ECONOMICS OF DAIRY FARMING IN GREECE

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ABSTRACT

In this paper an attempt is made to present the viability and competitiveness of our dairy farming based on cow milk production data of 38,360 dairy cows from four Centres of Genetic Improvement of Animals in Greece and physical and economic data from 45 modern and well organized dairy farms from the most important milk production regions. Under present (1999) economic conditions pure dairy farms which produce less than 5,000 kg milk per cow are not viable, those which produce between 5,000 and 6,000 kg milk per cow are viable but not competitive.

Pure dairy farms however which produce more than 6,000 kg milk per cow are not only viable but also competitive. The decision tree analysis showed that the gross return achieved in actual practice is 6,8% lower than that estimated by multiplying milk yield and price without probabilities.

Taking into account that the prospects in the European Union are for milk prices to decrease, it can be said that the viability and much more the competitiveness of the greek dairy farming must be based on the increase of the average productivity of cows (more than 6,000 kg milk yield per cow), the decrease of the total feed costs (by 8-10%), the decrease of the labour used (by over 50%) and the decrease of interest rate of short and long term loans (under 10%).

RÉSUMÉ

Ce travail porte sur la viabilité et la compétitivité de notre élevage de bétail laitier basées sur les données de production de 38.360 vaches laitières provenant de quatre Centres de génétique et sélection animale en Grèce, et sur les données physiques et économiques de 45 exploitations laitières modernes et bien organisées situées dans les régions laitières les plus importantes. Dans les conditions économiques actuelles (1999), des exploitations laitières pures qui produisent moins de 5.000 kg de lait par vache ne sont pas viables, tandis que celles qui produisent entre 5.000 et 6.000 kilogrammes de lait par vache sont viables mais non compétitives. Toutefois, des exploitations laitières pures qui produisent plus de 6.000 kg de lait par vache sont non seulement viables mais aussi compétitives. L'analyse de décision en arbre a montré que, dans la pratique, la rentabilité brute réalisée est de 6,8% inférieure à celle estimée en multipliant le rendement en lait par le prix sans probabilité.Tenant compte du fait qu'au niveau de l'Union Européenne l'on prévoit une diminution du prix du lait, l'on peut dire que la viabilité, et beaucoup plus la compétitivité de l'élevage laitier en Grèce doivent se baser sur l'augmentation de la productivité moyenne des vaches (plus de 6.000 kg de rendement en lait par vache), une diminution des coûts totaux des fourrages (de 8-10%), une diminution de la main-d'oeuvre utilisée (de plus de 50%) et une diminution du taux d'intérêt des prêts à court et long terme (au-dessous de 10%).

Dairy farming is one of the basic branches of the Greek livestock economy even though it faces certain technical and economic problems.

This is true taking into account that nowadays there are more than 27,000 dairy farms with about 180,000 milk cows which produce 750,000 tons of fluid milk per year.

The main problems the greek dairy farming faces are the small herd size (average number 6.8 cows), the low productivity (average milk yield 4,000 kg per cow), the lack of suitable land for producing certain feedingstuffs and especially forages, the low technical and economic education of dairy farmers and the high annual interest rates of loans which prevent the creation of modern dairy farm businesses. The increasing competition in the European Union requires the creation of larger herd size dairy farms with cows of high productivity and good quality milk.

This work is based on the physical data available from the various Centres of Genetic Improvement of Animals in Greece and the physical and economic data from 45 modern and well organized dairy farms from the Central and Northern Greece, which constitute the most important milk production regions (84.9% of the total dairy farms, 87.0% of the total milk cows and 87.3% of the total milk production).

More specifically, from the above mentioned Centres we took the milk yield and the calves born per lactation from an average number of 38,360 milk cows for the five-year period 1995-99. On the other hand, by using records and accounts we collected data from the forementioned dairy farms referring to the value of cows, calves, buildings and machinery, the wages of workers, the quantity and price of the various kinds of feed (concentrates and forages), the price of milk, the annual interest rates for short and long term loans and the expenses for veterinary, fuel, electricity, water etc. for the year 1999. The selection of the 45 dairy farms was made in a systematic way and not randomly because of the inability and unwillingness of the majority of them to keep detailed, reliable and accurate reproductive, physical and economic data for a long period.

This paper attempts to present the economics of the existing dairy farms and to show how these farms can become viable and competitive under the present economic conditions in the European Union.

The economic data and financial results are expressed in greek currency (drs), but for comparison purposes please note the following equivalents: 1 euro= 340 drs, $1= 300 drs and 100 lirretes= 17 drs.

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Milk yield per cow according to lactation for each class of milk production.

The milk yields of the 38,360 cows were divided into four classes, namely those cows of which the milk yield of every lactation was under 5,000 kg, those of which it was between 5,000 and 6,000 kg, those of which it was between 6,001 and 7,000 kg and those of which it was above 7,000 kg, (**table 1**). The average milk yield of a cycle of six lactations per cow and year is 4,260, 5,475, 6,480 and 7,760 kg for each class of milk production respectively. In all classes of milk production, the milk yield per cow increases until the third lactation and after that decreases until the sixth lactation. In the following, all physical and economic data and the financial results refer to the average milk yield of the six lactations per cow for each class of milk production.

Physical and economic data per cow for each class of milk production

All the physical and economic data increase according to each class of milk production per cow. More specifically, the live weight of cows increases from 500 to 615 kg. The same is true for the percentage of calves born alive (from 85.6 to 92.2), for the mortality of cows (from 1.94 to 2.45) and calves (from 3.6 to 5.5), for the percentage of calves weaning (from 82.5 to 87.1), for the value of cows as productive animals (from 430,000 to 575,000 drs) and as slaughtered ones (from 160,000 to 185,000 drs), for the value of calves weaned (from 55,000 to 57,500 drs) and for the cost of producing heifers until 7 months pregnant (from 436,385 to 452,117 drs) (**table 2**).

Of the other economic data, the monthly wages of a worker (187,750 drs) do not depend on the productivity of a cow. The milk price presents significant variation between cows of low yields (106 drs/kg) and cows of high yields (118 drs/kg).

This is due to the fact that dairy farmers of large herd size who keep cows of high yields and better quality of milk achieve higher prices from the big milk processing factories compared with dairy farmers of small herd size who keep cows of low yields and poor quality of milk.

The total capital invested in land improvements, buildings and machinery, which amounts to 1,150,000 drs per cow, does not change for each class of milk production per cow. Finally, the annual interest rate of short term loans is 17% and that of long term loans is 16%.

Gross return, production costs, profit, farm income and efficiency of capital per cow for each class of milk production

In **table 3** it can be seen that the contribution of milk value increases from 90.9 to 94.7% according to each class of milk production per cow, while the corresponding one of the calf value decreases from 9.1 to 5.3%. This is due to the fact that the milk yield increases more rapidly (79.8%) than the calf value (5.6%). The faster increase of the gross return (91.7%) in relation to milk yield (79.8%) shows that the former is also affected by the increase of milk price (from 106 to 118 drs/kg) according to each class of milk production per cow. Of the total production costs, the fixed one decreases from 76.6 to 70.2% and the variable one increases from 23.4 to 29.8% according to each class of milk production. This is true taking into account that the variable costs (mainly feed) increase more rapidly (77.5%) in relation to fixed costs (mainly depreciation, maintenance, mortality or insurance and interest of livestock, land improvements, buildings and machinery) (12.8%). In other words the total production costs increase from 568,142 to 791,798 drs per cow (e.g. 39.4%)

Table 1 ***Milk yield of a cow per lactation for each class of milk production per cow***

Cycle of lactations	Classes of milk production in kg per cow			
	<5,000	5,000-6,000	6,001-7,000	>7,000
1	3,902	5,028	6,030	7,030
2	4,327	5,560	6,546	7,779
3	4,509	5,795	6,780	8,106
4	4,434	5,696	6,650	7,971
5	4,242	5,450	6,488	7,626
6	4,143	5,323	6,386	7,448
Average	4,260	5,475	6,480	7,660

Table 2 ***Physical and economic data of dairy cows for each class of milk production per cow***

Physical and economic data of dairy cows		Classes of milk production in kg per cow			
		<5,000	5,000-6,000	6,001-7,000	>7000
Average milk yield per cow	(kg)	4,260	5,475	6,480	7,660
Average live weight per cow	(")	500	550	565	615
Number of calves born per cow	(%)	85.6	87.1	89.6	92,2
Mortality of cows	(")	1.94	2.06	2.28	2.45
Mortality of calves	(")	3.6	4.2	4.7	5.5
Number of calves weaned	(")	82.5	83.5	85.4	87.1
Value of a cow as productive animal	(drs)	430,000	485,000	525,000	575,000
Cull value of a cow	(")	160,000	170,000	174,000	185,000
Calf value at weaning	(")	55,000	55,500	57,200	57,500
Cost of producing a heifer	(")	436,385	442,863	444,830	452,117
Total capital invested per cow	(")	1,150,000	1,150,000	1,150,000	1,150,000
Monthly wages of a worker	(")	187,500	187,750	187,750	187,750
Average milk price per kg	(")	106	110	110	118
Interest rate for long term investment	(%)	16	16	16	16
Interest rate for short term investment	(")	17	17	17	17

according to each class of milk production, namely smaller than that of milk yield per cow (79.8%). The cost of milk production per kg is higher than the milk price in the first class of milk production (122.7 instead of 106.0 drs/kg) and lower in the other three classes of milk production (108.4, 101.9 and 96.9 instead of 110.0, 110.0 and 118.0 drs/kg respectively). The same shows the loss or profit per kg of milk and per cow according to each class of milk production. In actual practice it can be said that from a business standpoint the profitability of dairy farming is achieved by cows producing more than 6.000 kg of milk. However, in Greece most dairy farms are family farms which are interested in farm income (1), which increases from 177,245 to 468,620 drs per cow according to each class of milk production. This means that the family income of dairy farmers increases from 4,431,125 to 11,715,500 drs for a herd size of 25 milk cows when all the production factors belong to the farmers. The efficiency of capital invested is lower (9.3%) than the interest rate (16.3%) in the first class of milk production and higher (17.9-32.5%) than the interest rate (16.3%) in the other three classes of milk production due to the loss and profit achieved respectively.

Possibilities and presuppositions for improving profitability of dairy cows according to each class of milk production

The most important kinds of expenses, irrespective of class of milk production, are feeding (33.5-40.4%), depreciation, maintenance, insurance and interest of land improvements, buildings and machinery (27.4-19.7%), depreciation, mortality and interest of livestock (19.1-19.5%) and labour wages (15.9-15.6%). From these kinds of expenses those of feed increase because of its faster increase in relation to others. On the contrary, the annual expenses of land improvements, buildings and machinery decrease because they remain unchanged irrespective of each class of milk production. The other two kinds of expenses (e.g. those of livestock and labour) do not change because they increase analogically to each class of milk production per cow (**table 4**). From the above it can be seen that the increase of the profitability of the dairy farming can be based on the decrease of feed cost and interest rate. The first of them can be achieved by using balanced feed rations through linear programming technique. Indeed, by using these rations the feed costs can decrease about 2.2%, 6.3%, 10.5% and 16.9% for the four classes of milk production respectively. On the other hand, by decreasing the interest rate by 10% (from 17 to 7% for short term and from 16 to 6% for long term) then the interest of fixed and variable capital used can be reduced to 36.2-36.7% depending on each class of milk production per cow. The decrease of feed costs and interest of capital can contribute to the reduction of total costs of the four classes of milk production per cow by 10.9, 11.8%, 12.9% and 15.3% respectively. The result of this

Table 3 ***Economic analysis of dairy cows for each class of milk production per cow***

Returns, costs, profits and incomes		Classes of milk production in kg per cow			
		<5,000	5,000-6,000	6,001-7,000	>7000
I. Gross return/cow					
1. Value of milk /cow	(%)	90.0	92.9	93.6	94.7
2. Calf value at wean./cow	(")	9.1	7.1	6.4	5.3
Total (drs/cow)		496,945	648,560	761,642	953,979
II. Production costs/cow					
1. Fixed costs/cow	(%)	76.6	73.6	71.2	70.2
2. Variable costs/cow	(")	23.4	26.4	28.8	29.8
Total (drs/cow)		568,142	639,788	709,297	791,798
III. Production costs	(drs/kg)	122.7	108.4	101.9	96.9
IV. Profits	(drs/kg)	–16.7	1.6	8.1	21.1
V. Profits	(drs/cow)	–71.197	8,772	52,345	162,181
VI. Farm income	(drs/cow)	177,245	277,196	336,706	468,620
VII1. Return to capital	(%)	9.3	17.9	22.4	32.5
VII2. Average interest rate	(")	16.3	16.3	16.3	16.3

Table 4 ***Production costs analysis of dairy cows for each class of milk production per cow and possibilities of their reduction***

Production costs analysis and possibilities of their reduction		Classes of milk production in kg per cow			
		<5000	5000-6000	6001-7000	>7000
I. Production costs	(%)				
1. Labour	"	15.9	15.8	15.9	15.6
2. Feeding	"	33.5	36.0	38.1	40.4
3. Depr.mortal. inter. of livestock	"	19.1	19.5	19.3	19.1
4. Depr. maint., insur., inter., of land improv. build., mach.	"	27.4	24.3	21.9	19.7
5. Veter. inter. of var. capital	"	4.1	4.4	4.8	5.2
Total	"	100.0	100.0	100.0	100.0
II. Part. of total inter. to costs	"	27.9	26.1	24.5	23.1
III. Reduction of feed costs by using balanced economic rations	"	2.2	6.3	10.5	16.9
IV. Reduction of total interest 7 by decreasing interest rate 10%	"	36.6	36.3	36.7	36.
V. Reduction of total costs (%)		10.9	11.8	12.9	15.3
VI. Production costs (drs/kg)		108.1	94.6	87.7	81.0
VII. Profits (drs/kg)		–2.1	15.4	22.3	37.0
VIII. Profits (drs/cow)		–9,049	84,035	144,257	283,327
IX. Farm income (drs/cow)		181,380	291,765	367,013	522,777
X. Efficiency of capital		9.7	19.4	25.2	37.6

(1) Farm income includes labour wages, interest of capital invested and loss or profit achieved.

decrease is the reduction of the production costs per kg to the level of 108.1 drs/kg and the decrease of loss from 16.7 to 2.1 drs/kg and from 71,197 to 9,049 drs/cow in the first class of milk production. On the other hand, this decrease leads to the increase of profit from 1.6 to 15.4, from 8.1 to 22.3 and from 21.1 to 37.0 drs/kg or from 8,772 to 84,035, from 52,345 to 144,257 and from 162,181 to 283,327 drs/cow respectively for the other three classes of milk production per cow. The farm income shows analogous increase (from 181,380 to 522,777 drs/cow) as does the efficiency of capital used (from 9.7 to 36.7%).

Determination of the break-even of milk yield according to milk price and vice versa

Table 5 shows the break-even milk price which corresponds to the average milk yield of each class of milk production. This price is higher than that achieved by farmers of the first class of milk production (122.7 in relation to 106.0 drs/kg) and lower than those achieved by farmers of the other three classes of milk production. This means that it is necessary the price of milk to be increased to 16.7 drs/kg in order for the dairy farmers who achieve milk yield 4,260 kg/cow to avoid loss. Taking into account the event that the prospects in the European Union are for milk price to decrease (average 100 drs/kg) then it is necessary for the farmers of the first class of milk production to increase the average milk yield to 1,360 kg/cow, namely from 4,260 to 5,620 kg/cow. In all other classes of milk production the break-even yield is lower than that achieved by dairy farmers or the break-even price is smaller than that achieved by them. In the case when the milk price decreases to 100 drs/kg then the break-even milk yield is 6,340 kg/cow, namely a little lower than the average of these three classes of milk (6,538 kg/cow). This yield is achieved by 40% of the 45 dairy farms studied and only by 8% of the total dairy farms in Greece.

Decision tree analysis

From the total number of 38,360 milk cows, the 30.8% achieve milk yield under 5,000 kg, the 38.3% between 5,000 and 6,000 kg, the 22,5% between 6,001 and 7,000 kg and the 8.4% more than 7,000 kg (**table 6**). In the same table the milk prices per each class of milk production and the probabilities for achieving these prices

Table 5 ***Determining break-even milk yield per cow according to milk price for each class of milk production per cow***

Classes of milk production (kg per cow)	Average milk yield achieved in kg and corresponding break-even milk price in drs		Milk price achieved in drs per kg			Break-even milk yield . per cow in kg corresponding to each milk price achieved		
	Yield	Price	Lowest	Average	Highest	Yield	Yield	Yield
<5000	4,260	122.7	97.5	106.0	110.0	5,882	5,212	4,948
5000-6000	5,475	108.4	100.0	110.0	115.0	6,140	5,364	5,045
6001-7000	6,480	101.9	100.0	110.0	115.0	6,662	5,813	5,465
>7000	7,660	96.9	105.0	118.0	125.0	6,828	5,809	5,377
Average	5,510	111.4	97.5	112.5	125.0	6,670	5,433	4,706

Tab. 6 ***Milk yield. Milk price and gross return per cow with and without probability and decision making***

	Classes of milk production (kg/cow)	Probability %	Milk price (drs/kg)	Probability %	Gross return without probability (drs/cow)	Probability %	Contribution to the gross return including probability (drs)
Decision tree analysis	<5,000 (4,260)	30.8	95	10.7	404,700	3.3	13,355
			105	34.3	447,300	10.6	47,414
			115	55.0	489,900	16.9	82,793
	5,000-6,000 (5,475)	38.3	100	10.8	547,500	4.1	22,448
			110	48.3	602,250	18.5	111,416
			118	40.9	646,050	15.7	101,430
	6,001-7,000 (6,480)	22.5	100	10.8	648,000	2.4	15,552
			110	48.3	712,800	10.9	77,695
			118	40.9	764,640	9.2	70,347
	>7,000 (7,660)	8.4	110	1.2	842,600	0.1	843
			120	84.5	919,200	7.1	65,263
			125	14.3	957,500	1.2	11,490
Total number of milk cows 38,360					**665,213**	**100.0**	**620,046**

are also given. Taking into account the milk yields, the fluctuation of milk prices and the corresponding probabilities, we receive the gross return of each class of milk production with the corresponding milk prices and probabilities. This means that the probability for achieving gross return 404,760 drs/cow is 3.3%, while for achieving 602,250 and 957,500 drs/cow is 18.5 and 1.2% respectively.

Comparing gross return per cow with and without probabilities it can be seen that the former (620,046 drs/cow) is 6.8% lower than the latter (665,213 drs/cow). This means that the gross return achieved in actual practice is always lower than that estimated by multiplying milk yield and price without probability. By using decision tree analysis we can estimate the actual gross return corresponding to each milk yield and price. In other words decision tree analysis is a useful tool in decision making.

PRODUCTIVITY ANALYSIS OF DAIRY FARMS

The productivity of the factors used in milk production and that of the two main kinds of feeds (concentrates and forages) are of special importance from an economic point of view because they may lead to the solution of some problems in dairy farming. These problems refer: a) to the contribution of each production factor to the gross return achieved, b) to the marginal productivity of the resources used in relation to their opportunity costs, and c) to the marginal rate of substitution of concentrates by forages and vice versa, for achieving the same amount of milk at the lowest feeding costs. The data used were analysed by applying the well known Cobb-Douglas production function of which the general equation is:

$$Y = aX_1^{b1}\, aX_2^{b2}\, aX_3^{b3} \ldots\ldots\ldots\ldots X_v^{bv}$$

Marginal value products of resources used and their opportunity costs

The four farm resources included in the given production function are: a) Cows (depreciation and mortality in drs/cow), b) Labour wages in drs/hour, c) Feed in drs/kg, and d) Buildings and Machinery or Equipment (depreciation, insurance and maintenance in drs/cow). The gross return achieved is also expressed in drs/cow. The data were analyzed as a whole and not by classes of milk production because in actual practice the analysis of a small number of data by using this production function is unfavorably affected and usually leads to unrealistic solutions.

The sum of production elasticities (1.03282) shows that there is a rather constant ratio between input and output, namely when the former is doubled, the latter is also doubled. On the other hand, the coefficient of multiple determination (0.968) shows that the variations in the gross return achieved depend, by 96.8%, on the variations of the above mentioned four farm resources used (**table 7**).

The marginal value product of cows is higher (126,540 drs/cow) than their opportunity costs (80,200 drs/cow), as can be seen by comparing marginal return to opportunity cost ratios (1.578). This means that it is profitable to keep cows of high potential milk yield because their productivity covers their opportunity costs.

The marginal value product of labour, amounting to 302 drs per hour, is lower than its wages (745 drs/hour), as is shown by its ratio to opportunity costs (0.405). The low marginal productivity of labour is due on the one hand to the fact that labour is not organised efficiently in dairy farming and on the other to the fact that labour is used in large quantities compared with those of the other three resources. In Greece the labour used in dairy farming and generally in livestock farming is mainly based on foreign workers of whom the productivity is low.

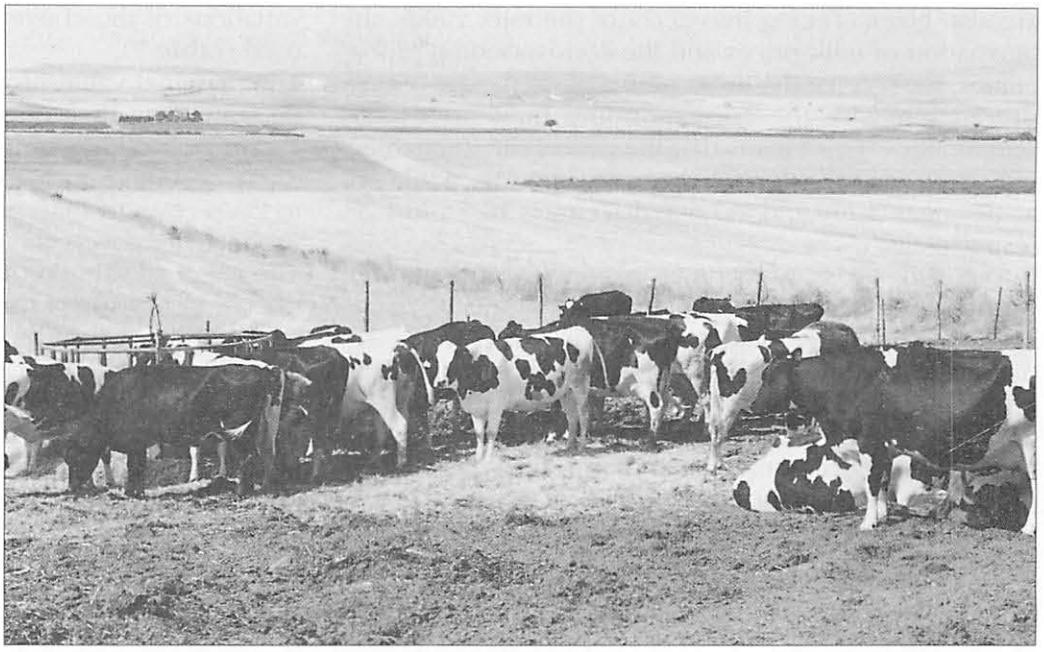
The marginal value product of feed, amounting to 60.9 drs per kg, is higher than its opportunity costs estimated at 29.4 drs per kg. This is confirmed by comparing marginal return to opportunity costs ratios (2.071). This means that cows yielding 6,000 kg and over of milk can utilise profitably more quantity of feed than that used. However, the feed needed for achieving maximum total profit depends on the capacity of each cow, on the price or costs of producing feedingstuffs and on the milk price.

The marginal value product of buildings and equip-

Table 7 ***Marginal productivity analysis of resources used in dairy farming***

Number of dairy farms	45
Period in years 1998-99	1
Y= Gross return	
X_1 = Cows	b1=0.15300[a]
X_2 = Labour	b2=0.03159[a]
X_3 = Feed	b3=0.78100[a]
X_4 = Buildings and equipment	b4=0.06723[b]
Sum of b's	1.03282
α	0.86300
R	0.984
R^2	0.968
Marginal value products	
Cows (drs/cow)	126,540
Labour (drs/hour)	302
Feed (drs/kg)	60.9
Buildings and equipment (drs/cow)	55,580
Opportunity costs	
Cows (drs/cow)	80,200
Labour (drs/hour)	745
Feed (drs/kg)	29.4
Buildings and equipment (drs/cow)	55,900
Marginal return to opportunity cost ratios	
Cows	1.578
Labour	0.405
Feed	2.071
Buildings and equipment	0.994

Probability level for t's
a) 0.001 >P> 0.0
b) 0.499 >P >0.275



ment, amounting to 55,580 drs per cow, simply covers their opportunity costs (55,900 drs/cow) as the marginal return to opportunity costs ratio (0.994) shows. From the above it can be seen that maximum total profits may be achieved by increasing feed at the level which the cost of the last unit of feed supplied (marginal cost) is equal to the value of the additional amount of milk produced (marginal value product) with the same level of labour, buildings and equipment used. The reliability of marginal productivity of farm resources is confirmed by the fact that the majority of production elasticities were found statistically significant at the 0.1 and 0.5 per cent level of probability.

Marginal value products of concentrates and forages and their opportunity costs

The feed supplied is divided into two main kinds i.e. concentrates and forages. Both kinds of feed are given in kg, although their composition in percentage and their value in drs are also known, so that the estimation of their opportunity costs and their new composition can be made. Thus, the first independent variable of the production function used represents concentrates in kg and the second one forages in kg, while the dependent variable represents the milk production in kg (**table 8**). The sum of production elasticities shows that there is a rather diminishing ratio between milk produced in kg and feed supplied in kg, while the coefficient of multiple determination shows that the variations in milk production depend by 95.3% on the variations of the feed supplied. The marginal value product of concentrates, amounting to 190.5 drs/kg, is too high compared with their opportunity costs (69.3 drs/kg) as is shown by the marginal return to opportunity costs ratios (2.75). The marginal value product of forages, amounting to 24.1 drs per kg, covers the opportunity costs (16.3 drs/kg) as is shown by the marginal return to opportunity costs ratio (1.48). Under these conditions both kinds of feed (concentrates and forages) should be supplied in larger quantities in milk production, when they used the one independently from the other.

Marginal rate of substitution between concentrates and forages and least cost combination of them

The higher marginal value product of concentrates compared with that of forages leads to an increase of the former and to a decrease of the latter for achieving a more economical ration. Indeed, the existing combination of these two kinds of feed in the actual ration is not the most profitable one, since it does not lead to a least cost ration for producing the same amount of milk. This is achieved by estimating the marginal rate of substitution of forages by concentrates.

The general equation of the marginal rate of substitution is:

$$dX_2 / dX_1 = b_1X_2 / b_2X_1$$

which shows the amount saved of feed X_2 by supplying one additional unit of feed X_1 for producing the same amount of milk. The marginal rate of substitution leads to a decrease in the total feeding costs per cow. How-

Table 8 ***Marginal productivity analysis of concentrates and forages***

Number of dairy farms	45
Period in years 1998-99	1
Y = Milk production	
X_1 = Concentrates	b1=0.645*
X_2 = Forages	b2=0.250*
Sum of b's	0.895
α	2,006
R	0.976
R^2	0.953
Marginal value products	
Concentrates (drs/kg)	190.5
Forages (drs/kg)	24.1
Opportunity costs	
Concentrates (drs/kg)	69.3
Forages (drs/kg)	16.3
Marginal return to opportunity cost ratios	
Concentrates	2.75
Forages	1.48

Probability level for t's
α 0.001 >P >0.0

ever, the least cost ration is achieved up to the point where this rate of substitution becomes 1 drs/drs This is true because the marginal rate of substitution decreases progressively when feed X_2 decreases and feed X_1 increases.

The quantity of feed X_2 which corresponds to a certain quantity of feed X_1 is estimated by the following equation:

$$X_2 = (Y/aX_1^{b1})^{1/b2}$$

From the above it can be seen that the marginal rate of substitution becomes 1 drs/drs when 2,992 kg of concentrates and 4,922 kg of forages are supplied to a cow producing 6,833 kg of milk. At this level of milk production and feedingstuffs the lowest possible feeding costs is achieved, namely 265,164 drs/cow instead of 289,737 drs/cow, or 8.48% lower (**table 9**). The reliability of the marginal productivity of concentrates and forages is confirmed by the fact that production elasticities were found statistically significant at the 0.1 per cent level of probability.

Table 9 ***Marginal rate of substitution between concentrates and forages for producing the same quantity of milk (6,833 kg) per cow***

Concentrates in kg per cow	Forages in kg per cow	Average marginal rate of substitution forages by concentrates		Cost of feeding in drs cow
		in kg	in drs	
2,640	8,046	7,864	1.855	289,737
2,667	6,628	6,409	1.512	270,106
2,716	6,320	6,004	1.416	268,596
2,764	6,043	5,641	1.331	267,489
2,812	5,783	5,305	1.251	266,638
2,860	5,533	4,992	1.177	265,938
2,908	5,297	4,700	1.109	265,449
2,958	5,081	4,432	1.045	265,388
2,992	4,922	4,244	1.000	265,164

Conclusions

The pure dairy farms in Greece which produce less than 5,000 kg milk per cow are not viable under the present economic conditions, since gross return is impossible to cover production costs (loss 16.7 drs/kg of milk and 71,197 drs/cow, capital return to interest rate ratio 0.57). On the other hand, pure dairy farms which produce between 5,000 and 6,000 kg milk per cow are viable but not competitive because gross return just covers production costs (profit 1,6 drs/kg of milk and 8,772 drs/cow, capital return to interest rate ratio 1.1). Pure dairy farms which produce more than 6,000 kg milk per cow however, are not only viable but also competitive (profit 14.6 drs/kg of milk and 107,263 drs/cow however, capital return to interest rate ratio 1.69). The decision tree analysis showed that the gross return achieved in actual practice is 6.8% lower than that estimated by multiplying milk yield and price without probabilities.

The marginal productivity analysis based on the data of 45 modern and well organised dairy farm (average yield 6,833 kg milk per cow) showed that it is profitable to keep cows of high potential milk yield which can utilise efficiently more quantity of feed with the same labour and building facilities. Based on the marginal value product of concentrates and forages a reduction of 8.48% of the total feeding costs can be achieved by substituting forages by concentrates up to the point where the rate of substitution between these two kinds of feed becomes 1 drs/drs. Taking into account that the prospects in the European Union are for milk prices to decrease it can be said that the viability and the competitiveness of the pure Greek dairy farming must be based on the increase of the average productivity of cows (more than 6,000 kg milk yield per cow), the decrease of the total feed costs (by 8-10%), the decrease of the labour used (by over 50%) and the decrease of the interest rate of short and long term loans (under 10%). ●

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