Dairy Quota and Farm Structural Change: A Case Study on the Netherlands

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Abstract

This paper sets out to analyse the impact of milk quotas had on the dairy farm structure of the Netherlands. In addition projections on the likely farm structure under different milk quota scenarios are explored. Moreover mobility indicators characterizing structural change are developed and calculated. A Markov probability model is estimated relying on a generalized cross entropy approach. The introduction of milk quotas as of April 1, 1984 froze the dairy farm structural adjustment, at least initially. However, later on mobility started to increase, which is likely to reflect the quota tradability and lease possibilities. Moreover there is evidence that the milk quota regime has increased concentration of dairy production among farms with 50-69 cows. If after quota abolition the dairy farm structural dynamics would be the same as in the 1972-83 period, then quota abolition in 2015 will lead to a substantial increase in the number of farms in 2022 as compared to the current status quo.

Key words: dairy, farm size, Netherlands, Markov chain, generalized cross entropy

1. Introduction

The European Commission has announced it will abandon the milk quota system in 2015 unless a qualified majority of the Member States will block it. Moreover, already in the Health Check, reforms of the European Union (EU) dairy policy will be considered anticipating this planned policy switch. This dairy policy reform is likely to come down to a gradual phasing out of the quota system. This paper sets out to analyse the impact of milk quotas on the dairy farm structure of the Netherlands. We have a twofold objective. First objective is to examine how the farm structure has changed over time and to detect to which extent the introduction of milk quotas in 1984 affected this structural change process. In order to assess these Markov transition probability matrixes (TPMs) and mobility indicators are estimated. Second, estimation results are used to run a counterfactual for the period 1984-2006 to project how the farm size distribution would have evolved if there would have been no milk quota. In addition some tentative projections on the likely Dutch dairy farm structure in the coming decade are made and compared.

The Markov probability model (Lee *et al*., 1970) of farm size distribution is able to analyse movements of individuals between different states when only aggregate data on finite size categories are available for a given time period. A generalized cross entropy (GCE) estimator, which is suitable when dealing, with limited data, is used (see Golan *et al*., 1996; Mittelhammer *et al*., 2000; Perloff *et al*., 2007). The standard Markov inverse problem of Golan *et al*., (1996) is estimated initially following a recursive-like type of estimation (Johnston and DiNardo, 1997: 117-118). In doing so one sample point is added at a time until all *n* sample points are used. This approach allows detecting the information content of each data point as well as turning points and other systematic time variation in the estimated coefficients due to policy changes.

This analysis is likely to be of interest to policy makers, in providing insight into how the farm structure has evolved and is could develop in the future. A particularly relevant issue is what will happen to the Dutch dairy farm structure after the quota removal in 2014-15. Potentially the analysis is also of interest to the upstream and downstream industries that have to decide on investments in dairy processing capacity, milk collection schemes, and providing farm input supplies.

The remainder of this paper is organized as follows. Section 2 describes milk quotas and dairy farm structure in the Netherlands. Section 3 specifies the information-theoretic Markov model. Section 4 discusses the sample data as well as prior information. Section 5 discusses results. Section 6 presents a counterfactual projection for the period 1984-2006 and two forward-looking policy scenarios. In Section 7, the conclusions are presented.

2. Milk Quotas and Dairy Farm Structure in the Netherlands

The Netherlands is one of the most important dairy producers in the EU. In 2006 it accounted for about 7 per cent of the total EU-27 cow milk production, being the sixth EU milk producer after Germany, France, United Kingdom, Poland and Italy. In the last seventeen years, dairy cow numbers have declined by 19.1 per cent and milk yields have improved by 15.9 per cent (Faostat, 2007). The introduction of the milk quota with super levy system in 1984 implied that each producer got a farm-specific quota. Producing in excess of this quota was not rational since the fine that had to be paid for surplus-milk was more that the milk price[1]. 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 the Netherlands the quota were distributed over farms based on production levels of 1983. Since in the last years before introducing the quota, milk production significantly increased. Therefore reductions had to be imposed on the 1983 reference in order to limit production to the level established by the EU (see Krijger, 1991 for further details). However, it already soon appeared that this restricted EU milk production was still evaluated by policy makers as too high and therefore insufficient to 'solve' the EU's surplus problems. In subsequent years, therefore further reductions of the dairy farmers' quota took place (e.g. Figure 1). As compared to the 1983 production level the reductions imposed implied an allowed raw milk production volume in 1988/89 which was nearly 20 percent lower. Initially most farmers exceeded their quota and had to pay a super levy. However, rather soon farmers learned how to adjust their production process in such a way as to come rather close to their allowed quota level. The quota regime which was first announced as a temporary measure (for a period of 5 years), was extended, initially for three years (till 1992), and is likely to achieve a total lifetime of 30 years.

Since quotas are fixing output at farm level, they are generally assumed to 'freeze' the structural adjustment. Moreover, since both relatively efficient and relatively inefficient farms are restricted in a proportional way, they are likely to introduce inefficiencies in production, implying that milk is not produced in the least-cost way (Burrell, 1989). The milk quota framework allowed member states to pursue an active structural policy, although this option has not been used by the Dutch government (Krijger, 1991: 193). However, in the first 5 years since the quota were introduced the Dutch government acquired about 5 percent of the quota (by buying quota and by imposing general

[1] Since 1992/93 the levy has been fixed for a long time at 115 percent of the target price of milk. Currently the levy is fixed at a somewhat lower level (€0.28/kg of milk).

reductions) which was redistributed over farmers in 'specific situations'(Boots, 1999:22). Moreover, in the same period about 7 percent of the initial quota was re-allocated through the market.

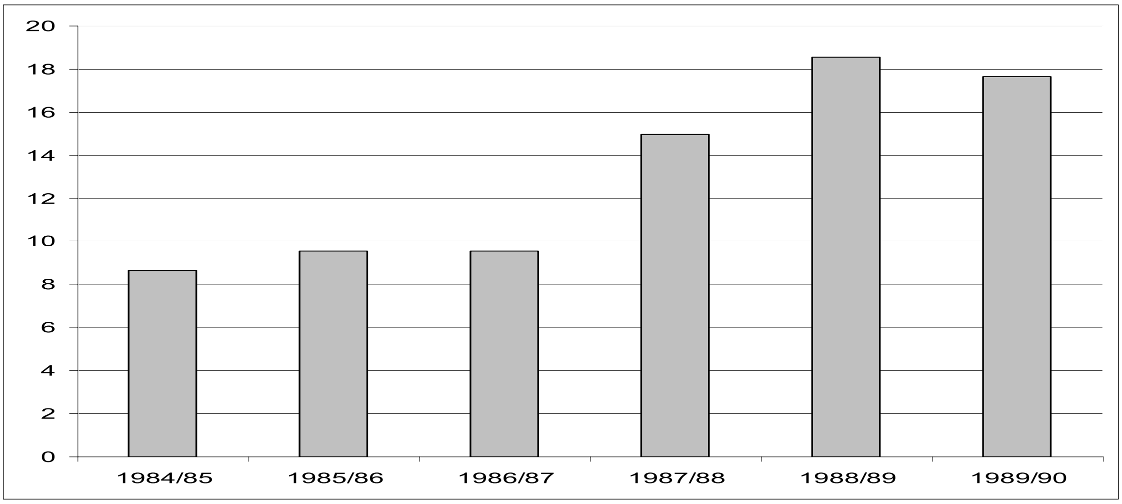

Figure 1. Average reductions in dairy farmers' quota due to EU and Dutch policy interferences.
Note: cumulative, as percentages of the 1983 milk deliveries.
Source: Krijger, (1991: 22).

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. Alongside buy and sell, already soon after the quota introduction, leasing has been used by farmers since 1989/90 as a management tool to absorb expected over-quota production (Oskam and Speyers, 1992).

A graphical illustration of the evolution of the dairy farm size distribution in the Netherlands is given in Figure 2. 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. The annual decline in the total number of active dairy farms for the pre-quota period (1972-1983) was 4.83 percent, whereas for the with-quota period (1984-2006) it was 4.39 percent.

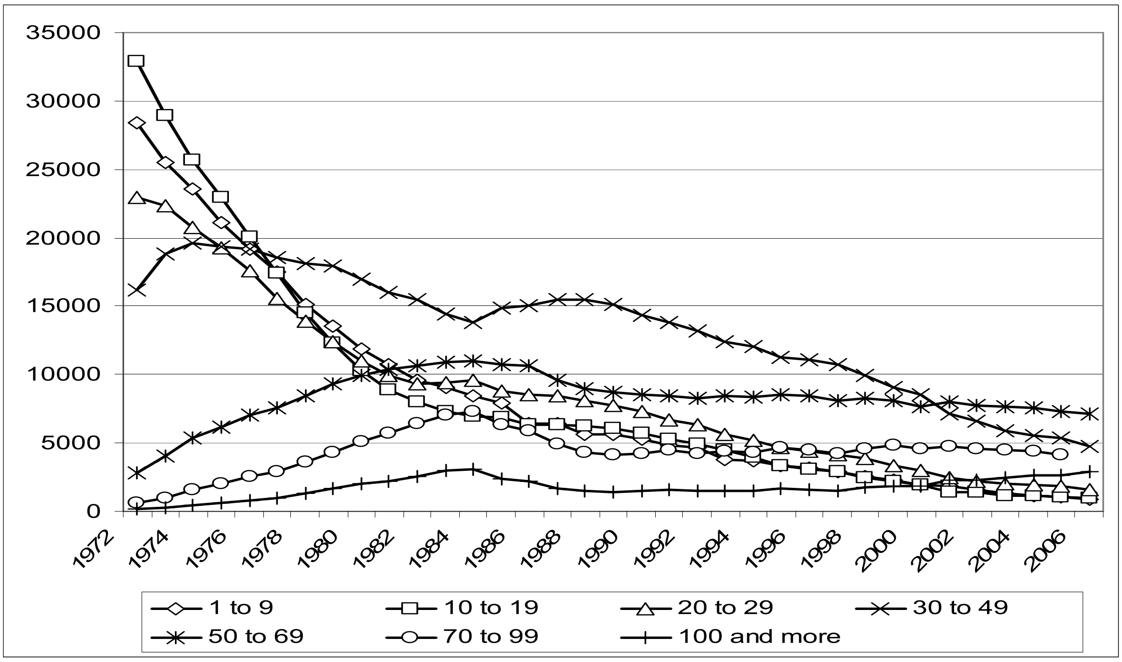

Figure 2. Dairy farm size evolution in the Netherlands, 1972-2006

Note: Data are in terms of absolute number of farms.
Source: Own calculations based on LEI-CBS, (various years).

The farm size patterns from the data are summarized in Table 1. The full sample and two sub-samples 1972-83 and 1984-06 are considered. Only farm sizes with more than 50 cows increase over the whole time period, with a 9.0 percent average annual growth rate for dairy farms with more than 100 dairy cows. The strongest decline is for farms with 1-19 cows with an average annual decline rate above 10 percent over the whole period. In the 1970s and early 1980s a large part of the dairy farms did switch or were 'enforced' by the dairies to switch their milk delivery system. Rather than using non-cooled 30 or 40 litre cans which were collected each day, they switched to the use of cooled milk tanks. Whereas in 1970 about 2% of the dairy farmers used the cooled milk tank system, at the end of the 1970s more than two third of the dairy farmers used this system (Bruurs and Wijnen, 1981).

Table 1. Average annual growth rates on Dutch dairy farm sizes.

	1-9	10-19	20-29	30-49	50-69	70-99	> 100	Total
1972-06	-10.12	-10.32	-7.81	-3.59	2.70	5.64	9.03	-4.53
1972-83	-10.40	-13.64	-8.10	-1.07	12.23	22.62	28.13	-4.83
1984-06	-9.99	-8.74	-7.66	-4.79	-1.86	-2.48	-0.11	-4.39

Note: Annual growth rates are computed by constructing logarithmic growth rates per year, and then averaging the yearly rates across the different sub-samples.
Source: Own calculations based on LEI-CBS, (various years).

The laggards were mainly concentrated in the farm size categories up till 20 to 30 cows herd sizes. The investments and adjustments associated with this 'transition' discouraged in particular small farms to continue their dairy farming business. At the same time it stimulated others to make strategic investments and expand in order to lower the fixed costs per unit of output. For example, in the same period about 25 percent of the dairy farmers invested in cubicle houses and milking parlours for their animals (Bruurs and Wijnen, 1981). Looking at the sub-sample 1984-06 it appears that the initial growth rate registered for farms with more than 50 dairy cows is reversed into a decline. In addition the rate of decline appears to be stronger in the small sizes as compared to the medium and large sizes.

3. The Information-Theoretic Markov Model

The Markov chain approach is very suitable when the only data available are count data in the form of observable proportions or aggregates rather than data at the level of micro units. Movements from state to state are represented by a stochastic process and are typically modelled by estimating the so-called Markov transition probabilities. For empirical analyses the following issues are typically encountered. First it is often the case that the proportions/count data are only available for the total aggregate and not for the net shifts, so that the number of unknowns in terms of transition probabilities to be estimated might exceed the number of available data points (i.e. ill-posed problem). Second, the proportions/count data may be potentially correlated (i.e. ill-conditioned problem). Third, there may be turning points and other systematic time variation in the data at hand.

In this context, the maximum entropy (ME) algorithm developed in Golan et al., (1996) and Mittelhammer *et al*., (2000) and Perloff *et al*., (2007) is a suitable candidate for extracting the maximal signal from an initial 'out-of-focus' problem. Our paper is based on a GCE formalism which is founded on the directed divergence or minimal discriminability principles of Kullback, (1959) and Good, (1963). GCE is suitable when some 'educated' guesstimates based on previous data, experiments or economic theory are available (i.e. prior estimates). As discussed by Golan, (2002), GCE is an information theory distance measure of the information contained in the posterior estimates as compared to the information contained in the prior estimates. Out of all the feasible solutions, GCE selects the one that minimizes the divergence between the data and the priors, the final solution being the closest to the data and priors.

In order to analyse to examine how the farm structure has changed over time it is useful to initially detect turning points in the data as well as systematic time variations. In doing so, the standard Markov inverse problem of Golan et al., (1996) is estimated recursively (Johnston and DiNardo, 1997: 177-188). First the model fits the first two t observations[2] (i.e. one transition), in this case the estimated TPM will fit the data perfectly. Next the model is fitted using the first $t + 1$ observations and another TPM is estimated. This procedure of adding one sample point at a time is repeated until another TPM is estimated based on all T sample points. The model follows the standard model of Golan et al., (1996) with $t = 2$, $t + 1,\dots,T$ and l, $k = 1,\dots,$ K an index fro the number size classes as given by

$$\min I\left(p_{lk}, q_{lk}, w'_{tkh}, u'_{tkh}\right) = \sum_{l}\sum_{k} p_{lk} \ln\left(p_{lk} / q_{lk}\right) + \sum_{t}\sum_{k}\sum_{h} w'_{tkh} \ln\left(w'_{tkh} / u'_{tkh}\right) \tag{1}$$

subject to the following constraints:

$$y_{tk} = \sum_{l} x_{tl} p_{lk} + e_{tk} , \tag{2}$$

with

[2] In our case we start for convenience with t =3 since our model contains an error term in the Markov consistency constraint.

$$e_{tk} = \sum_h V_{tkh} w_{tkh} \tag{3}$$

and

$$\sum_k p_{lk} = 1 \tag{4}$$

$$\sum_h w_{tkh} = 1 \tag{5}$$

Equation (1) represents the GCE criterion which minimizes the divergence between the data in the form of posterior transition probabilities p_{lk} and the transition priors q_{lk}; p_{lk} denotes the probability a farm in size class *l* at time *t* will move to size class *k* at time t+1. Probabilities p_{lk} are elements of a $L \times K$ squared matrix of transition probabilities where *l, k* =1,..., *K* and q_{lk} are the counterpart prior elements; w_{tkh} are the elements of a $TKH \times 1$ vector of error posterior probabilities and u_{tkh} are the counterpart prior elements. Equation (2) represents the Markov data consistency constraints, where y_{tk} are the elements of a $TK \times 1$ vector of known proportions falling in the *k*-th Markov states in time (t+1), x_{tl} are the elements of a $TL \times 1$ vector of known proportions falling in the *l*-th Markov states in time (t).

The error term e_{tk}, included in equation (2), is reparameterized as given by equation (3), following the classical maximum entropy formalism (Golan et al., 1996: 107-110), where $\mathbf{V}_{tk}$ is an *H*-dimensional vector of support points and $\mathbf{w}_{tk}$ is an *H*-dimensional vector of proper probabilities with $H \geq 2$. Given that each Markov state can be characterized by a different variance, a specific definition of support bounds for each Markov size class is considered following the statistical model presented in Golan et al., (1996: 182-185). By so doing, different error support bounds are specified for each Markov state relying on the 'three sigma' rule of Pukelsheim, (1994) as done in Tonini and Jongeneel, (2008). Equation (4) represents the set of additivity constraints for the required Markov row constraint, while equation (5) does so for the proper probabilities of the reparameterized error. All proper probabilities of signal and noise are required to be non-negative $(\mathbf{p}, \mathbf{w}) >> 0$.

The relative information content of the estimated parameters is evaluated through the normalized entropy measure as well as by its complement, the so-called information index described in Golan et al., (1996: 93). The normalized entropy is defined for values between zero and one, with values approaching zero in the case of no uncertainty and values approaching one in the case of perfect uncertainty (i.e. uniform distribution). The normalized entropy index for the signal part is formulated as follows

$$S(\tilde{\mathbf{p}}) = \frac{-\tilde{\mathbf{p}}' \ln(\tilde{\mathbf{p}})}{-\mathbf{q} \ln(\mathbf{q})} \tag{6}$$

The analogue information index is equal to $1 - S(\tilde{\mathbf{p}})$ and it measures the reduction in uncertainty.

The Markov process as applied in this study describes the structural change in the Dutch dairy sector. As such a TPM reflects a certain degree of farm mobility over size classes. Notice that a salient characteristic of the obtained TPMs is that these matrices will be diagonally dominant: from one year to another most farms remain in the same size class. Most of the probability mass is therefore expected to be concentrated on the diagonal, implying little overall transitions. The literature (e.g. Shorrocks, 1978; which is extended by Geweke *et al.*, 1986; and more recently by Jaffry and Schuermann, 2003) has developed a number of mobility indices, which maps the mobility information inherent in the $K \times K$ TPM into a scalar metric $M(P)$. A good example of such an index is the Shorrocks, (1978) mobility index M. With P being the TPM and *n* being the number of size classes. M is equal to

$$M = \frac{(n - tr(P))}{(n-1)} \tag{7}$$

If there would be no mobility the TPM would be an identity matrix (all diagonal elements equal to 1) and the trace of the TPM would be equal to *n*. M would be equal to zero than. In case of perfect mobility M is equal to one, because then all diagonal terms of the TPM except for one will be equal to zero[3]. Because of this the trace of P is equal to 1 and M reduces to 1[4].

The Shorrocks index gives information on mobility but not on its direction. Here two additional indices are developed in order to provide information about this. We are not aware whether these indices were used by others in the literature. The basic idea is clearly related to that of the Shorrock principle. It could be stated that probabilities in the lower (off-diagonal) triangle part of the TPM indicates downward shifts. In contrast the upper triangle represents upward shifts. Note also that the sum of upward and downward shifts is the mirror side of what happens at the diagonal. Let's define $1 - p_{kk}$ the mobility part of the diagonal element *k*. Aggregating all these 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. An upward mobility index M^U could then be the sum of the upper triangle probabilities of the TPM deflated by the deflator described above, or

$$M^U = \frac{\sum_{i}^{n} \sum_{j>i}^{n} p_{ij}}{\sum_{k}^{n} (1 - p_{kk})} \tag{8}$$

If there would be maximum or full upward shift and no downward shift the index would be 1, since the sum of the upward triangle probabilities of the TPM would than be exactly equal the sum of the mobility part of the diagonal elements. If there would be no upward shift 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 as given by

[3] A TPM always has at least one ergodic or absorbing state. Usually there are two of such stages, one for the inactive farms and one for the active farms. In the latter case the maximum value of the Shorrocks index is equal to (n-2)/(n-1). For example if n=8 the maximum value of the S-index associated with perfect mobility would be 6/7=0.857.

[4] Note that this mobility measure does not focus on one size class or the number of active versus inactive farms, but takes in principle transitions between all size classes into account. Of course the values obtained for the Shorrocks index will depend on the definition and band-width of the size classes.

$$M^D = \frac{\sum_{i}^{n}\sum_{j<i}^{n} p_{ij}}{\sum_{k}^{n}(1-p_{kk})} \tag{9}$$

If all mobility would be downward shift the index would be 1; if no down ward shift, the index would be zero. Note that by definition it should hold that $M^U + M^D = 1$ or $M^D = 1 - M^U$.

The projections of farm numbers were obtained exploiting the relationship as expressed in equation (2). According to this, projecting the farm size distribution (y(s)) *s* periods ahead, starting from a base year *x(0)* is equal to multiply the base year with the TPM raised to the power *s*, or

$$y(s) = x(0)P^s \tag{10}$$

4. Data and Prior Information

Aggregate data on the size distribution of dairy farms in the Netherlands are used. Holdings were classified according to their herd size classes. The data cover the period from 1972 to 2006 and allow the recovery of the number of dairy farms belonging to seven[5] farm size classes: 1-9 cows, 10-19 cows, 20-29 cows, 30-49 cows, 50-69 cows, 70-99 cows, and > 100 cows (LEI-CBS, various years). In order to account for exit and entry an additional size class was defined which contains the 'inactive farms' and 'potential entrants' $(l, k = 0)$[6]. Data were normalised by a common scalar equal to the maximum number of farms contained in the aggregate transition counts.

The researcher may follow several principles in order to best approximate farm size growth and to guess or estimate the probability of a farm being in a given size class. In order to avoid data mining and ensure efficiency in estimation, the prior information should be derived from sources which are as independent as possible of the sample data. The prior information on Markov transition probability estimates may concern three types of information: the probability of a farm persisting in the same farm size class (i.e. persistency), the probability of a farm entering and/or exiting the sector (i.e. entry/exit), and the probability of moving to another farm size class (i.e. net shifts). In this study we followed the extensive investigation of previous research done by Tonini and Jongeneel, (2008) and the lessons (general patterns) drawn from this formed the basis of the prior information used. Based on these findings in the literature, the priors on the diagonal transitional probabilities were set, moving from the top left corner to the low right corner of the TPM from 0.65 to 0.80 (i.e. $p_{22} = 0.65$, $p_{kk} = 0.70$ for $k = 3$, and $k = 5$, $p_{44} = 0.75$ and for $k = 6,7$). As regards exit and considering the already specified priors on persistency the priors on the exit probabilities p_{l0} for $l = 2,...,7$ were set at 0.35, 0.25, 0.20, 0.15, 0.05 and 0.05 respectively.

5 Eight farm size classes considering the artificial entry and exit class size.

6 The number of farms in this artificially created size class is (arbitrarily) set to zero for the first observation 1972. For later years it includes the number of exiting farms less the number of farms re-entering the dairy sector.

With respect to entry, in all the studies observed the total number of businesses shows a clear tendency to decline over time. Generally very little information was known about entering firms, let alone about the probabilities of entrance in different size classes. Given this finding and the character of our data, which required us to focus on net-transitions (net entry), it was decided to specify no positive priors on any entry probabilities $(p_{0k} = 0, \forall k \neq 0)$. Since by definition $\sum_k p_{0k} = 1$ these priors on entry also imply that once a farm is out of business it will likely stay out of business. Similarly it was assumed that also $p_{88} = 1$ in order to comply with the absorbing states notion within Markov chain approaches.

As regards the net shifts, one pattern observed from the literature is that farms show a tendency to gradually develop. This implies that the probability of a farm moving from its current size class to an adjacent size class is generally higher than the probability of moving to more distant size classes. A second finding is that usually there is a switch-size class, below which farms show a tendency to decline and ultimately go out of business, whereas above this size class farms expand their business. This finding is likely to be partly related to the dominant family-business character of farming. As a consequence of this, farm succession is tied to the family cycle (e.g. where there is no-one to take over the farm, farmers are likely, as they get older, to gradually downsize their business). Another explanatory factor might be that farms need a certain critical scale in order to be considered as 'viable', i.e. be able to finance expansion relying on generated internal savings and on the possibilities for attracting external credit.

Reviewing previous studies it appeared that the location of the turning point size class is generally country and case specific (depending for example also on the specified number and width of size classes). Our prior estimate of the switch size class is therefore based on the particular sample considered and set at the size class with 50 to 69 cows (see also Table 1). As regards the farms in this size class, our prior is that they have a larger probability to expand rather than to contract because of their relatively large capital stock. Their probability to move down was equal to 0.05 (i.e. $p_{43} = 0.05$) with a probability of moving up equal to 0.10 (i.e. $p_{45} = 0.10$). Farms in larger size classes are assumed to move up to the adjacent size class with a probability of 0.15, whereas farms in lower size classes are assumed to move down to the next size class with a probability of 0.05 (conditional on assumptions previously made about exit for the lower size classes). The prior assumptions made so far imply that most of the lower and upper off-diagonal elements of the TPM have prior expectations equal to zero (see Disney *et al*., (1988); Zepeda, (1995) for similar assumptions).

5. Estimation Results

The Markov model was initially estimated following a recursive-like type of estimation, adding one sample point at a time. This procedure allows to first evaluate the information content attached to each sample point detecting turning points and systematic time variations. The information content of each sample data is assessed by computing the normalized entropy for the signal part and its counterpart, the so-called information index.

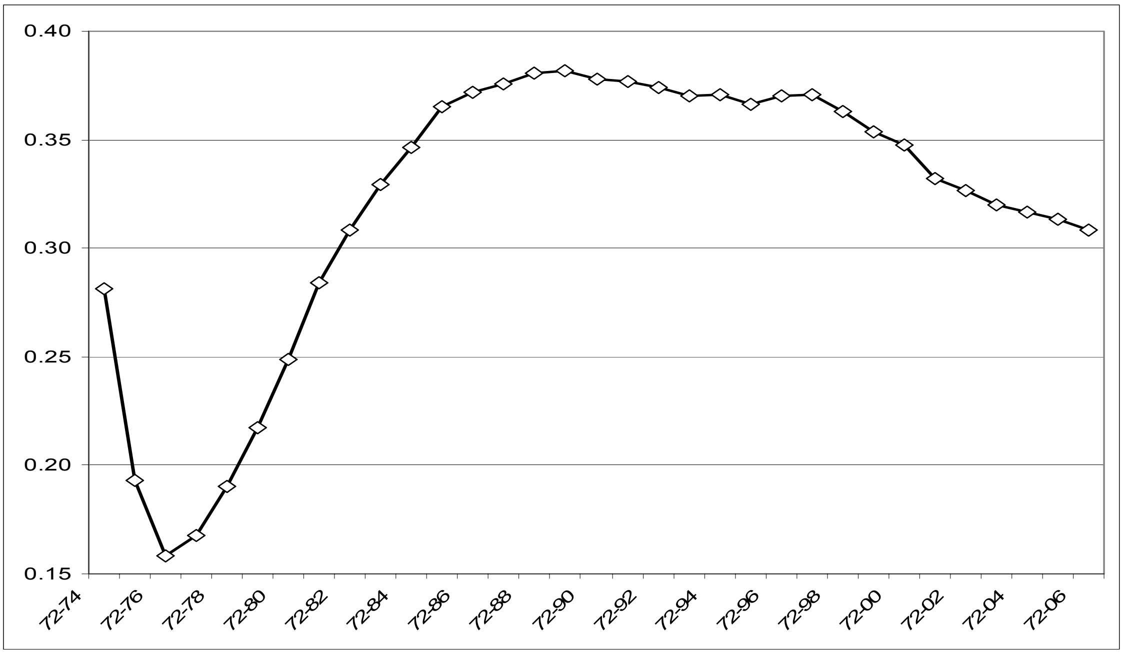

Figure 3. Information index evolution for recursive samples

Note: The information index is computed as $1 - S(\tilde{\mathbf{p}})$ where $S(\tilde{\mathbf{p}})$ is the normalized entropy.

Source: Our estimates.

In Figure 3 the information index is presented for each recursive sub-sample starting from 1972-74. In a cross entropy framework when the information index is zero, priors and estimates are equivalent. From an inspection of Figure 3 it appears that the information content sharply increased from 1976 to 1985 indicating that the addition of each single data points in these period increased the overall information content of the model estimates. The contribution of each data point was rather stable between 1985 and 1999, one could also say that the priors were conforming to the final estimates (i.e. posteriors). These findings suggest a turning point in the information content of the data after 1984. Therefore it was decided to split the sample 1972-06 into two sub-samples: 1972-83 and 1985-06, excluding year 1984 when milk quotas were introduced.

In Table 2 and Table 3 the estimated TPMs are reported for the sub-samples 1972-83, 1985-2006[7]. The normalized signal entropy $S(\tilde{\mathbf{p}})$ for the system was 0.6707, and 0.6165 for the period 1972-83 and 1985-06 respectively. The information index $I(\tilde{\mathbf{p}})$ was 0.3292 and 0.3835 for the period 1972-83 and 1985-06 respectively. The entropy indicators suggest a slight increase in information for the with-quota period.

The estimated TPMs already provide insight into the dynamic adjustment of dairy farms. For example, during both periods considered there was a strong tendency for farms to persist in the same size class from one year to the next (see transition probabilities on the diagonal containing elements p_{kk}). Comparing for example the estimated TPMs, estimated (i.e. 1972-83 and 1972-06 reported in the Appendix) it appears that using the full sample 1972-06 the magnitude of the diagonal elements is decreased as compared to the period 1972-83. The off-diagonal elements of the transition matrix

7 The TPM estimated over the full sample 1972-06 is available in the Appendix.

provide information on the extent to which dairy farms are going to scale up or down. For example considering Table 2, from one period to the next, about 4 percent of all farms with 30-49 cows will probably grow into dairy farms with 50-69 cows. In the period 1985-06 entry is found for the class sizes with more than 30 cows (see Table 3), whereas in the period 1972-83 entry is found only for farms with 30-49. At the same time between 1972 and 1983 small farm size classes are attracted towards the middle size class with 30-49 cows, whereas a similar growth process is found towards the large size classes with more than 70 cows when using the full sample.

Table 2. TPM for sub-sample 1972-83

Class	Exit	1-9	10-19	20-29	30-49	50-69	70-99	> 100	$S(\mathbf{p}_i)$
Entry	0.99992	0.00000	0.00000	0.00000	0.00000	0.00007	0.00001	0.00000	0.9973
1-9	0.17179	0.82577	0.00000	0.00000	0.00242	0.00001	0.00000	0.00000	0.6282
10-19	0.10581	0.05886	0.82407	0.00000	0.01124	0.00002	0.00000	0.00000	0.7115
20-29	0.06523	0.00000	0.03641	0.89810	0.00026	0.00001	0.00000	0.00000	0.4203
30-49	0.00027	0.00000	0.00000	0.00030	0.95473	0.04469	0.00000	0.00000	0.0594
50-69	0.00621	0.00000	0.00000	0.00000	0.00000	0.90896	0.08483	0.00000	0.3850
70-99	0.02810	0.00000	0.00000	0.00000	0.00000	0.00000	0.89851	0.07340	0.4849
> 100	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	1.00000	0.9999

Note: $S(\mathbf{p}_i)$ is the normalized entropy measure for the signal part of the estimated parameters.
Source: Our estimates.

Table 3. TPM for sub-sample 1985-06

Class	Exit	1-9	10-19	20-29	30-49	50-69	70-99	> 100	$S(\mathbf{p}_i)$
Entry	0.98933	0.00031	0.00001	0.00001	0.00019	0.00314	0.00683	0.00017	0.6362
1-9	0.18060	0.81940	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.6396
10-19	0.12147	0.06089	0.81764	0.00000	0.00000	0.00000	0.00000	0.00000	0.7101
20-29	0.08602	0.00000	0.06798	0.84599	0.00000	0.00000	0.00000	0.00000	0.6839
30-49	0.01926	0.00000	0.00000	0.03232	0.93032	0.01810	0.00000	0.00000	0.1891
50-69	0.03727	0.00000	0.00000	0.00000	0.00000	0.93049	0.03224	0.00000	0.2875
70-99	0.18308	0.00000	0.00000	0.00000	0.00000	0.00000	0.81622	0.00070	0.7856
> 100	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.99999	0.9998

Note: $S(\mathbf{p}_i)$ is the normalized entropy measure for the signal part of the estimated parameters.
Source: Our estimates

In Figure 4 the Shorrocks mobility index is reported for the two sub-samples, showing how the addition of one sample point at a time affected the mobility index in these two sub-samples. In the sub-sample 1972-83 mobility shows an inverse U-curve pattern, which is likely to be related to the switch in milk delivery system and associated farm investment strategies discussed before. In the second sub-sample, after 1984 mobility decreases to its lowest level in 1991, whereas afterwards 1990s it gradually increases. As such this confirms the hypothesis that the introduction of the milk quota system, at least immediately after its introduction, froze farm size adjustment in the Dutch dairy sector. However, in the course of time mobility increased, which is likely to be related to the increased possibilities to trade and lease of milk quota and the continued pressure on farmers to increase their scale as a strategy to minimize (fixed and labour) costs per unit of milk output.

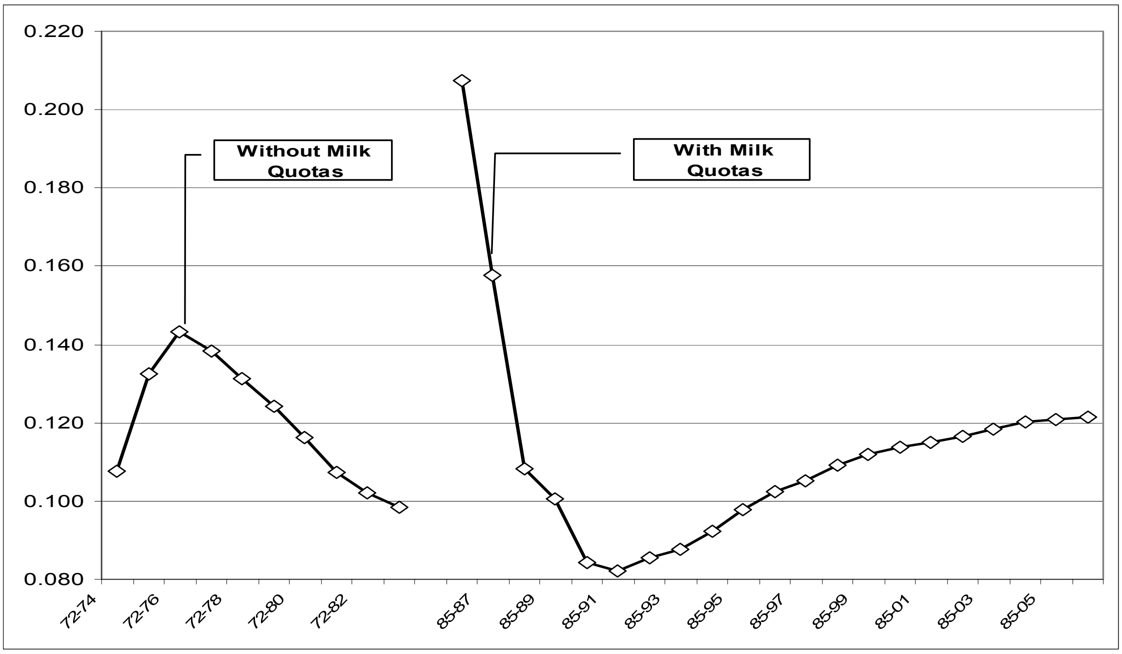

Figure 4. Shorrocks index for recursive samples
Source: Our estimates.

In Table 4 the mobility indices based on the two estimated TPMs (see Table 2 and Table 3) are reported. Overall we can say that Dutch dairy farms are rather immobile and mobility is larger when considering the with-quota period. As compared to the pre-quota period, the introduction of the quota increased the downward mobility and lowered the upward mobility. This is non-surprising since in order to expand one farm production rights have to be acquired, which can only be obtained by buying out other farms or leasing quota. This fits in with the estimated relatively large probability of exit during the with-quota period.

Table 4. Mobility indices for the estimated sub-sample TPMs.

	1972-83 Sample with Quota	1985-06 Sample without Quota
Shorrocks Index	0.098563	0.121516
Upward Mobility	0.314447	0.072555
Downward Mobility	0.685553	0.927445

Source: Our estimates

6. Projections

In this section the projections for the Dutch farm size dairy distribution are derived based on the estimated Markov transition probability. First a counterfactual projection is made in order to assess how the farm size distribution would have evolved if there would have been no milk quotas. In doing so the estimated TPM for the period 1972-83 was used selecting year 1983 as base year for projections. Figure 5 presents projected and actual farm size distribution in percent for the year 2006. As the Figure shows in the no-quota case, the fraction of farms in size classes 30-49 cows and >100 cows would have been larger than is currently realized and the farm size would have been dual with small farm with 1-29 cows on one side and large farms with more than 30 cows on the other side. The actual number of farms during the quota period suggests a concentration of milk production towards medium farms with 50-69 cows. Note that without the quota the number of very large dairy farms ('mega'-farms with herd sizes >100 dairy cows) would have significantly increased.

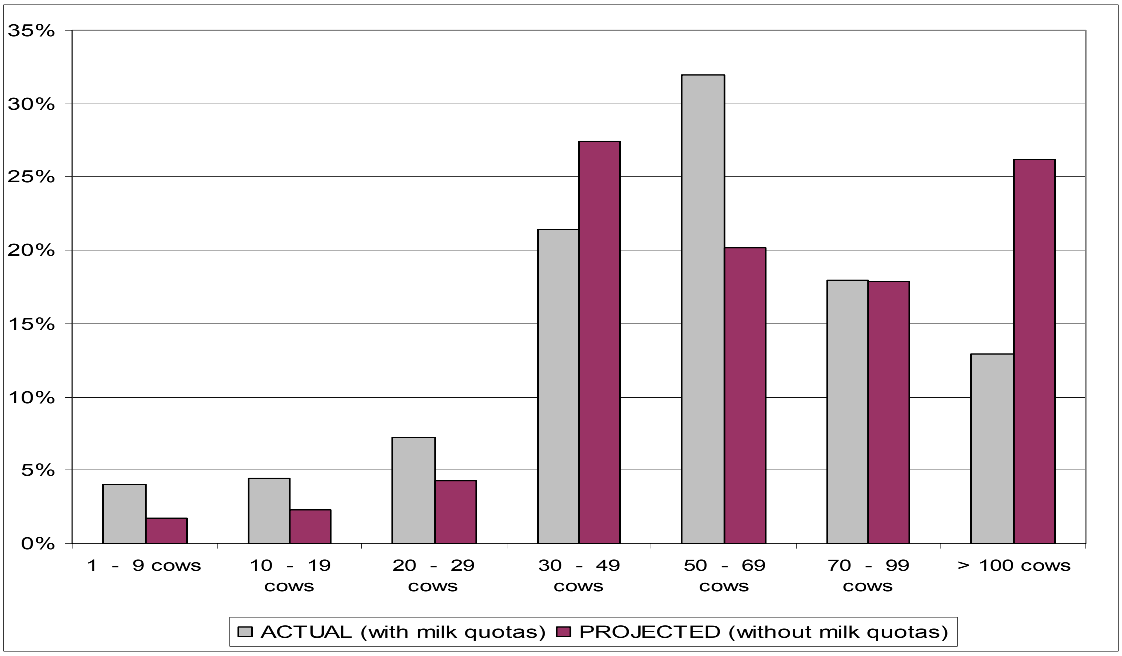

Figure 5. Projected versus actual farm size distribution for the year 2006 (percent)
Source: Our estimates.

The second set of projections is forward looking and more tentative as it tries to assess what would have been the Dutch dairy farm size distribution if after 2015, the structural adjustment in the Dutch dairy sector would be similar to that observed during the period 1972-83 when there were no milk quotas. Therefore two additional types of projections are done for the period 2007-2022. In the first scenario (i.e. Scenario 1, Figure 6) we assume that milk quotas will stay in place until 2022 (continuation of status quo) and projections are done using the TPM estimated for 1985-06. In the second scenario (i.e. Scenario 2, Figure 7) we assume a temporary continuation of milk quotas until 2015, whereas for the period 2015-22 milk quotas will be abolished and projections for this second period are done using the TPM estimated for 1972-83. It is assumed, that irrespective of which anticipatory trajectory is chosen, the milk quota will remain binding for the Netherlands until 2015. Comparing Figure 6 and Figure 7 shows that the abolition of milk quotas leads to an increase in the number of farms with more than 30 cows (see also Table 4) whereas for the small farms a decline is predicted. This has to do with the fact that during the period 1972-1983 many small dairy farms went out of business (see Figure 2) and no significant entry probabilities were estimated in the 1972-83 TPM (see Table 2). As Table 5 illustrates the predicted total number of dairy farms in case of quota abolition would be 11469, which is about 20 percent above than in the with quota scenario.

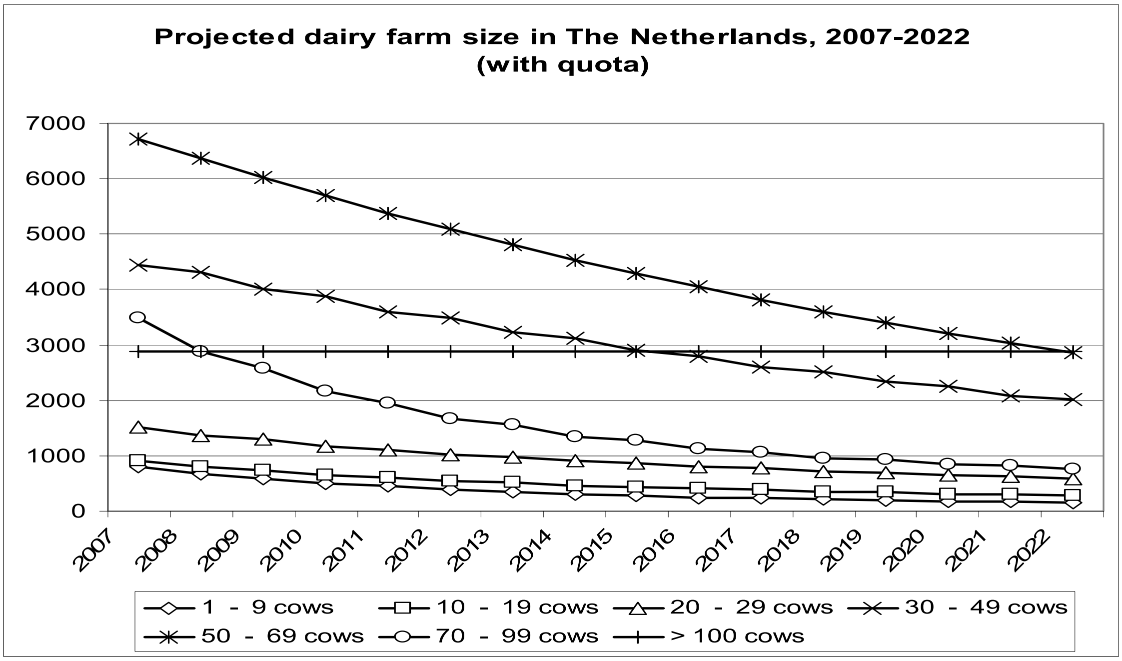

Figure 6. Projected dairy farm size distribution in the Netherlands (with quota scenarios).
Source: Our estimates.

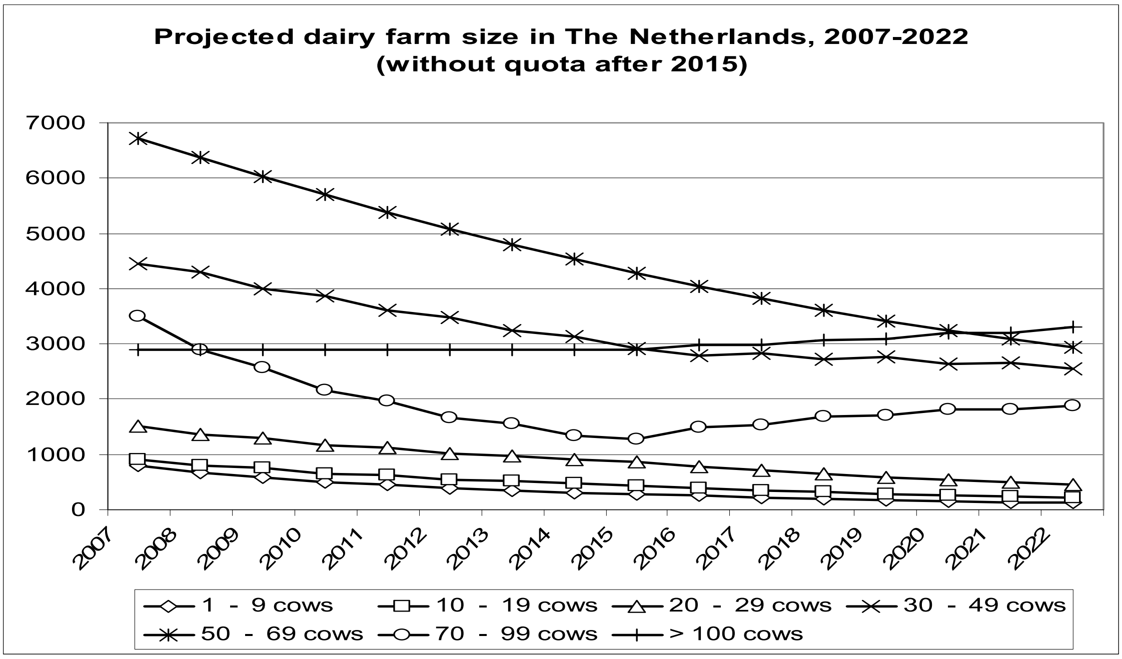

Figure 7. Projected dairy farm size distribution in the Netherlands (without quota scenarios).
Source: Our estimates.

Table 5. Projected farm size distribution for 2007, 2016 and 2020 for two forward looking scenarios

Year	Scenarios	1-9	10-19	20-29	30-49	50-69	70-99	> 100	Total
2006	Scenario 1, 2	804	913	1520	4444	6724	3496	2887	20788
2015	Scenario 1, 2	279	442	863	2906	4287	1269	2891	12937
2022	Scenario 1	157	280	591	2010	2868	753	2891	9550
	Scenario 2	126	208	445	2549	2948	1885	3308	11469

Source: Our estimates.

7. Conclusions

This paper analysed the impact of milk quotas on the dairy farm structure of the Netherlands. Initially it was examined how the farm structure has changed over time detecting to which extent the introduction of milk quotas in 1984 affected this structural change process. In doing so Markov TPMs and mobility indicators were estimated for two sub-periods: 1972-83 and 1985-06. The estimation results were then used to run a counterfactual scenario for the period 1984-2006 to project how the farm size distribution would have evolved if there would have been no milk quotas. In addition tentative forward looking projections on the evolution of the Dutch dairy farm structure were made for the period 2007-22 assuming two scenarios: milk quota prolongation up to 2022, and milk quota phasing-out by 2015.

As the Shorrocks mobility indicator shows, the introduction of milk quotas in April 1, 1984 at least initially reduced mobility and structural adjustment. However, after some years mobility started to increase, which is likely to reflect the developed possibilities to trade and lease quota. On average the introduction of the quota has not reduced farm mobility, but rather increased it (as is reflected in the estimated pre and post-quota TPMs). The introduction of the quota significantly affected the direction of farm mobility. Relative to the without quota period, after 1984 the downward mobility increased at the expense of upward mobility. This finding emphasizes that the quota system increased the interdependencies between dairy farms as regards their structural adjustment. For a farm to expand, it has to acquire production rights, which only can be obtained by buying or leasing them from other farms.

There is evidence for the statement that the milk quota system favoured a concentration towards medium farms (i.e. farm with 50-69 cows). On the one hand milk quota might keep milk in certain areas where otherwise dairy would have been closed. However, milk quota limits milk output and with the ongoing increasing farm scale tendency this drives down the number of dairy farms and dominates other effects. Without quotas it was found that the number of mega-dairy farms (herd size > 100 dairy cows) strongly increased.

The estimated model does not explicitly account for changes in economic signals (price support, direct payments). In pre-quota period there was no limit on output, but generous price support, making dairy an attractive business. When quota will be abolished the milk price is expected to be not or much less supported and is likely to be much lower. So the economic conditions are expected to be rather different, although in both cases there are no quotas. Projections, in particular the forward looking ones, need therefore to be interpreted with due care. On other hand, the farm structure shows a tendency to gradually adjust and to be rather well-approximated by Markov models.

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Appendix

Table A1. TPM for sub-sample 1972-06

Class	Exit	1-9	10-19	20-29	30-49	50-69	70-99	> 100	$S(\mathbf{p}_i)$
Entry	**0.9999**	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.9980
1-9	0.1830	**0.8167**	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.6488
10-19	0.1183	0.0593	**0.8220**	0.0000	0.0000	0.0000	0.0001	0.0004	0.6945
20-29	0.0702	0.0000	0.0393	**0.8905**	0.0000	0.0000	0.0000	0.0000	0.4594
30-49	0.0035	0.0000	0.0000	0.0047	**0.9317**	0.0601	0.0000	0.0000	0.1606
50-69	0.0223	0.0000	0.0000	0.0000	0.0000	**0.9104**	0.0673	0.0000	0.4077
70-99	0.0938	0.0000	0.0000	0.0000	0.0000	0.0000	**0.8889**	0.0172	0.5188
> 100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**1.0000**	0.9999

Note: $S(\mathbf{p}_i)$ is the normalized entropy measure for the signal part of the estimated parameters.
Source: Our estimates