IMPACT ASSESSMENT OF THE 2003 CAP REFORM AND THE NITRATE DIRECTIVE ON THE ARABLE FARMING SYSTEM IN THE MIDI-PYRÉNÉES REGION: BIO-ECONOMIC MODELING AT FIELD, FARM AND REGIONAL LEVELS

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Abstract

This paper analyses the impact of the 2003 CAP reform (the so-called Fischler Reform) and its interaction with the Nitrate Directive on the sustainability of selected arable farming systems in a French region (Midi-Pyrénées). The Nitrate Directive is one of the oldest EU environmental programs designed to reduce water pollution by nitrate from agricultural sources, through a set of measures, defined at regional level, and mandatory for farmers of vulnerable zones. This impact analysis is performed through a bio-economic modelling framework coupling the crop model CropSyst and the farm-based model FSSIM developed, within the EU FP6 SEAMLESS project (Van Ittersum et al., 2008). The 2003 CAP reform was compared first to the continuation of Agenda 2000 Regulations and then to a policy scenario combining the CAP reform with the application of the Nitrate Directive.

Compared to the continuation of Agenda 2000 Regulations, the implementation of the 2003 CAP reform leads to (i) a decrease of durum wheat area, as the supplement for durum wheat in traditional production zones was reduced and integrated in the single payment scheme, (ii) a slight increase in the land used for irrigated crops, especially for maize grain, considering that 25% of the payments for these crops remain coupled and (iii) an amelioration of farm income due to a better crop allocation. Regarding the environmental results, the 2003 CAP reform induces a decrease of nitrate leaching mostly because of the drop in the level of durum wheat growing under cereal rotations in profit of soft wheat-sunflower rotation which generates less pollution levels.

The impact analysis of the policy scenario shows that the potential 3% premium cut is not enough to compel farmers to adopt the Nitrate Directive and to substitute entirely the current activities by the alternative ones based on better N management. The farm income is marginally affected in spite of this premium cut thanks to the implementation of certain alternative activities which are more competitive. The impact on nitrate leaching is not always positive and swings between -6% to +5% depending on farm types. This implies that the partial adoption of better N management is not sufficient to ensure a reduction of leached nitrate. A sensitivity analysis shows that 17% of premium cut is required to enforce all arable farmers in the region to implement this directive.

Keywords: Integrated assessment; Agricultural Policy; Nitrate Directive; Bio-economic modelling; multi-scale analysis.

JEL: Q18, Q52, Q58.

Background and objectives

In 2003 an agreement was finalized to promote the most significant reform of the European Union's (EU) Common Agricultural Policy (CAP) since its inception. Motivated primarily by budgetary concerns, this reform seeks several goals such as the distribution of agricultural income, promotion of good agricultural practices in marginal agricultural areas, simplification of the CAP operation, facilitation of the process of eastward enlargement of the EU and defence of the CAP in the WTO negotiation (CEC, 2003b). The most important measures of this reform are the adoption of decoupled direct payment, the introduction of a new modulation system, and the enforcement of agri-environment schemes. The decoupled payment consist on the replacement of all Direct Producer Payments associated with beef, sheep, and arable crops production (and planned future dairy payments) with a 'single payment per farm (SFP)' received by beginning in 2005. Such single farm payments are calculated on the basis of 'a reference amount in a reference period 2000-2002' and are paid to those holding land with a payment entitlement. This implies that the amount of the payment would not depend on what and how much the farmer actually produces but essentially on area and historical entitlement. Farmers are free to decide what they want to produce in response to demand without losing their entitlement to support. The reform, however, gives each EU Member State the possibility to choose a 'degree of decoupling' among some options, which can be applied at national or regional level. In the arable sector the proposed options are based on up to 25% of hectare payments or, alternatively up to 40% of the supplementary durum wheat aid (OECD, 2004).

The modulation system introduced in this reform aims to finance the additional Rural Development Regulation (RDR) measures through the reduction of direct payments by 5% from 2007 for farms with more than 5000€ direct payment a year. This 5% reduction, known as "modulation", will result in additional RDR funds of EUR 1.2 billion a year (CEC, 2003b).

The 2003 CAP reform has been also promoting the multifunctional role of agricultural. Farmers are viewed not only as food suppliers but also as the custodians of the countryside. This role of farmers has been acknowledged in the EU Common Agricultural Policy through a number of regulations that enforce agri-environment schemes and cross-compliance. These measures have been introduced under the Agenda 2000 regulation as optional but the 2003 CAP reform made them obligatory for all farmers receiving compensation payments. The nitrate directive is one of the first programs promulgated by the Environmental EU commission (91/676/EEC) to reduce water pollution caused by nitrate from agricultural sources i.e. chemical fertiliser and livestock manure. Defined at regional level, this Directive stipules that each Member State draws up at least one code of good agricultural practices. This code has the objective of reducing pollution by nitrate in the vulnerable zones, taking into account regional specificities across EU. In arable farming systems, this directive is based on the following measures: (i) better management of mineral and organic nitrogen fertilization; (ii) respect of the restricted period for applying manure or nitrogen fertilizer taking into account the type of fertilization and the land use; and (iii) maintenance of a minimum quantity of vegetation cover during (rainy) winter periods for the uptake of the nitrogen from the soil. If one of these measures is not respected a range of penalties linked to EU premiums can be applied (Belhouchette et al, 2005).

The objective of this paper is to analyse through a bio-economic modelling approach the potential impact of the 2003 CAP reform as well as of the Nitrate Directive on the performance of arable farming systems and on a set of sustainable development indicators (e.g. nitrate leaching, soil erosion, nitrate use...). Performed in a French region (Midi-Pyrénées), this study aims to answers the following questions: (i) what are the impacts of the simulated scenarios on the economic and environmental sustainability of the selected arable farms? (ii) What happens if all the farmers are enforced to respect the nitrate directive? (iii) Which policy instruments could be applied in order to stimulate/force farmers to adopt the Nitrate Directive?

In Section 2 the used modelling approach is illustrated, followed by a description of the study area, data requirement, model calibration and simulation scenarios. In section 3 the results of policy scenarios at farm and regional levels are presented and discussed. Conclusions and suggestions are given in Section 4.

Materials and Methods

Impact assessment of the European agricultural and environmental policies on farm's performance and sustainability has become a central issue for researchers, producers and policy makers. An increasing body of literature has been developed on methods for the evaluation of present policies, with special attention to the economic aspects. In contrast, there is a lack of tools to support the design of future policy schemes through *ex-ante* assessment and to take into account the impact of policies in terms of technical, environmental and landscape issues. This seems to be due on the one hand to the complexity of new policy schemes, and on the other hand to the necessary of multi-disciplinary approach of policy decision making. Such integrated assessment can be performed through the bioeconomic modelling chain "CropSyst-FSSIM" designed and used in this case study.

Modelling approach: CropSyst - FSSIM model chain

CropSyst is a biophysical model developed, by the Biological Systems Engineering Department of the Washington State University, to serve as an analytic tool to simulate the effect of cropping systems management on productivity and the environment (Donatelli et al., 1997). It was used in this application to quantify, at field level and according to agro-ecological conditions, the effects (in term of yields and environmental externalities) of the current and alternatives activities defined as a combination of crop rotation, soil type and management type.

FSSIM is a farm model developed, within the SEAMLESS project to assess the economic and environmental impact of agricultural and environmental policies and technological innovations (Louhichi et al., 2007). For our case study, FSSIM was designed to describe farmer's behaviour given a set of biophysical, socio-economic and policy constraints, and to predict his/her responses under EU policy changes, using data generated from CropSyst as well as other data sources (Farm Accountancy Data Network (FADN), expert knowledge, surveys…).

The general context in which FSSIM was developed and the variety of policy questions that is called to address justifies a combination of choices that makes this model unique:

- Comparative static model: FSSIM is a mono-periodic model which optimizes an objective function for one period (i.e. one year) over which decisions are taken. This implies that it does not explicitly take account of time. Nevertheless, to incorporate some temporal effects, agricultural activities are based on "crop rotations" and "dressed animal[1]" rather than individual crops and animals.

- Primal based-approach: FSSIM follows a primal-based approach, where technology is explicitly represented. It uses engineering production functions generated from agronomic theory and biophysical models (Hengsdijk and Van Ittersum, 2003). These engineering functions constitute the essential linkage between the biophysical and economic models. This discrete mathematical programming approach can (better) capture the technological and policy constraints than a behaviour function in econometric models.

- A positive model, where the main objective is to reproduce the observed production situation as precisely as possible by making use of the observed behavior of economic agents (Janssen and Van Ittersum, 2007).

- A risk programming model, taking into account the risk according to the Mean-Standard deviation method in which expected utility is defined under expected income and risk (Hazell and Norton, 1986).

- Modular model: it has a modular setup to be re-usable, adaptable and easily extendable to achieve different modelling goals. Thanks to this modularity, FSSIM provides the capabilities to activate and deactivate modules according to regions and conditions. It allows also the subsequent incorporation of additional modules which might be needed to simulate activities not included in the existing version, such as perennial activities, and the replacement of modules with alternative versions.

[1] The concept of 'dressed animal' represents an adult animal and young stock taking into account the replacement rate.

- Generic model: it was designed sufficiently generic and with a transparent syntaxes in order to be applied to many different farming systems across Europe and elsewhere, and to assess different policies under various conditions.

The mathematical structure of FSSIM can be formulated as follows:

Maximise: $U = Z - \phi\sigma$ (1)

Subject to: $Ax \leq B$ **;** $x \geq 0$ (2)

Where: **U** is the variable to be maximised (i.e. utility), **Z** is the expected income, **x** is a (n x 1) vector of agricultural activity levels, **A** is a (m x n) matrix of technical coefficients, **B** is a (m x 1) vector of levels of available resources, **ϕ** is a scalar for the risk aversion coefficient and **σ** is the standard deviation of income according to states of nature defined under two different sources of variation: yield (due to climatic conditions) and prices.

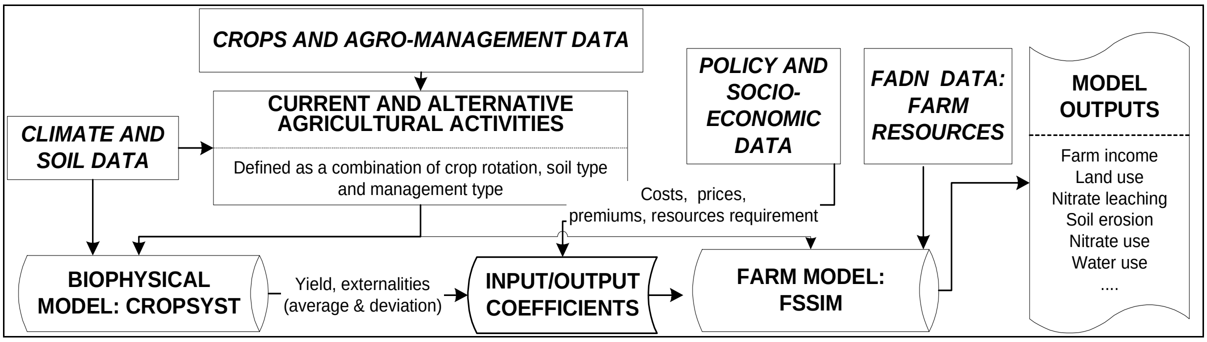
The expected income (**Z**) is a non-linear profit function. Using matrix notation, this gives:

$$Z = \sum_{j} p_j q_j + \sum_{j,l} p^a_{j,l} q^a_{j,l} + \sum_{i,t} s_{i,t} \frac{x_i}{\eta_i}(1-\alpha b) - \sum_{i,t} c_{i,t} \frac{x_i}{\eta_i} + \sum_{i,t}\left(d_{i,t} + \frac{\psi_{i,t} x_i}{2} \right)\frac{x_i}{\eta_i} - \varpi L \quad (3)$$

Where: **i** indexes agricultural activities, **j** indexes crop products, **l** indexes quota types (e.g. for sugar beet these are A and B), **t** indexes number of years in a rotation, **p** is a vector of average product prices, **q** is a vector of sold production, $\mathbf{p^a}$ is a vector of additional price that the farmer gets when selling within quota l, $\mathbf{q^a}$ is a vector of sold production within quota l , **s** is a vector of subsidies per crop within agricultural activity *i* (depending on the Common Market Organisations (CMOs)) , **c** is a vector of variable cost per crop within agricultural activity *i,* **d** is a vector representing the linear term used to calibrate the model (depending on the calibration approaches), **Ψ** is a symmetric, positive (semi-) definite matrix of quadratic term used to calibrate the model (depending on the calibration approaches), **η** is a vector representing the length of a rotation within each agricultural activity, **ϖ** is a scalar for the labour cost and **L** is the number of hours rented labour (Louhichi et al, 2007).

Figure 1 gives an overview of the used bio-economic modelling approach as a combination of a biophysical model "CropSyst" and a farm model "FSSIM".

Fig. 1. Bio-economic modelling framework: CropSyst-FSSIM model chain



Application of the CropSyst-FSSIM model chain

The application of this model chain to our case study is based on the following steps: (i) selection of relevant farm types representative of the arable farming system in the region using the SEAMLES typology (Andersen et al., 2006) and the FADN data sources; (ii) identification of the "average" farms (i.e. a virtual farm derived by averaging historical data from farms that are grouped in the same type) that represent adequately the whole farms that belong to the same farm type (iii) modelling each farm type separately in order to reproduce the farmer's observed behaviour (model calibration); (iv) definition and implementation of the selected scenarios and analysis of their impacts at farm level through a set of relevant indicators and (v) aggregation of the results across selected arable farm types.

Description of the case study

Midi-Pyrénées is the largest region in France with a surface of 45348 km^2. It is as big as Denmark and bigger than Belgium, Switzerland or Holland. Agriculture in Midi-Pyrénées is very important, with production equally divided between livestock and crops. It represents the first French region by its number of holdings (around 60.000) and the fifth by the value of its agricultural production.

The main crops cultivated in the region are cereals, protein crops and oilseeds. They represent approximately 40% of the cultivated areas of the region (Agreste-annual farm statistics, 2006). 5% of the total cultivated area of the region was lying fallow in 2006: 9% of the total cultivated area is irrigated. Rainfed annual grain crops are therefore predominant in the Midi-Pyrénées region. In this application the crops are the main ones cultivated in the region without distinction of cultivars inside species. The soil types in the region can be limited to the two main soil types locally known as: calcareous clay and clay-loam.

The Midi-Pyrénées region is known by the problem of water pollution by nitrate from agricultural sources. In 2002, more than 45% of the water quality in term of nitrate concentration is judged as average or very bad. Only 3% of the water body is considered of very good quality (Ifen, 2002).

Selection of representative farm types

Modeling all individual arable farms in the Midi-Pyrénées region is not feasible because of the large number and the diversity of farms. For that reason it was decided to use the farm typology developed in the SEAMLESS project. Based on FADN and Farm Structural Survey (FSS), this farm typology provides a set of farm types relatively homogenous defined by 4 criteria: size, intensity, land use and specialisation.

From this typology we have selected three farm types to represent the arable farming system in Midi-Pyrénées. For each farm type average endowment characteristics and observed crop pattern have been computed and reported in Table 1.

Table 1. Main characteristics of the three arable farm types in the Midi-Pyrénées region

	Farm type 1	**Farm type 2**	**Farm type 3**
Specialisation_land use	Cereal	Cereal/Fallow	Mixed
Farm represented (number)	2330	990	1736
Area by Farm (ha)	113.9	101.5	123.3
Irrigable area by Farm (%)	37	30	13
Soil Types (% of texture)	Clay (40%) Clay-loam (60%)	Clay (36%) Clay-loam (64%)	Clay (41%) Clay-loam (59%)
Available labour (hours)	2901.6	3260.3	3179.0
Observed Crop allocation (ha)			
Cereals	72.8	52.4	53.3
Oilseeds	19.5	17.7	43.3
Protein crops	2.9	4.3	5.9
Fallow	11.4	18.9	11.5

Source: FADN database (average of the three years around 2003)

Collecting required data

Three types of data are required to apply the CropSyst-FSSIM model chain:

- Bio-physical data characteristics of the agri-environmental zones used as input for the bio-physical model CropSyst.

- Farm resource data such as available farm land per soil type, irrigated land, available family labour and observed crop allocation (i.e. crop pattern). These data are collected from the FADN sources and used in the FSSIM model for the definition of constraints' RHS value and for the calibration process.

- Identification of the current and alternative activities and quantification of theirs input output coefficients such as yield (average and variability), input use (e.g. fertiliser, water, labour…), prices (average and variability), costs, premiums, etc. To collect these data in the Midi-Pyrénées region a survey has been designed and used, completed by local expert knowledge and statistical database. These data have been collected for the most frequent cropping systems in the region. They take into account climatic variation and other factors as pests and weeds. In total 65 rotations were identified, with 11 different crops. The principal types of rotations are soft wheat-sunflower, durum wheat-sunflower and maize-maize for grain. Combined to ago-management and soil types, these rotations define the so-called current agricultural activities. For each crop within agricultural activities a set of data were collected. It includes the data on amount, nature, method and temporality of management events: sowing, harvesting and tillage events, weed, pest and disease management (pesticide events and tillage events), water management, nutrient management, labour use, average yield, yield variability…(For the moment technical crop coefficients are not rotation dependent). Additionally, for each crop a set of economic data has been specified including producer prices (the average value and the variability), variable costs and premiums. The expected producer prices are collected from regional database and based on the 1999-2003 average. Variable costs are calculated by adding input costs for fertilizers, seeds, irrigation, biocides and the application costs associated with each event. The premiums are of the three years average around 2003 according to Agenda 2000 regulation taken as base year policy. An example of a set of input-output data used in this application is given in Table 2.

Table 2. Selected set of input-output coefficient

Crops	Production techniques	Yield (T/ha)		Variable costs (Euro/ha)		Prices (Euros/T)	Premiums through Agenda 2000 (Euro/ha)
		Soil Clay-loam	Soil Calcareous Clay	Soil Clay-loam	Soil Calcareous Clay		
Soft wheat	rainfed	5.5	7	362	430	116.23	309
	irrigated	-	-	-	-		
Durum wheat	rainfed	-	5.5	-	496	135.3	613
	irrigated	-	-	-	-		
Barley	rainfed	7	5	492	357	93.75	309
	irrigated	-	-	-	-		
Maize	rainfed	6.5	-	517	-	119.66	309
	irrigated	9.5	9.5	859	859		469
Sunflower	rainfed	-	2.2	-	293	213.27	363
	irrigated	-	-	-	-		
Soya	rainfed	2	2	297	386	196.30	363
	irrigated	3.3	2.5	512	297		469
Rapeseed	rainfed	1.9	2.5	277	416	203.78	363
	irrigated	-	-	-	-		
Peas	rainfed	4	4	365	365	132.68	364
	irrigated	4.5	4.5	423	383		549
Oats	rainfed	3.6	3.6	492	492	116.23	309
	irrigated	-	-	-	-		
Fallow	rainfed	-	-	61	61	-	309
	irrigated	-	-	-	-		

Source: Chambre d'Agriculture Midi-Pyrénées

Model calibration

The CropSyst model was calibrated, for each crop, against observed yield during the simulated years. The values of the biomass-transpiration (KBT) and of light conversion to above ground biomass (KLB) coefficients were adjusted within a reasonable range of variation based on previous research and expert knowledge in order to have the best model estimation of the biomass accumulation observed for each crop in the calibration experiments (Donatelli et al., 1997). Adjustment ends when further modification of crop parameters would generate little or no improvement on the basis of the relative error, a statistical index is used to quantify the degree of fitness in the relationship between measured and simulated aboveground biomass (Cabelguenne et al., 1990).

The calibration of FSSIM is based on two steps: in the first step, we apply the risk approach in order to calibrate the model, as precisely as possible. The model assigns automatically a value to the risk aversion coefficient which gives the best fit between the model's predicted crop allocation and the observed values. The difference between both values is assessed statistically by using the Percent Absolute Deviation[2] (PAD). The aim of this step is to ensure that the model produces acceptable results before going to the second step. In the second step, a Positive Mathematical Programming (PMP) variant is implemented in order to calibrate the model exactly to the observed situation and guarantee exact reproduction of the base year situation (Howitt, 1995; Heckelei, 2003). PMP is a two step approach. In the first step, a number of calibration constraints are added to the model, to ensure that the observed situation at the base year is reproduced. The objective is to calculate the shadow price of the binding calibration constraints. In the second step, the calibration constraints are taken out and their shadow prices are used to calculate the non-linear costs (Louhichi et al., 2008).

The base year information for which the model is calibrated stems from a three-year average around 2003. In term of policy representation the Agenda 2000 (since 2000) Regulation constitutes the base year policy.

Building baseline (reference run)

The baseline scenario is interpreted as a projection in time covering the most probable future development in term of technological, structural and market changes. It represents the reference for the interpretation and analysis of the selected policy scenarios. In our case study, the 2003 CAP reform is considered as the principal policy assumption operating in the baseline scenario. In term of technological and market change, three exogenous assumptions

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$$PAD\ (\%) = \frac{\sum_{i=1}^{n} \left| \hat{X}_i - X_i \right|}{\sum_{i=1}^{n} \hat{X}_i} . 100$$

Where $\hat{X}_i$ is the observed value of the variable *i* and X_i is the simulated value (the model prediction). The best calibration is reached when PAD is close to 0.

are adopted: (i) an assumed regional inflation rate of 1.19% per year; (ii) a projection in producer prices obtained from the market model CAPRI (Britz, 2002) and (iii) a yield trend to reflect technical progress coming also from CAPRI database (Table 3). All the others parameters (including farm endowments as well farm's weight on the region) are assumed to remain unchanged up to 2013, taken as time horizon for baseline definition.

Table 3. Price and yield changes between base year and baseline scenarios

Crops	Price change (%)	Yield change (%)
Durum wheat	10	22
Soft wheat	4	-7
Barley	-3	15
Maize	-13	5
Sunflower	0	1
Soya	-19	-1
Rapeseed	11	21
Peas	9	-4
Oats	-8	20
Maize fodder	29.9	13.2

Source: CAPRI database

Layout and implementation of policy scenarios

The simulated policy scenario combines the 2003 CAP reform and the first measure of the Nitrate Directive (the other measures are not retained as they require more time in data collection and in CropSyst simulations). This measure consists to apply better management of nitrogen mineral fertilisation in order to limit nitrate lixiviation without reducing yield. It stipulates that farmers should fertilize according to the crop requirement and the soil provision of nitrogen. The implementation of this measure in the model chain CropSyst-FSSIM was achieved through the following steps (Table 4):

1. Generating a set of alternative activities (AA) based on current crops but with better management of nitrogen mineral fertilisation:

- *Nitrogen from mineral fertilizers needed by AA are calculated based on the "local advisory services" recommendations (simple nitrogen balance) using the current yield as* *target yield since expert observed that the yield of this type of AA are very close to the corresponding current activities (CA).*

- *Yield and yield variability of AA are generated from CropSyst.*
- *Costs of AA are calculated as the cost of the corresponding current activity minus the reduction in fertiliser costs due to reduction of N use.*
- *A 5 transaction cost related to the collection of information on policy implementation, the participation in training sessions… was introduced for AA.*
- *Environmental externalities associated to each AA are quantified by CropSyst.*

2. Application of cross-compliance restrictions related to AA: *3% cut of EU premiums if AA are not applied.*

Table 4. Definition of base year, baseline and policy scenarios

	Base year [2003]	**Baseline [2013]**	**Policy scenario: Nitrate Directive [2013]**
Exogenous assumptions		- Projection in producer prices from 2003 to 2013 - Yield trend from 2003 to 2013 - Inflation rate of 1.19% per year	
EU Common Agricultural Policy	Agenda 2000	2003 CAP reform (with an option of 25% partial coupling as arable crops area payments chosen for France and 5% modulation)	
Agricultural activities	Current activities (CA)		Current activities (CA) + Alternative activities (AA)
Measures	none		Cross-compliance restrictions: 3% cut of EU premiums if AA are not applied

However before analysing the impact of the Nitrate Directive scenario, a brief comparison of the likely impacts of the 2003 CAP reform and the continuation of Agenda 2000 Regulations is presented and discussed. In this comparison all the exogenous assumptions adopted in the baseline scenario are deactivated in order to asses the separate impact of 2003 CAP reform. Table 5 summarises the principal differences between Agenda 2000 and 2003 CAP reform scenarios.

Table 5. Definition of Agenda 2000 and 2003 CAP reform scenarios

	Base year [2003]	**Agenda 2000 [2013]**	**2003 CAP reform [2013]**
EU Common Agricultural Policy	Agenda 2000	Continuation of Agenda 2000	2003 CAP reform (with an option of 25% partial coupling as arable crops area payments chosen for France and 5% modulation)
Agricultural activities	Current activities (CA)		Current activities (CA)

Results and discussion

The impacts of the different scenarios are illustrated through a set of technical (crop allocation), economic (farm income and EU premiums) and environmental indicators (nitrate leaching and soil erosion). In order to make the results comparable across scenarios and farm types, the economic indicators are expressed in constant 2003 prices (i.e. deflated prices) and the environmental indicators are defined per hectare of usable farmland. First, the results for each farm type are shown. Subsequently, the aggregated results across all the simulated arable farm types are computed as the weighted sum of the results for each farm type. The weights for each farm type correspond to the share of real farms belonging to that farm group.

Impact analysis of 2003 CAP reform at farm and regional levels

Compared to the continuation of Agenda 2000 Regulations, the adoption of the 2003 CAP reform leads, as shown in Table 6, to a largest change in crop allocation manifested by (i) a fall in durum wheat area explained by the fact that the supplement for durum wheat in traditional production zones was reduced and integrated in the single payment scheme; (ii) a slight increase in the land used for irrigated crops, especially for maize grain, considering that 25% of the payments for these crops remain coupled and; and (iii) a rise on the area devoted to oilseeds and protein crops as these crops become more competitive under the decoupled payment. These tendencies are observed in all three farm types of the Midi-Pyrénées region, with different degrees according to farm's resource endowments.

In terms of economic impacts, the 2003 CAP reform would induce a decrease of EU support level (i.e. EU premiums) owing to modulation system and a slight amelioration of farm income, reaching the 5%, due to a better crop allocation. Indeed, the decoupled system stimulates farmers to choose activities according to market opportunities and without losing their entitlement to support. Unfortunately, none results in term of market impacts can be presented here as we are using individual farm model (i.e. prices are exogenous).

Regarding the environmental results, the implementation of the 2003 CAP reform leads to a decrease of nitrate leaching from 5 to 13% depending on farm types, mostly because of the drop in the level of durum wheat growing under cereal rotations in profit of soft wheat-sunflower rotation which generates less pollution levels. The impact in soil erosion is quite different across farm types. It seems positive in farm type 1, marginal in farm type 2 and negative in farm type 3. This is explained by the fact that in farm type 3 the irrigable land is low and completely used (i.e. the irrigable land constraint is binding) and so the substitution of durum wheat was done in favour of rained cereals that have large soil erosion coefficients.

Most of the technical, economic and environmental results obtained at the farm level remain consistent when aggregated at the regional level: (i) a decrease of EU premiums, nitrate leaching and durum wheat area and (ii) an increase of farm income, soil erosion and oilseed and protein crop areas. These results could be explained by the large similarity between arable farms in the region but also by the fact that the flexibility inside the arable sector is very restricted (Table 6).

Table 6. Technical, economic and environmental impacts of the 2003 CAP reform compared to the continuation of Agenda 2000: farm and aggregated impacts in the Midi-Pyrénées region

	2003 CAP reform (% change to Agenda 2000)			
	Farm type 1 (cereal)	Farm type 2 (cereal/fallow)	Farm type 3 (mixed)	**Average farm at regional level**
Farm income (% change)	2	1	5	3
EU premiums (% change)	-6	-6	-6	-6
Nitrate leaching (% change)	-13	-5	-8	-10
Soil erosion (% change)	-3	0	54	14
Crop allocation (% change)				
Cereals	-9	-9	-2	-7
Oil seeds	27	20	2	14
Protein crops	18	7	2	9
Fallow	0	0	0	0

Source: model results

Impact analysis of the Nitrate Directive at farm and regional levels

Table 7 reports the technical, economic and environmental results of the policy scenario in comparison to baseline. The main result shown in this Table is that none of the farm types has adopted entirely the first measure of Nitrate Directive. This implies that the penalty of 3% is not enough to compel farmers to adopt the Nitrate Directive and to substitute entirely the current activities by the alternative ones based on better N management. In another term, it would be more profitable to accept a 3% cut of premiums than to adopt fully the alternative N management since not all the alternative managements are competitive under the taken assumptions (e.g. 5% transaction costs). This appears clearly while looking to the change in crop allocation provoked by this policy scenario. Indeed, the share of alternative activities in the total farm area is less than 36% in the three farm types (i.e. 23% in farm type 1; 21% in farm type 2 and 36% in farm type 3). The other impacts in term of crop allocation are dominated by the substitution of oilseeds by soft wheat which becomes more profitable with the adoption of better N management.

The impact on farm income is marginal either in relative or absolute terms in spite of the 3% cut of premiums. This implies that the reduction of premiums was entirely compensated with the partial adoption of alternative activities which are more competitive to their corresponding current activities. However, this substitution is still marginal compared to the directive goal: a full adoption of better N management.

Regarding the environmental results, the impacts of the policy scenario seem very positive in term of soil erosion but uncertain for leached nitrate. Indeed, soil erosion decreases in the three farm types reaching the 30% in some cases. This is due mainly to the reduction of spring crops (sunflower and soya bean) and the increase of winter soft wheat, thereby reducing the bare soil area during winter. However, for nitrate leaching the impact is not regularly positive and swing between -6% to +5% depending on farm types. This implies that the partial adoption of better N management is not enough to ensure a reduction of leached nitrate and the solution could be through a fully implementation as proposed in the Nitrate Directive. The questions that emerges is how to stimulate/force farmers to adopt the better N management since the 3% is not enough to reach this goal and which policy instruments could be applied for that? This is aim of the sensitivity analysis developed in the last section.

Despite some differences between farm types, the trend obtained at the farm level was kept after aggregation at the regional level: no change in farm income and in nitrate leaching, a slight decrease of premiums and a significant reduction of soil erosion (Table 7).

Table 7. Technical, economic and environmental impacts of the Nitrate Directive at farm and aggregated levels in the Midi-Pyrénées region

	Nitrate Directive (% change to baseline scenario)			
	Farm type 1 (cereal)	Farm type 2 (cereal/fallow)	Farm type 3 (mixed)	**Average farm at regional level**
Farm income (% change)	-1	0	0	0
Premium (% change)	-3	-3	-3	-3
Nitrate leaching (% change)	5	1	-6	0
Soil erosion (% change)	-16	-21	-29	-22
Crop allocation (% change)				
Cereals	27	18	13	21
Oil seeds	-36	-26	-17	-28
Protein crops	9	22	21	15
Fallow	0	0	0	0
Share of AA area in the total farm area (%)	23	21	36	23

Source: model results

Sensitivity analysis

The aim of this sensitivity analysis is to estimate the thresholds of penalty (i.e. percentage of premium cut) to apply in each farm type in order to enforce farmers to respect the nitrate directive and also to show the sensitivity of these thresholds to the percentage of transaction costs assumed on the implementation of this directive.

As reported in Table 8, from 13 to 17% of penalty, according to farm type, was required to force the farmer to adopt the alternative N management. These thresholds of penalty allowed a reduction of used N fertiliser and of leached nitrate in all the farm types with a slight loss of farm income (around 6%).

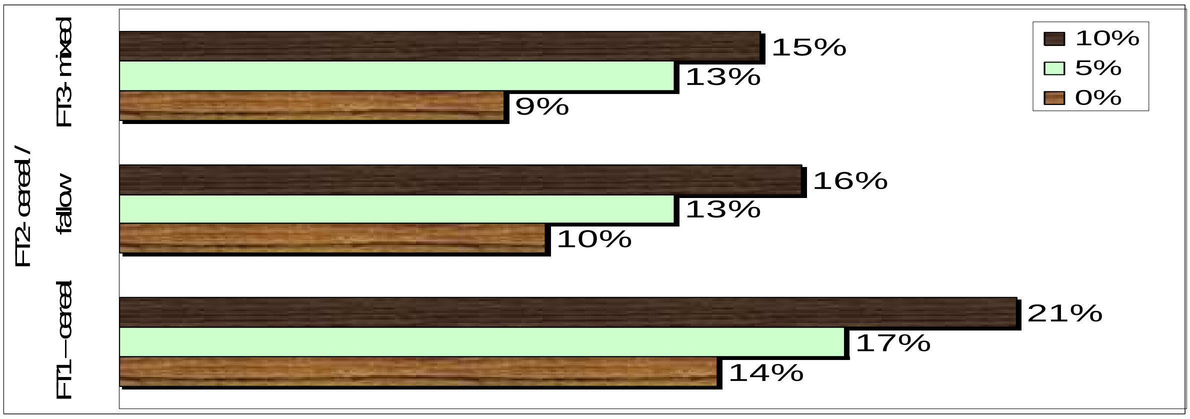
Table 8. Economic and environmental impacts of the compulsory application of Nitrate Directive in the Midi-Pyrénées region

	Nitrate Directive (% change to baseline scenario)			
	Farm type 1 (cereal)	Farm type 2 (cereal/fallow)	Farm type 3 (mixed)	**Average farm at regional level**
Penalty (%)	17	13	13	17
Farm income (% change)	-6	-5	-6	-6
N fertiliser used (% change)	-28	-26	-29	-28
Nitrate leaching (% change)	-5	-6	-14	-9

Source: model results

Figure 2 summarises the sensitivity of these thresholds to transaction costs. To perform this sensitivity analysis, we shift the initial value of the transaction cost to more less 100% (the use of same percentage allows assessing the degree of symmetry in the sensitivity) and then we run the model several times in order to establish the new penalty threshold for each farm type from which nitrate directive would be applied. As expected, the penalty threshold seems very sensitive and positively correlated to the transaction costs as the change in penalty threshold is important and would affect hardly the economic and environmental results of the selected farms. For this reason it would be appropriate to establish a consistent method for estimating these costs in a realistic manner.

Fig. 2. Sensitivity of penalty threshold to transaction costs



Conclusion

This paper has presented the results of the first application of the model chain CropSyst-FSSIM to asses the impact of the 2003 CAP reform and its interaction with the Nitrate Directive on the sustainability of arable farming systems in the Midi-Pyrenees region. The main conclusions, in terms of policy impacts, coming up from this study are: (i) the implementation of the 2003 CAP reform affects positively but moderately farmer's income due to a better crop allocation induced by decoupling system; (ii) the 3% cut premium is not enough to compel farmers to adopt the Nitrate Directive and to substitute entirely the current activities by the alternative ones based on better N management; (iii) the impact of nitrate directive, as currently implemented, on nitrate leaching is not always positive and depends on farm types, implying that the partial adoption of better N management is not enough to ensure a reduction of leached nitrate (iv) the sensitivity analysis shows that a threshold of 17% in premium cut is required to enforce all arable farmers in the region to adopt the nitrate directive. However, this threshold remains very sensitive to the transaction costs connected with the implementation of this directive.

This study highlights the relevance and the power of this type of bio-economic modelling approach for making more transparent the relationship between biological processes and economic decisions and for analysing complex policy scenarios integrating technical, economic and environmental aspects. It provides insights in some key methodological aspects to be considered and improved in further research. The main aspects are: i) the need for several interactions with local experts and further methodological development for a better models calibration and validation at field and farm levels, ii) the need for better consideration of transaction costs connected with nitrate directive in order to bring the analysis even closer to reality.

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References

Andersen, E., Elbersen, B., Godeschalk, F., Verhoog, D., 2006. Farm management indicators and farm typologies as a basis for assessment in a changing policy environment. *Journal of Environmental Management 82*, 352-362

Belhouchette, H., Wery, J., Thérond, O., Duru, M., Bigot, G., Was, A., Kloczko-Gajewska, A., Leenhardr, D., Majewski, E., Josien, E., Bergez, J-E., Henning, J., Thenard, V., 2005. Report on the major characteristics of environmental policies and agro-ecological technologies to be studied in test case 2. Seamless project, report N° 11, PD 6.1.2. 87pp.

Britz W., Henrichsmeyer W., Wieck C., Perez I., 2002. Impact analysis of the European Commission's proposal under the mid-term review of the Common Agricultural Policy (using the CAPRI model). Final Report, 75p, University of Bonn.

Cabelguenne, M., C.A. Jones, J. R. Marty, P. T. Dyke, and J. R. Williams. 1990. Calibration and validation of EPIC for crop rotations in southern France. *Agricultural Systems* 33, 153-171.

CEC, 2003b. Council Regulations relative to CAP changes, Interinstitutional Files 2003/0006, 2003/0007, 2003/0008, 2003/0009, 2003/0010, 2003/0011, 2003/0012, September, Brussels.

Donatelli M. 2002. Simulations with CropSyst of cropping systems in Southern France. Common Agricultural Policy Strategy for Regions, Agriculture and Trade (QLTR-200-00394). CIEAHEM report. 13p.

EEC, 1991. Implementation of Nitrate Directive. European Environment Commission report, Annex 2: Code(s) of good agricultural practices. 1991.

Hazell P.B.R., Norton R.D., 1986. Mathematical Programming for Economic Analysis in Agriculture. Macmillan Publishing Co, New York, 400p.

Hengsdijk, H., Ittersum, M.K. van, 2003. Formalizing agro-ecological engineering for future-oriented land use studies. *European Journal of Agronomy* 19 (4), 549 - 562.

Howitt R E. 1995. Positive Mathematical Programming. *American Journal of Agricultural Economics* 77: 329-342.

Ifen, 2002. Les dépenses des Départements en matière d'environnement. Les données de l'environnement, n°79, 4 p.

Janssen, S., Van Ittersum, M.K. 2007. Assessing farm innovations and responses to policies: a review of bio-economic farm models. *Agricultural Systems* 94, 622-636.

Louhichi K., et al., 2008. Application of FSSIM in two Test Case regions to assess agro-environmental policies at farm and regional level, PD 6.3.2.2, SEAMLESS integrated project, EU 6th Framework Programme, contract no. 010036-2, www.SEAMLESS-IP.org, 67 pp.

Louhichi K., Flichman G., Blanco M. 2007. A Generic Mathematical Programming Model (FSSIM-MP) for farming systems analysis. *Farming System Design 2007*, September 2007, Catania, Italy.

Louhichi, K., Flichman, G., Blanco, M. 2007. - A generic Template for FSSIM for all farming systems-, PD3.3.11, SEAMLESS integrated project, EU 6th Framework programme, contract no. 010036-2, www.SEAMLESS-IP.org, 85p.

OECD, 2004. Analyse of the 2003 CAP reform. Paris.

Van Ittersum, M.K., Ewert, F., Heckelei, T., Wery, J., Alkan Olsson, J., Andersen, E., Bezlepkina, I., Brouwer, F., Donatelli, M., Flichman, G., Olsson, L., Rizzoli, A.E., van der Wal, T., Wien, J.E., Wolf, J., 2008. Integrated assessment of agricultural systems - A component-based framework for the European Union (SEAMLESS). *Agricultural Systems* 96, 150-165.