Impact of the EU Milk Quota on Structural Change in the Dairy Sectors of Germany and The Netherlands*

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1 Introduction

Over the past decades farm numbers have been declining drastically, whereas the average farm size has increased. This structural change is a dynamic process over time and a result of adaptation processes of farms to changing macroeconomic conditions. This affects the structure of farms and has long been an issue considered by agricultural policy both in Europe (Keane and Lucey, 1997) and the U.S. (Sumner, 1985). Given the main policy aim of supporting farmers' incomes and the close relationship between agricultural income distribution and farm size, this concern for distributional issues is no surprise.

With the milk quota announced to be abolished in the future, the dairy sector is going to face a considerable policy regime shift. This paper sets out to analyze the impact of milk quotas on the dairy farm structure of two important milk producing member states: Germany and the Netherlands. Thereby the aim is to find out if and how the EU milk quota regime affects structural change in the dairy sectors. A further intention is to detect how different implementation schemes, regional policies and structures of milk production affect the structural adjustment processes.

For this purpose we assume that farmers' behaviour follows a dynamic stochastic optimal control problem. Based on this model we postulate a Markov chain model the probabilities of which reflect farm individual behaviour. The main advantage of the Markov chain model is the joint consideration of farm growth and exits allowing for interrelation. This is in particular important under conditions of binding milk quota, which is the general case among German and Dutch dairy farmers. To quantify the impact of the milk quota system on farm size dynamics we split up the time series of observed farm size distributions in form of aggregate share data and estimate a pre-quota period and a quota period Markov chain. Moreover, we develop and estimate four mobility indicators mapping the information of the transition probability matrix into scalar indicators. Using these mobility indicators and the approximated standard errors it is possible to test several hypotheses about the impact of the milk quota scheme on structural change.

Structural change in the dairy sector has long been an issue in the relevant literature.

More recent studies mainly focus on the impact of the milk quota scheme on farm growth (Kumbhakar et al., 2008 or Colman et al., 2002). However, farm growth is only possible if others decline or exit the dairy sector and release quota. Jongeneel and Tonini (2008) analyse farm size distributions under the milk quota scheme, however, the inference is rather difficult limiting the capacity of the results. Studies focussing on the impact of the milk quota scheme on farm-level adjustments (for instance, Burell 1989, Alston 1992, Naylor 1993 and Barichello 1995) conclude that the milk quota scheme in combination with high product prices induces often large rents and only the initial holders of the quota are benefiters from the system. Moreover, inefficient production systems due to high production costs are a result of the milk quota scheme (Richards and Jeffrey, 1997). The magnitude of these inefficiencies depends strongly on the transferability of the production rights (Colman, 2000). More generally, the milk quota system imposes structural rigidity because of keeping inefficient farms in production and growth of efficient farms is only limited possible. However, some effects are reversing (Hanf, 1989), for instance the structural rigidity effect of the quota scheme implies that inefficient production systems hinder farm exits. Contrarily, the value of the milk quota might give an extra premium to exiting farms by selling it. Within our approach it is possible to show the pre-dominating effect of the milk quota scheme on the farm size distributions in the respective country.

Markov chain approaches to analyse firm size distributions are commonly used in the relevant literature about structural change[2], in particular if micro data are not available (cf. among others, Tonini and Jongeneel, 2007 or Golan et al., 1996a). Traditional estimators (e.g., Zepeda 1995a and 1995b) are in the context of a low number of observations inefficient which limits the capacity of the results. For this reason often entropy based estimation approaches are found (among others, Karantininis, 2002). However, appropriate inference is limited because the majority does not provide standard errors[3].

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[2] There is a wide literature investigating farm growth and exits from farming with the intention to understand structural change. A detailed review of modelling structural change can be found in Zimmermann et al. (2006).

[3] Stokes (2006) provides bootstrapped standard errors but not for all estimated transition probabilities.

The major challenge here is to provide econometric inference in the context of limited data availability. Over this period, including a sufficiently large number of observations without milk quota scheme, are only aggregate share data available and no farm individual transitions between the size classes. This long period is required to explore the impact of the milk quota system by enough observations with and without milk quota scheme. This circumvents Lucas' Critique of econometric policy evaluation. We refer to the maximum entropy approach to estimate the Markov chain models. In addition we derive approximated standard errors to test the hypotheses about the impact of the milk quota scheme. The results show that farm growth is still possible under the milk quota system but farm exits from the dairy business is reduced. The results further indicate different speeds of mobility under the quota scheme between the countries but not in the direction.

The remaining part of this paper is organized as follows. First the dairy farm size structure in Germany and the Netherlands is presented, followed by the theoretical Markov model. The empirical specification and the estimation procedure are explored next. Results and conclusions round off this article.

2 The structure of milk production in Germany and the Netherlands

In what follows we analyse the dairy farm size distribution of West Germany[4] and the Netherlands with sizeable dairy sectors (about 18 percent of the agricultural production value) accounting for 28 % of the total EU-27 milk quota in 2007/08.

The introduction of the milk quota with super levy system in 1984 induced a fundamental change in the Common Agricultural Policy at that time. Each producer got a farm specific quota. As an initial reference point for determining the amount of quota in the EU, the level of milk production as realized in 1981 (increased with 1 percent) was chosen. In Germany and in the Netherlands the quotas were distributed over farms based on production levels of 1983 cut by 7 %, in West Germany also by 14 % depending on the amount of

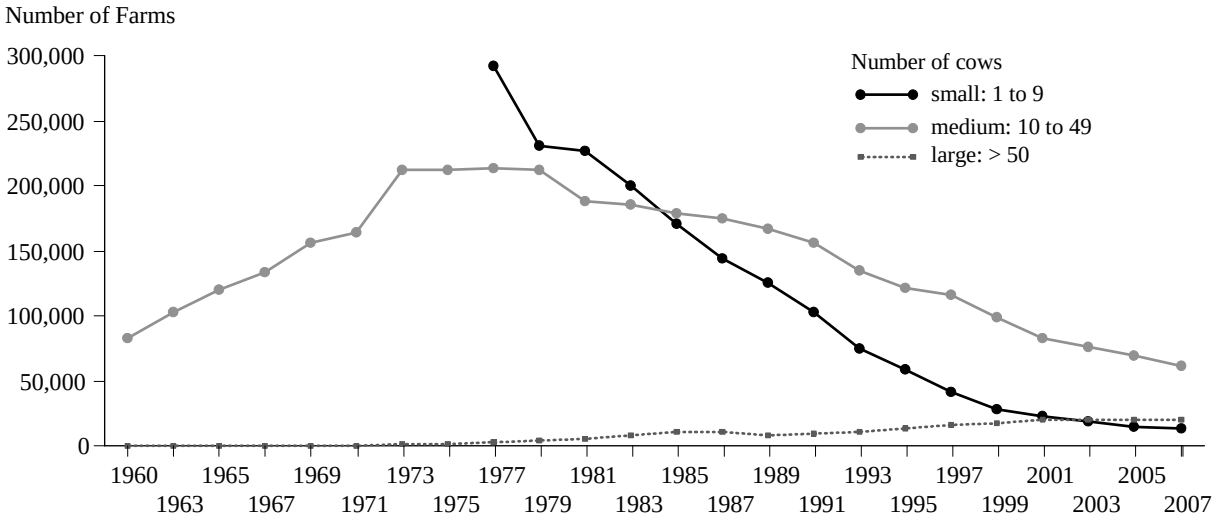
[4] We do not analyse East Germany because only the years 1991-2007 are available; data for East Germany before the German reunification (1990) is not trustable. Inference based on such a low number of observations with high disturbances due to the transition process is rather difficult.

deliveries. In the Netherlands the super levy is attached to the processors whereas in Germany it is attached to the milk producer which is expected to affect the farms' incentives to grow. In the first years of the quota system the transfer of quota in **West Germany** was rather restrictive but flexibility increased over time. In the first 6 years all transfers have been attached to grassland whereby within every transaction except by relatives the quota was cut by 30 %. This amount was redistributed at the Laender level (NUTS II). In 1990/91 quota leasing was introduced which allowed transferring quota without land and also in a short term manner. In the milk quota period this implied a fundamental change as it is commonly known that transferable quotas are better than non-transferable quotas. After the German reunification, in East Germany the milk quota was introduced in 1990/91 based on the milk production in 1990 shortened by 6.7 %. In 2000 the regional milk quota auctions have become the official way to transfer milk quota. Dairy farming in West Germany is mainly characterized by family farms with a strong North-South-divide with respect to farm size[5]. Farms in southern Germany are on average smaller than farms in northern Germany.

The data for West Germany represent the distribution of dairy farms in the period 1960-2007 comprising 3 size classes. The number of cows is a common measure to define size classes for dairy farms. The classes were chosen to achieve the maximum of consistency in the data over the period. The small size classes (<10 cows) show a strong decline over time. The medium size class (10-49 cows) increases in the pre-quota period until 1981 and declined then slightly, in particular the first years in the quota period and then more after 1990 (German reunification). The largest size class (> 50 cows) increased more or less constantly over the period. The evolution is visualized in figure 1.

[5] We abstract from analysing northern and southern Germany separately as regionally disaggregated data are not available for the whole period 1960-2007. This aggregation bias was chosen to be less than resulting inefficient estimators from the low number of observations.

Figure 1: Evolution of the dairy farm size distribution in West Germany



Source: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten, diverse volumes.

Over the period studied the number of dairy farms decreased by about 92 %from 1,216,700 in 1960 to 96,989 in 2007 with an annual decline of 5.24 %. Differentiating between the pre-quota period and quota period the approximated annual growth rates show for all farms together only minor differences between the periods: -4.77 % in the pre-quota period and -5.82 % in the quota period. The differences are more pronounced in the size classes. In particular the medium size class shows a large difference, in the pre-quota period, the number of farms increased on average, whereas a declining tendency for the quota period is confirmed. Further, the growth rate of the number of farms in the large class is less in the quota period. The following table summarizes.

Table 1: Average growth rates for the number of farms in the size classes in West Germany

	West Germany	
	Pre-Quota Period 1960-1983	Quota Period 1985-2007
Small <10 cows	-7.26	-10.72
Medium 10-49 cows	3.56	-4.76
Large >50 cows	9.81	2.93

Note: Annual growth rates are derived using logarithmic growth rates p.a.

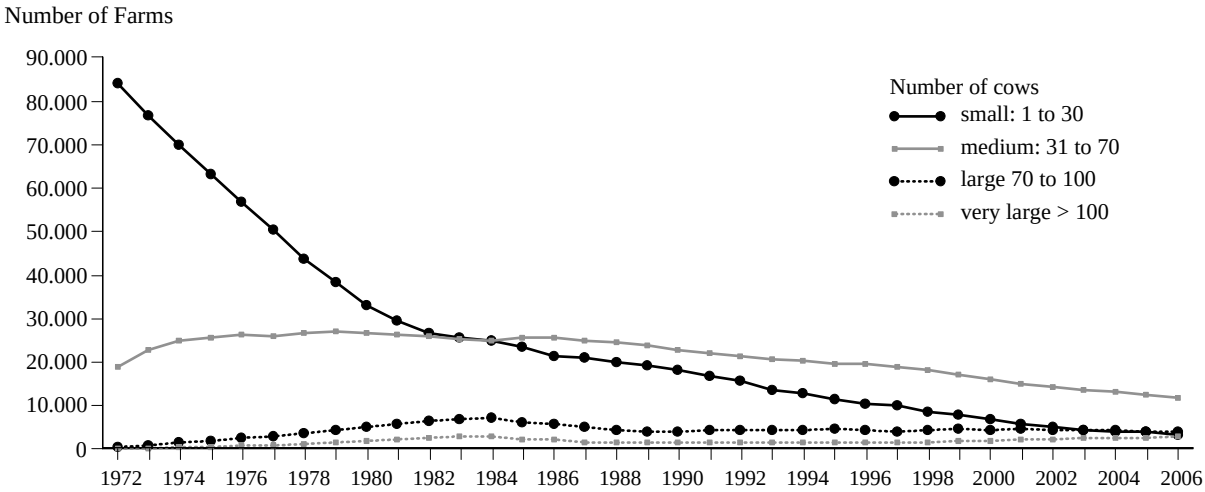
This declining tendency is further confirmed by a decreasing number of cows in the sector in the quota period. In the small size class, the average annual decline rate of the number of cows in the pre-quota period is -3.33 % and in the quota period -7.59 %. In the medium class this

negative tendency is confirmed, whereas in the large size class, the number of cows increases, but to a fewer extent (15.30 % to 8.14 % in the quota period). Contrarily, the average farm size measured in the number of cows increases more or less constantly from 5 cows in 1960 to 34 cows in 2007. Similarly, milk yield increased also more or less constantly over time.

In **the Netherlands**, in the first five years since the milk quota was introduced the Dutch government acquired about 5 % of the quota which was redistributed over farmers in 'specific situations' (Boots, 1999: 22). Moreover, in the same period about 7 % of the initial quota was re-allocated through the market. In the course of time the tradability of quota became more flexible and well-functioning buyer-seller and lease markets were established. In general milk quotas are attached to land and cannot be freely traded. If a whole farm is transferred, reference quantities are referred to the new owner. If only part of a farm is transferred, an amount proportional to the number of hectares (or another objective criteria) used will be transferred. In the Netherlands in particular this latter rule has been used to transfer quota permanently via a temporary lease of land, thus circumventing the link between quota and land (Boots, 1999: 25). In general in the Netherlands there is a maximum of 20 thousand kilograms of milk per hectare, whereas there is also a minimum to the amount of kilograms of milk transferred per transaction.

The data for the Netherlands represent the Dutch dairy farm size distribution from 1972-2006 and comprise 4 size classes. The farms consisting of size classes (1-30), show a sharp decline up till 1984, which is continued after the introduction of the milk quota, but at a lower rate of decline. The two largest size classes (70-99 and > 100) show an increase over the pre-quota period, a decline in the first five years after the introduction of the quota, and more or less stabilize thereafter. The medium size class (31-70) increases in the pre-quota period and then declines. Figure 2 visualizes the evolution over time.

Figure 2 Evolution of the dairy farm size distribution in The Netherlands



Source: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten, diverse volumes.

Over the period 1984-2006 the total number of active farms declined by 37,932 farms or about 63 % an annual decline of 4.3 %. The annual approximate growth rate can be further differentiated by the size classes. Whereas except the small size category shows an increasing number on average in the pre-quota period, the negative tendency for all size classes is confirmed for the quota period. The details are given in the following table

Table 2: Average growth rates for the number of farms in the size classes in the Netherlands

	The Netherlands	
	Pre-Quota Period 1971-1983	Quota Period 1984-2006
Small 1-30 cows	-5.02	-8.55
Medium 31-70 cows	1.25	-3.28
Large 71-100 cows	11.42	-2.72
Very large >100 cows	14.40	-0.27

Note: Annual growth rates are derived using logarithmic growth rates p.a.

3 The Model

We refer to a partial equilibrium approach in line with Stokes (2006) to derive optimal policies of herd size choice. In the first part we show that the optimal herd size inherits the Markov property. In the context of the aggregate share data we refer in the second part to a Markov chain model to examine the dynamics of structural change in the dairy sector. The estimation procedure and the mobility indicators are explored afterwards.

3.1 Theoretical Model

Based on a classical Markov decision problem the objective of a representative farm is to maximize its expected net profit over an infinite planning horizon. The following optimal stochastic control problem characterizes the representative farmer's decision problem[6].

$$V(y,c,t) = \max_{\mathbf{x},n} \left\{ E_t \int_t^T e^{-\rho \cdot t} \cdot \left[p^m \cdot y(\mathbf{x},n) - \boldsymbol{\omega}\mathbf{x} - \omega_n \cdot n \right] dt + e^{-\rho \cdot T} \cdot c(T) \right\} \tag{1}$$

Net profit is defined as the expected discounted profit flow, $p^m \cdot y(\mathbf{x},n)$, minus input costs plus the respective terminal value of the farm, $c(T)$. p^m refers to the milk price and $y(\mathbf{x},n)$ refers to the production function of milk which is left unspecified and assumed to be well behaved. ρ refers to the discount rate, $\boldsymbol{\omega}$ denotes vector of input costs and ω_n refers to the input cost attached to the dairy herd. t indexes time. The respective control variables of this optimization are a vector of inputs, $\mathbf{x}$, and the dairy cow herd size n. The respective state variables, milk production and termination value of the farm, are specified in the following transition equations.

$$dy = \sigma_y(y,n,t) \cdot dz_y \tag{2}$$

$$dc = \mu(c,t) \cdot dt + \sigma_c(c,t) \cdot dz_c \tag{3}$$

The transition equations of milk production and the farm's value are represented by stochastic differential equations with variances $\sigma_y^2(y,n,t)$ and $\sigma_c^2(c,t)$, respectively. Milk production refers to a driftless stochastic process with expected change of zero; the expected increase in the farm's value is $\mu(c,t) \cdot dt$. In both equations denotes $dz_{y/c}$ the Wiener increment capturing external shocks. It is assumed that the first order stochastic differential equations representing milk production and the farm value over time have a unique solution inheriting the Markov property. Assuming that all farmers behave according to this stochastic optimal control problem, it can be shown that the Markov process is reflected by the farm size evolution. A detailed proof can be found in Stokes (2006).

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[6] The continuous time representation allows to give intuition and to show that the optimal herd size policy inherits the Markov property without exact specification of the production function.

Optimal herd size is assumed to be Markovian and the Markov chain model can be used model dairy farm size distributions over time. The Markov model relates the observed size class distributions by transition probabilities describing the probability to move from one size class to another size class over time. The respective transition probabilities reflect individual farm behaviour which is not directly observable over the period studied. This allows investigating responses at the micro level in an aggregate manner without directly modelling these.

3.2 The empirical Markov Chain Model

We assume that firm size in the dairy industry can be divided into J size categories as presented above. Besides the evolution of the size distribution an important and related issue is the modelling of entry and exit from the industry. The number of assumed potential entrants to the industry is known to have an important effect on both (short-run) projections and equilibrium solutions, even though it will not affect the estimated proportions of active firms falling in each size category (Stanton and Kettunen, 1967). Thus, an absorbing state is added, which allows the modelling of entry and exit in the industry as well as the change in the size distribution of the 'active' or producing firms. This linkage between farm growth and exits is a main advantage of the Markov chain model. However, with respect to the dairy industry, in particular under the milk quota system, entry conditions seem a limiting factor. Therefore, the total number of dairy farms at the initial date will be used as an indicator of the total number of firms implying that the number of firms in this state is zero at the starting points.

In order to explore the dynamics of farm size distribution over time the following Markov chain model is defined

$$n_{tj} = \sum_{i=1}^{J} n_{t-1,i} \cdot p_{ij}\,; \quad j = 0,...,J \tag{4}$$

where n_{tj} denotes the number of farms in the jth category at time t where $j = 0,....J$, $i = 1,...,J$ and $t = 1,....T$ .The total number of farms existing at time t, N_t, is equal to $\sum_{j=0}^{J} n_{tj}$. The probability of transition from size class i at time t-1 to size j at time t is denoted by p_{ij}; all probabilities fulfil the following properties

$$\sum_{j=0}^{J} p_{ij} = 1 \quad \forall t = 1,...,T \tag{5a}$$

and

$$0 \le p_{ij} \le 1 \tag{5b}$$

The individual probabilities are collected in the stochastic transition probability matrix, $\mathbf{P}$. Imperfectly observed data, for instance due to rounding errors, require the use of an disturbance term (MacRae, 1977). Adding an error term u_{tj} with zero expected value and finite variance σ_u gives

$$n_{tj} = \sum_{i=1}^{J} n_{t-1,i} p_{ij} + u_{tj}; \quad \forall i, j = 0,..., J \tag{6}$$

This empirical specification (6) of the Markov chain model is the base to recover the transition probabilities. The aim is to quantify the impact of the milk quota scheme on farm size distributions. Due to the rather weak database it is not possible to consider the milk quota as an exogenous variable affecting the transition probabilities. Thus we split up the series of observations to obtain a pre-quota and a quota period. For each period and each country a stationary[7] Markov chain model is estimated and compared afterwards using mobility indicators. These map the information of the transition probability matrix intro a scalar metric easing the comparison. The comparison is further supported by tests whether there are differences between the periods.

3.3 Estimation

There exist a number of possibilities in the relevant literature to recover the transition probabilities (Gourieroux 2000). Our estimation problem with two transition matrices for each country refers to an ill-posed problem which limits the possibilities (Mittelhammer et al. 2000). The number of unknown probabilities to be recovered is large whereas the number of observations is low. Any inference based on asymptotic distributions does not hold here. We refer to a non-traditional estimation technique for model fitting, a parametric method based on

[7] The low number of observations and the lack of pre-sample information about individual transitions limit the estimation possibilities to estimate a non-stationary Markov chain.

the generalized maximum entropy principle (a detailed discussion can be found in Golan et al., 1996).

We apply the generalized maximum entropy approach with noise (Golan et al., 1996). First, the transition probabilities and the error terms have to be rewritten in terms of discrete support points and the corresponding probability weights. Second, the maximum entropy objective function is defined containing the entropy measure for the unknown probability weights of the parameters and the errors. The aim is to maximize the objective function subject to the data consistency constraint. Thereby the estimation problem reduces to a convex maximization problem. The estimated probability weights derived from the maximization problem are then used to recover the unknown parameters.

To obtain the information theoretic specification of the Markov chain model we rewrite the unknown transition probabilities in terms of a discrete set of support points z_{mij} and the corresponding probability weights q_{mij} where m denotes the support points with $m = 1,...,M$. M is some positive integer with $M \geq 2$.

$$p_{ij} = \sum_{m=1}^{M} z_{mij} q_{mij} \tag{7}$$

The transition probability matrix can be rewritten as

$$\underset{(J\times J)}{\mathbf{P}} = \mathbf{1}_J \otimes \left(\underset{(1\times JM)}{\mathbf{q}_{\mathbf{M}}^{'}} \; \underset{(JM\times J)}{\mathbf{Z}^{'}} \right) = \mathbf{1}_J \otimes \left(q_{01} \cdots q_{M0} \quad \cdots \quad q_{J0} \cdots q_{JM} \right) \begin{pmatrix} z_{10} & & & \\ \vdots & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ z_{M0} & & & \\ & z_{11} & & \\ \mathbf{0} & \vdots & \mathbf{0} & \mathbf{0} \\ & z_{M1} & & \\ & & \ddots & \\ & & & z_{1J} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \vdots \\ & & & z_{MJ} \end{pmatrix} \tag{8}$$

In the same manner the disturbances u_{tj} have to be bounded within specified support points v_k and are parameterised as $u_{tj} = \sum_{k}^{K} v_k w_{tjk}$ where w_{tjk} denotes the corresponding probability weights with $k = 1,...,K$, and K is some positive fixed integer determining the number of support points.

The problem of mathematical inversion is converted to a problem of approximate reasoning. We seek to make the best, most objective predictions possible from the available information. The objective function of the GME-problem is

$$\max_{q,w}\left\{H(\mathbf{Q},\mathbf{W}) = -\sum_j\sum_i\sum_m q_{mij}\ln(q_{mij}) + \sum_j\sum_k\sum_t w_{tkj}\ln(w_{tkj})\right\} \tag{9}$$

where $H(\cdot)$ refers to the measure of entropy. This maximization is subject to the consistency (data) constraint which is the parameterized Markov chain model. Using further shares rather than the absolute numbers of size class counts, denoted by $n_{tj}^* = n_{tj} / N_t$, it follows

$$\sum_t n_{tj}^* = \sum_t\sum_i n_{t-1,i}^* \sum_m z_{mij}\cdot q_{mij} + \sum_t\sum_k v_k \cdot w_{tkj} \tag{10}$$

The maximization is further subject to the adding up constraint for each probability weight q_{mij}

$$\sum_m q_{mij} = 1, \tag{11}$$

the adding up constraint for each of the J states:

$$\sum_m\sum_j z_{mij} q_{mij} \tag{12}$$

and the adding up constraint for each probability weight w_{tjk}

$$\sum_k w_{tkj} = 1 \tag{13}$$

The positivity of the probability weights is implicitly assumed. The solution is obtained using the Lagrange function. However, under weak data conditions there is no closed form solution available. The numerical solution depends on the Lagrangian multipliers for the model constraints $\hat{\boldsymbol{\lambda}}$, i.e., $\mathbf{q_M}\left(\hat{\boldsymbol{\lambda}}\right)$ and $\mathbf{w}\left(\hat{\boldsymbol{\lambda}}\right)$.

To recover the transition probabilities of the empirical Markov chain model we adjust the consistency constraint to the moment constraint[8] (Golan et al., 1996).

$$\sum_t n_{i,t-1}^* \cdot n_{tj}^* = \sum_t\sum_i n_{i,t-1}^* \cdot n_{t-1,i}^* \sum_m z_{mij}\cdot q_{mij} + \sum_t n_{i,t-1}^* \cdot \sum_k v_k \cdot w_{tkj} \tag{14}$$

Inference is based on the finite sample approximations of the standard errors in line with

[8] Using the moment based GME the model fit improves and the standard errors are reduced. This implies that the data are better described by its moments.

Golan et al. (1996). Because of the close relation of the maximum entropy approach and the empirical likelihood approaches the commonly known tests for maximum likelihood estimates, for instance the Wald-test, can be further used for inference (Mittelhammer et al. 2000). In the entropy environment an information index is widely used as a measure of fit. The information index can be further used to compare model definitions. It is defined as

$$I = 1 - S(\hat{\mathbf{q}}) = 1 - \frac{-\sum_i \sum_j \hat{q}_{ij} \ln(\hat{q}_{ij})}{J \cdot \ln(M)} \tag{15}$$

where $S(\hat{\mathbf{q}})$ refers to the normalized entropy measure indicating the relative information content of the explanatory variables, i.e., the lagged distribution over the size classes, and the estimated parameters, i.e., the transition probability matrix. *S* equal to zero implies that there is no uncertainty with respect to the parameters; in a traditional econometrics context this would be comparable to a perfect fit. An entropy measure of one indicates that there is no informational content in the data. Accordingly, a higher information index *I* indicates a better 'fit'.

3.4 Mobility Measures

The Markov process as applied in this study describes the structural change in the German and Dutch dairy sectors. The transition probability matrices (TPMs) reflect a certain degree of farm mobility over size classes (Jongeneel and Tonini, 2008). However, the comparison of matrices can very cumbersome. The literature (for instance, Shorrocks, 1978) offers a number of mobility indices, which maps the mobility information inherent in the TPM into a scalar metric, *M(P)*. Referring to Shorrocks (1978) an overall mobility index M^{OV} is defined as

$$M^{OV} = \left[J - tr\{\mathbf{P}\} \right] \cdot \left[(J - 1) \right]^{-1} \qquad 16$$

where $tr\{P\}$ denotes the trace of the transition probability matrix. If there is no mobility the TPM would be an identity matrix and the trace of the TPM would be equal to *J*. In this case, M^{OV} would be equal to zero. In case of perfect mobility, M^{OV} is equal to one.

In order to be more precise with respect to the direction of mobility changes, we add three further mobility indicators in addition to the one of Shorrocks decomposing the mobility into upward, downward and exit mobility. These can be interpreted as shares of

the overall mobility and sum up to one. Probabilities in the lower (off-diagonal) triangle part of the TPM indicate downward mobility. In contrast the upper triangle represents upward mobility. We define $\left(1-p_{jj}\right)$ as the mobility part of the diagonal element. The aggregation of the diagonal mobility elements gives a sum which is exactly equal to the aggregated value of all off-diagonal terms. This sum of the mobility part of the diagonal is used as a 'deflator' in the upward and downward mobility indices. Thus, we define the upward mobility index M^U as the deflated sum of the upper triangle probabilities of the TPM.

$$M^U = \left[\sum_i \sum_{j>i} p_{ij}\right] \cdot \left[\sum_j (1-p_{jj})\right]^{-1} \tag{17}$$

If there is full upward mobility and no downward mobility the index would be equal to one, since the sum of the upward triangle probabilities of the TPM would than exactly equal the sum of the mobility part of the diagonal elements. If there is no upward mobility the index would be zero since then the sum of the probabilities of the upper triangle of the TPM would be equal to zero. Likewise, if we sum the lower triangle TPM elements and divide this by the deflator we get an index for the downward mobility, M^D. Different to the upward mobility, we exclude the downward-exit mobility to the zero size class.

$$M^D = \left[\sum_i \sum_{j<i,\, j\neq 0} p_{ij}\right] \cdot \left[\sum_j (1-p_{jj})\right]^{-1} \tag{18}$$

If only downward mobility exists this index would be one and vice versa. With regard to exits – the downward mobility can be further decomposed into 'normal' shrinking mobility and the exit-mobility. For exits we define the following mobility index:

$$M^E = \left[\sum_i p_{i0}(t)\right] \cdot \left[\sum_j (1-p_{jj})\right]^{-1}. \tag{19}$$

The maximum value of the index (indicating all mobile farms are exiting) is one. Lower values indicate lower shares of the exit mobility on the overall mobility.

4 Hypotheses and Results

4.1. Hypotheses

We use the data as presented in the previous section, however, we refer to the shares of the size class counts rather than the counts. In order to quantify the impact of the milk quota system we split up the time series into a pre-quota period and a quota period. The split-up point is chosen at 1984. The impact of the milk quota system on the structural change is ambiguously discussed in the literature (Hanf, 1989). The effects are expected to be present at the same time, in our analysis it is only possible to extract the predominating effects. In terms of the mobility measures the following hypotheses with respect to the milk quota system were aimed to be tested. The pre-quota period is indicated with 'pre' and the quota period with 'quo'.

- The milk quota system imposes structural rigidity and hinders efficient structural change, i.e., $M_{\text{Pre}}^{OV} \gg M_{\text{Quo}}^{OV}$ in both regions. Contrarily changes in herd size distributions are closer linked under the milk quota system because growth is not possible unless others decline or exit and free quota is available. Thus, the interaction between size classes is expected to be accelerated, i.e., $M_{\text{Pre}}^{OV} \ll M_{\text{Quo}}^{OV}$.

- The milk quota rent fosters inefficient production and hinders farms from exiting the sector, i.e., $M_{\text{pre}}^{E} \gg M_{\text{quo}}^{E}$; contrarily the possibility to sell quota might give exitors a premium to exit, i.e., $M_{\text{pre}}^{E} \ll M_{\text{quo}}^{E}$.

- Fostering inefficient production systems and slowing down exits hinders growth as free quota is not available, i.e., $M_{\text{pre}}^{U} \gg M_{\text{quo}}^{U}$. Contrarily under the quota system growth of efficient farms is still possible. The capitalization of the quota and the interpretation of the system as a guarantee of higher prices in the future can foster specialisation of farms, i.e., $M_{\text{pre}}^{U} \ll M_{\text{quo}}^{U}$. This might also include a risk-reducing effect of the milk quota system

- Under the milk quota system an increased downward tendency is expected due to technical progress, i.e., less cows are required to fulfil the quota with increasing milk yields per cow, i.e., $M_{\text{pre}}^{D} \ll M_{\text{quo}}^{D}$.

4.2. Results

In the following we present first the results[9] for the stationary Markov chains for each period and country in form of the transition probability matrices. The results for West Germany show a rather good fit and the majority of the parameters is significant at least at the 5 % level. The highest values are on the diagonal elements. This tendency to persist in the respective size class is commonly known, in particular in the small size classes. Re-entry is significant in the pre-quota period, however, under the quota system it is limited (confirmed by a Wald-test). The following figure depicts the transition probability matrices for West Germany.

Figure 3: Estimated transition probability matrix for West Germany

Transition probabilities West Germany								
	Pre-quota period 1960-1983				*Quota period 1985-2007*			
Size class[1)]	Exit	1-9	10-49	> 50	Exit	1-9	10-49	> 50
Entry	0.847	0.000	0.148	0.005	0.965	0.000	0.024	0.011
1-9	0.075	0.854	0.072	0.000	0.121	0.533	0.346	0.000
10-49	0.599	0.023	0.379	0.000	0.355	0.155	0.487	0.002
> 50	0.247	0.231	0.244	0.278	0.286	0.154	0.251	0.309
R-squared	*0.99*	*0.99*	*0.83*	*0.77*	*0.96*	*0.91*	*0.98*	*0.71*
	I = 0.53				*I = 0.46*			

1) No. of cows

Note - except the grey shaded are all probabilities significant at least at the 5% level.

The results for the Netherlands show also a good fit. Figure 4 shows the transition probability matrices for both periods. As in West Germany, the highest values except for the larger size classes are on the main diagonal indicating a tendency to persist in the respective size classes, in particular for smaller farms. Re-entry under the milk quota system is also in the Netherlands confirmed to be limited.

[9] All estimation results were obtained using SAS 9.1.3 using PROC ENTROPY. It should be noted that this is still an experimental release.

Figure 4: Estimated transition probability matrix for the Netherlands

Transition probabilities the Netherlands										
	Pre-quota period 1971-1983					*Quota Period 1984-2006*				
Size class[1)]	Exit	1-30	31-70	71-100	> 100	Exit	1-30	31-70	71-100	> 100
Entry	0.843	0.000	0.056	0.081	0.020	0.912	0.000	0.086	0.002	0.000
1-30	0.000	0.897	0.103	0.000	0.000	0.032	0.553	0.320	0.073	0.022
31-70	0.238	0.000	0.720	0.038	0.004	0.207	0.237	0.442	0.096	0.018
71-100	0.335	0.002	0.240	0.230	0.193	0.169	0.269	0.255	0.177	0.131
> 100	0.274	0.039	0.232	0.235	0.221	0.180	0.235	0.220	0.192	0.173
R-squared	*0.99*	*0.96*	*0.91*	*0.99*	*0.99*	*0.96*	*0.91*	*0.95*	*0.69*	*0.69*
	I = 0.56					*I = 0.45*				

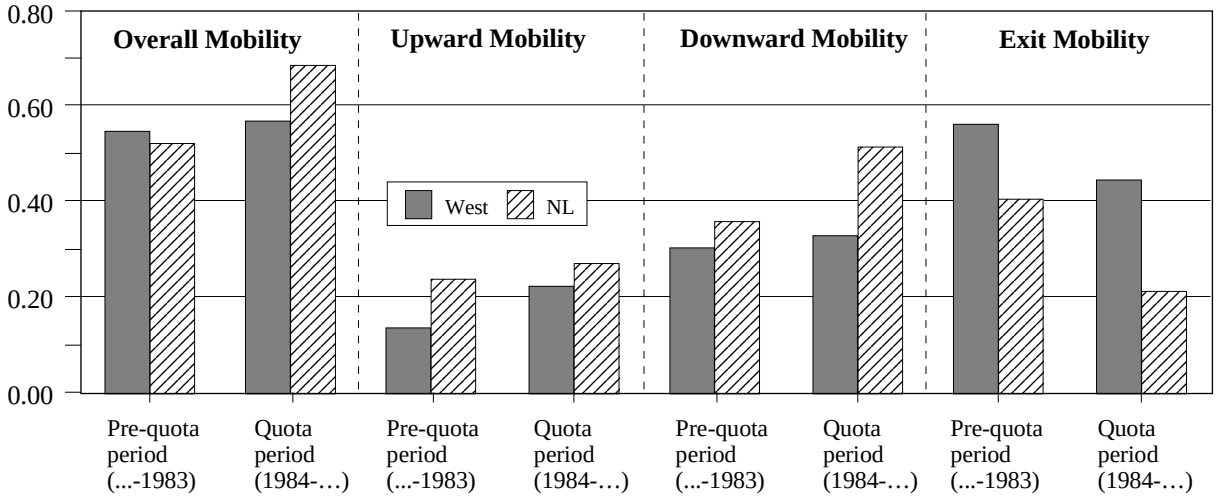
1) No. of cows

Note - except the grey shaded are all probabilities significant at least at the 5% level.

We estimate stationary transition probabilities for each period because of the limited data availability it is not possible to estimate non-stationary transition probabilities. It is very unlikely that these are constant over time and are expected to depend on explanatory variables. Albeit this shortcoming our focus is on the impact of the milk quota scheme on farm size distributions. Using stationary Markov chain models it is still possible to investigate the expected different response behaviour of farms to changing conditions with and without milk quota. We intend to quantify the impact of the milk quota system and assume that the transition probabilities are only constant under the respective policy scheme. In other words, the implementation of the milk quota scheme changed the responses of dairy farms to changing conditions. Factors affecting farm level profitability such as milk prices are influenced by the milk quota scheme. But nevertheless the question of interest is the response to changing milk prices. This reply is expected to be different under the milk quota system.

In what follows we further explore differences induced by the milk quota scheme and test whether these are significant. Therefore we use the mobility indicators defined in the previous section. In order to test the differences between the pre-quota period and the quota period we derive the standard errors of the mobility indicators using the delta-method (Greene 2003) and use a score test to test whether the differences are significant. Figure 5 depicts the respective indicators.

Figure 5: Estimated Mobility Indicators



Source: Own calculations.

Overall mobility increases in both regions in the quota period, the effect in West Germany is rather low. This confirms the expectation that the size classes are stronger linked under the milk quota system because of the strong relationship between growth and decline or exit. This is also known as the acceleration effect (Hanf, 1989). The absolute increase in overall mobility is higher in the Netherlands reflecting the higher degree of flexibility in the quota transfer scheme compared to West Germany.

Upward mobility increases in the quota period significantly; this difference is rejected for the Netherlands. This shows that under the quota system growth of efficient farms is still possible enabled by the transferability of the production rights. The milk quota system itself gives farms a higher price expectation for future prices and reduces price risk which stimulates specialisation processes of dairy farms. Upward mobility in the quota period is higher in the Netherlands as in West Germany indicating a more efficient market to trade the ‘free’ quota.

Downward mobility increases in the quota period in both regions, however the effect for West Germany is rather neglectable and not significant. The differences in the downward mobility in the Netherlands show high standard errors and are rejected at the 16 % level. However, the differences in the overall and exit are significant. The difference between the periods of the exit mobility cannot explain the difference in overall mobility. Thus, we conclude that the difference in downward mobility must play a

role. This downward tendency reflects technical progress in milk production and farm adjustments to the milk quota system. Fewer cows are required to fulfil the amount of quota.

Exit mobility declines in the quota period in both regions significantly. This confirms the structural rigidity even though relatively high milk quota prices are observed in both countries (higher prices in the Netherlands). The quota system might give some extra premium to exitors but the effect of keeping small and inefficient farms in production predominates. The high share of exit mobility in West Germany in the pre-quota period might be explained by a governmental restructuring programme at the end of the 1970ies. Farms exiting the dairy sector received an extra premium. A similar programme was implemented after the introduction of the milk quota system but less successful with respect to the number of exits.

Both countries show the same tendencies but the magnitudes of the differences between periods differ. These differences are mainly induced by a different milk quota implementation schemes and transfer rules. Compared to the Netherlands, dairy farms in Germany showed a lower degree of specialisation. In the Netherlands, the milk quota value is higher as well the competition among land and quota is higher. Nevertheless the results indicate differences between the regions, it should be acknowledged that in West Germany farm size structure is characterized by a North-South-divide which could not be taken into account. This North-South divide was further fostered by the milk quota system as the cuts of amount of distributed quota have been the higher the higher the amount of quota. According to that it is expected that farms in the North of Germany show less differences to the Netherlands.

5 Concluding Remarks

This paper analysed the dairy farm size distribution in West Germany and the Netherlands The intention thereby was to improve the understanding of structural change under the quota regime. The comparison of both regions allowed comparing the farms size distributions under different quota implementation schemes. For this reason mobility

measures were established mapping the information of the transition probability matrix to interpretable scalars. The results show that structural change processes differ over countries. Moreover a clear impact of the milk quota on structural change was detected. As such also policy reversal, i.e., the expected upcoming abolishment of the milk quota system, is likely to affect the future dairy farm size evolution. The farm structure dynamics are well-captured by the Markov model. However, these results leave space for improvements with an improved data base.

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