Title:

The impact of dairy policy-regulations on structural change, production costs, milk quality and N-excretion: Evidence for the Flemish dairy sector

Authors:

Bart Van der Straeten(*)
Department of Agricultural Economics, University of Ghent

Jeroen Buysse
Department of Agricultural Economics, University of Ghent

Guido Van Huylenbroeck
Department of Agricultural Economics, University of Ghent

Ludwig Lauwers
Department Social Sciences, ILVO (Institute for Agricultural and Fisheries Research)

*Corresponding Author: Bart.vanderstraeten@ugent.be

Abstract

Since 1987, the EU allows dairy quota transfers within member states, but the trading rules differ across member states and in time. In the Flanders case, before 1996, quota transactions happened in a free market with high quota prices, from 1996 to 2004 they have been centrally organised with a fixed lower price. Various studies have quantified quota transfer inefficiencies by comparing the observed quota allocation and the allocation that should appear under a perfect quota market. This study uses a Markov chain model to quantify observed quota transactions and the resulting structural development of the Flemish dairy sector. The results show that structural development is higher during the free market period and that this has also an influence on the aggregate sector performance with respect to total production cost, nitrate emission and milk quality. With the free quota market policy, structural development would lead in 2014 to a decline of the total production costs of 3.04%, a reduction of milk quality penalty points of 20% and a decrease in the N- excretion of 2.95%. With a restricted quota mobility, structural development resulted only in improvements of 2.58% (-15.1%), 14.26% (-28.7%) and 2.20 % (-25.4%) respectively.

1 Introduction

Since the introduction of the common agricultural policy, the European agricultural sector has faced an important structural change. This is in particular the case for dairy farming. In Flanders, the northern part of Belgium, for example, the number of farms has dropped from 27,663 in 1984 to 8,862 in 2005. In this period the European policy has changed several times. The introduction of dairy quota in 1984 was the most important policy change in recent history. At that time, the system of guaranteed prices had created large government stocks of butter and powdered milk, consuming a significant part of the EU budget. This European policy of limiting milk production is considered as one of the most notable applications of quotas (Alvarez et al. 2006).

Since 1987, the EU allows quota transfers within member states, but trading rules differ across member states (Bailey 2002; Alvarez et al. 2006). In Flanders the quota transfer system can be divided in three periods. At the start in 1987/88, a rather liberal system of quota transfers has introduced. This system has undergone only minor changes until in 1996/97 the quota trade regulation has been reformed drastically. Before 1996 free quota mobility between farmers was allowed and merging was possible, however liable to a siphon. The siphon was subject to the farm quota size and changed over time. Because of some perverse effects of the liberal system in particular high quota prices, the basic idea of the major reform of 1996/97 was to (1) safeguard the sector profitability, (2) work out an acceptable regulation for young farmers, ensuring reasonable quota prices, and (3) pursuit an efficient, adaptable and manageable system. Therefore free quota mobility between farmers has been forbidden in that year. Since then, transfers of quota were only possible through a centrally organised quota fund, or by means of taking over an existing farm or establishing a new farm. A third period started in 2004/2005 in which free mobility is again allowed albeit a bit more regulated than in the first period (Jespers et al. 2006). Because of this drastic change in the rules, the Flemish situation is an exemplary case to study the effect of quota trade regulations on the structural change in the dairy sector.

The goal of this paper is to understand the role of quota exchange policy on structural change and its impact on some key characteristics of the Flemish dairy sector. Flanders is a region in Belgium (E.U.) with an intensive agriculture. In 2005 Flanders has 34,410 farms with a total agricultural production value of 4.471 billion €. The dairy sector is third most important sub sector with a production value of 552 million € (11.7%). In 2005, Flanders counts 8,862 dairy farms, holding 308,883 dairy cows, and dairy quota amounts 1.940 billion litres.

The effect of structural change on other sector parameters is hardly examined (Huffman & Evenson 2001). Weersink and Tauer (1991) have found that structural change causes changes in productivity. Effects on other parameters have, according to the authors knowledge, so far not been analysed yet. In this research, the effects of structural change on productions costs, milk quality and nutrient emissions are measured. These three parameters are selected because of data availability and because of the importance to look also to non-economic parameters when evaluating quota transfer policies which are often inspired by other than economic reasons. Production costs can be seen as an economic parameter, nutrient emissions and milk quality are respectively an environmental and health or processing parameter.

The structure of the article is as follows. First, we motivate a simplified approach to analyse structural change, given the specificity of quota regimes and data availability. Second, the use of Markov-analysis to define and analyse structural change is discussed in detail, followed by a description of the Markov chain model and data used in this study. Then three structure dependent variables are described. In the following section the structural change is calculated under two policy assumptions and simulations of the structural evolution path till 2014/15 are made (because the quota policy is likely to be abolished at the end of March 2015). The implications of the structural change on the sector performance are illustrated by means of describing the evolution of the three variables mentioned before. The final section contains a summary and some conclusions.

2 Structural change and sector characteristics in relation to quota regimes

Several studies have dealt with the issue of structural change in agriculture. A majority of them looked at the effect of several government policies concerning the whole agricultural sector, e.g. R&D and government payments to structural change in the U.S. (Huffman & Evenson 2001; Yee & Ahearn 2005). Also Tweeten (1984) discusses structural change of the US farm sector and relates it to his micro-economic foundations: he concludes that technology, national economic growth and off-farm income are driving forces and must be taken into account when describing structural change. Goddard et al. (1993) adds changes in human capital, demographics, off-farm employment, related market structure, and public programs as other important determinants. According to Weiss (1999) most of the theoretical literature stresses on managerial ability and life-cycle patterns as major reasons why firm/farm sizes changes over time. Although it is important to look to some general principles, knowing the effect of some sub sector specific policies is important as well.

The importance of the impact of quota on the structural evolution of a sector is recognised by Bailey (2002) and Alvarez et al. (2006). Both studies use an estimated cost function to describe inefficiencies and changes in the quota market. Bailey (2002) focuses on differences between 6 European Union member states and Alvarez et al. (2006) on differences between milk producers within Spain. Once the cost functions and quota rent are estimated both Bailey (2002) and Alvarez et al. (2006) compare the actual situation with a situation of a perfect quota market. Bailey (2002) concludes that countries applying strict quota rules are likely to experience less structural change than those with more liberal quota trade arrangements.

In contrast to Bailey (2002) and Alvarez et al. (2006), this paper presents an approach based on Markov analysis. The advantage of this methodological choice is that simulations do not rely on the assumption of a perfect quota market and that also the stopping behaviour of different types of farms is taken into account. Simulations reflect observed quota transaction patterns and structural change. In the Flemish case, this means that changes in policy regimes can be compared. Assuming continuation or change of these policies, projections can then be made of structural change and its impact on other parameters.

On the other hand, the presented approach simplifies other models in literature of structural change. There are two reasons for not taking into account some important economic parameters, such as prices, costs and technological change. The first motivation is that the simplification is possible because the quota restriction limits the total size of the dairy sector. The logic of this simplification is illustrated in Figure 1.

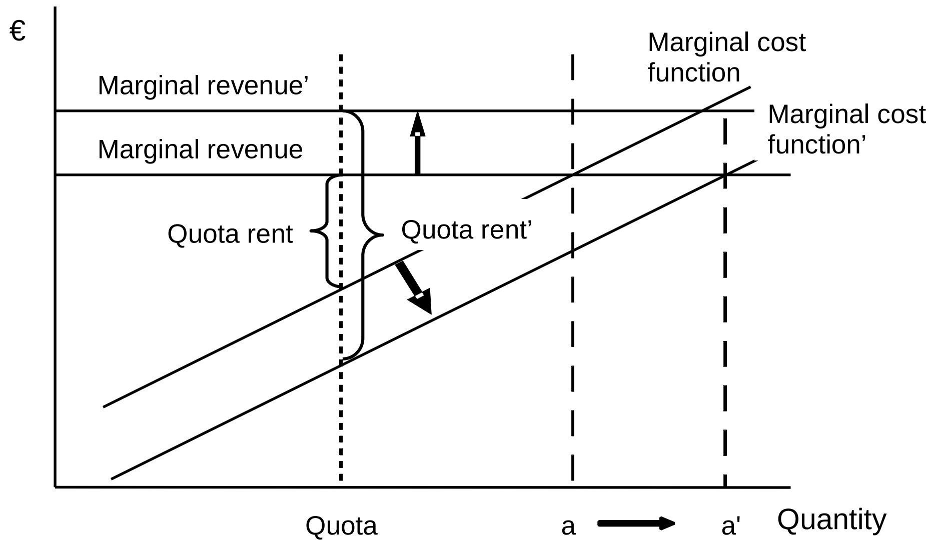

Figure 1: Illustration of shift in production as a consequence of changed marginal revenues and cost in case of quota or without quota.

As long as the firm or sector, as illustrated in Figure 1, does not face any quota constraint, the quantity produced is a. This production will increase to a**'** when the marginal cost decreases to the marginal cost**'** and even further when the marginal revenue increases to the marginal revenue**'.** When the firm or sector is subject to a binding quota constraint, the production is not affected by changes of marginal revenues or marginal costs (dotted line in Figure 1). As long as the quota remains a binding constraint, the variation of economic parameters is absorbed in changes of quota rent, which becomes quota rent**'**. In a quota regime, as it is the case in Flanders, actual growth and stopping behaviour of farms is not directly influenced by prices and costs changes, but by their translation in quota rent. .

While the aggregate level of prices and costs is not so important in the structural change of the dairy sector, Alvarez et al. (2006) argues that the variability between farms of these prices and costs for general efficiency reasons should play a role in the exchange of quota. A farm with a high margin on milk, and thus a high quota rent, should be able to acquire additional quota from a less profitable farm. A higher difference in profitability among dairy farms should therefore lead to more quota exchanges, which again reduces variability between farms. In Flanders, however, the differences between farm gate milk prices are relatively small because of the limited number of processors and the EU sustained milk powder and butter prices. The costs variations between farms are more important because of differences in efficiency and scale of the farms. Alvarez et al. (2006) have shown that in Spain differences in efficiency and scale both contribute to differences in quota rent.

From the great disparity in profitability among dairy farms, on the one hand, and only limited exchanges, on the other hand, Alvarez et al. (2006) conclude that the dairy quota market is not transparent and not functioning well due to complex policy restrictions of quota transfers. This is also empirically confirmed by Van Passel et al. (2006) for the Flemish case. With an econometrically estimated panel model, Van Passel et al. (2006) measure the impact of efficiency and size, as two components of cost differences, on the growth of Flemish dairy farms. They have found that efficiency is not a significant contributor to dairy farm growth, while farm size is highly significant. Due to quota trade restrictions, a higher efficiency alone apparently is not sufficient to acquire additional quota. The link between farm size and growth is probably significant because in Flanders the differences in costs are more related to size than to efficiency and quota transaction restrictions are often linked with size limits. Therefore, it is important to include besides farm size also quota transfer policies and actual transfer behaviour to make a simple but yet reliable model of structural change in the Flemish dairy sector.

The disadvantage of such a simplified model of structural change is that it can not simulate the impact on quota rents, but the lower data demand can be seen as an advantage of the approach.

The second motivation for using a simple model is that the data on prices, costs and technological change are often not accessible and, if available, are based on not representative samples. The proposed model works with data available at administrative level for the whole population to assess accurately the process of structural change. Based on the number of farms in each size category and the average characteristics for each size category calculated with a non-representative sample, a reliable analysis is possible of the impact of structural change on other parameters such as production costs, milk quality and nutrient emissions (N).

3 Markov chain model and data

3.1.Analysis of structural change with Markov analysis

We perform our analyses in three steps. The first step is to measure structural change by changes in size distribution of farms. This is to characterize the probability of mobility of an individual farm from and to different states of size and to identify how the quota transfer policy affects this mobility path. Markov-models are used because they are known as a convenient tool for analyzing the systems evolutions (Mohapatra et al. 2007). Also Padberg (1962) suggests that a Markov process is appropriate to analyze the dynamics of the number of firms and to evaluate the changes in size distributions of firms within an industry. A list of examples of agriculture related Markov studies is given by Zepeda (1995a; Zepeda 1995b).

Padberg (1962), Hallberg (1969) and MacMilla, Tung and Tulloch (1974) point out following shortcomings of a stationary Markov process: movement, entry, and exit are forced to be proportional to farm numbers while other economic factors are not allowed to influence farming structure. They recommend a non-stationary model incorporating economic factors as explanatory variables, but in the case of quota with positive rent the economic factors explain less as they are captured by changes in the quota rent. Therefore, we argue that in sectors with a quota system, stationary Markov processes indeed can be used.

Before we can measure the structural change of the sector, the order of the Markov chain must be defined. While in first-order Markov chains the transition probabilities controlling the future state depends only on its current state, in higher-order Markov chains the current state alone is not sufficient to measure the future state (Cazacioc & Cipu 2005). Considering a second-order Markov chain, the transition probabilities depend on the states at lags of both one and two time periods (Cazacioc & Cipu 2005).
We make use of the Akaike Criterion (AIC) to define the order of the Markov model. This criterion is based on the loglikelihood functions for the transition probabilities of the Markov chains constructed on a certain data series. These log-likelihoods depend on the transition counts and the estimated transition probabilities (Cazacioc & Cipu 2005). The log-likelihoods for Markov chains of order 0, 1, 2 and 3 are:

$$
\begin{aligned}
L_0 &= \sum_{j=0}^{s-1} n_j \ln(\hat{p}_j) \\
L_1 &= \sum_{i=0}^{s-1}\sum_{j=0}^{s-1} n_{ij} \ln(\hat{p}_{ij}) \\
L_2 &= \sum_{h=0}^{s-1}\sum_{i=0}^{s-1}\sum_{j=0}^{s-1} n_{hij} \ln(\hat{p}_{hij}) \\
L_3 &= \sum_{g=0}^{s-1}\sum_{h=0}^{s-1}\sum_{i=0}^{s-1}\sum_{j=0}^{s-1} n_{ghij} \ln(\hat{p}_{ghij})
\end{aligned}
\tag{1}
$$

Here the summations are performed over all the states s of the Markov chain. The Statistics of AIC can be seen below:

$$AIC(m) = -2L_m + 2s^m(s-1) \tag{2}$$

The order m that minimizes equation (2) is chosen as appropriate. For the policy measures that will be analyzed in this paper, the chain seems to be of second order, which gives following notation for the transition probabilities:

$$P_{hij} = \Pr(X_{t+1} = j \mid X_t = i, X_{t-1} = h) \tag{3}$$

For farms which are in state *1* in year *t-2*, the probability matrix of year *t* is given as:

$$
\begin{bmatrix}
P_{100} & P_{101} & \cdots & P_{106} \\
P_{110} & P_{111} & \cdots & P_{116} \\
\vdots & \vdots & \ddots & \vdots \\
P_{160} & P_{161} & \cdots & P_{166}
\end{bmatrix}
\tag{4}
$$

The change in farm size distribution is the key parameter to structural development. While in literature often use is made of herd size to measure farm size (Zepeda 1995a; Bailey 2002; Colman et al. 2002; Kim et al. 2005), we prefer, however, the quota size as measure for farm size. Taken together with the herd size, this parameter also capture cow productivity. As cow productivity can vary among different farms and as returns depends on total milk production and not on the number of cows, we argue that quota size is a better indicator for the farm size than the number of cows.

3.2. data and model choice

The analysis uses data from the so-called ‘administrative’ data base, this is the data base from the administrative follow-up of the quota regulation. The data base is set up by the Flemish Department for Agriculture and Fishery (DAF, in Dutch ALV). The data set contains the quota size of each Flemish farm for every year along the period 1987-up to now (for the current paper, data up to 2005 are used). The quota size of each Flemish dairy farm is recorded at the end of each dairy quota year (31st of March). The farms were categorised into seven farm states with different quota sizes (Table 1). These categories allows to perform further research on the impact of structural development on other sector parameters.

Table 1: The seven states of farm size, based on farm quota

number	Quota size (litres of milk)
1	0
2	0 – 100,000
3	100,000 – 200,000
4	200,000 – 300,000
5	300,000 – 400,000
6	400,000 – 500,000
7	>500,000

While some researches assume that farms typically do not decrease in size without going out of business (Disney et al. 1988), others assume that in a single period farms could change by only one size category (Zepeda 1995a). In the dataset all possible transition occurred and, therefore, the model also allows transitions between all different states. This means that farms can both increase of decrease in size from one to another year.
Using time as a proxy for the policy regulation we divide the period into two sub periods. The first period, called ‘free mobility’, is the period where free mobility between farmers was allowed (1987/88-1995/96). The second period, called ‘restricted mobility’, is the period where free mobility was forbidden (with some exceptions) and where every quota transaction had to pass along the public Quota Fund (1996/97-2003/04). For both investigated policy regulations a transition matrix is calculated. The third period (from 2003/2004 on) with again free mobility is not considered because of not yet enough observations.

Central to the application of the Markov chain model to data is the estimation of its transition probability matrix. Let X_t denote the quota size of the farm at time t. The state space of X_t is [0,1,…,6]. For each year we can count the number of times that $X_t = i$ is preceded by $X_{t-1} = h$ and is followed by $X_{t+1} = j$ for h,i,j= 0,1,…6. This summed over all years per period gives us the transition records for ‘free mobility’ and ‘restricted mobility’. The estimates of the transition probability matrices are obtained by dividing each row element of transition records by its corresponding row total. The summing over all years assumes that the Markov chain is homogeneous in time.

We use a Markov chain model, based on the Markov process proposed by Chavas and Magand in Zepeda (1995a). They characterize the process as a function of net new entries (new entries minus exits) and movement between size categories. The net new entries in Zepeda (1995a) are a function of economic parameters while in the model proposed in this paper the new entries are a function of not filled quota of existing farms while the exits are a function of the number of existing farms and transition probabilities and therefore incorporated in the probability matrix.

$$n_{kt} = d_{kt} + \sum P_{ijkt} * n_{i\ j(t-1)} \qquad (5)$$

The number of first time entrants to state *k* between *t*-1 and *t* are defined by d_{kt}. The movements between size categories (states) at time *t* equals the transition probability P_{ijkt} times the number of farms making the transition from state *i* at time *t-2* to state *j* at time *t-1*.
To simplify the analysis, following assumptions are made: (1) the average quota size in each state is constant over time (based on actual figures of the period 1987-2005), and (2) the distribution of new entries over the different states is constant over time (based on actual figures of the period 2003-2005).

The model is build up as follows: we start from two given basic years t and t+1, of which the true size distribution is know. A matrix is formulated with the number of transitions between both years. In the next step this matrix is multiplied by the corresponding probability matrix. For each state we measure the number of farms and calculate the total quota of farms in that state. The sum of quota of each state is subtracted of the national (Flemish) quota. The difference between national and pre-occupied amount is filled up with new entries according to the fixed distribution over the different states. The total active farms per state is the sum of the number of farms calculated by using the probability matrix and the new entries. This sequence of events is repeated each year.

3.3. Production costs, milk quality and total N-excretion

Based on the structural change in terms of farm size distribution, the second phase of the research simulates the effect of the structural change on three other sector parameters, such as the effect on the production costs of milk (€/litre), the average milk quality (in terms of penalty points) and the total N-excretion of the Flemish dairy sector.

To measure the impact of structural development on the milk production costs, data of the accounting system of Boerenbond (Flemish farmers union) are used. The dataset contains 693 dairy farms (7.81% of the total number of Flemish dairy farms) (Table 2)

Table 2: Comparison of the number of farms and the average quota size per state between the Boerenbond-dataset and the ALV-dataset

	Boerenbond dataset			ALV dataset			Deviation average quota size (%)
	Number of farms	Farms (%)	Average quota size	Number of farms	Farms (%)	Average quota size	
State 1	8	1.16	78,920	2,408	27.17	54,302	-31.1932
State 2	73	10.53	155,570	2,568	28.98	142,315	-8.52022
State 3	166	23.95	252,020	1,532	17.29	247,808	-1.6713
State 4	169	24.39	346,254	1,094	12.34	343,856	-0.69247
State 5	130	18.76	443,285	622	7.02	441,212	-0.46771
State 6	147	21.21	639,717	638	7.20	627,250	-1.94878

The Boerenbond-dataset contains relatively more large farms than the ALV-dataset. However the average quota size per state are relatively equal between both datasets, except for state 1 and 2 (Table 2).

The total production cost of milk per farm is derived from the accounting data (variable + fixed costs). To obtain the average production cost (€/litre) the total production cost is divided by the size of production. The milk price is relatively constant and mainly varies among farms according to the milk quality. Therefore, the total production cost gives us an indication about the farm profitability as well.

A second variable in our research is the average milk quality. This parameter is important to the processing industry. A higher quality leads to lower processing costs. For the farms it is important as well, as the received milk price is derived of the milk quality. There are six parameters in the official quality determination: bacterial count, cell count, freezing point, sediment, disinfectants and inhibitors. The first five parameters are evaluated in a penalty point system. The dairy farm gets penalty points according to a specific scheme if the milk does not meet certain standards. A price deduction of 0.62 EUR per 100 litres is applied for each penalty point at the monthly payment of the milk delivered by this dairy farm. The bacterial count indicates the bacterial infections after milking. The cell count gives an indication of the udder health. A higher freezing point indicates if the milk is diluted with water. Sediments point at an insufficient purification of the udder and the udder environment. Disinfectants are necessary in keeping the milk installation bacteria free. Remnants however, show an insufficient rinsing of the installation. As the penalty points system of a farm contains five out of six quality parameters, it gives a good indication of the farm milk quality. The average milk quality is measured per state en is expressed as penalty-litre-points. This parameter is obtained by multiplying the penalty points with the delivered quantity of milk. It allows to take the number of penalty points into account as well as the quantity of milk delivered with that certain quality. Thus this parameter seems to give a better indication of the quality of the total Flemish milk quota than only counting the given penalty points. Penalty-litre-points are larger either when a larger quantity is delivered or when a higher number of penalty points is given (two penalty points lead to double penalty-litre-points for the same delivered quantity as one penalty point).

The third variable is N-excretion, which is an important variable, as the Flemish region faces an excess of manure (N). The N-excretion is subject to a strict legislation and the rights to produce manure (in terms of N) are divided among farms by means of transferable nutrient emission rights. A decline (increase) of the sector N-excretion can lead to an excess (shortage) of nutrient emission rights in the sector. This would mean an extra benefit (cost) for the sector. The N-excretion of a cow is proportional to the cow productivity. A higher milk production per cow leads to a higher N-excretion (equation 6):

$$Y = 50 + 0.008 * X \qquad \text{with Y = N-excretion (Kg N/cow)} \qquad (6)$$

And X = cow productivity (litre milk/cow)

During the analysis averages values for each farm size category can be calculated for the variables production costs, milk quality and nitrogen excretion. These averages per category are multiplied by the number of farms per category that are obtained from the ALV dataset and simulations of the Markov Chain. Despite the fact that the sample of the Boerenbond dataset is not representative, the final aggregate result is representative because the ALV dataset covers the total population and is used to weight the parameters of the Boerenbond dataset.

4 Results

4.1.Effects of policy regulations on structural change in the Flemish dairy sector:

Since the introduction of quota transfers, the Flemish dairy sector experienced a major structural development. Table 3 illustrates the difference between the rate of change between the two most important policy alternative periods and indicates that structural development is higher during the free mobility period than during the restricted mobility period.

Table 3: Average annual growth rate of the number of farms and the average quota size during the free mobility and restricted mobility period

	Number of farms		Average quota size	
	Rate of change Farms/Year	% change	Rate of change litres/Year	% change
Free mobility	-1,008	-6.22	8,099	+6.64
Restricted mobility	-331	-3.07	5,715	+3.17

Table 4: The mean probability of non-mobility per size category and per policy period (free mobility and restricted mobility) (* significance of the independent t-test between period with free mobility and period with restricted mobility)

Transition (*)	Period of free mobility (1988/89-1995/96)	Period of restricted mobility (1996/97-2003/04)	Significance(*)
2-2-2	0.882051197	0.908965695	0.065**
3-3-3	0.899924503	0.946903187	0.049***
4-4-4	0.864300079	0.945965796	0.003***
5-5-5	0.843465046	0.947176368	0.001***
6-6-6	0.825652842	0.94909578	0.002***
7-7-7	0.934160305	0.987872106	0.009***

(*)First number indicates the original state or size category, the second and third numbers indicate the two successive years. As we report the farms remaining in the same state, the states are the same for the three periods

Table 4 gives the mean probability of remaining in a state per policy measure and per state or size category. For every state the probability of non-mobility is higher in the period where mobility is restricted. It can therefore be concluded that the choice of policy has a significant influence on the transition probabilities and, as a result, on the rate of structural change.

Based on the calculated probabilities for the two types of transfer policy, it is possible to perform simulations of the total number of farms, the size distribution of the farms and the size distribution of the Flemish quota.

Figure 2 shows the total number of farms actually observed until 2006 and the simulated number of farms until 2014 under the assumption of a free mobility quota regulation and restricted mobility quota regulation respectively.

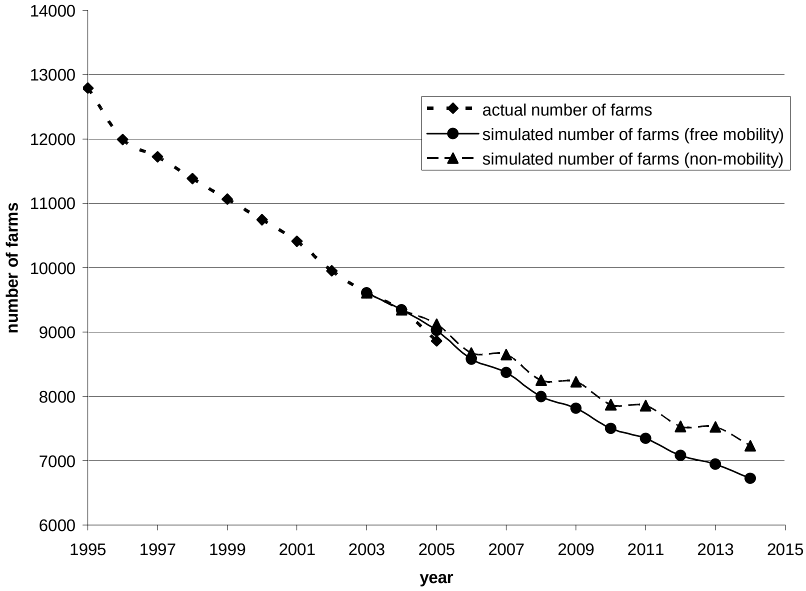

Figure 2: number of farms in the period 1995-2014

It is clear that the trend of decreasing number of farms will continue in the nearby future. Assuming free mobility, the number of farms will drop from 8,862 farms in 2005 to 6,725 in 2014. Assuming restricted mobility, the number of farms in 2014 will be 7.5% higher than assuming free mobility (7,231). Besides this decreasing total number of farms, the distribution of farms over the different states changes as well (Figure 3). The number of smaller farms (with a quota less than 200,000 litres) drops the most. Their relative importance decreases under both assumptions ‘free mobility’ and ‘restricted mobility’ from more than 55% to respectively 39.4 % and 43.2 %. Larger farms (quota more than 400,000 litres) form a larger part of the total number of farms. Their share grows from less than 15% to 26.6% and 21.4% (resp. free mobility and restricted mobility).

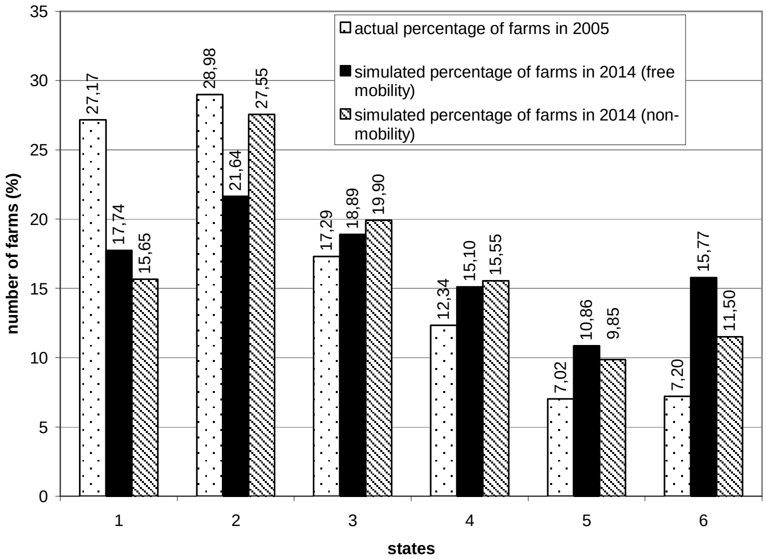

Figure 3: Distributions of farms per state for 2005 (actual figures) and simulated in 2014 under assumption of free mobility and restricted mobility

This trend is also reflected in the total quota per size category (Figure 4). Small farms are loosing importance while larger farms collect a higher share in the total national quota. In 2005 more than a quarter (25.8%) of the total national (Flemish) quota is in hands of the smaller farms. In 2014 these farms only will produce less then 15% when free mobility is assumed. When the government imposes a restricted mobility policy, the loss of quota will be less and they will produce 18.11%. Looking at the larger farms, they have now a share of 35.9%. In 2014 the larger farms will produce more than half (51.4%) assuming free mobility and 44.0% assuming restricted mobility.

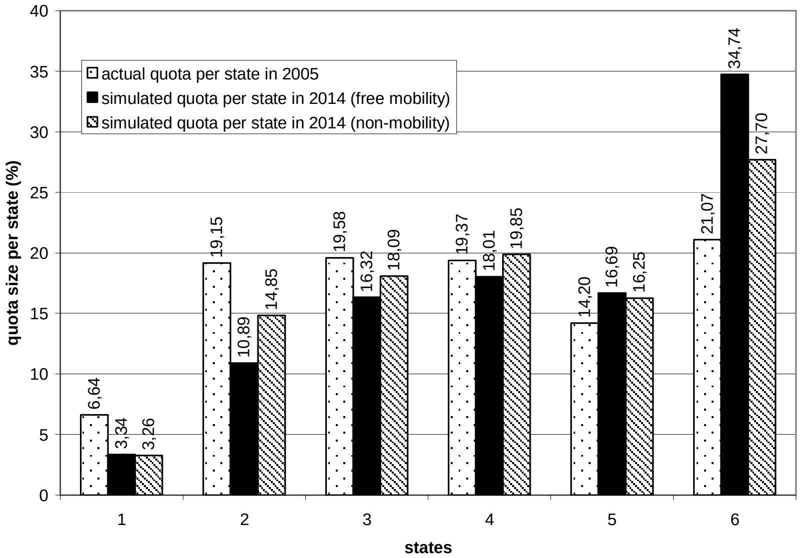

Figure 4: Distributions of the total quota per state for 2005 (present figures) and simulated in 2014 under assumption of mobility and restricted mobility

The simulated number of farms per size category is the input in the assessment of structural development and the influence of quota transfer policy on the rate of change of some key sector parameters. The following sub section first describe the production cost and the milk quality and then the change of N-excretion.

4.2. Effects of structural change on total production cost and average milk quality

The structural change is given in terms of discrete size distribution of the farms. To evaluate the evolution of both sector parameters we first calculate the mean values of these parameters for each state (Table 5: average production costs (€/litre milk) and milk quality (penalty-litre-points/litre quota) given per state). The production cost is the total (variable + fixed) costs per litre produced milk over the years 2002-2005. Milk quality is based on data of the period July 2005 until September 2006.

Table 5: average production costs (€/litre milk) and milk quality (penalty-litre-points/litre quota) given per state

Quota state	Production costs (€/litre milk)	Milk quality (penalty-litre-points/litre quota)
1	0.2454	0.190454
2	0.2003	0.115299
3	0.1896	0.058469
4	0.1850	0.045169
5	0.1809	0.033123
6	0.1749	0.032476

Larger farms seems to perform better than smaller farms in terms of average production costs per litre produced milk (P=0,000), due to the economy of size. Also the milk quality is significantly higher on larger farms (P=0.000). As we can find significant differences between the states for both parameters it is likely that structural change indeed can also influence the aggregate outcome of these sector parameters.

The comparison between the actual quota distribution (2005) and the quota distribution in 2014 for both policy assumptions is shown in Table 6. Table 7 gives, based on the figures in Table 6, the total production costs and the total penalty points per state and for the whole sector.

Table 6: Distribution of the national (Flemish) quota (litres quota) in 2005 and 2014 (assuming free mobility and assuming restricted mobility)

State	Actual distribution (2005)	Simulated distribution in 2014 (free mobility)	Simulated distribution in 2014 (restricted mobility)
1	128,965,098	36,074,387	30,142,701
2	372,136,287	129,004,614	210,534,250
3	380,469,262	246,161,811	303,383,914
4	376,390,172	304,991,336	376,212,338
5	276,080,514	341,310,113	343,890,009
6	409,555,211	876,605,624	669,984,670

Table 7: production costs (€) and penalty points (number) given per state in 2005 (present figures) and simulated in 2014 under assumption of free mobility (FM) and restricted mobility (RM)

state	Production costs (€)			Penalty-litre-points		
	2005	2014 (FM)	2014 (RM)	2005	2014 (FM)	2014(RM)
1	31,648,035	15,873,833	15,490,162	24,561,919	12,319,621	12,021,856
2	74,538,898	42,195,338	57,523,980	42,906,942	24,288,968	33,112,618
3	72,136,972	59,866,035	66,321,730	22,245,657	18,461,536	20,452,348
4	69,632,182	64,451,738	71,038,,625	17,001,168	15,736,327	17,344,560
5	49,942,965	58,380,113	56,865,797	9,144,615	10,689,466	10,412,193
6	71,631,206	117,523,071	93,693,336	13,300,715	21,822,066	17,397,283
total	369,530,259	358,290,129	360,933,630	129,161,015	103,317,984	110,740,859

The total costs of producing the Flemish quota has decreased in the recent past and is expected to further decline due to the structural development. Under the mobility policy, the total production costs will yearly fall on average with 1,248,903 € (-0.338%) during the coming 9 years. With a restricted quota mobility, the total production cost falls only with 955,181 €/year (-0.258%). The average milk quality (expressed by penalty-litre-points) benefits from the structural change as well. In 2005 129,161,015 penalty-litre-points were given to the whole Flemish sector. In 2014 this number will be very much lower. Assuming free mobility 20.00% less penalty points are expected in 2014, while assuming restricted mobility we predict only 14.26% reduction in penalty points or in other words a lower improvement in quality of about 5.74 %.

4.3.Effects of structural change on sector N-excretion

The total sector N-excretion is based on the total number of cows per size category, which, in turn, can be derived from the average productivity per cow for each state. Edwards et al. (1985) argue that farm productivity is a function of technological change and structural change. This is confirmed by our empirical analysis that shows that the average cow productivity during the period 1995-2005 increased (from 5,885 to 6,375 litres). Nevertheless,

the changes in N-excretion are calculated with a constant productivity because this research tries to measure the effect of structural change only.
Using the average cow productivity in the period 2002-2005 as reference productivity, the number of cows per state can be derived by dividing the total quota of farms in that state by the average cow productivity in that size category. The N-excretion for each size category can be defined by implementing the number of cows and the average cow productivity of that size category in the formula (6). Results in Table 8 show that the number of cows will further decrease.

Table 8: number of cows and Total N-excretion (kg) given per state in 2005 (actual figures) and simulated in 2014 under assumption of free mobility (FM) and restricted mobility (RM)

state	Average cow productivity	Number of cows (number)			N-excretion (kg)		
		2005	2014 (FM)	2014 (RM)	2005	2014 (FM)	2014 (RM)
1	4,105	33,675	15,758	15,377	2,789,656	1,305,372	1,273,821
2	5,567	67,681	37,841	51,588	6,398,277	3,577,334	4,876,901
3	6,459	62,406	48,885	54,157	6,344,963	4,970,250	5,506,220
4	6,995	53,181	49,805	54,895	5,635,038	5,277,365	5,816,705
5	7,289	37,015	44,275	43,127	4,009,152	4,795,512	4,671,122
6	7,573	49,419	88,729	70,738	5,464,938	9,812,003	7,822,458
total		303,377	285,293	289,881	30,642,024	29,737,836	29,967,227

The current number of cows (303,377) will fall to 289,881 with restricted quota mobility and even to 285,293 with free quota mobility. Despite the drop in total number of cows, the number of cows in the largest farms (> 500,000 litres) will raise spectacular (free mobility: + 79.5% and restricted mobility: + 43.1%). This evolution will influence the total N-excretion of the Flemish milk sector: under the free mobility assumption in 2014 the total N-output will be decreased with 904,188 kg N (-2.95%) and with the restricted mobility assumption the total N-output will fall with only 674,797 (-2.20%).

5 Discussion and Conclusions

This article assesses the effects of differences in quota transfer policy on structural change and how these structural development changes affect the aggregate sector production costs, milk quality and N-excretion in the Flemish dairy sector. The Flemish dairy sector is an exemplary case because of the rather drastic change in quota transfer policy in 1996. Between 1987 and 1996 quota mobility was free while in the period 1996-2004 quota transferability was highly restricted. Since 2004 mobility is again liberalized. The presented approach first quantifies the rate of structural change with different policy regimes and, secondly, the effect of the structural change on the three other sector parameters. The structural change in the period 2005-2014 is simulated by means of a discrete second order Markov chain model, using aggregate data on the number of farms by size category. This Markov chain model is much simpler than other models for structural development in literature because less variables are used to explain farm growth. This model is, on the other hand, based on data that describe actual quota transactions and can therefore take into account that the quota market is not perfect. As a result, it is also possible to compare quota exchanges and structural development of different periods in which different quota transaction policies were in place.

It is obvious that in the nearby future many farms will leave the sector. Given the transferability of quota and the fixed national quota, the remaining farms will have a higher average quota size. Moreover the size distribution of these farms will change as well. Smaller farms will have the choice: to grow or to leave the sector. Looking at the past, the majority of these farms will sell their quota and leave the sector. A small part of the farms will buy additional quota and will shift to a higher size category. The remaining farms will be larger and the majority of the farms will have a quota higher than 400,000 l. The production continues to concentrate within large size farms. These findings are consistent with the trends observed by Weiss (1999) in upper Austria, Zepeda (1995a) and Kim et al. (2005) in the U.S and simulated by Colman et al. (2002) for the U.K.

The research also shows that policy measures indeed have an impact on the rate of structural change. The results show that structural development is higher during the free market period because there appears a demand gap for quota since farms will only sell quota when the quota price compensates the foregone profits in the future. Simulation of a continuation of each policy until 2014 shows a large difference in the number of farms (7.5% more for restricted mobility) and in the change of the size distributions of the Flemish quota (e.g. 14.5% less quota for larger farms in case of restricted mobility).

The trend of increasing average quota size and declining number of farms will influence other sector parameters as well. Average production costs, milk quality and the total N-excretion of the Flemish milk herd will all evolve in a positive manner as a result of structural change, *ceteris paribus*. As we can see in the current sector parameters, larger farms produce milk at lower costs while obtaining a better milk quality. Because of the average higher productivity of those farms, the total N-excretion will fall as well. Consequently, for the sector performance a higher structural change is favourable. Imposing restrictions on the quota mobility will lead to a lower rate of structural development and this would also impact the evolution of the other sector parameters negatively.

The results have some important policy implications. Two recommendations can be drawn. The first lesson is that if quota are implemented and the aim is to have an efficient allocation, attention must be paid to the development of a good market structure and market information for the farms. Our and other literature results indicate that even in situations with a ‘so-called’ free market, a large difference can be found in terms of efficiency indicating that the quota market is not functioning well. A second policy advice is that before the quota transaction policy is supplemented with social corrections, the impact of these social corrections on other policy objectives should be analysed. The objective of the social correction in the quota transaction policy in 1996 to enhance the possibility to start new farms has not been reached and the results of current study also show that the policy has contributed negatively to the reduction of N-excretion objective and led to lower quality of milk. In this case, benefits from social objectives could therefore not compensate efficiency losses and the negative impact on environmental objectives.

These policy recommendation may be very important for the near future. In 2015, the European dairy policy is expected to undergo a significant change which may have important implications for the structural development. Therefore some member states, such as The Netherlands, ask to anticipate this potential shock with earlier adjustments of the quota policy with the possibility of quota transfers among member states. The results presented in this paper indicate that significant changes in structural development of such a policy may be expected.

The presented modelling approach and results can on the other hand not be used as predictions of the future as only the structural change and the impact of it on other elements is assessed. Many other elements, such as technology change, fodder prices and world market prices influence the analysed parameters production cost, N-excretion and milk quality as well. When an attempt is made to make a general descriptive and predictive sector model, researcher should, however, keep the effects of structural change in mind, certainly for long-term simulations or projections.

References

ALVAREZ, A. ARIAS, C. & OREA, L. (2006). Explaining differences in milk quota values: the role of economic efficiency. *American Journal of Agricultural Economics* **88**(1), 182-193.

BAILEY, A. (2002). Dynamic effects of quota removal on dairy sector productivity and dairy farm employment. In *Phasing out milk quota in the EU* (Ed Coleman).

CAZACIOC, L. & CIPU, E. C. (2005). Evaluation of the transition probabilities for daily precipitation time series using a Markov chain model. In *3-rd International Colloquium "Mathematics in Engineering and Numerical Physics* Bucharest, Romania,: Balkan Society of Geometers, Geometry Balkan Press 2005.

COLMAN, D. BURTON, M. RIGBY, D. & FRANKS, J. (2002). Structural change and policy reform in the UK dairy sector. *Journal of Agricultural Economics* **53**(3), 645-663.

DISNEY, W. T. DUFFY, P. A. & HARDY, W. E. (1988). A Markov chain analysis of pork farm size distributions in the South. *Southern Journal of Agricultural Economics* **20**, 57-64.

EDWARDS, C. SMITH, M. G. & PETERSON, R. N. (1985). The changing distribution of darms by size: a Markov analysis. *agricultural economics research* **37**(4), 1-16.

GODDARD, E. WEERSINK, A. CHEN, K. & TURVEY, C. G. (1993). Economics of structural-change in agriculture. *Canadian journal of agricultural economics - revue Canadienne d'economie rurale* **41**(4), 475-489.

HALLBERG, M. C. (1969). Projecting the size distribution of agricultural firms - An application of a Markov process with non-stationary transition probabilities. *American Journal of Agricultural Economics* **51**(2), 289-302.

HUFFMAN, W. E. & EVENSON, R. E. (2001). Structural and productivity change in US agriculture, 1950-1982. *Agricultural Economics* **24**(2), 127-147.

JESPERS, K. CAMPENS, V. BAS, L. & ELST, L. (2006). evaluatie van bijsturing van de melkquotaregeling in het tijdvak 2005-2006. p. 38. Brussel: Vlaamse overheid: Beleidsdomein Landbouw en Visserij.

KIM, C. S. SCHLUTER, G. SCHAIBLE, G. MISHRA, A. & HALLAHAN, C. (2005). A decomposed negative binomial model of structural change: a theoretical and empirical application to U.S. agriculture. *Canadian Journal of agricultural Economics* **53**(2-3), 161-176.

MACMILLA, J. TUNG, F. L. & TULLOCH, J. R. (1974). Migration analysis and farm number projection models - synthesis. *American Journal of Agricultural Economics* **56**(2), 292-299.

MOHAPATRA, S. ROZELLE, S. & GOODHUE, R. (2007). The rise of self-employment in rural China: development or distress? *World Development* **35**(1), 163-181.

PADBERG, D. (1962). The use of Markov processes in measuring changes in market structure. *journal of Farm Economics* **44**(1), 189-199.

TWEETEN, L. (1984). Causes and consequences of structural change in the farming industry. Washington DC: National planning Association.

VAN PASSEL, S. MATHIJS, E. & VAN HUYLENBROECK, G. (2006). Explaining differences in farm sustainability: evidence from Flemish dairy farms. In *The international association of agricultural economists conference* Gold Coast, Australia.

WEERSINK, A. & TAUER, L. W. (1991). Causality between dairy farm size and productivity. *American Journal of Agricultural Economics* **73**(4), 1138-1145.

WEISS, C. R. (1999). Farm growth and survival: econometric evidence for individual farms in upper Austria. *American Journal of Agricultural Economics* **81**(1), 103-116.

YEE, J. & AHEARN, M. C. (2005). Government policies and farm size: does the size concept matter? *Applied Economics* **37**(19), 2231-2238.

ZEPEDA, L. (1995a). Asymmetry and nonstationarity in the farm size distribution of Wisconsin milk producers: an aggregate analysis. *American Journal of Agricultural Economics* **77**(4), 837-852.

ZEPEDA, L. (1995b). Technical change and the structure of production: A non-stationary Markov analysis. *European Review of Agricultural Economics* **22**(1), 41-60.