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Review of Main Methodological Approaches Quantifying the Economic Effects of the European Milk Quota Scheme

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Review of Main Methodological Approaches Quantifying the Economic Effects of the European Milk Quota Scheme

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Foreword

This report provides a review of the most recent studies modelling the European milk quota. The focus is on milk quota rents, which are a central element in carrying out impact analyses on dairy policies.

The report forms part of the project "Economic Impact of the Abolition of the Milk Quota Regime – Regional Analysis of the Milk Production in the EU" (AGRI-2007-0444), initiated by DG Agriculture and Rural Development (DG AGRI). The project was carried out from December 2007 until February 2009 by the European Commission's Joint Research Centre - Institute for Prospective Technological Studies (JRC-IPTS, Spain) in cooperation with EuroCARE (Bonn, Germany) and the collaboration of the Agricultural Economics Research Institute (LEI, the Netherlands) and the Catholic University of the Sacred Heart (Unicatt, Italy).

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Executive Summary

Milk quotas were introduced in the European Union (EU) on April 1st 1984 by Council Regulations 856/84 and 857/84, and may have one of two characters: a production-enhancing objective or a production-restricting objective. Milk quotas were initially introduced as a temporary measure and afterwards extended to additional years. The European Commission made recently clear in occasion of the Common Agricultural Policy Health Check that the dairy quota regime will expire by March 31, 2015. The aim of this report is to review the most recent studies modelling the European milk quota. The focus is on milk quota rents, which are a central element in carrying out impact analyses on dairy policies.

When modelling dairy policies, at least two important sources of information are required. First is the milk shadow price, the producer price that would induce a profit-maximising producer to produce the current quota level in the absence of production restrictions, which facilitates positioning the shadow supply price faced by a dairy producer when producing the quota amount and no output constraints apply. Second are milk supply elasticities, which permit information to be recovered on the price responsiveness of the shadow supply function to price changes when milk output is not restricted.

The introduction of a quota creates a departure from standard competitive market pricing, where profit-maximising agents equate marginal revenue to marginal cost. The difference between market price and shadow price defines the so-called quota rent, which is necessary for simulating the likely impacts of dairy policy reform, particularly in the context of milk quota removal. Quota rent identifies the amount of surplus generated by a restriction on supply, with levels dependent upon the current milk price at farm gate level, marginal costs, and the length of runs (short, medium and long).

Modelling milk quotas in the EU began to receive particular attention in the mid-1980s. In the literature they have been modelled by making use of the duality theory of production (Beattie, et al., 1993, Chambers, 1988), which states that from a cost function (or a profit function) it is possible to consistently recover the underlying production function that could have generated the cost function (or the profit function). Moschini, (1988a) and Helming, et al., (1993) developed the microeconomic framework for modelling supply with constraints. Fulginiti and Perrin, (1993) explained the relationship between constrained and unconstrained behaviour. The effects of quota and its tradability on asset value has been analysed in Burrell, (1989), Dawson, (1991), Boots, (1999) and Colman, (2000), among others.

There are several options for estimating milk quota rents as discussed in Grinsted and Nielsen (2004). First, 'direct approaches' use micro-econometric frameworks that mostly estimate marginal cost functions by relying on market prices from the farm accountancy data network (FADN). Milk quota rent estimates are then derived by subtracting marginal cost from market

milk prices. Second, an 'indirect approach' can be followed when the milk quota price is available in terms of rent or lease prices. In this case, marginal costs are estimated by making assumptions on the annual value of the quota. The milk quota value depends on whether or not farmers expect to be compensated for further changes in the quota system. Finally, a third approach consists of 'guesstimating' the potentially occurring quota rent at Member State level. This requires assuming different quota rent levels and obtaining marginal costs as a difference from the assumed milk quota rent and the milk market price.

The report provides empirical evidence on milk quota rent estimates. To ease comparison among the different studies, milk quota rent estimates are reported as a percentage of the milk market price. In addition, milk quota rent estimates are ranked by country according to the magnitude of their levels. Although a direct comparison between the various studies is difficult because of the different approaches and sample used, several facts can be shown. The Bouamra, et al., (2002) and INRA-Wageningen-Consortium (2002) studies facilitate checking the robustness of the quota rent estimates to the choice of different functional forms. The estimates of Moro, et al., (2005) permit a comparison of quota rent estimates between different lengths of run. Comparing Cathagne, et al., (2006) with Moro, et al., (2005) the results are very similar, especially for the short run specification. Comparing the estimates of Wieck and Heckelei (2007a) with those of Moro, et al., (2005) and Cathagne, et al., (2006) the United Kingdom and Germany show similar rankings. The nonparametric estimated marginal costs of Wieck and Heckelei (2007b) are very close to the estimates obtained in Wieck and Heckelei (2007a), which use an SGM relying on a SUR type estimation.

Direct approaches to estimating milk quota rents are the only option for providing empirically gained estimates to be used in equilibrium models. From the reviewed empirical estimates, it appears that differences in magnitude and rankings are present across the considered studies. This poses serious problems when these estimates are used for calibration, because equilibrium models are highly sensitive to the assumptions made on quota rents. Differences in empirical quota rent estimates are present due to different estimation types, different underlying data and variables used, as well as different functional forms used. In addition to these technical differences, there seems to be difficulty in translating those estimates for calibrating purposes in equilibrium models. Another difficulty lies in the choice of the length of run used when calibrating. As previously mentioned, equilibrium models are sensitive to the assumptions made on quota rents and different lengths of run may lead to different policy conclusions.

At this stage, given that the micro-econometric estimation of milk quota rents seems to be an ongoing issue and its translation for equilibrium models far from being settled, it is advisable to perform sensitivity analysis using, whenever possible, different sets of estimates in order to assess the robustness of policy analysis.

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1 Introduction

Milk quotas were introduced in the European Union (EU) on April 1st 1984 by Council Regulations 856/84 and 857/84, and were originally integrated in Council Regulation 804/68 on the Common Market Organisations (CMOs) for milk and milk products. Since 1992, the council regulation establishing a levy in the milk and milk products sector has been explicitly separated from that of the CMOs for milk and milk products. The amended regulation establishing a levy in the milk and milk products sector is embedded in Council Regulation 1788/2003. The levy on milk quantities collected or sold for direct consumption above a certain guarantee threshold was initially introduced as a temporary, five-year instrument. Despite several critiques on the consequences of milk quotas[1], the council extended the milk levy, which is expected to run until 2014/15. For an historical overview on milk quotas, see Bianchi, (2004).

Milk production quotas date back to the early 20th century and may have one of two characters: a production-enhancing objective or a production-restricting objective. Production-enhancing objectives were clearly present in the post-war period to support the food supply, whereas nowadays the production-restricting objective prevails as a consequence of the excesses generated by increased productivity. The objectives of milk quotas are to curb production, limit budget pressure, maintain market price support and ensure revenue stability for dairy farmers. At the time of their introduction, milk quotas were considered the most efficient, minimum-impact instrument for controlling the milk supply without affecting milk revenue (OECD, 2005:7-11). The main pillars of the milk quota system in the EU are based on the determination of the individual national reference quantities, the levy payment in case of overrun, the management of the national reserve, and the milk quota transfer.

Milk quotas were initially introduced as a temporary measure and afterwards extended to additional years. The European Commission made recently clear in occasion of the Common Agricultural Policy Health Check that the dairy quota regime will expire by March 31, 2015. If the status quo on milk quotas would persist, it is likely that a sustained quota value would prevent efficient dairy farmers from exploiting other opportunities and also expose disadvantaged producers in mountainous areas to risk because of lower prices resulting from the phasing out of milk quotas. Therefore, one of the main issues is preparing for transition (i.e. a "soft-landing") from a supply management scheme to a more market-oriented policy. It is likely that the milk quotas' abolition by 31 March 2015 will be accompanied, *ceteris paribus*, by lower domestic prices. However, this will depend on the development of further cuts on trade instruments and consumption subsidies. As a consequence, the "Health Check" is also expected to revise current dairy market instruments in order to accommodate a "soft

[1] Notably: protections of inefficient dairy farms, capitalisation of milk quotas into land and support in the farm assets.

landing". Therefore, there is an urgent need for quantitative approaches to analyse the impact of the quota system's expiry.

The aim of this report is to review the most recent studies modelling the European milk quota. The focus is on milk quota rents, which are a central element in carrying out impact analyses on dairy policies. This is done as background support for the project "Economic Impact of the Abolition of the Milk Quota Regime – Regional Analysis of the Milk Production in the EU" (AGRI-2007-0444), initiated by DG Agriculture and Rural Development (DG AGRI).

The structure of the report is organised as follows. The second section describes the concept of milk quotas while also providing insights on milk quota trade. The third section provides a synthetic description of milk quota microeconomics. The fourth section reviews the most recent approaches modelling milk quota rents in the EU. Section five provides empirical evidence on milk quota rent estimates, while the sixth section presents concluding remarks.

2 Milk quotas and quota tradability

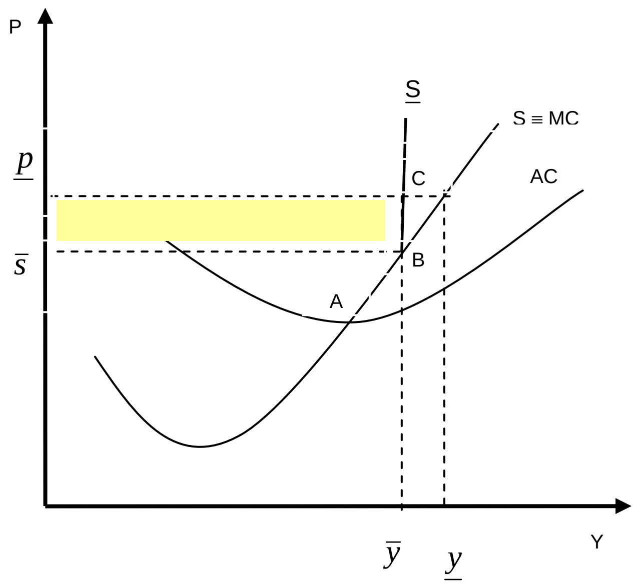
When modelling dairy policies, at least two important sources of information are required. First is the milk shadow price, which facilitates positioning the shadow supply price faced by a dairy producer when producing the quota amount and no output constraints apply. Second are milk supply elasticities, which permit information to be recovered on the price responsiveness of the shadow supply function to price changes when milk output is not restricted. The difference between market price and shadow price defines the so-called quota rent, which is necessary for simulating the likely impacts of dairy policy reform, particularly in the context of milk quota removal.

2.1 The concept of milk quota rent

Quota rent can be defined as the discounted sum of the future stream of net benefits to milk producers which comes from maintaining the quota (OECD, 2005). It is therefore an income generating asset for the person who holds the quota. Quota rent identifies the amount of surplus generated by a restriction on supply, with levels dependent upon the current milk price at farm gate level, marginal costs, and the length of runs (short, medium and long).

Milk quota and milk quota rent are represented at the producer level in Figure 1. The supply curve S coincides with the increasing part of the marginal cost (MC) curve which is above the intersection with the average cost (AC) curve, i.e. the section above A on the MC curve. The average cost curve is assumed to be U-shaped and the MC curve crosses the AC curve at the minimum.

Figure 1: Milk quota and milk quota rent at producer level



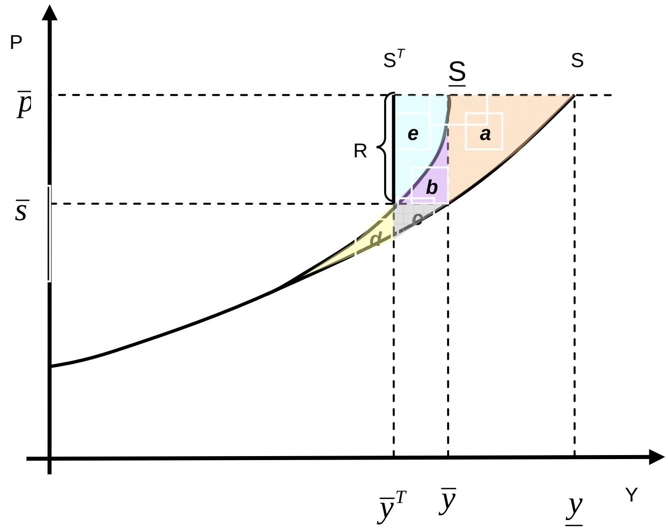
Source: Own figure adjusted from Guyomard, et al., (2004) The introduction of a quota creates a departure from standard competitive market pricing, where profit-maximising agents equate marginal revenue to marginal cost. If a quota is binding, production will be limited compared to the unrestricted market equilibrium. The new level of production will be fixed at $\bar{y}$ (see Figure 1) which represents the binding quota level on the left hand side of the initial production equilibrium level $\underline{y}$. The supply will be kinked at point B and becomes perfectly inelastic at the quota level (i.e. vertical on the segment $\mathsf{B}\underline{\mathsf{S}}$). The new supply curve will be constituted by the segment $\mathsf{AB}\underline{\mathsf{S}}$, so that it is no longer possible to directly observe production responses to price changes if quotas are binding. At $\bar{y}$ marginal revenue is greater than marginal cost and marginal cost coincides with the so-called output shadow price.

The milk shadow price is the producer price that would induce a profit-maximising producer to produce the current quota level in the absence of production restrictions. The difference between the market price and the shadow price defines the so-called unit quota rent, which in Figure 1 corresponds to $\bar{p} - \bar{s}$. The total quota rent will be composed by the area ($\bar{p}\bar{s}\mathsf{BC}$) highlighted by light yellow fill. In addition to the standard milk quota and milk quota rent description presented in Figure 1, there are at least four additional cases where farmers do not respond according to the magnitude of the quota rent, but rather according to the difference generated by the difference between milk market price and the average cost at quota level (see Figure 3 in the Appendix for further details).

2.2 Trading of milk quotas

The microeconomics of tradable milk quotas has been analysed in Burrell, A. (1989), among others. A comparative, static example of tradable milk quotas is presented in Figure 2. We begin from a situation where quotas are not in place. The quantity produced will be $\underline{y}$, generating the farm revenue $\bar{p}\underline{y}$. Farm revenue is allocated among the variable resources (i.e. the area below supply curve S) and fixed resources (i.e. area above supply curve S). Let us then introduce a limit on milk production denoted by $\bar{y}$. In a quota regime, the reference quantities are attributed based on historical production levels, assuming that all producers face the same cost structure. Thus, if farmers are exposed to the same percentage cut on production, it is likely that some efficient production will be lost and some inefficient production will be maintained. This renders the initial supply S to shift to $\underline{\mathsf{S}}$. The upward supply shift causes a decrease in the producer surplus by area (*a* + *b* + *c* + *d*). However, the total loss in producer surplus can be decomposed into two losses. First, due to the quota's introduction, area (*a*) is lost. Second, because of the inefficient attribution of reference quantities (i.e. grasped on an historical basis) supply becomes steeper than the original supply, which causes the loss of area (*b* + *c* + *d*).

Figure 2: Introduction of tradable quotas



Source: Figure adapted from Burrell, A. (1989)

Let us assume that quota rights can be traded (i.e. leased out or sold). Under this assumption, less efficient producers are expected to transfer quota rights to more efficient producers, thereby achieving more efficient resource allocation than in the case where quota cannot be traded. The price under which quota rights are exchanged is the annual rental value of the quota, given by the difference between market price $\bar{p}$ and marginal cost $\bar{s}$ (i.e. R in Figure 2). At this price, the quantity $\left(\bar{y}^T - \bar{y}\right)$ would be exchanged. Revenue equals area (*e* + *b*) is generated for producers who lease out or sell the quantity $\left(\bar{y}^T - \bar{y}\right)$ where area (*e*) acts as a compensation for the loss of income to fixed resources. At the same time, those producers who lease in or buy gain the area (*e* + *b* + *c* + *d*) at the cost of (*e* + *b*) (i.e. (*d* + *c*) is the net benefit). In a free quota trade market, supply would be restored at the equilibrium under quotas (see the kinked supply $\underline{S}$ in Figure 2) that eliminate initial distributional inefficiencies due to the different cost structures. The net benefits for the sellers in terms of area (*b*) and for the buyer in terms of area (*d* + *c*) will depend on the sector's inefficiency distribution. Quota mobility will have twofold effects. First, there will be an explicit incentive for a seller to eliminate their quota, gaining area (*b*) pushing for structural changes within the sector. A similar effect in a non-marketed mechanism would require budgetary incentives. Second, quota trade will push quota rights away from less efficient to more efficient producers[2].

[2] There are several points against the 'efficient argument'. First, it is likely that quota rights may end up in the hands of less efficient producers (which own different income sources or have better cash flows) who would use it in order to escape from the superlevy or as a speculative asset. Second, it is likely that quota rights will end up in farms in the expansion phase of their life cycle regardless of their efficiency (see BURRELL, 1989).

3 The microeconomics of milk quotas and milk quota trade

Modelling milk quotas in the EU began to receive particular attention in the mid-1980s. In the literature they have been modelled by making use of the duality theory of production (Beattie, et al., 1993, Chambers, 1988), which states that from a cost function (or a profit function) it is possible to consistently recover the underlying production function that could have generated the cost function (or the profit function). Moschini, (1988a) and Helming, et al., (1993) developed the microeconomic framework for modelling supply with constraints. Fulginiti and Perrin, (1993) explained the relationship between constrained and unconstrained behaviour. The effects of quota and its tradability on asset value has been analysed in Burrell, (1989), Dawson, (1991), Boots, (1999) and Colman, (2000), among others. In this section we present the standard microeconomic framework for modelling milk quotas by largely following Moro, et al., (2005). The analytical framework presents both cost and profit microeconomic frameworks.

Let us start from a general production function, which is specified as a transformation function in the form of:

$$T(\mathbf{y},\mathbf{x},\mathbf{z}) = 0\,, \qquad (1)$$

where **y** is a vector of output quantities, **x** is a vector of input quantities, and **z** is a vector of fixed quantities. As mentioned, the technology as given in equation (1) has an underlying cost function (or profit function).

Cost function approach

The underlying cost function is defined as follows:

$$C(\mathbf{y},\mathbf{w},\mathbf{z}) \equiv \min_x \left\{\mathbf{wx} \middle| T(\mathbf{y},\mathbf{x},\mathbf{z}) = 0\right\}, \qquad (2)$$

where **w** is the vector of input variable prices.

Assuming that only one output is under a quota regime, let us partition the output vector **y** into $\bar{y}$, which is the constrained output (e.g. milk) and $\underline{\mathbf{y}}$, which represents the vector containing all unconstrained outputs. The cost function, considering the constrained output, can be rewritten as

$$C(\bar{y},\underline{\mathbf{y}},\mathbf{w},\mathbf{z}) \equiv \min_x \left\{\mathbf{wx} \middle| T(\bar{y},\underline{\mathbf{y}},\mathbf{x},\mathbf{z}) = 0\right\}. \qquad (3)$$

The marginal cost for the constrained output $\bar{y}$ can be derived by taking the first derivative:

$$\overline{MC} = \frac{\partial C(\bar{y},\underline{\mathbf{y}},\mathbf{w},\mathbf{z})}{\partial \bar{y}} = \bar{s}(\bar{y},\underline{\mathbf{y}},\mathbf{w},\mathbf{z}). \qquad (4)$$

The marginal cost for the constrained output $\bar{y}$ (e.g. milk) is equivalent to the shadow price function $\bar{s}(\bar{y}, \underline{\mathbf{y}}, \mathbf{w}, \mathbf{z})$, which represents the output price that would lead a profit- maximising agent to produce the given output $\bar{y}$ in the absence of a quota scheme. The difference between the market price and the shadow price of the constrained output defines the so-called unit quota rent for the constrained output as given by $\bar{R}(\bar{p}, \bar{y}, \underline{\mathbf{y}}, \mathbf{w}, \mathbf{z}) = \bar{p} - \bar{s}(\bar{y}, \underline{\mathbf{y}}, \mathbf{w}, \mathbf{z})$.

When relying on multi-output technologies, the average cost of milk can be approximated by the following equation, since total cost in a multi-output function contains elements that belong to other outputs:

$$\overline{AC} = \frac{\left[C(\bar{y}, \underline{\mathbf{y}}, \mathbf{w}, \mathbf{z}) - C(0, \underline{\mathbf{y}}, \mathbf{w}, \mathbf{z})\right]}{\bar{y}}. \tag{5}$$

Input demand in a cost-minimising framework is obtained by using Sheppard's lemma and is given by

$$\frac{\partial C(\bar{y}, \underline{\mathbf{y}}, \mathbf{w}, \mathbf{z})}{\partial w_i} = x_i(\bar{y}, \underline{\mathbf{y}}, \mathbf{w}, \mathbf{z}). \tag{6}$$

Profit function approach

The underlying profit function is defined as follows:

$$\Pi(\mathbf{p}, \mathbf{w}, \mathbf{z}) \equiv \max_{y} \{\mathbf{py} - C(\mathbf{y}, \mathbf{w}, \mathbf{z}) | T(\mathbf{y}, \mathbf{x}, \mathbf{z}) = 0\}, \tag{7}$$

where $\mathbf{p}$ is the vector of output prices. The profit function for a constrained output is developed in Moschini, (1988a, 1988b, 1989) and Fulginiti and Perrin (1993) using the definition of restricted profit function[3] as given by McFadden, (1978). The restricted profit function is defined as:

$$\bar{G}(\underline{\mathbf{p}}, \mathbf{w}, \bar{y}, \mathbf{z}) \equiv \max_{\underline{y}} \{\underline{\mathbf{p}}\,\underline{\mathbf{y}} - C(\bar{y}, \underline{\mathbf{y}}, \mathbf{w}, \mathbf{z}) | T(\bar{y}, \underline{\mathbf{y}}, \mathbf{x}, \mathbf{z}) = 0\}, \tag{8}$$

where $\underline{\mathbf{p}}$ is the vector of the unconstrained output prices. The maximum profit attainable is

$$\Pi(\bar{p}, \underline{\mathbf{p}}, \mathbf{w}, \mathbf{z}) \equiv \bar{p}\,\bar{y} + \bar{G}(\underline{\mathbf{p}}, \mathbf{w}, \bar{y}, \mathbf{z}). \tag{9}$$

The shadow price function $\bar{s}(\underline{\mathbf{p}}, \mathbf{w}, \bar{y}, \mathbf{z})$ can be derived by taking the first derivative of the restricted profit function $\bar{G}(\underline{\mathbf{p}}, \mathbf{w}, \bar{y}, \mathbf{z})$ with respect to the constrained output $\bar{y}$:

[3] The restricted profit function corresponds to the cost of producing the restricted output.

$$\frac{\partial \overline{G}(\underline{\mathbf{p}}, \mathbf{w}, \overline{y}, \mathbf{z})}{\partial \overline{y}} = \overline{s}(\underline{\mathbf{p}}, \mathbf{w}, \overline{y}, \mathbf{z}). \tag{10}$$

The shadow price $\overline{s}$ is equivalent to the marginal cost of the constrained output. The unit quota rent for the constrained output can be defined analogously, as done within the cost function approach, by the difference between the market price and the shadow price of the constrained output as given by $\overline{R}(\overline{p}, \underline{\mathbf{p}}, \mathbf{w}, \overline{y}, \mathbf{z}) = \overline{p} - \overline{s}(\underline{\mathbf{p}}, \mathbf{w}, \overline{y}, \mathbf{z})$.

Input demand in a profit-minimising framework is obtained using Hotelling's lemma and is given by

$$\frac{\partial \overline{G}(\underline{\mathbf{p}}, \mathbf{w}, \overline{y}, \mathbf{z})}{\partial w_i} = -x_i(\overline{y}, \underline{\mathbf{y}}, \mathbf{w}, \mathbf{z}). \tag{11}$$

Introducing milk quota trade

In a tradable quota regime (for further details see Boots, 1999: 50-53) the profit-maximisation problem from equation (9) translates to:

$$\Pi(\overline{p}, \underline{\mathbf{p}}, \mathbf{w}, r, \overline{y}_0, \mathbf{z}) \equiv \max_{\overline{y}_1, \underline{\mathbf{y}}} \left\{ \overline{p}\,\overline{y}_1 + \underline{\mathbf{p}}\,\underline{\mathbf{y}} - \mathbf{wx} - r(\overline{y}_1 - \overline{y}_0) \middle| T(\overline{\mathbf{y}}, \underline{\mathbf{y}}, \mathbf{x}, \mathbf{z}) = 0 \right\}, \tag{12}$$

where *r* is the rental price of the quota and vector $\overline{\mathbf{y}}$ is partitioned into $\overline{y}_0$, which in the initial quota level is not biding under the assumption of tradable quotas, and into $\overline{y}_1$, which is the aggregate national quota and remains binding. The difference between the aggregate national quota level and the initial quota endowment determines the amount of quotas traded. The difference is positive when the quota is bought and negative when it is sold. Rearranging terms, equation (12) translates into

$$\begin{aligned} \Pi(\overline{p}, \underline{\mathbf{p}}, \mathbf{w}, r, \overline{y}_0, \mathbf{z}) &\equiv \max_{\overline{y}_1, \underline{\mathbf{y}}} \left\{ (\overline{p} - r)\overline{y}_1 + \underline{\mathbf{p}}\,\underline{\mathbf{y}} - \mathbf{wx} + r\overline{y}_0 \middle| F(\overline{\mathbf{y}}, \underline{\mathbf{y}}, \mathbf{x}, \mathbf{z}) = 0 \right\} \\ &\equiv \max_{\overline{y}_1, \underline{\mathbf{y}}} \left\{ \Pi(\overline{p} - r, \underline{\mathbf{p}}, \mathbf{w}, \mathbf{z}) + r\overline{y}_0 \middle| F(\overline{\mathbf{y}}, \underline{\mathbf{y}}, \mathbf{x}, \mathbf{z}) = 0 \right\}, \end{aligned} \tag{13}$$

representing the profit equation where quotas are tradable. Expression (13) depends on the price difference between the output price under a quota regime and the rental price of the quota, and is no longer dependent on the initial quota level. Differentiating the function $\Pi(\overline{p} - r, \underline{\mathbf{p}}, \mathbf{w}, \mathbf{z})$ with respect to the price difference between the output price under the quota regime and the rental price of the quota, a supply function is defined for the tradable quota regime as given by:

$$\frac{\partial \Pi(\overline{p} - r, \underline{\mathbf{p}}, \mathbf{w}, \mathbf{z})}{\partial(\overline{p} - r)} = \overline{y}_1(\overline{p} - r, \underline{\mathbf{p}}, \mathbf{w}, \mathbf{z}). \tag{14}$$

4 Approaches modelling milk quota rents in the EU

This section provides an overview of the most recent approaches to modelling milk quota rents in the EU, with a focus on micro-econometric approaches. However, several pragmatic solutions used in equilibrium models (i.e. both general and equilibrium models) are also taken into account.

There are several options for estimating milk quota rents as discussed in Grinsted and Nielsen (2004). First, 'direct approaches' use micro-econometric frameworks that mostly estimate marginal cost functions by relying on market prices from the farm accountancy data network (FADN). Milk quota rent estimates are then derived by subtracting marginal cost from market milk prices. Second, an 'indirect approach' can be followed when the milk quota price is available in terms of rent or lease prices. The prices paid per litre of quota in different Member States are reported in the Appendix (Table 4). In this case, marginal costs are estimated by making assumptions on the annual value of the quota. The milk quota value depends on whether or not farmers expect to be compensated for further changes in the quota system. Finally, a third approach consists of 'guesstimating' the potentially occurring quota rent at Member State level. This requires assuming different quota rent levels and obtaining marginal costs as a difference from the assumed milk quota rent and the milk market price[4]. In the following subsection, 'direct approaches' are discussed, with other options regarded as second best options being adopted in equilibrium models.

4.1 Direct approaches for estimating milk quota rents

In this subsection, the most recent micro-econometric studies on estimating milk quota rents in the EU are described.

Bouamra, et al., (2002) and INRA-Wageningen-Consortium (2002)

Bouamra, et al., (2002) and INRA-Wageningen-Consortium (2002) provide milk quota rent estimates for the EU-15 as a result of the 2002 Commission's report on milk quotas (SEC(2002)789 Final). Quota rents are estimated using a dual cost function framework relying on multi-output multi-input technology. Particular attention is given to assessing the robustness of quota rent estimates in relation to different functional forms. Thereby, two types of flexible functional forms are estimated: quadratic and translog (transcendental logarithmic). Both functional forms are selected because of their second order Taylor approximation to the true underlying technology and their simplicity in providing a milk

[4] The OECD PEM model assumes quota rent to be equal to 20 percent of the market price, which is about 25 percent of the producer price (for further details see OECD, 2005). The Common Agricultural Policy Regionalised Impact (CAPRI) model (SVN revision 1091, November 2007) also assumes a product price of 20% of the quota rent for Member States, when no explicit information is available.

shadow function. Flexible functional forms are generally well behaved and largely consistent with theory. One of the drawbacks of the quadratic form is that marginal costs are linear and cannot be U-shaped. In addition to the two selected flexible functional forms, an ad-hoc truncated cubic functional form is also estimated. Ad-hoc functional forms allow marginal costs to be U-shaped and parameters to be farm-specific. However, their flexibility may outweigh the theoretical underpinnings.

Two output variables (milk and other outputs) and two input variables (land and family labour) are considered. The dependent variable is total cost, defined as the sum of variable and fixed costs, minus the opportunity cost of land and family labour. The estimated cost functions are medium-run cost functions, given that only land and family labour were considered as quasi-fixed inputs.

The estimation procedure is based on a sample of dairy farms extracted from the FADN for 1996, 1997, and 1998. Several steps were followed to eliminate outliers from the original database. First, dairy farms with non-positive variables, such as milk output, other outputs, herd size and land area were eliminated from the sample. Second, observations that exhibited a farm gate milk price greater or lower than the average milk price plus/minus two times the standard deviations were eliminated. Third, outliers were eliminated using the Tukey method[5]. In the estimation, variable input prices are not considered, which implicitly assumes that farmers face the same variable input prices. The absence of variable input prices from the FADN database does not permit reliance on a systematic type of estimation. Thus, only the cost function is estimated without the input demand equations losing efficiency. In addition, a common technology across all farms is assumed in each EU member state sample without exploiting the panel dimension of the database.

Colman and Harvey (2002)

Colman, (2002) analyses the phasing out of milk quotas for the UK by relying on the so-called "Manchester Dairy Model" (MDM). The MDM is an econometric model of UK milk supply (Colman, et al., 2002). The theoretical framework is based on an average cost function, while the empirical specification consists of a farm level long run average quadratic function. The quadratic functional form allows the average cost curve to be U-shaped, which potentially represents the three neoclassical stages of returns to scale (i.e. decreasing, constant, and increasing)[6].

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5 Observations with milk output larger than the third quartile, plus 1.5 interquartile variation or lower than the first quartile, minus 1.5 the interquartile variation.

6 Previous empirical analyses suggest that in the long run, the average cost curve is L-shaped, as discussed in BAILEY, (2002). However, the cost of farm land constitutes one of the major constraints to accommodating large increases in herd sizes in order to reach the minimum efficient size.

The dependent variable is total long run average cost, determined as the difference between total cost of production and inferred overheads, quota costs, and rent attributable to dairying, all divided by the expected milk output. Given that other products are not considered, it is assumed that dairy farms only produce one specific output - milk. Average costs are quadratic in herd size, yields and farm area. Other explanatory variables introduced during estimation are: regional determinants, concentrated feed costs, wage rates and yield deviations. Yield deviations are introduced in order to take into account differences between production levels anticipated prior to food scare outbreaks and production level actually achieved. It is assumed that only the herd size is able to influence milk output, given that milk yields are assumed to be fixed. Farm area affects the degree of the economy of size a farmer can achieve. In so doing, farm area also determines the minimum of the average cost function, as well as the herd size level at which the minimum is obtained.

As far as the estimation is concerned, it is based on a cross section type of estimation for a set of UK representative farms introducing regional identifiers (i.e. dummies) that capture differences in land and weather conditions in England and Wales[7]. Representative farms are then weighted in order to represent the aggregate UK situation. The estimated function is separated into two parts. One part combines all the effects of the variables not related to herd size (i.e. intercept, regional identifiers, concentrate feed, yield, and wage and yield deviation), which are all embedded in an intercept. Another part comprises all parameters affected by herd size (i.e. herd size and its second order effects). Average and marginal cost curves are estimated at the mean values of the intercept terms and mean observed levels of farm area and milk yields for each region.

Data used during estimation is borrowed from the Special Study into the Economics and Milk Production (SSEMP), commissioned by the Ministry of Agriculture, Fisheries and Food for the year 1996/97. In total there are 377 English and Welsh dairy farmers, 86 of which are upland farms, with the remainder being lowland farms. The sample is then extended to also accommodate Scotland and Northern Ireland in order to represent the entire UK at an aggregate level. In so doing, the individual production levels are weighted in order to extrapolate nationwide aggregated results.

Input prices are withdrawn in order to avoid multicollinearity problems due to the small variations in input costs across farms. However, compound feed prices and wages rates are incorporated as farm-specific determinants. The homogeneity of degree zero in prices of the cost function is neither imposed nor respected. For a cross section type of estimation, the model performs well, indicating that more than fifty percent of the between-farms variance in the long run average cost is properly explained. The statistical significance of the model is

[7] Five regions were explicitly identified during estimation: Wales, North-west England, East England, South England, and South-west England.

assessed with an F-test and accepted at 5 percent statistical significance level. Curvature conditions are neither tested nor imposed during estimation.

Moro, Nardella, and Sckokai (2005)

Moro, et al., (2005) analyse the regional distribution of short-, medium- and long-run quota rents across EU-15 milk producers. Their estimation of marginal costs relies on a cost-minimisation theoretical framework[8]. The empirical specification of the cost function is based on a hybrid-translog flexible functional form (Moschini, 1988a), which is selected for its theoretical consistency in allowing regularity conditions to be either checked or imposed. Several regularity conditions are imposed for identifying parameters: symmetry in input prices, output quantities, quasi-fixed factors and linear homogeneity through an adding up condition. Concavity in input prices and convexity in fixed inputs are checked ex-post by assessing the eigenvalues associated with the matrix of estimated parameters for the input prices and fixed inputs. In case of violation, curvature is imposed ex-ante, with a Choleski decomposition of the input prices and fixed inputs matrices.

The study uses unbalanced panel data from 1996-2001. The data source is the FADN database. Only one data set is compiled for all dairy farms (i.e. unspecialised and specialised dairy farms are aggregated). The database contains only a subset of dairy farms for which the value of the following items are positive: 1) total farm output; 2) total utilised land; 3) total labour input; 4) total livestock units; 5) hectare of forage; 6) number of dairy cows; 7) milk production; 8) milk yields; and 10) beef production. In addition, farms with implausible milk yields and/or milk prices are excluded from the sample when outside the range determined by the average, plus or minus two times the standard deviation. The steps followed are similar to Bouamra, et al., (2002) and the INRA-Wageningen-Consortium, (2002). The FADN database is biased towards farms above a certain size and managed on a professional basis.

Data are prepared for the EU-15 member states, with the following variables being utilised: two outputs, milk[9] and outputs[10] different from milk are used. Six input prices are considered. A dairy inputs price index is defined as the weighted sum of dairy feeds and veterinary service price indexes, where the weights are their respective cost shares. The non-dairy inputs price index consists of the weighted sum of energy, plant and crop protection, fertilisers and soil improvers, and finally, general expenses price indices weighted by their respective costs

[8] The motivation for their choice is that profit maximization frameworks are usually more demanding in terms of data. In order to model the behaviour of dairy farmers it is necessary to have repeated observations not only of the same economic unit in different time periods, but also for the unrestricted outputs.

[9] Milk output is defined as total production of fluid milk and dairy products in milk equivalent.

[10] Other outputs different from milk is defined as the weighted sum of cattle production, other livestock production and crop production where the weights are given by the share of their revenue.

shares. Hired labour price is obtained by the ratio between the sum of wages and the social security charge to wage earners and the variable hired labour. Dairy cow stock price index is given by the weighted sum[11] of prices for female cattle (1-2 years), breeding heifers, dairy cow and other cattle (<1 year). The capital price index is defined as the weighted sum of building and machinery price index, where the weights are given by expenditure shares. The land price index is given by the ratio between the opening value of land and hectares of owned land. Finally, four fixed inputs are considered. The dairy cow quantity index is obtained by a weighted sum of closing number for other cattle (<12 months), female cattle between 12 and 24 months, breeding heifers and dairy cows. The variable land consists of land occupied by the owner, rented land and land in share-cropping. Quantity of capital is an aggregate for a buildings and machinery quantity index. Family labour is defined as the sum of total unpaid labour hours.

Three types of cost functions are estimated: short-, medium-, and long run. Short-run cost functions are specified with two aggregates of variable costs: dairy variable inputs (veterinary expenses and feed costs) and non-dairy variable inputs (energy costs, seed and plant costs, fertilisers and soil improvers costs, crop protection costs and general expenses). All inputs are considered fixed in the short-run. In the short-run, a non-linear system composed of the cost function and the two input share equations[12] is estimated. In the medium-run, all fixed inputs can adjust, with the exception of family labour and land, which remain fixed so that all other inputs are added to the short-run costs to determine an implicit cost of capital. A non-linear system of six equations was estimated: the cost function and the five input share equations for dairy inputs, non-dairy inputs, buildings and machinery, cow stock and hired labour[13]. Finally, in the long-run all production factors can adjust, with the exception of family labour. The implicit cost of land is added to the medium-run costs. A non-linear system of seven equations is estimated comprising the cost functions and the six share equations for dairy inputs, non-dairy inputs, land, buildings and machinery, cow stock and hired labour[14].

Compared to the other approaches described in this section, the cost function is jointly estimated, with the share equations in a system increasing the efficiency of the estimation procedure and also being able to identify all parameters. The estimation is not tested but only corrected ex-ante for heteroscedasticity, given that in the FADN the population size of each representative farm varies within the group. The properties of the error term are not tested, but assumed to be normally distributed and not serially correlated. The system is estimated using a full information maximum likelihood estimation procedure. The regularity conditions (i.e.

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[11] Weights are expressed in terms of Livestock Unit (LU).

[12] Note that due to homogeneity, the non-dairy variable inputs share equation is dropped from the short-run system.

[13] Note that due to homogeneity, the capital share equation is dropped from the medium-run system.

[14] Note that due to homogeneity, the land share equation is dropped from the long-run system.

convexity in fixed inputs and concavity in input prices) are treated differently depending on the estimated length of run of the cost function. In the short-run, only convexity in fixed inputs is imposed, whereas concavity in input prices is only checked. In the medium-run and long-run, convexity in fixed inputs is only checked, whereas concavity in input prices is imposed. In order to take into account the heterogeneity in the cost structure of dairy farms, the system of equations is estimated for a representative sub-sample for the EU-15 members distinguished by regional location, altitude, and the size class of milk operations.

Moro, et al., (2005) use several approaches when calculating marginal costs. In the first approach, they derive marginal cost estimates calculated at the sub-sample mean of each explanatory variable. In order to provide average marginal costs at the national level for simulation purposes, the results of each sub-sample are weighted by the share of farms[15] represented by each sub-sample in the FADN population. In the second approach, they compute farm-specific marginal costs for each sub-sample by considering a family of cost curves that differ in their position due to farm-specific shifters. The average marginal cost is then computed by taking a weighted average of each farm-specific marginal cost, where the weights are the number of farms that each farm represents in the FADN. Marginal cost estimates from the sub-sample level are then scaled up to the national level by relying on FADN weights. This approach appears to be well-suited when it is necessary to find the "height" of the milk shadow supply.

Cathagne, Guyomard, and Levert (2006)

Cathagne, et al., (2006) analyse the distribution of marginal costs and quota rents for the EU milk sector. Their estimation of marginal costs relies on a theoretical cost-minimisation framework, which is not directly motivated, although they put more emphasis on it to explain the selected empirical specification. In order to derive a marginal cost function as flexible as possible, they specify a truncated cubic cost function, similar to Bouamra, et al., (2002), in which only the cross-terms involving milk production are introduced to mitigate potential multicollinearity problems. Thus, the derived marginal cost function is quadratic for milk output.

The study uses a very similar dataset to the one used in Moro, et al., (2005); an unbalanced data panel from 1996-2001 is used and extracted from the FADN database. Two data sets are prepared and used for estimation: one set only comprises specialised dairy farms, defined as farms receiving more than 66 percent of their income from milk production; another data set comprises all dairy farms (i.e. unspecialised and specialised). To avoid inconsistent data from

[15] An alternative would consist of using as weights the share that each sub-sample represents in total milk production. This approach is likely to produce higher reference quantities and marginal costs, particularly for large producer countries.

the database, only farms with a positive value for the following items are kept: 1) total output value; 2) milk output value; 3) milk output quantity; 4) labour quantity; 5) number of dairy cows; 6) land quantity; 7) milk yields; and 8) the total number of animals. In addition, outliers are eliminated from the database once milk output was outside the "inner fence" determined by the Tukey's method. These steps are very similar to those followed in Bouamra, et al., (2002), the INRA-Wageningen-Consortium (2002) and Moro, et al., (2005).

Bias in the FADN database is similar to the bias mentioned in Moro, et al., (2005), with the following variables utilised; the three outputs are milk, beef, and other outputs. Thus, the relationship between milk and beef production can be explicitly derived. Costs of energy, seeds and plants, fertilisers and soil improvers, crop protection inputs, veterinary services, feed, contract work and other direct inputs are grouped into two aggregate categories of variables costs. A dairy variable input is defined as an aggregate of veterinary expenses and feed costs. An aggregate variable input comprises all other variable inputs unrelated to dairy. Concerning fixed factors, three lengths of run are considered. In the short-run labour, land and capital are assumed to be fixed factors. In the medium-run, only family labour and land are fixed, thus the cost of hired labour and an implicit cost of capital are added to the short-run costs in order to derive medium-run costs. In the long-run, only family labour remains fixed. An implicit cost of land is computed and added to medium-run costs to recover long-run costs. In order to consider differences in dairy technology, several explanatory variables are also introduced during estimation, for example, the ratio of the total number of livestock units on forage area, milk yields per dairy cow, and the share of fodder maize area in total forage area.

The cost equation is estimated using a weighted least square (WLSQ) approach in order to correct for heteroscedasticity given the heterogeneous size of farms in the FADN population. The variables are transformed using an approach similar to that of Moro, et al., (2005) following Greene, (2000: 290). Preliminary estimates indicate low statistical significance for many parameters. Therefore, several model selection procedures are adopted and tested through log-likelihood tests in order to decrease multicollinearity problems and to decrease the amount of parameters to be estimated.

Wieck and Heckelei (2007a)

Wieck and Heckelei (2007a) analyse the determinants and development of marginal costs in some of the most important regions in the EU based on Wieck, (2005). The estimation of marginal costs relies on a theoretical cost-minimisation framework assuming that a cost-minimising set of unrestricted input factors is selected subject to quasi-fixed factors and output quantities. It is assumed that farmers are price takers for both inputs and outputs. The authors support the choice of their cost-minimisation framework by stating that the introduction of milk quotas creates a departure from profit-maximisation. Milk quotas are implemented and attributed to farmers regardless of their competitive behaviour. In a competitive market under profit-maximisation and decreasing return to scale, dairy farmers produce at the output level, where marginal cost equates market price. However, milk quotas could restrict production below the point where marginal costs cross average cost in the region where average costs decrease (see Figure 3**)**. Thus, by exploiting increasing returns, dairy farmers can expand their production.

The empirical specification of the cost function is based on a multi-input multi-output Symmetric Generalized McFadden[16] (SGM) cost function. The advantage of the symmetric specification over the simpler generalised McFadden is that it is invariant to the choice of the numéraire for normalisation. The SGM is linearly homogeneous, non-decreasing, and concave in input prices. It is continuous and twice differentiable with respect to all its arguments. Linear homogeneity in output and quasi-fixed factors was not *a priori* imposed but only tested given that the hypothesis of constant return to scale in dairy production has been rejected several times in the literature. Marginal costs are recovered by differentiating the SGM cost function with respect to output quantities. The derived marginal cost function is homogeneous of degree one in input price. Input demand equations are recovered using Sheppard's lemma for the cost function.

A system of input demand equations is estimated using panel data techniques. A fixed effects model[17] is applied, assuming restricted exogeneity between the exogenous variables and the error term and allowing for structural differences (i.e. differences in management, inputs, soil quality, etc.) to be captured by individual intercepts. The system is estimated by iterated seemingly unrelated regressions (SUR) in order to capture contemporaneous correlation across the error terms. Several regularity conditions are imposed for identifying parameters, such as symmetry in input prices, output quantities, and quasi-fixed factors, as well as linear homogeneity and concavity in input prices by using inequality constraints. However, the system of input demand equations is not jointly estimated as done in Moro, et al., (2005) with the cost function losing efficiency during estimations.

The study uses a balanced panel data from 1989-2000. The main sources of the data are the FADN database, the Economic Account of Agriculture (EAA), and the regionalised database of the Common Agricultural Policy Regionalized Impact (CAPRI) modelling system. The database contains only a subset of dairy farms, more precisely, dairy farms that produced milk

[16] The SGM provides a second order approximation to the unknown underlying function, at any point being a so-called flexible functional form.

[17] Fixed effects estimation is suitable when the number of observations is relatively small with respect to the time dimension, and individuals are "one-of-a-kind" (see VERBEEK, 2004).

over the complete time horizon of the sample[18], dairy farms with plausible milk yields and a number of dairy cows equal to or greater than ten percent of the regional average herd size. The sample is biased towards farms above a certain size and only includes farms managed on a professional basis, as already mentioned in the previous studies referred to in this subsection; the farms were not, however, selected according to their degree of specialisation. Data are prepared for two British regions (North and West England), two French regions (Pays Loire and Brittany), two German regions (Lower Saxony and Bavaria) and Netherlands and Denmark.

Three outputs and three inputs are specified for the short-term cost function. The inputs are: milk expressed as a gross production, with standardised fat and protein content; animal-specific outputs expressed in net value of milk; crop outputs excluding fodder from arable or grassland expressed in value. The three inputs are: animal-specific inputs comprising purchased and home-grown feed, other animal-specific expenses, and dairy cow stock; crop-specific inputs comprising seed, fertiliser, plant protection, and other crop-specific inputs; other variable inputs comprising costs for machinery, buildings, energy, other direct inputs, and paid rents.

The system of input demand is estimated using an iterative SUR estimation procedure despite output endogeneity problems in three of the eight regions considered, notably Lower Saxony, Pays Loire, and Netherlands. Heteroscedasticity is initially diagnosed as being total farm output correlated with the error term. Equations are corrected ex-post by assuming a proportional or a squared error variance with the farm output index. Curvature regularity conditions on the input side are not satisfied and as a consequence are *a priori* imposed through inequality restrictions. The hypothesis of constant return to scale is rejected by the sample.

Wieck and Heckelei (2007b)

Wieck and Heckelei (2007b) compare nonparametric techniques to traditional parametric approaches by estimating marginal costs in dairy production for the North of England. In their analysis they focus on estimating the level and distribution of marginal costs using nonparametric locally weighted regression approaches. They also rely on a cost-minimisation framework. Their model specification uses a multi-input multi-output cost function, which is estimated using several variants of second-order local polynomials. First, they use an SGM functional form and then a Normalised Quadratic (NQ) functional form. For the SGM, they use a Gaussian kernel (i.e. weighting function), while for the NQ they use two kernels: Gaussian and Epachenikov. This type of locally weighted regression can be thought as a

[18] This raises some suspicion over what the authors initially call an "unbalanced panel data". If only observations which are available for the complete time horizon are utilized in a panel data, the panel is balanced.

WLSQ estimation where the weights are derived from the specific kernel function chosen for the problem at hand. They employ their nonparametric estimation approach because of the potential bias introduced by parametric approaches, which are due to the restrictiveness implicit in the chosen functional forms, which approximate heterogeneous production systems. Compared to traditional estimation techniques, nonparametric approaches let the functional relationships among the variables unspecified, thus gaining more flexibility and rendering the imposition of the required microeconomic regularity conditions relatively easy.

An input demand system derived from the original cost function is estimated locally for each observation by imposing behavioural restrictions. The cost function is not jointly estimated with the system of input demand equations as done in Moro, et al., (2005). The input demands are specified as polynomial and linearly dependent on parameters that are estimated for each observation. The original explanatory variables are consistently transformed according to the type of polynomial chosen. The input demands are estimated in a SUR type of estimation, relying on Bayesian techniques for the imposition of the required curvature conditions. This means following several steps when preparing the estimation procedure. First, the vector of kernel weights is determined for the different type of kernel used during estimation (i.e. Gaussian and Epachenikov). The bandwidth matrix is then increased in order to avoid singularity problems. Second, a locally weighted restricted SUR is estimated by incorporating homogeneity and symmetry restrictions. Third, posterior sampling imposing curvature conditions (i.e. concavity in prices of the cost function) is carried out by relying on a Gibbs sampler. Finally, point estimates are computed by relying on the previous step, using the sample mean of the posterior distribution. The employed data are from Wieck and Heckelei (2007a) and had the same structure for the specified variables. Only data for North England are used during the estimation. The use of the same database allows direct comparison between the locally estimated weighted regression and the parametric SUR estimation performed in Wieck and Heckelei (2007a). Later, Wieck and Heckelei (2007b) compared summary statistics of the estimated nonparametric models differentiating the performances according to the polynomial and type of kernel chosen.

Table 1: Summary table on recent micro-econometric approaches for estimating milk quota rents in the EU

	INRA Wageningen (2002)	Colman and Harvey (2002)	Moro, Nardella and Sckokai (2005)	Cathagne, Guyomard and Levert (2006)	Wieck and Heckelei (2007a)	Wieck and Heckelei (2007b)
Theoretical Framework	Cost Function	Cost Function	Cost Function	Cost Function	Cost Function	Cost Function
Functional Form	Flexible Functional Forms and Ad-hoc	Flexible Functional Form	Flexible Functional Form	Ad-hoc	Flexible Functional Form	Locally Weighted Polynomials
Data Source	FADN 1996-97-98 Dairy Farms	SSEMP 1996-97 Dairy Farms	FADN 1996-2001 Dairy Farms	FADN 1996-2001 Specialised Dairy Farms and All dairy Farms	FADN, EAA, CAPRI 1989-2000 Dairy Farms	FADN, EAA, CAPRI 1989-2000 Dairy Farms
Country Coverage	EU-15	Wales, North-West England, East England, South England, and South-West England	EU-15 (without Luxembourg)	EU-15 (without Greece)	North and West England, Pay Loire and Brittany, Lower Saxony and Bavaria, Netherlands and Denmark	North England
Variable used	Outputs: Milk, Other Outputs Quasi-Fixed Inputs: Land, Family Labour No Variable Input Prices	Output: Long Run Average Cost for Milk Explanatory Variables: Herd Size, Yields, Farm Area, Regional Determinants, Concentrated feed Costs, Wage rates and Yields deviation	Outputs: Milk, Other Outputs Input Prices: Dairy, Non-dairy, Hired Labour, Dairy Cow Stock, Capital and Land Fixed Inputs: Dairy Cow, Land, Capital, Family Labour	Outputs: Milk, Beef, Other Outputs Inputs: Dairy Variable Inputs (Veterinary Expenses and Feed Costs) and Non-dairy Variable Inputs Fixed Factors: Labour, Land, and Capital	Outputs: Milk, Other Animal-Specific Outputs, Crop Outputs Inputs: Animal-Specific Inputs, Crop Inputs, and Other Variable Inputs	Outputs: Milk, Other Animal-Specific Outputs, Crop Outputs Inputs: Animal-Specific Inputs, Crop Inputs, and Other Variable Inputs
Estimation	Cross Section	Cross Section	Unbalanced Panel Data. Fixed Effects	Unbalanced Panel Data, Fixed Effects	Balanced Panel Data, Fixed effects	Balanced Panel Data/Non Parametric
Curvature Conditions	-	Not Tested/Imposed	Tested/Imposed		Imposed	Imposed
Length of Run	Medium Run	Long Run	Short Run, Medium Run, Long Run	Short Run, Medium Run, Long Run	Short Run	Short Run

Source: Own table.

In terms of goodness of fit, the NQ polynomial performs better than the SGM, which nevertheless has a larger number of significant parameters. The percentage of observations respecting the curvature condition is larger in the SGM polynomial. Different kernels seem not to impact the marginal cost levels, whereas larger discrepancies are found when changing the polynomial functional form. The distribution of marginal cost appears to be very similar for the NQ polynomial estimates using the Gaussian and Epachenikov kernels. Differences are found when comparing the SGM with Gaussian and the NQ with Gaussian for 1999. This suggests that the distribution is more affected by the type of polynomial rather than by the type of kernel used. In addition, the SGM with Gaussian is more sensitive to outliers, whereas the NQ with Epachenikov appears to be more robust in terms of results. The SGM with Gaussian has a rather similar distribution to the SGM iterative SUR estimation. When changing the polynomial and using the same kernel, more differences in the tails are encountered, with less farms persisting in the same quartile. When associating farm characteristics to the tails of the distribution, there is evidence, at least for the year 1999, that large farms have lower marginal costs. In addition, farms in the middle range quartile (i.e. 75 percent) display average size in terms of milk output, farm endowment, outputs and inputs. Table 1 summarises the methodological micro-econometric approaches described in this section.

4.2 Selected indirect and guesstimating approaches

In this subsection, several pragmatic solutions used in equilibrium models are briefly described.

Quota rent estimates in the Global Trade Analysis Project (GTAP) computable general equilibrium model

Jensen and Frandsen (2004) carry out a study modelling the impacts of the EU’s Eastern European accession and the 2003 reform of the CAP using the GTAP model, which is a standard multi-regional, static, computable general equilibrium model. Initial quota rents for the 1997 base year are calculated using quota rents as a percentage of producer prices. In the base year, all quota rents are positive, given that milk quotas were binding across all EU-15 member states. Thereafter, milk quota rents are endogenously recovered by the model and milk production is exogenously determined according to the foreseen quota expansion stipulated in Agenda 2000. Whenever milk quotas are found to be non-binding in the baseline, milk quota rents are exogenously adjusted to zero and the model endogenously calculates milk production. Initial milk quota rents are derived assuming a 4 percent interest rate with an infinite depreciation rate, which is equivalent to an annual cost equal to 4 percent of the quota price. When computing annual quota costs as done in Jansson and Britz (2002), quota rent values calculated with an infinite depreciation rate provide lower estimates than those obtained with shorter depreciation time. An infinite depreciation time assumes that farmers are likely to expect policy compensation for any change made in the CAP regime[19].

Grinsted and Nielsen (2004) show the importance of general equilibrium models with different assumptions in the initial quota rent estimates for dairy policy analysis. The authors based their analysis on the computable general equilibrium (CGE) Global Trade Analysis Project (GTAP) model and database version 6.2. They prepared four different databases based on four different assumptions. Concerning quota rent estimates, they used two sets of estimates separately: small quota rent estimates borrowed from Jensen and Frandsen (2004), and large quota rent estimates from INRA-Wageningen-Consortium (2002). These two sets of estimates provided different interpretations of the competitiveness of milk producers across the EU. In addition, they carried out their analysis for each EU-15 member, as well as for an EU-15 aggregate. An illustrative simulation is performed which relied on the four databases.

Grinsted and Nielsen’s simulation example consists of analysing the impact of removing dairy export subsidies, which then results in eliminating EU dairy exports to third countries. Such an outcome appears to be insensitive to the choice of quota rent estimates (i.e. small versus large quota rent estimates). Concerning EU imports from third countries, it appears that the decrease is larger when a large quota rent is assumed, since production is less sensitive to price decline and domestic production is only slightly affected. However, repercussions for the domestic market appear to be relatively larger and dependent on the initial assumptions on quota rents. Declines in domestic production are larger for small quota rents. In other words, the removal of EU export subsidies increases domestic competition, which levels down price and quota rents. As such, the countries that are more competitive (i.e. with relatively large quota rents) are less sensitive to increased domestic competition. Different assumptions on quota rents have led to minimal percentage changes in production and dairy exports. However, differences in rankings were evident for Denmark. On one hand, under the small quota rent assumption, Denmark is ranked among the least competitive countries, leading to a decline in its exports because of the increased competition. On the other hand, under the large quota rent assumption, Denmark is ranked among the most competitive EU countries in terms of welfare benefits from removing export subsidies, particularly when small quota rents are used, given that the decline in production is larger. Internationally competitive countries such as Australia and New Zealand also benefit from the removal of export subsidies, whereas the United States suffers due to efficiency losses related to inefficient supports.

Lips and Rieder (2005) analyse the abolition of the raw milk quota in the EU using a CGE modelling approach similar to Grinsted and Nielsen (2004) but with one exception: they have

[19] During Agenda 2000, a compensation of 17.24 Euro/ton was introduced for dairy farmers as a result of a decline in price support.

introduced production quotas in the GTAP model. Milk quotas are introduced as a complementary problem where a switch is envisaged from a binding to a non-binding regime. In this approach, production quantity and quota rents are endogenously adjusted. In order to leave the worldwide GTAP database unchanged, quota rents are introduced in the model as additional payments to the factors. As such, they assume that milk quotas are efficiently distributed among dairy producers and that a quota rent exists and is defined as the difference between milk market price and marginal costs. In order to include milk quota as a primary factor payment, factor payments were divided into two parts: minimal necessary factor payments and additional factor payments whose sum coincides with quota rents. Given that dairy producers receive milk quota rents in the form of a higher producer price rather than as a transfer payment, milk quota rents are included in the output value. In order to satisfy the zero profit condition, the output value is required to equal all input costs. It is assumed that the primary factor inputs include the quota rents. In order to attain a general equilibrium, the authors implement four main modifications to the GTAP model. First, they introduce a complementary condition that introduces milk quota rents in order to represent binding and non-binding regimes. Second, the zero profit condition is introduced net of quota rent in the output value including all factor payments. Third, the primary factor markets clear the minimum necessary factor payments. In so doing, factor inputs are used regardless of the existence of the quota rents. Fourth, the revenue of the regional household comprises regional income including the necessary and additional factor payments. Additional factor payments are equal to quota rents in the database and are only distinguished during simulation in order to maintain independence between factor inputs and quota rents.

Instead of using a consistent set of estimated quota rents, Lips and Rieder (2005) prefer to rely on mixed sources. In so doing, they obtain estimates for the ratio between milk market price and milk shadow prices for Austria and Germany from national experts. They then rely on Kleinhanss, et al., (2001), who provide an aggregate EU raw milk quota rent of 7.9 billion Euros in order to get an aggregate residual quota rent for all EU-15, with the exception of Austria, Germany, Greece, and Portugal[20]. The authors then use information on raw milk prices and quota quantities at the member state level in order to disaggregate the residual quota rent for each EU nation. They also do this relying on quota rent estimates from the INRA-Wageningen-Consortium (2002). For consistency, the obtained quota rents are downsized in order to meet the constraint of the guesstimated residual quota rent.

[20] The last two countries listed have no quota rents since their quotas are not binding for the base year. Therefore, they are exempt from any quota rent calculations.

Quota rent estimates in the Common Agricultural Policy Regionalised Impact (CAPRI) partial equilibrium model

Jansson and Britz (2002) use mixed sources on quota rent estimates for the CAPRI model. For Germany and Netherlands, where milk quotas can be exchanged through sales and lease, lease prices from quota exchanges are used. Quota purchase prices are available for Sweden and then transformed into lease prices assuming a depreciation time of 8 years and an interest rate of 6 percent. For an example of this type of information, see Table 4 in the Appendix. In the case of an absence of data from quota markets, estimates from different modelling teams are relied upon. In the case of an absence of market data and expert estimates, milk quota rents are defined as 20 percent of the national milk price.

5 Empirical evidence

This section provides empirical evidence on milk quota rent estimates. Table 2 and Table 3 present recent estimated and calibrated milk quota rents in the EU that were found in the literature. To ease comparison among the different studies, milk quota rent estimates are reported as a percentage of the milk market price. In addition, milk quota rent estimates are ranked by country according to the magnitude of their levels in a descending order from left to right. Although a direct comparison between the various studies is difficult because of the different approaches and sample used (i.e. reference quantities), several facts can be shown.

The Bouamra, et al., (2002) and INRA-Wageningen-Consortium (2002) studies facilitate checking the robustness of the quota rent estimates to the choice of different functional forms. Comparing results from the quadratic functional form with those obtained with the translog (transcendental logarithmic) functional form, it appears that the averages of the EU-15 quota rent estimates are very similar in their levels. In addition, it is not possible to say that the estimates from the quadratic form are systematically greater/lower than the one obtained from the translog (transcendental logarithmic) form. Under the two specifications, Ireland and Germany are among the most competitive countries in terms of quota rent. Netherlands, France and Portugal attain a similar ranking, whereas for Austria and Finland, there appear to be differences. Relying on the ad-hoc functional form, Demark performs better than Germany compared to the other two types of functional forms. The long run results for the United Kingdom obtained by Colman, (2002) are remarkably greater than those found by Moro, et al., (2005) and Cathagne, et al., (2006).

The estimates of Moro, et al., (2005) permit a comparison of quota rent estimates between different lengths of run. There appears to be similarities when comparing the ranking between medium run and long run estimates, particularly in the lower tail of the distribution. In addition, Moro, et al., (2005) calculate quota rents using two different ways of estimating marginal costs. First, they calculate quota rents using marginal costs computed in each sub-sample from the average of the marginal cost function evaluated at the sample mean. Second, they calculate quota rents from the marginal cost computed in each sub-sample as a weighted average of the farm-specific marginal cost. The authors suggest using the first procedure when one is interested in determining the marginal cost curve at the sub-sample level. The second procedure, on the other hand, provides more accurate estimates of the average marginal cost of each farm by allowing the verification of the amount of farms in the increasing part of their marginal costs above the minimum of the average cost curve. The results show that on average, the second procedure tends to produce a greater level of quota rent estimates than do the counterpart estimates in the first procedure. However, the ranking of the estimates is largely preserved, with the exception of Finland and Germany.

Comparing Cathagne, et al., (2006) with Moro, et al., (2005) the results are very similar, especially for the short run specification. The standard deviation of the estimated quota rents in Cathagne, et al., (2006) is larger than the one of Moro, et al., (2005), indicating larger differences in the estimates. It should be remembered that as a default option, Cathagne, et al., (2006) use a database comprising specialised dairy farms. A more direct comparison between the two studies can be made when referring to the database for all dairy farms. In this case, rankings are very similar (e.g. Belgium occupies the same position). Negative quota rents are found for the long run, indicating that milk quotas are no longer binding and that the milk supply is responding to current market prices.

Table 2: Estimated and calibrated milk quota rents in the EU (to be continued in the next page)

Study	**Run**	**Function**	**Micro-econometric Approaches Estimating Milk Quota Rents in the EU**															
INRA Wageningen 2002	MR	*Quadratic*	**IRE**	**AUS**	**GER**	**UK**	**DEN**	**SPA**	**GRE**	**ITA**	**NET**	**FRA**	**BEL**	**LUX**	**POR**	**FIN**	**SWE**	**AVG**	**STD**
			49.5	45.5	45.0	42.6	41.6	37.5	37.1	36.6	36.0	35.5	32.2	29.2	26.9	24.4	15.2	35.6	0.090
	MR	*Translog*	**IRE**	**GER**	**GRE**	**ITA**	**UK**	**DEN**	**SPA**	**AUS**	**NET**	**FRA**	**FIN**	**BEL**	**POR**	**SWE**	**LUX**		
			48.8	47.9	46.2	45.2	44.0	41.3	40.0	38.3	34.8	30.3	29.9	29.0	25.7	25.5	25.1	36.8	0.087
	MR	*Ad-hoc*	**DEN**	**GER**	**FRA**														
			54.8	54.7	40.0													49.8	0.085
Colman and Harvey 2002	LR	Quadratic	**UK**																
			28.6																
Moro, Nardella, and Sckokai (2005)	SR	Hybrid Tr	**GRE**	**BEL**	**DEN**	**SPA**	**ITA**	**SWE**	**NET**	**FIN**	**UK**	**IRE**	**AUS**	**GER**	**FRA**	**POR**	**LUX**		
			82.5	79.7	65.1	64.6	63.9	56.6	53.1	52.9	51.7	51.4	51.3	49.2	45.2	35.7	-	57.3	0.128
	MR	Hybrid Tr	**UK**	**SPA**	**IRE**	**AUS**	**BEL**	**FIN**	**NET**	**ITA**	**GER**	**DEN**	**SWE**	**FRA**	**POR**	**GRE**	**LUX**		
			42.5	39.4	38.7	38.7	37.8	33.0	32.9	32.6	31.7	23.4	19.5	18.4	9.2	2.9	-	28.6	0.121
	LR	Hybrid Tr	**SPA**	**AUS**	**NET**	**UK**	**ITA**	**IRE**	**BEL**	**SWE**	**DEN**	**GER**	**FRA**	**POR**	**GRE**	**FIN**	**LUX**		
			29.9	23.0	23.0	18.8	17.3	16.2	13.6	4.4	-4.7	-12.6	-16.5	-37.8	-38.4	-56.8	-	-1.5	0.272
	MR*	Hybrid Tr	**SPA**	**GER**	**BEL**	**NET**	**UK**	**AUS**	**IRE**	**FRA**	**FIN**	**ITA**	**DEN**	**GRE**	**SWE**	**POR**	**LUX**		
			46.4	45.3	45.1	44.7	44.5	43.7	43.0	37.1	34.2	33.8	32.5	26.3	21.3	8.4	-	36.2	0.112
Cathagne, Guyomard, and Levert (2006)	SR	*Tru. Cubic*	**BEL**	**AUS**	**LUX**	**NET**	**IRE**	**GER**	**UK**	**FRA**	**DEN**	**FIN**	**SWE**	**SPA**	**ITA**	**POR**	**GRE**		
			95.6	79.5	73.2	72.7	71.2	66.5	57.2	55.9	51.2	48.2	40.7	37.4	37.1	18.2	-	57.5	0.205
	MR	*Tru. Cubic*	**BEL**	**IRE**	**NET**	**LUX**	**GER**	**AUS**	**UK**	**FRA**	**FIN**	**SPA**	**DEN**	**ITA**	**SWE**	**POR**	**GRE**		
			68.6	58.6	53.4	45.4	40.6	39.4	38.0	33.2	27.2	23.5	22.2	14.9	10.2	-7.9	-	33.4	0.203

*Note: * Quota rents are derived using marginal costs computed for each sub-sample as the weighted average of the farm-specific marginal costs and then additionally weighted by the number of farms in each sub-sample as compared to the FADN population using shares. ** Quota rent estimates are derived using the FADN sample only for specialised dairy farms. AVG means sample average. STD means standard deviation. Hybrid Tr. is the acronym for Hybrid Translog. Tru. Cubic is the acronym for Truncated Cubic.*
Source: Own calculation based on estimates from the literature.

Table 3: Estimated and calibrated milk quota rents in the EU (continued)

Study	**Run**	**Function**	**Micro-econometric Approaches Estimating Milk Quota Rents in the EU**																
Cathagne,	LR	*Tr. Cubic*	**NET**	**BEL**	**SPA**	**UK**	**ITA**	**IRE**	**FRA**	**FIN**	**DEN**	**SWE**	**GER**	**LUX**	**AUS**	**POR**	**GRE**	**AVG**	**STD**
Guyomard			32.3	30.7	13.5	8.6	5.0	3.9	1.3	-0.9	-1.8	-2.3	-7.1	-10.1	-10.9	-19.0	-	3.1	0.147
and Levert	MR**	*Tr. Cubic*	**NET**	**IRE**	**LUX**	**FRA**	**BEL**	**GER**	**UK**	**AUS**	**DEN**	**FIN**	**SPA**	**SWE**	**ITA**	**POR**	**GRE**		
(2006)			62.1	56.9	46.5	44.2	43.2	41.7	38.0	38.0	28.7	28.4	26.0	9.9	9.4	-19.4	-	32.4	0.212
Wieck and	SR***	SGM	**DEN**	**FRA**	**GER**	**UK**	**NET**												
Heckelei			59.6	58.6	53.9	51.7	48.0											54.3	0.048
(2007a)																			
Wieck and	SR	SGM-G	**UK**																
Heckelei			39.8																
(2007b)	SR	NQ-G	**UK**																
			37.2																
	SR	NQ-EPA	**UK**																
			40.0																
			Calibrated Milk Quota Rents in Computable General Equilibrium Models																
Jensen and			**NET**	**GER**	**BEL**	**LU**	**FRA**	**AUS**	**UK**	**IRE**	**POR**	**SPA**	**DEN**	**ITA**	**GRE**	**SWE**	**FIN**		
Frandsen						**X**													
(2004)			16.6	12.0	11.9	11.9	10.5	9.0	8.9	7.2	5.9	5.8	5.3	5.3	2.6	2.2	1.6	7.78	4.276
Lips and			**IRE**	**UK**	**DEN**	**SPA**	**ITA**	**NET**	**FRA**	**BEL**	**GER**	**LUX**	**AUS**	**FIN**	**SWE**	**GRE**	**POR**		
Rieder			31.0	27.0	26.0	24.0	23.0	23.0	22.0	20.0	20.0	18.0	17.0	15.0	10.0	-	-	21.2	0.055
(2005)																			

*Note: ** Quota rent estimates are derived using the FADN sample for all dairy farms. *** Estimates should be carefully interpreted since they have been aggregated through sample averages of a selected number of regions. AVG means sample average. STD means standard deviation. Tru. Cubic is the acronym for Truncated Cubic.*
Source: Own calculation based on estimates from the literature.

Comparing the estimates of Wieck and Heckelei (2007a) with those of Moro, et al., (2005) and Cathagne, et al., (2006) the United Kingdom and Germany show similar rankings. The nonparametric estimated marginal costs of Wieck and Heckelei (2007b) are very close to the estimates obtained in Wieck and Heckelei (2007a), which use an SGM relying on a SUR type estimation. The nonparametric approach provided further insights on the marginal cost distribution. Concerning the quota rents used for calibration in the equilibrium models, assuming a medium run horizon, it appears that their magnitudes fall short of the empirical estimates found in the literature.

6 Concluding remarks

This report provided a review of the most recent approaches to quantifying the economic effects of the European milk quota scheme. This review was carried out as background support for the study entitled: "Economic Impact of the Abolition of the Milk Quota Regime – Regional Analysis of the Milk Production in the EU" (AGRI-2007-0444), initiated by DG Agriculture and Rural Development (DG AGRI). The review itself was based on the most recent studies found in the literature modelling milk quotas and milk quota rents. The primary focus was on milk quota rents, which are one of the most important variables for carrying out impact analyses on dairy policies.

Direct approaches to estimating milk quota rents are the only option for providing empirically gained estimates to be used in equilibrium models. From the reviewed empirical estimates, it appears that differences in magnitude and rankings are present across the considered studies. This poses serious problems when these estimates are used for calibration, because equilibrium models are highly sensitive to the assumptions made on quota rents.

Differences in empirical quota rent estimates are present due to different estimation types, different underlying data and variables used, as well as different functional forms used. In addition to these technical differences, there seems to be difficulty in translating those estimates for calibrating purposes in equilibrium models. Equilibrium models are based on aggregate supply functions which assume that farms lie on the increasing region of the marginal cost curve above the minimum of the average cost curve. However, as mentioned in Section 2.1, there could be a departure from this standard assumption, which is also confirmed in the aforementioned micro-econometric studies. In this context, the researcher is faced with a choice between economic plausibility and empirical findings. Micro-econometric analyses able to discern the number of farms that are pursuing increasing marginal costs may help in understanding to what extent economic plausibility is respected and equilibrium models are able to consistently depict the underlying sector.

Another difficulty lies in the choice of the length of run used when calibrating. As previously mentioned, equilibrium models are sensitive to the assumptions made on quota rents and different lengths of run may lead to different policy conclusions. For example, when looking at the reviewed quota rent estimates, it appears that short run estimates are larger than medium run estimates, which are in turn larger than long run estimates. Therefore, following this hierarchy, it can be envisaged that the units under analysis (e.g. farmer, country) will likely tolerate larger price cuts before responding to price changes in the short run than they would in the medium run or long run. Thus, calibrated quota rents must reflect similar assumptions on the underlying fixed factor modelled in equilibrium models. Ideally, when calibrating simulation models one should use long run estimates because of the long time horizon used when setting the baseline and simulations. However, difficulties in measuring the implicit cost of land tend to decrease the reliability of long run estimates; this favours the use of medium run estimates.

At this stage, given that the micro-econometric estimation of milk quota rents seems to be an ongoing issue and its translation for equilibrium models far from being settled, it is advisable to perform sensitivity analysis using, whenever possible, different sets of estimates in order to assess the robustness of policy analysis.

Aspects of the issue recommended for further research are: Analyses capturing the development of quota rents over time which are also able to provide empirically grasped projections, which are needed when setting baselines in equilibrium models; Analyses providing empirical estimates for the EU27.

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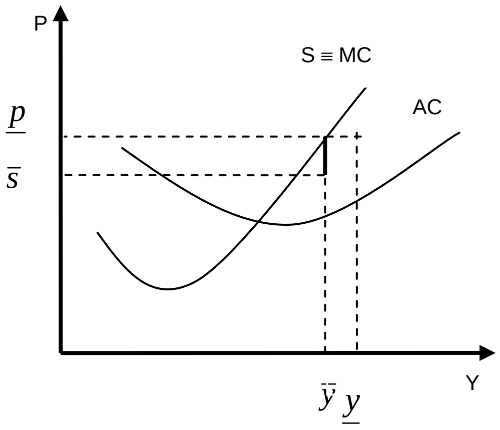
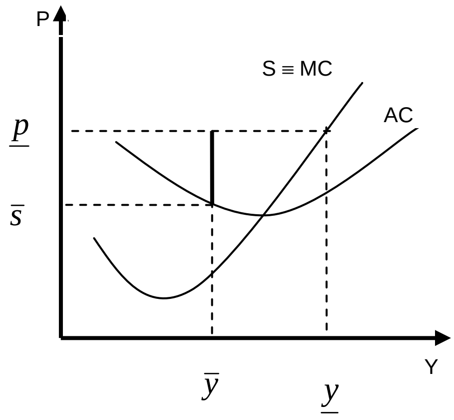
Annex

8 Annex

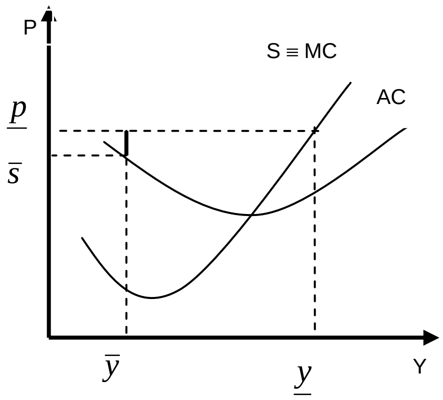
Figure 3: Categories of dairy farms according to quota level

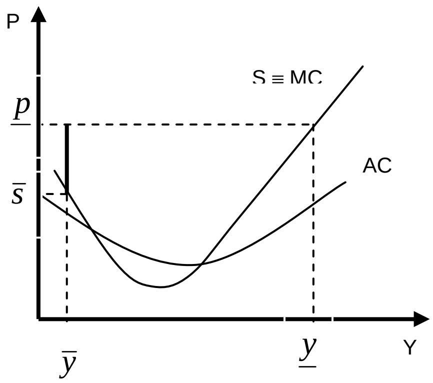




<u>CASE 1</u>:
P > MC(Quota) > AC(Quota) > Min AC

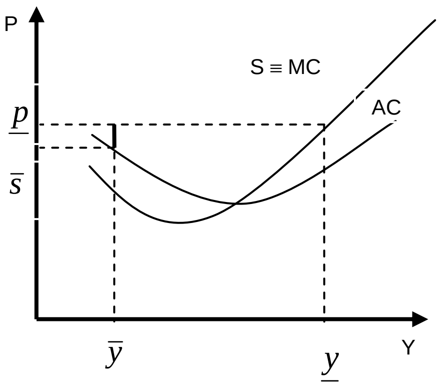
<u>CASE 2</u>:
P > AC(Quota) > Min AC > MC(Quota)





<u>CASE 3</u>:
P > AC(Quota) > Min AC> MC(Quota)

<u>CASE 4</u>:
P > MC(Quota) > AC(Quota) > Min AC



<u>CASE 5</u>:
P > AC(Quota) > MC(Quota) > Min AC

Source: Own figure.

Table 4: Prices paid per litre of quota in different Member States

Country	2007 Market price (Euros)	2007 Administrative price	Development since last year
Cyprus	1.33		Increasing
Luxembourg	1.20		Increasing
Netherlands	0.70-0.80		Decreasing
Latvia	0.43-0.72		Increasing
Denmark	0.62		Increasing
Austria	0.50-0.70		Stable
Poland	0.07-0.34		Increasing
Germany	0.23-0.42		Stable
Belgium (FL/W)		0.25-0.37	Decreasing
Italy	0.30		Stable
Ireland	0.10-0.28	0.12	Increasing
Finland	0.06-0.36	0.04	Decreasing
Czech Republic	0.07		Decreasing
France		0.15	Stable
Sweden	0.09		Stable
Hungary	0.06		Increasing
United Kingdom	0.06		Increasing

Source: Krijger, A. (2007).

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Abstract

This report is based on the outcome of a study carried out by the European Commission's Joint Research Centre - Institute for Prospective Technological Studies (JRC-IPTS, Spain) in cooperation with EuroCARE (Bonn, Germany) and the collaboration of the Agricultural Economics Research Institute (LEI, the Netherlands) and the Catholic University of the Sacred Heart (Unicatt, Italy). The report provides a review the most recent studies modelling the European milk quota. The focus is on milk quota rents, which are a central element in carrying out impact analyses on dairy policies. Direct approaches to estimating milk quota rents are the only option for providing empirically gained estimates to be used in equilibrium models. From the reviewed empirical estimates, it appears that differences in magnitude and rankings are present across the considered studies. This poses serious problems when these estimates are used for calibration, because equilibrium models are highly sensitive to the assumptions made on quota rents. Another difficulty lies in the choice of the length of run used when calibrating. As previously mentioned, equilibrium models are sensitive to the assumptions made on quota rents and different lengths of run may lead to different policy conclusions. Given that the micro-econometric estimation of milk quota rents seems to be an ongoing issue and its translation for equilibrium models far from being settled, it is advisable to perform sensitivity analysis using, whenever possible, different sets of estimates in order to assess the robustness of policy analysis.

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