Impacts of the French bio-fuel policy on the French arable crop sub-sector

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Abstract— **The paper provides an analysis of the impacts of the biofuel policy on the French arable crop sub-sector. The model used is a biofuel supply model composed of an agricultural module and an industrial biofuel processing module. The agricultural supply model is an aggregation of 1094 farm models, based on data from the French Farm Accountancy Data Network (FADN). Different biofuel chains are included in the model: ethanol from wheat and sugar beet, biodiesel (Vegetable Oil Methyl Ester) from rapeseed and sunflower. Scenarios are built upon the recent policy of an increased demand of biofuels for the next years, under the assumption of fulfilling the targets with domestic production only.**

Results show that the incorporation target of 7% of biofuels in transport fuels would have small impacts on the wheat and sugar beet cultivated areas but would lead to a considerable increase in the rapeseed area. In the main producing regions, the rapeseed area would reach approximatively a third of the total farmed area. This would not be without consequences on the environment, due to the increase in pesticide use that this change in cropping patterns would most certainly induce. It would not be possible to reach a 10% incorporation target without imports. Furthermore, we analyse the impacts of reaching these production levels on the rapeseed opportunity costs, and show that reaching high level of incorporation (above 7%) will need a very high increase in rapeseed prices paid to farmers. We calculate the impacts of this opportunity cost increase on the competitiveness of biofuels with respect to fossil oil, for different levels of oil prices. We test the sensitivity of the results against the wheat price, and show that this latter will have a significant impact on the biodiesel competitiveness.

Keywords— **biofuel, agriculture, France**

I. INTRODUCTION

The development of biofuels in Europe, the United States and several other countries in the world in the early 2000s is of major importance for the world agriculture. This development is largely driven by public policy. It has thus recently stimulated much economic and environmental evaluation questioning the effects and efficiency of those biofuel public policies. (see in particular Rajagopal and Zilberman, 2007, for a review of the literature).

In the EU the framework of the current policies is given by the 2003 directives. The directive promoting biofuels (2003/30/EC) fixes the biofuel incorporation targets to be reached in road transport fuels (5.75% in 2010. The directive on energy tax (2003/96/EC) allows MS to adopt partial or full tax exemption for biofuels in relation to the general tax system for fossil fuels. The European Commission (EC, 2007) estimates that without mandatory blending policies the targets of the 2003 biofuel directive will not be met in 2010. This is also shown by other authors (Banse *et al*, 2008). Thus, in March 2007, EU leaders commit themselves to a mandatory incorporation rate of 10% of transport fuel in each member state to be provided by biofuels by 2020. In January 2008 the EU Commission presents a proposal for a new directive on renewable energies that confirms the “10% binding target” for 2020.

While first studies using life cycle analysis methodology showed that the balances for the reduction of greenhouse gas emissions are globally positive although strongly dependent on the technologies and chains used (Farell 2006, Eucar/Concawe/JRC, 2006), more recent studies highlight the potentially negative environmental effects of changes in land use or intensification of agricultural production that are not taken into account in classic life cycle analysis. (Doornbosch et al. 2007, Fargione et al. 2008, Searchinger et al. 2008).

Studying the potential effect of a new “10% binding target” in the EU, the EC-JRC (EC-JRC 2008) showed that achieving a 10% target would need an important increase of imports (direct or indirect) that could lead to indirect land use change. The authors concluded that it cannot be asserted that the net effect of the biofuel policy on the environment would be positive, and that the costs of using biofuels outweigh the benefits of doing so.

The new EU biofuel directive and the "10% binding target in 2020" is still under discussion, and the issue is a matter of considerable controversy. Member States positions and policies differ largely. France is currently one of the countries that promote the most strongly the development of biofuels. In 2005 targets have been set that go further than those of the EU 2003 directive, putting at 7% the level of biofuels to be incorporated in fuels in 2010 and at 10% the target for 2015.

Our work is centred on analysing the impact of this French biofuel policy on the arable crops farming. While most of the studies estimate the possibility of reaching those targets on the basis of global calculations our analysis rely on a microeconomic based model. Our biofuel supply model includes an agricultural supply model developed from farm mathematical programming models and a module for the processing of agricultural raw materials to produce biofuels. The originality of our approach relies on the characteristics of the model. Based on individual farm models, it allows us to assess the impacts in terms of land allocation for different French regions, and thus potentially the environmental impacts due to land-use changes. Aggregated at the national level and linked with a biofuel module, it permits to build a supply curve for bio-diesel, to analyse its competitiveness in comparison with diesel for different oil price levels, and thus to address the issue of sustainability of biofuel policy.

The context, the model and the assumptions are presented in the first part of the paper. The results are presented in the second part.

II. CONTEXT, MODEL AND ASSUMPTIONS

A. *Context*

The development of biofuels in the EU results from a voluntarist policy, which results in incentives in both sectors of agriculture and energy. The 1992 reform of the Common Agricultural Policy (CAP) gave the first impulse by permitting non-food crops on set-aside lands. The 2003 CAP reform introduced a second incentive with a specific aid for energy crops produced on non set-aside lands. However, it was chiefly the implementation of a policy aiming at encouraging biofuel use which helped their development. In 2003, two European community directives set the common framework while leaving the member states the choice of measures to be implemented. The directive promoting biofuels (2003/30/EC) fixes the biofuel incorporation targets to be reached in road transport fuels: (2% in 2005 and 5.75% in 2010. The directive on energy taxation (2003/96/EC) allows members states to adopt tax reduction or exemption for biofuels in relation to the general tax system for fossil fuels.

France set up a policy to support biofuel sub-sectors that was first aimed at accompanying the production of biofuels from crops grown on set-aside land. The instrument of this policy is a reduction of the *Taxe Intérieure sur la Consommation* (TIC, formerly the *Taxe Intérieure sur les Produits Pétroliers* [Domestic tax on petroleum products]) that compensates the added cost of biofuels in comparison with traditional fuels. This tax reduction is awarded for biofuels produced by units that have received approval after a European call for bids. This measure enabled the development of two biofuel chains: bioethanol mainly used in the form of ETBE (Ethyl Tertio Butyl Ether) and biodiesel or FAME (Fatty Acids Methyl Esters).

The policy was strengthened substantially from 2005 onwards as more ambitious objectives were set than those decided at EU level. The European objective of a 5.75% biofuel share in 2010 has been advanced to 2008 and targets of 7% in 2010 and 10% in 2015 have been set. Tax cuts are granted for specific quantities, set so that the targets can be met. They have been increased up to 2010. In addition, a change in the fuel tax system resulted in the application of a supplement to the *Taxe Générale sur les Activités Polluantes* (TGAP, General Tax on Pollutant Activities) for fuel distributors. Retailers can avoid paying this second tax by incorporating a certain percentage of biofuels. Tax rates increase over time in line with the increase in the incorporation target up to 7 % in 2010. This measure results in a high penalty for fuel distributors who do not respect the share of biofuels to be incorporated and thus could be considered similar to a biofuel mandate. Although biofuels developed fairly weakly until 2005, resulting in particular in a share that fell short of the objectives set, the reaction to the newly installed instruments was much stronger in 2006. Thus the shares set for 2006 and 2007 were reached.

The objectives set by the French government involve the substantial speeding up of biofuel development in the coming years and major consequences on the agricultural sector. As regards those consequences, there is a clear difference between oilseeds on the one hand and sugar beet and grains on the other. For the latter, attaining the ethanol production objectives set can be envisaged without major impact on cropping patterns, firstly because of the small amount of petrol in comparison with diesel (petrol forms 25% of the fuel currently used in France) and secondly because of the large areas under cereals. The situation is different for oilseeds, where the target share of biodiesel requires large quantities of oils, and an increase of rapeseed cultivated area far beyond the current cultivated area.

B. Description of the model

The 'OSCAR' model is a biofuels supply model aiming at assessing the impact of public policies in that domain. OSCAR consists of an agricultural supply model based on microeconomic data (activity model) and a module for the industrial processing of crops into liquid biofuels. The agricultural supply model consists in an aggregation of individual models of farms specialised in grain and arable crops. Each farm model maximises farmer's total net income under regulatory and agronomic constraints, and the aggregation uses farm representativeness coefficients The sample consists of 1094 farms from the Farm Accountancy Data Network (OTEX subgroups 13 and 14). Crops are declined in different cropping activities depending on the preceding crop. Gross margin data are calculated for each farm using FADN data and other information sources, through a gross margin estimation procedure (Guindé et al., 2004). The biofuel module includes processing costs and technical coefficients for the production of biofuels and by-products.

Approximately 75,000 farms are thus represented; in 2004 they produced 66% of French wheat, 88% of sugar beet and 74% of rapeseed. Rapeseed production is concentrated (83%) in nine regions; we examined the results for these in greater detail.

Agronomic constraints are modelled as a maximum percentage of certain crops in the rotation. The constraints include a maximum of 30% of farmed land under sugar beet, 15% under protein plants and 30% under sunflower. Two rapeseed cropping techniques were incorporated in the model to simulate the possible impact of the development of biodiesel on the position of rapeseed in cropping patterns. In the first, 'rapeseed A', the crop appears in the rotation less than one year in four. That is the situation currently observed in our sample in 2004. The proportion of the 'rapeseed A' is therefore limited to a maximum of 25% of the area. In the second technique, 'rapeseed B', the crop returns more frequently in the cropping pattern; it is considered that this practice could be developed in a context of increased demand for biofuels. The overall constraint on the total area under rapeseed on each farm specifies that the sum of the area under 'rapeseed A' and 'rapeseed B' can be as much as 40% of the total cultivated area. 'Rapeseed B' assumes the use of a new crop management sequence with greater use of nitrogen fertilisers and pesticides and a decrease in yield. The decrease in yield was estimated in collaboration with agronomists on the basis of the data available (in particular Lefèvre

2005), and set at -20%. The increase in inputs was on the basis on the same sources, assumed to be 95 €/ha;

C. Assumptions and scenarios

The model forces the arable crop sub-sector to produce the quantities of biofuels required to attain the shares desired by the public authorities. The quantities required are corrected by the weight of the sample in the production of the raw materials used in biofuels. Prices are exogenous, with the exception of those of rapeseed and sunflower (for food and energy purposes) and of wheat and sugar beet used for energy. We have assumed that certain quantities of rapeseed and sunflower will continue to be produced for edible oils, with the present level maintained, and for export. The dual value of the production constraints provides the opportunity cost of the production, in other word the minimum price to offer the farmers to reach the fixed demand. Thus, varying the quantities of biofuels required generates a supply curve for each crop.

The model is validated for the year 2004 with a 0.93% biofuel share. The reference year is 2015.

The CAP reforms currently being implemented have been included : the Luxemburg compromise and the 2006 reform of common market organisation of sugar. No new CAP reform has been modelled. The specific aid of 45 euros/ha for energy crop is maintained (within a maximum limit of 460000 ha). A set-aside rate of 10% has been set (and sensitivity analysis of its elimination has been done). Yields increases have been estimated on the base of 1990-2004 trends. We assume a total fuel consumption in road transportation of 45.5 million tonnes. A maximum of 20% sunflower oil can be used in biodiesel, with the rest consisting of rapeseed oil. The proportions of wheat bioethanol and sugar beet bioethanol are set at 80% and 20% respectively in the simulations (according to the level of tax exemption quantities awarded by the government for 2010).

Agricultural raw material accounts for more than 95% of the final cost of biodiesel (after deduction of the value of cake) and so movements of prices of such raw materials strongly affects the cost price of biodiesel. Oilcake prices are also an important component. The European Commission forecasts a 56% decrease in the price of rapeseed oilcake for a biofuel share of 7% (EC, 2007) and Gohin (2007) forecasts a 15% fall, taking the price to €110 per t, in the 5.75% scenario. We have used the figure of €110 per tonne here. A sensitivity analysis has been done on the rapeseed cake price. Other assumptions are glycerine at €180 per t, methanol at €300 per t and a processing cost of €150 per tonne of FAME produced.

Our analysis emphasizes the impact of the increasing demand for biodiesel. In the simulations reported here, the quantity of bioethanol is set so as to represent 7% of petrol fuel consumption. The demand for biodiesel is increasing up to a quantity corresponding to a 10% incorporation rate in diesel. Sensitivity analysis shows that other targets for bioethanol (from 1.77% to 10%) don’t change the results, because this parameter impacts only the respective share of food and non-food uses for wheat and sugar beet without any effect on the land allocation between crops.

Tableau 1 Scenarios

	Sref	S1	S2	S3	S4
Biodiesel incorporation rate	1.77%	5.75%	7%	9%	10%
Biodiesel production (thousand tonnes)	631	2050	2495	3208	3565

Agricultural product prices that are exogenous to the model were estimated from simulations for 2015 of the GOAL model (Gohin, 2007). A second set of prices was tested to measure the sensitivity of our results to an increase in wheat and grain prices comparable to that observed in 2007. The prices used were estimated for all grains, in relation with wheat prices. The latter was set at €120 per tonne in the 'low grain price' assumption (Gohin, 2007) and at €200 per tonne in the 'high grain price' assumption. Other cereal prices have been increased in the same proportions.

III. RESULTS

A. Land allocation

As might be expected, the first result of our simulation was an increase in the areas under rapeseed and sunflower when the biofuel share required increases. This takes place at the expense of grain (mainly wheat and barley) and protein crops. A considerable increase in the area under rapeseed is observed; this increases from 8% in the reference scenario to 23% in the S3 scenario (Table 1).
The second result is that it is not possible to attain a share of 10% biofuels with present exports and food use maintained and within the framework of the farming systems envisaged in our model.

Table 2. Distribution of land area among crops

Scenario	Sref	S1	S2	S3
Cereals	67%	63%	61%	57%
Protein crop	5%	3%	3%	2%
Sugar beet	3%	3%	3%	2%
Rapeseed	8%	16%	19%	23%
Sunflower	3%	5%	5%	7%
Uncultivated land	10%	7%	7%	6%
Other	3%	3%	3%	3%

Analysis of disaggregated results shows that the regional results differ significantly than the aggregated ones. In the nine regions in which most of the rapeseed is currently grown, the rapeseed share in the total cultivated land reaches around 25% in the scenario S1 and more than 30% in several regions for the scenario S2. (table 2)

Table 2. Proportion of the area under rapeseed by region

Scenario	Sref	S1	S2	S3
Centre	19%	27%	31%	36%
Champagne	12%	24%	28%	38%
Picardie	10%	23%	29%	38%
Poitou-Charentes	19%	25%	27%	34%
Bourgogne	18%	28%	31%	35%
Île de France	15%	27%	31%	38%
Haute Normandie	13%	24%	30%	37%
Lorraine	21%	30%	34%	38%
Nord-Pas de Calais	12%	19%	23%	35%

We calculate that in the scenario S3 , from 43% (in Poitou-Charentes) to 86 % of the farms (in Lorraine) grow rapeseed on more than 25% of their land.
It can thus be seen that the 5.75% share targeted still seems compatible with good agricultural practices on most regions. This is not the case when demand is greater than this.

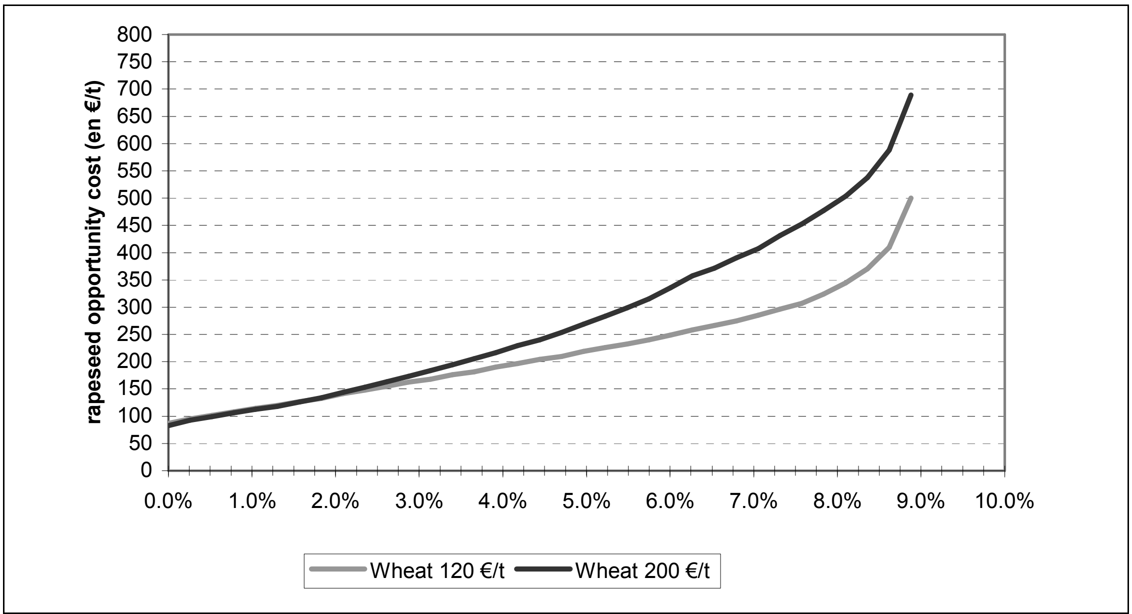
B. Cost prices and competitiveness of biodiesel

The curves in Graph 1 below show the impact of increased demand for biodiesel on the opportunity cost of rapeseed. The dual value of the constraint that makes it necessary to produce an increasing amount of rapeseed depends on the quantities of biodiesel required. For each quantity required it represents the minimum price that must be offered to farmers for them to produce the quantity of rapeseed (and sunflower) needed. Our results complete those of other work using a previous version of the model and in particular work examining smaller demand for biodiesel resulting in the cultivation of oil crops for energy purposes mainly on set-aside land (Rozakis and Sourie, 2005) or whose use for energy purposes would be at the expense of food use (Sourie et al., 2005). The approach used here analyses the consequences of greater demand which would result in substantial changes to cropping systems and in consequence would require an increase in the prices paid to farmers.

It is thus seen that for a 7% biofuel share (S2), a minimum of some €280 per tonne with low grain prices and €400 per tonne with high grain prices would be required for farmers to produce the quantities of rapeseed required. These figures rise to €340 and €500 per tonne to produce the quantities needed to reach a 8% biofuel share.

Two phenomena can be seen in Graph 1: first the strong increase in the dual price when the biofuel share increases and second the strong sensitivity of this price to grain prices. This is explained by what we have seen, that is to say that the increase in areas under rapeseed is to a considerable extent a replacement of grain crops. In most regions this growth should be achieved by changes in crop management sequences involving increased costs and smaller yields.

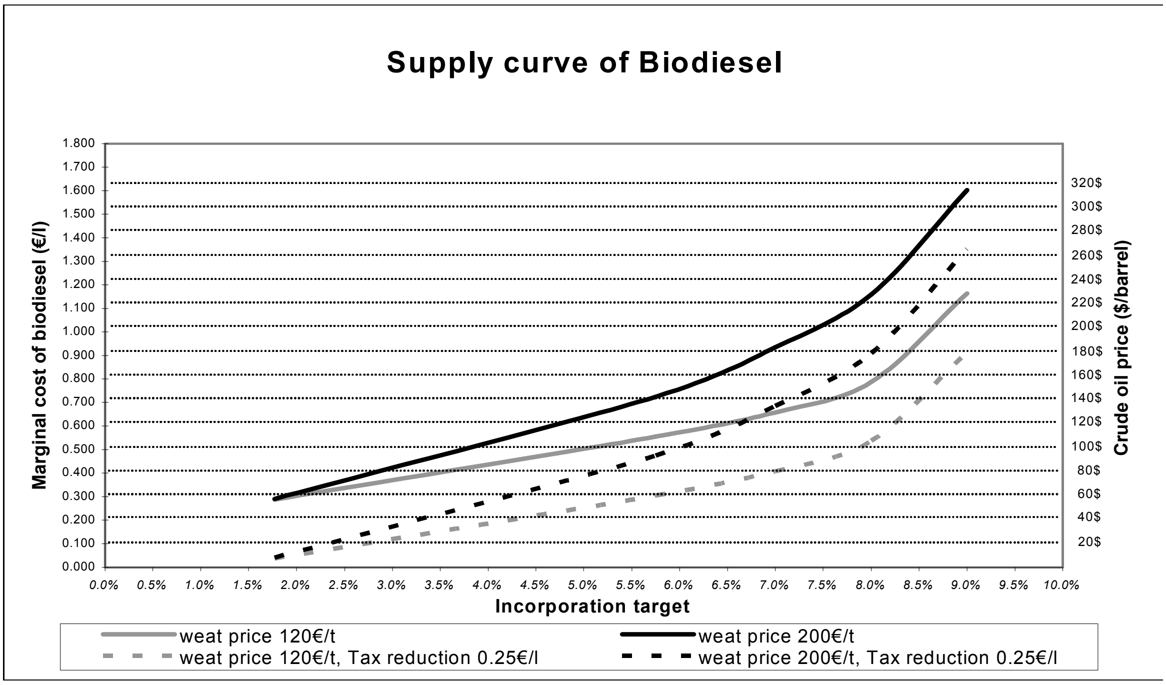
Graph 1. Rapeseed ester supply curve



The opportunity costs for rapeseed and sunflower are used to calculate the cost price of biodiesel, also taking processing and inputs costs into account and deducting the price of by-products (glycerine and oilcake). Comparison of this biodiesel cost price with the price of diesel under different grain prices assumptions makes it possible to discuss the competitiveness of biodiesel in comparison with the fuel that it replaces.

The results for the high grain price (black curves) and low grain price (grey curves) scenarios are shown in Graph 2.

Graph 2. Cost price and competitiveness of biodiesel



The continuous lines show the price of biodiesel (shown on the y-axis) for different biofuel shares(shown on the x-axis) . The second y-axis shows the equivalent of the biodiesel price in terms of oil prices (allowing for the relation between the diesel and oil prices and the different calorific value of biodiesel/diesel[1]). The dotted curves incorporate the tax relief currently awarded to biodiesel.
It can thus be seen from the black curve (i.e. in the high grain price scenario) that with a 5.75% share biodiesel would be competitive when the price of oil exceeds $130 per barrel. The tax reduction on biodiesel lowers this threshold to $80 per barrel. In the low grain price scenario (grey curves), the figures would be $95 and $50 per barrel respectively.

Graph 2 shows that the competitiveness of biodiesel decreases strongly when the biofuel share increases. At the 7% share required, the price of oil should be over $165 per barrel if grain prices are high and with no subsidy. The profitability threshold falls to $115 per barrel in a low grain price scenario. The results of the same simulation with rapeseed cake at €150 per t (instead of €110) show that with the same biofuel share (and in the high grain price scenario), the competitiveness threshold would be reached for oil at €155 per barrel. These results show that the competitiveness of biodiesel in comparison with diesel depends of course on the price of the latter and on the rate of exchange but is also strongly affected by other components of the economic context and in this case the price of grain crops and the price of oilcake, the main by-product.

IV. CONCLUSION

The development of biofuels in Europe is the fruit of a policy whose aims are indisputably very important: combating global warming by reducing greenhouse gas emissions and diversifying energy supplies by reducing dependence on fossil oil. The expected impacts of the development of biofuels are fairly small in relation to these two objectives as it is estimated that, at the EU level, incorporating a 10%

[1] And assuming an exchange rate of $1.40 to €1.00

share of biofuels in fuels would reduce oil imports by 3% and greenhouse gas emissions by only 1% (Bamière et al. 2007). However, even if they are minimal, these positive impacts should not be ignored.

French policy has the same perspectives as European policy but the objectives go beyond those of the latter. The aim of our work was to measure the consequences that this policy might have for the farming systems most directly concerned to provide matter for though that can contribute to the evaluation of the public choices currently made.

We have shown that attaining a 7% share objective in 2015 on the basis of French agricultural production would result in a very large increase in the area under rapeseed; the crop should then be grown on nearly a third of the agricultural area in the main French production regions. The increase would be at the expense of the areas under grain crops, protein crops and also covered indirectly by the cultivation of part of the set-aside land. To our knowledge there have been few studies of the environmental consequences of such a modification to cropping systems. However, more pesticides spraying is probable as a result of increased pest pressure and the difficulty of controlling the occurrence of diseases because of the frequent return of rapeseed in the same field and the larger area of rapeseed in proportion to the other crops in the same region. In a simulation of the effect of different economic scenarios on pollution of groundwater by nitrates in Alsace in France and Baden in Germany, Graveline *et al.* (Graveline *et al.*, 2006) showed that the biofuel development scenario would be that resulting in the greatest increase of pollution as a result of the increased share of rapeseed in rotations.

Our results also show that it would be impossible to attain a 10% biofuel share, even with changes in practices of this kind, without resorting to imports. France and Germany are the two leading rapeseed producing countries in Europe and have biodiesel consumption development objectives that exceed the present production capacities of both countries and that will certainly have to be covered by imports from third countries. However, many countries in the world have biofuel consumption development programmes that will certainly weight strongly on the world oil and oilseed market.

Another conclusion of our work is that a substantial increase in the price of rapeseed would be required to encourage French farmers to grow the quantities necessary to cover biofuel share objectives greater than 5%. We have tested the results against two grain prices assumptions with the highest based on wheat at €200 per tonne—still well below present prices—and we observed great sensitivity in the results at this price as a result of crop substitutions in land use.

Finally, our results show that the competitiveness of biodiesel may decrease strongly as production requirements increase. The tax reduction required to make up for the difference in competitiveness between biofuels and classic fuels should also increase, as would public expenditure under the combined effect of decreased competitiveness and substantial increase of the volumes approved for biofuels. However an increase in oil prices that would be stronger than the ones of agricultural prices could impact this result.

An assessment of the overall environment impacts of the development of biofuels remains to be performed. Such an assessment should take into account the effects of the changes in land use. Our model can be improved in order to make a contribution to this by including crop management systems and cropping systems other than those used by farmers today. Economic models capable of simulating the impacts on choice of crops, farmers' agricultural practices and their environmental consequences will be necessary on a broader basis in order to analyse the consequences of the changes in agricultural, energy and environmental policies that will be made in the coming years.

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