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Abstract. In this paper, we discuss the productive and economic implications of several options for the future Common Agricultural Policy (CAP) focusing on French dairy farms (as France includes 16% of the EU milk quota). The options studied follow the proposals made by the European Commission in May 2008 for the "Health Check" of the CAP. We examine the cross effects, on the productive strategy of French dairy farms, of the phasing out of milk quotas and a simplification of the single payment scheme (adoption of a full decoupling and implementation of a regionalization according to Articles No. 58-59 of Council Regulation (EC) No 1782/2003). To do this, a model based on mathematical programming has been developed. This model, which can be qualified as "bio-economic", enables us to measure the impact of a change in the CAP on supply behaviour. 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. This is done through the "Utility efficient programming" method which enables us to represent the utility of the farmer in a negative exponential form. Thus, the model maximises the expected utility of income while taking into account a set of constraints: regulatory, structural, zootechnical, agronomic and environmental. The model is applied to four types of dairy farms to reflect the diversity of production systems in France. The model is used to produce quantitative estimations and to evaluate policy changes through the simulation of the CAP Health Check implementation. The results show that with the end of milk quota system, dairy farmers have a high productive potential. The adoption of a full decoupling of the single payment encourages farmers to substitute a part of corn silage by grass. However, rising prices of agricultural production encourage, on the contrary, farmers to intensify their system in order to free up land for growing cereals.

Keywords: dairy farm, CAP Health Check, abolition of milk quotas, price volatility, bio-economic model, Utility efficient programming

INTRODUCTION

For EU dairy farmers, the Luxemburg agreement, decided in 2003, marked a new phase in the process of Common Agriculture Policy (CAP) reform. The direct payments were decoupled and the Single Payment Scheme (SPS) was implemented. It was the first time, since the setting up of milk quota in 1984, that the dairy common market organisation was deeply modified. This reform aimed to increase the competitiveness of European agriculture and to promote a market orientated agricultural sector. The Health Check of the CAP maintains these objectives and the European Commission made several proposals in this sense (European Commission, 2008) :

i) Increase of milk quota by 1% annually from 2009 to 2013 to help the sector with gradual transitional measures to prepare to a market without quotas post 2015.

ii) The removal of set aside: set aside entitlements become normal entitlements;

iii) Full decoupling for many vegetal productions (arable crops, seeds and hops) and some animal activities (slaughter premium for young animals, slaughter premium for adult animals and special beef premium) ;

iv) These proposals allow Member States to change their decisions on the i

v) Implementation of the SPS model: Member States applying the historic model are allowed to change over to the regional model. The regional model provides more equitable support to farmers, despite some initial redistribution of support.

vi) In EU-15, basic modulation, applying to all payments above € 5 000, increases by 2% annually from 2009 until it reaches 13% in 2012. This is a budgetary transfer from farmer direct payments (Pillar I) to rural development (Pillar II) measures.

In France, more than in some others EU member states, these proposals raise questions because the national authorities chose a partial decoupling and the allocation of the single payment based on historical references. Moreover, these authorities have historically favoured a balanced geographical distribution of milk production through an administration of milk quotas. For French dairy farmers, these changes occurred simultaneously with an unprecedented market situation, namely high price fluctuations of agricultural raw materials.

In this context, the aim of this article is to study the implications of CAP Health Check modifications on dairy farmers' behaviour (i.e. effects on the production system as the feeding of animals, the allocation of areas to crops and the level of intensification) with different hypothetical prices. A Linear Programming (LP) 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. Four technical systems are considered in this study according to the intensification of forage area and the level of specialization. This method enables a representation of the system at farm level with a high level of accuracy. 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.

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 performed to analyse the impact of the CAP Health Check proposals on the dairy farms. These simulations try to resolve these three following questions: i) What would be the productive implications of the abolishment of milk quotas, under different conditions (contractualization, different price options). ii) What would be the consequences of the implementation of a full decoupling, particularly for agricultural productions associated with the dairy activity? iii) What would be the effects of the implementation, in France, of a more uniform single payment amount between farms in the same region (i.e. regionalization)? For these three issues, the sensitivity of the results is evaluated by taking into account several price options for cereals and livestock.

1. METHODOLOGY

1.1. Linear Programming: a Farm Level Approach

LP is a mathematical technique which enables us to represent the farm functioning in reaction to a set of constraints. LP has long been used as a farm analysis tool because its hypotheses correspond to those of classic micro economics: rationality and the optimising nature of the agent (Hazell and Norton, 1986). This method has several limitations that are inherent to this technique: the yields of the inputs are linear; producers act in a situation of perfect information and adjustments between the inputs are instantaneous. However, the strength of this approach is to represent precisely the productive complexity of the farm. It also allows us to study the threshold effects and to calculate dual values of inputs. Farm-level modelling enables simultaneous consideration of production, price and policy information. LP can: (i) incorporate new production techniques by adding new activities, (ii) add agricultural and environmental policy by including new restrictions in the model or by putting levies on undesired outputs (Van Calker et al., 2004).

Any model derived from linear optimisation has three basic elements : (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. Linear programming presents a collection of relevant technical opportunities offered to the farm by separate activities in a matrix. The rows in this matrix form the constraints that represent the technical relations between the activities. Given the objective function, the model determines the optimal solution considering all activities and restrictions simultaneously. Marginal values of the resources are part of the solution.

1.2. One Model for Four Types of Farming

Perrot et al. (2007) notes that, regarding the level of competitiveness of French dairy farms compared with different countries in the EU, the largest structures are located in the northern part of the EU and particularly in the United Kingdom, Denmark and Netherlands. France, the second largest contributor to the milk quota of the Union (with 24.7 billion litters, or 17% of the volume produced by the EU 25), has a high number of dairy farms (90 000 compared to 5000 in Denmark), therefore, the structures are smaller than the EU average (243 000 litters of quota versus 279 000 liters). The share of farms with more than 700 000 kg of milk quota is around 40% in the UK and Denmark, compared with 10% in Germany and about 1% in France. In the case of France, the public regulation of quotas fixed the milk distribution of the territory level. This maintains dairy farms in disadvantaged regions such as mountain areas. During the last ten years, the restructuring of the French dairy farms, 4% per year, has been higher than that of other agricultural sectors, but much lower than in other European countries. Spain sees nearly 13% of its dairy farms disappear each year, while Denmark and Italy are restructuring at 8% per year. French dairy farms produce less milk by agricultural work unit (AWU) than those in the north of European Union. The level of productivity per AWU is higher by more than twice in the United Kingdom, Denmark or the Netherlands. The price of milk is similar to the average in EU.

In France, there is a high diversity of dairy farms in terms 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 predominate in the west of France. The data come from the annual survey of the Institut de l'Elevage (2008) with more than 600 dairy producers in the western regions.

1: *"Grazier farm"* is a 78 ha family farm with 255,000 liters of milk quota. It produces milk with a large part of grass, which provides high food autonomy. The milk yield per cow is low (5,500 litters per year) but the prices of milk and meat are higher thanks to a better milk composition (fat and protein) and heavier carcasses (Normand 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 corn silage. This system represents 8% of the operations in this area.

2: *"Semi-intensive farm"* is a 50 ha family farm with 290,000 liters of milk quota (18% of the farms). The calving period is in the autumn, that's why the use of corn is higher than in the previous case. The cows are more productive: Prim' Holstein with a milk yield of 8,000 liters per year and an age of first calving of 24 months.

3: *"Milk + cereals farm"* is a highly intensive system with 137 ha and 460,000 liters of milk quota. Each cow can produce 8,500 l per year, consequently the use of corn silage in the diet is not limited. Dairy production is the main activity, however cereal crop activity is developed in parallel. It represents 22% of the farms in this region.

4: *"Milk + Young bull farm"* has 100 ha and 400,000 liters 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 in this one, young bull fattening activity replaces the cereal activity.

1.3. The Model

1.3.1 Optimisation of the Gross Farm Excess

The model optimises the farm plan, which represents the quantities of different outputs produced and inputs used. The economic results follow from the quantities of inputs and outputs 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.

The central element in the LP model is the dairy cow. The model represents the functioning of the farm for a one-year period. The duration of lactation is 305 days for all the cows, but the fecundity rate is lower for the most productive cows ("Milk + cereals" and "Milk + Young bulls" farms) decreasing, as a result, the number of calves per cow per year. At the end of the lactation, cull cows are sold and benefit from the female slaughter premium. Regarding the progeny, it is assumed, according to the intensification level of the type of farming, that 25% to 40% of the dairy cows are replaced per year by heifers raised on the farm (Institut de l'Elevage, 2008). For the "Milk + Young bulls" farm, the model can choose to fatten (or not) the males calves and buy (or not) other male calves to reach 80 young bulls. These animals are slaughtered when they are 20 months old. Specific costs are considered for each type of animal: artificial insemination, medicines, straw, minerals and other animal costs.

Regarding the vegetal production, the forages produced are mainly corn 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 rare activities linked to exceptional events (e.g., drought or exceptional harvest) in this area. For the cereal crops, each type of farming can produce wheat but the "Milk + cereals" type of farming can also produce rape, corn and pea. Farmers must comply with the set-aside's criteria in order to benefit from the crop premium. It is assumed that this productions is sold at the harvesting time, there is no stock except for wheat used to feed the cows: the total cost is the cost of production per hectare plus the storage and grain milling costs. As well as animal production, specific costs are also allocated for each type of crop: seed, fertilisers, treatments and harvesting.

Since the setting up of the Luxemburg Agreement, each farm receives a single payment. In France the SFP is granted according to the historic model. The decoupling is partial for some different types of subsidies. Thus, the objective function maximizes the Farm Gross Excess (**FGE**).

FGE = vegetal production output– specific vegetal costs
+ milk output + meat output– specific animal costs – concentrate feed
+ subsidies and single payment (crop, set-aside and animals)
– fixed costs (mechanisation, buildings, rent paid for land, farm taxes, interest paid)

This objective function incorporates neither interest rates nor depreciation. It is therefore not possible to simulate structural changes such as investments or expansion. Thus, the model determines the optimum composition of the herd, the distribution of crops and food intake in order to maximize the farm's income.

1.3.2 The interactions between forage system and animal production

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. In order to precisely describe the interactions between forage system and animal production in dairy systems, this model consists of five key components.

1) Particular attention has been paid to the feeding system. The quantity ingested per cow per day is determined by using i) nutritional requirements in energy and protein (Herrero et al., 1999; Tedeschi et al., 2000) and ii) the composition of forages and concentrates according to the Unit Feed Lactation system (INRA, 2007). Home-produced forages available in the model are pasture, grass silage, hay and corn silage. The purchased feeds are soybean, rapeseed meal, wheat, production concentrate and milk powder. The model has the possibility to use wheat and milk produced on the farm. This model also includes a requirement concerning the structure of the diet, i.e. the equivalent of effective fibre in long roughage is incorporated. At least one-quarter of the dry matter of the diet must consist of structural material to avoid acidosis. Moreover, animals cannot ingest food more than their intake capacity.

2) The model consider two separate units: the area of production (in hectares) and the volume of production (in kg) that is a function of the yield for each crop, in order to take account of multiple production on the same unit area. Grassland is a specific forage: it can produce grass, hay and silage on the same surface and in the same year.

3) Four periods (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. The model is more able to reflect temporal conditions thanks to the addition of these parameters.

4) The milk production per cow is not fixed in order to give more flexibility to the model. Farmers have the possibility to reduce or increase milk production by modifying the feeding system (with more or less concentrate). The model can set the milk yield per cow in a range of 1,000 liters. Then the model is calibrated to correspond to the observation for each type of farming.

5) 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.

$$y = y_{\max} - (y_{\max} - y_{\min}) \times e^{-\sum t_i N_i}$$

where y is crop yield, y_{min} and y_{max} 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 to take the increasing price of nitrogen into account.

Consequently, milk production, feeding requirements and grass production are assessed for each period. Thanks to the dissociation between surface and quantity for crop production, the model reproduces an optimal production plan which is well fitted to the dairy food system.

1.3.3 The constraints

The set of constraints consists of requirements related to the farm structure, biological rules, production techniques, environmental and political regulations.

Technical and structural constraints. The model takes the demographic equilibrium of the herd into account: the cows give birth to 50% males (sold at the age of 8 days) and 50% females which are reared according to the restocking rate. Buildings are mainly free-stall housing in which the number of places is flexible according to the age of the animals. The only building constraint integrated into the model is the number of places available for the cows. It is assumed that the number of cows can increase by 10%: the application of the Global Monitoring for Environment and Security 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 preceding crop.

Respect for the environment. The CAP reform of 2003 places environmental respect as one of its first objectives with the setting up of cross compliance measures such as water resource management, food safety, animal and plant health, animal welfare standards and sustainable development. To avail themselves of various government grants and EU premiums and to be compliant with legislation, farmers must operate within codes of good practice. The main environmental measures included in the model are:

i) the European Council directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (No: 91/676/ EEC) which requires measures be taken in respect to farm practices. Farmers cannot exceed organic nitrogen application rates of 170 kg nitrogen per hectare;

ii) the measure requiring farmers 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, provided 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. This premium (75€/ha) finances the “grazier farms” which are less productive but more environmentally friendly.

Seasonal labour. Labour constraints are introduced by allocating labour needs to each activity. Agricultural labour is not regular over the year. Because we distinguish four periods in a year, we can integrate the work peaks (harvesting and calving time). However the difficulty is to quantify the labour needs of each activity. Labour data used in the model are based on studies carried out by Caramelle Holtz (2004) on labour use on French dairy farms. A constraint on available labour is included. 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 calibration step is very important: the model's results and the empirical observations have to be close. Results were compared to four key points: percentage of cereal crop area, percentage of silage corn area, milk yield per cow per year and the ratio gross farm excess / total output. These data come from a network of 640 French dairy farms (Institut de l'Elevage, 2008) and from the FADN. We consider the solutions to be representative of the cases studied when all four key criteria were close to reality.

1.3.4 Price variations: how to take risk into account?

During the year 2007, 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 2400 €/t in January to 4000 €/t in August. It stabilized at 2300 €/t in September 2008 (Office de l'Elevage, 2008). Prices of cereals such as wheat and corn doubled in 2007, from 125 €/t in January to 250 €/t in December. Then the price decreased to reach 180€/t in September 2008. Cereals play a special role in dairy farming: they are both input and output. Increasing prices are favourable to crop production but, on the other hand, are negative for the production of downstream products. Many studies have demonstrated that farmers typically behave in a risk-averse way (Hardaker et al., 2004a). 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.

Many methods have been developed to include risk in mathematical programming farm models. The E-V, quadratic risk programming and its linear approximations MOTAD models (Hazell, 1971) and Target MOTAD (Tauer, 1983) are the most commonly used methods. But these approaches require that the decision maker must have a quadratic utility function or an income distribution that is normal. An assumption of normally distributed income can be both unrealistic and unsatisfactory for risk-averse farmers who are not indifferent between symmetrical and skewed distributions (Patten et al., 1988). 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, can accomodate the assumption that the utility function is monotonically increasing and concave (risk-averse). Patten et al (1988) and then Hardaker et al (2004b) and Torkamani (2005) 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 (Flaten and Lien, 2007).

In this study we use the UEP with a negative exponential utility function:

Maximize: $E[U] = p\ U(z, r)$, r varied

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:

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

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 the model the input prices (concentrates and milk powder) and the output prices (meat, milk and cereals) are subject to variation. It is difficult to know whether the situation in the markets will be prolonged longer. That is why, the price of wheat used for the simulation is 180€/t, while the market price is 240€/t in February 2008.

2. RESULTS AND DISCUSSION

Within the framework of the CAP Health Check, the European Commission proposes, on the one hand to remove some instruments of supply control (milk quota and set-aside) and, on the other hand to simplify procedures for granting direct payments (implementation of a full decoupling and progressive uniformisation of the amount of the single payment per hectare). Based on the bio-economic model built previously, simulations are conducted to assess the impact of these proposals on productive strategies of French milk producers. The results of scenarios are compared to a baseline 2007 which takes into account the implementation of the single payment scheme, according to the national options adopted (partial decoupling[1] and historical model). The removal of the set-aside, whose effects are naturally low on the dairy farms studied, was introduced directly into the baseline. The simulations concerns, first the abolition of milk quotas (scenario *S1*), then the adoption of a full decoupling in substitution of the partial decoupling (scenario *S2*), and finally the implementation of a uniform single payment per hectare between farms in a same region (scenario S3). The scenarios are addressed in a cumulative way, i.e. that scenario 2 incorporates the results of the implementation of scenario 1 and scenario 3 incorporates those of scenarios 1 and 2.

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[1] In France, some categories of direct aids were kept coupled according to a variable rate itself: the suckler cow premium (100%); the slaughter premium for calves (100%); ewe premium (50%), the bovine slaughter premium (40%); cereal crop premium (25%). Other premiums (special premium for bovine male SPBM and direct aid to milk sector) as well as premium for set-aside were, however, fully decoupled.

2.1. Abolition of milk quota: a high production potential (S1)

The second simulation deals with the abolition of milk quotas. In France, as in all member states of the EU, milk production is regulated since 1984 at the producer level (any excess over the authorized quantity causes a financial penalty). Milk quotas were introduced in order to control the supply of milk in a context where the storage cost of dairy products surplus became an important issue for the EU budget. Moreover, in a context marked by a modest growth in domestic consumption of dairy products and a strong competition with the countries of Oceania (Australia and New Zealand) on export markets, the authorities have been forced to progressively reduce quotas in most member states. Thus, France has lost 12% of its milk production for twenty-five years and nearly half of his herd of dairy cows (due to the steady rise in the milk yield). In France, state intervention in the management of milk quotas is stronger than in most other Member States, particularly the United Kingdom, Denmark and the Netherlands where milk quotas are tradable. Indeed French authorities have adopted rules to limit the geographic concentration of milk production in regions / departments with comparative advantages: milk quotas are managed administratively in each department and they are link to the land. A producer who wishes to increase its milk production must necessarily acquire or rent hectares. The transactions of quota between producers are made by administrative decision (free attribution of volume to priority producers) and not through the market, which is the case in the northern countries mentioned above.

This regulation method for the milk supply (quota) within the EU and France is not entirely original because this choice is also used in other countries such as Canada (where quotas are tradable between producers) and New Zealand (where the volumes are managed by the monopolistic cooperative enterprise, Fonterra, which provides the collection, processing and export of milk). In Canada, where milk producers play a very important role in guiding the national dairy economy (the objective price of milk is based on production costs), the quota is based on the domestic demand in milk fat (Gouin, 2005). Exports are marginal, unlike the situation of New Zealand (32% of the global market of dairy products in volume), EU (31% of the world market in volume) and France (at the second rank in the world behind Germany with 4.5 billion euros per year) (CNIEL, 2007). In the United States, unlike the EU and France, milk production strongly increased over the past fifteen years (1 million tons of milk per year). This increase in supply, in a non limited system, allows mainly to meet domestic demand, because exports on the world market is still relatively limited (8% of the world market in volume).

Twenty-five years after the implementation of milk quotas, the European Commission (2008) estimates that: “The current market outlook situation indicates that the conditions for which milk quotas were introduced in 1984 are no longer relevant.” In its proposals of 20 May 2008, it proposes a phasing-out of milk quotas with a gradual annual increase to prepare farmers to a market without quotas post 2015. This proposal was made considering that milk quotas are no longer suited to the current international context of the dairy economy, characterized by a rapid increase in demand. It also joins some theoretical arguments against this way of regulation. Colman (2000) shows that the milk quota system is source of inefficiencies with a non-optimal allocation of quota among producers because a high number of vulnerable and inefficient producers remain in milk production. Even if milk quotas are tradable there are lags in adjustment and imperfections such that the theoretical optimum has not been achieved.

The European Commission's proposal to remove milk quotas by 2015 is the subject of much debates among EU member states. These debates are influenced by how the countries consider the territorial role of milk production, their export dynamism on international markets and also the number of milk producers. This proposal, which seems to be accepted by the majority of EU member states, raises many questions in France. These questions concern, on the one hand, the evolution in the geographical concentration of production on the national territory and, on the other hand, the evolution in milk prices paid to producers. On this last point, it is clear that the milk quota system has allowed the French and European producers to benefit from stable and remunerative prices over the past two decades. Despite the principle of market unity, the price level is however different from one country to another depending on the value of dairy products and on the firms. Thus, the French milk producers have obtained, until now, a milk price near the EU average, but lower than the Danish and Italian producers and higher than the English and Irish producers.

Without supply regulation, creating a balance between supply and demand for milk requires establishing and maintaining a balance between: on the one hand the need for producer prices to remain high enough to maintain production, but not so high as to encourage surplus production and, on the other hand, the willingness and ability of consumers to pay for milk and dairy products (Manchester and Blayney, 2001). In the absence of milk quota, the risk of a greater price volatility and lower prices exists, all the more so as the elasticity of demand is low in this sector. Several studies, based on partial equilibrium model, have already assessed the impact of the abolition of milk quotas on the price level in the EU (Bouamra-Mechemache and Réquillart, 2002; Kleinhanss et al., 2002; Westhoff and Young, 1998). They showed that such a policy would lead to an increase in European milk production between 7% and 10% for a diminution in prices from 21% to 26%. Without the use of milk quotas, the future milk price is, however, not predetermined. It will depend on many factors including the possible contractualization on volumes between firms and producers. Indeed, companies, cooperatives or private, could be encouraged to take over from the public regulation through these contractual policies. They also have an industrial interest that the milk supply is regular and consistent with the range of flow on internal and external markets. If these contractual policies, conducted within each company, are moving to a rigorous management of the collective supply, the producer milk price reduction could be less intense than calculated by the theoretical models. The firms may have a heightened power on the pricing of milk, and on the link between milk price and internal requirements to the company (product quality, seasonality of supply, etc.) as well as in the evolution of the farms restructuring (allocation of volume through contracts).

In the scenario *S1* (abolition of milk quotas), the model assumes that milk producers have the opportunity to increase their milk production up to 20% compared to the baseline in 2007. This rate was fixed arbitrarily by considering that the removal of quotas would result by an increase in contracts between milk producers and processing companies. The producers will be limited in their productive potential by the rules established within the framework of a contract, itself dependent on the historical milk quota. Thus, the growth allowed here is mainly the fact that the restructuring of dairy farms is strong and will allow companies to offer, over time, additional volumes to perennial producers. This opportunity will be even larger than the companies manage to export a growing share of domestic production on third markets.

In comparison with the base year situation, the implementation of a contractualization system (with a constant farm structure) leads to significant changes (see Table 1 *S1*). First of all, the dairy farms studied have an high production potential since they produce from +13% to +20% more milk. This rise in volume is permitted by intensification of production system: increasing the number of cows and the milk yield per animal (with a rise consumption of concentrates). Therefore the milk quantity per ha of forage, the nitrogen pressure per ha and the working time increase except for the "Milk + Young bull" farm which replaces bulls by dairy cows.

Looking at how each type of farming adapts to the abolition of the milk quota, we note that the "Semi-intensive farm" and the "Milk + cereal farm" cannot attain the production cap of 20%. The "Semi-intensive farm" is constrained by building space whereas the "Milk + cereal farm" is constrained by the available working time. The model is then modified to lift these constraints (possibility to enlarge the cowshed and to hire workers[2]) : the "Semi-intensive farm" needs 3 additional places to reach the threshold of a +20% increase (+1% FGE) and the "Milk + cereal farm" need 240 hours of supplementary working time (+5% FGE) (see Table 1 scenario *S1 without constraint*). About the economic results, an additional 20% of authorized milk volume leads to an increase of 10% FGE (for Semi-intensive and Milk + cereals). The marginal yield (or quota rent) of an additional liter of milk is about the half paid price as shown by Cathagne et al (Cathagne et al., 2006) and Moro et al (Moro et al., 2005). The FGE increases proportionally less than the produced milk quantity because of the additional variable costs (dairy cows, concentrates) and crop – forage mix (cereal crop replaced by forage productions).

These results show that dairy farmers have great potential to increase their milk production, perhaps by more than the 20% we allow (with a constant structure or with some investment). The main reason for this productive potential is that the agricultural area of French dairy farms has increased by 52% during the last 11 years while the quota per farm increased by only 28%. In France milk quotas are linked to the land and farmers have to rent or buy additional land to increase their quota. Therefore, to use this land, farmers developed alternative activities such as feedlots or cereals, which they can reduce or remove in case of quota abolition.

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[2] The cost of one place in the building is about 4000€ per cow: 330€ with a 12 year amortization. The cost of one hour of salaried work is about 15€ (all taxes include).

Table 1. Implementation of the Health Check proposals: simplification of the SPS and removal of supply control mechanism (quota)

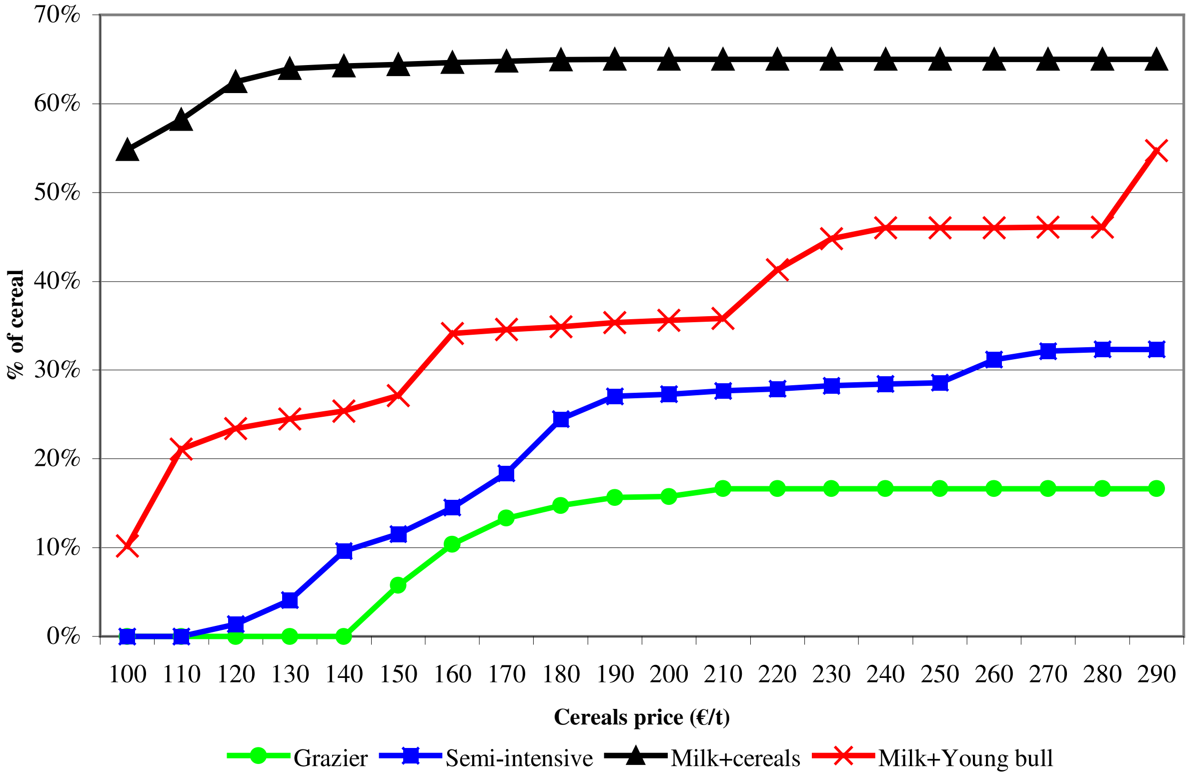
	Grazier Farm			Semi-intensive Farm			Milk+cereals Farm			Milk+Young bull Farm		
	Baseline	S1[1]	S1 without constraint [2]	Baseline	S1	S1 without constraint [2]	Baseline	S1	S1 without constraint [2]	Baseline	S1	S1 without constraint [2]
FGE (€)	66 600	79 300	79 300	69 300	75 400	78 400	169 000	183 400	185 400	163 700	174 400	174 400
Crop area												
Cereals	13.0	12.3	12.3	18.2	15.2	12.8	89.0	89.0	89.0	43.5	35.1	35.1
Silage maize	6.5	6.2	6.2	13.7	15.0	16.1	24.0	22.9	24.0	46.4	45.5	45.5
Grassland	58.5	59.5	59.5	18.1	19.8	21.1	24.0	25.1	24.0	10.1	19.4	19.4
Premium for grassland	yes	yes	yes	no	no	no	no	no	no	no	no	no
Animal activity												
Total produced milk (l)	285 000	342 000	342 000	290 500	325 520	348 000	460 000	537 970	552 000	400 000	480 000	480 000
Dairy cows (nb.)	56	57	57	35	38	41	60	64	65	47	55	55
Young bull (nb.)										75	59	59
Milk yield (l/year)	5 350	6 000	6 000	8 500	8 500	8 500	7 900	8 500	8 500	9 000	9 000	9 000
Milk l/ha forage area	4 380	5 210	5 210	8 120	9 350	9 360	9 590	11 220	11 500	7 080	7 400	7 400
Concentrates (kg/year)	440	610	610	1 470	1 470	1 470	810	1 180	1 170	1 440	1 160	1 160
Nitrogen pressure (kg/ha)	130	132	132	127	139	149	78	79	81	147	146	146
Working time (h/awu/year)	2 000	2 030	2 030	1 620	1 730	1 830	2 060	2 140	2 190	2 070	2 040	2 040
Economic results												
Total output (€)	167 600	191 300	191 300	162 600	172 100	178 000	366 000	391 400	396 500	366 900	367 700	367 700
Milk output (€)	97 900	117 500	117 500	99 600	111 800	119 500	158 000	184 800	189 600	137 400	164 900	164 900
Meat output (€)	33 600	34 000	34 000	16 100	17 600	18 800	25 100	23 5000	24 100	99 800	86 100	86 100
Crop output (€)	13 300	12 700	12 700	24 100	20 100	17 000	123 600	123 900	123 500	61 700	49 900	49 900
Total subsidies (€)	22 700	22 700	22 700	22 800	22 700	22 600	59 300	59 200	59 300	68 000	69 500	69 500
Variable costs (€)	40 100	45 200	45 200	45 000	47 800	50 000	96 400	105 600	108 400	108 400	98 500	98 500
Fixed costs (€)	60 900	62 400	62 400	48 300	49 100	49 600	100 500	102 300	102 700	94 800	94 800	94 800
Marginal yields												
Additional milk quota (€/t)	304	42	42	238	0	183	263	0	79	252	156	156
Additional milk yield (€/l)	n.c.[3]	4198	4 198	317	3225	1 222	n.c.	5156	3 789	158.6	1721	1721
Additional area (€/ha)	393	388	388	897	967	1 023	898	834	1 050	949	843	843
Additional building place	n.c.	n.c.	n.c.4	n.c.	2037	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Additional work hour (€/h)	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	104	n.c.	n.c.	33	33

[1] S1: 2007 situation with milk quota abolishment ; [2] S1 without constraint: S1 situation without production constraint ; [3] n.c.: not a constraint

The situation on dairy markets during the end of 2007 and the beginning of 2008 confirms these impressions. Indeed, in France, the price of milk during this period has risen to encourage farmers to increase their production. They have shown a strong capacity to respond to these incentives since the production increased by 10% in only five months (-1% in October, +1% in November, +4% in December, +7% in January and 9% in February: (Office de l'Elevage, 2008)).

We can also note that, one additional liter of milk productivity per cow per day causes income to rise by 5 000€ (for the *milk+cereal farm*). It is the economic gain permitted by the genetic level of animals. Indeed, cows which have a greater productive potential may produce a higher quantity of milk at a lower cost: less need for additional animals for the same quota, thus freeing areas for other activities. Naturally, such conclusions depend on the relative prices of milk, cereals and meat. The next section discusses how dairy farmers respond to the evolution of those prices.

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



The Figure 1 shows the evolution of the cereal component in the total farm area according to the cereals price (with a fixed milk price: 350€/t). The main point is that whatever the cereal price, all the farms produce all the authorized milk quantity. Farmers increase cereal production when cereal prices increase: they intensify milk production to free up land for cereal crops (more corn silage with concentrate instead of grass). The "Milk + Young bull farm" has larger possibilities to increase the cereal production because it can reduce the fattening activity. We also observe that with a price below than 140€ per ton, that was the price for the year before 2006, cereal production strongly decreases (two farms totally remove this production). The soaring price of fertilizers during the year 2008 (1.25€ per nitrogen kg in May 2008) plays a crucial role in this situation by diminishing the gross margin of this production.

We also test the adaptation of farmer's strategy by varying milk price (from 200 to 400 €/t) and cereal price (form 100 €/t to 300€/t). We note that the milk price variation has no impact on land use because farmers always produce their available quota. To see cereal production become more profitable than milk, cereal price must be higher than 250€/t with a milk price lower than 230 €/t: these are very extreme prices. The "Milk + cereal farm" does not produce all the authorized quantity with a milk price below 280 €/t : at this point the use of employed workforce is no more profitable. The other types of farming do not decrease their production.

2.2. Simplification of the Single Payment Scheme

This second section presents, on the one hand, the impact of the implementation of a full decoupling and, on the other hand, the effects of introducing a uniform single payment amount per hectare across the farms of a same region (principle of regionalization, under Articles 58 and 59 Regulation No. 1782).

2.2.1 Full decoupling: a stable income (S2)

In France, authorities decided to implement partial decoupling because they feared that the application of a full decoupling would lead to a geographical concentration of production in areas with comparative advantages. In other words, they feared that the full decoupling leads to a total abandonment of agriculture in difficult areas (with its consequences on the land settlement and dynamics of these rural territories) and to an intensification of production in areas where problems of water pollution may already encountered. Two years after the introduction of partial decoupling in France, the European Commission invites Member States that have used it to move towards a full decoupling of direct payments. It advocates the full decoupling of crops premium, but agrees that direct payments granted to suckler cows, sheep and goats can be kept coupled. This implicitly suggests that it was sensitive to territorial arguments often developed by France. Such a strengthening of decoupling would further improve the EU's position in ongoing negotiations at the WTO on support to agriculture. Indeed, according to the Agricultural Agreement of the Uruguay Round (URAA), subsidies granted to farmers shall not be related to, or based on, the production factors (land and cattle) employed because they are seen as distorting for production and trade.

In 2006, in France, the amount of the single payment was 5.6 billion euros with coupled aid represent 3.3 billion euros (1.1 billion euros for crop production and 1 billion euros under the suckler cow premium). Direct aid allocated per tonne of milk quota to compensate for the drop in prices (about 850 million euros) were directly integrated into the single payment for all member states. Thus, for dairy farms, the question of the implementation of a full decoupling arises only through agricultural productions associated with milk activity. Similarly, increased milk production will not lead tomorrow to increased direct milk aid. The increase future payment will depend solely on the acquisition of additional land or, more marginally, the purchase of payment rights (which is taxed in France when not accompanied by acquisition of additional agricultural land). In France, the amount of the single payment already represent, in national average, two thirds of all direct aid allocated to dairy farms. In the plain areas, where supports from rural development are low, this share is often close to three quarters. Thus, the full decoupling concerns essentially the direct payments allocated to crop production (including corn silage, particularly developed in France) and the slaughter premium.

All things being equal, the full decoupling has no effects on income because the amount of subsidies remain constant. Indeed, only the nature of support differs. However, farmers have greater adaptability in this situation because they have the option of dropping some agricultural production while preserving the benefits of direct aid acquired under these productions. Thus, the introduction of a full decoupling offers the possibility to improve income thanks to a reorientation of the production system: farmers therefore optimise their system regardless of decoupled direct payments.

To better understand the potential changes which may occur following the implementation of a full decoupling, it is useful to consider the impact of the implementation, in 2006, of the full decoupling of the SPBM and 75% of the crop premium. A simulation, also from the same model, indicated that milk producers are encouraged to remove the fattening activity, because the profitability of this production is in balance with grain production (Lelyon et al., 2008). In fact, this movement has been seldom observed in France because, on the one hand, producers of young bulls were often engaged in contractual relations with slaughterhouses and, on the other hand, 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. Besides, production of young bulls increased in France during the years 2007 and 2008 (Office de l'Elevage, 2008). Decoupling 75% of the crop premium resulted in a extensification of the dairy production, i.e. a slight substitution of cereal and corn silage by grasslands.

The scenario S2 estimates the impact of the implementation of a full decoupling of all premiums, starting from a baseline where milk quotas are abolished (scenario S1). According to the model, the productive implications of a full decoupling for dairy producers are, over all, quite limited (see Table 2). They are, all the more, if we compare these results to those obtained with the abolition of milk quotas. Note that for some milk farms, not studied here, especially those associating suckler cows with the dairy activity, this could encourage farmers to reduce beef livestock in favour of crop production and, assuming new allocations of dairy productive rights, dairy production.

Table 2. Implementation of the Health Check proposals: simplification of the single payment scheme (full decoupling and regionalization)

	Grazier Farm		Semi-intensive Farm		Milk+cereals Farm		Milk+Young bull Farm	
	S2[1]	S3[2]	S2[1]	S3[2]	S2[1]	S3[2]	S2[1]	S3[2]
FGE (€)	79 300	85 800	74 900	71 700	182 300	174 700	174 200	146 200
Crop area								
Cereals	10.6	10.6	12.9	12.9	89.0	89.0	34.9	34.9
Silage maize	5.3	5.3	15.0	15.0	22.5	22.5	45.5	45.5
Grassland	62.1	62.1	22.1	22.1	25.5	25.5	19.6	19.6
Premium for grassland	yes	yes	no	no	no	no	no	no
Animal activity								
Total produced milk (l)	342 000	342 000	325 520	325 520	538 000	538 000	480 000	480 000
Dairy cows (nb.)	57	57	38	38	64	64	55	55
Young bull (nb.)							59	59
Milk yield (l/year)	6 000	6 000	8 500	8 500	8 500	8 500	9 000	9 000
Milk l/ha forage area	5 070	5 070	8 760	8 760	11 230	11 230	7 370	7 370
Concentrates (kg/cow/year)	620	620	1 360	1 360	1 180	1 180	1 150	1 150
Nitrogen pressure (kg/ha)	133	133	139	139	79	79	146	146
Working time (h/awu/year)	2 030	2 030	1 720	1 720	2 140	2 140	2 040	2 040
Economic results								
Total output (€)	185 700	192 800	168 900	165 400	390 500	382 300	367 200	337 100
Milk output (€)	117 500	117 500	111 800	111 800	185 000	185 000	164 900	164 900
Meat output (€)	34 500	34 500	17 600	17 600	23 500	23 500	86 200	86 200
Crop output (€)	10 900	10 900	17 100	17 100	124 000	124 000	49 500	49 500
Total subsidies (€)	22 800	29 900	22 400	18 900	58 000	58 000	66 600	66 600
Variable costs (€)	44 100	44 100	45 200	45 200	105 900	105 900	98 200	98 200
Fixed costs (€)	62 300	62 900	48 800	48 500	102 200	101 700	94 800	92 600
Marginal yields								
Additional milk quota (€/t)	172	139	0	0	0	0	164	164
Additional milk yield (€/l)	2 734	2 250	3 200	3 200	5154	5154	1584	1584
Additional area (€/ha)	430	360	846	846	806	806	747	747
Additional building place	n.c.	n.c.	2 020	2 020	n.c.	n.c.	n.c.	n.c.
Additional work hour (€/h)	n.c.	n.c.	n.c.	n.c.	97	97	30	30

[1] S2: S1 situation with full decoupling ; [2] S3: S2 situation with regionalization of the SP ; [3] n.c.: not a constraint

2.2.2 *Regionalization of the subsidies: significant redistributions (S3)*

Finally, we simulate the implementation of flatter payment rates per entitlement received by farmers in a region: the regionalization. The regionalization allocates the same amount of direct aid per hectare to all farmers in a region. The global payment is then equal to the product of this amount for the eligible area of the farm. The text leaves some opportunities in the definition of a regional scale, with or without distinction between arable and grazing lands. So we apply this flat rate model to the S2 situation (without distinction between arable and grazing lands). The amount is allocated by administrative region. It is an important question because in the French dairy sector the allocation of aid based on a historical reference economically promotes farms with an intensive production system. Farms using a system based on grass, often seen as more environmentally friendly, receive a lower amount of aid (for the same level of production).

The decoupling of subsidies poses the problem of the legitimacy of this support with the increasing time in relation to the historic reference. France (such as Spain and Italy) chose to define the value of the SP based on the farm's historical references as opposed to England and Germany which decided to apply the principle of regionalization. The SFP per hectare (for all farms in France), is about 345 €/ha. Nonetheless, this figure hides disparities between types of production: 420 €/ha for intensive dairy farms and 330 €/ha for the extensive one (Chatellier, 2006).

We compared the S2 situation (with full decoupling) to a regional flat rate payment. The simulation indicates (see Table 2) an income transfer between farms: the Milk + Young bulls type of farming sees its FGE decrease by 16% while the FGE of the grazier farm increases by 8%. The extensive farms with large surfaces benefit from this transfer: they receive subsidies which originally were intended for beef-cattle farms and crop farms. Furthermore, the model shows that the crop area, the number of animals, the milk yield per cow or the feeding system are identical to the baseline. When the subsidies are totally decoupled, the farmer chooses the more efficient production, considering price and performance of each activity. The model suggests that there is no relationship between the amount of aid given and the production system chosen. However the model does not take into account the investments: a farmer receiving a significant amount of aid can modernize his production equipment to make it more efficient and increase his income (either through an increase in the product or lower expense), or he may also expand his farm.

CONCLUSION

This model, based on the linear programming methodology, shows its ability to analyse the impact of the CAP Health Check on French dairy farms. In order to represent realistic behaviour, we place the technical, biological, structural, environmental and regulatory realities at the heart of the producer's choice. However, keep in mind the limitations of the method which is based on instantaneous adjustments, constant yields and the idea that the actors are primarily guided by a desire to maximize their income. Some improvements are possible such as using a multi objective function to take into account other considerations which may play an important role (like, for example, the time of work). Other types of farming can also be integrated into the study. A "*Milk + Pigs*" farm could allow detailed analysis of the environmental topic, especially with regard to nitrogen surplus. Finally, the increasing volatility of prices puts risk at the heart of farmers' consideration. The UEP method takes into account the risk of price variation but no attention is paid to the upward or downward expectations made by the farmers. Indeed, the techniques for taking the risk into account incorporate the amplitude of price variation but not the path of their evolution. Integrating this element in linear programming models is an important issue in a context of increasing price volatility.

In terms of public policy, according to our simulations, the full decoupling of direct supports (compared to a situation with a partial decoupling) would not have a strong impact on French dairy farms' strategies. This is due to the fact that the direct payments which are granted to these farms have been largely decoupled since 2005. As to the implementation of a SFP regionalization, we estimate that the impacts concern the distribution of incomes between types of farm: the extensive farms benefit from a transfer of aid from the more intensive ones. However, the productive choices are not affected by this scenario. The removal of the set-aside will have just a little influence, both on income and production plan. For dairy farms, the most important measure of the CAP "health check" is, of course, the abolition of the milk quota. Our simulations show that farmers, in plain regions, have a strong potential to expand milk production, even with constant structure of the land. All things being equal, and whatever the prices, dairy farmers always try to reach the maximum quantity of milk allowed by our model. Nevertheless, the fluctuations of cereal prices have an impact on crop rotation and the intensification level. It is important to note that the current situation prevailing in agricultural markets is unprecedented and changes the balance between inputs and outputs.

The future of dairy production will be also closely connected to the strategies developed by dairy companies (whether private or cooperative), especially because they will have more power in the milk market regulation. Without the milk quota, the strategies of the firms will influence the milk production model in France (concentration, enlargement, intensification) and therefore the location of dairy farms on the French territory.

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