REGIONAL DISTRIBUTION OF SHORT-RUN, MEDIUM-RUN AND LONG-RUN QUOTA RENTS ACROSS EU-15 MILK PRODUCERS.

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Abstract
This paper evaluates the distribution of short- and long-run marginal costs and quota rents across the EU-15 milk producers, by estimating a system of cost and input share equations on a panel data of dairy farms from 1996 to 2001. Regional and geographical location and the size of milk operations have been considered as the major factors affecting marginal costs. The results on quota rents highlights that Italian and Greek dairy farmers receive the highest economic rent (260 €/ton), while in Portugal the lowest (101 €/Kg) at least in the short-run. This is an indication that Italian and Greek milk supply would be the least 'sensitive' to a reduction in the intervention price. Several countries show negative long-run quota rents, indicating that in the long-run current market prices influence dairy farm's production plans.
Keywords: dairy, quota rents, marginal costs
JEL codes: C21, Q13, Q18.

1. Issues at the stake in the dairy industry.

The dairy industry is worldwide the most distorted agrifood industry, despite the multilateral efforts in reducing domestic support and in liberalizing international trade. In the three year period 2001-2003, the percentage producer subsidy equivalent among OECD countries is 48%. Japanese dairy farms are the most supported and protected; on average a Japanese dairy farmer receives 77 cents of support from taxpayers and consumers for every euro of sale at the farm gate. On the other hand, the least protected and supported dairy farmers are in New Zealand with a percentage PSE of 1% [1]. Figure 1 illustrates the changes in producer subsidy equivalent (PSE) of dairy sector across major OECD countries before and after the implementation of the Uruguay Round Agreement on Agriculture (URAA).

The policy instruments adopted among OECD countries to protect and support dairy farmers are different (Table 1). Two common aspects emerge from comparing them. First, they all guarantee a 'fair' price to dairy farmers. Second, they implement border measures to protect the domestic industry from international market forces. In general, the 'fair' price to dairy farmers is guaranteed through marketing quotas. The USA are the only exception, since a price discrimination mechanism [Schmitz, Furtran and Baylis, 2001]. On the other hand, the protection of the domestic market from international competition is assured by tariff-rate quotas (TRQs). Note that before the tariffication process, initiated soon after the URAA, quantitative import restrictions guaranteed the border protection to domestic dairy markets.

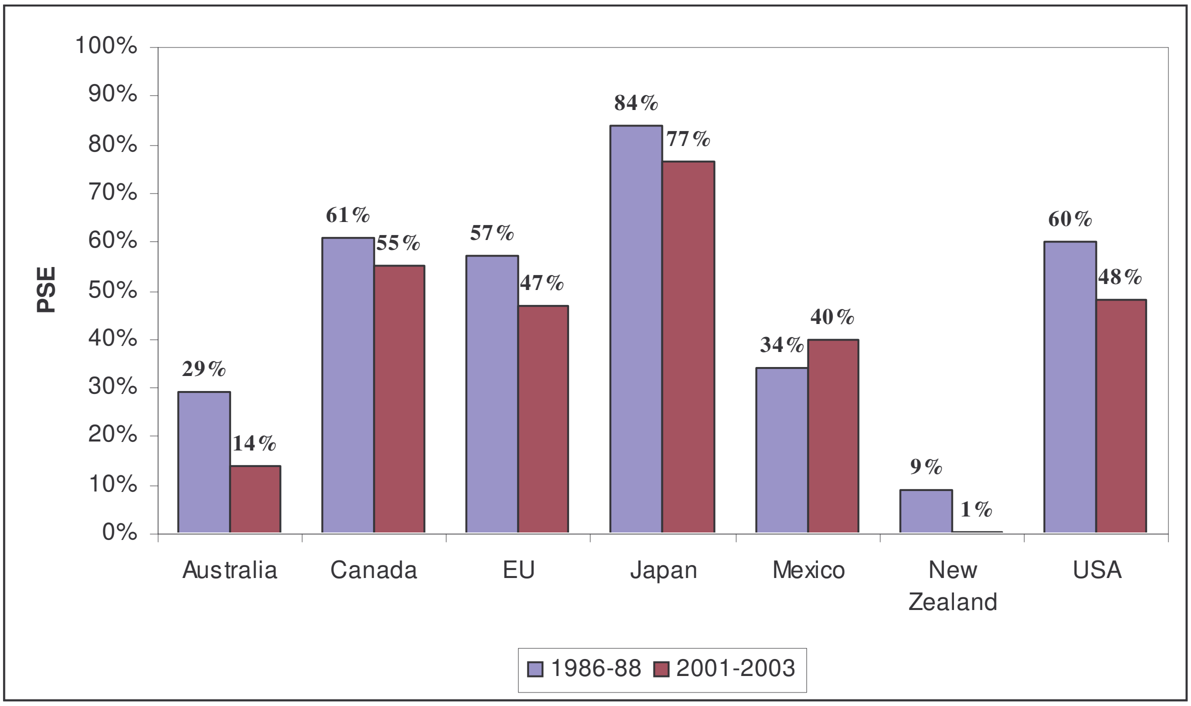
Marketing quotas became popular in the late 50s when Cochrane proposed them to deal with agricultural overproduction and the consequent low returns in farm assets[2]. Since then, they

[1] The producer support estimate (PSE) is defined as "an indicator of the annual monetary value of gross transfers from consumers and taxpayers to support agricultural producers, measured at farm gate level, arising from policy measures which support agriculture, regardless of their nature, objective or impacts on farm production or income" [OECD, 2004a, p.7]. The percentage PSE is the ratio between the PSE and the gross revenue.

[2] Indeed Cochrane evaluates two possible supply controls: one achieved by means of marketing quotas, the other through restriction on the use of an important production factor. However, marketing quotas appear to be more efficient

have been widely adopted to provide a price support and an income stabilization in the dairy industry without entailing public outlays. However, the supply restraint has numerous unintended consequences for the farm sector: it limits structural changes; it favours inefficient farms; it capitalizes the effect of protection and support in the farm assets.

Figure 1. PSE for dairy sectors among the major OECD countries.



source OECD (2005)
http://www.oecd.org/document/58/0,2340,en_2649_201185_32264698_1_1_1_1,00.html

Table 1. Dairy industry policies in selected OECD countries.

Region	Domestic Measures		Border measures before the URAA	Border measures after the URAA
	Price support	Supply management		
Australia	Market and supplementary support	Marketing quotas on fluid milk	Tariffs, Quotas	Tariff-rate quota
Canada	Target price, Subsidy payments	Marketing quotas	Tariffs, Quotas, licenses	Tariff-rate quota
EU-15	Intervention price Payment quota	Marketing quotas	Variable levies	Tariff-rate quota
Japan	Deficiency payments	Marketing quotas	Tariffs, Quotas	Tariff-rate quota
New Zealand	-	-	-	-
USA	Price support	Diversion and Termination plans	Tariffs, Quotas	Tariff-rate quota

Source: Agriculture and Agri-Food Canada [1994]; Schmitz, Furtran and Baylis [2001]

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than the second institutional setting because farmers might invalidate the latter approach simply substituting the restricted input.

Worldwide the European Union is the largest milk producer and consumer, with a share of 21% both in world production and in world consumption. However, the new strategic vision of the Common Agricultural Policy (CAP) will likely change this equilibrium in the international market with inevitable welfare impact for domestic producers and consumers. In fact, the recent "mid-term review" (MTR) of the CAP, which decreases the intervention prices for butter and skimmed milk powder, while leaving the quotas in place up to 2014 and introducing a single farm payment decoupled from production, is likely to heavily affect the European dairy sector. One crucial point is to evaluate the 'sensitivity' of EU dairy supply to different policy scenarios. In fact, as long as the milk quota rent is positive a decline in the farm gate price would not affect the milk supply.

Aim of this paper is to contribute to the ongoing policy debate on the European dairy policy evaluating long-, medium- and short-run marginal costs and quota rents for the major EU-15 milk producers. The objectives are the following:

- to evaluate the distribution of dairy farming and farm structure across the major dairy producer countries in the EU;
- to assess milk production under a quota regime specifying an appropriate economic model;
- to set an empirical framework to estimate milk marginal costs, and hence the milk quota rents across the major EU-15 dairy producers;
- to determine input and output variables/indices to be used in the estimation of the cost function;
- to evaluate short-run and long-run marginal costs, and hence the milk quota rents across the major EU-15 dairy producers.

The paper is divided in 7 sections. From the European Farm Accountancy Data Network (FADN) farm structure and dairy farming activities are evaluated across the major EU-15 milk suppliers. Next the attention is focused in specifying an appropriate theoretical framework to evaluate the farm cost minimizing behaviour and its empirical specifications. Then, the procedure to prepare variables to be used in cost estimation is illustrated. The estimates of marginal costs and quota rents follows. Finally, concluding remarks end this paper.

2. Farm structure and dairy farming activities in the EU.

Milk production represents the most important agricultural output both in the EU as a whole and for the majority of its member countries. Statistics show that milk production accounts for 14% of the total value of agricultural production.

The whole milk production is not evenly distributed across EU member states. In the three-year period 1996-1998, the average milk production of Germany, France and United Kingdom contributed to more than 50% of the total milk production, while Italy and The Netherlands follow these major producers.

In Germany, three major production areas can be identified. In the regions of Schleswing-Holstein, Niedersachsen, and Nordrhein-Westfalen (North-West part of Germany) medium-large dairy farms contribute to 37% of total German production. On the other hand, in the regions of Baden-Württemberg and Bayern (South of Germany) medium-small dairy farms contribute to 38% of milk supply. The remaining milk production is located mostly in the former East Germany.

In France the regions of Bretagne, Pays de la Loire and Basse-Normadie have the highest regional production shares, respectively 21%, 14% and 11%, and medium-large dairy farms (>300 tons/year) are responsible for most of the milk production.

This regional and structural polarization in milk production characterizes also other countries. In the UK medium-large dairy farms contribute to 86% of the total milk production; 57% of these farms are located in North- and West-England. In Italy 84% of milk supply is located in the North, in particular in the regions of Lombardia (34%) and Emilia-Romagna (30%). Medium-large specialized dairy farms supply 54% of the Italian milk production. In Spain, the small regions of Galicia, Asturias and Cantabria (coastal areas in the North-West) contribute to 64% of total milk production. However, here small farms (<150 tons/year) supply a large share of total Spanish production. In The Netherlands and in Denmark medium-large dairy farms contribute to a large share of the national production. More than the 80% of milk is produced in medium-large dairy farms.

These facts highlight that each country has its own peculiarities in terms of farm structure and milk production, which need to be effectively addressed in the evaluation of milk quota rent.

3. Model.

In presence of marketing quotas, milk production decisions may be evaluated either in a profit maximization or in a cost minimization framework. Let us consider a farm whose technology can be represented by a standard production function (eq.[1])

$$F(y, x, z) = 0 \qquad [1]$$

where y is a vector of output quantities, x is a vector of variable input quantities, and z is a vector of fixed input quantities. The presence of marketing quotas restricts the farm milk output to the quota level.

If farmers maximize profits by adjusting the unrestricted output, y^1, and the level of variable inputs subject to marketing quota and quasi-fixed factor constraints, then their production decisions can be described by a restricted profit maximization function:

$$G(p^1, w, y^0, z) \equiv \max_{y^1, x}\left\{ p^1 y^1 - wx \,\middle|\, F(y^0, y^1, x, z) = 0 \right\} \qquad [2]$$

where p is the vector of exogenous output prices and w is the vector of exogenous variable input prices[3] and y^0 is the output subject to production quota.

An equivalent representation is the cost minimization approach. If farmers adjust production inputs given quasi-fixed factors, marketing quotas, output level and input prices, then the following minimization problem describes their behaviour:

$$C(y^0, y^1, w, z) \equiv \min_{x}\left\{ wx \,\middle|\, F(y^0, y^1, x, z) = 0 \right\} \qquad [3]$$

In a profit maximization framework, dairy production is either an investment or disinvestment decision depending upon future profit expectations, because of purchase/sale or marketing quotas. Moschini [1988] points out that to model this behaviour "one needs repeated observations on the same economic unit in different time periods" [p.189] (i.e. balanced panel data). This stringent data requirement together with the non availability of such dataset lead us to adopt a cost minimization approach as the one outlined in equation [3] [4]. The first derivatives of equation [3] with respect to the restricted output (milk) evaluates the milk marginal costs [eq.4], while the unit quota rent r^0 is given by the difference between the milk farm gate price, p^0, and the marginal cost (eq.[5]).

$$MC^0(y^0, y^1, w, z) = \frac{\partial C(y^0, y^1, w, z)}{\partial y^0} \qquad [4]$$

$$r^0(p^0, y^0, y^1, w, z) = p^0 - MC^0(y^0, y^1, w, z) \qquad [5]$$

[3] Note that, if milk is the only farm output, the restricted profit function is just the cost function.

[4] Among the studies on milk quotas adopting the cost function approach, see, for example, Moschini [1988], Guyomard et al. [1995, 1996], Colman et al. [1998], Bouamra et al. [2002], Wieck and Heckelei [2004].

In the medium-run, unpaid labour and land are considered fixed factors. Finally, in the long-run, we can assume that farmers may adjust all their production factors, except unpaid labour, since the existence of farming al least in EU is intimately linked to the family farm.

4. Empirical specification

Two different classes of functional forms can be adopted: *ad-hoc* functional forms and flexible functional forms (FFF). The former has the advantage to be easily implemented and estimated, while some difficulties may be encountered during the estimation of FFF, especially in a multi-output setting, because the model can easily become overparameterised. On the other hand, a FFF has the advantage of providing a local second-order approximation to the true (unknown) cost function at least at one point [Diewert and Wales, 1987].

In this empirical evaluation of dairy quota rents within the European dairy industry, we have adopted a flexible functional form, because of its theoretical consistency (theoretical properties can either be checked or imposed). Among the possible FFF, a hybrid-translog cost function has been chosen following Moschini [1988] (eq.[6]).

$$\ln CT = a_0 + \sum_i a_i \frac{y_i^\lambda - 1}{\lambda} + \sum_j b_j \log(w_j) + \sum_l g_l \log(z_l) + \frac{1}{2}\sum_i\sum_m a_{im}\left(\frac{y_i^\lambda - 1}{\lambda}\right)\left(\frac{y_m^\lambda - 1}{\lambda}\right) + \frac{1}{2}\sum_j\sum_n b_{jn}\log(w_j)\log(w_n) + \sum_i\sum_j mu_{ij}\left(\frac{y_i^\lambda - 1}{\lambda}\right)\log(w_j) + \sum_i\sum_l f_{il}\left(\frac{y_i^\lambda - 1}{\lambda}\right)\log(z_l) + \sum_j\sum_l h_{jl}\log(w_j)\log(z_l) + \frac{1}{2}\sum_l\sum_q k_{lq}\log(z_l)\log(z_q) \qquad [6]$$

where

$i, m = 1,\ldots, I$
$j, n = 1,\ldots, J$
$l, q = 1,\ldots, L$

Applying Sheppard's lemma one gets the set of input share equations:

$$S_j = b_j + \sum_n b_{jn}\log(w_n) + \sum_i mu_{ij}\left(\frac{y_i^\lambda - 1}{\lambda}\right) + \sum_l h_{jl}\log(z_l) \qquad [7]$$

The marginal cost can be computed as:

$$\frac{\partial CT}{\partial y_1} = \exp\left(a_0 + \sum_i a_i \frac{y_i^\lambda - 1}{\lambda} + \sum_j b_j \log(w_j) + \sum_l g_l \log(z_l) + \frac{1}{2}\sum_i\sum_m a_{im}\left(\frac{y_i^\lambda - 1}{\lambda}\right)\left(\frac{y_m^\lambda - 1}{\lambda}\right) + \frac{1}{2}\sum_j\sum_n b_{jn}\log(w_j)\log(w_n) + \sum_i\sum_j mu_{ij}\left(\frac{y_i^\lambda - 1}{\lambda}\right)\log(w_j) + \sum_i\sum_l\left(\frac{y_i^\lambda - 1}{\lambda}\right)\log(z_l) + \sum_j\sum_l h_{jl}\log(w_j)\log(z_l) + \sum_l\sum_l k_{ll}\log(z_l)\log(z_l)\right)\left(a_1\frac{y_1^\lambda}{y_1} + \sum_i \frac{a_{i1}(y_i^\lambda - 1)y_1^\lambda}{\lambda y_1} + \sum_j mu_{1j}\frac{y_1^\lambda \log(w_j)}{y_1} + \sum_k f_{1k}\frac{y_1^\lambda \log(z_k)}{y_1}\right) \qquad [8]$$

The cost function has to satisfy some theoretical restrictions to be well-behaved. Symmetry conditions require that $a_{im} = a_{mi}$ for all i and m, $b_{jn} = b_{nj}$ for all j and n, and $k_{lq} = k_{ql}$ for all l and q.

The adding-up constraint needs that $\sum_n b_{jn} = 0$. Finally, the cost function must be concave in input prices, *w*, and convex in fixed inputs, *z*.

Symmetry conditions and the adding-up constraint are easily imposed on equation [6]. Instead, concavity in input prices and convexity in the fixed assets are evaluated by the sign of the eigenvalues in the matrix $[b_{jn}]$ ($\forall\ j,n = 1 \ldots J$) and in the matrix $[k_{lq}]$ ($\forall\ l,q = 1 \ldots L$) respectively[5]. If these conditions are violated, it may be possible to impose the appropriate curvature conditions through a Choleski reparameterization[6].

5. Data.

The dataset used in this empirical investigation is an unbalanced panel data set of farms surveyed across the major European milk producing countries (i.e. Denmark, France, Germany, Italy, Netherlands, Spain and United Kingdom) from 1996 to 2001. The source of the data is the European Farm Accountancy Data Network (FADN). This database contains considerable information on farm structure and economic activities, as well as information on input variables. Each farm in the sample has a weight corresponding to the number of agricultural holdings it represents. Thus, each record has a different representativeness of the FADN population. However, the FADN database is biased, since only farms above a certain size and managed on a professional basis are included. Details on the definition of the variables used in the investigation and on sample selections are in Appendix A.

Short-run costs are calculated as the sum of the following cost items: energy, seeds and plants, fertilizers and soil improvers, crop protection, veterinary services, feeds, contract work and other direct inputs. Because most of these items have a small incidence on the total short-run costs, two aggregates of variable costs have been postulated: dairy variable inputs (i.e. veterinary expenses and feed costs) and non-dairy variable inputs (i.e. energy costs, seed and plants costs, fertilizers and soil improvers costs, crop protection costs and general expenses). Hours of paid and unpaid labor, used land, dairy cow stock and capital assets such as buildings and machinery are considered fixed in the short-run. The non-linear system of simultaneous equations has three equations: the cost function, equation [6], and share equations for dairy and non-dairy input demands, equations [7]. Machinery and buildings, land, cow stock, hired and family labor are considered fixed in the short-run.

To obtain the medium-run cost, the cost of hired labor (i.e. wage, social security charge and insurance of wage earners)[7] and the implicit cost of capital assets such as buildings, machineries and animal stock are added to the total short-run costs. Since farmers own these assets, an implicit cost of capital (ICC) of an asset *z* is calculated as follows

$$ICC_z = RV_z\,(\gamma + \delta - \pi) \qquad [9]$$

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[5] There is a strict relationship between the properties of a quadratic form and its eigenvalues. In fact, a necessary and sufficient condition for a matrix A to be negative definite (positive definite) is that all its eigenvalues are negative (positive) [Johnston and DiNardo, 1997].

[6] For a matrix A, a necessary and sufficient condition for convexity is that it can be written as A=T'T (A=-T'T for concavity), where $T \equiv [\tau_{ij}]$ is an upper triangular matrix. However, since the estimation of a model with curvature imposed commonly produces convergence problems, a semiflexible version of the model was estimated, adopting the technique proposed by Diewert and Wales [1988] and applied to demand analysis by Moschini [1998]. In practice, the semiflexible model can be obtained by restricting the rank of the matrix T'T: if we want to restrict such a matrix to a rank K<(maximum rank), we just need to set to zero all the τ_{ij} elements for i>K (i.e., to set to zero all the rows of T from (K+1) to (maximum rank)). This procedure implies a gain in degrees of freedom, while reducing the flexibility of the chosen functional form, since it constrains the matrix of the elasticities of substitution.

[7] Unpaid labor –family labor– is considered a fixed input for farmers even in the long-run.

where RV_z is the nominal replacement value of a generic capital asset z, γ and π are respectively the nominal prime lending rate of capital and the inflation rate for a given country in a given year, and δ is a depreciation rate [Moschini, 1988]. For building and machinery, the depreciation rate is set respectively to 0.04 and 0.125, and for livestock to 0.02, where the 'depreciation rate' should be interpreted as a mortality rate. Thus, the system of simultaneous equations has six equations: the cost function and the input demands for dairy inputs, non-dairy inputs, buildings and machinery, cow stock and hired labor; family labor and land are considered fixed input in the medium-run.

The long-run costs are derived adding to the total medium-run costs, the implicit cost of land [eq.9] setting the depreciation rate equals to zero. Furthermore, it is worth noting that, in the case of land, its nominal replacement value also accounts for the rent paid for additional land, taxes on land and buildings, and finally for the costs of insurances on farms and buildings. Therefore, the system of simultaneous equations has seven equations: the cost function and the input demands for dairy inputs, non-dairy inputs, land, buildings and machinery, cow stock and hired labor; family labor is considered fixed also in the long-run.

Finally, since the assumption concerning the machinery depreciation rate is critical for empirical results, we evaluate the effect of different amortization plans on the estimates of quota rents for three large milk producers: Germany, France and Italy. During this sensitivity analysis we have considered two alternative hypotheses on machinery depreciation rate: 0.10 and 0.075.

6. Estimation procedure.

The parameters of the cost function are estimated using the cost function [6] and *J-1* input share equations [7]. One share equation[8] is omitted to avoid the problem of singularity during the estimation. The stochastic version of this share system can be expressed as:

$$\mathbf{Y}_t^* = \mathbf{f}^*(\boldsymbol{\mu};\mathbf{X}_t) + \mathbf{e}_t^* \qquad [10]$$

where $\mathbf{Y}_t^*$ is the vector of the dependent variables (i.e. total cost and *J-1* input shares) for the observation t, $\boldsymbol{\mu}$ is the vector of all parameters to be estimated, $\mathbf{X_t}$ is the vector of all exogenous variables for the observation t, and $\mathbf{e}_t^*$ is the vector of the error terms for the observation t.

Since each observation in the FADN database refers to an 'average' farm representing a group of agricultural holdings with similar features in the population and since the population size within each group varies widely, the estimation of equation [10] would introduce a problem of heteroskedasticity if it were not appropriately corrected. To address this issue equation [10] is transformed as:

$$\mathbf{Y}_t = \mathbf{f}(\boldsymbol{\mu};\mathbf{X}_t) + \mathbf{e}_t \qquad [10]$$

where $\mathbf{Y}_t = c_t\mathbf{Y}_t^*$, $\mathbf{e}_t = c_t\mathbf{e}_t^*$ and $\mathbf{f}(\cdot) = c_t\mathbf{f}^*(\cdot)$. The coefficient c_t is calculated for each FADN observation as follows:

$$c_t = \frac{N\sqrt{n_t}}{\sum_t \sqrt{n_t}} \qquad [11]$$

where N is the number of observations in the dataset and n_t is the number of agricultural holdings that each FADN record t represents [Greene, 1993, p.290]

After this correction one can assume that error terms are contemporaneously correlated, but not serially, hence E[$\mathbf{e_t}$]= 0, E[$\mathbf{e_t}$ $\mathbf{e}_t^{'}$] = $\boldsymbol{\Omega}$, and E[$\mathbf{e_t}$ $\mathbf{e}_s^{'}$] = 0 ($\forall$ t $\neq$ s), where $\boldsymbol{\Omega}$ is the variance-covariance matrix. In addition, one assumes that $\mathbf{e_t}$ is normally distributed. Given these

[8] The land share equation is omitted for the long-run estimation, the non-dairy input share equation is omitted in the short-run.

assumptions a maximum likelihood estimator is consistent and asymptotically efficient. The nonlinear system of simultaneous equations is then estimated using a full information maximum likelihood procedure imposing symmetry and adding-up constraints. When the short-run cost function violates convexity in fixed inputs, a semi-flexible cost is specified imposing the positive definiteness conditions on the matrix $[k_{lq}]$ through a Choleski decomposition. Concavity in input prices is only checked, since in the short-run we are considering only one input and the matrix $[b_{jn}]$ is reduced to one parameter.

If the long-run cost function violates the concavity in input prices, a semi-flexible cost function is estimated imposing the negative definiteness conditions on the matrix $[b_{jn}]$ through a Choleski decomposition. Convexity in fixed inputs is only checked because in the long-run family labour represents the only fixed input.

To account for structural and regional aspects characterizing milk production, the short- medium-, and long-run specifications of equation [10] have been estimated on well defined farm sub-samples considering the regional location, altitude, and class size of milk operations. The hypothesis underlying this choice is that farms distinguished by these factors display different cost structures.

7. Empirical results.

Due to space constraints, we provide here only national estimates (aggregated using production shares). Details on regional estimated short-, medium- and long-run marginal costs, percentages of significant parameters at 5% level, and on properties of the estimated cost function (i.e. concavity in input prices, and convexity in fixed input) are available from the authors on request. These estimations have been carried out on *ad-hoc* farm samples, which have been defined considering regional and geographic farm location, as well as the size of dairy operations in each country. Then, milk production shares have been used as weights to aggregate these results on a national basis.

The hypothesis, underlying these estimates, is that the machinery depreciation rate is 12.5%. To evaluate the robustness of results, as the machinery depreciation rate changes, we have re-estimated the simultaneous equation system considering a rate of 10% and 7.5% for three large dairy producers: France, Germany and Italy.

Table 3. Estimates of short-, medium- and long-run marginal costs across EU-15 members, with a machinery depreciations rate of 12.5%.

Country	n. of *ad-hoc* farm sample	farm size (tons of milk)	short-run cost (€/ton)	medium-run cost (€/ton)	long-run cost (€/ton)
Denmark	3	527	125	272	366
France	9	268	149	271	326
Germany	15	504	180	270	394
Italy	10	343	143	257	329
The Netherlands	3	567	134	219	237
Spain	12	203	126	178	189
United Kingdom	6	637	150	179	259
Austria	3	79	149	187	228
Belgium	3	269	63	184	201
Finland	3	135	161	236	551
Greece	1	26	55	306	436
Ireland	3	255	129	171	263
Portugal	3	186	165	247	359
Sweden	3	252	149	275	328

Source: own estimations

Table 3 provides an overview of short-, medium- and long-run marginal costs aggregated at the national level, considering the machinery depreciation rate of 12.5%. If we did not consider the cost behaviour in some outlier countries, short-run marginal costs would appear evenly distributed among EU-15 members in a range between 125 and 150 €/ton. However, in Greece and Belgium dairy farmers bear the lower marginal costs, respectively 55 and 63 €/ton, while in Germany and Finland there are the higher short-run marginal costs, respectively 161 and 180 €/ton. Considerations on the farm size help to reconcile these puzzling results. In fact, marginal costs have been evaluated at the sample mean within each *ad-hoc* farm group, and then aggregated at national level. A further important aspect to take in account to interpret these results is the geographical localization of dairy operations, which undoubtedly affects yields of milk cows. In this sense, Greece and Finland are disadvantage areas for dairy production.

The differences in the regional distributions of long-run marginal costs are strong: the minimum marginal costs are registered in Spain, 189 €/ton, while dairy farmers in Finland bear the larger marginal costs, 551 €/ton. This wide distribution of marginal costs can be an indication of a different degree of capitalization of dairy farm. However, estimates have to be interpreted with care, since the implicit costs of land, which heavily affect results, is not of easy determination. To appraise the impact of the implicit costs of land on long-run marginal costs, we estimate a medium-run version of the simultaneous equation system. In this case, regional distribution of marginal costs is narrowed and ranges between 171 and 271 €/ton. An exception is represented by Greek dairy farms, which register a medium-run marginal costs of 306 €/ton.

Table 4. Estimates of short-, medium- and long-run quota rents across EU-15 members.

Country	milk price	short-run quota (€/ton)	medium-run quota (€/ton)	long-run quota (€/ton)
Austria	301	152	114	73
Belgium	295	232	111	94
Denmark	337	212	64	-30
Finland	333	172	97	-218
France	310	161	39	-16
Germany	364	184	95	-29
Greece	315	260	9	-121
Ireland	289	160	117	26
Italy	403	260	147	74
The Netherlands	324	189	105	87
Portugal	266	101	20	-93
Spain	284	158	106	94
Sweden	343	194	67	15
United Kindgom	293	144	115	34

Source: own estimations

The estimated value of dairy quota among the EU-15 members are in Table 4. They represent the excess of surplus accruing from restricting milk supply by means of marketing quotas. Its magnitude depends on the prevalent milk price at the farm gate, on the marginal costs, and on the time horizon (i.e. either short-run, medium-run or long-run).

Evaluating the distribution of the farm gate milk price, we found that the highest price is paid in Italy, 403 €/ton, while Spanish farmers receive the lowest milk price. Hence, *ceteribus* *paribus*, Italian farmers should capture the higher quota rent and the Portuguese farmers the lowest. This is partially confirmed by the distribution of short-, medium- and long-run quota rents in table 4. In fact, Italian farmers have the highest quota rents in the short-run, 260 €/ton, while Portuguese farmers have the smallest quota rents 101 €/ton. This implies that Italian milk supply is the least 'sensitive' to a scenario in which the intervention price is reduced. In fact, in the short-run a downward pressure on the Italian milk supply would be observed only for a decline larger than 255 €/ton. Instead, Portuguese farmers would review their milk production plans for smaller reduction. A reduction of 101 €/ton the intervention price is enough to observe for a decline in the Portuguese milk supply.

In the long-run, while Spanish (94 €/ton), Belgian (94 €/ton), and Dutch (87 €/ton) dairy farmers, among others, have large positive quota rents, some countries show negative values, indicating that their long-run milk supply is responding to current market price. Since the previous considerations on the robustness of implicit cost of land hold also here, estimates have to be interpreted with care. On the other hand, the medium-run quota rents are all positive. In particular, for the major European dairy producers these estimates are evenly distributed in the range of 95 and 117 €/ton. Italy and France are two exceptions. In Italy, the quota rent of 147 €/ton is mainly due to the high milk price at the farm gate, whereas in France, structural inefficiencies, generated by the absence of quota trade regime, may explain the low estimates, 39 €/ton.

Table 5. Estimates of short-, medium- and long-run marginal costs considering three different hypothesis on the machinery depreciations rate

H_0 on machinery depreciation rate	France	Germany	Italy
short-run (H_0: r=12.5%)	149	180	143
short-run (H_0: r=10.%)	149	181	143
short-run (H_0: r=7.5%)	133	179	143
medium-run (H_0: r=12.5%)	271	270	257
medium-run (H_0: r=10.%)	268	263	253
medium-run (H_0: r=7.5%)	252	259	250
Long-run (H_0: r=12.5%)	326	394	329
long-run (H_0: r=10.%)	315	387	326
Long-run (H_0: r=7.5%)	311	374	324

Source: own estimations

Table 5 reports the estimated marginal costs under three different hypothesis of machinery depreciation rate. The results highlights how the impact of a different hypothesis on the farm machinery amortization plan has a small impact on the short-, medium- and long-run marginal costs.

8. Concluding remarks

This paper has evaluated the distribution of short- and long-run marginal costs and quota rents across the EU-15 milk producers, estimating a system of cost and input share equations on a panel data of dairy farms from 1996 to 2001. Regional and geographical location and the size of milk operations have been considered as the major factors affecting marginal costs.

Comparing the distribution of long-run marginal costs among the EU-15 members states strong differences emerge, reflecting perhaps the different degree of capitalization of dairy farms.

However, these results have to be interpreted with care, since the implicit costs of land, which heavily affect estimates, is not of easy determination. To assess the impact that the implicit costs of land has on the estimate marginal costs, we estimated a medium-run version of simultaneous equation system. In this case, regional distribution is narrowed and estimates are in range of 171-271 €/ton.

The results on quota rents highlights that Italian and Greek dairy farmers receive the highest economic rent (260 €/ton), while in Portugal the lowest (101 €/Kg) at least in the short-run. This is an indication that Italian and Greek milk supply would be the least 'sensitive' to a reduction in the intervention price. In fact, only for a price decline greater than 260 €/Kg one would observe a downward pressure on the short-run production plans of Italian and Greek farms.

A different perspective on the state of European dairy industry one would get, if one looked at long-run quota rent estimates. In fact, several countries show negative quota rents, indicating that in the long-run current market prices influence dairy farm's production plans.

Finally, a positive note on the assumption concerning the depreciation rate of farm machinery. Varying the depreciation rate in a range between 7.5% and 12.5%, we observe small, and in most cases negligible, changes in estimates of marginal costs.

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APPENDIX A. Variable Definition.

For the purpose of estimating short-, medium- and long-run cost functions, only farm records with consistent information on farm activities have been extracted from the FADN database[9]. Furthermore, farms with milk yield and/or milk price outside the range ($\mu \pm 2\sigma$), where μ is the sample mean and σ is the sample standard deviation, have been discharged.

To account for the different degree of farm specialization across European countries, farm production is sub-divided in two outputs: dairy and non-dairy productions. The first represents total production of fluid milk and dairy products expressed in tons of milk equivalent, while non-dairy output is an aggregate of beef, other livestock and crop productions. Beef output is obtained dividing the value of cattle' sales and farm consumption by a beef price index, calculated from the FADN database. In particular, this index is the weighted sum[10] of the ratio between closing value and closing number of certain type of cattles[11]. Other livestock output is obtained dividing the value of total livestock sales and farm consumption, excluding cattle, by a livestock price index[12]. Finally, the crop output is calculated dividing total crop sales and farm consumption[13] by a crop price index[14]. The overall non-dairy production is then obtained as a weighted sum of beef, other

[9] In this setting information about farm activities is considered consistent if the value of the following items are positive: 1) total farm output, 2) total utilized land, 3) total labour input, 4) total livestock units, 5) hectares of forage, 6) number of dairy cows, 7) milk production, 8) milk yield, 9) milk sales, 10) beef production.
[10] Weights are the corresponding livestock units (LU).
[11] We have considered the following animal categories: female cattle (12-24 months), breeding heifers other cattle (<1 years) and dairy cows, while male cattle (1-2 years), fattening heifers and calves, cull dairy cows and other cows a farm output.
[12] The other livestock price has been calculated as weighted sum of the ratio between closing value and closing number of horses, other goats, other sheep pig for fattening, other pigs, table chickens and other poultry; LU are the weights.
[13] Crop productions refer to: common wheat, durum wheat, barley, oats, grain maize, dry pulses, potatoes, sugar beet, fodder roots, other forage plants, agricultural fallows, temporary grass, permanent pasture, rough grazing, contract rearing, fodder maize, other silage cereals, rape, sunflower, soybean, tomatoes.
[14] It is a weighted sum of all farm specific crop prices; weights are their respective revenue shares.

livestock and crop productions, where weights are their respective revenue shares. Details are in table A1.

Table A1.

Variables		Definition	Unit/Base	Source
y_1	**Milk quantity**	total production of fluid milk and dairy products in milk equivalent	ton	FADN
	Milk price	ratio between total sales and volume of milk quantity as previously defined. This price changes over time and across farms.	€/ton	FADN
	price of a livestock category	ratio between the closing value (€) and closing number of that particular livestock category.	number of livestock	FADN
	Beef price	weighted sum of prices for the following livestock categories: calves for fattening, male cattle (1-2 years), heifers for fattening, cull dairy cows, other cows; livestock units (LU) for each category are the weights. This price changes over time and across farms.	€/LU	FADN
	Beef production	ratio of total value of cattle production (€) and beef price (€/LU); The total value of cattle production is obtained summing sales and farm consumption of cattle	LU	FADN
	Other Livestock price	weighted sum of prices for the following livestock categories: horses, other goats, other sheep, pigs for fattening, other pigs, table chickens and other poultry. Livestock units (LU) for each category are the weights. This price changes over time and across farms.	€/LU	FADN
	Value of other livestock production	difference between the sum of sales and farm consumption of total livestock products and the sum of sales and farm consumption of cattle and dairy products	€	FADN
	Other Livestock production	ratio between value of other livestock production and other livestock price	LU	FADN
	Price for a single crop production	ratio between total value of production (sales at the farm gate, farm consumption and farm use) and total production for a given crop. This price changes over time and across farms.	ton	FADN
	Crop production price	weighted sum of prices of all farms crops; weights are their respective revenue shares. Crop productions are: common wheat, durum wheat, barley, oats, grain maize, dry pulses, potatoes, sugar beet, fodder roots, other forage plants, agricultural fallows, temporary grass, permanent pasture, rough grazing, contract rearing, fodder maize, other silage cereals, rape, sunflower, soybean, tomatoes.	€/ton	FADN
	Value of crop production	sum of total sales and farm consumption of all crops produced at any given farm	€	FADN
	Crop production	ratio between value of crop production and price of crop production	ton	FADN

y_2	**Other output different from milk**	weighted sum of cattle production, other livestock production and crop production, where the weights are given by the share of their revenue.	mixed (ton and LU)	FADN
	Energy quantity index	ratio between energy costs (i.e. expenditures in motor fuels and lubrificant, electricity, heating fuels) and its relative price index Eurostat (=100 in 1995)		FADN and Eurostat
	Seed and plant quantity index	ratio between expenditure in seeds and plants relates to agricultural and horticultural crops and its relative price index Eurostat (=100 in 1995)		FADN and Eurostat
	Fertilizers and soil improvers quantity index	ratio between expenditure in fertilizers and soil improvers and its relative price index Eurostat (=100 in 1995)		FADN and Eurostat
	Crop protection quantity index	ratio between expenditure in crop protection and its relative price index Eurostat (=100 in 1995)		FADN and Eurostat
	Feed quantity index	ratio between feeding costs and its relative price index Eurostat (=100 in 1995)		FADN and Eurostat
	Veterinary service quantity index	ratio between expenditure in veterinary services and its relative price index Eurostat (=100 in 1995)		FADN and Eurostat
	General expense quantity index	ratio between expenditure in feeding costs for pig and poultry, contract work and other direct inputs and the Eurostat general expenses price index (=100 in 1995)		FADN and Eurostat
w_1	**dairy inputs price index**	weighted sum of dairy feeds and veterinary service price indexes; weights are their respective costs shares	€	FADN and Eurostat
	dairy inputs quantity index	the sum dairy feeds and veterinary expenses is divided by the dairy inputs price index		
w_2	**non-dairy inputs price index**	weighted sum of energy, plant and crop protection, fertilizers and soil improvers, and finally general expenses price indices; weights are their respective cost shares	€	FADN and Eurostat
	non-dairy output quantity index	the sum of expenditures in energy, plant and crop protection, fertilizers, soil improvers, and general expense is divided by the non-dairy output price index		
	Hired labor	it is defined as the time worked in hours by paid labor input on holding	hours	FADN
w_3	**hired labor price**	it is the ratio between the sum of wages and social security charge (and insurance) of wage earners, and the variable hired labor	€/hour	FADN
w_4	**dairy cow stock price index**	weighted sum of prices for the following livestock categories: female cattle (1-2 year), breeding heifers, dairy cows and other cattle (<1 year); livestock units (LU) for each category are the weights. This price changes over time and across farms.	€/LU	FADN
	building price index	it is equal to 100 in 1995		Eurostat
	Machinery price index	average of ‘machinery and other equipment’ and ‘farm machinery and other installations’ price indices. It is equal to 100 in 1995		Eurostat

w_5	**capital price index**	weighted sum of building and machinery price index, where weight are given by their expenditure share. It is equal to 100 in 1995		Eurostat
w_6	**land price index**	ratio between opening value of land and hectares of own land	€/Ha	FADN
z_1	**dairy cow quantity index**	weighted sum of closing number for the following livestock categories: other cattle (<12 months), female cattle between 12 and 24 months, breeding heifers and dairy cows. Livestock units (LU) for each category are the weights.	LU	FADN
z_2	**land**	it consists of land in owner occupation, rented land and land in share-cropping. It does not account for areas used for mushrooms, land rented for less than one year on an occasional basis, woodland and other farm areas (roads, ponds, non-farmed areas, etc.)	Ha	FADN
	building quantity index	ratio between the building opening value and the building price index		FADN/Eurostat
	machinery quantity index	ratio between machinery opening value and machinery price index, which is defined as the average between 'machinery and other equipment' and 'farm machinery and other installations' price indices.		FADN/Eurostat
z_3	**Capital quantity index**	sum of building and machinery quantity index	€	
z_4	**Family labor**	sum of the total unpaid labor hours	hours	FADN