The Impact of Milk Quota Abolishment on Dutch Agriculture and Economy: Applying an Agricultural Sector Model Integrated Into a Mixed Input-Output Model

John Helming
e-mail: j.f.m.helming@lei.wag-ur.nl

Jack Peerlings
e-mail: jack.peerlings@alg.aae.wag-ur.nl

Paper prepared for presentation at the X[th] EAAE Congress
'Exploring Diversity in the European Agri-Food System',
Zaragoza (Spain), 28-31 August 2002

The impact of milk quota abolishment on Dutch agriculture and economy; applying an agricultural sector model integrated into a mixed input-output model

John Helming
Agricultural Economics Research Institute
Postbox 29703
2502 LS Den Haag
The Netherlands
e-mail: j.f.m.helming@lei.wag-ur.nl

Jack Peerlings
Agricultural Economics and Rural Policy Group
Department of Social Sciences
Wageningen University
Hollandseweg 1
6706 KN Wageningen
The Netherlands
e-mail: jack.peerlings@alg.aae.wag-ur.nl

The impact of milk quota abolishment on Dutch agriculture and economy; applying an agricultural sector model integrated into a mixed input-output model

Abstract
A modelling system is presented and used to analyse the impact of milk quota abolishment on Dutch agriculture and economy. The modelling system consists of a regionalised, agri-environmental, partial equilibrium, mathematical programming model of agriculture supply in the Netherlands integrated into a mixed input-output model. It was found that abolition of the milk quota system has large impacts on milk production and livestock numbers and composition. The latter is explained by the strict mineral and manure policies in the Netherlands; an increase in the numbers of dairy cows leaves less room for other livestock. It is also found that, although the total effect on gross value added in the Dutch economy is limited, the effects for individual industries can be large.

Keywords: Mathematical programming, Manure markets, Input-Output, Dairy policy

1. Introduction

The most important instruments of the current EU dairy policy are: (1) export subsidies limited both in value as in quantity, (2) import tariffs, (3) intervention for butter and skimmed milk powder and (4) supply quota for raw milk. The milk quota system has been introduced in 1984 to overcome the problem of growing milk surpluses and budget costs. In 1999 the European Council agreed upon new reforms of the Common Agricultural Policy, the so-called Agenda 2000 agreements. Agenda 2000 extends the milk quota system for at least another 6 years. Moreover, in 2005 intervention prices will be decreased with 15% in three yearly steps of 5%. Dairy farmers will be partly compensated through direct payments per kilogram milk and through the use of a national envelope.

In the Agenda 2000 agreement, a mid-term review is anticipated in 2002 to review the policy reforms. Some EU countries want to use the mid-term review to accelerate reforms in the dairy sector and to discuss the abolition of the milk quota system after 2006. For the Netherlands quota abolition would probably lead to a growth in milk production and therefore increase mineral (Phosphate (P_2O_5) and Nitrogen (N)) surpluses. Moreover, quota abolition would not only affect dairy farming but also other industries in agriculture and agricultural input delivering and output processing industries.

Three types of models could be used to analyse the effects of quota abolition. First, mathematical programming models on farm level (e.g. Berentsen, 1998). These farm models allow a very detailed analysis on farm level but ignore effects on sector level. Moreover possible effects of the policy reform on input and output prices and other industries are ignored. Second, micro-econometric simulation models (e.g. Boots, 1999). Micro-econometric models calculate the policy effects on both farm and sector level. Econometric models have the advantage of empirical estimation and testing of actual behaviour. However, like other farm level models they ignore the effects on input and output prices and other industries. Compared to mathematical programming models a lot of detail on farm level is lost. Finally, applied general equilibrium (AGE) analysis could be used (e.g. Komen and Peerlings, 2001). AGE models allow for the calculation of policy effects for individual agricultural industries and agricultural inputs delivering and output processing industries and the economy as a whole. Major drawback of AGE models is the high level of aggregation of commodities and industries (Lehtonen, 2001). Important for the Netherlands for example is the inclusion of mineral balances at the farm or crop level and modelling farm and regional mineral surpluses.

The aims of this article are twofold. First to analyse the structural and economic effects of abolition of the milk quota system for Dutch agriculture. For that purpose a regionalised, partial equilibrium, mathematical programming model will be used that combines the technical detail, including technology options available to farmers in different regions of the Netherlands, of mathematical programming farm models with some market effects at sectoral level. It explicitly takes into account the manure market. This model is called the Dutch Regionalised Agricultural Model (DRAM). Results from DRAM will focus on effects on agricultural production through changes in the markets of animal manure, regional effects and technology switches in the dairy farming sector. The second aim of this paper is to present a method to integrate DRAM with an input-output (IO) model and to extent the analysis to the Dutch economy as a whole. A mixed input-output model is developped (Millar and Blair, 1985; Roberts, 1994) that uses gross output of agriculture and related output processing industries as exogenous variables. The advantage of this integrated modelling system compared to AGE models is that the high level of aggregation of commodities and industries are avoided.

This article contributes to the existing literature because a modelling system is presented which contains the relevant elements of farm models and AGE models for the analysis of dairy quota abolition. Articles describing the integration of an input-output model with technical models can be found in the literature, especially in the field of energy economics (James, Musgrove and Stocks, 1986). However no applications in the field of agricultural economics were found. Furthermore, different procedures to that used by James, Musgrove and Stocks (1986) are applied to integrate the modelling systems and to calculate economic effects.

The next section presents DRAM. Special emphasis is put on modelling dairy farming and technology switches. Section 3 presents the methodology behind the mixed input-output model and the integration of this model with DRAM. Section 4 discusses in more detail data harmonisation between DRAM and the input-output model. Section 5 presents policy simulations and results with respect to the abolishment of the milk quota system. The paper ends with a summary and conclusions.

2. The Dutch Regionalised Agricultural Model (DRAM)

The general structure of DRAM is very similar to the set-up of other mathematical programming agricultural sector models. Some selected examples of more or less comparable models are Horner et al. (1992) and Lehtonen (2001). DRAM can be characterised as a regionalised, agri-environmental, partial equilibrium, mathematical programming model of agriculture supply in the Netherlands. DRAM assumes that farmers behaviour at sector level can be described by maximisation of total profits from agriculture under the restriction that all markets taken into account are in equilibrium. To reach an optimal solution marginal costs should equal marginal revenues for all regional agricultural activities. Marginal costs and marginal benefits and hence are steered by regional differences in production possibilities, regional differences in prices of inputs and outputs and regional activity levels relative to a base year level.

Inputs and outputs observed at individual farms are aggregated to the regional level in DRAM. The model distinguishes between 14 regions. Out of the fourteen regions, seven regions have clayey soil, five regions have sandy soil and two regions have peaty soil. Beside differences in soil type there are also important differences in the regional concentration of agricultural production in the Netherlands. Intensive livestock and milk and beef production are mainly concentrated in the sandy regions in the south, the east and in the middle of the Netherlands. The arable production is concentrated in the clayey regions in the north, middle and south-west of the Netherlands. In the regions with peaty soils, grassland production is predominant, while arable production, including maize is almost impossible. Regional differences in soil type and concentration of agricultural production justify a regional specification of the model. Regionalisation of the agricultural sector is also a relevant feature of the model when evaluating manure policies. This enables to take into account transportation of manure from surplus areas to other areas in the Netherlands as an important option for the regional farmer to reduce surpluses.

DRAM includes agricultural outputs from agricultural activities as detailed as possible. A detailed description of agricultural outputs is important because they are characterised by differences in economic importance and environmental effects. Within each of the 14 regions, 13 arable cropping activities, 2 forage crops activities, 1 non-food activity and 6 intensive livestock activities, including calf fattening, two beef cattle activities and 9 dairy farming activities are distinguished.

The arable activities include cereals, pulses, sugar beets, ware potatoes, seed potatoes, starch potatoes, unions, other arable products, mangolds, flower bulbs and three types of vegetables in the open. The forage crop activities are grassland and maize. Arable activities, forage crop activities and the non-food activity produce only one specific output per activity in the model. Horticulture under glass, trees and sectors alike are left out of the model. In the Netherlands there is limited interaction between these sectors and other agricultural activities.

The intensive livestock activities included in the model are meat calves, sows, fattening pigs, laying hens, meat poultry and mother animals of the meat poultry. Beef cattle activities are male and female beef cattle. The dairy farming activities include different types of milking cows. Livestock activities produce more than one output. For example, the activity sows produces meat, piglets and manure. It is assumed that each livestock activity produces a specific type of manure because the mineral content differs per manure type. Furthermore, the usefulness of nitrogen in animal manure for crop growth differs per manure type.

The following purchased inputs are distinguished in DRAM: purchased concentrates, pesticides, mineral fertilisers (nitrogen and phosphorous) and other variable inputs. Other variable inputs consist of services, other fertilisers, seed and planting materials, energy, hired labour and by-products (as a negative input). Fixed inputs included in DRAM are quotas and land. Quotas included are quotas for milk, sugar beet and starch potatoes. Milk quotas limit national milk production, but can be regionally traded. Quotas for sugar beet and starch potatoes are fixed at the regional level. The agricultural area is determined and fixed at the regional level.

Yields are fixed for all livestock and crop activities. Feed balances are used to meet the minerals requirements of the livestock. Fixed input-output relationships are used between yield per animal per year and the use of purchased concentrates per animal per year and between yield and the use of roughage products.

The relationship between crop yield per hectare and minerals requirements is arranged through the crop and regional specific fertilisation balances in DRAM. The fertilisation balances include mineral fertilisers and minerals from animal manure as variables. To meet the fertilisation requirements per crop per region both mineral fertilisers and/or minerals from animal manure can be used. However, technical limitations with respect to the application of animal manure to some arable crops are taken into account by DRAM. Furthermore, Dutch minerals and manure policies also restrict the (economic) application of both mineral fertilisers and animal manure.

Figure 1: Dairy farm activities in DRAM.

Activity	Description (between brackets model abbreviation)
1	Low milk production per cow, low level of pure nitrogen per hectare of grassland (LMLN)
2	Medium milk production per cow, low level of pure nitrogen per hectare of grassland (LMMN)
3	High milk production per cow, low level of pure nitrogen per hectare of grassland (LMHN)
4	Low milk production per cow, medium level of pure nitrogen per hectare of grassland (LMMN)
5	Medium milk production per cow, medium level of pure nitrogen per hectare of grassland (MMMN)
6	High milk production per cow, medium level of pure nitrogen per hectare of grassland (HMMN)
7	Low milk production per cow, high level of pure nitrogen per hectare of grassland (LMHN)
8	Medium milk production per cow, high level of pure nitrogen per hectare of grassland (MMHN)
9	High milk production per cow, high level of pure nitrogen per hectare of grassland (HMHN)

DRAM includes nine dairy farming activities which produce milk, grass, maize, youngstock and manure. The classification of dairy farming activities is based on milk production per cow and nitrogen input per hectare of grassland as important economic and environmental variables (figure 1).

The calibration of the model is done using the PMP approach (Howitt, 1995). PMP ensures perfect calibration of the model activities to observed base year levels. Furthermore, the PMP model shows a smooth adjustment path following exogenous shocks. The exact PMP procedure used by DRAM is presented in Helming, Veenendaal and Peeters (2000). A mathematical presentation of the model and a detailed description of the calibration of the model is available from the authors upon request.

DRAM has both advantages and disadvantages for analysing the economic problem at hand. An important advantage of the model is that agriculture as a whole is included. This is important because, through the manure and land balances, abolition of the milk quota system not only affects dairy farming, but other agricultural industries as well. A disadvantage is that individual activities at farm level are aggregated to activity groups at the regional level. This is done in order to keep the model and the computation time manageable. An important consequence is that behavioural and structural differences between farms are not taken into account.

3. The mixed input-output model

"In the usual form of the standard demand-side input-output model $(I - A)X = D$ and $X = (I - A)^{-1}D$, the final demand elements, D, and the matrix of technical coefficients, A, are considered exogenous. Changes in the D_i 's come about as a result of forces that are outside the model (e.g., changes in consumer tastes, government purchases), and it is the effects of these changes on industrial gross outputs, X_i's, that are quantified through the input-output model" (Miller and Blair, 1985).

It is also possible to employ a mixed type of input-output model, in which final demands for some sectors and gross outputs for the remaining sectors are specified exogenously. Roberts (1994) used a mixed input-output model to analyse the economy wide impact of the introduction of the milk quota system on the UK economy. A disadvantage of that research was that possible substitution effects within agriculture were not taken into account. In this research substitution between agricultural industries is calculated by DRAM. Here, a modified input-output model (Millar and Blair, 1985; Roberts, 1994) is applied that uses DRAMs gross output of agriculture and related output processing industries as exogenous variables. Furthermore, technical input-output coefficients for agriculture in the IO-model are also adjusted by DRAM.

To explain the link between agriculture and the rest of the economy consider a four sector model; agriculture (1), output processing industry (2), agricultural input delivering industry (3) and non-agriculture (4).[1]

Gross output from agriculture (X_1) is an exogenous variable into the mixed input-output model. Gross output from agriculture is taken from DRAM.

Because DRAM and the IO model are harmonised, transactions from agriculture to all other industries are know from model simulations with DRAM. As a result the gross output of the output processing industry can be calculated by:

$$X_2 = \frac{X_{12}}{a_{12}} \tag{1}$$

Where X_2 denotes the gross output of the output processing industry, X_{12} the known transaction from agriculture to the output processing industry and a_{12} the known technical input-output coefficient between agriculture and output processing industry. The technical coefficients describing transactions from the agricultural input delivering industry to agriculture (a_{31}) can be recalculated before applying the mixed input-output model:

$$a_{31} = \frac{X_{31}}{X_1} \tag{2}$$

Where X_{31} denotes the known transaction from the agricultural inputs delivering industry to agriculture, X_1 denotes known gross output of agriculture and a_{31} the technical input-output coefficient between the agricultural input delivering industry and agriculture. To close the mixed type input-output model, final demand from the agricultural input delivering industry (D_3) and the non-agriculture (other) industry (D_4) is assumed exogenous. So, endogenous variables in the mixed type input-output model are gross output of the agricultural input delivering industry (X_3), non-agriculture (X_4) and final demand of agriculture (D_1) and the output processing industry (D_2).

[1] To explain the method, here it is assumed that all industries fit in one of the 4 categories. In reality a particular industry can belong both to the output processing and to the input delivering industry.

With X_1, X_2, D_3 and D_4 as the exogenous variables at the right hand side and the endogenous variables X_3, X_4, D_1 and D_2 on the left, the basic input-output relationships can be written as (exogenous variables are indicated using an overbar) (Miller and Blair, 1985):

$$-a_{13}X_3 - a_{14}X_4 - D_1 + 0D_2 = -(1-a_{11})\overline{X_1} + a_{12}\overline{X_2} + \overline{0D_3} + 0\overline{D_4} \quad \text{(3a)}$$

$$-a_{23}X_3 - a_{24}X_4 + 0D_1 - D_2 = a_{21}\overline{X_1} - (1-a_{22})\overline{X_2} + \overline{0D_3} + 0\overline{D_4} \quad \text{(3b)}$$

$$(1-a_{33})X_3 - a_{34}X_4 + 0D_1 + 0D_2 = a_{31}\overline{X_1} + a_{32}\overline{X_B} + \overline{D_3} + 0\overline{D_4} \quad \text{(3c)}$$

$$-a_{43}X_3 + (1-a_{44})X_4 + 0D_1 + 0D_2 = a_{41}\overline{X_1} + a_{42}\overline{X_2} + \overline{0D_3} + \overline{D_4} \quad \text{(3d)}$$

or in matrix form,

$$\begin{bmatrix} -a_{13} & -a_{14} & -1 & 0 \\ -a_{23} & -a_{24} & 0 & -1 \\ 1-a_{33} & -a_{34} & 0 & 0 \\ -a_{43} & 1-a_{44} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_3 \\ X_4 \\ D_1 \\ D_2 \end{bmatrix} = \begin{bmatrix} -(1-a_{11}) & a_{12} & 0 & 0 \\ a_{21} & -(1-a_{22}) & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 \\ a_{41} & a_{42} & 0 & 1 \end{bmatrix} \begin{bmatrix} \overline{X_1} \\ \overline{X_2} \\ \overline{D_3} \\ \overline{D_4} \end{bmatrix} \quad (4)$$

Let the first matrix on the left be denoted as M and the first matrix on the right be denoted as N, the endogenous variables can be computed as:

$$\begin{bmatrix} X_3 \\ X_4 \\ D_1 \\ D_2 \end{bmatrix} = M^{-1}N \begin{bmatrix} \overline{X_1} \\ \overline{X_2} \\ \overline{D_3} \\ \overline{D_4} \end{bmatrix} \quad (5)$$

The DRAM/IO system applies the small country assumption since prices of purchased variable inputs and outputs in agriculture are exogenous. Moreover, it is assumed that the supply of factor inputs is perfectly inelastic in agriculture and perfectly elastic in non-agriculture. Given the small market share of Dutch agriculture in the EU, the relative small effect for the Dutch economy as a whole of milk quota abolition, the limited alternative possibilities to use agricultural land and the organisation of agriculture in family farms these assumptions seem reasonable.

4. Data harmonisation between DRAM and the input-output model

Prices and quantities used by DRAM are yearly averages for the period 1993/94-1995/96. A three year average is used to correct for occasional events. DRAM is based on data from the Dutch Agricultural Census collected yearly by the Dutch Central Office of Statistics (CBS), the Dutch Farm Accountancy Data Network (FADN), and specific findings in the literature. The Dutch Agricultural Census is used to obtain regional cropping plans and livestock numbers. The FADN is a stratified random sample of some 1000 farms representing about 95% of the production and some 65% of the farms and contains very detailed technical and economic data.

The Agricultural Economics Research Institute in the Netherlands (LEI) constructs on a regular base a so-called Agricultural Input-Output Table (AIOT) as a extension of the national Input-Output table (Koole and van Leeuwen, 2001; van Leeuwen and Verhoog, 1995). The AIOT includes 18 different agricultural industries. Moreover, a detailed desaggregation of the output processing industries has been applied. The agricultural industries included in the AIOT are presented in figure 2.

Figure 2: Agricultural industries in the AIOT

1. dairy farming (*)	10. potplant holdings
2. other animal farming (sheep, goats, horses) (*)	11. mushroom growers
3. calf fattening (*)	12. field vegetable holdings (*)
4. pig farming (*)	13. fruit
5. poultry farming (laying hens) (*)	14. flower bulb growers (*)
6. poultry farming (fattening) (*)	15. tree nurseries
7. arable farming (*)	16. gardening
8. vegetables under glass holdings	17. agricultural services
9 cut flower holdings	18. forestry

(*) covered by DRAMs agricultural activities.
Source:van Leeuwen and Verhoog, 1995;

The mixed input-output model assumes that gross output from agriculture not covered by DRAM is endogenous and final demand is exogenous.

The DRAM database is harmonised with the AIOT both with respect to transactions between agriculture and agricultural input delivering industries and agriculture and output processing industries. Harmonisation is necessary because of the differences in statistical background between DRAM and the AIOT and resulting differences in aggregated economic variables. Below the harmonisation process will be explained.

The outputs produced and inputs used by the DRAM activities are linked to industries in the AIOT by means of a distribution matrix. Following James, Musgrove and Stocks (1986), the required distribution matrix is a three dimensional array since specific inputs and outputs from DRAM agricultural activities are linked to specific agricultural industries in the AIOT which in turn are linked to other industries and final demand and primary costs components in the AIOT. For example, the ith agricultural output produced by DRAM can be linked to the jth agricultural industry in the AIOT and contributes to the transaction of the jth agricultural industry with AIOT industry k. The value of output i linked to industry j and k, z_{ijk}, can be written as:

$$z_{ijk} = z_{ij} t_{ijk} \qquad (6)$$

where z_{ij} is a matrix that links the total input or output i from DRAM activities to agricultural industry j in the AIOT:[2]

$$z_{ij} = p_i q_i o_{ij} \qquad (7)$$

Where parameter p_i is the price of agricultural input or output i, q_i is the supply or demand of i and parameter o_{ij} is the linkage parameter between agricultural inputs or outputs in DRAM and agriculture j in the Dutch AIOT.

The parameter t_{ijk} in equation (6) is the proportion of z_{ij} that is further distributed to the kth component of the AIOT, including industries, final demand and primary cost components. The parameter t_{ijk} is found by applying the following maximum entropy model for every industry k:

[2] Regional dimension is omitted in this section.

$$\max \quad E(P_k) = -\sum_s \sum_i \sum_j P_{sijk} LOG(P_{sijk}) \qquad (8a)$$

$$x_{jk} = \sum_s \sum_i p_i q_i u_{sijk} P_{sijk} \qquad (8b)$$

$$1 = \sum_s P_{sijk} \qquad (8c)$$

Where set s are the support points, u_{sijk} is the support point s for agricultural output (input) i that is produced (used) by agricultural industry j and sold (bought) to other industry k, x_{jk} is the transaction between agricultural industry j and other industry k, and P is the matrix of probabilities to be estimated. Equation (8b) is called the data consistency constraint while equation (8c) expresses the adding-up condition. The measure $E(P_k)$ reaches a maximum when all probabilities P_{sijk} are equal (Golan, Judge and Miller, 1996). The value of the support point u_{sijk} is crucial and based on expert knowledge and information from national accounts. A maximum entropy procedure is applied because of the flexibility to include additional information to the model.

From the results of the maximum entropy model the parameter t_{ijk} can be calculated:

$$t_{ijk} = \sum_s u_{sijk} P_{sijk} \qquad (9)$$

The integrated objective function of DRAM before calibration can be written as:

$$\max \quad Z = \sum_i \sum_j \sum_k z_{ij} t_{ijk} \qquad (10)$$

Where Z is gross value added.

Once DRAM is harmonised with the AIOT, the mixed input-output model described in section 4 can be applied to calculate economy wide effects of changes taking place in agriculture. One further remark on the data is necessary. Given the lack of data the harmonisation of DRAM had to be based on the AIOT of 1996 and not on the average of 1993/94-1995/96 used to calibrate DRAM.

5. Policy simulations and results

This section presents the policy simulations and results from the DRAM/IO system. Policy simulations are directed to possible abolition of the milk quota system in 2008 under different assumptions concerning income payments and minerals policies. Exogenous values are put to expected levels for 2008. Effects on agricultural production will be analysed by investigating the development and composition of the livestock herd and cropping plan. It will be argued that the manure market will play a decisive role on the level of the agricultural activities. Furthermore, structural effects will be analysed by looking at regional changes in milk production and technology switches in dairy farming. Finally, the results from the mixed input-output model are presented.

5.1 Policy simulations

The DRAM/IO system is used to calculate the economic and structural effects for agriculture and the rest of the Dutch economy of abolition of the milk quota system. The results of different scenarios are compared with the base scenario in which the milk quota system is continued. In the scenarios with milk quota abolition different assumptions are made for the level of compensation payments and the prevailing manure and mineral policy.

In the base scenario it is assumed that the milk price off-farm will decrease with 30 percent. It is assumed that this is the price on the world market after abolition of the milk quota system. A compensation of 49.6 € per ton milk will be paid to farmers to compensate the income loss. In the base scenario the compensation payment equals about halve of the price decrease. Of special importance is the possible application of the European nitrate directive in the Netherlands. The nitrate directive means that on a hectare base, no more than 170 kilogram of nitrogen from animal manure can be applied to agricultural land. At the moment the Dutch ministry of agriculture is in a negotiation process with the European Commission in Brussels to allow 250 kilogram of nitrogen from animal manure per hectare on grassland for the Netherlands (derogation request). The Dutch argument is based on the relatively high yield and resulting uptake of nitrogen on grassland in the Netherlands. The base scenario assumes that derogation is permitted.

Scenario 1 assumes the abolition of the milk quota system. All other assumptions e.g. the exogenous milk price, are maintained. The compensation payment, 49.6 € per ton, is paid to the full milk production after quota abolition. Scenario 2 assumes that the compensation is only paid for the historical milk production, determined by the volume of the national milk quota in the base scenario. Scenario 3 equals scenario 2, however, derogation is not permitted.

Besides the EU nitrate directive, all scenarios take into account the Dutch mineral accounting system at farm level. It is assumed that all farms are obliged to keep an up to date mineral accounting system. This system calculates the input (e.g. through the purchase of feed, mineral fertilisers and animal manure) and the output of minerals (e.g. through the sales of milk, meat, cereals, manure and so on) at the farm level. Mineral surpluses above a certain threshold are taxed. The Dutch legislation takes into account different thresholds for different regions and crops. This system is translated to the regional crop activity level in DRAM. Different threshold levels per crop and per region are taken into account as well.

5.2 Results

Agricultural production

Scenario results with respect to the number of animals are presented in table 1. After abolition of the milk quota system, the number of milking cows increases strongly compared to the base scenario. However, if derogation is not permitted, as assumed in scenario 3, the number of milking cows decreases compared to the base scenario.

The increase of the number of milking cows after the abolition of the milk quota system under scenarios 1 and 2 is reached at the expense of the volume of poultry and beef cattle[3]. This works through changes in demand and supply of animal manure and resulting price changes on the animal manure market. All scenarios take into account that the application of animal manure to agricultural land is controlled through the mineral accounting system and manure application norms. If after the abolition of the milk quota system the supply of animal manure from milking cows,

---

[3] Poultry consist of laying hens, meat poultry and mother animals of meat poultry. Especially the number of laying hens is affected. The relatively small decrease in number of fattening pigs and sows hide the large decrease from the period 1993/94-1995/96 to 2008. In 1993/94-1995/96 the number of pigs and sows in the Netherlands amounted to 7.0 and 1.3 million animals respectively.

including youngstock, increases, the manure application possibilities linked to agricultural land become more scares. This increases the price of animal manure and leads to a decrease in the supply of animal manure from less competitive agricultural activities. The process described above is strengthened in scenario 3 when Dutch derogation from the EU nitrate directive is not permitted and animal manure application norms are therefore lowered.

Prices of animal manure and livestock numbers are very sensitive to assumptions concerning exports of different types of animal manure, large scale manure processing and feeding practices. Exports of different types of animal manure are based on and limited to expected levels in 2003 (van Staalduinen et al., 2001). In reality the exports to other countries might be higher as a function of high manure prices after abolition of the milk quota system. Excretion of minerals by the animals is influenced by feeding practices. Information used is again based on van Staalduinen et al. (2001). Large scale processing of animal manure is not taken into account. The reason for this is that we are uncertain about the economic feasibility of manure processing and about the available capacity in the longer term.

Table 1: Livestock numbers under different scenarios (*1000).

Activity	Scenarios	Index (base=100)		
	base	1	2	3
	milk quota, milk price -30%, compensation, derogation	idem base but abolition milk quota system	idem 1 but income compensation based on historical milk production	idem 2 but no derogation
Cows	1,370	135	129	97
Beef cattle[1]	466	66	79	64
Meat calves	763	100	100	100
Sows	1,148	98	100	99
Pigs	6,005	93	100	88
Poultry	96,078	64	75	62

1. In Livestock Units

Source: calculations by DRAM/IO

With respect to arable and fodder crop production the abolition of the milk quota system increases the area of fodder crops and decreases the area of arable crops, especially cereals and other arable crops. When derogation from the EU nitrate directive is not allowed milk quota abolition has very limited impact on land use at the national and sectoral level.

Regional effects

Table 2 gives insight into the effects of abolition of the milk quota system on regional milk production. Abolition of the milk quota system increases milk production in all regions. The largest increase of the regional milk production is found in the sandy regions and in the other regions. This can be explained by the possibility to substitute arable land for fodder crops in these regions. Fodder crops are an important input in dairy farming (section 2). This substitution is very limited in the peat regions, because most of the agricultural land is already used for fodder crop production. Fodder crop production can be increased through intensification. But possibilities are limited due to EU and Dutch minerals and manure policies.

Table 2: Regional milk production under different scenarios (1000 ton)

Region	Scenarios	Index (base=100)		
	base	1	2	3
	milk quota, milk price -30%, compensation, derogation	idem base, abolition milk quota system	idem 1 but income compensation based on historical milk production	idem 2, no derogation
Sandy-/livestock regions[1]	5,069	143	135	102
Peat regions[2]	3,622	121	116	98
Other regions[3]	2,941	149	140	99
Total Netherlands	11,631	138	130	100

1. Sandy-/livestock regions: Southern sand region, Dutch Limburg, River area, Eastern sand region, Central sand region
2. Peat regions: Northern peat region, Western peat region
3. Other regions: Northern clay region, Central clay region, Southern clay region, Peat colonies, Northern sand region, Rest of Northern Holland, Rest of Southern Holland.
Source: calculations by DRAM/IO

Technology switches

DRAM distinguishes nine types of dairy farm activities who represent different types of specialised dairy farms. Table 3 shows the possible relative shift in milk production between activities under the different scenarios. Table 3 shows a shift of the milk production from activities with low milk production per cow to activities with high milk production per cow under scenario 1. This redistribution is less clear under scenario 2, when the income compensation is limited to historical milk quota. However, if derogation is not permitted, there will again be a strong shift in the milk production towards activities with high milk production per cow. The explanation for this is that the minerals production per kilogram of milk is lowest for activities with a high milk production per cow. This means that the competitiveness of activities with a high milk production per cow will increase when the application possibilities of minerals from animal manure decrease.

Table 3: Milk production per dairy farm activityunder different scenarios (1000 ton).

		Index (base=100)		
Activity	base	1	2	3
	milk quota, milk price -30%, compensation, derogation	idem base, abolition milk quota system	idem 1 but income compensation based on historical milk production	idem 2, no derogation
Low[1]	5,219	116	120	77
Medium[2]	4,664	150	136	112
High[3]	1,748	172	145	137
Total	11,631	138	130	100

1. Low milk production per cow (LMLN, LMMN, LMHN): 7,500 kilogram per milking cow at average
2. Medium milk production per cow (MMLN, MMMN, MMHN): 9,200 kilogram per milking cow at average
3. High milk production per cow (HMLN, HMMN, HMHN): 10,360 kilogram per milking cow at average

Source: calculations by DRAM/IO

Gross value added

Table 4 shows the effects of the scenarios on gross value added of a number of selected industries. Gross value added is defined as revenues minus variable costs and contains depreciation and compensation for labour, capital (including quota) and land. Table 4 indicates that the economic impact of abolition of the milk quota system for agriculture as a whole is limited. The positive impact of increasing milk production and re-allocation of milk production to more efficient farming systems are largely off-set by increasing marginal costs in dairy farming and income losses in other industries due to decreasing production because of manure and mineral policies.

According to table 4 abolition of the milk quota system has a negative impact on the dairy farming industry. This is surprising because the milk price and the income compensation are kept unchanged compared to the base scenario. The positive impact of the increase in milk production and re-allocation of milk production towards more efficient farms is more than off-set by the increase in marginal costs per milking cow and by the increase in manure costs. This shows the importance of the manure markets. Income possibilities in other livestock industries are also negatively affected by the higher manure prices. The results in table 4 suggest that under the assumed circumstances, the income payments to compensate for lower milk prices result in higher prices of animal manure because milk production and manure production are higher in this case.

Given the exogenous gross output, gross value added is affected most in the dairy manufacturing and meat industry (table 4). The increase in the dairy manufacturing industry follows the increase in milk production. The decrease in the meat industry mainly follows the gross output development of the intensive livestock industry. Within the group of other output processing industries grain manufacturing and fruit and vegetable manufacturing are affected most by the abolishment of the milk quota system if derogation is permitted. Table 4 shows little impact on the agricultural input delivering industries (e.g. compound feed industry). Again, the positive impact of increased input demand from dairy farming is partly off-set by the decrease in demand from other industries. Finally, table 4 indicates that the change in gross value added for the economy as a whole can be larger than for agriculture alone. Under scenario 1 the increase in gross value added in the economy as a whole is mainly coming from agriculture (60%). However, when direct income payment is limited up to the historical milk production level, this is only 10%. When agricultural output decreases as is the case under scenario 3, the share of agriculture in total loss is also low, less than 20%.

Table 4: Gross value added per industry under different scenarios (*mln €)

		Difference with base (*mln €)		
	base	1	2	3
	milk quota, milk price -30%, compensation, derogation	idem base, abolition milk quota system	idem 1 but income compensation based on historical milk production	idem 2, no derogation
Dairy farming, including other animal farming	1,688	-86	-88	-420
Calf fattening	137	-21	-4	-40
Pig farming	556	-251	-167	-296
Poultry farming	166	-102	-54	-145
Arable farming	605	577	324	738
Other agriculture	3,914	43	20	74
Total agriculture	**7,065**	**160**	**31**	**-89**
Dairy manufacturing	907	137	110	0
Meat industry	921	-94	-27	-104
Other output processing industries	939	-45	-29	6
Agricultural input delivering	176,192	92	189	-281
Non-agriculture	38,900	14	18	-16
Total Netherlands	**224,925**	**265**	**292**	**-484**

Source: calculations by DRAM/IO

6. Summary and conclusions

This article analyses the effects of abolition of the milk quota system on Dutch agriculture and economy in 2008. Special emphasis is given to manure prices and how these price effect agricultural production after abolition of the milk quota system in 2008.

Results from the model show that abolition of the milk quota system will increase milk production in the Netherlands. This increase however, is conditioned by the derogation from the EU nitrate directive request. The increase in milk production will take place in those regions were arable land can be substituted for fodder crops. The increase in milk production is partly based on an increase in milk production per cow. Model results show a large negative impact on livestock numbers in other livestock industries. This is explained by the increase in manure prices following the increase in number of milking cows after abolition of the milk quota system. These results show the competitiveness of dairy farming in the Netherlands. Changes in gross output in agriculture are fed into a mixed input-output model to calculate economy wide effects of the policy switch. It was found that economy wide effects exceed changes in agriculture by far.

The model presented can be characterised as a short term model, since technology (except in dairy farming) and factors are fixed. In the longer term factors are no longer fixed and alternative technologies may come available. Among the uncertainties mentioned in the article are large scale manure processing, exports of animal manure and changes in feeding practices.

Notwithstanding the uncertainties, it is believed that the proposed modelling system offers a flexible and consistent tool for policy analysis at the level of the Dutch agricultural sector and economy.

References

Berentsen, P.B.M. (1998). Economic-environmental modelling of Dutch dairy farms incorporating technical and institutional change. Ph.D. thesis. Wageningen University.

Boots, M. (1999). Micro-economic analysis of alternative policies for Dutch dairy farming. Ph.D. thesis. Wageningen Agricultural University.

Golan, A., Judge, G. and Miller, D. (1996). *Maximum Entropy Econometrics: Robust Estimation With Limited Data*. John Wiley, New York.

Helming, J.F.M., Peeters, L. and Veenendaal, P.J.J. (2001). Assessing the consequences of environmental policy scenarios in Flemish agriculture. In: Hackelei, T., Witzke, H.P and Henrichsmeyer, W. (eds.) *Agricultural Sector Modelling and Policy Information Systems*. Proceedings of the 65th European Seminar of the European Association of Agricultural Economists (EAAE), Wissenschaftsverlag Vauk Kiel KG, 237-245.

Horner, G.L., Corman, J., Howitt, R.E., Carter, C.A., and MacGregor R.J. (1992). The Canadian Regional Agriculture Model, Structure, Operation and Development*,* Technical Report 1/92, Agriculture Canada.

Howitt, R.E. (1995). Positive Mathematical Programming. *American Journal of Agricultural Economics*, 77(May), pp 329-342

James, D.E., Musgrove, A.R. deL. and Stocks, K.J. (1986). Integration of an economic input-output model and a lineair programming technological model for energy systems analysis. *Energy Economics* 8(2): 99-112

Komen, M.H.C. and Peerlings, J.H.M. (2001). Endogenous technology switches in Dutch dairy farming under environmental restrictions. *European Review of Agricultural Economics* 28(2): 117-142.

Koole, B. and Leeuwen, van, M.G.A. (2001). *The Dutch agro-complex in 2001* (in Dutch), Report 5.01.05, Agricultural Economics Research Institute (LEI BV), The Hague.

Leeuwen, van, M.G.A. and Verhoog, A.D. (1995). *The agro-complex in 1990 and 1993; an input-output analyses* (in Dutch), Research report 138, Agricultural Economics Research Institute (LEI), The Hague.

Lehtonen H. (2001). Principles, structure and application of a dynamic regional sector model of Finnish agriculture. PhD Thesis, Agrifood Research Finland, Economic Research (MTTL), Publications 98.

Miller, R.E. and Blair, P.D. (1985). *Input-Output Analysis: Foundations and Extensions*, Prentice-Hall, London.

Roberts, D. (1994). A modified Leontief model for analysing the impact of milk quotas on the wider economy. *Journal of Agricultural Economics* 45(1): 90-101

Staalduinen, L.C. van, e.a. (2001). Het landelijk mestoverschot 2003 (in Dutch). Series environmental planning office 15.