Influence of Animal Feeding on Milk Supply in Navarre

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Abstract

Determining the competitive position of dairy farms depends on several technological, economic and institutional variables. Among them, are remarkable those related to animal feeding in the current context of high variability on prices. In this context, the aim of our study is to analyze the effects on milk supply and the competitiveness of dairy farms with different models of land intensification, with greater reliance on market purchases or self-production of livestock feed. Our work is based on an econometric approach to a variable cost function, in a fixed effects model for unbalanced panel data of specialized dairy farms in Navarre (Spain). From this region, we use 3 geographical areas in relation to the availability of grazing land. It has been tested the absence of sample selection bias and satisfaction of regularity conditions. The study shows a flexible milk farm supply with respect to the price of milk and very dependent on the evolution of feed prices. This aspect has been emphasized by the restructuring of farms, characterized by strong size increases and productivity gains based on a greater reliance on purchases of animal feed. The provision of grazing land has an important role in determining the average costs and farm profitability. In addition, grazing land use permits greater exploitation of economies of scale present in the dairy sector.

Keywords: multiproduct cost function, panel data, milk, animal feed, dairy farms.

1.   **Introduction**

Milk quota phase-out process introduces a big uncertainty over the future evolution of the milk sector in the European Union. Because of that, they are a variety of researches that develop policy simulations in order to predict the sector evolution. In this context, the key point is setting the competitive position of the dairy farms, setting the potential supply and the basic variables that determine production costs. This question is treated by economic literature in different studies.

 The objective of this paper is complementing this previous literature by paying attention to the role played by animal feed in the setting of the potential milk supply. Animal feed is the main expenditure item in dairy farms, and it has a double way of provision, by means of market purchases (outsourcing) or self-production by means of using the land resources (internalization). Current instability of the fodder price evolution remarks the convenience of this study.

The research shows an econometric approach to the function of variable cost of the dairy farms in order to set the potential supply and the key competitive factors for the dairy sector in Navarre, a region in the North of Spain. To analyze different systems of animal feed, with bigger or smaller level of outsourcing, this work uses the particular characteristics of this region. The big geophysics variety of the region has clearly differenced three production areas depending on fodder land availability and their mechanization possibilities. This establishes two areas of traditional production with land using, and a third one of milk production without land exploitation. In the two first cases, the basic difference is the plot size and the possibility for a mechanized management of land. Although the scope of the

study is Navarre, it is considered to give information in order to understand the role played by animal feed in the whole dairy sector.

2.   Econometric model

The dairy farming behaviour can be approached by means of a short run multiproduct cost function[1], for which specification has been chosen a multiproduct symmetric generalized McFadden cost function (MSGM)[2]. This flexible function characterized by a rigorous performance of the homogeneity conditions on prices of the cost function inputs, and its flexible characteristics provide a second order approximation to the unknown cost function for any point. Furthermore, given its hessian matrix of second derivates respect to the input prices, the curvature properties are evaluated in a global way. Additionally, the variable input demands are represented symmetrically on the function, thereby by imposing the condition of homogeneity to these variable input prices, it is not required a differentiated treatment. Finally, the MSGM function allows the introduction of null values for input demands as an added advantage. The algebraic expression of the specified functional form is:

$$C(w,z,y) = \frac{1}{2}(\theta'w)^{-1}(\varphi'y)w'Aw + \alpha'w + (\varphi'y)\beta'w't + w'Fy + w'Cz$$
$$+ (\theta'w)[y'Ey + z'Bz + y'Gz] \tag{1}$$

Where w is a vector of sector prices of the variable inputs (subindex i,j). Quasi-fixed factors are expressed by the vector z of K order (subindex k,l). Products are expressed by means the vector y of M order (subindex m,n). Technical change is represented by the temporal variable t. Unknown parameters of the function are the vectors α and β, and the matrix A (I*I), F (I*M), C (I*K), E (M*M), B (K*K), G (I*K).

The a priori determination of parameter vectors θ(1*I) y φ(1*M)[3] allows the parsimonious specification of the MSGM functional form, keeping the consideration of flexible function (Diewert and Wales, 1987). Demand functions for variable factors are retrieved from the variable cost function applying Shepard´s lemma:

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[1] This approach needs the implicit existence of a regular technology for the whole sector (Chambers, 1988), which required conditions are imposed or evaluated.

[2] The symmetric generalized MacFadden cost function (SGM) was proposed by Diewert and Wales (1987) as an extension of the quadratic functional. It was expanded by Kumbhakar et al. (1989) in order to include quasi-fixed factors, and to consider the multiproduction, by Kumbhakar (1994). Combined version can be found in Rask (1995) or Peeters and Surry (2000).

[3] Product $\theta'w$ can be interpreted as price index of variable inputs; meanwhile product $\varphi'y$ can be considered an index of amount of productions. Vector θ is made up of parameters θ_i which represent, for each input i, the percentage of the average cost for the whole sample. Vector φ is made up of parameters φ_m, and represents the percentage of the average income for the whole sample of each product m.

$$x_i = \partial C(w, y, z)/\partial w_i = (\varphi' y)(\theta' w)^{-1} A_i w - \frac{1}{2} \theta_i (\varphi' y)(\theta' w)^{-2} w' A w$$
$$+ \alpha_i + (\varphi' y) \beta_i t + F_i y + C_i z + \theta_i [y' E y + z' B z + y' G z] \qquad , \forall i \in I. \qquad (2)$$

Where x_i is the variable input amount i. A_i y F_i are, respectively, the ith rows of the matrix A and F. The MSGM functional form provide a symmetric system of functions of input demand, which contains all unknown parameters of the cost function. This represents a substantial advantage respect to other flexible functions in their empiric application by doing the incorporation of the cost function in its estimation dispensable.

3.   Data

The empirical analysis uses an unbalanced data panel of 139 dairy farms, covering the period between years 1994-2005, and providing 850 observations. Farm data set is provided by Instituto Técnico y de Gestión Ganadero (ITG-G), and its scope is the specialized dairy farms in Navarre (a region in the north of Spain).

Price data come from Instituto Navarro de Estadística and Eurostat. Main complimentary livestock farm activities are nonexistent or are not considered due to their relatively low repercussion. This is possible because of cost allocations carried out by ITG-G[4]. Milk farm activity is represented by considering four variable inputs, two quasi-fixed factors and two products of milk activity. Table 1 presents main statistics and ccomposition of variables is described in detail below.

The four variable inputs are: external animal feed ($i = 1$), cattle expenses ($i = 2$), other variable expenses ($i = 3$), salaries ($i = 4$). External animal feed includes input purchases for dairy cow feed that have been made out of the milk farm. It represents the main expenses, which reaches a 47 % on average.

Bovine expenses bring together veterinarian expenses, other specific expenses for the animal handle and the attributed cost to the dairy cow stock. Other variable expenses show the remainder of general expenses not previously included and the amortization of the machinery and installations. Finally, wage-earning labour force used in the milk farm is also included as variable input. As assumption, producer's behaviour is related to the expectations over market prices and not directly over current prices. Therefore, one period delayed prices are considered as model variables[5]. Quantities are represented by expenses (constant prices), which are the general expenses divided by price index.

The consideration of quasi-fixed production factors is justified, at the empirical level in case of land ($k = 1$) and family labour ($k = 2$), because they are specific factors with a high level of rigidity for its allocation possibilities. Family labour is expressed in annual labour units assigned to milk production. Land associated to feed production and animal handle are expressed in hectares. Presence of land is not an essential factor in the milk production, as it

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[4] The sample has been previously selected in order to exclusively collect farms with a size over a UTA and a livestock over 10 cows.

[5] Laspeyres price index (2005=1), and adjusted by the average expenses of the sector for each item.

shown by the fact that a 5% of the sample data are null for this concept. All null values are concentrated in the farms located on flat areas, zone 3, which is an indicative factor of the structural disparity among farms from different geographical areas.

The majority of dairy cow farms in Navarre are specialized in milk production. Nevertheless, this activity brings together a complimentary meat production, which comes from the births and the renewal of the old animals[6]. Whole sample correlation coefficient between both productions is 0,7. Given that milk production is only capable to partially explain this complimentary production, we include it as independent product in the cost function. Thereby, the two products considered in the study are cow's milk ($m = 1$) and associated products to milk production ($m = 2$). Cow's milk collects amounts assigned to sales measured in tones. Prices p are specific for the milk farm and show milk sale prices and subsidies directly associated to milk production prorated by the total production are expressed in euro per tone. Rest of associated products includes sales of residual products of milk production, and derivative products from the renewal of the livestock and calf sales. Amounts are expressed as expenses at constant prices, whereas prices are approached by means a Laspeyres index from series of sector prices.

Table 1: Descriptive values of data panel

Variables	Average	Est. Deviation	Minimum	Maximun
Cows	61,5	35,8	10,0	220,0
cv	133.529	104.039	8.099	575.626
w_1	0,949	0,065	0,829	1,004
w_2	0,856	0,089	0,707	1,000
w_3	0,778	0,160	0,388	1,000
w_4	0,805	0,097	0,674	1,000
y_1	464,5	324,5	41,7	1.769,0
y_2	12.697	10.939	431	73.085
z_1	1,53	0,65	0,50	4,00
z_2	23,9	18,0	0,0	100,0
x_1	66.181	52.365	2.871	303.951
x_2	36.648	25.028	3.678	139.621
x_3	44.450	32.613	4.071	218.821
x_4	1.781	5.572	0	46.975
r_1	13.067	1.558	11.025	16.137
r_2	121	14	99	141
p_1	297	26	231	370
p_2	0,998	0,057	0,894	1,060

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[6] This phenomenon can be included by considering a product added that collects both productions (Pierani and Rizzi, 2003), as independent product (Cathagne *et al.*, 2006; Stefanou *et al.*, 1992) or, in other case, being removed from the model (Álvarez *et al.*, 2006; Colman *et al.*, 2005).

4. Estimation

On the basis of an unbalanced panel data, a variable cost function has been specified in order to explain the behavior of a group a farms. The estimation of the unknown parameters of the cost function is developed by means a system of equations of variable input demand (equation 2). The specification of the symmetric generalized McFadden function allows revealing all unknown parameters directly from this system of equations of input demand. The outcomes of the Hausman test justify the selection of a model with fixed effects in the selection to take farm specific effects into account.

The strong restructuring process of the milk sector can produce the presence of a sample selection bias for unbalanced panel data. To evaluate this possibility Wooldridge (1995) and Verbeek and Nijman (1992, 1996) give two alternative tests. Outcomes, in both cases, allow to reject the existence of this sample selection slant (respectively, $\chi^2(4) = 17,7 > 9,5$ and $\chi^2(35) = 9,5 < 49,8$).

One of the targets of the study is to analyze the effect of the Navarra geophysics diversity on the cost structure of the dairy farms. Accounting analyzes and previous estimations indicate that this regional variable can be significant. This diversity is synthesized by considering three different areas indicated by technicians of ITG-G, figure 1. Zone 1 or mountainous area, which includes populations of the North Navarra, with high pluviometry, and difficulties for the productive management of the pastures due to the small size and sharp slopes of the fields. Zone 2 or area of valleys in the Center and North of Navarre. In this area, high pluviometry and wide valleys provide suitable fields for fodder production. Finally, production located in the Center and South part of Navarre, zone 3 or flat area. Here, there are a low pluviometry and big fields, both unirrigated and irrigated, for agricultural production.

Figure 1: Farm classification by geographical area in Navarre
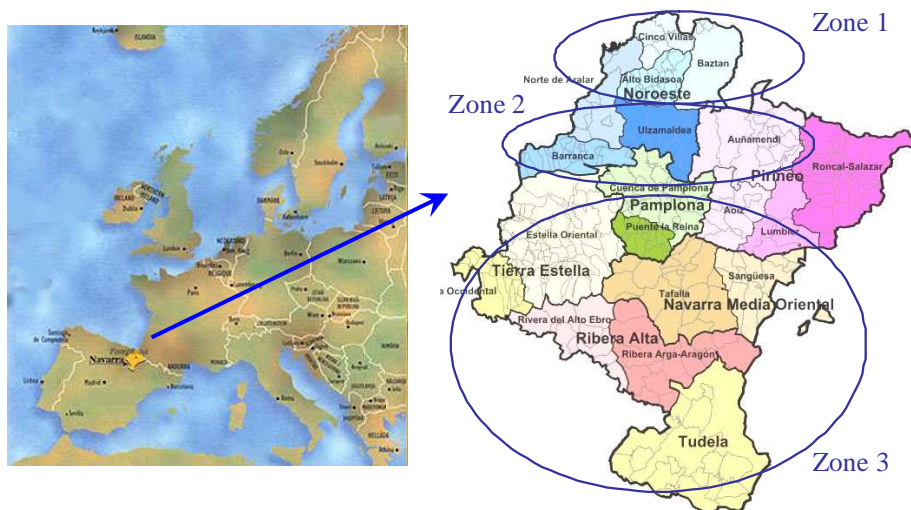
To bring together this variety among zones, the system of compensated demands of inputs is complemented with the introduction of dummy variable depending on the production area. The dummy variables make interactions with milk production and input prices. Hence, the zone effect remains associated to the constant of the marginal cost curve of milk production, pointing out possible divergences among the marginal costs of the farms depending on the zone.

The parameters[7] of demand system expressed in differences respect to the farm average are estimated by using the procedure SUR for apparently non related equations of the statistic software TSP 4.5. These parameters have been calculated by applying the White method that correct the presence of heteroscedasticity. Corrected coefficients of determination are satisfactory. They reach a 96% for external feed and cows, a 92% for general inputs, and a 39% for wage-earning labour force. Estimated parameters present a high level of significance. P-values of the estimated parameters indicate that an 80% of the parameters for a level of confidence of 95%.

The specification of the function does not impose any scale economies of scale, pending the evaluation of the presence of constant scale output[8]. Wald test of combining significance associated to the hypothesis has a value of 148,1 and it allow to reject the presence of constant scale outputs. Later on, it will be developed a further study of the existing scale economies in the sector. The non combining production hypothesis for the case of the MSGM functional form presents, as necessary condition[9], the rejection of $E_{mn} = 0, m \neq n, \forall m, n \in M$. For the current specification, this null hypothesis is $E_{12} = 0$, and it is rejected because the estimated parameter is significantly different of zero for a level of significance of 1% . This outcome is coherent with the consideration of milk as main good, and the rest of products as residual goods in the productive process.

5.   Results

We will show now the most relevant results coming out of the econometric estimation.

Marginal cost, quota rent and variable average cost

The average value of the marginal costs is 255 €/t for the full period. This values stays on the same level along the sample time. This marginal costs deflected have not been influenced by the sector's strong restructuration, mainly on size (from 50 to 77 cows per premise) within this period. The valid prices perceived by the farms show an average value of 347 €/t. This value remains constant through the period used as a sample, except for a 10 % down suffered in the last period. The quota rent, which is the difference between the milk price and the marginal cost, shows an average value of 91€/t through the sample period, This

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[7] Estimated parameters are not presented due to lack of space but they are available upon request to authors.

[8] This hypothesis is presented by the combining significance of the matrix of parameters E, B y G (Wieck and Heckelei, 2007)

[9] This condition allows rejecting the hypothesis of non combining production, but it does not mean the acceptance of the combining production hypothesis (Stewart, 2009).

value follows a declining trend up to the last period, when the average value is 73 €/t. The Quota Rent value against the obtained price, on percentage has gone done from 30 to 22% between the 1st and the last period sampled. The results show stable standard deviations through the different periods, both for the quota rent and the marginal costs. The institutional rights assignment and quota market transfers do not show a convergence process between farms. The comparison with previous studies is difficult, due to different variables and periods considered. For similar periods and samples, with comparable cattle size, Cathagne *et al*. (2006), INRA-Wageningen (2002) y Moro *et al*. (2005) show marginal costs slightly higher than ours. Our results are inferior to those obtained by Miguel *et al*. (2003) in Galicia and Álvarez *et al*. (2006) in Asturias, which are the main milk producer regions in Spain.

The variable average costs estimated (Baumol *et al*., 1982) are lower than the marginal costs and the market prices for all the farms. This means, in microeconomic terms, that dairy farms operate in the growing side of the marginal costs, having milk quotas above the minimum of activity.

Results by activity zone and farm size

In order to go deep inside the analysis of the marginal costs in the farms, studying their distribution by geographic area and size is interesting. Zone 2 (Big Valleys) marginal costs are 15% lower than in all the others. This zone effect explain half of this difference, whilst the rest is related to the fixed factors (land and family labour). The average variable costs also show differences depending on the area. Values in Area 2 are 30 % lower than zone 2 (mountain) 's and 20% lower than zone 3 (plain).The biggest livestock, more than 70 cows, show a 10% raise in the marginal costs and 10% reduction quota rent against the others.

On the other hand, the average variable costs for the milk production go down as the size of the farm increase. The area does not have an impact on this, despite the fact that the big size facilities in zone 1 and 3, + 90 cows, increase the cows per hectare ratio.

Marginal cost elasticity's

The figure obtained from the elasticity of the marginal costs against the dairy production increase is a key result. The average estimated elasticity for the last triennium is 0.54, and keeps positive values for the whole sample. This implies that the farms position themselves in the growing side of the marginal costs curve. The effect of the farm size over the elasticity of the marginal costs on short term is notorious. The estimation results on 0.26 for the small sizes, 0.47 for the mid sizes and 0.95 for the big sizes. These values represent the restrictive effects of the fixed factors have over the increase of farm sizes. This result contrast with other obtained in the in the European Dairy Sector, with the existence of farms with positions in the negative part of the marginal costs curve (Cathagne *et al*., 2006, Skolokai, 2007, and Wieck and Heckelei, 2007).

All the input prices have a positive effect over the marginal costs, as it has to be with the behaviour of the normal inputs. The price increase of the external feeding is the most pressing factor of the marginal costs (0.54). This result show the importance of the external feeding in the process of cattle expansion for the dairy farms. The marginal cost elasticity for

the dairies in relation to the fix factors is -0.19 for the family work and – 0.12 for the land. At last, the existence of a technical change is observed, though it has a weak quantitative effect[10]

Input demand Elasticity

The own-price elasticity for the external feeding is close to one (0.945). This phenomenon happens with independence of the land and indicates that the dairy production increase is associated with the increase of the purchase of external feeding. This dependency accentuates the importance of the external feeding price evolution in order to determine the profitability for the potential increases of Dairy production in the farms. In reference to the dedicated land to the animal feeding, the estimated elasticity show complementary relationships with the external labour and the general costs, including the depreciation of the farm machinery. This indicates the combined usage of land, capital and external labour in the farm management of the land. Besides, the land shows a replacement relationship over the usage of the external feeding (0.176).

In order to evaluate the replacement relationships amongst factors, this study has calculated the Morishima's elasticity version used by Peter and Surry (1993). The elasticity's indicate a production replacement relationship between the external feeding and the expenses in milk cows, with high values independent from the variable considered price (0.769 and 0.600). This implies that, for a dairy production level, the companies adapt the relationship between the number of cows and the external feeding supplied, base on the input price evolution. In certain way, the cows' productivity is conditioned to the price of the feed, intensifying (reducing) the productive pressure of the cows in front of reductions (increases) of the feed price. This variable relationship support the specification proposed in the study and means an improvement against the previous sector studies[11]

Correlation between marginal cost and average cost

It is interesting to analyze their relationship with certain structural variables, which are not directly considered within the model. The results of this analysis show a weak but direct correlation between marginal cost and livestock size (0.11). On the other hand, the results demonstrate a heavier impact with in the zones 1 and 3 (0.29 in both cases), whilst it is neglectable in zone 2 (0.06). This divergence shows the pressure produced by marginal cost over the expansion of the dairy production, mainly based in bigger variable input consumption. The correlation between the marginal cost and dairy productivity is 0.27. It is a direct weak relationship, with neglectable differences in between zones. This result rejects the hypothesis that takes the dairy productivity as a proxy variable of the technical change and they seem to indicate that their value it is more related with the company's productive decision even with an increase of the Marginal costs. At last, this contrast with the

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[10] Dairy Industry studies show mixed results about the presence of technical change. For example, Kumbakhar and Heshmati (1995) found negative technical change in Sweden, Brümmer et al. (2002) negative in Holland and positive in Germany, and Álvarez et al. (2008) positive for the case of Asturias (Spain).

[11] Similarly, Colman et al. (2004) appreciate a substitution of concentrate feed for a bigger use of pasture as a result of the low profitability of farming in the UK.

hypothesis stating that the farms getting a higher price for the milk have a lower incentive for the cost reduction. Wieck y Heckelei (2007) ratifies this last hypothesis in their study of 8 European Regions. Estimation results indicate that, the price against marginal cost and average cost is negative (-0.20 & - 0.23). These results imply a rejection of the hypothesis presented for Navarre's case. An alternative hypothesis would be that a higher milk price is related with quality bonuses, and indirectly related with feeding, handling conditions and management aspects.

Economies of Scale

The plant capacity used, corrected for the non–homothetic technology case, CPU^C, shows values close to 1 for the farm average, with a certain presence of over – usage. And a slight decrease as the time passes by – 1.04 in the first period to 1.01 in the last period - .

We have developed the expression presented by Morrison (1985) for this calculation. The CPU^C is the one between parenthesis:

$$\varepsilon_{CT,y}^{lp} = \varepsilon_{CT,y}^{cp} \left(1 - \left(\sum_k \sum_m \frac{\partial CT^{cp}}{\partial z_k} \frac{z_k}{CT^{cp}} \frac{dz_k}{dy_m} \frac{y_m}{z_k} \Big/ \varepsilon_{CT,y}^{lp} \right) \right) \tag{3}$$

On the short term, the cost sensibility to the aggregated production increases show values lower than 1, but increasing ones as the time pass by. Given that the usage of plant capacity value in close to 1, the cost elasticity on the mid term is comparable to the one shown in the long term estimation.

In term of performance to grade, EE^{lp}, it means the existence of growing economies of scale on average for the whole of the sample, but on decreasing weight through the studied time frame, moving from 1.43 in the first triennium to 1.16 in the last one. The empiric evidence of economies of scale due to size in the Navarre's dairy sector, for + 100 cows, is in line with the result of recent studies on average cost in the European Union area Europea (Smyth *et al*., 2008, Colman y Zhuang, 2005). In Spain, Álvarez y Corral (2008) estimates the elasticity's in the economies of scales over the production function with values between 0.94 and 1.17.

6.   Final comments

The dairy sector faces the uncertainty created by end of the quotas. This, together with instability of milk and animal feeding prices, endanger the farms profitability. This study mainly focuses in the farm structure related to the higher or lower degree of external animal feeding. The geophysical variability of Navarre, allows us to approach this animal feeding in three different zones. Amongst the all the inputs being part of the variable costs, we have made a difference between the cattle and the purchase of food, in order to evaluate the flexible relationship over the dairy productivity and up to what level of feed price increase the sector can assume.

The average marginal costs are 255 €/t which mean a22% quota rent in reference to the Milk price on the last sample triennium (2003/2005). The average variable costs estimated are 204 €/t with a curve elasticity in the marginal costs of 0.54. The marginal costs are higher than the Average costs in all cases, and the quota rent is positive for most of the simple cases. But, the dispersion of the of the quota rent estimated holds on the level through the whole sample period, even after suffering the strong re - organisation in the sector. The institutional lack of flexibility in the transfer of quota might be a direct cause of this result.

The results indicate that the expansion of milk production is based over equivalent increases of external feeding, with no relation with farm's grazing land. That's why; the production evolution in the sector is especially sensitive to the price evolution of the external feeding. And, the external feeding prices impact on the relation between cattle and external feeding, justifying the treatment given to the split of costs function. But the zone with better quality of grazing land shows marginal costs between 15%-20% lower than others.

Referring to the plant capacity used, the companies have values close to the optimum employment. This term is misleading, since conjugates 2 contradictory effects, the under – utilisation in terms of family employment and the over–utilisation in terms of land. We provide the measurement for the non–homothetic multiproduct farms, which corrects deviations of the previous measurements to the under–utilisation of the plant capacity, in order to support these results. The study shows the presence of growing economies in the sector. They trend to get exhausted as the size of the farms grows. This trend is accentuated for the farms with a higher percentage of animal food purchased out of the farm.

Summing up, the study of the farms in Navarra indicates that, their profitability is defined at short term by the milk price, the input price and the management of the Quota rights. On the long term, the key factor in the sector development are the milk price, the price of the food for the cattle and the capacity for profiting the economies of scale inside the sector and depending on the production level and the land.

7.   References

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