Structural Change in the Dairy Sectors of Germany and the Netherlands - A Markov Chain Analysis

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Abstract— **With the milk quota announced to be abolished in the future, the dairy sector is going to face a significant 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. Based on proper behavioral assumptions, non stationary Markov chain models are specified and estimated using a generalized cross entropy procedure, which takes into account both sample and prior information. Moreover four mobility indicators characterizing structural change are developed and calculated. Structural change in the dairy sector as measured by the mobility measures is faster in West Germany than in the Netherlands. However, in the transition region East Germany structural change outpaces that of the traditional German and Dutch dairy sectors by a factor two or more. The introduction of milk quotas as of April 1, 1984 reduced overall farm mobility for the Netherlands, but increased mobility in West Germany. However, in both cases the milk quotas lead to an increase in upward mobility.**

Keywords— **Markov Chain, Milk Quota, Structural Change.**

I. 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 size distribution and structure of farms and has long been an issue considered by agricultural policy both in Europe [1] and the U.S. [2]. 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. This article aims at improving the understanding of structural change in the dairy sector and its policy-dependence for two of the main milk producing countries in the European Union, Germany and the Netherlands. Thereby is expected that the EU milk quota regime strongly influences structural change in the dairy sector. This hypothesis is tested by distinguishing and comparing two sub-periods, notably the pre-quota period (until 1983) and the quota period, for West Germany and the Netherlands. This allows for comparing structural dynamics under different implementation schemes of the milk quota system. Moreover, it enables to compare structures mainly characterised by family farms in the Netherlands and West Germany with a transition region, which is characterized by large farms as it is the case in East Germany.

For this purpose we assume that farmers' behaviour follows a stochastic optimal control problem. Based on this we postulate a non-stationary Markov chain model to explain the farm size distribution over time. The model is estimated by Generalized Cross Entropy, which allows for taking into account prior information from empirical and theoretical sources. For the comparison we further refer to mobility measures mapping the information of the transition probability matrix into scalar mobility indicators.

The remaining part of this paper is organized as follows. After a brief literature review the dairy farm size structure in the Netherlands and Germany is presented, followed by the Markov model. Prior information is presented afterwards. Finally, the results and conclusions round off this article.

II. PREVIOUS LITERATURE

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 [3] and of farm size can be found in [4]. The variety of approaches is large, however, depends strongly on the availability of data. Two main strands can be made up distinguishing between the levels of aggregation for the used data sets. Analyses based on micro-data (among others, [5], [6] or [7] mainly refer to classical microeconomic household models. These have been complemented by the institutional theory or more recently by sunk cost theory [8].

Alternatively, macro approaches can be found that are mainly based on the use of share data at the aggregate level. These applications are either based on household models (cf. among others, [9]) or based on a Markov model[1] which is widely used in this context (cf. among others, [10]. Thereby the Markov chain model is either estimated by classical estimators like seemingly unrelated regressions (SUR) (cf. among others, [11] or [12]). Alternatively, the Generalized Cross Entropy method has been used in more recent studies to overcome the shortcomings of parametric estimators (among others, [13]).

The motivation of empirical analyses relies often on Gibrat's law, also known as the law of proportionate effects [14]. It states that the farms' growth rate is independent of farm size, which is consistent with the hypothesis of constant returns to scale. However, empirical studies reject the general validity of Gibrat's law, in particular for small farms [5], [15] and for farms in transition economies [16]. Moreover, numerous empirical studies give evidence on influencing factors on farm growth or farm exits [13]. Under conditions of binding milk quota, which is the general case among German and Dutch dairy farmers, a strong interdependence between all farms is expected. Larger farms cannot grow unless these get 'free' milk quota of exiting or shrinking (small) farms. Against this background we refer to a more theoretically based approach capturing the dynamics.

[1] The Markov chain approach is also applied to micro data as [17], for instance, show for Louisiana dairy farms.

III. THE STRUCTURE OF MILK PRODUCTION IN GERMANY AND THE NETHERLANDS

In what follows we analyse the dairy farm size distribution of Germany[2] and the Netherlands with sizeable dairy sectors (about 18 percent of the agricultural production value) and accounting for 28 % of the total EU-27 milk quota in 2007/08. However, in both countries the number of dairy cows declined in the last seventeen years, in the Netherlands 19.1 percent [18] and in Germany by 24 per cent [19]. At the same time milk yields have improved by 15.9 per cent in the Netherlands, by 29.33 percent in West Germany and by 61.6 percent in East Germany. The introduction of the milk quota with super levy system in 1984 implied that 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 quota were distributed over farms based on production levels of 1983, however 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 *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 Länder level (NUTS II). In 1990/91 quota leasing was introduced which allowed transferring quota without land and also in a short term manner. 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.

The data for *West Germany* represent the distribution of dairy farms in the period 1971-2005 comprising 6 size classes. Dairy farming in West Germany is mainly characterized by family farms with

[2] We analyse East and West Germany separately because the size structure differs for historical reasons and data for East Germany before the German reunification (1990) is not trustable.

a strong North-South-divide with respect to farm size. Farms in southern Germany are on average smaller than farms in northern Germany. The small size classes (<20 cows) show a strong decline over time, even in the pre-quota period (1984). The medium size classes (20-29 cows, 30-49 cows) increase in the pre-quota period and declined slightly in the first years in the quota period and then more strongly after 1990 (German reunification). Larger size classes (50-99 cows and > 100 cows) increased more or less constantly over the period. Over the period studied, the number of dairy farms decreased by about 85 percent from 711,064 in 1971 to 107,405 in 2005 with an annual decline of 5.4 percent.

For *East Germany* data from 1991-2005 comprising 7 size classes were used. Very small farms (less than 10 cows) decline strongly until 1999, afterwards the decline slows down. Size class with 10-19 cows only slightly decreases over time. Medium size classes (20-29 cows, 30-49 cows, 50-99 cows) increase in the first years after reunification, and decrease after 2001. The largest size classes (100-499 cows and > 500 cows) develop differently. Size class 100-499 cows increases until 1997 while the number of farms with more than 500 cows decreases. Since 2001, size class 100-499 cows declines while the number of farms with more than 500 cows increases. It should be noted that even though economic transition in East Germany took place rather rapidly compared to other post-socialist countries, about two thirds of the observations in the analysed period fall into the major transition period. Summarizing, the total number of farm East Germany increased in the early 90ies but declined until 2005 from 6,500 to 4,300 farms with an annual rate of 2.9 percent.

In *The Netherlands*, in the first five years since the quota were introduced the Dutch government acquired about 5 percent of the quota which was redistributed over farmers in ‘specific situations’ [20]. Moreover, in the same period about 7 percent 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 criterion) 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 [20]. 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 represent the Dutch dairy farm size distribution from 1972-2006 and comprise 7 size classes. The farms consisting of size classes (1-29), 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. Class 50-69 shows similar pattern, but is still going to slightly decrease from 1989 onward. The mid size class (30-49) shows a cyclical behaviour, with, however, a clear downward trend. Over the period 1984-2006 the total number of active farms declined by 37,932 farms or about 63 percent an annual decline of 4.3 percent.

IV. THE MARKOV CHAIN MODEL

In the context of the aggregate share data we refer to a non stationary Markov chain model to examine structural change in the dairy sector. Starting from a more general dynamic programming model [21] it is assumed that the farmer maximizes the discounted profit flow with discount rate ρ over time plus its terminal value of land ($v(T)$). This is expressed in terms of the value function:

$$V(q,v,t) = \max_{\mathbf{x},n} \left\{ E_t \int_t^T e^{-\rho \cdot s} \cdot \left[p^m \cdot q(\mathbf{x},n) - \boldsymbol{\omega}\mathbf{x} - \omega_n \cdot n \right] ds + e^{-\rho \cdot T} \cdot v(T) \right\} \quad (1)$$

where $\boldsymbol{\omega}$ denotes vector of input costs, ω_n refers to the input cost attached to the dairy herd and p^m refers to milk price. $q^m(\mathbf{x},n)$ refers to the production function of milk. The respective control variables are a vector of inputs, $\mathbf{x(t)}$, and the dairy cow herd size

$n(t)$. Stokes [21] shows that this optimization subject to two stochastic state variables (milk production and land value), under plausible assumptions follows a Markov process. If farmers behave according to this stochastic optimal control problem, the Markov process can be shown to be also reflected in the farm size evolution (see detailed proof in [21]).

We assume that firm size in the dairy industry can be divided into *J* size categories and denote these by n_{jt} where $j = 0,....J$ and $t = 1,....T$ denotes time. 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 [22]. Thus, an absorbing state, $i=0$ 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. 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 state $i = 0$ at that date is zero.

More generally the Markov chain process can be expressed as

$$n_{jt} = \sum_{i=1}^{I} p_{ij} n_{i,t-1} ; \quad j = 0,...,J , \tag{2}$$

where p_{ij} is the probability of transition from size n_i at time *t*-1 to size n_j at time *t*, and *i* and *I* similar to *j* and *J*. The total number of farms existing at time *t*, N_t, is equal to $\sum_{i=0}^{I} n_{it}$. The model to recover the transition probabilities p_{ij} is best estimated using a generalized cross entropy approach (GCE) as it allows the use of prior information and circumvents the problem of negative degrees of freedom as in the classical parametric approaches. Following [23] and [13], the GCE estimator is applied. In matrix notation and adding an error term the stationary Markov process can be written as

$$\mathbf{n(t) = P'n(t-1) + u(t)}, \tag{3}$$

where $\mathbf{n(t)} = (n_{0t},...,n_{St})'$ is a Kx1 column vector of the proportions of the number of farms in the respective size class. $\mathbf{P} = (\mathbf{p}_0, \mathbf{p}_2, ..., \mathbf{p}_K)$ denotes the transition probability matrix (TPM) with each vector $\mathbf{p}_i' = (p_{0i}, p_{2i},..., p_{Ki})$. The probability matrix is a stochastic matrix to be estimated and satisfying the following conditions on probabilities: $p_{ij} \geq 0$, and $\sum_{j=0}^{J} p_{ij} = 1$. $\mathbf{u}$(t) denotes a vector of disturbances with zero mean bounded within a specified support vector $\mathbf{v}$ and is parameterised as $u_{it} = \sum_{m}^{M} v_m w_{itm}$. Thereby denotes $\mathbf{w}$ an M–dimensional vector of weights for each $\mathbf{u}$, and $\mathbf{v}$ is an M–dimensional vector of supports. Referring to [10] we use size class specific error support space bounds. For each state the bounds are defined according to the three-sigma-rule (e.g. [24]). Accordingly, the (stationary) Markov chain model can be written as

$$\sum_{t} n_{tj} = \sum_{t}\sum_{i} n_{it-1} \cdot p_{ij} - \sum_{t}\sum_{m} v_m \cdot w_{jtm} \tag{4}$$

The objective of the GCE estimator is to minimize the joint entropy distance between the data and the priors. Prior information about **P** is incorporated in the form of a matrix of priors **Q**. The results are very sensitive to the empirical specification of the prior matrix; the particular specification of the prior information will be discussed in the following section. The objective function of the GCE model is

$$\min_{\mathbf{p,w}} \left\{ H(\mathbf{P,W,Q,W^o}) = \sum_{i}\sum_{j} p_{ij} \ln(p_{ij}/q_{ij}) + \sum_{i}\sum_{t}\sum_{m} w_{itm} \ln(w_{itm}/w^o_{itm}) \right\} \tag{5}$$

where w^o_{itm} refers to prior information on the disturbances. However, as no detailed information is available these are assumed to be uniformly symmetric about zero. H(·) refers to the measure of cross entropy and is minimized by minimizing the distance between the priors and the probabilities taking into account the aforementioned data or consistency constraints and normalisation and non-negativity constraints. The solution to the above system of equations is derived by [24].

As was argued before, the Markov process is unlikely to meet stationarity conditions because farmers are assumed to optimize an intertemporal value function. Therefore a time-variant TPM, **P**(t), should be estimated for each *t* or alternatively the source of this non-stationarity should be examined. In particular explanatory variables associated with (optimizing) milk production $q^m(\mathbf{x}, n)$, such as milk price, input prices and technical change induce the *non-stationarity* of the transition probabilities (see equation 1). For that purpose it is assumed that p_{ij} from (2) is a function of a set of explanatory variables, $\mathbf{z}(t-1)$. The covariates, $\mathbf{z}(t-1)$, can be thought of as policy variables influencing the transition probabilities and as non-policy variables approximating the state of the 'environment' the dairy sector is facing. These variables are expected to have an impact on the dynamics of the system.

In line with [23] the information of the covariates in Z_{tn} (TxN matrix of N covariates) can be incorporated in the GCE model following an instrumental variable generalized cross entropy approach. Both sides of the consistency constraint (4) are premultiplied by Z_{tn} and this leads to

$$\sum_t z_{tn} \cdot n_{tj} = \sum_t \sum_i z_{tn} \cdot n_{it-1} \cdot p_{ij} - \sum_t \sum_m z_{tn} \cdot v_m \cdot w_{jtm} \qquad (6)$$

$\forall\, j = 0, \ldots, J, n = 1, \ldots, N.$

This approach reflects the belief that the structural variables are correlated with the variables to be explained and the explanatory variables. No specific functional relationship is assumed, leaving open the exact relationship between the z-s and the x variables[3].

The Markov process as applied in this study describes the structural change in the German and Dutch dairy sectors. The transition probability matrices reflect a certain degree of farm mobility over size classes [25]. However, the obtained TPMs are diagonally dominant as most of the probability mass is on the diagonal, implying little overall transitions. The relevant literature (for instance, [26] or [27] offers a number of mobility indices, which maps the mobility information inherent in the TPM into a scalar metric, *M*(*P*). This enables to compare the mobility of farms in different sub-periods (pre-quota period and quota period), differing structures (family farm structure versus larger farm structure) and in different regions (Netherlands, East and West Germany). Referring to [26] an overall mobility index M^{OV} is defined.

$$M^{OV} = \frac{(J - tr(P))}{(J-1)} \qquad (7)$$

where $tr(P)$ denotes the trace of the transition probability matrix. If there would be no mobility the TPM would be an identity matrix and the trace of the TPM would be equal to 1. In this case, M^{OV} would be equal to zero. In case of perfect immobility, M^{OV} is equal to zero.

In order to be more precise with respect to the direction of mobility changes, we add three other mobility indicators in addition to the one of Shorrocks (see also [25]). 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 *k*. 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.

$$M^U = \frac{\sum_i \sum_{j>i} p_{ij}}{\sum_j (1 - p_{jj})} \qquad (8)$$

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

[3] For further details about the relationship between the farm size evolution and the covariates (e.g., impact elasticities) see [10] and references cited therein.

triangle TPM elements and divide this by the deflator we get an index for the downward mobility, M^D.

$$M^D = \sum_i \sum_{j<i} p_{ij} \Big/ \sum_j (1 - p_{jj}) \qquad (9)$$

If only downward mobility exists this index would be one; if no downward mobility exists the index would be zero. With regard to exits or the exit-mobility we define the following mobility index:

$$M^E = \sum_i p_{i0} \Big/ \sum_j (1 - p_{jj}) . \qquad (10)$$

The maximum value of the index (indicating all mobile farms are exiting) is one. Lower values indicate lower degrees of exiting from the dairy business.

V. PRIOR INFORMATION

The generalized cross entropy estimator is very sensitive to the prior information. In order to avoid any biases the prior data should be independent of the used data set. We refer to the suggestion of [10] and use empirical results of former studies. In this context prior information can be classified into three general types *a.)* information on the probability to persist, *b.)* on the probability for net shifts from one size class to another size class and *c.)* information on the probability of entry or exit.

Ad a.) and *b.)* Reviewing previous studies the probability to persist in the current size class was the highest. Accordingly, it is further assumed that the probabilities to stay in the respective size class are the highest of each class. Thereby it is assumed that there exists a switching size class, below this size class, the probability to stay is lower than for size classes above this switching class. Below this trigger-class the probability to close down dairy business is higher than for farms in size classes above. *Ad c.)* Some research has indicated that farms typically do not decrease in size without going out of business, whereas other studies argue that might scale up or down in size, but with no more than one size category per transition [12]. The latter assumption, which seems to be rather plausible when growth is considered as a continuous process, would imply that in general: $x_{it} = p_{i-1,i,t} x_{i-1,t-1} + p_{i,i,t} x_{i,t-1} + p_{i+1,i,t} x_{i+1,t-1}$, with all other elements in the *i*-th row of the probability matrix expected to be equal to zero. Rather than imposing this as a restriction, here this information is used as prior information, which may be overruled by the data. Since the number of dairy farms in West Germany and the Netherlands is consistently diminishing over time and referring to [28] we assume that the probabilities of re-entry are equal to zero, or $p_{0j} = 0$ for all $j = 1, ..., K$ with the zero subscript denoting the entry-exit category. It is acknowledged that the number of farms in East Germany increased in the first years of the economic transition, which is mainly due to political issues. However, the more recent years show also a tendency of declining number of farms and accordingly in our prior we also exclude the probability of re-entry for East Germany.

The vector of covariates induces the non-stationary transition probabilities and should therefore refer to the control variables: the production function of milk. This, the vector of inputs would be the best choice; however, as only aggregated data are available, we refer to the milk price and milk yield also serving as a trend variable. For Germany additionally a dummy for the milk quota auction system, which was introduced in 2000, is taken into consideration. Even though the behavioural model implies a stochastic environment price volatility was not explicitly considered for reasons of parsimony and lack of precise data. Moreover, under the quota system which is accompanied by intervention prices the volatility over the year is induced by a seasonal pattern which is rather constant over the years.

VI. RESULTS

The IV GCE Markov model was estimated including further a constant variable. Goodness of fit (as reflected by pseudo R^2 values) was satisfactory. Due to space limitation we do not present the estimated transition probabilities here, these can be found in the Appendix. The estimated transition probability matrices provide insights into the dynamic adjustment process of dairy farms.

Table 1: Estimated mobility indicators

	Prior matrix Q			Pre-quota period (...-1983)		Quota period (1987-…)		(1991-2005)
	West Germany	*East Germany*	*The Netherlands*	*West Germany*	*The Netherlands*	*West Germany*	*The Netherlands*	*East Germany*
Overall	0.11	0.24	0.11	0.14	0.12	0.24	0.06	0.47
Upward	0.23	0.10	0.33	0.75	0.84	0.74	0.86	0.54
Downward	0.76	0.30	0.66	0.24	0.17	0.25	0.13	0.46
Exit	0.35	0.35	0.35	0.05	0.10	0.26	0.04	0.39

The respective estimates for West Germany and the Netherlands show in both periods a strong tendency to persist in the size class. The off-diagonal elements indicate upward and downward transition probabilities of the dairy farms. However, in order to compare the countries and the periods we refer to the mobility indicators. Table 1 depicts the respective indicators.

Comparing West Germany and the Netherlands, the overall mobility is very similar in the pre-quota period. In the quota period it increased in West Germany and declined in the Netherlands, which is likely to reflect the different milk quota implementation schemes in both countries. This is further confirmed by the exit-mobility which increases by 0.2 in West Germany and declines by 0.06 in the Netherlands. Compared to the Netherlands, dairy farms in Germany showed a lower degree of specialisation. Accordingly, this difference is reflected by the mobility terms and indicates the tendency to further specialisation. In addition, the milk quota transfer attached to grassland in West Germany made it profitable to give up active milk production by leasing grassland with quota. The comparison of the estimates to the mobility indicators of the prior matrix shows substantial differences between the estimates and the implicit priors. This suggests that even though it seems that the prior information has a relatively strong impact on the estimates, this does not preclude the parameter adjustments to the data in such a way that the mobility indicators change drastically.

Milk prices appear to have low impact on the probabilities of the respective size class mobility (impact elasticities not reported). An increase in the milk price increases the probabilities of exits in the Netherlands in both periods only slightly (4.2 % and 1.9 %) but by 14.5 % in West Germany in the pre-quota period. Contrarily, in the quota period an increasing milk price reduces the probability of exits by 25% (along with 1 % price increase). This confirms the previously discussed conjecture that farms stay longer in business under the milk quota system and growth is hindered. The increased flexibility of quota transfer can be shown to have a slight positive impact on the farm exit probability but by 1 %.

The estimates for East Germany indicate that these dairy farms are more mobile than farms in West Germany and the Netherlands. All mobility indicators are higher than the measures for West Germany and the Netherlands. A possible reason can be seen in the transition period where re-entry of former disposed farmers was rather easy possible and encouraged by government. These results are further reflected in the estimated transition probability matrix. Interestingly, the milk quota auction dummy is rejected by the results meaning the introduction of the auction-transfer system did not affect the dairy farm size distribution. This confirms the observed tendency that only a minor share of quota is transferred by the auctions and the main share by complete firm transfers.

VII. CONCLUDING REMARKS

This paper analysed the dairy farm size distribution in West Germany and the Netherlands for the pre-quota period (until 1983) and the quota period (starting in 1987 after a few adoption years). The intention thereby was to improve the understanding of structural change under the quota regime and further to find out if the milk quota system hinders farm growth. The comparison of both regions in two sub-periods allowed comparing the farms size distributions pre-quota period versus quota period and further 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 and regions, with the transition-region having the highest mobility scores. Moreover although a clear impact of the milk quota on structural change was detected, the direction of it was non-uniform over countries. 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 are not final and leave space for improvements. In particular the use of covariates needs to be carefully interpreted – these act as instrumental variables and not directly as explanatory variables. In future research this problem might be addressed by a two-stage estimation procedure, in which transition probabilities and the explanatory part are estimated separately.

REFERENCES

1. Keane M, Lucey D (1997) The CAP and the Farmer. In Ritson C, Harvey D R, eds. The Common Agricultural Policy (2nd edition). CAB International, Wallingford pp 227-239
2. Sumner D A (1985) Farm Programs and Structural Issues. In Gardner B, ed. U.S. Agricultural Policy: The 1985 Farm Legislation, AEI Symposia series No. 85c, Washington DC
3. Zimmermann A, Heckelei T, Pérez I (2006) Working paper – Literature Review of Approaches to Estimate Structural Change, SEAMLESS report No. 16
4. Eastwood R, Lipton M, Newell A (2004) Farm size. Paper prepared for Volume III of Handbook of Agricultural Economics, mimeo
5. Weiss C (1999) Farm growth and survival: econometric evidence for individual farms in upper Austria. Am. J. Agric. Econ. 81: 103-116
6. Kimhi A, Bollmann R (1999) Family farm dynamics in Canada and Israel: the case of farm exits. Agric. Econ. 21:69-79
7. Pietola K, Väre M, Oude Lansink A (2003) Timing and type of exit from farming: farmer's early retirement programmes in Finland. Eur. Rev. Agric. Econ. 30(1):99-116
8. Foltz J D (2004) Entry, exit, and farm size: assessing an experiment in dairy price policy. Am. J. Agric. Econ. 86 594-604
9. Breustedt G, Glauben T (2007) Driving Forces behind Exiting from Farming in Western Europe. J. Agric. Econ. 58:115-127
10. Tonini A, Jongeneel R (2007) The distribution of dairy farm size in Poland: a markov approach based on information theory. Appl. Econ. 1:1-15
11. Zepeda L (1995a) Asymmetry and non–stationarity in the farm size distribution of Wisconsin milk producers: An aggregate analysis. Am. J. Agric. Econ. 77:837–852.
12. Zepeda L (1995b) Technical change and the structure of production: A non–stationary Markov analysis. Eur. Rev. Agric. Econ. 22:41–60
13. Karantininis K (2002) Information Based Estimators for the Non-stationary Transition Probability Matrix: An Application to the Danish Pork Industry. J. Econometrics 107:257-290.
14. Gibrat R (1931) Les Inégalités Economique. Libraire du Recueil Sirey, Paris
15. Kostov P, Patton, M, Moss, J, McErlean S (2006) Does Gibrat's law hold amongst dairy farmers in Norhtern Ireland? Munich Personal RePEc Archive Paper No 3370
16. Bakucs L, Fertö I (2007) Gibrat's law in a transition economy. The Hungarian case. Paper presented at the joint IAAE -104th EAAE seminar Corvinius University Budapest, September 6-8
17. Rahelizatovo N, Gillespie J (1999) Dairy farm size, entry and exit in a declining production region. J. Agr. Appl. Econ. 31:333-347
18. Faostat. (2007) Livestock primary and processed at http://faostat.fao.org/site/569/default.aspx. Accessed 27 December 2007
19. Statistisches Jahrbuch ueber Ernaehrung, Landwirt-schaft und Forsten: diverse volumes
20. Boots M (1999) Micro-economic analysis of alternatives policies for Dutch dairy farming. PhD thesis, Mansholt Institute, Wageningen: University of Wageningen
21. Stokes J (2006) Entry, exit, and structural change in Pennsylvania's dairy sector. Agr. Resource Econ. Rev. 35:357-373
22. Stanton B F, Kettunen L (1967) Potential Entrants and Projections in Markov Process Analysis. J. Farm Econ. 49:633-642
23. Golan A, Vogel S J (2000) Estimation of non–stationary social accounting matrix coefficients with supply side information. Econ. Systems Res. 12
24. Golan A, Judge G, Miller D (1996) Maximum entropy econometrics. John Willey and Sons, Chichester

25. Jongeneel R, Tonini A (2008) Dairy Quota and Farm Structural Change: A Case Study on the Netherlands. Paper presented at the 107th EAAE Seminar "Modeling of Agricultural and Rural Development Policies". Sevilla, Spain, January 29th -February 1st
26. Shorrocks A F (1978) The measurement of mobility. Econometrica 46:1013-1024
27. Sommers P S, Conslik J (1979) Eigenvalue immobility measures for Markov chains. J. Math. Sociol. 6:253-276
28. Geurts J A M M (1995) Technical & structural changes in Dutch dairy farms. MSc thesis, Wageningen University

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APPENDIX

Table A1 Estimated transition probability matrix for West Germany and the Netherlands

	Transition probabilities in pre-quota period							Transition probabilities in quota period						
	West Germany							*West Germany*						
Size class[1]	0	1-9	10-19	20-29	30-49	50-99	> 100	0	1-9	10-19	20-29	30-49	50-99	> 100
0	0.497	0.068	0.272	0.125	0.037	0	0	0.014	0.001	0.457	0.305	0.213	0.010	0
1-9	0.046	0.884	0.066	0.005	0	0	0	0.034	0.944	0.022	0.000	0	0	0
10-19	0	0.162	0.819	0.000	0.019	0	0	0.230	0.000	0.770	0.000	0	0	0
20-29	0	0	0	0.991	0.009	0	0.001	0	0	0.095	0.905	0	0	0
30-49	0	0	0	0	0.958	0.042	0	0	0	0	0.001	0.949	0.049	0
50-99	0	0	0	0	0	0.997	0.003	0	0	0	0	0	0.984	0.016
> 100	0	0	0	0	0	0	1.000	0	0	0	0	0	0	1.000

	The Netherlands								*The Netherlands*							
Size class[1]	0	1-10	11-20	21-30	31-50	51-70	71-100	> 100	0	1-10	11-20	21-30	31-50	51-70	71-100	> 100
0	0.599	0.052	0.021	0.017	0.052	0.132	0.080	0.046	0.871	0	0	0	0	0.040	0.088	0
1-10	0	0.932	0	0	0.068	0	0	0	0.007	0.937	0	0	0.056	0	0	0
11-20	0.099	0	0.874	0	0.026	0	0	0	0.006	0.019	0.962	0	0.013	0	0	0
21-30	0	0	0.039	0.961	0	0	0	0	0.001	0.000	0.000	0.966	0.033	0	0	0
31-50	0	0	0	0	0.927	0.072	0	0	0	0	0	0	0.950	0.050	0	0
51-70	0	0	0	0	0	0.913	0.087	0	0.022	0	0	0	0	0.957	0.021	0
71-100	0	0	0	0	0	0	0.951	0.049	0	0	0	0	0	0	0.959	0.041
> 100	0	0	0	0	0	0	0	1.000	0	0	0	0	0	0	0	1.000

1) No. of cows

Table A2 Estimated transition probability matrix for East Germany

	Transition probabilities							
Size class[1]	0	1-9	10-19	20-29	30-49	50-99	100-499	> 500
0	0.152	0.001	0.003	0	0.061	0.253	0.257	0.272
1-9	0	0.812	0.026	0.035	0.044	0.018	0.028	0.037
10-19	0.154	0.429	0.363	0	0.053	0.001	0	0
20-29	0.156	0	0.295	0.549	0	0	0	0
30-49	0.002	0	0	0.132	0.349	0.518	0	0
50-99	0.045	0	0	0	0	0.778	0.177	0
100-499	0.009	0	0	0	0.086	0	0.905	0
> 500	0.025	0	0.188	0	0	0	0	0.786

1) No. of cows