Effects of agri-environmental measures and changes in EU single farm payments on Dutch agriculture

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Abstract

Part of the Health check of the Common Agricultural Policy (CAP) of the European Union in 2008, will be a discussion of the linkage between direct payments to farmers and the contribution of agricultural production to social important values. The objective of this paper is to analyse the economic and environmental effects of extra region specific environmental measures and a redistribution of direct payments to the Dutch agricultural sector in 2020. In doing so a chain of models is used from the dairy farm level to the regional sector level in the Netherlands to the European sector level. From the dairy farm model it is found that the extra-environmental measures result in a decrease in the number of dairy cows per ha and a decrease in the gross margin per ha in the regions at hand. At maximum the gross margin decreases with about € 1,300 per ha. This is the case on intensive types of dairy farms in the Nature2000 areas. Linking and aggregating these results to the regional sector level and using the sector model of the Netherlands it is found that income from dairy farming at sector level and national milk production decreases with about 6%. Emission of ammonia decreases with 11% and Nitrogen (N) surplus at soil level decreases with 22%. However, economic and environmental results can be very different per type of dairy farm and province.

Key words: economic models, model linking, policy, regions, dairy farming, environment and nature.

1 Introduction

There is growing public concern as to the negative externalities of agricultural production. Enforced by this, environmental concerns play a vital role in the EU's Common Agricultural Policy (CAP). Direct payments to farmers in the EU are linked to the obligation of Good Farming Practice or GFP (cross-compliance) (http://ec.europa.eu/agriculture/envir/index_en.htm).

In 2008 a mid-term review of the CAP will take place, the so-called Health check of the CAP. Part of the Health check will be an evaluation of the cross-compliance. Whether the Health check will result in a drastic change of the CAP is unknown. However, many countries agree that direct payments to farmers have to be further discussed in the light of the contribution of agricultural production to social important values (environment, nature, landscape, food safety, animal welfare, etc.). Hence, it is expected that the Health check will further explore the possibility to use targeted payments under the CAP to influence the contribution of agricultural production to these values.

If the policy change as explained above will take place, it will enforce a redistribution of agricultural subsidies. Moreover, the direct payment will more and more become a financial compensation to farmers of extra cost due to extra contributions to the environment, landscape or other social important values. With this in mind, a project was started to analyse the effects of a transition from the current system of EU direct farm payments in the Netherlands (which is based on historic entitlement) to payments per hectare of cultivated agricultural land (flat-rate) and targeted payments for extra region-specific agri-environmental measures (van den Heiligenberg, et al., 2007; Helming and Schrijver, 2008). As extra agri-environmental measures and extra cost differ per region, the resulting hectare payments differ per region. The redistribution of payments is such that at a national level, hectare payments (including financial compensation for extra costs) cannot exceed the available CAP direct payments in the Netherlands in the starting situation (€ 850 mln in euros of 2002). The effects of the above mentioned scenario with hectare payments and extra environmental restrictions are compared with a reference scenario. This reference scenario includes changes in the market conditions: further liberalisation of agricultural markets, abolition of the EU milk quota system, the current system of EU direct payments per country and an overall 25% decrease in EU direct payments (Nowicki et al., 2007). The time frame for the analysis is 2020.

Different types of model are necessary in order to analyse the economic and environmental effects of important policy switches towards different levels of aggregation (Kuhlman, et al; 2006). The complexities of the economic issues and interactions of policy switches of different kinds, are such that a model that is fully consistent at all levels of aggregation is not available – and would probably not be feasible either. Looking at the agricultural sector, farm-level models give details about farmers' behaviour and farm management, but ignore interaction with other farms and the market level. On the other hand, sectoral and market models often give too little detail regarding all possible input and output changes at the farm level. Different models could be linked in order to achieve results that are more realistic and consistent with the economic behaviour at different levels of aggregation. This could be done iteratively until convergence is achieved for the shared variables. The objective of this technical paper is to describe the link between the Common Agricultural Policy Regional Impact (CAPRI) model, the Dutch Regionalised Agricultural Model (DRAM) and the so-called Farm-scale Integrated Optimisation Model of Nature and Agriculture (FIONA). The linked model system will then be used to analyse the effects of extra region specific environmental measures and a redistribution of direct payments to the Dutch agricultural sector in 2020.

We start this paper with a limited description of the individual models. More details about the models are provided in the literature. The models are linked through the linkage of individual variables. This is described in section 3. Section 4 and 5 present the scenarios and the iterative procedure in more detail respectively. In section 6 the outcomes of the scenarios are presented. We end this paper with discussion and conclusion in section 7.

2 Model description

Firstly, FIONA is used. FIONA is a bio-economic model with which the effects of changes in the institutional or physical environment on income, agricultural production, nature and the environment can be analysed at the level of the individual dairy farm (Groeneveld and Schrijver, 2006).

FIONA maximizes the farm's financial balance within a set of restrictions that describe the structure of the farm under consideration. The model consists of five parts: a cattle module, a fodder accounting and land use module, a labour module, a soil nutrient module and an objective module. Apart from the objective module, which calculates the financial balance, all modules describe a different part of the farm.

The cattle module calculates the number of cattle that the farm can keep, its direct benefits, its fodder demands, its direct costs and its labour demand. The fodder demands go into the fodder accounting and land use module, whereas the amount of manure produced is used in the soil nutrient module. The amount of labour needed goes into the labour module and the direct costs and benefits go into the objective module.

The fodder accounting and land use module calculates how the farm can meet the cattle's fodder demands by production and purchase, how much fodder can be sold and how much land is needed for this.

Soil nutrients needed for fodder production are fed into the soil nutrient module, labour demands go nto the labour module and the direct costs and benefits of land use go into the objective module. Given the amount of manure produced, and the amount of nutrients needed for fodder production, the soil nutrient module calculates how much fertilizer needs to be purchased and how much manure must be removed from the farm.

The labour module calculates the amount of labour needed for the different activities that take place on the farm, how much labour is available and how much needs to be rented. Costs of labour go into the objective module.

The input data of FIONA include biophysical, farm specific and financial data. Biophysical data include the fodder demands of different types of cattle, and the production of different types of fodder. Farm specific data include the size and type of the stable, the available plots and their size and average milk production per cow. Financial input data include prices of different production factors such as labour, fertilizer, fodder and concentrates, but also sales products such as milk and meat.

In addition, DRAM is used. This is a model of the regional agricultural sector in the Netherlands (Helming, 2005). DRAM consists of the following equations: one objective function maximizing national revenue minus variable costs from agriculture, regional agricultural product balances, regional balances for intra-sectorally produced inputs (animal manure, roughage and young animals), nutrient requirements per crop The model is completed with quotas (milk, starch potatoes and sugar beets), production rights (pigs and poultry) and land balances.

DRAM aggregates agricultural activities from the individual farm level to the regional level. The version of DRAM that is used in this paper distinguishes between twelve regions. These are the twelve provinces in the Netherlands. Regional differentiation is important because of heterogeneity of soil types per region and because of regional concentration of agricultural production.

In DRAM agricultural outputs are produced by agricultural activities. The selection of agricultural activities, outputs and inputs is determined by economic importance and possible environmental effects. Within each of the twelve provinces in DRAM, sixteen arable crop activities, three fodder crop activities (grass, maize and other), seven intensive livestock activities (beef cattle, fattening calves, sows, fattening pigs, laying hens, meat poultry and mother animals of meat poultry) and eight types of dairy cow activities are distinguished. More detail is included to model milk production because of the economic importance and impact of dairy farming on land and manure markets.

Technical input coefficients concerning the total use of nutrients N and P, either from animal manure or mineral fertilizer), young animals and roughage (grass and maize) differ per activity per region and are treated as exogenous variables. Yield per activity is exogenous as well. Purchased variable input costs (concentrates, pesticides and other variable inputs) per activity are modeled using a quadratic variable cost function. The approach of Positive Mathematical Programming (PMP) is used to calculate the parameters of the cost functions in such a way that the observed activity level is almost exactly reproduced (Howitt, 1995). To overcome the problem of degrees of freedom in the standard PMP approach, prior information about the supply elasticities are used to calculate the parameters of the regional and activity specific cost functions (Heckelei and Britz, 2005; Helming, 2005).

As is the case with FIONA, prices of marketable outputs and purchased inputs are treated as exogenous variables in DRAM. Internal inputs in DRAM are different qualities of roughage, young animals and manure. Internal inputs are produced and consumed within agriculture. Prices of the internal inputs are partly endogenous within DRAM. Animal manure can be traded between regions and internationally (Takayama and Judge, 1971). Young animals and roughage are not traded between regions, but they can be traded internationally[1].

Fixed inputs in the model are land and quotas. Capital is assumed not to be restrictive in quantity and price in agriculture.

Finally, in this project use is made of CAPRI. This model is comparable with DRAM but gives a description of the European agricultural sector at regional level. In contrast to DRAM, the prices of marketable agricultural products within CAPRI are determined endogenously. This is possible because CAPRI contains a market module, in which supply and demand at the European level and trade with the rest of the world are optimised simultaneously (Britz, Heckelei and Kempen, 2007).

3 Model linkage

The reason for linking the different types of model is that the chain of models gives results that are more realistic and consistent with the economic behaviour at the different levels of aggregation. The model linkage focuses on linking the variables that are shared by at least two out of the three models. Moreover, the variables that are shared between the models should be endogenous in one model and exogenous in the other. The shared variables between FIONA and DRAM are described below.

[1] International trade include the use and produce of internal deliveries by activities not included in the model e.g. horses and sheep.

Table 1. Description of type of dairy cow activities in DRAM.

Dairy activity type	Milk production (kg per dairy cow)	Dairy cows (heads per hectare)	Dairy cows (heads per farm)
D1	< 7450	< 1.6	< 60
D2	< 7450	< 1.6	> 60
D3	< 7450	> 1.6	< 60
D4	< 7450	> 1.6	> 60
D5	> 7450	< 1.6	< 60
D6	> 7450	< 1.6	> 60
D7	> 7450	> 1.6	< 60
D8	> 7450	> 1.6	> 60

DRAM describes regional agricultural production via eight types of dairy cow. These are presented in table 1. Each type of dairy cow in DRAM corresponds with a certain type of dairy farm. Each type of dairy farm is modelled in detail by the independent farm-level model FIONA. Therefore, FIONA and DRAM share the different types of dairy farm. The following variables are endogenous in FIONA and exogenous in DRAM:

- dmgrasperha 'grass production per hectare in kg dm per ha'
- dmmaisperha 'maize yield in kg ds per ha'
- dmgrasperkoe 'grass consumption in kg ds per cow'
- dmmaisperkoe 'maize consumption in kg ds per cow'
- hgrasperkoe ‘hectare grassland per dairy cow’
- hmaisperkoe ‘hectare green maize per dairy cow’
- stikaanwhgras 'minimum application of nitrogen from fertilizer and animal manure in kg N per hectare grass'
- saldoperkoe 'gross margin in euros per cow'

The prices of marketable agricultural products, purchased variable inputs and internal supplies at the sector level are exogenous in FIONA and endogenous in CAPRI. Only prices of internal supplies are endogenous in DRAM. As a first step price changes in CAPRI are linked to DRAM. Next, DRAM adds price changes of internal supplies (manure and roughage products) and the full set of new prices are send to FIONA. Hence, we consider CAPRI/DRAM here as one model system.

During model simulations the following variables are read from CAPRI/DRAM into FIONA:

Milk price	'milk price per type of dairy cow in euros per tonne'
Grass price	'grass price in euros per tonne dm'
Maize price	'maize price in euros per tonne dm'
Manure price	'manure price per dairy cow in euros per m3'
Feed price	'price index for purchased feed basis is 100'
Beef price	'price index for beef basis is 1'

3.1 Shifters

In this study the variables that are exogenous (or constant) in one model are made endogenous (or variable) per scenario by reading them from another model where the variables in question are indeed endogenous. In this way a number of prices for inputs (in particular feed) and end products in DRAM are read per scenario from CAPRI. FIONA delivers detailed information to DRAM pertaining to the milk production per hectare and expenses, consumption of purchased variable capital goods and manuring of the roughage crops per type of dairy cow activity.

The linkage of CAPRI, DRAM and FIONA is now achieved through shifters. This is illustrated in table 2. The figures in table 2 relate to a fictitious example.

Table 2. Linkage of CAPRI and DRAM, and of FIONA and DRAM, through shifters. The amounts are intended for illustrative purposes only.

	REFERENCE		SCENARIO	
Shifter	CAPRI	DRAM	CAPRI	DRAM
	MILK PRICE (€ per tonne)		MILK PRICE (€ per tonne)	
180/200=0.9	200	180	180/200=0.9	200
	REFERENCE		SCENARIO	
Shifter	FIONA	DRAM	FIONA	DRAM
	HGRASPERKOE (ha/animal)		HGRASPERKOE (ha/animal)	
0.4/0.5=0.8	0.5	0.4	0.7	0.8*0.7=0.56

In table 2 the reference milk price in DRAM is equal to € 180 per tonne. In CAPRI that is € 200 per tonne. In the reference, the so-called ‘Shifter’ between the milk price in DRAM and the milk price in CAPRI is thus equal to 180/200 = 0.9. The milk price is a constant factor in DRAM but is a function of policy changes or other scenario-specific changes in CAPRI. In CAPRI the scenario leads to an increase in the milk price from € 200 to 220 per tonne. With the aid of the shifter, the milk price in DRAM in the scenario is now defined as 220*0.9 = € 198 per tonne. We do the same for the link between FIONA and DRAM. The variable HGRASPERKOE or ha/animal per type of dairy cow activity is endogenous in FIONA and exogenous per type of dairy cow activity in DRAM. Through shifters, built upon a certain reference or initial situation, the change in FIONA can be passed on to DRAM.

4 Scenarios: reference and optimisation of environment and nature

4.1 The reference scenario

This study concerns the year 2020. For the models CAPRI, DRAM and FIONA this means that data pertaining to agricultural production, the consumption of variable inputs, transportation flows in relation to the prices of agricultural products and inputs per region, and in some cases per type of business, have to be estimated for 2020 (for example, the development of labour productivity per business in FIONA). These estimates are based on the extrapolation of trends, the outcomes of other models, estimates by experts and our own model calculations. Of course, our determination of which policy changes to include and which not to include is also important in the reference scenario. With regard to the macro economic data such as economic growth, population growth, etc., the reference scenario fits the Strong Europe scenario as described in the report *Welvaart en Leefomgeving*

(Prosperity and the Living Environment) produced in 2007 by the Netherlands Bureau for Economic Policy Analysis (CPB), the Netherlands Environmental Assessment Agency (MNP) and the Netherlands Institute for Spatial Research (RPB).

Common Agricultural Policy of the European Union
- Linking slaughter premiums in cattle and veal-calf farms to production.
- Premiums for starch potatoes linked to production on 60% basis.
- Other payments based on the historical basis and linked to the business.
- 25% modulation of direct payments: this means that a discount of 25% is applied to the farm payment and the linked payment. The funds made available by this will be used for the second pillar, the so-called rural policy.
- Abolition of milk quota system in the EU.

Trade policy
- Abolition of basic prices for dairy products and of export refunds for dairy products.
- Lowering of import tariffs for all agricultural products in question according to the EU proposal, as described in Kuiper and Banse (2007).

Nature and environmental policy
- A maximum of 170 kg N from animal manure per ha per region. An exception applies to the Netherlands, namely a maximum of 230 kg N from animal manure per ha.
- A maximum of 60 and 90 kg of phosphate from animal manure per ha farmland and grassland respectively.

4.2 Optimisation environment and nature

Common Agricultural Policy of the European Union
- Flat rate per hectare per EU member state.
- Abolition of milk quota system.
- Discount on the total amount of the flat rate: the funds made available by this will be used to compensate the extra expenses of area-specific and generic measures.

Trade policy (see reference scenario)

Nature and environmental policy
- A maximum of 170 kg N from animal manure per ha per region. An exception applies to the Netherlands, namely a maximum of 230 kg N from animal manure per ha.
- A maximum of 60 and 90 kg phosphate from animal manure per ha farmland and grassland respectively.
- Feed adjustments in the dairy farm sector to reduce the nitrogen (N) excretion per animal.
- Installing buffer strips.
- Measures relating to Nature 2000 Areas.
- More intensive meadow bird management in the meadow bird areas (areas where the black-tailed godwit lives).

Measures relating to Nature 2000 Areas

- Agricultural nature conservation in the form of botanic management with subsequent grazing on 80% of the farm area. With this policy it is not permitted to transport manure out onto the lots and grazing may only be applied starting from August.
- Increase in soil water level on the operational parts subject to nature conservation.
- Less manuring around the Nature 2000 Areas. The placement space of lots that are subject to nature conservation will be set at zero. This means that the lots receiving no manure cannot be compensated by increased manuring elsewhere within the business.

Measures in the meadow bird areas

- Increase in soil water level on lots with mowing dates postponed from GT IV to GT II.
- Agricultural meadow bird management with postponed mowing dates on 60% of the farm area. The policy thereby consists half of 'light' packages with mowing dates postponed until 1 June or 8 June and for the other half of 'heavy' packages with mowing dates postponed until at least 15 June or 22 June.

The effects of the scenario optimization environment and nature is also analysed at European level using CAPRI. However, details about extra cost of extra region specific agri-environmental measures are unknown at regional level in Europe. Hence, redistribution of direct payments is not taken into account at European level in this study. The difference between the reference scenario and the scenario optimization environment and nature in CAPRI is limited to the abolition of the direct payments in the scenario optimization environment and nature.

5 Running through the scenario: the iterative procedure

Based on the scenarios, the procedure to be followed for the calculation of scenarios can be summarised in the following step-by-step plan.

Step 1
CAPRI/DRAM develops a 2020 reference scenario. This reference scenario is based on the extrapolation of trends, the outcomes of other models and the effects of policy changes, such as in trade policy and the EU milk-quota policy. The structural data for the farms (the number of dairy cows per business and per hectare and milk production per cow), the prices of agricultural products, the prices of internal deliveries (young stock, roughage and manure) and the prices of variable capital goods in 2020 are passed on to FIONA.

Step 2
FIONA calculates a reference scenario for 2020 per type of dairy farm per area, given the outcomes from Step 1. Then FIONA calculates the extra expenses of area-specific measures, as defined in the optimisation environment and nature scenario. FIONA thus delivers the outcomes at the operational level for any given area.

Step 3

CAPRI calculates the effects of an equivalent of the environment and nature scenario at the European level. In this case, the outcomes that are of particular importance for the combination of CAPRI/DRAM/FIONA are the prices of agricultural products, young stock and feed.

Step 4
DRAM calculates the effects of the environment and nature scenario at the regional and national level (production of cattle farms, soil use, number of companies in the dairy farm sector, sectoral income, etc). The inputs for the DRAM calculations are the prices of agricultural products, young stock and feed from CAPRI, changes in methods (yield per ha grassland, dairy cows per ha, expenses and yields per ha, etc) per type of dairy cow per area according to FIONA, and, naturally, the generic extra nature and environmental measures pertaining to the scenario. Within DRAM effects of area-specific measures from FIONA (see Step 2) which apply only to a specific region (for instance a Nature 2000 Area or grassland) are converted into averages per province.

Step 5
FIONA recalculates the environment and nature scenario, given the prices of milk, meat, manure and roughage from CAPRI/DRAM (see Step 3 and Step 4). Given the changes in prices, the FIONA outcomes also change as compared with Step 1. Step 4 may have to be repeated several times, depending on the degree to which the FIONA outcomes change as compared with Step 1.

6 Outcomes

Outcomes of CAPRI/DRAM and FIONA - Step 1 and Step 2
In the reference scenario for 2020, the milk price decreases by more than 50% as compared with the level in 2002. The prices of various inputs also decrease, although less markedly. The price of disposing of superfluous animal manure outside of the business is expected to increase by a factor of 1.54 during this period. Under these conditions, it will be advantageous for the companies to keep the manuring intensity on the grassland as low as possible. Consequently, the yield or net yield of the grassland will be exceptionally low in comparison with 2002. The shortage of roughage can be supplemented (relatively cheaply) by using green maize, silage grass and/or by means of removal from the common meadow. Table 3 provides insight into the outcomes and assumptions of the scenario optimisation environment and nature. In table 3 outcomes of FIONA (Step 2) are aggregated to the regional and national level.

Table 3. Summary of the Step 1 and Step 2 results of the scenario optimisation environment and nature in 2020. The amounts are in 2002 prices (on a real terms basis).

Priority	**Technical measure**	**Regional indication**	**Area (1000 ha)**	**Compensation € per ha**	**Total compensation (millions of €)**
1	Measures relating to Nature 2000 Areas including:	Around Nature 2000	120	945	113
2	More intensive meadow bird management	Meadow bird areas	132	346	46
3	General environmental measures, for example for the NEC-guideline and KRW. These include:	Generic			
	Feed adjustments	Generic	1333[a]	50[b]	67
	Buffer strips	Generic	34	785	27
4	Landscape as connection between nature	Between Nature 2000	t.b.c.	t.b.c.	t.b.c.
5	Flat rate	Generic	1718	204	350
	Total				602[c]

a. per 1000 cows; b. € per cow; c This is 850 million euros on a nominal basis (1.9% inflation per year)

Outcomes of table 3 can be explained as follows. The extra costs or income loss of the extra environmental measures in the Nature 2000 areas, vary between about € 550 per ha at dairy farm type D2 (low level of milk production per ha) to more than € 1300 per ha at dairy farm type D8 (high level of milk production per hectare)[2]. The extra cost per ha or income loss is mainly the result of a decrease of number of dairy cows per ha in the Nature 2000 areas (see table 6). According to FIONA (Step 2) the number of dairy cows per ha at dairy farm type D8 decreases from about 2 to less than 1 per ha in the Nature2000 Areas in the scenario optimisation environment and nature. Given the distribution of dairy farm types in the different provinces with Nature 2000 areas in 2020, at.average the extra cost and the financial compensation per ha equals to about € 945 per ha at national level (see table 3). It is estimated that the financial compensation is paid to about 120,000 ha of mainly grassland and maize in the Nature 2000 Areas. Share of Nature2000 Areas in total agricultural area per province are especially high in provinces in the east of the Netherlands (Overijssel, Gelderland) and provinces in the south of the Netherlands (Noord-Brabant, Limburg). Location of Nature 2000 areas and meadow bird areas are presented in Map 1. Meadow bird areas are mainly in the north and the west of the Netherlands.

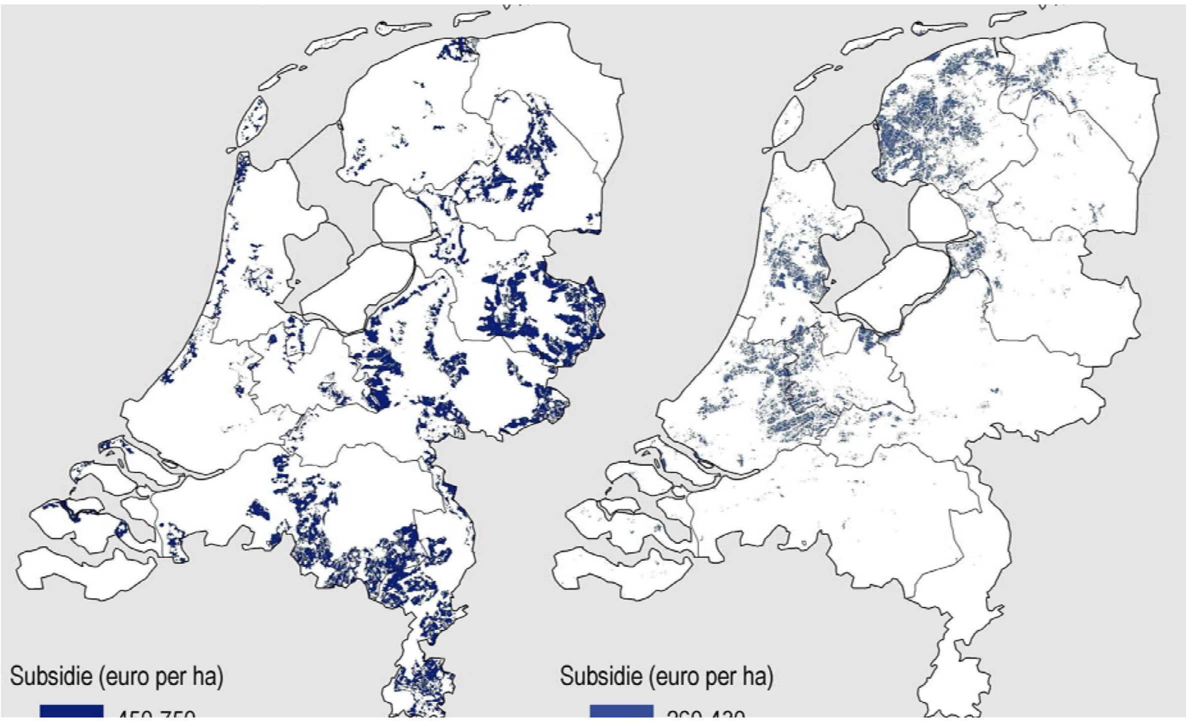
Extra cost of measures in the meadow bird areas vary from about € 240 per ha for dairy farm type D5 (average level of milk production per ha) to almost € 460 per ha voor farm type D8. At average the

[2] These are FIONA results of Step 2 and they differ slightly from FIONA results of Step 5.

extra cost and the financial compensation equals about € 346 per ha. In total this compensation is paid to about 132,000 ha (see table 3).

General measures of the scenario optimisation of environment and nature are feed adjustments to decrease the Nitrogen (N) excretion of the dairy cows and the introduction of buffer strips. The feed adjustment costs are assumed to be equal to € 2,50 per kilogram N excretion reduction. Moreover, it was assumed that N excretion of the dairy cow could not decrease below 120 kg N per dairy cow. Buffer strips means that part of the land was set-aside from agricultural production, manure application etc. The financial compensation for this equals € 750 per ha.

The financial compensation for extra environmental measures is paid from the available direct payments to the farmers from the CAP of the EU. In the Netherlands this is about € 850 mln (prices of 2002). After the financial compensation for extra environmental measures is deducted, the remaining part is paid to the farmers as a flat rate (instead of the current system of direct payment based on historic entitlement).



Map 1. Location of the Nature2000 areas (left hand side) and the meadow bird areas (right hand side) in the scenario optimisation environment and nature.

Outcomes of CAPRI/DRAM - Step 3 and Step 4

CAPRI results show that effects on milk prices and prices of other agricultural products of the scenario optimisation environment and nature as defined at European level (see Section 4.2) are very limited. This is explained by the fact that in the reference most direct payments are already decoupled from production.

Table 4 provides insight into the effects of the nature and environment scenario on the average prices of roughage and manure in the Netherlands using DRAM. The most remarkable outcome is the 12%

decrease in the price of manure from dairy cows as compared with the reference in 2020. This, of course, is a result of reduced N excretion by dairy cows due to the feed adjustments. Moreover, the number of dairy cows in the scenario optimisation environment and nature decreases by 6% at the national level, while the number of other cattle also decreases somewhat. This leads to less pressure on the manure market. With regard to the effect on the number of dairy cows, we see large differences per province. The decrease in the number of dairy cows in the scenario optimisation environment and nature scenario is most pronounced in the provinces of Overijssel and Noord Brabant, at -15% and -8% respectively. This, of course, is related to the area-specific measures that lead to an important decrease in the number of dairy cows per hectare in the Nature 2000 Areas (see above and table 6). These areas form a relatively large proportion of the aforementioned provinces, hence the large effects per province. Moreover, the distribution of dairy farm types in nature2000 Areas per province in 2020 play a role as well. Provinces which are effected most by the scenario optimisation environment and nature have a high share of dairy farms with relatively high levels of milk production per ha.

Table 4. Price development of internal supplies (roughage products and manure disposal cost (€ per m^3)) in 2020 in the scenario optimisation environment and nature (index, reference = 1)

	Reference	Optimisation environment and nature
Grass	1	1.03
Green Maize	1	0.99
Manure disposal costs	1	
- poultry	1	0.98
- dairy cows	1	0.88
- remaining cattle	1	1.00
- fattening pigs and sows	1	0.95

Total milk production and sectoral income (revenue, excluding financial compensation for extra environmental measures minus variable cost)in the dairy farm sector also decrease by 6% in the scenario optimisation environment and nature in 2020. The decrease in sectoral income from dairy farming is again highest in Overijssel, namely -12%.

Aggregated to the national level, the environmental effects of the scenario optimisation environment and nature are positive. In 2020 the emission of anhydrous ammonia will decrease by 11%, or from 121 million kg NH_3 in the reference scenario to approximately 108 million kg NH_3. The effect on the nitrogen balance is even larger. In the Netherlands the nitrogen surplus to the soil balance decreases by an average of 22%, namely from approximately 62 kg N per ha to somewhat more than 48 kg N per ha. The effects differ per province and per region. The variation in the change in the application of animal manure per ha per province is indicative of this. In the provinces of Overijssel and Gelderland, the application of nitrogen from animal manure in 2020 decreases by more than 20% in the nature and environment scenario in comparison with the reference. In Noord Brabant and Limburg the figures are approximately -17% and -15% respectively. In the other provinces the decrease in the application of animal manure lies between -3% and -10%.

The feed adjustments pertain only to the N excretion per dairy cow. This means that the average national effect of the nature and environment scenario on the application of phosphate from animal manure per ha is also limited. However, once again there are important regional differences. In the provinces of Limburg, Noord Brabant, Overijssel and Gelderland, the application of phosphate from animal manure decreases by approximately 10%. In the other provinces, the application of phosphate actually increases; the maximum is an increase of more than 10% in the province of Zuid Holland.

The placement of buffer strips in the nature and environment scenario makes arable farming companies start to intensify their soil use. This means that there is a tendency to let the proportion of potatoes, vegetable crops and sugar beet in the total cropping plan increase somewhat.

However, the greatest effect on land use comes from the changes in the number of hectares of grassland and green maize per dairy cow, particularly in the Nature 2000 Areas. On a national scale this leads to the grassland area increasing by 4% as compared with the reference scenario, whereas the feed maize area decreases by 17% as compared with the reference scenario. At the regional level the change in the grass area varies from almost +11% in Noord Brabant and Overijssel to approximately 0% in Flevoland and Zeeland. The change in the green maize area varies from -15% and -35% in Noord Brabant and Overijssel respectively to approximately +0.5% in Flevoland and Zeeland.

Outcomes in FIONA - Step 5

The FIONA outcomes in Step 5 are arrived at as follows. The number of dairy cows per business, milk production per cow and the number of dairy cows per hectare per type of dairy farm are kept constant as compared with the reference in 2020 (see Step 2). However, the prices and amounts of the subsidies per cow and per ha are again read from CAPRI/DRAM (see Steps 3 and 4). We wish to identify the so-called isolated effects of the area-focused measures on the loss of income per type of dairy farm. In order to determine this, both the reference scenario and the policy scenario must be recalculated using the new set of prices and new amount of the subsidies per business[3]. In the following, the outcome of the new reference scenario is indicated by ‘no management iteration 2.’

[3] It is in fact assumed that area-focused policy does not have any influence on the prices of agricultural products and consumed inputs (such as roughage, manure, soil, etc). This is not completely correct, but in the context of this study it was not yet possible to separate the effects of the different policy measures that are being introduced simultaneously.

Table 5. Technical and financial outcomes for meadow bird management accompanied by raising water levels on peatland in the meadow bird areas in the scenario optimisation environment and nature.

	DRAM business type							
Technical outcomes FIONA	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
Number of cows per business								
No management iteration 2	62	167	56	144	70	132	81	141
Meadow bird management 30-30 iteration 2	62	167	56	131	70	132	81	140
Number of cows per ha								
No management iteration 2	1.20	1.35	1.52	1.62	1.49	1.33	1.50	2.05
Meadow bird management 30-30 iteration 2	1.20	1.35	1.52	1.48	1.49	1.33	1.50	2.03
OEB business (*1000 kg)								
No management iteration 2	18	43	14	37	15	34	22	35
Meadow bird management 30-30 iteration 2	5	11	3	7	11	15	8	15
Gross margin per ha (€)								
No management iteration 2	1144	1273	1546	1469	1962	1734	1787	2125
Meadow bird management 30-30 iteration 2	842	952	1196	1099	1722	1468	1492	1671

Upon the application of meadow bird management (30% with a cutting date postponed until at least 15 June and 30% with a cutting date postponed until at least 1 June), business D4 no longer fully utilises its stall capacity (in view of low milk production per cow, extensive and intensive). This business therefore starts to become more extensive (see table 5). All companies increase the nitrogen load to counteract the consequences of raising water levels (on 60% of the farm acreage). Nevertheless, grassland production decreases even further in all companies. Green maize, which also made an appearance in the peat meadow area in the latter days of product support, virtually disappears from the cropping plan. Notwithstanding the fact that the total nitrogen load increases upon the introduction of meadow bird management, environmental gains are also realised. The Unstable Protein Balance (or UPB) that ensures a higher anhydrous ammonia discharge is significantly lower than it would be without meadow bird management, owing to the relatively low protein content of meadow bird grassland. The introduction of meadow bird management accompanied by raising water levels has varying financial consequences for those parts of the business, ranging from approximately €300 per hectare for relatively extensive companies, to between €400 and €450 per hectare for those intensive companies that (as it was presumed) do not apply summer stall feeding.

Table 6. Technical and financial outcomes for botanic management of sandy soil accompanied by raising water levels and restriction of the possibilities for manure sales in the Nature2000 Areas in the scenario optimisation of environment and nature.

	DRAM business type							
	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
Technical outcomes FIONA								
Number of cows per business								
No management iteration 2	62	167	56	144	70	132	81	141
Botanic management with subsequent grazing iteration 2	32	123	26	62	70	132	52	66
Number of cows per ha								
No management iteration 2	1.20	1.35	1.52	1.61	1.49	1.33	1.49	2.04
Botanic management with subsequent grazing iteration 2	0.62	0.99	0.71	0.69	1.49	1.33	0.98	0.96
OEB business (*1000 kg)								
No management iteration 2	15	35	14	38	15	34	22	36
Botanic management with subsequent grazing iteration 2	2	5	2	4	4	13	2	3
Gross margin per ha (€)								
No management iteration 2	1129	1235	1544	1472	1971	1744	1784	2131
Botanic management with subsequent grazing iteration 2	492	686	519	535	1325	1152	805	840

The consequences of the botanic management of 80% of the farm area have a far reaching effect on operations (see table 6), even more so than is the case with respect to meadow bird management. This effect is greater still due to the raising of water levels at those lots around Nature 2000 Areas that are subject to botanic management under the environmental scenario and the fact that those lots do not have storage space for animal manure. Almost all companies drive down their production drastically (i.e. become more extensive) in order to restrict the consequences of the intervention as much as possible. Companies D5 and D6, which participate in summer stall feeding due to their high milk production per cow, are better able to face the disadvantages of botanic management than, for example, companies D7 and D8, where the milk production per cow is somewhat lower and where the cows graze outside during the day. There is no longer any room at all for green maize in the companies' cropping plans. Another significant difference is the nitrogen application on the land, which is now extremely low (the botanical grassland cannot be manured at all and the other land is now subject to a maximum of 230 kg N/ha). In environmental terms, the UPB is now even more favourable than is the case with meadow bird management. Upon the introduction of the package of measures, the income decreases by amounts ranging from €550 per hectare for the smaller extensive business with low milk production per cow, to €1300 per hectare for the large intensive business with high milk production per cow.

7 Discussion and conclusion

Further harmonisation databases

The linkage of CAPRI, DRAM and FIONA has now been realised via shifters (see Section 3). The use of different data for the same agricultural activities (for instance, dairy cows of type D1 up to and including D8 occur in FIONA as well as in DRAM) leads to different expenses and yield ratios per agricultural activity. This again means that equal percentage changes in individual yields and expense components, via the use of shifters, still lead to different model outcomes (for instance in gross margin per type of dairy cow). Therefore, it is better to endeavour to achieve further harmonisation of overlapping data in the different models.

Micro and macro tuning

In this study, the 2020 reference scenario was imposed on FIONA on the basis of CAPRI/DRAM. Developments in technical/economic variables are usually based on trend extrapolations, expertise, literature or ad hoc estimates by the researcher. However, thanks to increased feedback between, on the one hand, FIONA and, on the other hand, CAPRI/DRAM, a more realistic estimate can be made of the different technical/economic developments at the operational level, given developments in price and quantity at the market level. This applies, for instance, to developments in the milk production per type of dairy cow in relation to the corresponding feed rations and cropping plan at operations level in the 2020 reference scenario. In CAPRI/DRAM, the aforementioned developments are based mainly on trend extrapolation and expert knowledge. Due to lack of time, the feed-back from FIONA to CAPRI/DRAM was limited. The consultation was limited to developments in labour productivity at operations level in relation to developments in price and quantity at market level. For the development of long-term references and scenarios, it would be highly desirable to have greater insight into possible technical/economic developments at the level of activities and at the level of companies (developments in productivity and efficiency per hectare/animal) in relation to market developments in general. This applies not only to dairy cows and dairy farms, but also to other activities in CAPRI and in DRAM. One solution would be to achieve further linkage of DRAM and CAPRI to technical models, such as the CAPRI/DRAM/FIONA link concerning the different types of dairy cow activities.

Sub-areas

In this study, the lowest aggregation level is the agricultural activity in a province. Naturally, this has the disadvantage that the effects of area-focused measures at the level of the sub-areas (such as Nature 2000, peat meadow areas, meadow bird areas and national landscapes) are not represented. The lowest aggregation level is, after all, the province. In principle, DRAM can also make calculations at the level of the 66 agricultural areas. The accuracy of the proportion of the different sub-areas (Nature 2000 or National Landscapes) per DRAM area (i.e. 66 agricultural areas) would increase and the insight into the effects at the level of the sub-areas would improve significantly. The CAPRI/DRAM/FIONA linkage is still in an experimental phase. Due to lack of time, it was decided to begin by calculating at provincial level. This saves significantly in calculation time, so that more time remains to experiment and to refine the links. Endeavours could be undertaken to make the area set-up in DRAM more flexible.

Different compensation per type of dairy farm

Following the results of the farm model (FIONA), extra cost of the region specific additional agri-environmental measures in the scenario optimisation environment and nature differ per type of dairy farm. For reason of simplicity it is assumed that financial compensation per type of dairy farm equals exactly the extra cost per type of dairy farm. This means that compensation not only differs by region, but also by type of dairy farm. In reality this might be rather difficult achieve.

Effects of the scenario optimisation environment and nature

In this study, the CAPRI/DRAM/FIONA linkage was focused on the calculation of two specific scenarios. Area-specific measures were focused on the dairy farm sector. In the environment and nature scenario, the loss of income per dairy farm as a consequence of the area-specific measures varies from approximately € 550 per ha for D2 to more than € 1300 per ha for D8 in the Nature 2000 Areas. The extra cost or income loss mainly result from sharp decreases in the number of dairy cows per ha, resulting from the environmental restrictions. The outcomes of the scenario optimisation environment and nature for the dairy farm sector as a whole can be summarised as follows:

- decrease of 6% in the total number of dairy cows and milk production in the Netherlands – the decrease in the number of dairy cows varies from 15% in Overijssel to between 3 and 4% in the northern and western provinces;
- Sectoral income from dairy farming at national level (revenue, excluding financial compensation for extra environmental measures minus variable cost) by 6% in the scenario optimisation environment and nature in 2020. The decrease in sectoral income from dairy farming is highest in Overijssel, namely -12%;
- decrease of 11% in the emission of anhydrous ammonia at national lvel;
- at the national level, the domestic application of animal manure decreases by approximately 12%. The nitrogen (N) surplus on the soil balance actually decreases by 22% to approximately 50 kg N per hectare in 2020.

Effects of the linkage

It is concluded that the CAPRI/DRAM/FIONA linkage offers a more consistent and expanded descriptions of the effects of policy measures at both operations level and market level. On the one hand, DRAM reads from FIONA very detailed changes in input-output parameters per type of dairy cow activity. On the other hand, FIONA results are guided by more consistent changes in relative price relationships steered by CAPRI/DRAM. Future applications could be the analyses of effects of different kind of EU agricultural policies and changes in the WTO.

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