



European Dairy Industry Model



Institut National de la Recherche Agronomique



Milk Quotas in the European Union: Distribution of Marginal Costs and Quota Rents

Adeline Cathagne (*INRA*)

Hervé Guyomard (*INRA and CEPII*)

Fabrice Levert (*INRA*)

Working Paper 01 / 2006



MILK QUOTAS IN THE EUROPEAN UNION
Distribution of Marginal Costs and Quota Rents

Adeline Cathagne, Hervé Guyomard and Fabrice Levert
INRA, Department of Social Sciences, France

January 2006

1. Introduction

The European Union (EU) introduced the milk quota regime in 1984. The 1992 Common Agricultural Policy (CAP) reform left the milk quota policy unchanged. The Agenda 2000 CAP reform included changes in the milk policy while maintaining the quota instrument until 2007/08. In the same way, the June 2003 CAP reform includes changes in the milk policy (support price cuts partially compensated by direct aids included in the Single Farm Payment) but it maintains the quota instrument until 2014/15. There is however increasing pressure for suppressing the quota instrument before that date. At the very minimum, there is increasing pressure for analysing what could be the potential impacts of further reforms of the EU dairy policy. In particular, there is increasing pressure for analysing what could be the impacts of a scenario where quotas would be freely transferable, not only in each Member State but also between Member States, and the consequences of various scenarios of milk quota exit. In that perspective, two parameters are clearly of crucial importance, i.e., milk production marginal costs and milk supply elasticities. The main objective of this study is to provide estimates of milk production marginal costs for the various EU Member States on the basis of individual data drawn from the European FADN database.

We first present the economic model (Section 2). We then present the data (Section 3) and the estimation procedure (Section 4). Estimation results are presented in Section 5 . They are discussed in Section 6 which deals with the problem of dairy farm heterogeneity within each Member State.

2. The economic model

We assume that the technology of a dairy farm can be represented by a multi-output cost function where milk is one of the outputs distinguished in the specification. The partial derivative of the cost function with respect to milk gives directly the marginal cost function of milk production.

We assume that the multi-output cost function depends on three outputs, that is milk, beef meat and other outputs.

As regards inputs, we consider three specifications corresponding to, respectively, a short-run, a medium-run and a long-run horizon.

- In the short run, all primary factors (hired and family labour, land and capital) are considered as fixed factors, all other inputs (raw materials) being assumed variable.
- In the medium run, family labour and land are still fixed inputs while raw materials, hired labour and capital are assumed variable.
- In the long run, only family labour is fixed all other inputs, including land, being assumed variable.

We include additional explanatory variables in order to take into account milk production technology diversity. More precisely, we add as explanatory variables the ratio of the total number of livestock units on forage area, the milk yield per dairy cow and the share of fodder maize area in total forage area. In a general way, these three variables capture production process intensification. The third variable allows us, in addition, to distinguish between grass-based and maize-based dairy farms.

Our objective was to derive a milk production marginal cost function as flexible as possible. In other words, our objective was to allow all explanatory variables to be potential arguments of the milk production marginal cost function. To that end, we assumed that the milk production marginal cost function could be written as:

$$(1) \quad C_m(y_1, y_j, z_l, w_n) = \eta_1 + \eta_{11} y_1 + \eta_{111} y_1^2$$

where y_1 is milk output, y_j is the vector of other outputs, w_n is the price vector of variable inputs and z_l is the vector of quasi-fixed inputs and the three additional explanatory variables. The vectors of variable input prices and fixed input quantities differ according to the time horizon which is considered (see above). The milk production marginal cost function $C_m(y_1, y_j, z_l, w_n)$ is defined as a quadratic function of milk output. The three coefficients of this quadratic function are not constant. Instead they potentially depend on all explanatory variables except milk output. In other words, we have:

$$(2a) \quad \eta_1 \equiv \eta_1(y_j, z_l, w_j)$$

$$(2b) \quad \eta_{11} \equiv \eta_{11}(y_j, z_l, w_j)$$

$$(2c) \quad \eta_{111} \equiv \eta_{111}(y_j, z_l, w_j)$$

The milk production marginal cost function (1) reduces to a constant when both η_1 and η_{11} equal zero. It is linear in milk output when η_{11} equals zero. It is U shaped when η_1 is (strictly) positive and η_{11} is (strictly) negative.

Specification (1) can be derived from the following truncated cubic functional form for the cost function¹:

$$(3) \quad \begin{aligned} C(y_1, y_j, z_l, w_n) = & d \\ & + \beta_1 y_1 + \beta_2 y_1^2 + \beta_3 y_1^3 \\ & + \sum_j \alpha_{1j} y_j y_1 + \sum_j \alpha_{2j} y_j y_1^2 + \sum_j \alpha_{3j} y_j y_1^3 \\ & + \sum_l \gamma_{1l} z_l y_1 + \sum_l \gamma_{2l} z_l y_1^2 + \sum_l \gamma_{3l} z_l y_1^3 \\ & + \sum_n \delta_{1n} w_n y_1 + \sum_n \delta_{2n} w_n y_1^2 + \sum_n \delta_{3n} w_n y_1^3 \end{aligned}$$

¹ A more general specification would be to consider a full third-order development. However, colinearity problems among explanatory variables make the estimation of this full specification problematic. The choice was thus made to focus on cross-terms involving milk production as farms considered in this paper are mainly dairy farms and our first objective is to derive a quadratic milk production marginal cost function as flexible as possible.

The first derivative of (3) with respect to milk output yields the milk production marginal cost function which can be written as:

$$\begin{aligned}
 Cm(y_1, y_j, z_l, w_n) = & \beta_1 + \beta_2 y_1 + \beta_3 y_1^2 \\
 & + \sum_j \alpha_{1j} y_j + \sum_j \alpha_{2j} y_j y_1 + \sum_j \alpha_{3j} y_j y_1^2 \\
 & + \sum_l \gamma_{1l} z_l + \sum_l \gamma_{2l} z_l y_1 + \sum_l \gamma_{3l} z_l y_1^2 \\
 & + \sum_n \delta_{1n} w_n + \sum_n \delta_{2n} w_n y_1 + \sum_n \delta_{3n} w_n y_1^2
 \end{aligned}
 \tag{4}$$

Equation (4) may equivalently be written as:

$$\begin{aligned}
 Cm(y_1, y_j, z_l, w_n) = & (\beta_1 + \sum_j \alpha_{1j} y_j + \sum_l \gamma_{1l} z_l + \sum_n \delta_{1n} w_n) \\
 & + (\beta_2 + \sum_j \alpha_{2j} y_j + \sum_l \gamma_{2l} z_l + \sum_n \delta_{2n} w_n) y_1 \\
 & + (\beta_3 + \sum_j \alpha_{3j} y_j + \sum_l \gamma_{3l} z_l + \sum_n \delta_{3n} w_n) y_1^2
 \end{aligned}
 \tag{5}$$

As a result, we have:

$$\eta_1(\cdot) = \beta_1 + \sum_j \alpha_{1j} y_j + \sum_l \gamma_{1l} z_l + \sum_n \delta_{1n} w_n
 \tag{6a}$$

$$\eta_{11}(\cdot) = \beta_2 + \sum_j \alpha_{2j} y_j + \sum_l \gamma_{2l} z_l + \sum_n \delta_{2n} w_n
 \tag{6b}$$

$$\eta_{111}(\cdot) = \beta_3 + \sum_j \alpha_{3j} y_j + \sum_l \gamma_{3l} z_l + \sum_n \delta_{3n} w_n
 \tag{6c}$$

The milk production average cost function is approximated using the following expression (Moschini, 1988b):

$$CM(y_1, y_j, z_l, w_n) = [C(y_1, y_j, z_l, w_n) - C(0, y_j, z_l, w_n)] / y_1
 \tag{7}$$

3. Data

The cost function is estimated using farm-level data for each EU Member State but Greece. Individual data are taken from the European Farm Accountancy Data Network (FADN). They form an unbalanced panel data set for the period 1996-2001. Each farm in the FADN sample corresponds to a certain number of holdings in the FADN population which differs from the real population as only farms above a certain size and managed on a professional basis are included. Although the analysis is based on individual data, country aggregates are also used for some variables (prices) when information is lacking in the FADN database.

In a first step, we deleted dairy farms we considered as “inconsistently” reported in the FADN database. More specifically, we did not consider farms for which at least one of the following variable was negative: total output value, milk output value, milk output quantity, labour quantity, number of dairy cows, land quantity, milk yield and the total number of animals. We also did not consider dairy farms for which the forage area was not strictly positive. Finally, we applied the Tukey method in order to suppress “very atypical” dairy farms (severe outliers). More specifically, we did not included in the sample used for estimating the cost function dairy farms with a milk output higher than the third quartile plus 1.5 the interquartile variation or lower than the first quartile minus 1.5 the interquartile variation.

Short-run costs include the costs of energy, seeds and plants, fertilisers and soil improvers, crop protection inputs, veterinary services, feed, contract work and other direct inputs. In practice, we grouped all these variable inputs in two aggregates, one for “dairy” variable inputs (veterinary expenses and feed costs) and one for all other variable inputs non specifically devoted to milk production. In the short run, labour, land and capital are considered as fixed factors.

In the medium run, only family labour and land are assumed fixed. Medium-run costs are thus calculated by adding to short-run costs defined above the cost of hired labour and an imputed (implicit) cost of capital. The cost of hired labour includes wages, social security charges and insurance for wage earners. The implicit cost of capital (*ICC*) is calculated using the following formula:

$$(8) \quad ICC_t = RV_t(\gamma + i - \pi_t)$$

where RV_i is the nominal replacement value of the considered capital asset (buildings, machinery and animal stock), γ is the nominal prime lending capital rate, i is the inflation rate and π_i is the depreciation rate. The depreciation rate is the same for all countries. It is equal to 0.02 for livestock, 0.04 for buildings and 0.125 for machinery. The inflation rate varies by country and per year.

In the long run, only family labour is assumed fixed. Long-run costs are thus calculated by adding to medium-run costs defined above an implicit cost of land. The latter is calculated applying equation (8) to land with a depreciation rate set to zero.

4. Estimation procedure

In a very compact and general way, the cost function (3) can be written as:

$$(9) \quad Y_i = C(X_i, \beta) + \varepsilon_i$$

where Y_i is the dependent variable for the i th dairy farm (i.e., short-run, medium-run or long-run costs), X_i is the vector of explanatory variables for this i th dairy farm, β is the vector of parameters to be estimated and ε_i is the error term.

As explained above, each farm in the sample represents a number of similar holdings in the FADN population. There is here a potential problem of heteroskedasticity as the groups of farms in the FADN population are of very different sizes. To address this issue, equation (9) is estimated using Weighted Least Squares (WLSQ). This is equivalent to use Ordinary Least Squares (OLSQ) on transformed variables

$$(10) \quad T_i Y_i = T_i C(X_i, \beta) + T_i \varepsilon_i$$

$$\text{where } T_i = \frac{N\sqrt{n_i}}{\sum_i \sqrt{n_i}}$$

with N the number of holdings in the sample and n_i the number of farms the sample i th farm represents.

Time dummies were included (except for the base year). In some cases, regional dummies were also included. They were introduced in a multiplicative way with milk output so that they are arguments of the “constant” coefficient η_1 of the marginal cost function.

Preliminary estimation results showed that many parameters were not statistically significant (at a five percent level of significance). In order to reduce the number of parameters to be estimated and the related problem of colinearity among explanatory variables, we used three standard methods of model selection. The backward elimination technique starts with all variables and deletes variables. Variables are deleted one by one until all the variables remaining in the model produce statistics indicating that they should be conserved. The forward selection method begins with no variables in the model and adds variables progressively. Variables are added one by one until no remaining variable produces a significant statistic indicating that the variable should be included. Once a variable is in the model, it stays. The stepwise method is similar to the forward selection method except that variables already in the model do not necessarily stay there. That means that after a variable is added, the stepwise method looks at all the variables already included in the model and deletes any variable that does not produce a statistic indicating that it should be maintained. The three methods have been applied. In each case, a log-likelihood test was carried out in order to compare the selected model with the full model which includes all explanatory variables.

5. Estimation results

Results for specialised dairy farms (TF 41)²

² In a very general way, specialised dairy farms are defined as obtaining more than 66 % of income from milk production.

Table 1 shows that per-farm average milk output varies considerably among countries, from 73 tons in Austria to 455 tons in the United Kingdom (average 1996-2001). In a general way, dairy farms are on average of smaller size in Austria, Finland and the three countries of the South of the EU (Italy, Portugal and Spain). They are on average of greater dimension in Denmark, the Netherlands and the United Kingdom. Of course, country averages mask wide variations within each Member State. Table 1 shows that average milk prices vary among countries, from 253 euros per milk ton in Portugal to 404 euros per milk ton in Italy. It is difficult to explain why milk prices differ so much among countries. There is no clear evidence of a simple relationships between dairy farm average size and milk prices. Here also, country averages mask the fact that milk prices vary from one dairy farm to another within the same Member State.

(Insert Table 1 and Figure 1)

Table 1 and Figure 1 display short-run, medium-run and long-run marginal costs of milk production evaluated at the FADN population mean. These marginal costs are obtained on the basis of expression (5) for the marginal cost function evaluated with estimated parameters and FADN population mean values for explanatory variables.

- (i) Short-run marginal costs vary from 62 euros per ton of milk in Austria to 254 euros per ton of milk in Italy. Short-run marginal costs estimated for Belgium are clearly too low (13 euros per ton) to be considered as realistic. Unfortunately, despite our efforts, it was impossible to correct this “implausible” figure. Short-run marginal costs are significantly lower than milk prices in all countries. They are comparatively higher in the countries of the North and the South of the EU than in other Member States. There is no clear evidence of a simple relationship between short-run marginal costs and milk prices. Short-run marginal costs are high in Italy and Portugal. Milk prices are high in Italy but low in Portugal. In the same way, there is no clear evidence of a simple relationship between short-run marginal costs and dairy farm size (measured by milk output). In Italy or Portugal, short-run marginal costs are rather high while milk output per farm is rather low. In the Netherlands, short-run marginal costs are rather low while milk output per farm is comparatively high. Milk output per farm is of the same order of magnitude in the Netherlands and Denmark, but short-run marginal costs are much higher in

Denmark than in the Netherlands. Overall, this suggests that an analysis at the country level on the basis of marginal cost functions evaluated at weighted sample mean values for the various explanatory variables is perhaps not very relevant as it does not take into account dairy farm heterogeneity within each Member State. In other words, this suggests that the within country heterogeneity is perhaps more important than the between country heterogeneity.

- (ii) Medium-run marginal cost estimates range from 93 euros per ton of milk in Belgium to 344 euros per ton of milk in Italy. Except for Portugal, medium-run marginal costs are still lower than milk prices. The country hierarchy established on the basis of short-run marginal costs is globally preserved. Medium-run marginal costs are comparatively high in Mediterranean countries (Italy and Portugal, Spain to a lesser extent) as well as in Nordic European countries (Finland and Sweden). Medium-run marginal costs are also rather high in Denmark but the dairy farm average size is much higher in this country (397 tons of milk to be compared with, for example, 88 tons of milk in Portugal or 117 tons of milk in Finland). Despite high farm sizes, medium-run marginal costs are comparatively low in the Netherlands and the United Kingdom, respectively 150 and 182 euros per ton of milk. In Ireland, the difference between short-run and long-run marginal costs is low, only 36 euros per ton of milk. Belgian and Irish medium-run marginal costs are the lowest.

- (iii) Long-run marginal costs are always greater than corresponding medium-run marginal costs. Long-run marginal costs are higher than milk prices in seven countries (Austria, Denmark, Finland, Germany, Luxembourg, Portugal and Sweden). They are equal to milk prices in France and Ireland, and they are lower than milk prices in Italy, the Netherlands, Spain and the United Kingdom. Long-run marginal cost estimate range from 206 euros per ton of milk in Belgium to 384 euros per ton of milk in Italy. It is because milk prices are very high in Italy (404 euros per ton of milk) that long-run marginal costs are lower than milk prices in this country. Differences between medium-run and long-run marginal costs vary a lot from one country to another. For a majority of Member States, the increase is around 40 - 60 euros per ton of milk. The increase is sometimes much higher, for example 85 euros per ton of milk in the United Kingdom or 99 euros per ton of

milk in France. These differences may reflect different degrees of land capitalisation of dairy farms. However, results and conclusions have to be interpreted with care as they obviously depend on the way the implicit cost of land is calculated (see Section 3).

Table 2 displays the difference between milk prices and short-run (column 3), medium-run (column 4) and long-run (column 5) marginal costs. These “unit quota rents” are also depicted on Figure 2.

(Insert Table 2 and Figure 2)

Information can be summarised as follows.

- Short-run “unit quota rents” are positive in all countries, but with large differences among countries (from 46 euros per ton of milk in Portugal to 240 euros per ton of milk in Austria).
- In some countries (Italy for example), a comparatively high short-run marginal cost (254 euros per ton of milk) is compensated by a high milk price (404 euros per ton of milk) so that the short-run “unit quota rent” is relatively high (150 euros per ton of milk). For other countries (the United Kingdom for example), the short-run “unit quota rent” is not very high (167 euros per ton of milk) although short-run marginal costs were very low (126 euros per ton of milk), this because of comparatively low milk prices (292 euros per ton of milk). In Portugal and Spain, both short-run marginal costs and milk prices are low and hence, short-run “unit quota rents” are low. In Finland and Sweden, short-run “unit quota rents” are higher because milk prices are greater. This simple analysis suggests that both marginal costs and milk prices will matter in milk policy reform scenarios involving quota mobility at the EU scale or quota suppression.
- Medium-run “unit quota rents” are positive in all countries but Portugal. They are however substantially lower than their short-run counterparts.
- Long-run “unit quota rents” are positive in seven countries and negative in seven countries. In a general way, one can distinguish four groups of countries. The first group

includes Belgium and the Netherlands with “high” long-run “unit quota rents”. The second group includes Italy, Spain and the United Kingdom with “slightly positive” long-run “unit quota rents”. The third group corresponds to countries for which long-run “unit quota rents” may be considered as null (Denmark, Finland, France, Ireland and Sweden). The last group corresponds to Member States with “negative” long-run “unit quota rents” (Austria, Germany, Luxembourg and Portugal).

- Short-run marginal costs are always lower than medium-run marginal costs that are themselves lower than their long-run equivalents. Similarly, short-run “unit quota rents” are always greater than medium-run “unit quota rents” that are themselves greater than their long-run counterparts. Furthermore, differences between short-run, medium-run and long-run indicators are important. This simple observation raises an issue of crucial importance for assessing the potential impact of dairy policy reform scenarios involving milk price cuts, greater quota mobility or quota removal. An assessment on the basis of short-run estimates suggests that all Member States could “support” a relatively large price cut before this cut translates in a milk output decrease. An assessment based on medium-run estimates (*a fortiori* long-run estimates) suggests that milk supply is more sensitive to milk price cuts and that a price cut of say 100 euros per ton of milk would be enough to induce milk supply reaction in countries like Denmark or Spain, for example. At this stage, it is important to recall that all results, and more particularly medium-run and long-run results, should be interpreted with great care given the way the (implicit) costs of capital and land are calculated. Furthermore, this analysis at an aggregate (country) level on the basis of a single marginal cost function for each country evaluated at FADN population mean values for all explanatory variables does not take into account dairy farm heterogeneity within each Member State. This point is discussed at length in the next section. Before that, two remarks are in order. The first remark addresses the question of evolution over time of marginal costs and “unit quota rents”. The second remark analyses to what extent results are different, or not, when all dairy farms, and not only specialised dairy farms, are taken into account.

Evolution of marginal costs and “unit quota rents” for specialised dairy farms from 1996 to 2001

Figure 3 displays short-run marginal costs (panel a), medium-run marginal costs (panel b) and long-run marginal costs (panel c) for each of the six years 1996 to 2001. Drawing definite conclusions from these figures is clearly a perilous exercise. One will note however that long-run marginal costs seem exhibit a downward trend from 1996 to 2001. France where quota mobility is highly regulated and restricted (there is market quota in this county) is a noticeable exception. The decrease over years in long-run marginal costs translates in an increase in long-run “unit quota rents” (Figure 4, panel c). In fact, Figure 4 suggests that short-run, medium-run and long-run “unit quota rents” tend to increase over time.

(Insert Figure 3 and Figure 4)

Specialised versus all dairy farms

The cost function (3) has also been estimated using the weighted FADN sample of all dairy farms. Table 3 shows that all dairy farms have on average a smaller quota than specialised dairy farms. One exception is the United Kingdom but the difference is not significant. In two countries, the difference is substantial: in Italy, the quota is 78 tons of milk for all dairy farms and 115 tons of milk for specialised dairy farms; in Belgium, the quota is 196 tons of milk for all dairy farms and 243 tons of milk for specialised dairy farms. As expected, differences in milk prices are much lower between specialised and all dairy farms. There is however the “specific” case of Ireland: in this country, the milk price of specialised dairy farmers (310 euros per ton of milk) is significantly higher than the price get in average by all dairy farmers (283 euros per ton of milk). Table 4 compares medium-run marginal costs and medium-run “unit quota rents” for specialised and all dairy farms. Before commenting these figures, a preliminary remark is in order. Using the sample of all dairy farms allows us the solve the puzzle of estimation results obtained for Belgium on the basis of the sample of specialised dairy farms. Estimates obtained with the sample of all Belgian dairy farms are clearly more “reasonable” and “realistic”. In a more general way, one will retain that the country hierarchy is globally the same whatever it is established on the basis of either the sample of specialised dairy farms or the sample of all dairy farms. For a majority of countries (Austria, Finland, Germany, Ireland, Italy, Spain, Sweden and the United Kingdom), medium-run marginal costs estimated from the two samples are not significantly different. In Denmark, a lower quota level may explain, at least in part, why the medium-run marginal cost of all dairy farms (242 euros per ton of milk) is lower than the medium-run marginal cost of specialised dairy

farms (263 euros per ton of milk). The same explanation can be applied to the Netherlands, but not to France. For quota levels more or less identical, around 200 tons of milk, medium-run marginal costs of all French dairy farms (173 euros per ton of milk) are substantially lower than medium-run marginal costs of specialised French dairy farms (209 euros per ton of milk).

(Insert Table 3 and 4)

6. Concluding comments: The “puzzle” of quota rents

In each country, “unit quota rents” presented in the previous section have been calculated by taking the difference between the average milk price observed in that country and the “average” milk production marginal cost in that country. The “average” milk production marginal cost has been evaluated from estimated cost functions. More precisely, the “average” milk production marginal cost is equal to the estimated marginal cost function evaluated at weighted sample mean values for all explanatory variables, including milk output. In other words, “unit quota rents” presented in the previous section are “unit quota rents” at average quota level, all other explanatory variables being evaluated at weighted sample mean values:

$$(11) \quad \bar{r} = r(\bar{p}_1, \bar{y}_1, \bar{y}_j, \bar{z}_l, \bar{w}_n) = \bar{p}_1 - Cm(\bar{y}_1, \bar{y}_j, \bar{z}_l, \bar{w})$$

From (11), one defines a unit quota rent function evaluated at weighted sample mean values for all explanatory variables but milk output:

$$(12) \quad r(\bar{p}_1, y_1, \bar{y}_j, \bar{z}_l, \bar{w}_n) = \bar{p}_1 - Cm(y_1, \bar{y}_j, \bar{z}_l, \bar{w})$$

This way of defining aggregate (country) quota rents and marginal cost functions from functions estimated using farm-level data is common practice (Moschini, 1988a, 1988b). It can however be criticised on several grounds, notably because it does not take into account dairy farm heterogeneity in terms of milk prices, other output levels, quasi-fixed input use or variable input prices. It implicitly assumes that all dairy farms are on the increasing part of

their marginal cost curve and that the marginal cost at quota level is greater than the average cost at quota level so that it is possible, first to define “unit quota rents as the difference between milk prices and marginal costs, second to define the industry marginal cost curve as the horizontal summation of individual marginal cost curves. In practice however, it appears that many dairy farms are not on the increasing part of their marginal curve. Furthermore, numerous dairy farms which are on the increasing part of their marginal cost curve are in a regime where the marginal cost at quota level is lower than the average cost at quota level.

This point is illustrated below in the specific case of Germany for the year 2000 on the basis of short-run (SR) estimates. In practice, German dairy farms in 2000 can be classified into four groups:

- The first group corresponds to the “standard” case of farms which are on the rising part of their SR marginal cost function with the following ordering: a milk price greater than the SR marginal cost at quota level itself greater than the SR average cost at quota level itself greater than the minimum of the SR average cost function. On a total of 1639 dairy farms, only 40 belong to this first group.

$$(13a) \quad p_1 > Cm(\bar{y}_1) > CM(\bar{y}_1) > \text{Min } CM(y_1)$$

(production at quota level on the rising part of the SR marginal cost function)

- The second group corresponds to farms which are also on the rising part of their SR marginal cost function but with the following ordering: a milk price greater than the SR average cost at quota level itself greater than the minimum of the SR average cost function itself greater than the SR marginal cost at quota level. On a total of 1639 dairy farms, 296 belong to this second group.

$$(13b) \quad p_1 > CM(\bar{y}_1) > \text{Min } CM(y_1) > Cm(\bar{y}_1)$$

(production at the quota level on the rising part of the SR marginal cost function)

- The third group corresponds to farms which are on the decreasing part of their SR marginal cost function with the following ordering: a milk price greater than the SR

average cost at quota level itself greater than the minimum of the SR average cost itself greater than the SR marginal cost at quota level. On a total of 1639 dairy farms, 907 belong to this third group.

$$(13c) \quad p_1 > CM(\bar{y}_1) > \text{Min } CM(y_1) > Cm(\bar{y}_1)$$

(production at quota level on the decreasing part of the SR marginal cost function)

- The fourth group corresponds to farms which are on the decreasing part of their SR marginal cost function with the following ordering: a milk price greater than the SR average cost at quota level itself greater than the SR marginal cost at quota level itself greater than the minimum of the SR average cost. On a total of 1639 dairy farms, 396 belong to this fourth group.

$$(13d) \quad p_1 > CM(\bar{y}_1) > Cm(\bar{y}_1) > \text{Min } CM(y_1)$$

(production at quota level on the decreasing part of the SR marginal cost function)

From this classification, it is clear that defining a single (aggregate) milk production marginal cost function for Germany where all explanatory variables (except milk output) are evaluated at weighted sample mean values does not take into account heterogeneity of situations. This point is illustrated by a simple descriptive analysis of farm characteristics in each of the four groups distinguished above. Characteristics differ substantially from one group to another. In a general way, it appears that farm size (measured by milk output, the number of dairy cows, the total number of animals, the land area or the forage area) continuously decreases when passing from the first to the fourth group.³

At this stage, the essential question is then: How do these four types of farms will react in, for example, a quota removal scenario? For simplicity, let us assume (unrealistically) that the milk price is maintained unchanged thanks to public intervention. Furthermore, let us assume that the milk price is the same for the four types of farms (there are no significant differences

³ In the specific case of Germany, milk yields per dairy cow exhibit a downward trend from the first to the fourth group. This is not general however as milk yields in for example Belgium do not exhibit a similar pattern.

in milk prices among the four groups of farms). Since we are in the short term, all primary inputs (labour, capital and land) are assumed fixed at 2000 year levels. It is clear that it is not possible to use estimation results ordered according to the classification defined above in four types of farms to predict milk output supply reactions. For example, it is impossible to imagine that dairy farms belonging to the third group will increase their milk output until around 800 000 tons of milk in a regime where primary factor levels are supposed fixed at base year levels! This very simple analysis clearly shows that it is not possible to use the four type classification defined above and corresponding milk production short-run marginal cost functions to assess what could be the short-term impact on aggregate milk supply of a quota removal scenario. In other words, it is not possible to use without additional assumptions and/or constraints this four type classification and corresponding short-run milk production marginal cost functions to define what could be German milk supply in a quota removal scenario, for an unchanged milk price. The “validity domain” of the four types of short-run marginal cost functions defined above is only local. As a result, these functions can only be used in the neighbourhood of their definition domain, that is in the neighbourhood of mean values corresponding to the type. Of course, in a quota removal scenario, milk market prices should adjust downward in reaction to a milk supply increase (maintaining milk prices at base period levels in a quota removal scenario is not sustainable). The open question is then to define an analytical framework allowing us to assess how the four types of dairy farms will react in a quota removal scenario where milk prices can adjust (very likely downward).

Overall, this decomposition of German dairy farms into four classes shows that using a single (aggregate) marginal cost function defined on the basis of weighted sample mean values is very likely not consistent simply because of German dairy farm heterogeneity. The same remark applies to other Member States. It also applies to medium-run and long-run estimation results. There is clearly here an avenue for further research.

References

Moschini G., 1988a, A model of production with supply management for the Canadian agricultural sector. *American Journal of Agricultural Economics*, 70, 318-329.

Moschini G., 1988b, The cost structure of Ontario dairy farms: A microeconomic analysis. *Canadian Journal of Agricultural Economics*, 36, 187-206.

Table 1. Short-run (SR), medium-run (MR) and long-run (LR) marginal costs of milk production (specialised dairy farms, average 1996-2001)

Countries	milk output (tons)	milk price (euros per tons)	marginal costs (euros per tons)		
			SR	MR	LR
Austria	73	302	62	183	335
Belgium	243	296	13	93	206
Denmark	397	338	165	263	345
Finland	117	334	174	244	338
France	204	313	138	209	308
Germany	188	310	104	184	332
Ireland	166	285	82	118	274
Italy	115	404	254	344	384
Luxembourg	228	317	85	173	349
The Netherlands	415	322	88	150	219
Portugal	88	253	206	273	301
Spain	98	281	176	216	243
Sweden	207	344	204	309	352
The United Kingdom	455	292	126	182	267

Source: own estimates

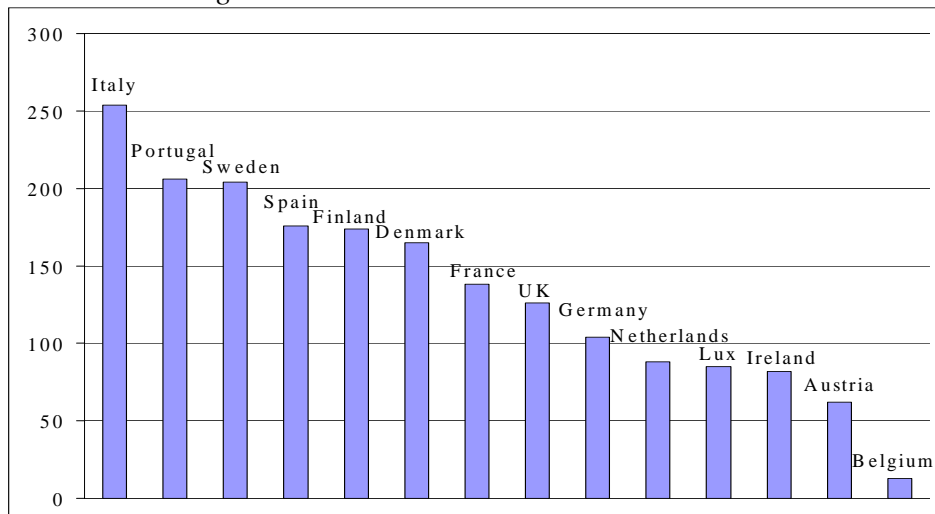
Table 2. Short-run (SR), medium-run (MR) and long-run (LR) “unit quota rents” (specialised dairy farms, average 1996-2001)

Countries	milk price (euros per tons)	“unit quota rents” (euros per tons)		
		SR	MR	LR
Austria	302	240	119	-33
Belgium	296	283	203	91
Denmark	338	173	75	-6
Finland	334	161	91	-3
France	313	175	104	4
Germany	310	206	126	-22
Ireland	285	203	167	11
Italy	404	150	60	20
Luxembourg	317	232	144	-32
The Netherlands	322	234	172	104
Portugal	253	46	-20	-48
Spain	281	105	66	38
Sweden	344	140	35	-8
The United Kingdom	292	167	111	25

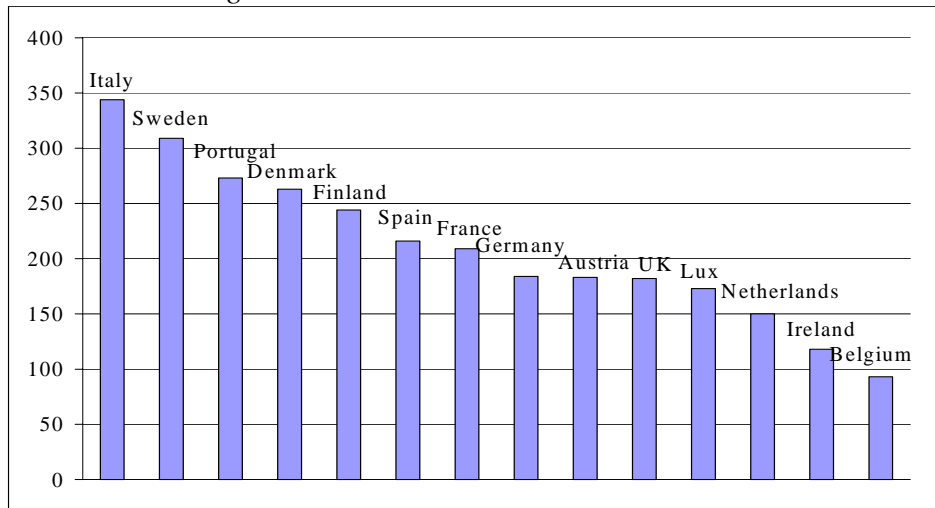
Source: own estimates

Figure 1. Milk production marginal costs (euros per tons, specialised dairy farms, average 1996-2001)

Panel a. SR marginal costs



Panel b. MR marginal costs



Panel c. LR marginal costs

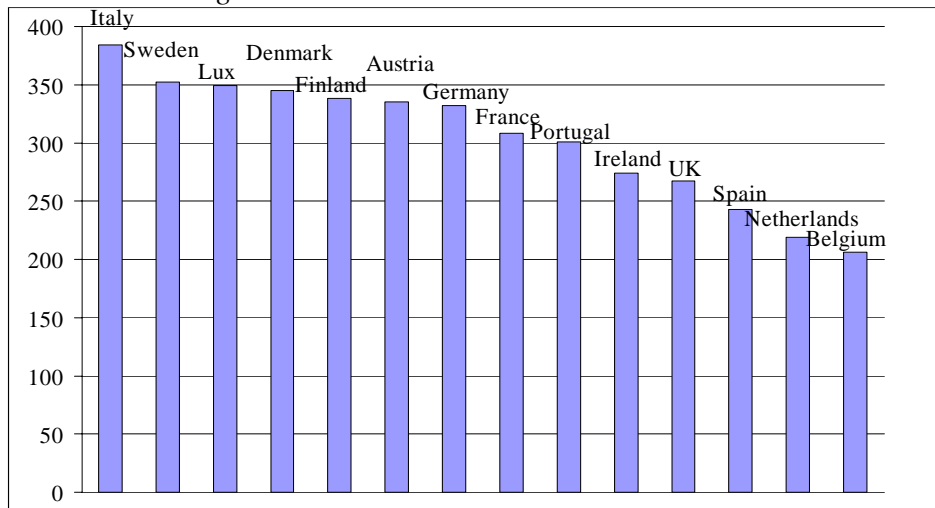
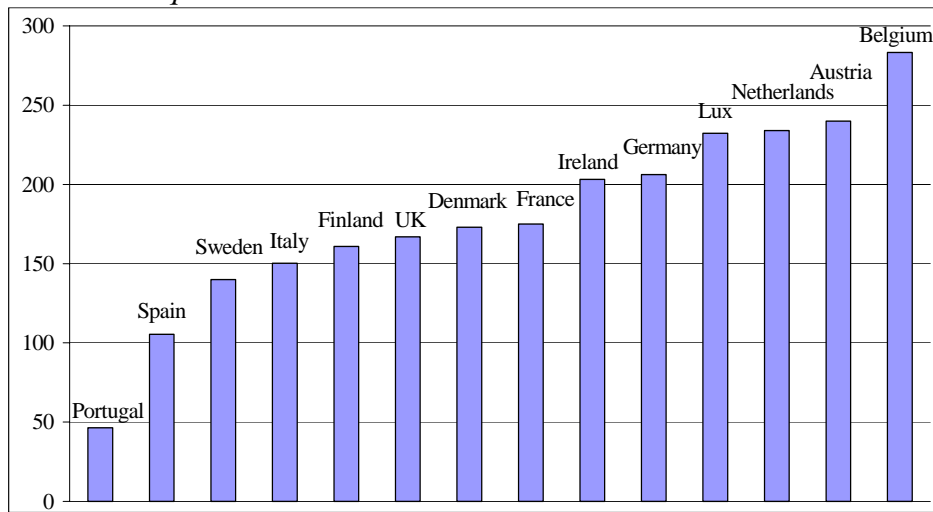
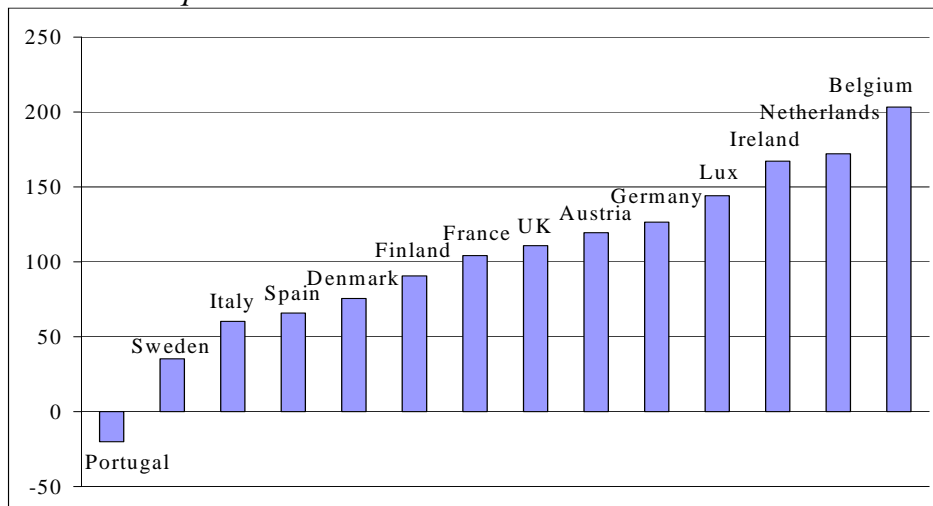


Figure 2. "Unit milk quota rents" (euros per ton, specialised dairy farms, average 1996-2001)

Panel a. SR quota rents



Panel b. MR quota rents



Panel c. LR quota rents

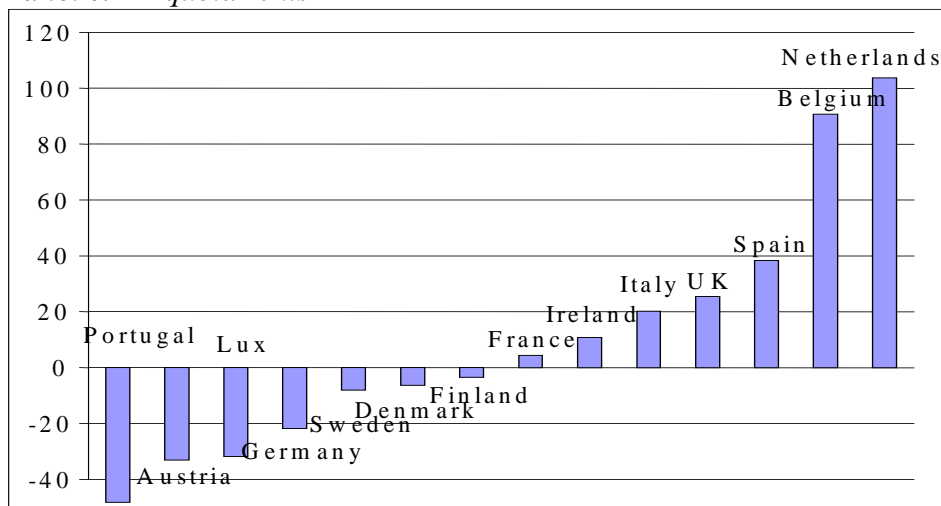
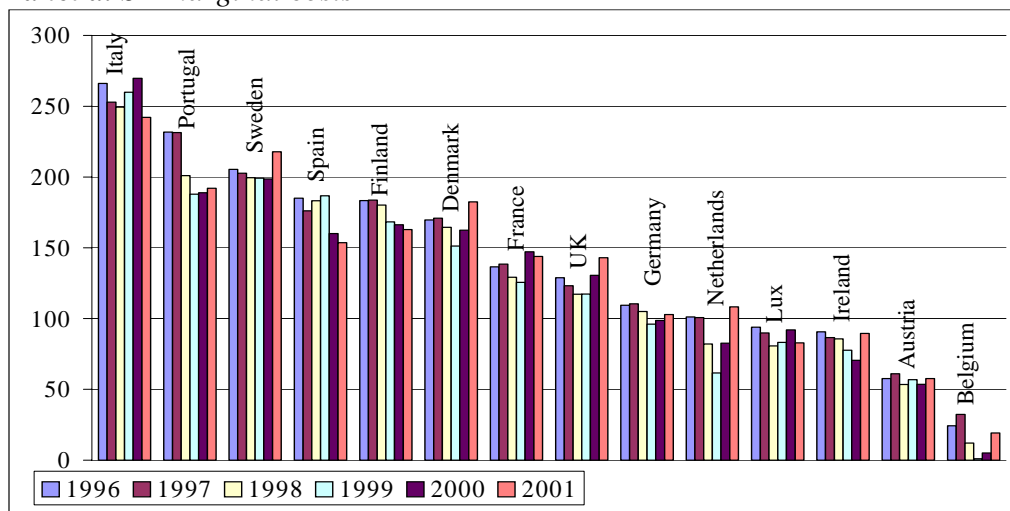
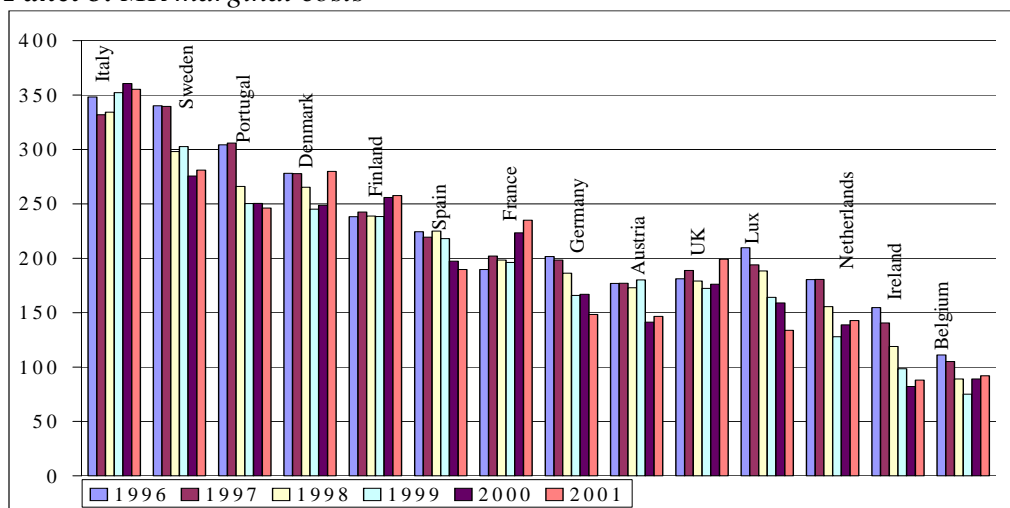


Figure 3. Evolution of milk production marginal costs from 1996 to 2001 (euros per ton, specialised dairy farms, average 1996-2001)

Panel a. SR marginal costs



Panel b. MR marginal costs



Panel c. LR marginal costs

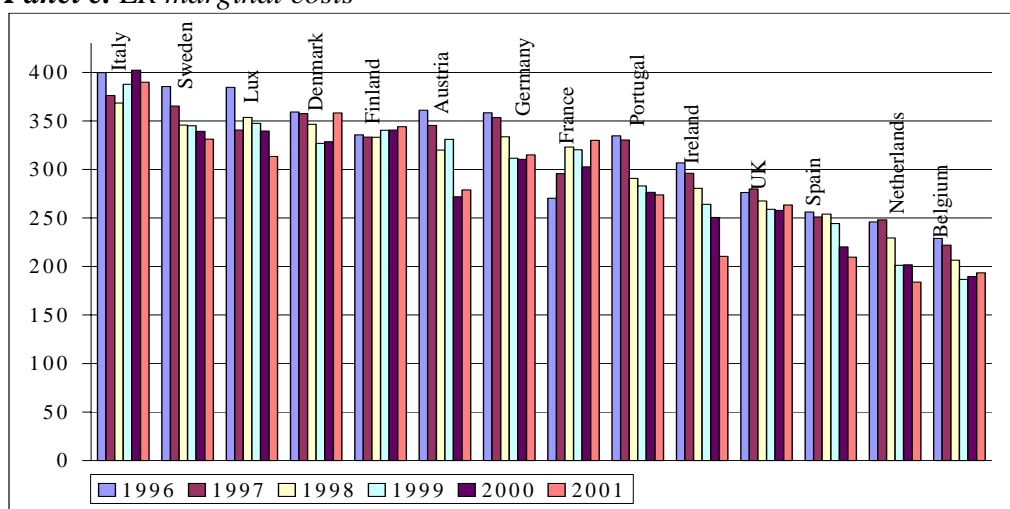
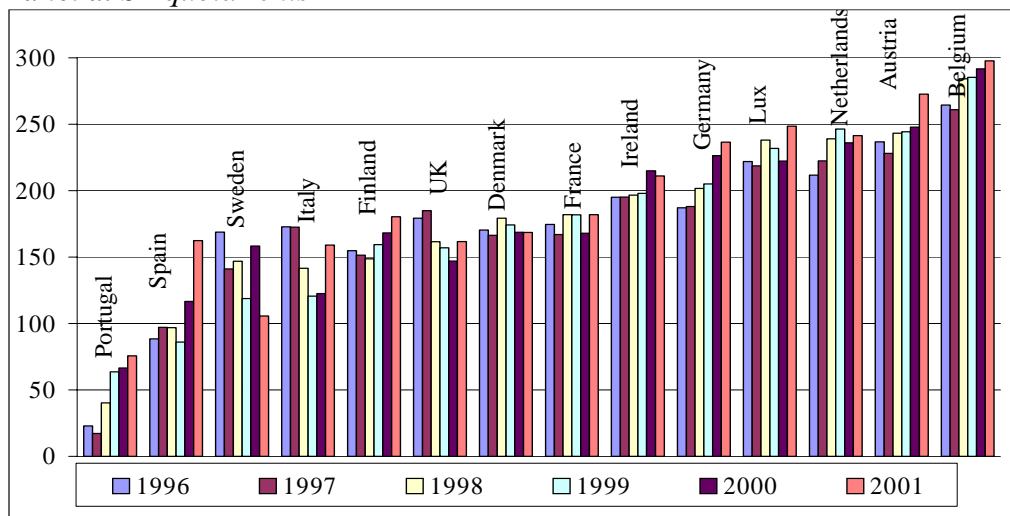
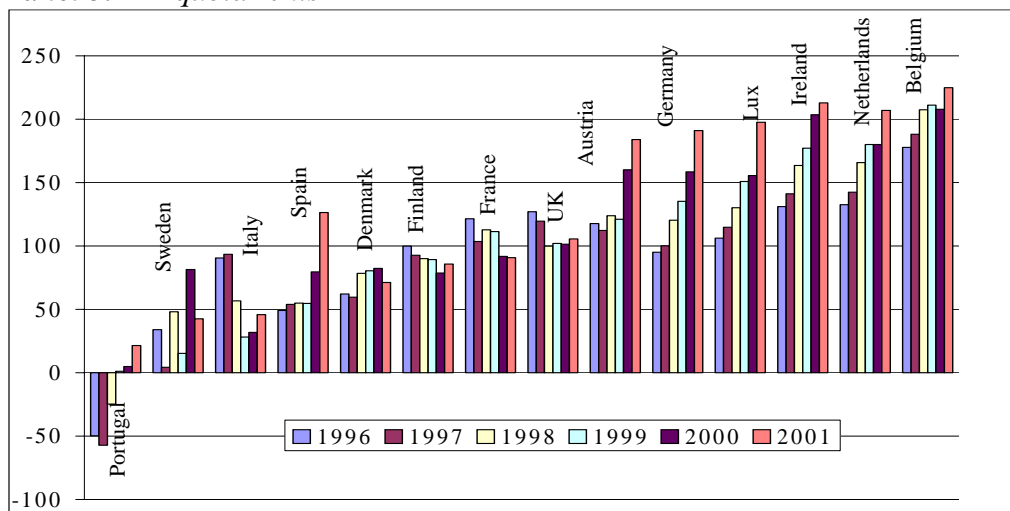


Figure 4. Evolution of “unit milk quota rents” from 1996 to 2001 (euros per ton, specialised dairy farms, average 1996-2001)

Panel a. SR quota rents



Panel b. MR quota rents



Panel c. LR quota rents

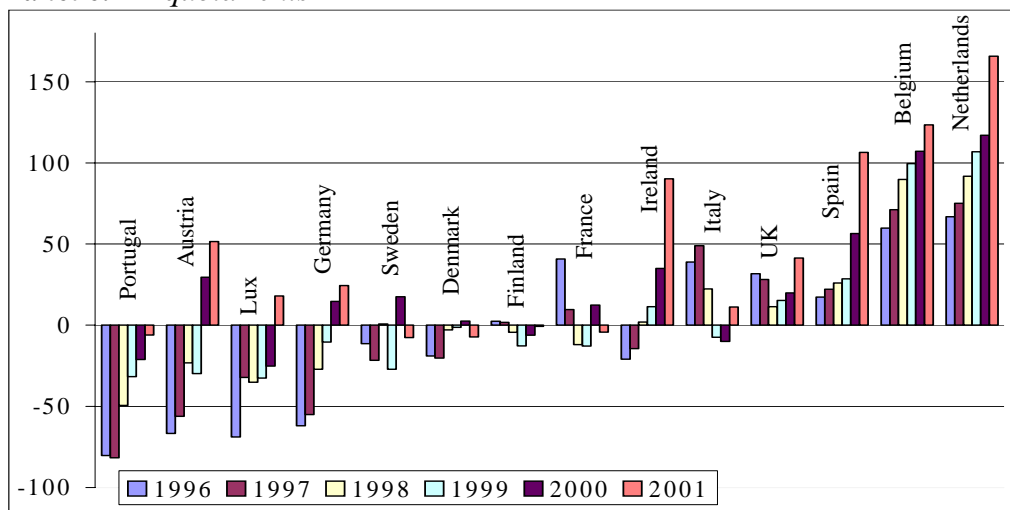


Table 3. Milk quotas and prices: all dairy farms versus specialised dairy farms (average 1996-2001)

Countries	Milk output (tons)		milk price (euros per tons)	
	specialised	all	specialised	all
Austria	73	64	302	300
Belgium	243	196	296	285
Denmark	397	374	338	338
Finland	117	114	334	334
France	204	198	313	310
Germany	188	171	310	309
Ireland	166	146	310	283
Italy	115	78	404	392
Luxembourg	228	224	317	318
The Netherlands	415	393	322	322
Portugal	88	52	253	248
Spain	98	78	281	273
Sweden	207	194	344	343
The United Kingdom	455	458	292	292

Source: own estimates

Table 4. Medium-run milk production marginal costs and ‘unit quota rents’: all dairy farms versus specialised dairy farms (average 1996-2001)

Countries	Marginal costs (euros per tons)		“unit quota rents” (euros per tons)	
	specialised	all	specialised	all
Austria	183	186	119	114
Belgium	93	162	203	123
Denmark	263	242	75	97
Finland	244	240	91	95
France	209	173	104	137
Germany	184	180	126	129
Ireland	118	122	167	161
Italy	344	355	60	37
Luxembourg	144	169	173	148
The Netherlands	150	122	172	200
Portugal	273	296	-20	-48
Spain	216	202	66	71
Sweden	309	309	35	34
The United Kingdom	182	181	111	111

Source: own estimates