Chapter 6

The impact of decoupling and price variation on dairy farmers' strategy: overview of theoretical and real effects

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The reform of the Common Agricultural Policy (CAP) in 2003 has resulted in substantial changes to the way in which dairy farmers are subsidized. Moreover, dairy farmers are also facing an unprecedented situation with major price fluctuations of agricultural raw materials. In this chapter, we discuss the cross effects on the productive strategy of French dairy farms due to the 2003 reform and to price variation. A model based on mathematical programming has been developed to determine how dairy farmers might re-evaluate their systems to identify an optimal production plan. While respecting the principle of agent rationality (maximization of profit), the model incorporates the economic risk related to the volatility of input and output prices. Thus, the model maximizes the expected utility of income while taking into account a set of constraints: regulatory, structural, zoo-technical, agronomic and environmental. This model allows a large choice in term of intensification level (input use) and productive combination. The model is applied to four types of dairy farms to show their different reactions to the reform. The simulations show how the implementation of the single payment scheme encourages farmers to increase the share of grassland. However, the increase in cereal prices is a strong incentive for farmers to intensify forage production in order to free up land for crop production. The decoupling of premiums for male bovines led farmers to reduce, all things being equal, this activity in order to increase cereal production.

Dairy farmers, in 2007, were facing an unprecedented situation on the markets with the soaring prices of agricultural raw materials. They then had to deal with the significant falls in those prices in the years 2008 and 2009. These fluctuations may lead them to change their system in order to adapt their production to this unstable economic situation. For French farmers, these changes occurred simultaneously with the implementation of the reform of the Common Agricultural Policy (CAP), decided in 2003. A key driver of this reform was the World Trade Organisation (WTO) Doha Round negotiations. Three innovations were introduced: 1) the decoupling of direct support based, in France, on the amount of direct subsidies received in 2000-02 (historical approach); 2) the modification of the dairy Common Market Organisation: the intervention prices of industrial dairy products (butter and powder) were reduced, and subsidies were granted to farmers according to their dairy quota; 3) deduction of part of the direct subsidies from Pillar 1 of the CAP to fund Pillar 2 (modulation).

In this context, the aim of this chapter is to study the behaviour of dairy farmers relating to the CAP reform with different hypothetical prices. A Mathematical Programming model is used and applied to different French dairy farms to represent the diversity of technical systems. In addition to their dairy enterprise, dairy farms often have cereal or beef production enterprises. In order to represent the diversity of technical systems, we consider four different types of farming according to the intensification of forage area and the level of specialization (grazing, semi-intensive, milk + cereals, milk + young bull). In this way, we can identify if farms have a different response to the reform according to their technical practices. This model pays particular attention to the interactions between the feeding system and the management of land, and also to the farmer's sensitivity to price changes. Thanks to these specifications, the model offer a large choice of production combinations (specialisation or diversification) and technical practices (level of intensification).

This chapter is divided into two parts. In the first part, a description of the mathematical model is presented; in the second part, some simulations are made to analyse the impact of the CAP reform on dairy farms. They try to give arguments around these following questions: 1) how do CAP reform and agricultural price variations influence dairy producers' incomes? and 2) how does decoupling change the balance of different kinds of production on a dairy farm?

Materials and method

In order to study the adaptation of farmers' practices in response to the implementation of the 2003 CAP reform, a mathematical programming model was built. This method allows us to identify the effects of the decoupling on the production system (i.e. the allocation of land areas to different crops, the level of intensification, environmental impact, etc.). An econometric model would not meet this objective because in that type of model there is no change of farmer's practice; the structure is constant. With the mathematical programming method, the model can stop certain activities or increase others.

Bio-economic model: a farm-level approach

We built a bio-economic model which takes into account the farmer's response to price variation and several technical and biological elements in order to represent as accurately as possible the functioning of a dairy farm. Mathematical Programming is a technique which enables us to represent the farm functioning in reaction to a set of constraints. It is an appropriate technique because its assumptions correspond to those of classic microeconomics: rationality and the optimising nature of the agent (Hazell and Norton, 1986). This method allows us to study threshold effects and to calculate dual values of inputs (marginal yields). Farm-level modelling enables simultaneous consideration of production, price and policy information.

Any model derived from mathematical optimisation has three basic elements (Matthews *et al.*, 2006): 1) an objective function, which minimises or maximises a function of the set of activity levels; 2) a description of the activities within the system, with coefficients representing their productive responses; and 3) a set of constraints that define the operational conditions and the limits of the model and its activities. Given the objective function, the solution procedure determines the optimal solution considering all activities and restrictions simultaneously.

The model optimises the farm plan, which represents the quantities of different outputs produced and inputs used. The economic results follow from those quantities and their prices. The model is used to estimate the effects of institutional, technical and price changes on the farm plan, economic results and intensification indicators.

Many studies have demonstrated that farmers typically behave in a risk-averse way (Hardaker *et al.*, 2004). As such, farmers often prefer farm plans that provide a satisfactory level of security even if this means sacrificing some income. For the farmer, the main issue raised by variability of price and production is how to respond tactically and dynamically to opportunities or threats in order to generate additional income or to avoid losses. Moreover, during the years 2007, 2008 and 2009, prices of agricultural commodities were subject to strong variations so that we had to take the farmer's sensitivity to price volatility. For example, the price of milk paid to the producers nearly doubled through 2007, from EUR 240/tonne to EUR 380/tonne before strongly decreasing to EUR 220/tonne in April 2009. Since the beginning of 2010, milk price seems to be on an increasing trend. Prices of cereals such as wheat have followed the same fluctuations. Cereals play a special role in dairy farming because they can be both input and output.

Lambert and McCarl (1985) present a mathematical programming formulation that allows identification of the expected utility function. Their approach, which does not require an assumption of normally distributed income (unlike the E-V, MOTAD and Target MOTAD methods), can accommodate the assumption that the utility function is monotonically increasing and concave (risk-averse). Patten *et al.* (1988) reformulated this approach as Utility Efficient Programming (UEP). Moreover, Zuhair *et al.* (1992) show that the negative exponential utility function (with Constant Absolute Risk Aversion, CARA) can better predict farmers' behaviour than cubic and quadratic functions. The CARA function is a reasonable approximation to the real but unknown utility function: the coefficient of absolute risk variation can be validly applied to consequences in terms of losses and gains for variations in annual income. The UEP method enables the model to take into account asymmetric price distribution: the skewness becomes an element of decision as well as the variation amplitude. Thus, the model maximizes the expected utility of the income as follows:

$$\textit{Maximize: } E[U] = p\, U(k, r), \quad r \text{ varying} \qquad [1]$$

with: $U_k = 1 - \exp(-r_a \times Z_k)$

where Z is the net farm income for state k, and r is a non-negative parameter representing the coefficient of absolute risk aversion:

$$r_a = (1 - \lambda)r_{min} + \lambda r_{max}, \text{ for } 0 \leq \lambda \leq 1 \qquad [2]$$

where λ is a parameter reflecting variation in risk preference, and r_{max} and r_{min} are upper and lower bounds of the coefficient of absolute risk aversion (r_a).

In a more detailed form, the income Z is defined by:

$$\begin{aligned} Z = & \sum_a (T_a \times mY_a) \times 305 \times mP \\ & + \sum_a (aS_a \times aW_a \times aP_a) \\ & + \sum_a \left(T_a \times (SP_a + SPBM_a)\right) \\ & - \sum_{a,p} \left(T_a \times \left(Qcf_{a,conc,p} \times cfP_{conc} \times 91.25 + I_a\right)\right) \\ & + \sum_c \left(X_c \times (Y_c \times cP_c - I_c - nQ_c \times nP + pr)\right) - FC \end{aligned} \qquad [3]$$

- The main part of the income Z is given by milk revenues: the milk quantity multiplied with Ta the total number of animal of type a (dairy cows, heifers, calves and young bulls); mYa the milk yield (litre/day) per animal by mP the milk price (EUR/litre).
- There is then the meat revenue with aS_a the number of animals sold, aW_a the animals' average carcass weight (kg) and aP_a the meat price (EUR/kg). At the end of the lactation, cull cows are sold and benefit from the female slaughter premium (SP_a) and young bulls benefit from the special premium for bovine male ($SPBM_a$).
- Then we take out livestock costs as: $cfQ_{conc,p,a}$ the quantity of concentrate feed ingested (kg/day/animal), cfP_{conc} the concentrate feed price (EUR/kg per type of concentrate *conc*); I_a the specific inputs for animals (artificial insemination, medicines, herd book, minerals).
- We add the crop revenue as: X_c the cultivated area (ha) for each type of crop c (wheat, maize (corn), rapeseed, pea, maize silage, pasture, hay and grass silage); Y_c the crop yield (kg/ha); cP_c the crop price (EUR/kg); I_c the specific crop inputs (seed, treatments and harvesting); nQ_c the nitrogen quantity (kg/ha); and nP the nitrogen price (EUR/kg).
- Finally we consider the fixed costs *FC* (electricity, water, mechanisation, buildings, rent for land, insurance, taxes and other fixed costs). These fixed costs are specific to each type of farming.

The central element in the Linear Programming model is the dairy cow. The model represents the operation of a dairy farm for a one-year period. The classical duration of lactation is 305 days, followed by 60 days of drying off. The year is divided into four seasons of 91.25 days. The fecundity rate is lower for the most productive cows, thus decreasing the number of calves per cow per year. Regarding the progeny, it is assumed that, according to the intensification level of the type of farming, 25% to 35% of the dairy cows are replaced per year by heifers raised on the farm. Concerning female calves which are not assigned to replace cows, the model can choose between: 1) selling the calves at the age of 8 days; and 2) keeping the calves until two years old and then selling to the slaughterhouse (with the female slaughter premium).

Regarding plant production, the forage crops produced in France are mainly maize silage, grass silage, hay and pasture. All farmers aim for forage self-sufficiency; the purchase and/or sale of forage are not considered because these are activities linked to exceptional events (e.g. drought or exceptional harvest) in these areas. Farmers must comply with the set-aside requirement in order to benefit from the crop premium: we use a binary variable which is 0 if the farmer does not set aside land, and 1 if he does. It is assumed that the cereals are sold at harvest time, *i.e.* no crop storage except for wheat used to feed the cows.

Thornton and Herrero (2001) show a wide variety of separate crop and livestock models, but the nature of crop-livestock interactions, and their importance in farming systems, makes their integration difficult. That is why, in order to precisely describe the operation of a dairy farm, this model considers four important characteristics: 1) the seasonality of labour and grass production, 2) the response of crop yield to nitrogen use, 3) the non-linearity of milk yield per cow, and 4) the interaction between crop and animal production.

Four periods *p* (spring, summer, autumn and winter) are distinguished in the model. It allows for seasonal specification of grass production and grassland use (Berentsen *et al.*, 2000). Seasonal variations enable us to integrate differences in the growth potential of grass during the growing season as well as the evolution of the nutrient content of grass. Moreover, we introduce seasonal labour constraints by allocating labour needs to each activity according to the work peaks (harvesting and calving). It is assumed that the farmer and his family/associates execute all the work, and thus there is no option to hire temporary labour. The model is more able to reflect temporal conditions thanks to the addition of these parameters.

For each period *p*:

$$\sum_{a}\left(\left(Wt_{a,p} \times T_a\right) + \left(Wt_{c,p} \times X_c\right)\right) + FL \leq AL_p \times AWU \qquad [4]$$

The global working time per period (with $Wt_{a,p}$ the working time per animal; $Wt_{c,p}$ the working time per ha of crop; *FL* is the fixed labour) has to be lower than the labour availability per period (AL_p the available labour for each annual work unit (*AWU*)).

Crop yield depends on the quantities of nitrogen used. Godard *et al.* (2008) formulated an exponential function, which satisfies economic requirements for attaining a mathematical optimum (the yield curve has to be concave and strictly increasing) and is consistent with its expected agronomic shape and with parameters with an agronomic interpretation.

$$Y_c = Ymax_c - (Ymax_c - Ymin_c) \times e^{-\sum t_i N_i} \qquad [5]$$

where Y_c is yield for each crop, and $Ymin_c$ and $Ymax_c$ are respectively the minimal and maximal yield (different according to the type of farming and its level of intensification); t_i represents the rate of increase in the yield response function to a nitrogen source *i* (e.g. manure, slurry, chemical nitrogen) the quantity of which is N_i. This enables us to take the increasing price of nitrogen into account and also the flow of organic nitrogen (such as manure) on the farm (Manos *et al.*, 2007).

In order to give more flexibility to the model, milk production per cow is not fixed. Farmers have the possibility to choose the milk yield per animal in a range of 1 000 litres below the dairy cow's genetic potential. It is also possible for farmers to produce beyond the genetic potential (Brun-Lafleur *et al.*, 2009); in this case, nutritional requirements needed to produce one litre of milk are increased (from 0.44 to 1.2 energy units per litre of milk, and from 48 to 140 units of protein per litre of milk) (Faverdin *et al.*, 2007).

With these three elements, we can very accurately represent the feeding system. The quantity ingested per cow per day is determined by using nutritional requirements in biological unit *b* (energy and protein), and the composition of forages and concentrate feed in equation 6 (INRA, 2007). The concentrate feeds *conc* available in the model are soybean meal, rapeseed meal, wheat, production concentrate and milk powder.

For each nutrient unit *b* and period *p:*

$$\sum_{a}\left(T_a\left(MR_{a,b}\times 365+mY_a\times LR_{a,b}\times 305\right)\right) \leq \sum_{a,c}\left(T_a\times\left(fQ_{c,p,a}\times fnc_{c,p,b}\times 91.25\right)\right) + \sum_{a,conc}\left(T_a\times\left(CfQ_{conc,p,a}\times Cfnc_{conc,p,b}\times 91.25\right)\right) \quad [6]$$

with: $MR_{a,b}$ the maintenance requirement (in energy and protein)

MYa the milk yield (in litre per animal per day)

$LR_{a,b}$ the lactation requirement (in energy and protein for one litre of milk)

$fnc_{c,p,b}$ the forage nutrient content (in energy and protein per kg of forage)

$fQ_{c,p,a}$ the forage consumption (kg) for each crop *c*, each period *p* and each type of animal *a*

$Cfnc_{conc,p,b}$ the concentrate feed nutrient content (in energy and protein per kg of concentrate)

$CfQcon_{c,p,a}$ the concentrate feed consumption (in kg per day per concentrate per period per animal)

The global nutritional needs for the herd must not exceed the availability in forage and concentrate feed.. Moreover, the forage consumption (for each type of forage *c*) has to be lower than the forage production:

subject to:

$$\sum_{a,p}\left(T_a\times\left(fQ_{c,p,a}\times 91.25\right)\right)\leq X_c\times Y_c \text{ for each type of crop } c. \quad [7]$$

Consequently, in order to maximise the farm's income, the model determines the optimum for the following endogenous variables: number of each type of animal (T_a and aS_a for sale); milk yield per cow (mY_a in kg per cow per day); concentrate feed and forage consumption for each type of animal and per period ($CfQ_{conc,p,a}$ and $fQ_{c,p,a}$ in kg per animal per day per season); the crop rotation (X_c in ha); the level of nitrogen fertilisation (nQ_c for chemical nitrogen and manure, in kg); and crop yield (Y_c in kg per ha).

The model tries to offer the largest choice of technical practice for crop and animal production. That is why we choose to incorporate each "quantity variable" (as ha and kg) as endogenous variables in the model. Thus, the model has access to all possible situations, e.g. the model can choose a full grass diet for a cow which produces 7 000 litres of milk or a full maize diet for the same cow. The model will therefore calculate the optimal quantity of input and output.

The constraints

Regarding the farm structure, the model incorporates the agricultural area, the milk quota and the available labour resources. As regards building constraints, we assume that the number of cows can increase by 10% in comparison to the base year: the implementation of the programme to control pollution of agricultural origin has motivated many dairy farmers to construct new buildings with more places than required. Regarding crops, the model meets the requirements for rotation frequency and cropping pattern (Mosnier *et al.*, 2009).

We also include three environmental measures as constraints in the model: 1) the Nitrate Directive No. 91/676/EEC requires that farmers cannot exceed organic nitrogen application rates of 170 kg per hectare (slurry and manure); 2) farmers have to keep grasslands aged over five years; 3) in addition to the CAP premiums, a premium for the maintenance of extensive livestock systems or "premium for grassland" is attributed (EUR75/ha), if there is at least 75% of grass in the total farm area and if the stocking rate is below 1.4 "livestock units" per hectare of grass.

Calibration: one model for four types of farming

In France, there is a high diversity of dairy farms in terms of location (mountains/plains), intensification (intensive/extensive), feeding system (pasture, maize silage) and specialisation of production (specialised/diversified). In this context, our choice focused on the four main types in the plains of France: these regions are not located in the less favoured areas and do not benefit from these specific supports, and we exclude the mountain areas that have a different milk production system. The data come from the annual survey of the *Institut de l'Elevage* (2008) with more than 600 dairy producers in the plains regions. Each type of farming is the result of the aggregation of several farms (from 20 to 45) representing similar structures and production methods (Table 6.1).

- The "Grass-based farm" is a 78 ha family farm with 285 000 litres of milk quota. It produces milk with a large area of grass, which provides high fed autonomy. The milk yield per cow is low (6 000 litres per year) but the prices of milk and meat are higher thanks to a better milk composition and heavier carcasses (Normand or Montbeliarde cow). The age of first calving is 30 months and the calving period is in the spring. Cows are housed for four months while they consume maize. It represents 8% of the dairy farms in this area.

- The "Semi-intensive farm" is a 50 ha family farm with 290 000 litres of milk quota (18% of the farms in the plain region). The calving period is in the autumn, which is why the use of maize is higher. The cows are more productive: Prim' Holstein with a milk yield of 8 500 litres per year.

- The "Milk + cereals farm" is a highly intensive system with 137 ha and 460 000 litres of milk quota. Each cow can produce 8 500 litres per year, and consequently the use of maize in the ration is not limited. Dairy production is the main activity on the farm, but cereal cropping is developed in parallel (wheat, rape seed, maize and pea). It represents 22% of the farms in the plains regions.

- The "Milk + young bulls farm" has 100 ha and 400 000 litres of milk quota. It is the most representative system of the area: 30% of dairy farms. It has the same characteristics as the previous type, but young bull fattening activity replaces the cereal activity. The model can choose to fatten (or not) the males and buy (or not) other male calves to reach 80 young bulls. These animals are slaughtered when they are 20 months old. The young bulls benefit from the male slaughter premium (EUR 80/animal) and the special premium for male bovines (EUR 110/animal).

Table 6.1. Farm data for 2005

	Grass-based farm	Semi-intensive farm	Milk+cereals farm	Milk+young bulls farm
Share of the system in France (%)	8%	22%	30%	18%
Total area (ha)	78	50	137	100
Milk quota (litres)	285 000	290 000	460 000	400 000
Annual Work Units (no.)	1.7	1.5	2.0	2.7
Building capacity (no.)	62	37	59	122
Restocking rate (%)	0.25	0.35	0.37	0.4
Dairy genetic potential (l/year)	6 000	8 500	8 500	9 000
Max crop yield (kg/ha/year)				
Wheat	6 100	8 100	8 100	8 100
Maize	n.a.	n.a.	10 000	n.a.
Rapeseed	n.a.	n.a.	3 800	n.a.
Pea	n.a.	n.a.	5 000	n.a.
Maize silage	10 200	12 200	15 200	14 200
Grass silage	8 500	8 500	8 500	8 500
Grass	8 500	7 000	6 000	6 000
Hay	8 500	7 500	7 500	7 500
Milk price (EUR/litre)	330	310	310	310
Meat price (EUR/kg)	3.0	2.6	2.6	2.6
Dairy cow carcass weight (kg)	375	325	325	325

n.a.: not available.

The farms of this study are located in plains areas and do not benefit from a protected designation of origin. Therefore, the milk processors, who collect the milk, produce cheese, yogurt, ice cream, and liquid milk, but also butter and milk powder which can be sold on the global market. In producing this milk, there are no specific price-premium requirements (e.g. a special feed regime).

A calibration step is necessary; the model's results and the empirical observations have to be close. We choose the year 2005 as baseline (i.e. before the implementation of the 2003 CAP reform).

Table 6.2 gives the price level and price variation for the main inputs and outputs. With these values, we build, for each product, a random distribution of price (for

1 000 states of nature *k*) within the range of variation and compute the model to calculate the expected utility. The use of the UEP method allows us to calculate the risk premium for each type of farming because we know the utility level.

$$E[U] = p\,U(k, r) \quad [8]$$

with: $U_k = 1 - \exp(-r_a \times (RP - Z_k))$

where: U is the level of utility, r_a the coefficient of absolute risk aversion, Z the income, and RP the risk premium.

We choose an appropriate value of the coefficient of absolute risk aversion in order to calibrate the model. Bontems and Thomas (2000) show that the ratio risk premium / income should be around 5%. Thus, the value of the coefficient of risk aversion is about 0.5 for the four types of farming. The results of the model are close to reality for the four main key criteria: income, milk yield per cow, share of cereal in total area, and share of maize silage in forage area.

Table.6.2. Price level and price variation for inputs and outputs

	2005 price level	Price variation
	EUR/kg	%
Milk (EUR/litre)	0.31	10
Meat (culled cow)	2.60	20
Meat (young bull)	2.90	20
Cereal crops		
Wheat	0.120	30
Maize	0.110	30
Rapeseed	0.240	30
Pea	0.130	30
Concentrate feed		
Cereal	0.140	30
Soybean meal	0.220	30
Rapeseed meal	0.180	30
Chemical nitrogen	0.150	30

Results

Theoretically, the decoupling of aid has no effect on income because it does not affect the amount of payment; only the method of payments different. However, decoupling can change production activities by making some products less attractive than before. The effect of direct payments on agricultural markets is one of the controversial issues in the WTO Doha Round agenda, and is generating considerable discussion both in these negotiations and in the economics literature. Dewbre *et al.* (2001) show that market price support is a relatively inefficient means of transferring income to farmers, and, furthermore, that it does so at the expense of relatively large distortions in world markets. They show that, on the contrary, land-based payments are highly effective at transferring income to farmers, while reducing world market price impacts. However, according to Chau and De Gorter (2005) direct land-based payments may induce an inefficient farmer, who is not able to cover his fixed costs and who, without the payment, would exit the market in the long run, to keep on producing. Moreover, Guyomard *et al.* (2004) show that land-based payments also influence farmers' productive behaviour: farmers choose to produce the most profitable activities and the land-based and headage-based payments increase the profitability of such activities. Therefore, coupled payments also have distortionary effects on price, and encourage inefficient farmers to keep on producing.

The European Union decided to implement a new income support program by fully decoupling the previous input-based payments. Cahill (1997) defines a policy as fully decoupled if it does not influence the production decisions of farmers receiving payments, and if it permits free market determination of prices. It is a concept centred on the adjustment process and not only on equilibrium values. He also defines effective full decoupling as that which results in a level of production and trade equal to what would have occurred if the policy were not in place. This concept is centred on the equilibrium quantities. OECD (2001) shows that decoupled policy always have effects on production, and describe several effects leading to this result: i) risk-related effects referring to policy measures that, usually, increase the wealth of the farmers and thus the incentive to produce for risk-averse farmers; ii) dynamic effects which relate to the policy measures that change current and future incomes and may affect current decisions. In a long-term perspective, farmers make intertemporal choices involving current and future income. Dynamic effects commonly affect investment decisions.

The model gives the opportunity to study the impact of this CAP reform on the economic performance of farmers and their productive choices: allocation between animal and vegetable production, intensification or extensification strategy. We compare the baseline situation (year 2005 with fully coupled premium) to two different scenarios (Table 6.3):

- S1 is the implementation of the 2003 CAP reform (decoupling, modulation, and the obligation to maintain the surfaces in permanent pasture) all other things being equal (except for milk price for which the intervention prices were reduced and offset by direct aid). The amount of the direct payment is based on the historical reference of the baseline (number of ha and head which benefited from premium);

- S2 proposes, in addition, to take a look at the impact of rising price as the agricultural sector. From the year 2007 to 2009, prices of agricultural commodities were subject to significant variations. For example, the price of industrial dairy products such as skim milk powder (0% fat) nearly doubled through 2007, from EUR 2 400/tonne in January to EUR 4 000/tonne in August before strongly decreasing to EUR 1 400/tonne in January 2009. Therefore, the price of milk paid to the producer also increased in 2007 and more in 2008 (by +30%) before dropping in April 2009 (EUR 220/tonne). Prices of cereals such as wheat and maize followed the same evolution: they doubled in 2007, from EUR 140/tonne in June to EUR 280/tonne in December. The price then decreased to reach EUR 110/tonne in February 2010.

In these simulations, the farm structure (land, workforce, milk quota) is constant, and the model does not make investments to change this structure. This analysis is thus focused on the short-term impacts of the implementation of decoupling: changes in production, and income evolution.

Table 6.3. Degree of decoupling and price variation according to the scenarios

		Baseline (fully coupled)	**S1** Partial decoupling	**S2** Partial decoupling and price variation
Premium		Value	Degree of decoupling	
Crop premium	EUR/ha	380	75%	75%
Set-aside premium	EUR/ha	380	100%	100%
Slaughter premium	EUR/head	80	60%	60%
Special premium for bovine male	EUR/head	210	100%	100%
Direct milk aid	EUR/litre	35.5	100%	100%
Price				
Milk	EUR/litre	0.31	0.275	0.29
Cereal (wheat)	EUR/kg	0.12	0.12	0.18
Meat (culled cow)	EUR/kg	2.6	2.6	2.9
Concentrate feed (soybean meal)	EUR/kg	0.22	0.22	0.32
Fertilizer (nitrogen)	EUR/kg	0.15	0.15	0.25

The CAP reform: a stable income

The first item discussed concerns the impact of the CAP reform on the economic performance of the farms studied. In France, the single payment is granted on the basis of the amount of direct aid allocated, during the 2000-02 period, according to the production factors: land, animals and quota (the historical model). It remains closely correlated to the farm's size. Moreover, France also chooses to not fully decouple some subsidies (the decoupling is partial): the crop premium is partially decoupled (75%) as well as the slaughter premium (60%) and other animal premiums (suckler cow, ewe); but direct subsidies based on the milk quota, special premiums for bovine male (SPBM) and set-aside premiums are fully decoupled (Table 6.3).

In the S1 scenario, the implementation of the CAP reform has little influence on economic performance (Table 6.4). The income is stable for two reasons. The 5% modulation (budgetary transfer of support from Pillar 1 to Pillar 2 for rural development) of direct payments decreases the total output. This is partly offset by a decrease of variable costs (grass-based production is cheaper than silage-based production). Even if income is stable, the weight of the payment in income rises strongly with the allocation of the direct milk aid as compensation for the decrease of institutional prices. The CAP reform increases the dependence of farmers on direct public support as showed by Chatellier (2006). There is also a great disparity between intensive and extensive systems: farms with cereal or fattening activities receive the largest amount of subsidies.

Table 6.4. Implementation of the CAP reform taking into account price increases

Average per farm		Grass-based Farm			Semi-intensive Farm			Milk +cereals Farm			Milk +Young bull Farm		
		Baseline	S1	S2	Baseline	S1	S2	Baseline	S1	S2	Baseline	S1	S2
Income	EUR	54 100	53 600	61 600	55 700	55 100	62 600	120 600	116 700	150 500	120 400	119 300	133 200
Crop area													
Grain prices	EUR/t	120	120	180	120	120	180	120	120	180	120	120	180
Cereals	ha	10.7	6.3	13.0	16.4	12.9	16.2	91.0	90.7	85.9	18.0	60.0	59.1
Maize silage	ha	5.3	3.2	6.5	14.7	10.0	14.4	20.0	19.3	24.4	45.4	22.4	21.3
Grassland	ha	62.0	68.5	58.5	15.5	23.6	16.0	13.7	14.7	14.4	29.6	10.0	10.6
Set-aside	ha	0.0	0.0	0.0	3.4	3.4	3.4	12.3	12.3	12.3	7.0	7.6	9.0
Premium for grassland		yes	yes	yes	no	no	no	no	no	No	no	no	no
Animal activity													
Dairy cows	Nber	57	57	56	34	34	34	54	56	54	50	46	45
Young bull	Nber										77	0	0
Milk yield	l/year	5 290	5 250	5 330	8 500	8 500	8 500	8 500	8 500	8 500	8 920	9 000	9 000
Milk yield	l/ha of forage area	4 440	4 270	4 600	9 630	8 650	9 580	13 670	13 580	11 900	5 950	12 670	12 590
Concentrates	Kg/year	290	230	240	1 100	1 080	1 100	2 020	2 020	1 250	1 130	1 330	1 320
Nitrogen application	Kg/ha	132	132	130	112	112	112	64	64	64	147	74	72
Working time	Hr/AWU/year	2 020	2 000	2 010	1 570	1 520	1 570	1 900	1 900	1 910	2 060	1 310	1 280
Economic results													
Total output	EUR	145 200	142 000	158 200	135 500	130 600	147 800	303 100	298 500	340 100	294 200	247 900	285 300
Milk output	EUR	94 000	84 100	88 300	89 900	79 800	84 100	142 600	126 500	133 400	124 000	110 000	116 000
Meat output	EUR	32 500	32 500	34 900	15 700	15 700	17 300	23 200	23 200	25 600	102 300	29 400	21 000
Crop output	EUR	6 800	4 000	13 500	15 300	12 100	22 700	88 200	88 100	120 300	16 800	61 300	92 800
Total subsidies	EUR	11 900	21 300	21 400	14 600	23 100	23 700	49 100	60 800	60 800	51 100	62 200	65 500
Variable costs	EUR	32 000	29 500	36 400	33 700	29 800	38 100	86 500	86 200	91 000	84 200	57 400	63 100
Fixed costs	EUR	59 100	58 900	60 100	46 100	45 700	47 100	96 000	95 700	98 600	89 600	86 300	88 900
Marginal yields													
Additional milk quota	EUR/t	347	299	269	231	183	163	229	185	158	290	208	174
Additional milk yield	EUR/l	n.c.1	n.c.	n.c.	268	267	407	589	635	900	n.c.	242	569
Additional area	EUR/ha	177	159	403	745	459	859	871	604	1040	722	356	864

n.c.: not a constraint.

The decoupling causes a significant decline in the shadow value of an additional litre of milk quota (from -8% to -20% depending on the type of farming) and an additional hectare of land available (from -20% to -50%). Regarding milk marginal yield, the work of Bouamra-Mechemache *et al.* (2008) and Moro *et al.* (2005) within the framework of the European Dairy Industry Model project confirms these results. The marginal costs (per tonne of milk) estimated by their computable general equilibrium model range between EUR 141/tonne to EUR 163/tonne (50% of the price of milk) for the French dairy farm after the CAP reform. Nevertheless, these marginal yields remain positive and, consequently, expanding the farm is economically beneficial. It is reassuring that the results of our farm-level model are close to those of the general equilibrium model; this suggests that the calibration of the model is precise.

In the S2 scenario, we simulate the reform with the rise of prices which occurred in 2007 and 2008 (Table 6.3). This increase in agricultural production prices improves the income for all the types of farming studied, from 7% to 36% (Table 6.4). This situation, very economically beneficial for the farms, helps to reduce the share of direct payments in income.

Decoupling: an incentive to produce with more grassland?

This section pays special attention to the distribution between silage maize and grassland in the forage area (intensification strategy versus extensification strategy) with the partial decoupling of the crop premium in France.

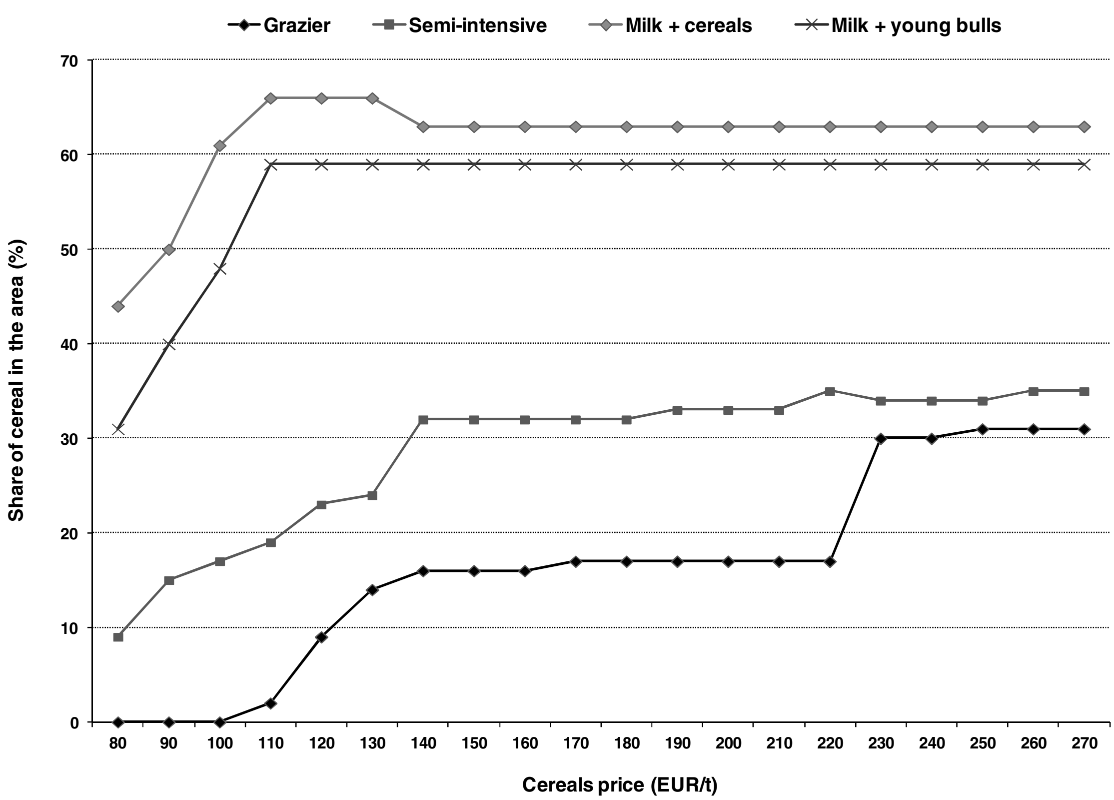
In S1 scenario, the implementation of the reform leads to the extensification of dairy production with a decrease in cereal and silage maize cropping and an increase in grassland (for the grass-based, semi-intensive and milk + cereals farms, see Table 6.4). The decoupling of 75% of crop premium (maize silage included) rebalances the choice between grass and maize but is not enough to encourage farmers to comply with the criteria for the premium for grassland (the grass-based farm is the only one to benefit from this premium). These results confirm those highlighted by Ridier and Jacquet (2002). Regarding environmental criteria (nitrogen application, livestock unit per ha of forage, and milk produced per hectare of forage), the decoupling has a positive impact and encourages farmers to extensify their production. With the increase of grass, the measure of maintaining surfaces in permanent pasture is never a constraint. Moreover, none of the farms studied see its production limited through the application of the Nitrate Directive.

Nevertheless, the model does not take into account some other elements, which affect farmers' behaviour. Many farmers will continue to focus on maize, since feeding management of dairy cows based on grass is more complex (nutritional values constantly change). Moreover, the labour constraint may curb the use of pasture, since it requires driving the animals to the plots and bringing them back for milking. Similarly, the greater use of milking robots requires grassland around the robot, which must be accessible at all times.

In the more favourable price conditions of 2007 and 2008 (S2), farmers sought to increase their cereal production by converting to cereals those areas which were previously under grass. The decline in gross margin of crop production caused by the decoupling is more than offset by the rise in prices: the marginal yield of an additional hectare of land increases by 20% between the baseline and S2 (and more than double for the grass-based farm). The gains generated by cereal production are higher than the savings arising from grass-based milk production. The model therefore proposes a production system close to the 2003 situation in its pattern crops and livestock composition. The milk + cereals farm, on the contrary, reduces a little its share of cereals in favour of its maize silage area. Indeed, with the rise of cereal prices, concentrate feed prices also increases. Therefore, the farmer reduces the quantity of concentrate feed for the cows (from 2.020 kg to 1.250 kg) and increases the share of forage in the diet.

Figure 6.1 shows the evolution of the share of cereals in the total area in the decoupled situation according to the cereal price. Farmers increase cereal production when cereal price increases. But the more intensive farms, which have the highest yields and the best techniques, take advantage more rapidly of a lower price and thus reach their rotation limits faster. At the same time, all types of farming reduce the share of grass in the diet of dairy cows and replace it by maize silage to intensify milk production. The intensity of this decline depends primarily on the yield and on the production costs of cereal crops and maize silage. We can also see that the "grass-based" farm chooses to no longer meet the criteria of the "premium for grassland" when cereals price exceed EUR 220/tonne.

Figure 6.1. Proportion of cereals in the total area according to the cereals price



The increase of cereal price encourages farmers to develop these crops. However, it appears that maintaining milk production is always a priority for farmers, regardless of the price considered (milk and cereals). Indeed, the costs incurred to establish a dairy operation are often too high for farmers to consider abandoning milk for cereal production. This is especially true because the agricultural area of dairy farms is often far below the threshold of profitability traditionally met with amongst specialised crop farms.

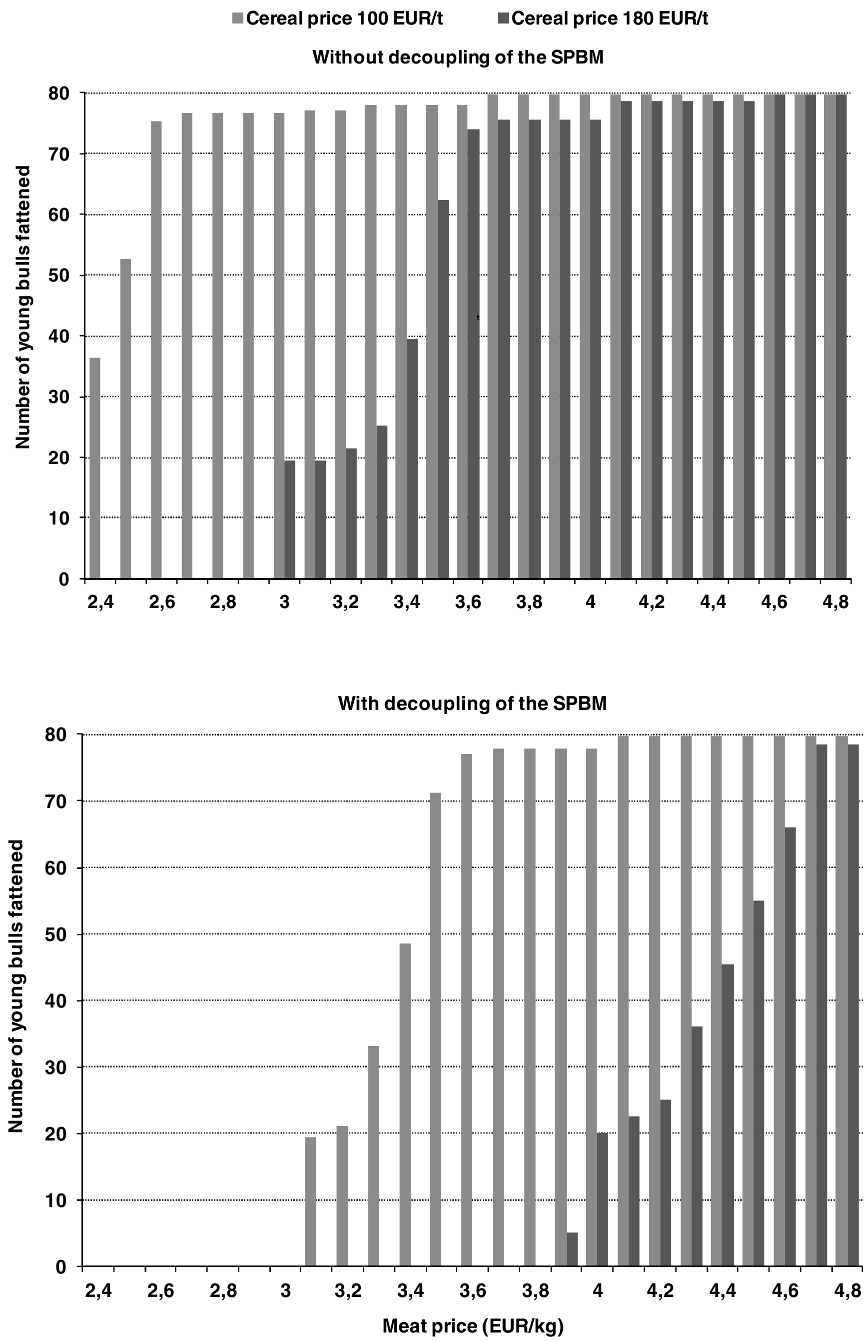
The decoupling: cessation of the fattening activity?

This section focuses on young bull fattening activity. The premium for these animals (SPBM) is totally decoupled, leading to a decrease in gross margin per animal of EUR 210 (plus EUR 48 for the slaughter premium). Our question focuses on maintaining this production, which benefited previously from large amounts of aid. The model is used to determine the choice of the farmer in this situation.

The implementation of decoupling encourages farmers to stop the fattening activity. The "Milk + young bull" farm completely ceases this production and uses the freed area to produce cereals (Table 6.4). Milk yield per cow is increased to the maximum (9 000 litres/year) in order to reduce the number of cows and thus the requirement in maize silage. Therefore, the farmer can produce more cereals. The model offsets the profitability of the feedlot with cereal crops. This change of production allows a decrease in working time (-40%), thus freeing permanently 1.2 AWU. Stopping the production of young bulls also decreases nitrogen emission (-50%).

Figure 6.2 shows that the fattening activity is conditioned both by meat and cereal prices because these are concurrent activities for the land. When cereal price increases from EUR 100/tonne to EUR 180/tonne in a non-decoupled situation (top of Figure 6.2), the meat price has to increase to more than EUR 3/kg to make the fattening activity more profitable than cereals. However, the full decoupling of the SPBM and the increase in the price of meat in 2007 and 2008 are not enough to encourage farmers to resume the fattening activity. In this situation (with a cereals price at EUR 180/tonne), the price of meat needs to increase by 30% (EUR 3.9/kg) to encourage farmers to start fattening bulls. Moreover, the cereals price rise also affects the concentrated feed of which bulls are large consumers. The full decoupling of the SPBM is strongly disadvantageous to this production: the price of meat has to increase by almost EUR 1/kg to offset this effect. In other words, farmers do not lose money by continuing to fatten bulls, but they could earn more by replacing this production with cereals.

Figure 6.2. Fattening of young bulls according to meat and cereals prices



SPBM: Special Premium for Bovine Meat.

Discussion

The model correctly reflects what occurred in French cereal production after the implementation of the reform. The French Agriculture Ministry database (Agreste) shows that the cultivated area in soft wheat increased from 4.78 million hectares in 2007 to 5.07 million hectares in 2008, following the rise in price, and then decreased to 4.75 million hectares in 2009. The evolution was similar for maize and rapeseed. In this case, the decoupling of subsidies modifies farmer behaviour: it restores to prices their role as indicators of the market situation, and farmers take their decisions based on those prices. The model also gives a good simulation of the evolution of dairy production in France. Despite the decoupling, the dairy activity remains the most profitable enterprise, and farmers produce up to their milk quota.

However, after three years of direct payments, we observe a difference between the model results and real farmers' choices, especially for beef production. The *Institut de l'Elevage* (2010) shows that the number of young bulls did not decrease in France in 2008 and 2009, despite implementation of full decoupling.

Theoretically, if the direct payments are supposed to have minimum effects on production, we identify several links between direct payments and farm production, which can explain the observed difference.

- *Long-term production requirements.* Agricultural production is a long-term activity, and farmers cannot change their system in a short time. Farmers develop their production enterprises (livestock fattening, cereals, etc.) within the framework of their labour organization, their use of equipment, and also the financial position of their farm, and these elements cannot be easily challenged.

- *Eligibility criteria for the payment*. Farmers have to meet the cross-compliance conditions (environmental and animal welfare measures) to get the payment. They also have to maintain the land in a good agronomic condition. These eligibility criteria may also create a link between payments and production.

- *Sociology/psychology of the farmer*. Some of these elements can also influence the farmer's decision. For example, cessation of fattening means not using an important set of buildings. Most farmers do not consider not using their buildings to their full capacity even if it is more advantageous from a business point of view.

- *Anticipation of a new reform*. Farmers are all aware that the CAP will be subject to further reform in 2013.Direct payments are now based on historical references, but farmers do not yet know the modalities of the future CAP reform. Some of them, anticipating the next reform, may want to maintain production in order to justify future payments (re-coupled or not).

- *Trade organization*. Farmers are price takers, and have no influence on prices, which are exogenous to the model. For the fattening activity, many farmers produce under a contract with a slaughterhouse. It is reasonable to assume that these companies will maintain this contractual policy to ensure sufficient production volumes and avoid significant price variations. Farmers who work with company under a contract (with a known price for a period) are less likely to alter their production.

- *Value of property assets*. Hennessy (1998) shows that direct payments modify the wealth of farmers and thus the incentive to produce for risk-averse farmers. Usually, policy measures increase expected farm income and reduce farm income variability. For a risk-averse farmer, this may lead to two distinct effects. The first is an insurance effect that results from the reduced income variability. The second is a wealth effect arising from the increased expected income, leading the farmer to adopt riskier behaviour. Both the insurance and the wealth effects may contribute to increased production.

The theoretical effect of decoupling, shown by the model, is not observed for beef production. We suggest that when the farmer owns the factors (land, buildings, machines, animals, etc.), he tries to use these inputs, even though he could increase his income with another productive combination. Femenia *et al.* (2010) show that the effect of the direct payments on wealth is underestimated for the farmer who owns the factor (land) on which payments are based. The capitalization of agricultural income support programs in farmland prices generates large wealth effects. These effects are a consequence of the importance of income support in farming profits, and generate modest changes in production levels.

Conclusions

The farm-level mathematical programming method is suitable for analysing the impact of public policy on dairy farmers' behaviour. The technique allows placing the technical, biological, structural, environmental and regulatory realities at the heart of the producer's choice. Because we consider the interactions between types of production (both plant and animal), the main laws of biological response and the seasonality of agricultural production, the model represents, as realistically as possible, farmers' behaviour, and supplies economic, technical and environmental responses to the implementation of the 2003 CAP reform. Moreover, by applying this model to four types of dairy farm, we can identify if the CAP reform causes different impacts according to the technical system. However, the limitations of the method based on instantaneous adjustment of production factors and perfect information should be kept in mind, along with the idea that the actors are primarily guided by the desire to maximise their income (while other considerations may play a more important role). Moreover, model prices are not endogenous variables, *i.e.* the producer does not make his decisions in light of the evolution of global supply. Based on the current construction, some improvements are possible, such as to integrate other goals (such as minimisation of labour and minimization of environmental impacts) into the objective function. In a context of increased volatility in prices, the UEP method could be modified to better integrate farmers' expectations facing the direction (positive or negative) of price changes. Moreover, if this type of model is suitable to study the short-term impact of an evolution in public policy, it cannot predict a long-term evolution without taking into account changes in the farm structure.

In term of public policy, this study has confirmed that the decoupling of supports to agriculture theoretically encourages dairy farmers to adopt a more extensive production system. The full decoupling of crop premium encourages farmers to use a larger share of grass in the cow's diet instead of maize. All things being equal, and given the considered prices, the 2003 CAP reform also encourages farmers to stop fattening bulls. This enterprise has to face a great loss of profitability with the full decoupling of the SPBM

(EUR 210/head). The increase in the price of agricultural commodities has a positive impact on the economic results, but it does not change the situation for young bulls, and contributes to an increase in cereal areas. However, the CAP reform partially reaches its goal of restoring to prices their role as indicators of the market situation. Indeed, after three years of decoupling, we observe that farmers react to price changes for cereals, but not for beef. We highlight the fact that, when farmers own their assets, decoupling has little effects on production.

All this is guided by the decisions of the Member States that are changing the CAP in accordance with the WTO negotiations and market trends. The CAP Health Check outlines future income support policy by addressing important issues for dairy farmers such as the phasing out of the milk quota which is already a subject of controversy. This last point leads to important questions for dairy producers and will certainly change the productive equilibrium on French dairy farms.

Note

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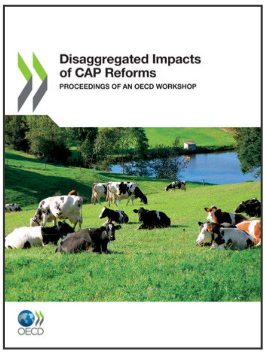
Disaggregated Impacts
of CAP Reforms
PROCEEDINGS OF AN OECD WORKSHOP