Evaluation of CAP Reform at Disaggregated Level

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Summary – The reform of European Common Agricultural Policy (CAP) in 2003 has resulted in substantial changes to the way dairy farmers are subsidized. Moreover, dairy farmers are also facing an unprecedented situation with the strong price fluctuations of agricultural raw materials. In this paper, we discuss the cross effects on the productive strategy of French dairy farms due to the Luxemburg Agreement 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 maximises the expected utility of income while taking into account a set of constraints: regulatory, structural, zootechnical, agronomic and environmental. This model give 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 reaction 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 of cereals price is a strong incitation for farmer to intensify the forage production in order to free up lands for crop production. The decoupling of premiums for bovine males led farmers to turn away, all things being equal, this activity to increase the cereal production.

Keywords: dairy farm, single payment, decoupling, price variation, mathematical programming, technical system

Impact du découplage et des variations de prix sur la stratégie productive des éleveurs laitiers. Revue des effets théoriques et réels

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Résumé – La réforme de la Politique Agricole Commune (PAC) de 2003 a entraîné d'importants changements dans l'attribution des soutiens aux producteurs laitiers. En outre, ceux-ci sont également confrontés à une très forte fluctuation du prix des matières premières agricoles. Dans cet article, nous discutons des effets croisés de la mise en œuvre de l'accord de Luxembourg et de la variation des prix sur les stratégies productives des exploitations laitières françaises. Un modèle basé sur la programmation mathématique a été construit afin de déterminer comment les producteurs de lait ré-évaluent leurs systèmes afin d'identifier le plan de production optimal. Tout en respectant le principe de rationalité de l'agent (maximisation du profit), le modèle intègre le risque économique lié à la volatilité des prix. Ainsi, le modèle maximise l'utilité espérée du revenu, tout en tenant compte d'un ensemble de contraintes : réglementaires, structurelles, zootechniques, agronomiques et environnementales. Le modèle offre un large choix de niveau d'intensification (utilisation d'intrant) et de combinaison productive. Ce modèle est appliqué à quatre types d'exploitations laitières afin de déterminer les impacts de la réforme sur différents systèmes techniques. Les simulations permettent de montrer en quoi la mise en œuvre du régime de paiement unique encourage les agriculteurs à modifier leurs assolements au profit d'une part croissante de prairies. Toutefois, l'augmentation du prix des céréales va dans le sens d'une intensification de la production fourragère permettant de libérer des surfaces pour les grandes cultures. Le découplage des aides spécifiques aux jeunes bovins conduit les agriculteurs à se détourner, toutes choses égales par ailleurs, de cette activité pour renforcer la production de céréales.

Mots clés : production laitière ; paiement unique ; découplage ; volatilité des prix ; programmation mathématique ; cas-types

JEL classification: Q12 – Q18 – C61

INTRODUCTION

Dairy farmers, in 2007, were facing an unprecedented situation on the markets with the soaring prices of agricultural raw materials. Then, they had to deal with the strong diminution of those prices in the year 2008 and 2009. These fluctuations can lead them to change their system in order to adapt their production to this unstable economic situation. For French farmers, these changes occur simultaneously with the implementation of the reform of the Common Agriculture Policy (CAP), decided in 2003. A key driver of this reform has been the recent WTO negotiations. Three innovations were introduced: i) the decoupling of direct support based, in France, on the amount of direct subsidies received in 2000-2002 (historical approach); ii) the modification of the dairy Common Market Organisation: the intervention prices of industrial dairy products (butter and powder) are reduced and subsidies are granted to farmers according to their dairy quota; iii) a part of the direct subsidies are deducted from the first pillar of the CAP to fund to the second pillar (modulation system).

In this context, the aim of this article is to study the dairy farmer's behaviour 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 system. Dairy farms often have, in addition to the dairy activity, cereal or beef production. 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 (grazier, semi-intensive, milk + cereals, milk + young bull). Thereby, 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 paper 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: i) How do the CAP reform and agricultural price variations influence dairy producers' income? ii) How does the decoupling change the allocation to different kinds of production on a dairy farm?

1. MATERIALS AND METHOD

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

1.1. Bio-economic model: a farm level approach

We build 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 a relevant technique because its hypotheses correspond to those of classic micro economics: rationality and the optimising nature of the agent (Hazell & Norton 1986). This method allows us to study the 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): (i) an objective function, which minimises or maximises a function of the set of activity levels; (ii) a description of the activities within the system, with coefficients representing their productive responses; and (iii) 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 optimum 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 to generate additional income or to avoid losses. Moreover, during the year 2007, 2008 and 2009, prices of agricultural commodities were subject to strong variations so 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 240 €/t to 380 €/t before strongly decrease until 220 €/t in April 2009. Since the beginning of 2010, milk price seems to be on an increasing trend. Prices of cereals such as wheat follow the same fluctuations. Cereals play a special role in dairy farming because they can be both input and output.

The model uses the Utility Efficient Programming method (UEP) with a negative exponential utility function in order to take the risk relative to price into account. Lambert and McCarl (1985) presented a mathematical programming formulation that allows identification of the expected utility function. Their approach, which does not require an assumption of normally distributed income (on the contrary of the E-V, MOTAD models 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 negative exponential utility function (with a constant absolute risk aversion CARA) can better predict farmers' behaviour compared with cubic and quadratic functions. The CARA function is a reasonable approximation to the real but unknown utility function: coefficient of absolute risk variation can be validly applied to consequences in terms losses and gains for variations in annual income. The UEP method enables the model to take into account asymmetric price distribution: the skewness become an element of decision as the variation amplitude. Thus, the model maximizes the expected utility of the income as follows:

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

$$\text{With:} \quad U_k = 1 - \exp(-r_a \times Z_k)$$

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

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

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:

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

- The main part of the income Z is given by milk revenues: the milk quantity produced with Ta the total number of animal of type a (dairy cows, heifers, calves and young bulls) ; mYa the milk yield (litter/day) per animal by mP the milk price (€/litter).
- There is then the meat revenue with aS_a the number of animal selling ; aW_a the animal's carcass weight (kg) and aP_a the meat price (€/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 the animal costs with: $cfQ_{conc,p,a}$ the quantity of concentrate feed ingested (kg/day/animal) ; cfP_{conc} is the concentrate feed price (€/kg per type of concentrate *conc*) ; I_a the specific inputs for animals (artificial insemination, medicines, herd book and minerals).

- We add the crop revenue with: X_c the cultivated area (ha) for each type of crop *c* (wheat, corn, rapeseed, pea, corn silage, pasture, hay and grass silage) ; Y_c the crop yield (kg/ha) ; cP_c the crop price (€/kg) ; I_c are the specific crop inputs (seed, treatments and harvesting) ; nQ_c the nitrogen quantity (kg/ha) ; nP the nitrogen price (€/kg).
- And 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 LP 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 day then with 60 days of drying up. The year is divided into four season of 91,25 days. The fecundity rate is lower for the most productive cows, decreasing as a result, 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 (Institut de l'Elevage 2008). Concerning the females which are not assigned to replace cows, the model can choose between: (i) selling the calves at the age of 8 days, (ii) keeping the calves until 2 years old and then selling to the slaughterhouse (with the female slaughter premium).

Regarding the plant production, the forages 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's criteria in order to benefit from the crop premium: we use a binary variable which is 0 if the farmer does not make set-aside and 1 if he does. It is assumed that the cereals are sold at the harvesting time, there is no stock except for wheat used to feed the cows.

Thornton and Herrero (2001) show that a wide variety of separate crop and livestock models exist, 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: i) the seasonality of labour and grass production, ii) the response of crop yield to nitrogen use, iii) the non linearity of milk yield per cow and iv) the interaction between crop and animal production.

i) 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, in equation 4, we introduce seasonal labour constraints by allocating labour needs to each activity according to the work peaks (harvesting and calving time). 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*:

$$\sum_a \left(\left(Wt_{a,p} \times T_a \right) + \left(Wt_{c,p} \times X_c \right) \right) + FL \leq AL_p \times AWU$$

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*)).

ii) 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.

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

where Y_c is yield for each crop, $Ymin_c$ and $Ymax_c$ 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 of the yield response function to a nitrogen source *i* (e.g. manure, slurry, chemical nitrogen, etc.) the quantity of which is N_i. This enables us to take the increasing price of nitrogen into account and the flow of organic nitrogen (such as manure) on the farm (Manos et al. 2007).

iii) The milk production per cow is not fixed in order to give more flexibility to the model. Farmers have the possibility to choose the milk yield per animal in a range of 1,000 liters below the dairy cow 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 liter of milk are increased (change from 0.44 energy unit per liter of milk to 1.2 unit, and from 48 to 140 units of protein per liter of milk) (Faverdin et al. 2007).

iv) With these three above-mentioned elements, we can very accurately represent the feeding system. The quantity ingested per cow per day is determined by using i) nutritional requirements in biological unit *b* (energy and protein) and ii) 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:*

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

With: $MR_{a,b}$ the maintenance requirement (in energy and protein)
MYa the milk yield (in litter per animal per day)
$LR_{a,b}$ the lactation requirement (in energy and protein for one litter 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. The lactation period is 305 days with then a drying up period of 60 days before calving. Moreover, the forage consumption (for each type of forage *c*) has to be lower than the forage production:

subject to: For each type of crop *c*

$$\sum_{a,p}\left(T_a\times\left(fQ_{c,p,a}\times 91.25\right)\right)\leq X_c\times Y_c$$

Consequently, the model determines the optimum for the following endogenous variables: number of each type of animals (T_a and aS_a for sale) ; the milk yield per cow (mY_a in kg per cow per day) ; the 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 the chemical nitrogen and the manure, in kg) and the crop yield (Y_c in kg per ha) in order to maximize the farm's income.

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

1.2. The constraints

Regarding the farm structure the model incorporates the agricultural area, the milk quota and the available labour resources. For the building constraint, we consider that the number of cows can increase by 10% in comparison to the base year: the implementation of the Global Monitoring for Environment and Security program has motivated many dairy farmers to construct new buildings with more places than required. Regarding crops, the model meets the requirements for the rotation frequency and cropping pattern (Mosnier et al. 2009).

We also include three environmental measures as constraints in the model: i) the European Council directive concerning the protection of waters against pollution caused by nitrates from agricultural sources requires that farmers cannot exceed organic nitrogen application rates of 170 kg per hectare (slurry and manure) ; ii) farmers have to keep grasslands aged over 5 years ; iii) in addition to the CAP premiums, a premium for the maintenance of extensive livestock systems or ''premium for grassland'' is attributed (75€/ha), provided 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.

1.3. 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 level (intensive/extensive), feeding system (pasture, maize silage) and specialisation of production (specialized/diversified). In this context, our choice focused in the four main types in the plains regions of France. The datas come from the annual survey of the Institut de l'Elevage (2008) with more than 600 dairy producers in the plain regions. Each type of farming is the result of the aggregation of several farms (from 20 to 45) representing similar structure and way of produce (intensive, extensive, other productions: see Table 1).

1. *"Grazier farm"* is a 78 ha family farm with 285,000 litters of milk quota. It produces milk with a large part of grass, which provides high food autonomy. The milk yield per cow is low (6,000 litters 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 4 months while they consume maize. It represents 8% of the operation in this area.
2. "Semi-intensive farm" is a 50 ha family farm with 290,000 litters of milk quota (18% of the farms in the plain region). The calving period is in the Autumn, that's why the use of maize is higher. The cows are more productive: Prim' Holstein with a milk yield of 8,500 litters per year.
3. "Milk + cereals farm" is a highly intensive system with 137 ha and 460,000 litters of milk quota. Each cow can produce 8,500 litters per year, consequently the use of maize in the ration is not limited. Dairy production is the main activity on the farm, however cereal crop activity is developed in parallel (wheat, rape seed, maize and pea). It represents 22% of the farms in the plain regions.

Table 1. Specific farm data for the year 2006.

	Grazier 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 (liters)	285 000	290 000	460 000	400 000
Annual Work Unit (nb)	1.7	1.5	2.0	2.7
Building capacity (nb)	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.[1]	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 (€/l)	330	310	310	310
Meat price (€/kg)	3.0	2.6	2.6	2.6
Dairy cow carcass weight (kg)	375	325	325	325

[1] n.a.: not available

4. “Milk + Young bulls farm” has 100 ha and 400,000 litters 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 of farming but, with this one, young bull fattening activity replaces the cereal activity. For the “Milk + Young bulls” farm, 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 (80€/animal) and the special premium for male bovine (110€/animal).

The farms of this study are located in plain areas and do not benefit from a *Protected designation of origin*. Therefore, the milk processors, who collect the milk, produce cheese, yogurt, ice cream, liquid milk, but also butter and milk powder, which can be sold on the global market. There are no specific requirements to produce this milk in order to receive some special promotion (better price for using a specific food…).

The calibration step is necessary: the model’s results and the empirical observations have to be close. We choose the year 2006 as baseline (before the implementation of the Luxembourg agreement).

The Table 2 gives the price level and the price variation for the main inputs and outputs. With these values, we build, for each product, a random distribution of price (for 1000 states of nature *k*) in the range of variation and we 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.

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

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

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

We choose the 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 the reality for the four main key criteria: the income, the milk yield per cow, the share of cereal in the total area and the share of maize silage in the forage area.

Table 2. Price level and price variation for the inputs and outputs

	2006 price level	Price variation (%)
Milk (€/l)	0.31	10%
Meat (culled cow)	2.60	20%
Meat (Young bull)	2.90	20%
Cereal crop		
Wheat (€/kg)	0.120	30%
Maize (€/kg)	0.110	30%
Rape seed (€/kg)	0.240	30%
Pea (€/kg)	0.130	30%
Concentrate feed		
Cereal (€/kg)	0.140	30%
Soybean meal (€/kg)	0.220	30%
Rapeseed meal (€/kg)	0.180	30%
Chemical nitrogen (€/kg)	0.150	30%

2. RESULTS

Theoretically the decoupling of aid has no effects on income because it does not affect the amount of subsidies, only the method of assigning is different. However, decoupling can change production activity 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 the negotiations and in the economical 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 cost 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 base payments also influence farmer's productive behaviour: farmers choose to produce the most profitable activities and the land-based and head-based payments increase the profitability of such activities. Therefore, the coupled payments also have distortionary effects on price and urge inefficient farmer to keep on producing.

Therefore, the European Union decided to implement a new income support program by fully decoupling the previous input-based payment. Cahill (1997) defines a fully decoupled policy as if it does not influence production decisions of farmers receiving payments, and if it permits free market determination of prices. It is a concept centered on the adjustment process and not only on equilibrium values. He also defines the *effective full decoupling* 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 centered on the equilibrium quantities. The OECD report (2001) shows that decoupled policy always have effects on production. They describe several effects leading to this result: i) *Risk-related effects* refer to policy measures that, usually, increase the wealth of the farmers and thus the incentive to produce for risk-averse farmers; iii) *Dynamic effects* relate to the policy measure that changes current and future income and may affect current decisions. In a long-term perspective, farmers make intertemporal choices involving current and future income. A 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 vegetal production, intensification or extensification strategy. We compare the baseline situation (year 2006 with fully coupled premium) to two different scenarios (see Table 3):

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

ii) S2 propose, 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 strong variations. For example, the price of industrial dairy products such as skim milk powder (0% fat) nearly doubled through 2007, from 2 400 €/t in January to 4 000 €/t in August before strongly decrease until 1 400 €/t in January 2009. Therefore, the price of milk paid to the producer also increased in 2007 and more in 2008 (+30%) before dropping in April 2009 (220 €/t). Prices of cereals such as wheat and corn followed the same evolution: they doubled in 2007, from 140 €/t in June to 280 €/t in December. Then the price decreased to reach 110€/t in February 2010.

In those simulations, the farm structure is constant (land, workforce, milk quota). The model does not make investment to change the structure. This study is focused on short-term impacts of the implementation of decoupling: productive changes and income evolution.

Table 3. Share of decoupling and price variation according the scenari**os**

	Baseline (fully coupled)	**S1** Partial decoupling	**S2** Partial decoupling and price variation
Premium	(Value)	(share of decoupling)	
Crop premium	380 €/ha	75%	75%
Set-aside premium	380 €/ha	100%	100%
Slaughter premium	80 €/head	60%	60%
Special premium for bovine male	210 €/head	100%	100%
Direct milk aid	35,5 €/litter	100%	100%
Price			
Milk	0.31 €/litter	0.275 €/litter	0.29 €/litter
Cereal (wheat)	0.12 €/kg	0.12 €/kg	0.18 €/kg
Meat (culled cow)	2.6 €/kg	2.6 €/kg	2.9 €/kg
Concentrate feed (soybean meal)	0.22 €/kg	0.22 €/kg	0.32 €/kg
Fertilizer (nitrogen)	0.15 €/kg	0.15 €/kg	0.25€/kg

2.1. 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 2000-2002 period, according to the production factors: land, animals and quota (historical model). It remains closely correlated to the farms' 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 (see Table 3).

In the S1 scenario, the implementation of the CAP reform has little influence on economic performance (see Table 4). The income is stable for two reasons. The 5% modulation (budgetary transfer of support from the first to the second pillar for rural development) of direct payment decreases the total output. But this is partly offset by a decrease of variable costs (grazier production is cheaper than a silage based production). Even if income is stable, the weight of the payment in the 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.

The decoupling causes a significant decline in marginal yields of an additional litter 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 European Dairy Industry Model project, confirms these results. The estimated marginal costs (per tonne of milk) by their calculable general equilibrium model range between 141 €/t to 163 €/t (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 a positive element that the results of a farm level model are close to the general equilibrium model. These results show that the calibration of the model is precise and exact.

In the S2 scenario, we simulate the reform with the rise of prices which occur in 2007 and 2008 (scenario *S2,* see Table 3). This increase in agricultural production prices improves the income for all the types of farming studied from 7% to 36% (see Table 4). This situation, very economically beneficial for the farms, helps to reduce the share of direct payment in the income.

Table 4. Implementation of the CAP reform taking into account price increases

	Grazier Farm			Semi-intensive Farm			Milk +cereals Farm			Milk +Young bull Farm		
	Baseline	S1	S2	Baseline	S1	S2	Baseline	S1	S2	Baseline	S1	S2
Income (€)	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 (ha)												
Grain prices (€/t)	120	120	180	120	120	180	120	120	180	120	120	180
Cereals	10.7	6.3	13.0	16.4	12.9	16.2	91.0	90.7	85.9	18.0	60.0	59.1
Corn silage	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	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	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 (nb.)	57	57	56	34	34	34	54	56	54	50	46	45
Young bull (nb.)										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 l/ha 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 pressure (kg/ha)	132	132	130	112	112	112	64	64	64	147	74	72
Working time(h/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 (€)	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 (€)	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 (€)	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 (€)	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 (€)	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 (€)	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 (€)	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(€/t)	347	299	269	231	183	163	229	185	158	290	208	174
Additional milk yield (€/l)	n.c.1	n.c.	n.c.	268	267	407	589	635	900	n.c.	242	569
Additional area (€/ha)	177	159	403	745	459	859	871	604	1040	722	356	864

[1]n.c.: not a constraint

2.2. Decoupling: an incentive to produce with more grassland?

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

In *S1* the implementation of the reform leads to extensify dairy production with a decrease of cereal crop and silage maize and an increase of grassland (for the grazier, semi-intensive and milk + cereals: see Table 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 grazier farm is the only one to benefit from this premium). These results confirm those highlighted by Ridier and Jacquet (2002). Regarding environmental criteria, (nitrogen pressure, 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 grasslands, 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. Therefore many farmers will continue to focus on maize: feeding management of the dairy cows based on grass is more complex (nutritional values constantly change). Moreover, the labour constraint may curb the use of pasture, it requires driving the animals to the plots and bringing them back for milking. Similarly, the larger use of milking robots requires grassland around the robot, which must be accessible at all times.

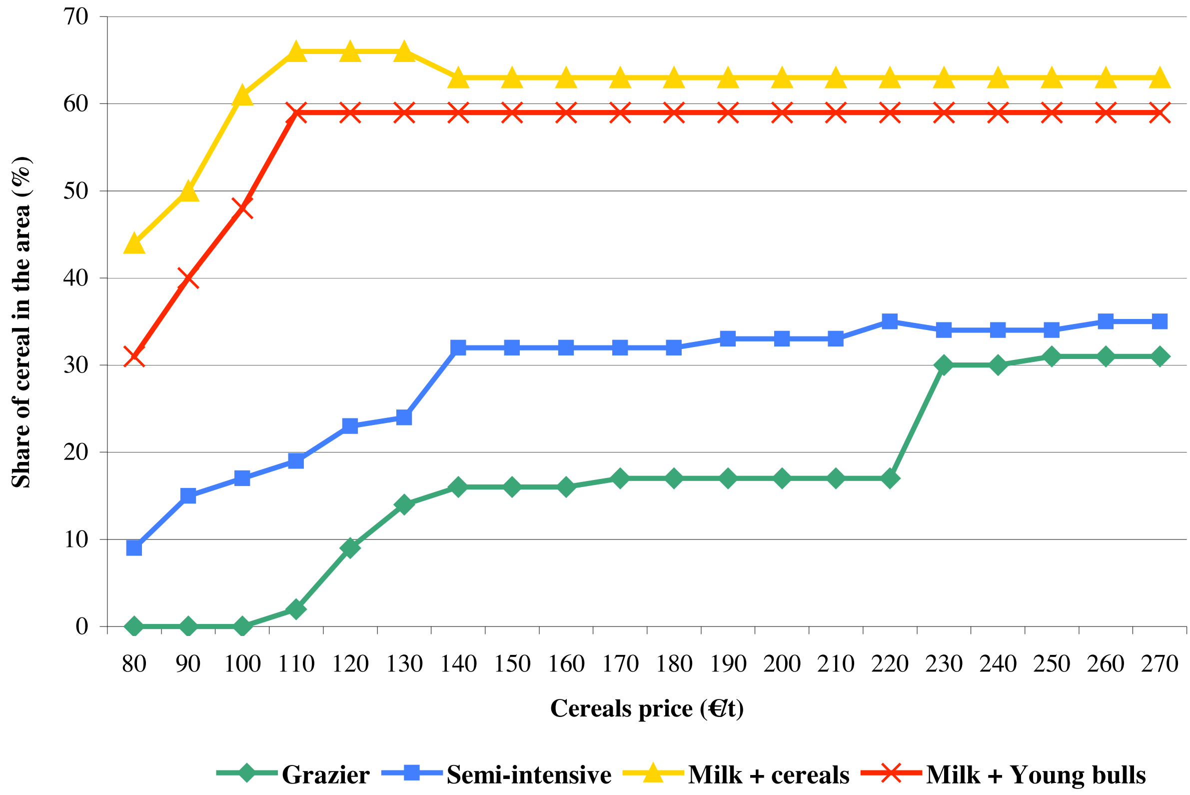
But in the more favourable price conditions of 2007 and 2008 (*S2*), farmers seek to increase their cereals production. Thus, farmers convert into cereals those surfaces they had previously released to grasslands. The decline in gross margin of crop production caused by the decoupling is more than offset 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 "grazier" farm). The gains generated by cereal production are higher than the savings arising from a grass-based milk production. The model therefore proposes a production system close to the 2003 situation (distribution of crops and livestock composition). The "milk + cereals" farm, on the contrary, reduce a little the share of cereal in favour of maize silage area. Indeed, with the rise of cereals price, the concentrate feed prices also increased. Therefore, the farmer reduced the quantity of concentrate feed for the cows (from 2,020 kg to 1,250 kg) and increased the share of forages in the diet.

The

Figure 1 Figure 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 corn silage to intensify milk production. The intensity of this decline depends primarily on the yield and on the production costs of cereal crops and corn silage. We can also see that the "grazier" farm chooses to no longer meet the criteria of the "premium for grassland" when cereals price exceed 220 €/tonne.

As we can see, the increase of cereals 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 in the specialized crop farms.

Figure 1. Proportion of cereals in the total area according to the cereals price



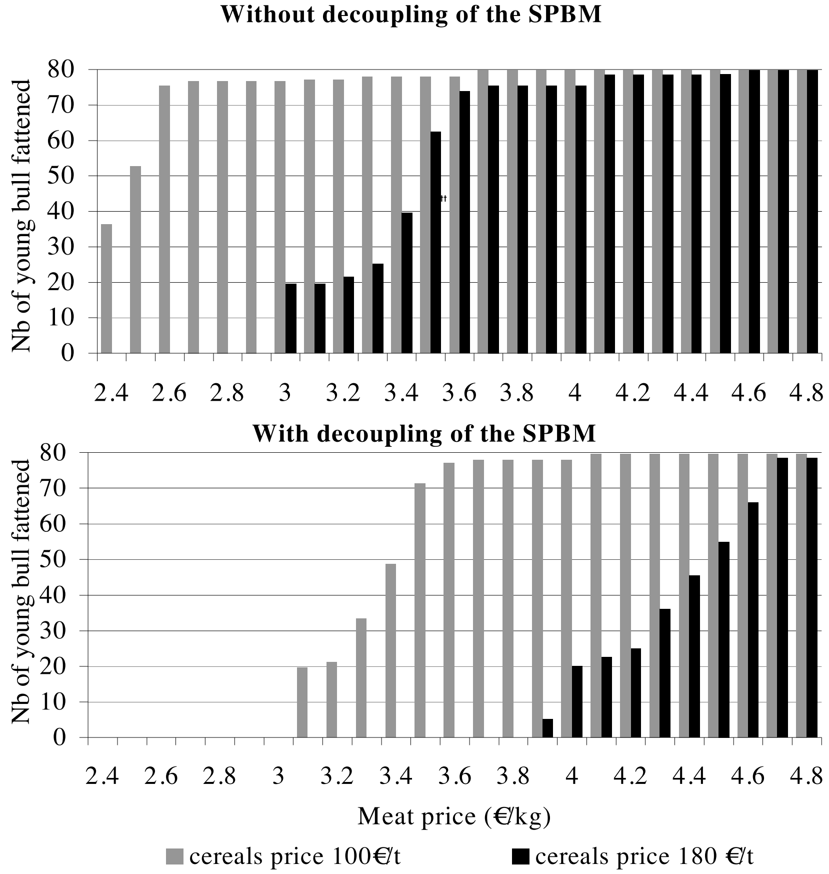
2.3. The decoupling: cessation of the fattening activity?

In this section, we are especially interested in the young bull fattening activity. The premium for these animals (SPBM) is totally decoupled leading to a decrease in gross margin per animal of 210 € (plus 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 removes this production and uses free area to produce cereals (see Table 4). The milk yield per cow increases to the maximum (9,000 litters/year) to free up lands for cereals. The model offsets the profitability of the feedlot with cereal crops. This change of production allows a decrease of working time (-40%) thus freeing permanently 1.2 AWU. Stopping the production of young bulls also decreases nitrogen discharge (-50%).

The Figure 2 shows that the fattening activity is conditioned both by meat and cereals prices because these are concurrent activities for the land. When cereal price increases, from 100 €/t to 180 €/t in a non-decoupled situation (top of the figure), the meat price has to increase to more than 3 € per kg to make the fattening activity more profitable than cereal. But with the full decoupling of the SPBM and despite the increase in the price of meat in 2007 and 2008, it is not enough to encourage farmers to resume the fattening activity. In this situation (with a cereals price at 180 €/t), the price of meat should increase by 30% (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 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 2. Fattening of young bulls according to the meat price and cereals prices



3. DISCUSSION

The model correctly reflects what occurred about the 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 millions hectares in 2007 to 5,07 millions hectares in 2008, following the rise in price, and then decrease to 4,75 millions hectares in 2009. The evolution is similar for corn and rapeseed. In this case, the decoupling of subsidies modifies the farmer behaviour: it restores to prices their role as indicators of the market's situation. Farmers take their decisions based on those prices. The model also gives a good estimation of the dairy production evolution in France. Despite the decoupling, the dairy activity remains the most profitable production and farmers produce their milk quota.

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

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

i) *Factors link to the long-term production requirement*. The agricultural production is a long-term activity, and farmers cannot change their system in a short time. Farmers develop their productions (fattening, cereals…) within the framework of the organization of labour, on the use of equipment, and also on the financial position of the farm and these elements cannot be easily challenged.

ii) *Factors link to the 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 agronomical condition. These eligibility criteria may also create a link between payments and production.

iii) *Factors link to the sociology/psychology of the farmer*. Some of these elements can also influence the farmer's decision. For example, stopping fattening means not using an important part of buildings. Most farmers do not consider not using their buildings to their full capacity even if it's more advantageous from a business point of view.

iv) *Factors link to the anticipation of a new reform*. Farmers are all aware that the CAP will know another reform in 2013. Now, direct payments are based on historical references but farmers do not know yet the modalities of the future CAP reform. Some of them, by anticipation of the next reform, may want to keep their production in order to justify future payment (re-coupled or not).

v) *Factors link to trade organization*. Farmers are price taker, they 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 shift their production.

vi) *Factors link to the property of the assets*. Henessy (1998) shows that the direct payments modify the wealth of the farmers and thus the incentive to produce for risk-averse farmers. Usually, policy measures increase the expected farm income and reduce farm income variability. For a risk-averse farmer, this may lead to two distinct effects. The first one is an insurance effect that results from the reduced income variability. The second one 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…), he tries to use these inputs, even if he could increase his income with another productive combination. Femenia et al. (2010) show that the effect of the direct payments on the 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 wealth effects are a consequence of the importance of income support in farming profits, and generate modest changes in production levels.

CONCLUSION

The mathematical programming method at the farm level is suitable to analyse the impact of public policy on dairy farmers' behaviour. This 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, this model represents, as realistically as possible, farmers' behaviour and supplies economic, technical and environmental response to the abolition of milk quotas. Moreover, by applying this model to four types of dairy farm, we can identify if the CAP reform causes different impact according to the technical system. However, keep in mind the limitations of the method based on instantaneous adjustment of production factors and perfect information, and the idea that the actors are primarily guided by the desire to maximize their income (while other considerations may play a more important role). Moreover, prices are not endogenous variables, 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 in the objective function (such as minimisation of labour and minimization of environmental impacts). 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 can not 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 encourage farmer 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 Luxembourg agreement also encourages farmers to stop fattening bulls. This production has to face a great loss of profitability with the full decoupling of the SPBM (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 surfaces. However, the CAP reform partially reaches its goal to restores to prices their role as indicators of the market's situation. Indeed, after three years of decoupling, we observed that farmers react to price changes for cereals, but not for beef. We underline the fact that when farmers own the assets, the decoupling has little effects on production.

All of 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" draws the outline of the 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 certainly will change the productive equilibrium on French dairy farms.

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