Economic impact of biofuel chains in France

Jean-Claude SOURIE, David TREGUER*and Stelios ROZAKIS,

Mixed Unit of Research INRA and INA P-G, Economie Publique, Paris and Grignon, FRANCE

May 31, 2006

Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Long Beach, California, July 23-26, 2006

Abstract

Given the current situation with the high price of oil (an average of $53 per barrel in 2005) and the risk of global warming, the European Union (EU) is reinforcing its objectives related to the production of biofuels: they should account for 5.75% of the overall fuel consumption by 2010 in France, as opposed to 1% in 2005. In keeping with the objective set for 2010, the biodiesel derived from rapeseed is still the preferred biofuel (27.5 million hectolitres projected), compared to the ethanol derived from wheat or sugarbeet (9.3 million hectolitres projected). Our model makes it possible to foresee that there will be a competition between

*corresponding author: treguer@grignon.inra.fr

food and energy crops by 2006 and that this will occur even before all of the fallow areas are requisitioned. Our paper stresses the fact that the energy and economic advantages of first-generation biofuels are not sufficient to replace large quantities of petroleum resources.

keywords: biofuels, food-energy competition

1 Introduction

Energy crops are about to become a major actor of the arable crops in France, in order to attain the recommended level of biofuel incorporation (5.75% by 2010). Moreover, the French government has decided to go beyond that suggested percentage of biofuel incorporation (7% in 2010). In the present background where the oil barrel oscillates around 70$ and where the fight against global warming tends to become a priority, biofuels seem to have many virtues. However, their energetic yield per hectare (which is quite low on the whole) and their production costs (which exceed their market price) lead us to relativize the very optimistic analyses about them. Biofuels are often described as purely energetic products. However, they are also an indirect means of subsidizing the agro-industry and agriculture. The practical modalities of these interventions are left to the discretion of each member State of the EU.

The main results presented in this article deal with France only. They have been obtained thanks to a partial equilibrium model: OSCAR, developed by INRA. The main advantages of this model stem from the detailed formalization of the agricultural supply (food and energetic crops). A particular attention has been dedicated to the consequences of biofuel production on the agricultural incomes and jobs.

2 Some facts about biofuels

A glance at the global repartition of biofuels shows the predominance of one continent: America and of one type of biofuel: ethanol. The latter is produced from sugar cane in Brazil or from corn in the United States.

The European landscape appears quite different in its choices of biofuels and of energy crops. These dissimilarities stem from agronomic and economic reasons (as far as the choice of energy crops is concerned) and from the predominance of diesel engines and the structure of the refining system (for the choice of biodiesel as the leading biofuel).

The original objective of biofuel production in France was to make up for the economic drawbacks linked to the land set-aside program decided in 1993 in order to control the food supply. The Rapeseed Methyl Ester (RME, also referred to as "biodiesel") was favored since it allowed to crop the maximum area of land (as "industrial" set-aside land, i.e. with energetic crops) for a given amount of public outlay since the production per hectare is particularly low (see table 1). More recently, the policies of global warming mitigation have changed the traditional vision of biofuels: they now appear as a keystone of the policy of the CO_2 mitigation in the transports.

Two main categories of biofuels are produced on an industrial scale: Ethyl-Tertio-Butyl-Ether (ETBE) made from wheat or sugarbeet ethanol and RME, made from rapeseed oil (table 1). Primary biofuels (ethanol and vegetable oil) are further processed in order to obtain secondary biofuels that are compatible with engine specifications: ETBE is mixed with gasoline, RME with diesel.

The replacement of a fraction of fossil fuel by RME allows to relax the constraint on the supply of diesel whose demand has grown rapidly. Incorporating RME also enhances the lubrication qualities of diesel, which has to contain ever less sulfur in order to cope with the new fuel specifications.

Ethanol could alternatively be mixed directly with gasoline, but this possibility has remained marginal until now, mainly because of technical problems (instability of the mix gasoline-ethanol in case of water traces, higher volatility in presence of ethanol, etc). Nevertheless, these technical barriers could rapidly be overcome thanks to the know-how of the French motorists, which are already implanted in ethanol producing countries such as Brazil.

Biofuels are slightly less energetic [1] with respect to the other petroleum-based products, especially ethanol. Hence, the biofuel-gasoline mixes tend to cause a small overconsumption. Therefore, biofuels are paid a little less with respect to gasoline.

Table 1 shows (for year 2005) the production of primary and secondary biofuels per hectare from the three agricultural raw materials. Rapeseed is by far the least productive crop. If the observed trend of increasing yields is to be extended in time, the per-hectare production will go on increasing, though in a more important way for ethanol compared to RME. This is the reason why the biofuel that has been favored in the biofuel program: i.e. RME will be land-consuming. Note that the palm oil production per hectare is 4 times greater.

[1] The measure of their energetic content is expressed through the Inferior Calorific Power (ICP), which is the quantity of heath emitted by the complete combustion of one unit of combustible, the water steam is assumed to remain uncondensed and the heath is not recovered.

3 A positive energy balance, but a small contribution to energetic independence

The production of biofuels requires a consumption of fossil energy all along the production process. It seems therefore essential to check if biofuels will really lead to fossil energy economies when they substitute for fossil fuels. The energy balances make the checkout possible. If these balances are greater than one, the gains of fossil energy are more important than the energetic spending. Making these energy balances proves difficult, since co-products are produced in the meantime. These co-products are either used for cattle feeding (Distiller's Dried Grains with Solubles or DDGS for wheat, cakes for rapeseed) or in the chemical industry (glycerin). The production of biofuels and co-products being intimately linked in the industrial process, it is therefore impossible to know the exact quantity of fossil energy used to obtain these co-products.

In the balances presented by the agencies ADEME-DIREM, the previous difficulty is circumvented by the use of an accounting method (table 2, column 2). It consists in assigning a fixed quantity of the fossil energy consumed by the chain to co-products, following a predetermined allotment rule. The rule used in this case is the ratio between the quantity of co-products and those of biofuels. This energy which is assigned to co-products is then deducted from the fossil energy attributed to biofuels, which therefore enhances the energetic balance of the latter. Of course, a different allotment rule could have been used, thus leading to different energetic balances.

In the face of such difficulties, the only satisfying method is a systemic approach which consists in assigning to co-products the fossil energy necessary to produce the products that these co-products will replace (for instance, the rapeseed cakes replace the soja cakes imported for animal feeding). Contrary to the previous method, this one will accurately measure the effects of the insertion of a new energetic chain in the economic activities and the resulting changes in the consumption of fossil energy. This method has been advocated by Shapouri as early as 1995 and has been used in the recent study jointly lead by EUCAR, CONCAWE and JRC. The energetic yields are markedly worse with this hypothesis, especially for ethanol.

Assuming the needs in biofuels forecasted for 2010 (9.3 Mhl of ethanol and 27.5 Mhl of RME) and taking into account the energetic yields of table 2, the net contribution of biofuels to oil economies ranges from 1.5 Mtoe[2](substitution value for co-products) and 2.0 Mtoe (weight allotment rule). The RME chain has a fairly good energetic yield per biofuel unity, but this yield becomes very modest when considered per hectare of land. As a whole, the contribution of biofuels to oil economies is low if we consider that agriculture has consumed 2.9 Mtoe of final energy (all different energy sources taken together) and France as a whole 92.8 Mtoe (oil only).

4 The competition with food productions

As the objectives of biofuel production are known by now, it seems interesting to assess the consequences on the total area of agricultural land required. Table 3 shows the estimated need of land in order to attain the 5.75% objective of biofuel incorporation by year 2010 (proposed by the EU Commission). Energetic crops had traditionally been confined to set-aside land. However, it seems clear that they will now extend well beyond this administrative limit (1.5M hectares) in order to reach the objective. Thus, a competition between food and energetic crops may arise.

This competition (studied by means of the OSCAR model) emerges principally between

[2]Millions of tons of oil equivalent

the two kinds of rapeseed (aimed for food or energetic purposes), and also between rapeseed and cereals. The competition appears as early as the RME production attains 8Mhl (figure 1), therefore quite rapidly in the unfolding of the biofuel program (which forecasts 27.6 Mhl of RME), and before that the total 1.5 Mha set-aside area is requisitioned. This result comes from the fact that an important fraction of the set-aside land is not usable for energetic rapeseed in the model: first, the rapeseed production is limited to 30% in the agronomic rotations, then 30% of the set-aside land is considered as unfit for cropping (land with a too important slope or too far away from the main building of the farm, etc.) and last, 34% of the farmers have never cropped rapeseed and are therefore left aside in our model. Besides, the supplementary subsidy of 45 euros per hectare awarded to areas outside the set- aside land which are used to produce energetic crops (this subsidy is however limited to 1.5Mha, EU-wide) also contributes to the replacement of food rapeseed by energetic rapeseed. Note that the rotations are exactly the same, the only difference lies in the subsequent use of rapeseed in the transformation process. This subsidy is justified on environmental grounds. Moreover, it contributes to regulating the cereals markets (the exports of cereals costs the EU 5 euros/ton on average). The framework of the competition analysis is certainly too rigid. Especially, we might consider that the group of rapeseed producers can increase swiftly. Even if energetic crops are slightly more profitable than food crops, they cannot replace completely the latter since their quantity is restricted by the State which allows biofuel production up to a certain quantity (which is subsidized).

This competition might lead to an increase of the rapeseed prices (food and energetic alike). In the case of corn in the USA, Gallagher has shown a possible rise of the prices if the ethanol made from corn were to replace methanol (a traditional additive to fossil fuel, which is believed to have environmental risks). This price increase favors corn producers, but penalizes (though to a lesser extent) the cattle breeders. In the EU, animal breeders and cattle feeding industries might on the contrary benefit from the development of RME and ethanol from wheat, since it might cause falling prices for rapeseed cattle cakes and DDGS. As a consequence, the costs of biofuel would soar, as the valorization of co-products are deducted from the production costs of biofuels.

5 Biofuel are not competitive with a $65 barrel

The costs of biofuels (as shown in figure 2) are computed from the field to the final product, before being distributed to the gas stations. These costs, estimated per liter, are calculated by adding the price of the agricultural raw material (wheat, rapeseed or sugar-beet) with the logistical and industrial transformation costs. The revenue from selling the co-products are deducted. These costs are established in a scenario of competition between food and energetic crops: the energetic rapeseed is produced both on set-aside land and on the area traditionally devoted to food crops. This competition therefore raises the prices of energetic wheat and rapeseed at least at the level of food crops (respectively 88 and 198 euros per ton). Owing to the specific regime of quotas, the price of sugarbeet (20 euros/ton) is a price that enables any sugarbeet producer to crop ethanol sugarbeet in a profitable manner (this result is based on a previous work completed by INRA). This theoretic price seems quite in line with what is observed in practice.

The valorizations of biofuels are indicated on the dark curve. They are calculated at the exit of refineries, and are diminished in order to take into account the overconsumption that biofuels incur when they are blended with gasoline. The valorization of biofuels is therefore inferior with respect to fossil fuels, especially ethanol with respect to gasoline (cf. substitution rate from table 1).

The comparison between costs and valorizations clearly shows that biofuels are still not competitive without a specific support. RME will become competitive with respect to diesel if the petrol price reaches $75 to $80 per barrel (1euro=$1.2).

6 An economic overcompensation by means of a partial tax exemption

In addition to the agricultural subsidies granted in the CAP framework, biofuels benefit from a partial tax cut (this tax is called TIPP, which stands for Interior Tax on Petroleum Products). The amount of the tax cut was 0.33euros/l for RME and 0.37-0.38 euros/l for ethanol in 2005. Thanks to such a tax cut, biofuels can be profitable when the oil barrel oscillates between $15 and $20. However, such a high level of tax cut is not justified anymore. The minimal tax cut that should be implemented (taking into account the energy and agricultural prices of today) can be estimated by the difference between the costs of biofuels and their valorization as shown on graph 2. For a petrol price of 65$ per barrel, these necessary fiscal exonerations are roughly the same for ETBE, ethanol and RME. The minimal exonerations are very inferior to the actual ones, notably for RME and ethanol used directly. They are more important in the case of ethanol used through the ETBE chain, owing to the supplementary cost of producing ETBE.

6.1 How are the surpluses divided between agriculture and the transformation industries?

The excess of tax cuts shown in table 4 gives a hint of the gains earned from the gathering of energy crops to the incorporation of biofuels in the fossil fuels. It seems quite sensible to compare these gains with those earned by the agricultural sector. We must keep in mind that agricultural concerns had been put forward in order to justify the first biofuel program of 1993.

Two main factors determine the level of the agricultural gains: the price paid for the energetic crops and the nature of the land used for the latter (i.e. set-aside land or land traditionally devoted to food crops). The prices retained are those previously used to compute the costs of biofuels (graphic 2), namely 198euros/t for rapeseed, 88euros/t for wheat and 20euros/t for sugarbeet. These prices apply irrespective of the localization of energetic crops (in or outside the set-aside land). In order to satisfy the demand for energetic crops, the farmers first produce on the set-aside land (as shown on graphic 1), before to replace food crops since the former choice is economically more interesting. The production on the set-aside land will occur as long as the impact on the agricultural income is higher than the subsidy given to energetic crops when they replace food crops (namely 45euros/hectare). Hence, today's production of approximately 300,000 hectares of energetic rapeseed is almost totally located on the set-aside land. The results of the division of the surpluses shown in table 5 depend on such a mechanism.

As long as the energetic crops substitute for set-aside land (table 5), the farmers gain a substantial supplementary income per hectare of wheat or rapeseed (ranging from 200euros to 300euros per hectare). These incomes are roughly equal to the average income per hectare of cereal-oriented farms. Thus, farmers take back part of the lost income stemming from the implementation of the mandatory set-aside in 1993. The income generated by the energetic sugarbeet exceeds by far the others': this comes from the price calculation method. We observe the opposite result per liter of biofuels, since the production of ethanol per hectare of sugarbeet is very important. The comparison of the agricultural gains with those of the industry requires that we express these supplementary agricultural income per liter of biofuels. It is then straightforward to observe that the figures are largely inferior to the income earned by the industry (coming from the excessive fiscal exoneration).

As soon as these crops replace food crops, the gains for agriculture diminish sharply. The increase in agricultural income for wheat and rapeseed falls to 45euros/hectare (the subsidy for energetic crops) and to 149euros/ha for sugarbeet. The gain per liter of biofuel then becomes very small (0.02-0.03euros/l). The income repartition clearly appears unfair in this case.

Thus, as long as energetic crops are produced on the set-aside land, the economic impact proves quite interesting for the farmers. However, when the energetic crops substitute for food crops, this impact becomes marginal. Note also that the economic fallout of the biofuel chains mainly pertains to cereal-oriented regions, which are doted with an important agro-industrial complex. Mixed farming regions are far less concerned by these gains.

7 The cost-benefit analysis of biofuels, a very controversial question

The estimation of the economic impacts of the biofuel program on the general economic activity (and particularly on job creations) is highly controversial. PriceWaterhouse-Coopers forecasts 3,800 jobs and 207M euros of added value stemming from today's biodiesel program (approximately 4Mhl). For the USA, Gallagher announces (for a supplementary production of 14Mhl of ethanol, in the Mid-West) 5,500 job creations in the industry and services (but rather few in agriculture) and a positive balance of $200M. On the contrary, a study of the "Direction de la Prevision" of the French Ministry of Finances (July 2000) points out the negative macroeconomic conclusions as long as the oil barrel remains below $60 and objects to the job creations balance, which only corresponds to sectorial measures. These important differences observed in the results arise from methodological discrepancies on the one hand and from taking into consideration or not the opportunity cost of public funds on the other hand.

The macroeconomic models that would enable a thorough analysis of the energy produced from biomass do not exist yet. As for us, we have strived to realize a simplified study of the macroeconomic effects deriving from the biodiesel program (27.5Mhl in 2010). The results conclude to 1,800 jobs created, of which 300 are maintained jobs in agriculture. All in all, these impacts are relatively modest, since a competition arises between food and energy uses. These results put together lead us to conclude (see table 6) that the situation is quite balanced.

To the strictly economic impacts above, we need to add the positive externalities arising from the CO_2 mitigation. However, this evaluation is quite virtual, since it hinges on a floating market price for CO_2 permits, and not on the real damages caused by greenhouse gases. The results based on life-cycle analysis are presented in table 7. The virtual valorization of CO_2 economies justify only part of the public subsidies granted to the biofuels chains. The result of the cost-benefit analysis depends tightly on the price of the oil barrel. A 10% decrease of the oil barrel would be enough to make the result of table 6 negative.

8 Conclusions

First-generation biofuels represent quite an inefficient energy production system. This observation had already been stated by the American National Commission on energetic Policy which preconized to abandon the corn ethanol program in favor of ethanol from lignocellulose. It is still too early to say whether these results can be extrapolated to the French case.

If the energetic uses compete with the traditional food uses (a very likely situation in the future), the microeconomic performance of biofuels will be negative, even if the oil price is at $65 per barrel. Stated otherwise, a public support is needed in order to obtain the economic equilibrium of these biofuel chains. However, the subsidies that are currently granted to the sector seem overvaluated.

The microeconomic performance of biofuels requires oil prices around $75 to $80 per barrel. The high levels observed in 2005, though inferior to the latter range, can favor investments of capacity: a subsequent decrease of the petrol price could result, which would automatically increase the microeconomic deficit of the biofuels. The International Energy Agency forecasts in the 2004 World Energy Outlook a price scenario of $35 (in constant $ of 2000). This average level, should it be maintained over a long period, would cause investments which would bring about a structural change of the world energy demand, and especially a 15% decrease of the global oil demand. This long-term, soft landing hypothesis for prices arises form the level of reserves, the technological progress in petrol extraction, the emergence of new non-conventional sources of petrol (asphaltic sands, heavy oil...) and from important possibilities of energy economies.

The microeconomic positive fallout for farmers will occur as long as the set-aside land is cropped for energetic purposes. These fallouts mainly concern the "Bassin Parisien", and far less the mixed farming regions.

Thus, the ambitious biofuel program concerns more the complex biofuel industries-oil firms, rather than the agricultural sector, unless an important effect is observed on the crop prices. This positive effect does not seem out of reach since the EU program is very ambitious, and so are the American or Brazilian ethanol programs (and also the Malaysian and Indonesian palm oil programs).

The macroeconomic evaluations shed a rather pessimistic light on biofuels. They are very positive for some authors (PriceWaterHouseCoopers, Gallagher), but only satisfying following our analysis. These economic balances are positive only to the extent that the oil price is maintained around $65 and that the positive environmental externality is taken into account. The CO_2 externality by itself is not enough to justify the public support given to biofuels. The production constrained to the set-aside land would have benefited from a far better economic balance.

As a conclusion, the energetic and economic results of the first generation of biofuels are not univocal. This form of renewable energy might not be considered as real alternative to oil reserves depletion. Thus, much is awaited from the second generation of biofuels, produced from lignocellulosic raw materials. They could limit the utilization of land, enhance the energetic yields and show lower production costs. First, some 5M tons of straw (1/4 of the total production)is available in France, while maintaining the soil fertility and the demand of breeders. This resource, representing 1.5Mtoe of primary energy would be enough to meet the 2010 EU objective in ethanol. Later on, specific crops (reed canary grass, miscanthus...) could be considered. A nation-wide research effort has just begun on this subject, along with EU-wide projects. In 10 years' time, the first biomass converting technologies should emerge.

References

[1] Shapouri, H.; Duffield, J.A.; Graboski, M.S. (1995). Estimating the net energy balance of corn ethanol, USDA, ERS, Agricultural Economic Report n 721, $http://www.ethanol-gec.org/corneth.htm$

[2] Gallagher, P. ; Otto, D. ; Dikeman, M. (2000). Effects of an oxygen requirement for fuel in Midwest ethanol markets and local economies. Review of agricultural economics, vol.22, n2, pp. 292-311.

[3] ADEME-DIREM (2002). Bilans energetiques et gaz a effets de serre des filieres de production de biocarburants en France. 19p., $http://www.ademe.fr/partenaires/Agrice/publciations/documents_francais/synthese-bilan-energetiques-fr.pdf$

[4] PricewaterhouseCoopers (2003). Evaluation des externalites et effets induits economiques, sociaux et environnementaux de la filiere biodiesel en France. Complete Report.

[5] International Energy Agency / OECD (2004). World energy outlook 2004 - Executive summary, 10p., *http://www.iea.org/textbase/npsum/WEO2004SUM.pdf*

[6] Rozakis S. ; Sourie J-C (2005). Micro-economic modelling of biofuel system in France to determine tax exemption policy under uncertainty. Energy Policy, vol.33, n2, pp.171-182.

Crop	Sugar-beet	Wheat	Rapeseed
Yield 2005 in t Evolution of yields in tons/year	79.4 0.98	8.1 0.12	3.3 0.02
Primary Biofuels	Ethanol	Ethanol	Vegetable Oil
Yield 2005 hl/ha density (a)	79 0.79	28 0.79	15 0.91
Secondary Biofuels	ETBE	ETBE	Ester
Yields hl/ha 2005 density (a)	180 0.75	64 0.75	15 0.88
Replaced fossil fuels	gasoline	gasoline	gasoil
Liter of fossil energy replaced per liter of biofuel *	0.83	0.83	0.92

*based on the ratio of Inferior Calorific Power

Table 1: Some technical data

Energetic yields function of the methodology used for co-products.

	Accounting Method *	Systemic Method **
Wheat ethanol	2.04	1,19 **
Sugar-beet ethanol	2.04	1,28 **
RME	2.99	2,5

* = ADEME DIREM 2002

** = Weel to Wheels report 2004, CONCAWE, EUCAR, JRC, European Union

(& modified by INRA)

Table 2: Energetic balances

		2004	2007	2010
Needs in Ethanol	Mio hl	2.68	5.95	9.27
Needs in RME	Mio hl	4.93	13.15	27.57
Needs in Hectares of wheat+sugarbeet	10^3 ha	60	145	225
Needs in Hectares of Rapeseed	10^3 ha	330	880	1800

Table 3: Estimation of the agricultural land required to attain 5.75% of biofuels in the total of fossil fuels

	Minimum tax-cut €/l oil price 65$/barrel	Actual TIPP taxcut €/l (2005)	Excess of tax-cut €/l
Wheat Ethanol used in ETBE	0.22	0.38	0.16
Sugar-beet Ethanol used in ETBE	0.20	0.38	0.18
Wheat Ethanol direct use	0.09	0.37	0.28
Sugar-beet Ethanol direct use	0.08	0.37	0.29
Rapeseed Methyl Ester	0.09	0.33	0.24

Table 4: Important tax cuts

	Price	Average Yields	Increase of agricultural income (energy crops on set-aside land)		Increase of agricultural income (energy crops competing with food crops)		Excessive tax cuts = gains of the transformation industries
units	€/t	t/ha	€/ha	€/l	€/ha	€/l	€/l
Wheat*	90	8.2	302	0.10	45	0.02	0.16
Sugar-beet*	20	79.5	606	0.08	149	0.02	0.18
Colza	200	3.3	199	0.14	45	0.03	0.24

* in ETBE

Table 5: Average impacts of energetic crops production on the agricultural income, in euros/ha and in euros/l of biofuels

Cost Benefit in euros/l, RME chain, 2010 situation, Oil Price 65$/b	
minimum tax-cut (loss in consumer's surplus)	-0.09
Variation of GDP, biofuel industries	0.05
Variation of agricultural surplus	0.04
sum	0.00

Table 6: Cost-benefit analysis

	Teq CO2 saved per /hl ADEME-DIREM	amount €/l	in % of minimum tax cut
Wheat ethanol in ETBE	0.22	0.02	9
Sugar-beet ethanol in ETBE	0.22	0.02	10
Wheat in direct ethanol	0.10	0.04	46
Sugar-beet in direct ethanol	0.10	0.04	57
RME	0.21	0.04	49

Table 7: CO_2 externality

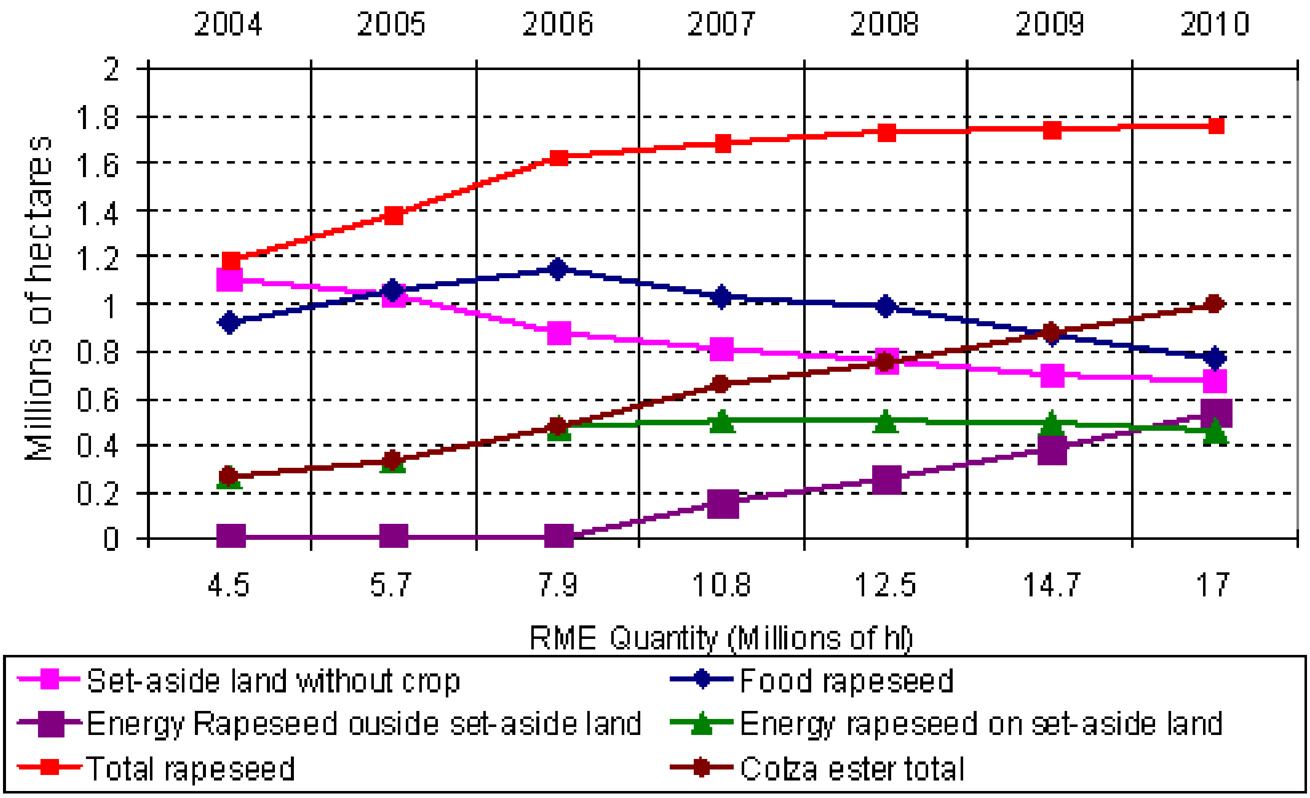

Figure 1: Competition between food and energetic rapeseed

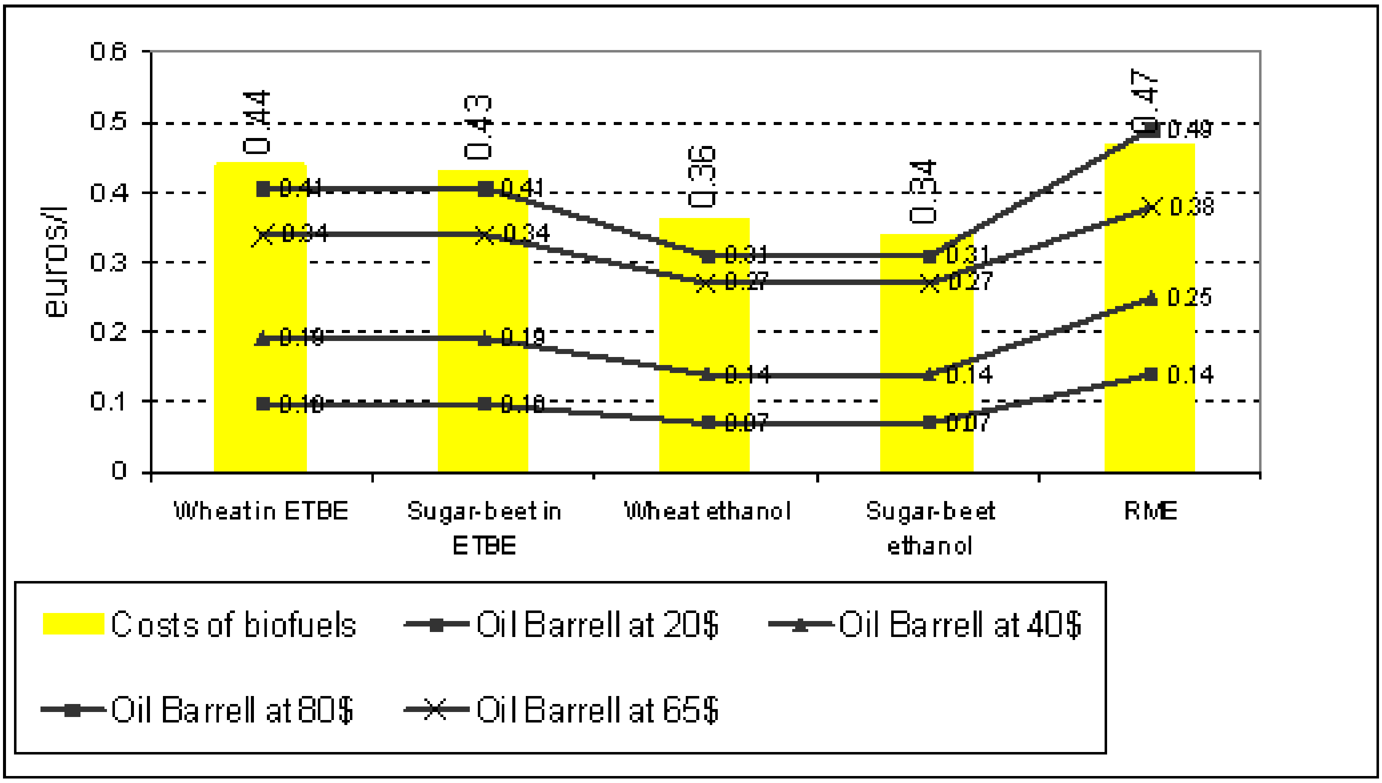

Figure 2: Costs and valorizations, function of the oil price