)

	Calf	Cattle (m)	Cattle (f)	Heifer	Bullock	Cow	Bull	Total

Year beginning	49	65	292	126	16	777	13	1.338
Purchased	214	0	0	51	0	28	0	293
Born	738	0	0	0	0	0	0	738
Died	24	4	7	2	1	25	0	63
Butchered	0	14	12	7	20	22	4	79
Sold	98	222	61	48	34	201	7	671
Year end	293	65	151	326	16	687	18	1.556

In the research area, the year's beginning total of animal existence was 1.338, and the year end total was 1.556 with an increase of 16,29%. The number of cattle average per enterprise was 11,03 head, and the distribution of them were; 4,87 cow, 2,31 heifer, 2,08 calf, 1,53 cattle (female and male), 0,13 bull, and 0,11 bullock.

In the research area, the total gross output value of dairy cattle breeding was 2,2 million USD. The proportional distribution of this value were; milk and milk products at 83%, the productive fixture value increase was 12%, manure income was 4%, and the milk premium payment was 1%.

4.2. Functional analysis of milk production

In the study, regression analysis was carried out in order to determine affects of some inputs on milk production. The regression model, the coefficients of the variables in the model, and their significance levels are given below:

$$Y = -2,253 * X_1^{0,228} * X_2^{0,183} * X_3^{0,284} * X_4^{0,139} * X_5^{0,144} * X_6^{0,247}$$

The determination coefficient of the function was R^2 = 0,868, ($F_{calculation}$146,76 > F_{table}2,80) and it was found significant at a 1% possibility level.

The determination coefficient indicates that 87% of the changes in the milk production amount (Y) are explained by the variables in the model (Table 2,3).

Table 2: Variance Analysis of Milk Production Function

	DF	SS	MS	F	P
Regression	6	9,965	1,661	146,76	0,000
Residual	134	1,516	0,011		
Total	140	11,482			

Durbin Watson-D Statistics (DW_h 2,069=4- DW_h)=1,931

Table 3: Milk Production Function and Significance Levels After Regression Analysis

Variables	Coefficients	Standard Errors (S_e)	"T Value"	"P Value"
Constant	-2,253	0,464	-4,853	0,000
X_1	0,228	0,035	4,541	0,000
X_2	0,183	0,049	3,359	0,001
X_3	0,284	0,032	5,585	0,000
X_4	0,139	0,070	3,415	0,001
X_5	0,144	0,034	3,595	0,000
X_6	0,247	0,134	7,186	0,000

S =0,106, R^2 = % 86,80, Adjusted R^2 = % 86,20, F:146,76 (P>0.01)

Variables of the model were found statistically significant at 1%. Coefficients of the function indicate that an increased level in the dependent variable when there is a 1 unit change, occur in one of the independent variables while other variables are stable. Within the study, the Durbin Watson-D statistical value was calculated as 1,931, and there was no autocorrelation detected due to the Durbin Watson-D statistical value being over the D_u value (DL1,530 ve DU 1,722).

The correlation matrix of the variables in milk production function is given in Table 4. The correlation between the dependent variable and independent variables was found statistically significant at a 1% significance level (the correlation value between yield and health expenses was at 5%). According to the correlation analysis results in Table 4, there was no high correlation (0,80 and over) between variables, which indicates that there was no multicollinearity.

Table 4: Correlation Coefficients Between Variables in Production Function

Variables	Y (Milk Production)	X_1 (Roughage)	X_2 (Concentrate Feed)	X_3 (Cereal Grains)	X_4 (Labor Force)	X_5 (Health Expenses)
X_1	0,795(*)	-	-	-		
X_2	0,791(*)	0,699(*)	-	-		
X_3	0,784(*)	0,661(*)	0,761(*)	-		
X_4	0,659(*)	0,589(*)	0,492(*)	0,504(*)		
X_5	0,633(*)	0,567(*)	0,560(*)	0,490(*)	0,451(*)	
X_6 (Yield)	0,550(*)	0,352(*)	0,334(*)	0,280(*)	0,354(*)	0,221(**)

(*): Significant at 1%, (**): Significant at 5%.

Some descriptive statistics (arithmetic mean, geometric mean, maximum and minimum values, standard deviation) about the variables which are used in milk production, and took place in estimating equations are given in Table 5.

Table 5: Descriptive Statistics about the Variables in Estimating Equation (Enterprise Means)

Variables	Arithmetic Mean	Geometric Mean	Max.	Min.	Std. Deviation
Y (Milk Production-lt)	21.214,10	20.771,39	178.200,00	6.000,00	1,93
X_1 (Roughage-kg)	7.972,54	7.610,01	472.800,00	1.200,00	2,55
X_2 (Concentrate Feed-kg)	7.857,29	7.633,43	101.145,00	1.350,00	2,06
X_3 (Cereal Grains-kg)	8.548,94	8.027,52	132.615,00	640,00	2,81
X_4 (Labor Force-Manpower)	424,38	419,67	2.193,75	273,75	1,47
X_5 (Health Expenses-USD)	1.186,61	1.138,71	13.225,00	225,00	2,15
X_6 (Yield-lt)	5.329,90	5.321,05	7.500,00	3.000,00	1,18

According to the research results, the production elasticity total of the variables in the estimating equation was found as (Σbi) 1,225 which shows increasing returns to scale. In the event of a 10% increase in variables of the function, it would make a 12,25% increase in the gross output value.

Marginal elasticities of the variables from the production function are explained below:

X_1 (Roughage): This production factor had a positive sign, and it was found statistically significant to explain the milk production amount. While other factors were stable, if a 10% increase in roughage amount were used, it would make a 2,28% increase in the milk production amount.

X_2 (Concentrate Feed): This production factor had a positive sign, and was found statistically significant to explain the milk production amount. While other factors were stable, in the event of a 10% increase in the concentrate feed usage amount, it would make a 1,83% increase in the milk production amount.

X_3 (Cereal Grains): This production factor had a positive sign, and was found statistically significant to explain the milk production amount. While other factors were stable, in the event of a 10% increase in the cereal grain usage amount, it would make a 2,84% increase in the milk production amount.

X_4 (Labor Force): This production factor had a positive sign, and was found statistically significant to explain the milk production amount. While other factors were stable, in the event of a 10% increase in labor force usage, it would make a 1,39% increase in the milk production amount.

X_5 (Health Expenses): This production factor had a positive sign, and was found statistically significant to explain the milk production amount. While other factors were stable, in the event of a 10% increase in health expenses, it would make a 1,44% increase in the milk production amount.

X_6 (Verim): This production factor had a positive sign, and was found statistically significant to explain the milk production amount. While other factors were stable, in the event of a 10% increase in the yield amount in a lactation period, it would make a 2,47% increase in the milk production amount.

Efficiency coefficients and marginal values about the factors which are used in milk production in the research area are given in Table 6. Within the study, geometric means of Y and X variables were taken into consideration in order to calculate the average product.

Table 6: Efficiency Coefficients and Marginal Values of the Factors

Y = 22.214,10 lt	**X_1 (Roughage)**	**X_2 (Conc.Feed)**	**X_3 (Cereal Grains)**	**X_4 (Labor Force)**	**X_5 (Health Expenses)**	**X_6 (Yield)**
Geo.Mean	7.972,54	7.857,29	8.548,94	424,38	1.186,61	5.329,90
Mrgl. Yield	0,635	0,517	0,738	7,276	2,696	1,029
Mrgl. Income	0,286	0,233	0,332	3,274	1,213	0,463
Factor Price	0,090(*)	0,420(*)	0,340(*)	14,080(**)	1,055(***)	1,055(***)
Effcy. Coeff.	3,176	0,554	0,977	0,233	1,15	0,439

(*): USD/kg; (**): USD/Manpower/Day; (***): Republic of Turkey-Agricultural Bank Interest Ratio for Livestock Breeding (%).

According to the analysis results (Table 6), labor force (X_4) provides the highest marginal income, followed by health expenses (X_5). The Efficieny Coefficient (EC) helps to decide whether the usage amount of a factor should be increased or decreased. EC = 1 indicates efficient factor usage, EC > 1 indicates underuse of a factor, and should be increased, EC < 1 indicates overuse of a factor, and should be decreased (Akçay and Uzunöz, 1999). Therefore, analysis results indicate that in order to achieve the economically optimum level in milk production; roughage (X_1) and health expenses (X_5) usage amounts should be increased, and concentrate feed (X_2) and labor force (X_4) usage amounts should be decreased. Among the factors in the production function, cereal grains (X_3) was found as the only variable that was being used at the optimum level.

The main reason for the low efficiency coefficient (EC<1) was the existence of native breed animals in enterprises' dairy cattle population. Nonetheless, efficiency levels of püre breed and pure breed cross cattle were far below other provinces and developed countries. Therefore, in order to increase the milk production amount, the number of pure breed and pure breed cross animals with high efficiency levels should be increased in herd populations.

Marginal technical substitution levels of the factors indicate the combination amount of each factor in order to achieve the "Y" production amount. A positive elasticity sign indicates a substitutional relationship between production factors in the function. Marginal technical substitution levels of the factors are given in Table 7.

Table 7: Marginal Technical Substitution Levels of the Factors (MTSL)/Price Levels (PL)

Factors	Indicators	X_2 (Conc. Feed Amt.)	X_3 (Cereal Grains Amt.)	X_4 (Labor Force)	X_5 (Health Expenses)	X_6 (Yield)
X_1 (Roughage)	MTSL (MTSL /PL)	-6,632 -1,400	-9,461 -2,497	-93,281 -0,591	-34,561 -0,088	-13,198 -1,116
X_2 (Concentrate Feed)	MTSL (MTSL /PL)	-	-1,426 -1,783	-14,070 -0,422	-0,063 -5,214	1,991 -0,572
X_3 (Cereal Grains)	MTSL (MTSL /PL)		-	-9,859 -0,237	-3,653 -0,035	-1,395 -18,623
X_4 (Labor Force)	MTSL (MTSL /PL)			-	-0,371 -0,148	0,141 -1,889
X_5 (Health Expenses)	MTSL (MTSL /PL)				-	-0,382 -12,745

In terms of the substitutional relationship between roughage (X_1) and concentrate feed (X_2); while other factors are kept stable at their geometric average levels, the roughage usage amount should be decreased by 6,63 kg in return for a 1 unit increase in concentrate feed.

The substitutional relationship between roughage (X_1) and cereal grains (X_3) was found as -9,46 which means that a 9,46 kg decrease in roughage usage amount in return for a 1 unit increase in cereal grains would provide the same production level. Substitutional relationships between other factors could be commented on in the same way.

In order to present the economic aspect, MTSL/PL ratios were examined, and only the roughage (X_1)/Yield (X_6) ratio was found close to 1 (-1,116), which means the combination of these two production factors was the only one being used at the economically optimum level. Also, the MTSL/PL ratio of roughage (X_1) and concentrate feed (X_2) (-1,400) could be said to be another factor combination that was close to the economic optimum level. However, as a general evaluation, the substitution ratios of the factors which are used in milk production were not found economical.

In this part of the study, findings of the research were anaylzed comparatively with the results of similar studies in the world.

Oğuz and Canan (2016) examined 50 dairy cattle enterprises which were divided into two groups, members of the milk producers' union and non-members. Within the study, relationships between milk production amount and some variables such as the number of dairy cattle, milking method, roughage, and concentrate feed were analyzed. Among the union member enterprises; the R^2 value was found as 0,58, the Durbin Watson d_h was found as 1.264, and the elasticity coefficient sum (Σb_i) of the variables was found as 0,241. Among the variables, roughage was the one which affected milk production most with a 0,234 coefficient. In terms of non-member enterprises; the R^2 value was 0,593, the Durbin Watson d_h was 1,832, and the elasticity coefficient sum (Σb_i) of the variables was 0,675. In this group, roughage was also found as the variable which affected milk production most with a 0,261 coefficient. In addition, the substitutional relationship (MTSL) between roughage and cereal grains was found as -0,257. Other findings of the study were; the total milk production average per dairy cattle was 6.636,98 lt/year, the average number of dairy cattle was 18,81 head, roughage usage per dairy cattle was 10.960,65 kg, and concentrate feed usage per dairy cattle was 4.705,54 kg.

Pandian et al. (2013a) studied 480 dairy cattle enterprises in India, and examined the factors that affect milk production amount by means of the Cobb-Douglas production function. Within the study the R^2 value was calculated as 0,743, and except for labor force, all the factors were found statistically significant. The elasticity coefficient sum (Σbi) of the variables was observed as 1,056, and it was found that increasing returns to scale occured. Health expenses had the highest elasticity coefficient with 0,469, and labor force was the only factor with a negative coefficient (-0,049), which affected the milk production amount negatively. Efficiency coefficients of the factors in the function were the following; concentrate feed was 1,596, green roughage was 0,929, dry roughage was 1,960, labor force was -0,079, and health expenses were 37,243. In conclusion, roughage and health expenses were found as the most important factors affecting milk production.

Haloho et al. (2013) examined the profitability levels of 80 dairy cattle enterprises in Indonesia. Within the study, relationships between some factors such as; income, silage feed cost, concentrate feed cost, labor force cost, productive capital, and farmer’s experience level were analyzed by using the Cobb-Douglas production function. In the assumption function the R^2 value was found as 0,565, and the elasticity coefficients of the variables were; silage feed cost was 0,392, concentrate feed cost was 0,47, labor force cost was -0,124, productive capital was 0,510, and experience level was -0,006. Among the variables, silage feed, concentrate feed, and capital were found statistically significant at a 5% significance level. Besides those findings, the milk yield mean was found as 9,14 lt/head, and the dairy cattle mean per enterprise was found as 2,4 head.

Ghebremariam et al. (2006) examined 120 enterprises in the 3 different zones of; Eritrea as the Central Zone (1st zone), Mendefera (2nd zone), and Dekemhare (3rd zone).

Milk yield values of the zones respectively were; 2.176 lt/head, 1.230 lt/head, and 1.351 lt/head. The variables of the equation were; concentrate feed, silage feed, labor force, health expenses, medicinal and surgical expenses, the number of dairy cattle, and the production area size of forage plants as the dummy variable. The elasticity coefficients of the variables based on the 3 zones respectively were; concentrate feed (0,311; 0,156; 0,190), silage feed (0,190; 0,410; 0,291), labor force (0,221; 0,376; 0,247), health expenses (-0,025; -0,016; 0,112), surgical and medicinal expenses (0,03; 0,029; 0,205), the number of dairy cattle (0,402; 0,664; 0;417), and the production area size of forage plants (0,077; 0,124; 0,133). Also in the study, the R^2 values and elasticity coefficient sums (Σb_i) respectively were found as; 0,897 and 1,124 (1st zone), 0,944 and 1,635 (2nd zone), and 0,961 and 1,462 (3rd zone).

Musliu et al. (2019) carried out a study in Kosovo on 92 enterprises and analyzed factors which were used in milk production by means of the Cobb-Douglas production function. The elasticity coefficients of the variables in the estimating equation were; concentrate feed was 0,44, silage feed was 0,45, and the elasticity coefficient of other expenses was 0,21. All the variables in the equation were found statistically significant at a 5% significance level, and the elasticity coefficient sum of the variables (Σbi) was calculated as 1,10.

Gündüz and Dağdeviren (2011) carried out a study on 79 enterprises to determine milk production cost, and to analyze the factors which are used in milk production. According to the Cobb-Douglas production function analysis results, the number of dairy cattle and concentrate feed usage were found statistically significant on milk production. Increasing returns to scale was another finding of the study, and the number of dairy cattle was discovered as the factor which had the highest marginal yield. In the estimating equation, R2 was 0,94, Durbin-Watson dh was 2,07, and the production elasticity coefficients sum (Σbi) was calculated as 1,457. The elasticity coefficients of the variables were; the number of dairy cattle: 1,279, milking method: 0,038, roughage usage: -0,251, and concentrate feed usage: 0,391. Among the variables in the equation, the number of dairy cattle and concentrate feed usage were found statistically significant at a level of 1%.

Gençdal et al. (2019) carried out a functional analysis to determine relationships between the milk production amount and factors that affect milk production such as; the number of cattle, milking period, roughage and concentrate feed usage, barn capacity, and labor force usage. In the estimating equation, R2 value was 0,94, and the elasticity coefficients sum (Σbi) was calculated as 0,945. Among the variables of the equation, the number of dairy cattle, roughage, and concentrate feed were found statistically significant at a level of 5%. The elasticity coefficients of the variables were; the number of dairy cattle: 0,576, milking period: -0,304, roughage: 0,237, concentrate feed: 0,194, barn capacity: 0,170, and labor force: 0,071.

Topçu (2008) examined factors which affect success in dairy cattle enterprises by means of the data gathered from 120 dairy cattle enterprises. In the production function; R2 value was 0,87, Durbin-Watson dh was 1,91, the elasticity coefficients sum (Σbi) of the factors was 0,754, and all of the variables from the equation were found statistically significant at a 5% significance level. Variables of the equation and their elasticity coefficients were; milk yield: 0,109, labor force usage: -0,252, the number of dairy cattle: 0,225, current period values of the barns: 0,430, distances of enterprises from the city center: -1,730, and the genotype situation of the dairy cattle: 1,487.

In the previous studies mentioned above, it can be seen that the multiple determination coefficient of the estimating equation (R2), which indicates relationships between milk production amount (or value) and production factors, were found at high levels. This situation indicates high explaination levels between variables.

While the efficiency coefficient sum (Σbi) was under "1" in some studies (Topçu, 2008; Oğuz and Canan, 2016; Gençdal et al., 2019), it was found over "1" in other studies (Gündüz and Dağdeviren, 2011; Pandian et al., 2013a; Musliu et al., 2019). This coefficient is an important indicator about the profitability situation of a production activity, and in most of those studies enterprises were generally found profitable.

In many studies the cattle existence amount of the enterprises varied. Therefore, cattle existence per enterprise increases as the development level of the countries increase. Also, enterprises increase their forage plant production area sizes as they lean more towards livestock breeding.

Roughage and concentrate feed usage affect milk production significantly. Therefore, forage is the most important cost factor in milk production cost. Accordingly, forage plants production within an enterprise helps to decrease milk production cost, and increase enterprise's competitiveness power.

Affects of roughage and concentrate feed usage on production function (efficiency coefficient) varied depending on the study. Oğuz and Canan (2016) found concentrate feed as the factor that affects the milk production most with a 0,234 coefficient. Pandian et al. (2013a) found efficiency coefficients as 1,596 for concentrate feed, 0,929 for dry roughage, and 1,960 for green roughage. Haloho et al. (2013) found the elasticity coefficients as 0,392 for silage forage cost, and 0,47 for concentrate feed cost. Musliu et al. (2019), found the production elasticity coefficient as 0,44 for concentrate feed, and 0,45 for silage forage. Gündüz and Dağdeviren (2011) found the elasticity coefficients as -0,251 for roughage, and 0,391 for concentrate feed. In a different study which was carried out by Gençdal et al. (2019), the elasticity coefficient of concentrate feed was 0,194, and was 0,237 for roughage. In this study, the elasticity coefficients of the factors were found as; 0,228 for roughage, 0,183 for concentrate feed, and 0,284 for cereal grains. These values indicate that roughage and concentrate feed usage affect milk production positively.

Marginal yield, marginal income, factor prices, and marginal efficiency coefficients show differences depending on the country. Hence, the level of the ingredients in forage combination to use in milk production shows differences depending on some factors such as; the situation of forage plants breeding, the variety of the forage plants which are grown within the enterprise, the situation of forage plants purchased from outside of the enterprise, and perhaps most importantly, the amount of pecuniary resources that enterprises can allocate for animal feed. Consequently, the socio-economic situation of countries should be taken into consideration in the evaluation of marginal efficiency coefficients. In this study, according to the research results, dairy cattle enterprises were advised to increase roughage usage amount, decrease concentrate feed usage amount, and keep the cereal grains usage amount stable which was already found as being used at an optimum level.

5. Conclusions and Recommendations

Worldwide, milk production has an important place in agricultural production value. Nowadays, the most important problem of dairy cattle enterprises is the increase in forage input prices. This situation affects dairy cattle enterprises’ activities significantly. In addition to this, cattle genotype is another factor that affects milk production significantly. In many studies, it’s proven that enterprises which have pure breed and pure breed cross animals in their herds, gain more milk production and accordingly more income than other enterprises. Around 75% of milk production costs consist of forage expenses.

In this research, the functional analysis was carried out in order to determine the factors that affect milk production, and the data were gathered from 141 dairy cattle enterprises in the Hatay province of Turkey.

In the research area, the gross output value of dairy cattle breeding was calculated as 2,2 million USD, and milk and milk products take the biggest place among this value with

83%. In addition, the milk production average per enterprise was 27,4 tons, and the milk yield average per dairy cattle was 18,73 lt/day.

In the functional analysis; roughage, concentrate feed, cereal grains, labor force usage, health expenses (veterinary and medicinal expenses), and the lactation yield average were taken into consideration. In the regression analysis, all of the variables were found statistically significant, and autocorrelation was not observed. In the function, labor force usage was found as the factor which had the highest marginal income with 3,27, and roughage was found as the factor which had the highest marginal efficiency coefficient with 3,18.

According to the economic analysis results of milk production in the research area, in order to reach the economically optimum level, it is necessary to increase the use of roughage, and decrease labor force and concentrate feed usages. According to the analysis results, cereal grains and health expenses were found as being used optimally.

In order to conduct more profitable milk production in the research area; producers should gather under producer unions which give services about milk production and marketing. Accordingly, inputs which are used in milk production would be obtained with reasonable prices, and milk and milk products would be sold with higher profit margins.

6. References

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