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Quota Deregulation and Organic versus Conventional Milk – A Bayesian Distance Function Approach

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Abstract

Milk quota trading rules differ across EU member countries. In Denmark a biannual milk quota exchange was set up in 1997 to promote a more efficient reallocation of milk quotas as well as to reduce transaction costs related to the searching and matching of sellers and buyers. Using two comprehensive panel data sets on organic and conventional milk farms this study attempts to disentangle the effects of the introduction of an increased quota transferability on the production structure of those farms as well as the probability of market entry and exit. Bayesian estimation techniques are used to estimate an input oriented generalized Leontief distance function as well as a curvature constrained specification. The results suggest that the deregulation in the quota allocation mechanism led to an increased efficiency with respect to organic as well as conventional milk production. A relative shift of the PPF in favor of the production of organic milk has been found. In the post deregulation period the probability of farms entering organic milk production from conventional milk production has been significantly increased and the probability of farms exiting organic milk production to produce other non-organic output has been significantly decreased.

Keywords

Organic Farming, Milk Quota, Distance Function, Bayesian Analysis

1 Introduction

Milk production accounts for a large proportion of conventional as well as organic farming in Europe. However, the EU milk market is regulated by a quota system on farm level tackling to balance future milk production. Quota transfers have been allowed in the EU since 1987, although trading rules differ across member countries. In Denmark, milk quotas have been traded in different ways. Until 1997 quotas were traded along with farmland, and were bought and redistributed (without land) by the Danish Dairy Board. In 1997, a biannual milk quota exchange was set up to promote a more efficient reallocation of milk quotas as well as to reduce transaction costs related to the searching and matching of sellers and buyers (effective in 1998). Using two comprehensive panel data sets on organic and conventional milk farms for the period of 1986 to 2005 this study attempts to disentangle the effects of the introduction of quota transferability on the production structure of those farms as well as the probability of market entry/exit. Applying Bayesian techniques - a Markov Chain Monte Carlo (MCMC) method based on a Gibbs sampling process - we estimate a generalized Leontief distance function. As milk production is quota restricted we assume cost minimization as the behavioural principle and consequently formulate an input oriented specification estimated by a fixed effects procedure. The fixed effects model is further estimated in a curvature constrained specification using an importance sampling process. Beside technical efficiency also allocative efficiency ias measured by using output specific shadow price estimates. Further, substitutional relations between organic milk and non-milk output as well as between conventional milk and non-milk output are investigated. Finally output and input specific bias

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measures are estimated for organic as well as conventional milk production. The following section overviews milk production in the EU and Denmark by highlighting the importance of organic milk farming as well as the milk quota trading system in place (section 2). Section 3 outlines the theoretical framework used to analyse the effects of a deregulation in the quota allocation system on producers' decisions and efficiency. This is followed by section 4 on the empirical modelling and the data sets used whereas section 5 introduces the applied estimation procedure. Section 6 reports and discusses the estimation results and finally section 7 concludes.

2 Milk Production and Milk Quota Allocation

In the early 1980's, the EU experienced a large surplus production of milk and dairy produce. To prevent further increase and to limit milk production, it was decided to introduce a milk quota scheme as a measure to control production. Each EU country was allocated a national quota covering the total production of a quota year, starting on 1st of April and ending on 31st of March. This milk quota system (effectively introduced in 1984) has put an effective limit on the amount of milk EU dairy farmers produce each year, and generally speaking, total EU production in any given year tends to match quota. If a farmer, hence, delivers more milk than his/her quota in any one year he/she can be penalised financially involving the payment of a 'superlevy'. All former EU-15 member states have experienced a radical structural development in dairy farming in recent years as a result of the pursued agricultural policy and the WTO agreement as well as intensified technological development, implying intensified competition in the world market for dairy products (EC, 2006). Denmark is one of the countries with the most significant structural development, the number of dairy farms decreased from about 33,000 in the quota year 1984/85 to about 5,900 in 2004/05 with an average number of 95 cows per herd (Danish Milk Board, 2006). Following experts' forecasts only about 3,000 dairy farms will be left in 2014/15. Organic milk production accounts for about 10% of total milk production in Denmark and is the largest individual product category among organic products on the domestic Danish market (about 60%). The number of organic milk farms increased from about 130 in 1993/94 to about 830 in 2000/01 with an average quota of about 550 tons per farm. During recent years organic production has been on decline in number of farms as well as in total milk quota. However, in comparison with conventional production the decline has been at a minimum in the past years and in 2004/05 about 500 organic milk farms produced with an average quota of about 800 tons (Danish Milk Board, 2006). In 2005 approximately 25% of the total milk sold in Denmark was organically produced whereas the Danes are world leader in percent consumption of organic milk (Kraemer and Holgaard, 2007). In Denmark, milk quotas have been traded in different ways. Until 1997 quotas were traded along with farmland, and were bought and redistributed (without land) by the Danish Dairy Board (Rasmussen and Nielsen, 1985). During this period (1984 - 1997) it was required by law that milk quota could not be transferred without land and that the Milk Board as the main regulatory body had to be notified about all transfers. In 1997, a biannual milk quota exchange was set up to promote a more efficient reallocation of milk quotas as well as to reduce transaction costs related to the searching and matching of sellers and buyers (effective in 1998). Since then practically all transfer of milk quota in Denmark takes place at the milk quota exchange.

Initially the Milk Board ran 2 quota exchanges a year. By 2005, however, 4 exchanges are run a year – on 1 May, 15 August, 1 November, and 1 February. Two months after the exchange the quota is transferred to the purchaser and can be immediately used. However, 1% is deducted and transferred to the 'free quantities' to be used for allocation to newly established farms. All conventional and organic milk producers are entitled to place one bid for quota purchase or quota sale at the exchange stating quantity and minimum price (sale) or quantity and maximum price (purchase). No limit on the total amount of quota to purchase exists. All bids received are recorded in a supply and a demand curve whereas the intersection point constitutes the equilibrium price or the market clearing price. The latter is based on an average fat content of 4.36%, the individual bids will be adjusted by a conversion factor in relation to the farm's representative fat content. Producers willing to sell at a price lower or equal to the clearing price will sell, producers willing to buy at a price higher or equal to the clearing price will purchase. Remaining offers are rejected by the Milk Board, however, such producers can again place an offer at the following quota exchange round (Danish Milk Board, 2006). The leading role of the Danish dairy sector in terms of structure and quantity as well as the relatively innovative quota allocation system in place justify the empirical focus of this study.

3 Theoretical Framework

Several studies so far investigate milk production in the EU from a more theoretical and/or empirical perspective (see RASMUSSEN and NIELSEN, 1985; STEFANOU et al., 1992; GUYOMARD et al., 1996; BOOTS et al., 1997). COLMAN (2000) summarizes the existing theory on the economic effects of quotas in agricultural production (following BURRELL, 1989; HARVEY, 1983 and DAWSON, 1991) and applies it to analyse inefficiencies in the UK milk quota system. By cost scenario analyses based on the year 1996/97 he finds that significantly more quota is needed to be transferred from less to more efficient producers and that a large number of inefficient producers remained in milk production as a consequence of the quota restrictions. Assuming an endogeneity of some of the inputs Ooms and Peerlings (2005) estimated a milk production function applying a generalised methods of moments estimator on an unbalanced panel of Dutch milk farms to analyse the effects of the 2003 EU dairy policy reform. The authors conclude in a threat for many small milk farms by the reform steps analysed. Alvarez et al. (2006) use a panel of Spanish dairy farms to explore the relationship between milk quota values and economic efficiency. Estimated quota values are then decomposed into efficiency, price, and scale effects to assess the relative influence of these factors. The study concludes that efficiency is important in explaining quota values but is not correlated with farm characteristics which questions the success of policy measures to allocate milk quotas to efficient farms. Ewasechko and Horbulyk (1995) as well as Lambert et al. (1995) have computed potential gains from a deregulation in milk quota transferability with respect to provinces in Canada. Balcombe et al. (2007) analysed the effects of deregulation on the Australian dairy manufacturing industry. Bogetoft et al. (2003) provide an in depth analysis of the Danish milk quota allocation system focusing the single-bid restriction on quota exchanges. Their analysis is mainly based on auction theoretical considerations demonstrating that multiple-bid auctions are superior to single-bid auctions. The latter creates distortions in two ways: First, milk quota buyers try to reduce the risk of foregoing profitable trade by submitting higher bids (the uncertainty effect) and second, buyers' behaviour can not be consistent with a downward sloping demand curve and hence demand and supply will be underestimated on the market level (the aggregation effect). To illustrate the empirical importance of their findings the authors use data from the milk quota exchange in Ontario/Canada which is based on a multiple bid mechanism.

To our knowledge, an empirical study investigating the effects of a remove of restrictions for milk quota transferability on the individual producer level over time does not exist so far. Further, no such empirical study does exist taking into account the differing production structure of conventional and organic milk farming. The following analysis tries to address these gaps by analysing the effects of a deregulation in the milk quota transfer regime on the production structure of conventional as well as organic milk farms in Denmark for a period of 20 years (1986 - 2005), namely the introduction of a milk quota exchange system in December 1997. Instead of simulating a change in the transferability of the quota we use panel data on 427 conventional and 66 organic farms (2938 and 493 observations) before and after the change in quota regulation. We aim to analyse potential effects on the farms' relative efficiency, resulting changes in the farms substitution between milk and non-milk output as well as input and output specific deregulation effects over time. We assume a significantly different production structure for conventional and organic milk farms, hence evaluate the models for each sample of milk farms separately. The specific research hypotheses to investigate by the empirical analysis are (1) deregulation in the milk quota allocation system has positive effects on the milk farms efficiency over time; and (2) deregulation in the milk quota allocation system has significant effects on the farms production structure, namely the output composition based on the substitutability between milk and non-milk output as well as organic and non-organic output. Different theoretical cases can be distinguished with respect to the milk quota allocation mechanism in place:

Case I: We consider a profit-maximising conventional or organic milk farmer who produces milk output y_m as well as non-milk output y_{nm} according to the well-behaved short-run or restricted cost structure $C(y_m,y_{nm},x,Z)$ where w is the market price vector of variable input quantities (as e.g. fodder, energy, veterinary expenses) and Z is the vector of quasi-fixed factor quantities (as e.g. land, labor, capital). The farmer is a price taker on all output and variable input markets. As none of the outputs is constrained by quotas, producer behaviour can be described by an unrationed restricted profit function $\pi(p_m,p_{nm},w,Z)$ where p_m is the milk output price and p_{nm} is an aggregated price for non-milk output. Short-run profit is maximised by

$$\pi\left(p_m, p_{nm}, w, Z\right) \equiv \max_{y_m, y_{nm}}\left[p_m y_m + p_{nm} y_{nm} - C\left(y_m, y_{nm}, w, Z\right)\right] \qquad (1)$$

This case describes the pre-1984 period for all European milk sectors.

Case II: When output y_m is constrained by a quota at level y_m' and if quotas are not traded among milk producers, the individual farmer chooses short-run cost minimisation based on a partly rationed restricted profit function $\pi_{sr}{}^r(p_m,y_m{}',p_{nm},w,Z)$. Short-run profit – the maximum profit attainable given the regime of non-tradable milk quotas - is then maximised by

$$\pi^r\left(p_m, y'_m, p_{nm}, w, Z\right) \equiv \left[p_m y'_m - \min_{C_m}\left(C_m\left(y'_m, w, Z\right)\right)\right] + \max_{y_{nm}}\left[p_{nm} y_{nm} - C_{nm}\left(y_{nm}, w, Z\right)\right] \qquad (2)$$

Long-run profit, however, is described by a partly rationed but unrestricted profit function $\pi_{lr}{}^r(p_m,y_m{}',p_{nm},w)$ where all inputs are variable and consequently (see also Burrell, 1989)

$$\pi^r_{lr}\left(p_m, y'_m, p_{nm}, w\right) \equiv \left[p_m y'_m - \min_{C_m}\left(C_m\left(y'_m, w\right)\right)\right] + \max_{y_{nm}}\left[p_{nm} y_{nm} - C_{nm}\left(y_{nm}, w\right)\right] \qquad (3)$$

Case III: If milk quotas can be freely leased and v is the rental price of the quota, then the individual farmer's behaviour is defined by

$$\begin{aligned} \pi^l\left(p_m, y'_m, p_{nm}, w, Z, v\right) &\equiv \max_{y_m, y_{nm}, q}\left[\left(p_m y_m - C_m\left(y_m, w, Z\right) - vq; y_m = y'_m + q; y_m \geq 0\right) + \left(p_{nm} y_{nm} - C_{nm}\left(y_{nm}, w, Z\right)\right)\right] \\ &\equiv \max_{y_m, y_{nm}}\left[\left(((p_m - v) y_m - C_m\left(y_m, w, Z\right); y_m \geq 0\right) + vy'\right) + \left(p_{nm} y_{nm} - C_{nm}\left(y_{nm}, w, Z\right)\right)\right] \end{aligned} \qquad (4)$$

where vq represents the cost of renting additional quota at a price v per unit (vq ≥ 0) or the revenue from leasing out part or all of the initial quota at a price v per unit (vq ≤ 0). Π^l is the maximum profit attainable in the regime of free milk quota lease (see Guyomard et al., 1996). This case describes the pre-1997/98 period for the Danish milk sector and corresponds to a decrease in the milk price received by producers (p_m-v) but no change in the consumer price for milk. Tradable rights to use milk quota hence work like a tax which restores marginal cost pricing in the diary industry while protecting the rents of the initial quota owners (Guyomard et al., 1996).

Case IV: If finally milk quotas are freely tradable among producers, but their trade is restricted to certain dates of the production year (e.g. bi-annually or quarterly), the individual farmer's behaviour at time t_0 can be described as follows

(5)

$$\pi_{t_0}^{ex}\left(p_m, y'_{m,t_0}, p_{nm}, w, Z\right) \equiv \left[p_m y'_{m,t_0} - \min_{C_m}\left(C_m\left(y'_{m,t_0}, w, Z\right)\right)\right] + \max_{y_{nm}}\left[p_{nm} y_{nm} - C_{nm}\left(y_{nm}, w, Z\right)\right]$$

after the first (bi-annual) quota exchange at time t^1

(6)

$$\pi_{t_1}^{ex}\left(p_m, y'_{m,t_1}, p_{nm}, w, Z, p_{q,t_1}\right) \equiv \left[p_m y'_{m,t_1} - \min_{C_m}\left(C_m\left(y'_{m,t_1}, w, Z, p_{q,t_1}\right)\right)\right] + \max_{y_{nm}}\left[p_{nm} y_{nm} - C_{nm}\left(y_{nm}, w, Z\right)\right]$$

and after the n-th (bi-annual) quota exchange at time t_n

(7)

$$\pi_{t_n}^{ex}\left(p_m, y'_{m,t_n}, p_{nm}, w, Z, p_{q,t_n}\right) \equiv \left[p_m y'_{m,t_n} - \min_{C_m}\left(C_m\left(y'_{m,t_n}, w, Z, p_{q,t_n}\right)\right)\right] + \max_{y_{nm}}\left[p_{nm} y_{nm} - C_{nm}\left(y_{nm}, w, Z\right)\right]$$

where the output levels $y'_{m,t0}$ is again the initial constrained output level y_m, $y'_{m,t1}$ is the quota constrained output level after one quota exchange round at time period t_1 and represents the adjusted but still quota constrained output level $y'_{m,t1} = y'_{m,t0} + \Delta y_{m,t1}$, and $y'_{m,tn}$ is the quota constrained output level after n quota exchange rounds up till time period t_n and represents the adjusted but still quota constrained output level $y'_{m,tn} = y'_{m,tn-1} + \Delta y_{m,tn}$. This follows from the regulatory constrained that milk production quotas q can be exchanged betweem producers but the exchange is limited to certain pre-defined dates (t_1 to t_n). Hence, the behaviour of the individual producer in the short-run is described by a partly rationed restricted profit function $\pi_{sr}^{ex}(p_m,y'_m,p_{nm},w,Z,p_q)$. Short-run profit equals maximum profit attainable in a time period given the regime of tradable milk quotas at certain points in time (see Bogetoft et al., 2003 and Alvarez et al., 2006). This case describes the post 1997/98 period for the Danish milk sector. Long-run profit, however, is described by a partly rationed but unrestricted profit function $\pi_{lr}^{ex}(p_m,y'_m,p_{nm},w,p_q)$ where all inputs are variable.

(8)

$$\pi_{lr,t_n}^{ex}\left(p_m, y'_{m,t_n}, p_{nm}, w, p_{q,t_n}\right) \equiv \left[p_m y'_{m,t_n} - \min_{C_m}\left(C_m\left(y'_{m,t_n}, w, p_{q,t_n}\right)\right)\right] + \max_{y_{nm}}\left[p_{nm} y_{nm} - C_{nm}\left(y_{nm}, w\right)\right]$$

Case V: Finally, if milk production quota are fully tradable on a completely free market without any legally set quota exchange regime as well as no time restrictions for the price and quantity bids, case III can be adjusted as follows

(9)

$$\pi^f\left(p_m, y'_m, p_{nm}, w, Z, p_q\right) \equiv \max_{y_m, y_{nm}, q}\left[\left(p_m y_m - C_m\left(y_m, w, Z, p_q\right) - p_q q; y_m = y'_m + q; y_m \ge 0\right) + \left(p_{nm} y_{nm} - C_{nm}\left(y_{nm}, w, Z\right)\right)\right]$$

$$\equiv \max_{y_m, y_{nm}}\left[\left(\left((p_m - p_q) y_m - C_m\left(y_m, w, Z\right); y_m \ge 0\right) + p_q y'\right) + \left(p_{nm} y_{nm} - C_{nm}\left(y_{nm}, w, Z\right)\right)\right]$$

where $p_q q$ represents the cost of purchasing additional quota at a price p_q per unit ($p_q q \ge 0$) or the revenue from selling part or all of the initial quota at a price p_q per unit ($p_q q \le 0$). Π^f is the maximum profit attainable in the regime of free milk quota trade in the short-run. This corresponds to a decrease in the milk price received by producers (p_m-p_q) but no change in the consumer price for milk.

Following cases III and IV outlined above, an adequate representation of the multi-output and multi-input production structure of conventional or organic milk producing farms has to be formulated which can then be translated into an estimable empirical model. Accounting for the multi-output nature of production one could choose a dual representation of the production technology such as a cost or profit function. However, the distance function representation of a production technology, proposed by SHEPHARD (1953, 1970), provides a multi-output primal alternative which requires no aggregation of outputs, no prices and no behavioural assumptions. By using such a framework the relative switch from organic milk to inorganic crop or livestock production and vice versa can be investigated by simply measuring the substitution between organic milk and other outputs produced over time. This could give an indication if the existing quota allocation scheme significantly increases or decreases the probability of entering and/or exiting organic milk production. An input-distance function considers by how much the input vector may be proportionally contracted with the output vector held fixed (FAERE, 1988; FAERE et al., 1994; GROSSKOPF et al., 1997; COELLI, 2000). Such a function seems adequate to represent a partially rationed profit framework implying a cost minimisation problem for the milk output as well as a profit maximisation problem for the non-milk outputs produced (see equations (3) and (8)). A theoretical input-distance function may be defined on the input set L(y,u), as

$$D_I(x,y,u) = \max\left\{\phi : \left(x/\phi\right) \in L(y,u)\right\} \quad 10)$$

where ϕ is the scalar distance by which the input vector can be deflated, and L(y,u) as the set of all input vectors x $\in$ R^K_+ comprising all production inputs named above, which can produce the output vector, y $\in$ R^M_+ comprising milk and non-milk output given the exogenous factors u (i.e. a vector of external production determinants such as technical and regulatory factors as e.g. the quota allocation system in place). That is,

$$L(y,u) = \left\{x \in R^K_+ : x \text{ can produce } y \text{ given } u\right\} \quad (11)$$

D_I(x,y,u) is non-decreasing, positively linearily homogenous and concave in x, and increasing in y, finally D_I(x,y,u) ≥ 1 if x $\in$ L(y,u).

4 Empirical Modelling

According to DIEWErt (1973) a flexible functional form provides a second order approximation to the real production structure by an arbitrarily chosen set of parameters. Hence, a functional form can be denoted as flexible if its shape is only restricted by theoretical consistency. MORRISON-PAUL et al. (2000) stress that the minimization of a priori restrictions implied by the choice of the functional form is particular important in a multi-output and multi-input context. Thus, a flexible technological representation allowing for substitution and regulatory impacts within the function is desirable as a basis for an empirical application. Restricted for correct curvature (i.e. consistency with the underlying behavioural assumptions) the TL shows no longer second order flexibility as curvature correctness has to be imposed at every individual observation (see e.g. Sauer, 2006). Unlike the TL, the generalized Leontief (GL) functional form can be globally restricted for curvature correctness by parameter restrictions (see DIEWERT and WALES (1987), requires no mathematical manipulations of the original data as e.g. taking logs of the variables, but incorporates all second-order (interaction- or cross-) terms across outputs and inputs and allows investigation of substitution possibilities without restrictive assumptions about the shape of the underlying technological relationship. HAILU and VEEMAN (2000) demonstrate that a theoretically consistent input distance function is non-decreasing and concave in inputs and non-increasing and quasi-concave in outputs.

An input-oriented distance function based on a generalized Leontief functional form with L outputs, K inputs and for I farms is given by

$$D_{In,i} = \alpha_0 + \sum_{l=1}^{L}\gamma_l y_{li} + 2\sum_{l=1}^{L}\sum_{n=1,n\neq l}^{L}\gamma_{ln} y_{li} y_{ni} + \sum_{k=1}^{K-1}\beta_k x_{ki} + 2\sum_{k=1}^{K-1}\sum_{o=1,o\neq k}^{K-1}\beta_{ko} x_{ki} x_{oi} + 2\sum_{k=1}^{K-1}\sum_{l=1}^{L}\delta_{kl} x_{ki} y_{li} \quad (12)$$

where *In* indicates an input-oriented distance function. Homogeneity of degree 1 is imposed by normalizing the function by one of the inputs (see Coelli, 2000). Incorporating a milk quota exchange deregulation related variable *qex*, technical change related dummies *t*, yearly based fixed effects *a* as well as a vector of other control variables *c* we reformulate (12) to

$$-x_{ki} = \sum_{l=1}^{L}\gamma_l y_{li} + 2\sum_{l=1}^{L}\sum_{n=1,n\neq l}^{L}\gamma_{ln} y_{li} y_{ni} + \sum_{k=1}^{K-1}\beta_k (x_{ki} - x_{Ki}) + 2\sum_{k=1}^{K-1}\sum_{o=1,o\neq k}^{K-1}\beta_{ko}(x_{ki} - x_{Ki})(x_{oi} - x_{Ki}) +$$

$$2\sum_{k=1}^{K-1}\sum_{l=1}^{L}\delta_{kl}(x_{ki} - x_{Ki}) y_{li} + \psi_{qex} qex_i + \sum_{k=1}^{K-1}\phi_{kqex}(x_{ki} - x_{Ki}) qex_i + \sum_{l=1}^{L}\phi_{lqex} y_{li} qex_i + \kappa_t t_i + \kappa_{tt} t_i^2 + \sum_{s=1}^{S}\varphi_s c_{si} + \sum_{a=1}^{A}\eta_{at} a_{ti} - d_{In,i} \quad (13)$$

where the outputs L are conventional or organic milk produced and other conventionally produced non-milk output, the inputs K are land, labor, capital, fodder, energy and veterinary expenses, qex is the quota deregulation related dummy, as well as c for off farm income, age of the farmer, proportion of land rented, proportion of hired labor, debt to own capital ratio, and the debt to total assets ratio of the farm i in question.[1] Although our GL specification of the input distance function satisfies homogeneity and symmetry by construction, monotonicity in outputs (non-increasing) and inputs (non-decreasing) as well as concavity in inputs and quasi-concavity in outputs have to be checked and imposed respectively. With respect to the parameters of the estimated function this implies the following restrictions: $\partial d_{In} / \partial x_k > 0 \; for \; k = 1,2,...K-1$, and $\partial d_{In} / \partial y_l < 0 \; for \; 1 = 1,2...L$, $\beta_{ko} > 0 \; for \; k = 1,2,...K-1$ and $\delta_{kl} \geq 0 \; for \; 1 = 1,2,...L$ and $k = 1,2,...K-1$.

Absolute, relative, and proportional measures for both inputs and outputs can be constructed by using the distance function in (13) and building the first- and second-order elasticities with respect to the arguments of the function. A broad range of input and output substitutability and compositional patterns can then be summarized (see e.g. Morrison-Paul et al., 2000). The duality of the distance function with the revenue function can be used to define r_l^* as the revenue-deflated shadow price of y_l via a distance-function oriented Shephard's lemma based on the derivative (see Faere, 1988)

$$\partial D_{In}(\mathbf{x},\mathbf{y}) / \partial y_l = r_l^*(\mathbf{x},\mathbf{y}) = \gamma_l + 2\sum_{n=1,n\neq l}^{L}\gamma_{ln} y_n + 2\sum_{k=1}^{K-1}\delta_{kl}(x_k - x_K) + \phi_{lqex} qex \quad (14)$$

The ratio of these shadow values for conventional or organic milk output y_m and non-milk output y_{nm} represents the slope of the production possibility frontier (PPF), or the marginal rate of transformation (MRT):

$$MRT_{m,nm} = r_m^* / r_{nm}^* \quad (15)$$

Analogue to the marginal product concept, these measures provide an indication of the valuation of the output in terms of its contribution to resulting overall output. The ratio in (15) is analogue to the ratio of the marginal products representing the marginal rate of technical substitution ($MRTS_{ko}$) for the inputs. It can be used to assess allocative efficiency by comparing it with the ratio of observed output prices where the two ratios are equal if profit maximization effectively takes place. This would mean for the overall milk market

$$AE_m = \left(mp_{org} / mp_{con}\right) / \left(r_{org}^* / r_{con}^*\right) \quad (16)$$

where mp is the observed milk price for organically or conventionally produced milk. The development of technical efficiency per year is measured by using the estimated parameters for the fixed effects η_{at} and correcting for the 'best' year by calculating the level of technical inefficiency τ_{at} in year t:

$$TE_t = (1 - \tau_{at}) = (1 - (\max_t(\eta_{at}) - \eta_{at})) \quad (17)$$

[1] Milk quota is not used as an explanatory variable in the model as auxiliary regressions showed an almost complete (deterministic) relationship between milk output and quota input. Further severe collinearity has been detected with respect to other variable inputs as e.g. cows. This approach is also followed by Stefanou et al., 1992; Ooms and Peerlings, 2005 and Alvarez et al., 2006.

following the approach by Kumbhakar (1989) and Sauer and Frohberg (2007).[2] Hence, by controlling for such sectoral technical inefficiency variation by year and rearranging the equation in (16) the shadow values obtained by (14) can be used to obtain the ouput specific allocative efficiency per individual farm as e.g. for (organic or conventional) milk output

$$OSAE_{mi} = \left(r^*_{coni} / mp_{coni} \right) = \left(r^*_{orgi} / mp_{orgi} \right) \tag{18}$$

which relates the estimated shadow values to the observed values of the output per farm i. Consequently, such output specific allocative efficiency reflects potential market distortions, e.g. regulatory impacts by the milk quota regime in place or the impacts by subsidies for organic production (see Lau and Yotopoulos, 1971). The difference between the observed milk price and the estimated shadow milk price as a proxy for allocative inefficiency (i.e. allocative inefficiency due to distortions by the quota system in place, due to other market distortions as well as due to managerial optimization failure on farm level) could be used as an indicative price for milk quota per kg and year. Such a proxy can be interpreted as an upper ceiling for the average price per quota unit used in the sector. Grosskopf et al. (1997) showed that the MRT measure is increasing in terms of levels as the ratio of outputs falls as the increased production of one output alone occurs at higher opportunity cost. By normalizing the marginal rate of transformation it reflects the substitutability between two outputs, as e.g. between milk and non-milk output

$$sub_{m,nmi} = \frac{r^*_{mi} / r^*_{nmi}}{y_{nmi} / y_{mi}} = \left(\frac{\gamma_m + 2\sum\limits_{n=1,n\neq m}^{L} \gamma_{m,n} y_{ni} + 2\sum\limits_{k=1}^{K-1} \delta_{k,m}(x_{ki} - x_{Ki}) + \phi_{m,qex} qex_i}{\gamma_{nm} + 2\sum\limits_{n=1,n\neq nm}^{L} \gamma_{nm,n} y_{ni} + 2\sum\limits_{k=1}^{K-1} \delta_{k,nm}(x_{ki} - x_{Ki}) + \phi_{nm,qex} qex_i} \right) / \left(\frac{y_{nmi}}{y_{mi}} \right) \tag{19}$$

where $sub_{m,nm} > 1$ (< 1) implies relative difficulty (ease) in y_m - y_{nm} substitution and hence, measures changes in output composition for farm i. With respect to the production of organic milk this measure can then be used to assess the development in the probability of milk farmers entering or exiting the organic milk market over time as in our framework the aggregated non-milk output is totally based on conventional production. The further exploration of second-order relationships of milk and non-milk outputs may deliver insights in the curvature of the PPF over time given exogenous effects of quota regulation changes. Cross-terms with respect to the y_l variables are interpretable as the effect these variables have on the contribution or valuation of y_l from a shift in the distance function. To distinguish the reform impact on organically produced milk, we can compute

$$B_{org,qexi} = \partial S_{orgi} / \partial qex_i = \frac{\frac{\partial D_{In}}{\partial y_{org}}}{\partial qex_i} = \frac{\gamma_{org} + 2\sum\limits_{n=1,n\neq l}^{L} \gamma_{org,n} y_{ni} + 2\sum\limits_{k=1}^{K-1} \delta_{k,org}(x_{ki} - x_{Ki}) + \phi_{org,qex} qex_i}{\partial qex_i} = \phi_{org,qex} \tag{20}$$

where S_{li} denotes the cost share in a cost function context and the proportional marginal product or implicit share measure in a distance function context (Morrison-Paul et al., 2000). The bias measure $B_{l,qexi}$ provides a relative measure of the productive impact of *qex* on output production and composition (as well as input composition by $B_{k,qexi}$) indicating whether a change in the quota regulation regime causes a change in the slope of the PPF or a twist of the PPF which for constant prices results in a movement around it. Whereas the overall impact of the regulatory change *qex* is obtained by the first-order *qex* elasticity $\varepsilon_{l,qex}$, the second-order

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[2] Our primary focus is on measuring the effects of quota deregulation on the production structure as well as the allocative efficiency, the substitutional relations and the entry/exit behaviour of farms in the milk sector over time. As the technical efficiency on producer level has been investigated before (Sauer et al., 2006) we do not explicitly model an error-components based distance frontier but control for significant changes in the technical efficiency on sector level over time by a fixed effects model specification.

bias term in (20) reflects differential impacts on inputs or outputs implying e.g. an increase in the value, share, or contribution of y_l relative to total output.

5 Bayesian Estimation and Data

We opt for the application of Bayesian estimation methods because of the following reasons: Beside disentangling the effects of regulatory policy measures on milk production we are also interested in the discrepancies between econometric measurement and economic theory with respect to the underlying behavioural assumption of output maximisation (see O'Donnel/Coelli, 2005; Sauer, 2006; Lancaster, 2006). So far, there are exclusively frequentist applications in the literature on milk production in Europe. However, a Bayesian approach enables the researcher to impose curvature constraints on the parameters of a GL distance function by means of importance sampling based on a Gibbs sampling procedure. We estimate our input-oriented distance function described in (13) as a normal linear regression model with an independent Normal-Gamma prior (see KOOP, 2005) assuming prior independence between β as the parameters to be estimated and h as the error precision defined as $1/\sigma^2$ with σ^2 as the variance. In particular, we assume prior independence between β and h defined by $p(\beta,h)=p(\beta)p(h)$ with p(β) as the prior distribution for β being Normal

$$p(\beta)=\frac{1}{(2\pi)^{\frac{k}{2}}}\left|\underline{V}\right|^{-\frac{1}{2}}\exp\left[-\frac{1}{2}(\beta-\underline{\beta})'\underline{V}^{-1}(\beta-\underline{\beta})\right] \quad \text{and} \quad p(h)=\left(\left(\frac{2\mu}{\nu}\right)^{\frac{\nu}{2}}\Gamma\left(\frac{\nu}{2}\right)\right)^{-1}h^{\frac{h\underline{\nu}}{2\underline{s}^{-2}}}\exp\left(-\frac{h\underline{\nu}}{2\underline{s}^{-2}}\right) \tag{21}$$

as the prior distribution for h being Gamma, where $\underline{\beta}=E(\beta|y)$ as the prior mean of the conditional probability of β given the dependent variable y and $\underline{s}^{-2}$ and $\underline{\nu}$ as the prior mean and degrees of freedom of h, $\underline{V}$ denoted the prior covariance matrix of β. The likelihood function for the normal linear regression is given by

$$p(y|\beta,h)=\frac{h^{\frac{N}{2}}}{(2\pi)^{\frac{N}{2}}}\left\{\exp\left[-\frac{h}{2}(y-X\beta)'(y-X\beta)\right]\right\} \tag{22}$$

with N as the total number of observations and X as the vector of exogenous variables. Consequently, we obtain as the joint posterior density for β and h

$$p(\beta,h|y)\propto\left\{\exp\left[-\frac{1}{2}\left\{h(y-X\beta)'(y-X\beta)+(\beta-\underline{\beta})*\underline{V}^{-1}(\beta-\underline{\beta})\right\}\right]\right\}h^{\frac{N+\underline{\nu}-2}{2}}\exp\left[-\frac{h\underline{\nu}}{2\underline{s}^{-2}}\right] \tag{23}$$

which requires posterior simulation as a simple analytical solution is not feasible (Koop, 2005). By matrix simulation and mathematical rearrangements we obtain the conditional posteriors for β

$$p(\beta|y,h)\propto\exp\left[-\frac{1}{2}(\beta-\overline{\beta})'\overline{V}^{-1}(\beta-\overline{\beta})\right] \quad \text{and h} \quad p(h|y,\beta)\propto h^{\frac{N+\underline{\nu}-2}{2}}\exp\left[-\frac{h}{2}\left\{(y-X\beta)'(y-X\beta)\right\}+\underline{\nu}\underline{s}^{2}\right] \tag{24}$$

which are used by the Gibbs sampler as a posterior simulator to produce estimates of posterior properties. The Markov Chain Monte Carlo (MCMC) method of Gibbs sampling is used (CASSELLA and GEORGE, 1992; ZELLNER and Min, 1995; GEWEKE, 1999) to approximate the marginal posterior distribution of a parameter of interest by generating a sample drawn from the marginal posterior distribution. The sample is derived by making random draws from the full conditional distributions of all parameters in a model. Estimates of the parameter vector β and the error precision h can be achieved by making successive sequential draws from the full posterior conditional distributions β given h, and h given β. The collection of random draws $\beta^{(s)}$ and $h^{(s)}$ for s = 1,…,S can then be averaged to produce estimates of posterior properties. We discard an initial S_0 = 5000 burn-in-replications and include S_1 = 50000 replications. To assess the approximation error in the MCMC algorithm we report different diagnostic measures: The numerical standard error following

$$NSE = \hat{\sigma}_g / \sqrt{S_1} \quad (25)$$

as well as the convergence diagnostic introduced by GEWEKE (1994)

$$CD = \left(\hat{g}_{S_A} - \hat{g}_{S_C}\right) / \left[\left(\hat{\sigma}_A / \sqrt{S_A}\right) + \left(\hat{\sigma}_C / \sqrt{S_C}\right)\right] \quad (26)$$

where $\hat{g}_{S_A}$ and $\hat{g}_{S_C}$ are the estimates of $E\left[g(\theta)|y\right]$ using the first S_A replications after the burn-in and the last S_C replications, respectively, and consequently $\hat{\sigma}_A / \sqrt{S_A}$ and $\hat{\sigma}_C / \sqrt{S_C}$ as the numerical standard errors of these two estimates. Sufficiently low values of CD indicate that $\hat{g}_{S_A}$ and $\hat{g}_{S_C}$ are quite similar, hence a sufficiently large number of draws has been taken. In a second modelling step we estimate our input-oriented distance function described in (13) as a constrained normal linear regression model again with an independent Normal-Gamma prior assuming prior independence between β and h following the steps outlined above. However, correct curvature (i.e. monotonicity in outputs and inputs as well as concavity in inputs and quasi-concavity in outputs) is imposed through individual parameter inequality restrictions which implies a global restriction for the chosen GL functional form. Hence, we assume that a region of the parameter space β which is not within the relevant (i.e. courvature correct) region A is a priori impossible and should receive a prior weight of 0. Accordingly, our prior is given by

$$p(\beta) = \left\{ \frac{1}{(2\pi)^{\frac{k}{2}}} |\underline{V}|^{-\frac{1}{2}} \exp\left[-\frac{1}{2}(\beta - \underline{\beta})' \underline{V}^{-1} (\beta - \underline{\beta}) \right] \right\} 1(\beta \in A) \quad (27)$$

where $1(\beta \in A)$ is the indicator function, which equals 1 if $\beta \in A$ and 0 otherwise. The posterior is accordingly given by $p\left(\beta | y, h\right) \propto \exp\left[-\frac{1}{2}(\beta - \overline{\beta})' \overline{V}^{-1} (\beta - \overline{\beta}) \right] 1(\beta \in A)$ (28)

For a general choice of A neither an analytical method nor Gibbs sampling work is appropriate (KOOP, 2005), hence importance sampling is used based on the following theorem (see GEWEKE, 1999): Let $\theta^{(s)}$ for s = 1,..,S be a random sample from q(θ) as the importance function with θ as a vector of parameters and define g(.) as the function of interest with the estimate

$$\hat{g}_S = \left(\sum_{s=1}^{S} w(\theta^{(s)}) g(\theta^{(s)}) / \sum_{s=1}^{S} w(\theta^{(s)}) \right) \quad (29)$$

where $w(\theta^{(s)}) = \frac{p(\theta = \theta^{(s)} | y)}{q(\theta = \theta^{(s)})}$. Then $\hat{g}_S$ converges to $E\left[g(\theta)|y\right]$ as S approaches infinity. To assess the approximation error in the importance sampling algorithm we report again the numerical standard error following (27) and the convergence diagnostic based on (28). Further we report posterior odds ratios calculated as the Bayes Factor based on the Savage-Dickey density ratios to compare nested models where both have the same inequality restrictions imposed (VERDINELLI and WASSERMAN, 1995):

$$BF_{12} = \frac{p(\beta = \beta_0 | y, M_2)}{p(\beta = \beta_0 | M_2)} = \frac{\overline{c} f_t(\beta = \beta_0 | \overline{\beta}, \overline{s}^{-2} \overline{V}, \overline{v}) 1(\beta \in A)}{\underline{c} f_t(\beta = \beta_0 | \underline{\beta}, \underline{s}^2 \underline{V}, \underline{v}) 1(\beta \in A)} = \frac{\overline{c} f_t(\beta = \beta_0 | \overline{\beta}, \overline{s}^{-2} \overline{V}, \overline{v})}{\underline{c} f_t(\beta = \beta_0 | \underline{\beta}, \underline{s}^2 \underline{V}, \underline{v})} \quad (30)$$

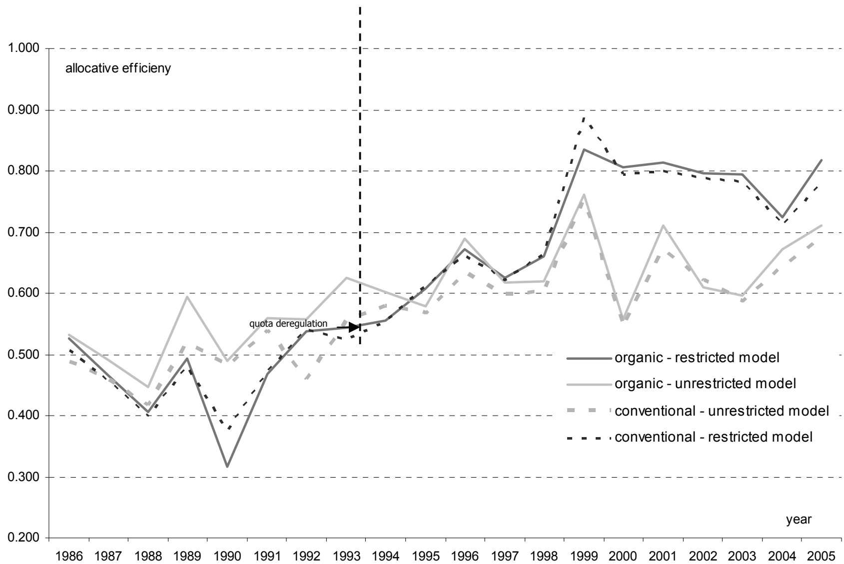
where M_2 denotes the model described by (29) to (31), $\underline{c}$ and $\overline{c}$ are the prior and posterior integrating constants ensuring that the densities integrate to one. In order to elicite reasonable informative priors some preliminary OLS regressions were performed based on different production function specifications. As this is not more than a first informed choice, little weight has been put to the prior for h (about 10%) reflecting the weight given to the data information. For the prior variances relatively low values have been selected as well as prior covariances of the value zero as any prior guesses on the values of the latter would seem to be rather arbitrary for a complex functional form (see KOOP, 2005).

We estimate the constrained and unconstrained distance function using a sample of 493 organic diary farms and a sample of 2938 conventional diary farms for the period 1986 to 2005. By this we assume that the underlying production technology of organic farms significantly differs from those of conventional farms as we suspect that the former is more labor the latter more capital and fertilizer intensive. We test for this assumption by running a simple regression using the pooled data set. The coefficient for conventional or organic showed to be highly significant at the 0.0001 level of significance, a LR-test performed on the significance of the estimate rejected the null hypothesis with a high level of confidence. Descriptive statistics for the two samples can be obtained from the authors. We use as outputs (organic or conventional) milk produced and an aggregate of other farm which is completely non-organically produced in the case of organic diary farms. We choose to aggregate over all non-milk outputs as our interest is primarily in the deregulation effects on milk production. Further the chosen functional form demands the inclusion of a large number of cross terms. This practice is in line with previous contributions (see e.g. OOMS and PERLINGS, 2005). As inputs land, labor, capital (as an aggregate for machinery, buildings, and stocks), cows, fodder, energy, and veterinary expenses are considered beside time related and quota deregulation related individual and cross terms. Finally off farm income, the age of the farmer, the share of rented land, the share of hired labor, the debt to equity ratio, and the debt to total assets ratio are included as control variables. Soil quality differences as well as climatic variations can be neglected for homogenous small countries as Denmark. Various auxiliary regressions including such variables confimrd this assumed insignificance (see also RASMUSSEN/NIELSEN, 1985 and Danish Milk Board, 2005). OOMS and PERLINGS (2005) assume significant endogeneity with respect to some production inputs. However, using a Hausman test formula such endogeneity could not be verified for none of the inputs used in this study (the null hypothesis of complete exogenous determination could not be rejected at the 10% level of significance). COELLI (2000) shows that consistent estimates of the input distance function can be obtained as by infering the cost-minimizing first order conditions only ratios of input quantities remain in the distance function.

6 Results and Discussion

We estimated an unrestricted and restricted model for a sample of organic farms as well as for a sample of conventional farms, i.e. nearly 300 parameters were estimated. Due to space limitations we do not report the individual coefficients here. The standard deviations of the estimates indicate that nearly all of them are statistically significant. The numerical standard errors for the approximation of $E(\beta|y)$ indicate the accuracy of the estimates based on 50,000 replications and 5,000 burn ins. The results for 'Geweke's CD', comparing the estimate of $E(\beta|y)$ based on the first replications (after the burn-ins) to that based on the last replications, suggest that the effect of the initial condition has vanished and an adequate number of draws have been taken for all parameters etsimated. Noting that CD is asymptotically standard normal, it can be concluded that convergence of the algorithms has been achieved as the highest CD value found is 1.79 in absolute value. The posterior odds ratios are in line with the evidence provided by posterior means and standard deviations. We found no strong evidence that $\beta = \underline{\beta}$. Finally, as assumed, the unrestricted models showed to be inconsistent with respect to the underlying theoretical requirements of monotonicity, concavity in inputs and quasi-concavity in outputs. However, as different contributions concluded in a trade-off between statistical significance and theoretical consistency (see Terrell, 1996; Sauer, 2006) we report the results for both model specifications. The output specific allocative efficiency for organic and conventional milk production on farm level is illustrated in figure 1. This measure refers to the part of the individual farm's allocative efficiency due to output production decisions (i.e. the relative quantities produced and the different input ratios employed). Accordingly, the gap between the shadow price and the observed market price for milk on farm level has been reduced during the time period investigated, especially in the subperiod following the quota deregulation in 1998. These estimates reveal three crucial findings: 1) the allocative efficiency for the production of organic and conventional milk increased in the period investigated by up to 30% (organic) and 27% (conventional) respectively; 2) the increase in efficiency in the period after the deregulation of the quota exchange mechanism has been relatively larger than in the period before the quota deregulation for both forms of milk production; and 3) the increase in allocative efficiency after the implementation of the quota deregulation has been relatively larger for organic milk production (by up to 3.5%). It is evident that both models suggest a higher price for organic milk in the period after the deregulation (i.e. a shadow price ratio of > 1) but also a diminishing gap between the estimated shadow price ratio and the observed price ratio in the period after the deregulation. This has been found to be more pronounced for the unrestricted model as the restricted price ratio estimates are closer to the oberved price ratio over the whole period investigated. The unrestricted models suggest an increase in allocative efficiency on the market level of about 5.5%.

Figure 1: Output specific allocative efficiency on farm level (annual means)



The allocative inefficiency with respect to the production of organic or conventional milk on farm level can be interpreted as a proxy for existing market distortions (see Lau and Yotopoulos, 1971 and Lovell and Sickles, 1983). If we assume that those market distortions are predominantly due to the quota regime in place based on the current CAP framework, then the difference between the observed and the estimated shadow price for milk can be interpreted as the maximum shadow price per unit milk quota used (here kg organic or conventional milk). In accordance with our previous findings these maximum shadow quota prices decrease over the period investigated as well as experience a relatively larger decrease in the post deregulation period (of up to 51% for organic and up to 46% for conventional milk). Following the chosen approach of a fixed effects model we estimate the mean technical efficiency per year for the sample of organic as well as the sample of conventional milk farms. Both models suggest 2002 as the year with the highest technical efficiency for both farm types. In 2005 a mean efficiency value of about 0.989 for organic farms and of about 0.992 for conventional farms is reported by the unrestricted model and a value of about 0.924 and 0.927 by the restricted model. No significant difference in the mean technical efficiency before 1998 and after could be found for the two samples. Given our research hypotheses more interesting are the empirical findings with respect to the substitutability between milk and non-milk output on farm level as well as organic and conventional milk on sector level. Our estimated substitution measures for organic milk and (non-organic) non-milk output and conventional milk and non-milk output are illustrated in figures 2 and 3. A value >1 (<1) implies relative difficulty (ease) in y_m and y_{nm} substitution. Accordingly, the marginal rate of transformation for the different years reflects a decreasing substitutability between organic milk and non-milk output as well as between conventional milk and non-milk output ($subst_{om,nm}$ and $subst_{m,nm}$ are increasing). Beside others this implies that after the invention of the quota exchange it has become increasingly difficult to switch from organic milk production to the production of other output. Hence, the regulatory change with respect to the allocation of milk quota led to a relative shift in the output composition on farm level in favor of the production of organic milk and in disfavor of other output produced. Consequently, the probability of farms exiting organic milk production has been decreased during these years. However, on the other hand, the probability of farms entering organic milk production from non-milk production has been also decreased during these years.

Figure 2: Substitutability between milk and other output

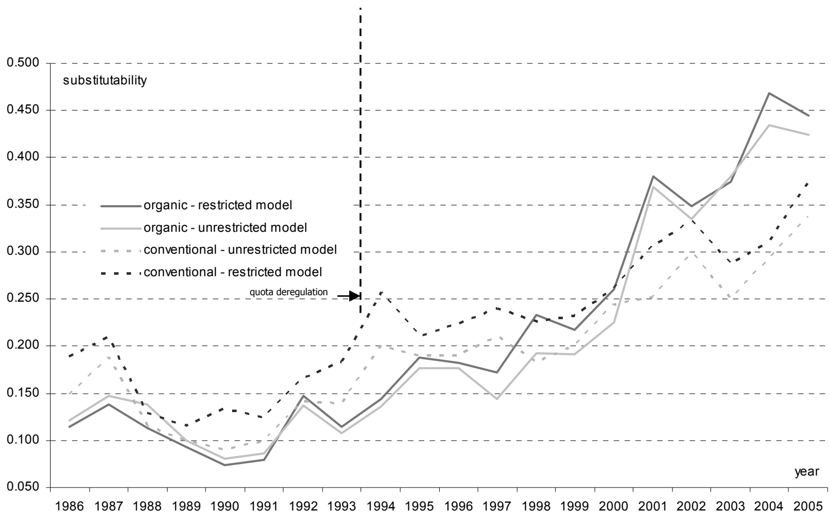
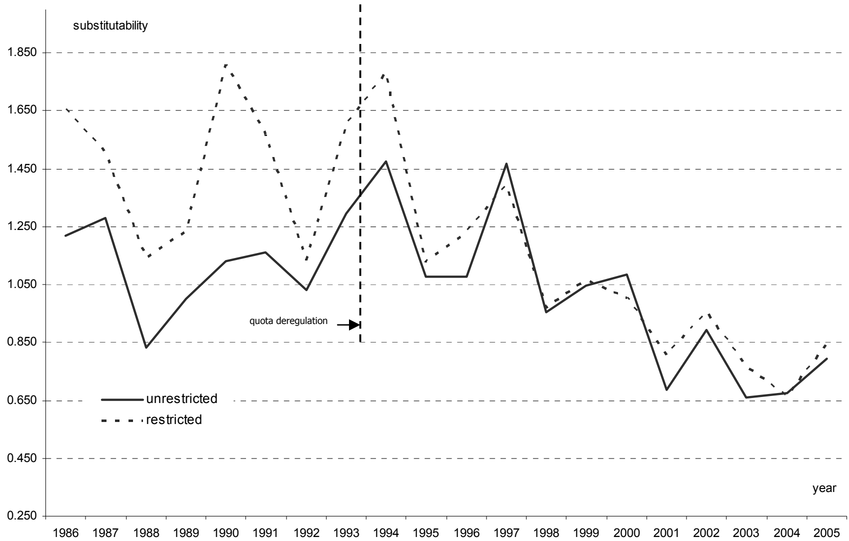


Figure 3: Substitutability between organic and conventional milk



On the level of the milk sector we found that the marginal rate of transformation for the different years indicates an increasing substitutability between organic milk and conventional milk output ($subst_{om,m}$ is decreasing). Hence, farmers have experienced decreasing costs of switching between these two forms of milk production over the years. This has been especially true for the post deregulation period where the value of the substitutability measure dropped by nearly 36% until 2005. Beside others this implies that after the invention of the quota exchange it has become increasingly easy to switch from conventional milk production to organic milk production and vice versa. Hence, the mobility in the milk sector has been increased as the costs of switching has been decreased. Consequently, the regulatory change with respect to the allocation of milk quota led to a relative shift of the PPF, or output composition on sector level, in favor of the production of organic milk and in disfavor of conventional milk produced. This implies that the probability of farms entering organic milk production has been increased during these years and corresponds well to the observed entry and exit behaviour of organic farms over the period investigated: The number of organic milk farms drastically increased up to 2000/01 and during recent years organic production declined at a significant lower rate than conventional production (Danish Milk Board, 2006).

These results are backed up by the empirical findings regarding a potential deregulation bias with respect to different outputs and inputs. These can be considered as relative measures for the productive impact of the quota deregulation. Both model specifications (unrestricted and restricted) indicate that a change in quota regulation generated a change in the slope of the PPF implying for constant prices a movement around it. The regulatory change with respect to the allocation of milk quota led to a relative shift of the PPF in favor of the production of organic milk (B_{om}=0.030 and 0.046) and in disfavor (or to the expense) of other output produced (B_{nm}=-0.004 and 0.021). Hence, the probability of organic market exit has been reduced in the post deregulation period. On the other hand our estimates suggest that the regulatory change with respect to the allocation of milk quota led to a relative shift of the PPF in disfavor of the production of conventional milk (B_{om}=-0.847 and -1.200) and in disfavor (or to the expense) of other output produced (B_{nm}=-0.509 and -0.495). However, the negative productive effect on milk production has been relatively stronger than on non-milk output. Hence, on the milk sector level this can be interpreted as an increasing probability of conventional farms entering organic milk production in the post deregulation period. Both models further suggest that the regulatory change with respect to the allocation of milk quota led to an increasing use of the inputs land as well as a decreasing use of the inputs capital and energy for organic milk producers. For conventional milk producers both models suggest an increasing use of land, labor and veterinary expenses as well as a decreasing use of capital, fodder and energy in the post deregulation period.

Given the reported estimates we can conclude that both our initially formulated research hypotheses can not be rejected by our empirical analysis: Hence, a deregulation in the milk quota allocation system had indeed positive effects on the milk farms' efficiency over time. Further, the deregulation in the milk quota allocation system had significant effects on the farms production structure, namely the output composition based on the substitutability between milk and non-milk output as well as organic and non-organic output. Finally, it can be derived that in the post deregulation period the probability of farms entering organic milk production has been significantly increased and the probability of farms exiting organic milk production has been significantly decreased. Contrasting our results with previous findings the following points have to be discussed: In general economists agree that transferable quotas are more efficient than non transferable quotas as they allow for cost minimisation on producer level and hence the maximisation of producer gains given product price and production quota (ALSTON, 1981 and 1992; HARVEY, 1984; GUYOMARD et al., 1996). Further, marketable quotas should lead to a more efficient resource allocation by a quota transfer from high to low marginal cost producers. However, transferable quotas do not eliminate welfare losses by suboptimal marginal social cost pricing (see GUYOMARD et al., 1996). Finally, the costs of quotas are mainly borne by the consumer and new market entrants. The latter being confronted with either higher direct or indirect costs of market entry. Our empirical analysis confirmed these general economic considerations showing that a more market oriented quota allocation mechanism leads to higher efficiency in the production of organic and conventional milk as well as a higher efficiency with respect to the production possibility frontier on the market level. Further our analysis revealed that the costs for entering organic milk production have decreased after the deregulation of the quota allocation mechanism. Our results confirm the conclusions drawn by STEFANOU et al. (1992) suggesting that the milk producers' responses to policy changes were driven by changes in the use of variable inputs indicated by the bias measures especially with respect to land and capital. In addition to the findings by BOOTS et al. (1997) our results suggest profit increases by efficiency gains for both organic and conventional milk producers as a consequence of the introduction of a more flexible quota trading mechanism. However, the productive effects by deregulation proved to be in favor of organic production and in disfavor of conventional production. Corresponding to COLMAN (2000) we find that a deregulation in the quota allocation mechanism is leading to a higher amount of quota transferred to more efficient producers shown by the relative allocative efficiency as well as the substitution and bias measures obtained. Finally, our analysis somehow contradicts the findings by ALVAREZ et al. (2006) who question the success of policy measures to allocate milk quotas to efficient farms. Despite the fact that a single-bid system still creates market distortions (see BOGETOFT et al., 2003), we found, that the deregulation measures with respect to the milk quota allocation mechanism have been successful in allocating milk quotas to more efficient farms leading to an increase in overall market efficiency over time.

7 Conclusions

The preceeding analysis uses two comprehensive panel data sets on organic and conventional milk farms for the period 1986 to 2005 to disentangle the effects of the introduction of an increased quota transferability on the production structure of those farms as well as the probability of market entry and exit. Based on our empirical analysis we can conclude that our initially formulated research hypotheses can not be rejected for the two samples: Hence, a deregulation in the milk quota allocation system had indeed positive effects on the milk farms efficiency over time. Further, the deregulation in the milk quota allocation system had significant effects on the farms' production structure, namely the output composition based on the substitutability between milk and non-milk output as well as organic and non-organic output. Finally, it can be derived that in the post deregulation period the probability of farms entering organic milk production from conventional milk production has been significantly increased and the probability of farms exiting organic milk production to produce other non-organic output has been significantly decreased. The successful transition of the phasing out of the milk quotas in 2014/15 is a crucial item on the CAP Health Check agenda. Our empirical findings show that the gradual deregulation of a quota allocation system based on decentralised quota bids can lead milk producers to an efficient adjustment of their production structure. Hence, a third policy option could consist of a complete introduction of a milk quota allocation system in the short run based on single or multiple quota price bids by individual producers. This could be linked to incremental quota increases for organic and/or conventional milk production per country and year distributed via the bidding mechanism in place. After a transition period of 5-10 years in which this system will have led to a more efficient market oriented at the overall PPF frontier a total phasing out of the milk quota system could be agreed on.

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