EFFECTS OF EU DAIRY POLICY REFORM FOR DUTCH AGRICULTURE AND ECONOMY: APPLYING AN AGRICULTURAL PROGRAMMING / MIXED INPUT-OUTPUT MODEL

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ABSTRACT

A modelling system is presented and used to analyse the effects of EU dairy policy reform (Agenda 2000 and milk quota abolition with and without decoupled direct income payments) 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 e.g. found that decoupling of direct income payments gives an extra stimulus to milk production after milk quota abolition. However, the increase in milk production is restricted by nutrient and manure policies in the Netherlands. It is also found that, although the total effect on Dutch GDP is limited, the income effects for individual industries can be large. Moreover, economy wide effects for non-agricultural industries exceed changes for agriculture.

INTRODUCTION

Milk quotas have been introduced in the EU in 1984 to overcome the problem of growing milk surpluses and budget cost. In 1999 the European Council agreed upon new reforms of the Common Agricultural Policy (CAP), 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 income payments per kilogram milk and through the use of a national envelope.

In the Agenda 2000 agreement, a mid-term review was anticipated in 2002 to review the policy reforms. As a result of the mid-term review the European Commission proposes some options of CAP dairy policy reform. Options range from no further reform after the implementation of Agenda 2000 to milk quota abolishment in 2006. Another important aspect of the proposals is to decouple the direct income payments (European Commission, 2002).

For the Netherlands quota abolition would probably lead to a growth in milk production, an increase in demand for land to produce feed for the increased number of dairy cows and an increase in the production of manure and nutrients (Phosphate (P_2O_5) and Nitrogen (N)). As a result, quota abolition would not only affect dairy farming but also other industries in agriculture, as in the Netherlands agricultural industries are interlinked through land and manure markets. The latter linkage results from stringent nutrients and manure policies in the Netherlands. Basically these policies limit the total amount of nutrients from animal manure and inorganic fertilisers that can be applied to the land.

Moreover, quota abolition not only affects dairy farming and other agricultural industries but also agricultural input delivering and output processing industries.

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At present only 30 to 40% of value added created in agribusiness (primary agriculture, agricultural input delivering and output processing industries) comes from agriculture (Koole and van Leeuwen, 2001). At industry level and for the economy as a whole the economic and environmental effects of milk quota abolition are complex. Models are needed to quantify these effects.

The aim of this article is twofold. First to analyse the environmental and economic effects of Agenda 2000, decoupling of direct income payments and milk quota abolition for Dutch agriculture, in the context of strict manure and nutrients policies in the Netherlands. For that purpose DRAM (Dutch Regionalised Agricultural Model), a regionalised, environmental, partial equilibrium, mathematical programming model of Dutch agriculture is used. The model 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 agricultural industry level e.g. land and manure markets.

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 IO model is developed (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 is avoided.

The next section presents DRAM. Section 3 presents the methodology behind the mixed IO model and integration of this model with DRAM. Section 4 discusses the data used. In section 5 DRAM and the mixed IO model are applied to analyse effects of EU dairy policy reform. The paper ends with a summary and conclusions.

THE DUTCH REGIONALISED AGRICULTURAL MODEL (DRAM)

DRAM assumes that farmers behaviour at industry level can be described by profit maximisation of agriculture under the restriction that all markets taken into account are in equilibrium[1]. An optimal solution is reached where marginal cost equal marginal revenues for all regional agricultural activities. Marginal cost and marginal revenues are steered by regional differences in production possibilities and regional differences in prices of inputs and outputs.

Regional differences in soil type and concentration of agricultural production justify a regional specification of the model. The model distinguishes between 14 regions. Out of the fourteen regions, seven regions have clay soils, five regions have sand soils and two regions have peat soils. Intensive livestock and milk and beef production are mainly concentrated in the sand regions in the south, the east and in the middle of the Netherlands. Arable production is concentrated in the clay regions in the north, middle and south-west of the Netherlands. In regions with peat soils, grassland production is predominant, while arable production, including fodder maize is almost impossible. Regionalisation of the model 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 nutrient surpluses.

DRAM includes agricultural outputs at a detailed level because of differences in economic importance and environmental effects. Within each of the 14 regions, 13 arable crop activities, 2 forage crop activities, 1 non-food activity and 7 intensive livestock activities (including calf fattening and beef cattle) and 9 dairy farming activities are distinguished.

The arable crop 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 fodder maize. Arable crop activities, forage crop activities and the non-food activity produce only one specific output per activity in the model. Horticulture under glass, trees and fruit are left out of the model. In the Netherlands there is limited interaction between these industries and other agricultural industries.

[1] A mathematical presentation of the model and the exact PMP procedure used can be obtained from the authors upon request.

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. One beef cattle activity is included because of the limited economic importance of beef cattle in the Netherlands. DRAM includes nine dairy farming activities. 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 of differences in transportation cost, differences in nutrient content and differences in the nutrients from inorganic fertilisers equivalents.

DRAM includes nine dairy farming activities which produce milk, grass, fodder maize and different types of calves and manure. The classification of dairy farming activities is based on milk production per dairy cow and use of nitrogen from inorganic fertilisers equivalents per hectare grassland as important economic and environmental variables. At industry and regional level there is a positive relationship between milk production per dairy cow and milk production per hectare. In the model producers can switch between different dairy farming activities. Besides differences in milk production per dairy cow and nitrogen from inorganic fertilisers equivalents per hectare grassland, dairy farming activities are characterised by differences in feeding rations and use of other variable inputs. Feeding rations are also determined by the fixed use of grassland and fodder maize per dairy cow.

The following variable inputs bought from input delivering industries are distinguished: concentrates, pesticides, nutrients from inorganic fertilisers (N and P_2O_5) 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 milk, sugar beet and starch potatoes quotas and land. Milk and starch potatoes quotas limit national production, but can be regionally traded. Sugar beet quotas are regionally fixed. The agricultural area is also fixed at the regional level.

Supply and demand of roughage, young animals and manure are modelled through regional balances and implicit elasticities of demand and supply can be derived from shadow prices. Manure and young animals can be transported international and between regions. It is assumed that roughage can be transported international, but not between regions. This is explained by differences in quality between domestic and international supply. In this paper inverse demand functions are included explicitly for consumption potatoes, marketable outputs, onions, different types of vegetables in the open and flower bulbs. The small country assumption is applied for all other output and variable input prices including export and import prices of roughage, young animals and manure.

Yields are fixed for all intensive livestock, crop and dairy farming activities. Feed balances are used to meet the feed requirements of intensive livestock and dairy farming activities.

The relationship between crop yield per hectare and nutrients requirements is modelled through crop and regional specific nutrient balances. To meet the nutrient requirements both nutrients from inorganic fertilisers and/or nutrients from animal manure can be used. For that purpose nutrients from animal manure are transformed into nutrients from inorganic fertilisers equivalents.

In the Netherlands two different set of policy instruments are used to reduce and control manure production and use. First, there is MINAS, a nutrients accounting system. MINAS calculates the input (e.g. through the purchase of feed, nutrients from inorganic fertilisers and animal manure) and the output of nutrients (e.g. through the sales of milk, meat, cereals and manure) at the farm level. Nutrient surpluses above a certain threshold level are taxed. Threshold levels are diversified per region and crops to take into account differences in environmental effects. The MINAS system is included in DRAM through decomposition of farm gate balances into animal and crop balances. Animal balances result in nutrients production or excretion per animal. Nutrients production from the animals is included into crop balances to calculate nutrients surpluses above the threshold level as defined by MINAS. Second, since 2000 there is the obligation to remove nutrient surpluses from the farm.

An important advantage of the model is that agriculture as a whole is included. This is important because, through the manure and land balances, dairy policy reform not only affects dairy farming, but other agricultural industries as well. However, activities are not differentiated per farm consequently behavioural and structural differences between farms are not taken into account.

THE MIXED INPUT-OUTPUT MODEL

In section 2 a model for Dutch agriculture was presented. Here we present a method to include results from the programming model into a mixed IO model.

In the usual form of the standard demand-side IO model $(I-A)X = D$ and $X = (I-A)^{-1}D$, the final demand elements, D, and the matrix of IO coefficients, A, are considered exogenous. Changes in final demand of industry i (D_i) are exogenous to the model and it is the effects of these changes on industrial gross outputs, X_i's, that are quantified through the IO model (Millar and Blair, 1985).

It is also possible to employ a mixed IO model, in which final demands for some industries and gross outputs for the remaining industries are specified exogenously. Here, a mixed IO 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, IO 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 industry model; agriculture (1), output processing industry (2), agricultural input delivering industry (3) and non-agriculture (4).[2]

Gross output from agriculture (X_1) is an exogenous variable into the mixed IO model and taken from DRAM. Agricultural output is divided proportionally between the different demand categories on the basis of the shares in the original IO table. This gives the transaction from agriculture to the output processing industry (X_{12}). The exogenous gross output of the output processing industry can now be calculated as: $X_2 = X_{12} / a_{12}$ Where X_2 denotes the gross output of the output processing industry and a_{12} the IO coefficient between agriculture and output processing industry. The transaction from the input delivering industry to agriculture (X_{31}) is taken from DRAM. Next the IO coefficient describing transactions from the agricultural input delivering industry to agriculture (a_{31}) can be recalculated: $a_{31} = X_{31} / X_1$.

To close the mixed IO model, final demand from the agricultural input delivering industry (D_3) and non-agriculture (other industry) (D_4) is assumed exogenous. So, endogenous variables in the mixed IO 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).

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 IO relationships can be written as (exogenous variables are indicated using an overbar):

$$\begin{bmatrix} -a_{13} & -a_{14} & -1 & 0 \\ -a_{23} & -a_{24} & 0 & -1 \\ 1-a_{33} & -a_{34} & 0 & 0 \\ -a_{43} & 1-a_{44} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_3 \\ X_4 \\ D_1 \\ D_2 \end{bmatrix} = \begin{bmatrix} -(1-a_{11}) & a_{12} & 0 & 0 \\ a_{21} & -(1-a_{22}) & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 \\ a_{41} & a_{42} & 0 & 1 \end{bmatrix} \begin{bmatrix} \overline{X_1} \\ \overline{X_2} \\ \overline{D_3} \\ \overline{D_4} \end{bmatrix} \tag{2}$$

The procedure described above has been applied to the model used in this paper. Given the different levels of aggregation in DRAM and the mixed IO model a data harmonisation procedure had to be applied.

The DRAM/IO system described provides a simple way of calculating economy wide effects of dairy policy reform. However, the assumptions underlying programming models and IO models apply also here.

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

So there are fixed IO coefficients (except for technology switches in agriculture), supply of factor inputs is perfectly elastic (except for land and quotas that are fixed for agriculture) and there is no explicit link between income formation and final demand (Millar and Blair, 1985).

DATA

Activity levels are calibrated against observed activity levels in 1996 taken from Dutch Agricultural Census collected yearly by Statistics Netherlands. Economic and technical variables (e.g. regional prices and yields per activity) are taken from the Dutch Farm Accountancy Data Network (FADN) and are based on a three year average from 1993/94-1995/96. Data for the nine different dairy farming activities also come from FADN. 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. A three year average is used to take into account coincidental variation in yearly results.

The mixed IO model is based on a Dutch agricultural IO table (Koole and van Leeuwen, 2001; van Leeuwen and Verhoog, 1995).

DRAMs database is completed with specific findings in the literature especially on nutrients, e.g. nutrients and manure production per activity, minimal nutrients requirements per activity, nutrients from inorganic fertiliser equivalents, crop uptake and maximum export of animal manure.

POLICY SIMULATIONS AND RESULTS

Policy simulations

The base scenario is a simulation of Dutch agriculture in the benchmark with Dutch manure and mineral standards (MINAS) set at 2003 levels.

Remaining scenario’s are:

- Scenario S1 is a simulation of Agenda 2000 as if it was fully introduced in the benchmark. This implies a reduction in the milk price of 15% and a milk quota increase of 1.5%. Direct income payments are coupled to production .
- Scenario S2 gives a simulation of Agenda 2000 with decoupled direct income payments. This is simulated in the model as if direct income payments are abolished at all. The direct income payments, equal to their level in scenario S!, are ex-post added to industries revenues.
- Scenario S3 is equal to scenario S1, except that now the milk quotas are abolished. In this scenario the milk price is equal to the world market that is assumed to be 30% lower than the milk price in the benchmark.
- Scenario S4 is equal to scenario S2, except for milk quota abolishment and a decrease of the milk price with 30%.

Results

Agricultural production

Results with respect to the number of animals are presented in Table 1. The number of dairy cows increases slightly in S1 as a result of the increase of 1.5% of the milk quota. Beef cattle gains from higher direct income payments. The decrease in the number of meat calves is explained by lower prices under Agenda 2000 which are not fully compensated for by direct income payments. Results for S2 show that a further decrease in the number of meat calves and beef cattle is expected when direct income payments are decoupled from production and production is fully determined by market prices. The decrease in the number of beef cattle and meat calves results in a decrease of manure and nutrients production. Manure prices go down and manure markets are less restrictive, this stimulates lower milk production per cow and lower milk production per hectare grassland. The number of dairy cows, pigs and poultry go up compared to S1.

As expected the number of dairy cows increases after milk quota abolition. The corresponding total increase in milk production in S3 and S4 equals 8% and 11%, respectively.

The increase in number of dairy cows results in higher production of manure and nutrients, higher prices for animal manure and a decrease of production in other livestock industries. Results show that dairy farming activities are very competitive on national manure markets after milk quota abolition.

Table 1 also shows effects on crop activities. Area of cereals decreases under S1 compared to the base scenario with about 7%. This decrease is larger when direct income payments are decoupled and after milk quota abolition. In S4 the area of cereals decreases with about 25%. In this scenario the area of other crops decreases with about 9%, mainly due to a decrease in the area of starch potatoes. Land that is not used for arable crops is mainly used for grass land to feed dairy cows. In S4, the area of grassland increases with about 9%.

Table 1. Percentage change in livestock numbers and land use under different scenarios (base in 1000 animals or 1000 hectares).

	Base	S1	S2	S3	S4
Cows	1648	1	2	8	11
Beef cattle[1]	339	6	-41	0	-45
Meat calves	593	-6	-34	-7	-28
Grassland	1050	2	7	4	9
Fodder maize	214	-2	-4	-2	-2
Cereals	194	-7	-17	-13	-25
Other crops	450	0	-7	-3	-9

1. In Livestock Units

Regional effects and technology switch in milk production

A small re-allocation of milk quotas towards the clay regions was found under S1. This re-allocation is strenghtened under S2 and can be explained by the large area of cereals in this region and substitution with fodder crops to increase the number of dairy cows and milk production. After milk quota abolition, the relative increase in milk production in the clay region is about twice as large as the national increase. Model results show that milk production after milk quota abolition is extra stimulated by decoupling of income payments, especially in the sand and clay regions.

DRAM distinguishes nine types of dairy farming activities representing different technologies used in dairy farming. Under S1 there is a limited shift towards the use of high productive dairy cows. This tendency is reversed under S2 as number of beef cattle further decreases and manure and nutrients policies become less restrictive. Under S3 there is again a strong increase in the use of high productive dairy cows. S4 stimulates the use of low productive dairy cows, relative to S3.

Profit

Table 2 and Table 3 show the effects on profits in a number of selected industries and the economy as a whole. Here profit is defined as revenues minus variable costs and includes depreciation and compensation for labour, capital (including quotas) and land. Table 2 shows a strong decrease of profits in dairy farming under S1. This is explained by lower market prices of milk under Agenda 2000 which are not fully compensated by direct income payments. Moreover, the use of variable inputs will increase related to a technology switch towards high productive dairy cows. Profits in the calve fattening industry decrease, following lower market prices of veal which are not compensated by direct income payments and lower prices of calves for replacement. Profits in the pig and poultry industry are hardly affected. Profit possibilities in arable farming also decrease under Agenda 2000, mainly due to decrease in cereals production and slightly lower prices of potatoes and onions.

Direct income payments per industry in S2 and S4 are assumed equal to direct income payments per industry in S1. In reality distribution of direct income payments might change as direct income payments in S2 and S3 are linked to land. Given the assumed distribution of direct income payments over industries, S2 has a positive effect on profits in dairy farming and calve fattening industries. Dairy farming gains from lower prices of grass and fodder maize and decreased use of variable inputs related to the increased use of low productive dairy cows. There is a small gain for the intensive livestock industry too, due to lower manure prices.

On the other hand, profit decreases in the arable and other agricultural industries compared to S1. This is explained by a decrease in total area of arable and vegetable crops, a decrease in the market prices of arable and vegetable crops and lower revenues from manure acceptation caused by lower prices of animal manure.

Table 2. Percentage change in gross value added for agricultural industries under different scenarios (base values in million €).

	Base	S1	S2	S3	S4
Dairy farming	2,025	-9	-7	-33	-32
Calf fattening	36	-28	7	-31	31
Intensive livestock farming	836	0	1	-2	-2
Arable farming	962	-5	-14	-2	-10
Other agriculture	3,723	0	0	0	0
Total agriculture	7,582	-3	-4	-9	-10

Profits in dairy farming after milk quota abolition in S3 and S4 decrease because of the milk price reduction of 30%. In the short term, this can not be compensated by increased milk production. From table 2 it can be concluded that milk quota abolition increases profit possibilities in arable farming, compared to scenario S1 and S2. This is explained by the relative high prices of vegetables and potatoes and relative high revenue from manure acceptation due to the increased manure and nutrients production from the increased number of dairy cows.

Table 3 shows the effect on profits in some selected non-agricultural industries and the economy as a whole. S1 has a negative effect on profits in the economy as a whole. The share of agriculture in total profit loss is relatively large. S2 shows a further decrease of profits in the economy as a whole. This is mainly explained by a decrease in profits in the meat industry, other output processing industry and input delivering industries. The decrease in the input delivering industries is explained by efficiency gain in agriculture as direct income payments are decoupled from production and allocation of inputs to activities is based on market prices only. Profits in processing industries decrease because of lower prices for arable crops and vegetables.

Table 3. Differences in gross value added agriculture, agricultural processing and input delivery industries under different scenarios (in million €).

	S1	S2	S3	S4
Total agriculture	-250	-283	-720	-756
Dairy manufacturing	-111	-111	-179	-151
Meat industry	-40	-114	-51	-113
Other output processing industries	-8	-103	-29	-116
Agricultural input delivering[1]	-8	-238	22	-138
Non-agriculture	0	-15	3	-7
Total Netherlands	-418	-863	-955	-1281

1. Includes transport of young animals and manure

Table 3 shows that milk quota abolition and a decrease of the milk price with 30% compared to the base, will decrease profits in agriculture and dairy processing. There is a strong increase in the share of agriculture in total profit loss in the economy as a whole. This is explained by more than proportional increase in the use of variable inputs in dairy farming. Notice, that the DRAM/IO model can not provide a full welfare analysis.

DISCUSSION AND CONCLUSIONS

This article aims to analyse the environmental and economic effects of Agenda 2000, decoupling of direct income payments and milk quota abolition for Dutch agriculture and the economy as a whole. The study takes into account the strict manure and nutrients policies in the Netherlands.

Results show that full introduction of Agenda 2000 has important effects on production and income in agriculture. Results are different per industry and region. Decoupling of direct income payments especially effects production in the beef, calf fattening and arable and vegetable industries.

Milk quota abolition will increase milk production in the Netherlands by about 8% to 11%, depending on if direct payments are coupled or not under Agenda 2000. The increase in milk production is conditioned by the Dutch nutrients accounting system known as MINAS. MINAS will result in higher manure prices following the increase in number of dairy cows after milk quota abolition. Results show the competitiveness of dairy farming in the Netherlands. Nitrogen surpluses at soil level are controlled by MINAS and are rather stable after milk quota abolition.

Changes in gross output in agriculture are fed into a mixed IO model to calculate economy wide effects of the dairy policy reform. It was found that economy wide effects of scenario's exceed changes in primary agriculture by far. However, the extent depends on scenario's.

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 nutrients production, uptake of nutrients by crops, manure export to other countries, manure processing cost 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 industry and economy.

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