Impacts of the European bio-fuel policy on the farm sector : a general equilibrium assessment

Draft prepared for the conference: "Bio-Fuels, Food and Feed Tradeoffs" sponsored by Farm Foundation and USDA, April 12-13, 2007, St Louis, Missouri.

Summary:

The European indicative bio-fuel policy is presently highly disputed as an efficient mean to tackle the EU energy security and the climate change issues. On the other hand there is no doubt that, if fully enforced, it will support the EU farm sector as a provider of bio-fuel raw materials. The purpose of this paper is to offer a numerical evaluation of this potential benefit with a farm-detailed computable general equilibrium model. Our simulation results suggest that most of the bio-diesel demand will be satisfied by (marginally taxed) imports while the bio-ethanol mostly by domestic production (thanks to significant import tariffs). We also show that downstream livestock sectors are never negatively affected. Finally the positive farm income effect is rather robust to our modelling assumptions: our central estimate is a 3.2 billion farm income increase. However the transfer efficiency of this policy is invariably limited. As a consequence the EU bio-fuel policy can not be justified only on that ground.

1. Introduction

Like many other countries, European Union (EU) member states are currently contemplating stringent policy instruments in order to boost their productions and uses of bio-fuels to the detriment of the consumption of imported fossil oils. The recent significant rise in the real world price of oil contributes to legitimate this policy for net importer countries of oil but is certainly not the sole factor. Similar oil price peaks have already been observed in the past without such strong reactions by EU policy makers. The evolutions of oil production capacity and world oil price are so uncertain that postponing any strong political decision is an understandable attitude from an economic point of view. In fact the current EU bio-fuel policy is mostly motivated as a way to address the adverse environmental effect (Green House Gas emission) of fossil oil consumption. However the environmental efficiency of the bio-fuel solution is still highly disputed between technology scientists with opponents claiming that the bio-fuel production requires nearly as much non renewable energy as it allows to save in transport activities. On the other hand there is no disagreement that this policy will allow to support the farm sector by offering new outlets for farm products and thus stimulating farm prices and revenues. Most pessimists even argue that this is the only benefit of this policy but to already heavily supported people by the Common Agricultural Policy (CAP). The recent evaluation performed by the European Commission (EC, 2007) confirms this beneficial effect with nearly 200 000 farm-jobs creation which in turn will generate positive social induced effects in poor and remote rural areas.

In the complex debate on the relevance of the EU bio-fuel policy, the main purpose of this paper is to offer a new numerical evaluation of the effects of the EU bio-fuel policy on EU markets of agricultural and food products as well as on the farm revenues. The extent to which this policy will benefit EU farmers may be lower than a priori expected for the two following reasons. On a one hand this new demand of agricultural products may not be completely fulfilled by the EU production. Bio-fuel refineries may rely on imports from the world market, particularly in the case for bio-diesel production which is not as much protected (by tariffs) as bio-ethanol production.[1] Indeed the EC estimation assumes that nearly one third of EU consumption of bio-fuel will be imported. On a second hand the EU bio-fuel policy will very likely strengthen prices of arable crops and consequently downstream agricultural (livestock) sectors may suffer through an increase of their production costs. In the case of the US bio-fuel policy, Elobeid et al. (2006) indeed find such negative effects for the US livestock sectors due to a significant increase of corn prices. While the EC evaluation did not provide numerical

---

[1] In the same vein the EU farm sector may potentially benefit from bio-fuel policies implemented in other countries. We ignore this effect in this paper.

effects on the EU livestock sector, this cereal price effect is assumed to be compensated by larger price decrease of bio-fuel co-products (oil cakes from bio-diesel production, corn gluten feed (CGF), pulp, dried distillers grains with solubles (DDGS) from bio-ethanol production) on livestock production costs. More generally, induced effects on the livestock sectors (and ultimately on the whole farm sector) are numerous and pull in opposite directions. For instance, anticipated increase of arable crops production may intensify competition on land usages with a possible decrease of pasture land. On the other hand this effect may be counteract by the possibility to grow energy crops on set aside land. Moreover anticipated increase of arable crop profitability may lower opportunity costs of some shared, farm-specific, primary factors of production like machinery equipments or labour in mixed farming systems.

In order to capture all these conflicting effects, we use an original Computable General Equilibrium (CGE) model of the EU15 economy where the farm sector is finely represented (in terms of product coverage, behavioural specification and policy instrument modelling). This model is first used as a projection tool in order to determine the evolution of the EU farm sectors and markets without the bio-fuel policy. In a manner quite similar to the EC (2007) we then simulate the EU bio-fuel policy as an exogenous increase of (public-financed) demand of both bio-ethanol and bio-diesel. Relative to the EC evaluation, our main contributions are firstly to estimate rather than assume the share of imported bio-fuel, secondly to estimate induced effects on livestock sectors and thirdly to consistently estimate production and employment effects with an unique modelling framework (more in the modelling section).

As expected our central simulation results show significant positive effects on the arable crop sectors with significant price and production increases. Despite the possibility to grow energy crops on set-aside land the EU bio-fuel consumption will be partly satisfied by increased imported of vegetable oils from the world market. On the contrary the new demand of bio-ethanol will be fully produced domestically but will induce large drop in cereal exports to the world market. Our results also point to a logical increase of land rental rates and an equally rational decrease of the price of feed by-products. In the case of the compound feed industry this last effect is nevertheless dominated by the cereal price increase, so that the whole animal feed complex leads to a small increase of production costs in livestock sectors (as in the US case, see Elobeid et al., 2006).

Quite surprisingly, we observe that the domestic prices of livestock slightly decrease and productions marginally expand. It appears that three marginal effects push in the same direction and altogether reverse the already small negative feed cost effect on livestock productions and costs. Firstly following the huge increase of vegetable oil for bio-fuel production, their domestic prices increase leading to some substitution effects at the final demand level in favour of dairy products and animal fats. All other things being equal, the price increase of the latter has a positive effect on livestock production. Secondly the growth of arable crop production is obtained thanks to larger areas (notably on previously idle land) as well with larger yields per hectare. These yield increases are only feasible with larger uses of inputs, including organic fertilizers. The subsequent price increase of livestock manure has a positive effect on livestock production. Finally the model specification exhibit production complementarities between livestock and arable crop activities due to the imperfect mobility of labour and capital across sectors. This specification practically reflects the existence of mixed farm systems and the possibility, even in the long run, of cross subsidisation between farm activities (Gohin and Bureau, 2006). Accordingly the increased profitability of arable crop productions allows to cross subsidy the use labour and capital in livestock activities and then ultimately on livestock productions.

Finally our results show a positive effect on farm jobs. Our figures (42 000 farm job creation in our central case) are nevertheless much less optimist than EC estimates because the bio-fuel inflow is partly diluted in higher variable production costs, partly transmitted to world markets and finally partly capitalised in increased land values. Without surprise our estimated market impacts are sensitive to the modelling assumptions regarding the possibility to use set aside land for energy crops, the reaction of foreign producers/consumers on the world markets of bio-fuels as well as the responses of the agricultural production capacity in the EU (captured by our price elasticities of farm supply). On the other hand our figures on the benefits of this policy to the whole farm sector are rather robust thanks to compensating cross market effects (for instance higher ethanol imports are compensated by lower decline of cereal exports). On the methodological front our results logically underline the usefulness of modelling all linkages operating through commodities and primary factor markets.

2. Modelling framework

2.1. The Computable General Equilibrium approach

There are two major benefits of using a CGE modelling framework for the assessment of the EU bio-fuel policy on the farm sector over a standard partial equilibrium analysis.[2] First is the modelling of (farm) supply functions

---

[2] CGE models also have a theoretical advantage in the global welfare assessment of policy experiments. As Gohin and Moschini (2006) show, this theoretical property may be empirically weak if the representation of non food sectors is rather crude. They also demonstrate that farm sector effects are nevertheless quite robust to the specification of these non food sectors. The CGE model used in this paper has a nicely specified farm and food module; on the other hand the energy module must still be developed. Accordingly we don't focus on the global welfare effect in this paper but can safely conduct our farm sector analysis. In more practical words, we are not able to conduct a global efficiency analysis of the EU biofuel policy because the energy complex (the

with both the specification of globally regular functional form for production technologies and the imposition of accounting identities (namely the zero profit condition which imposes that farm receipts are equal to all farm expenditures including the rewards of primary factors of production). This modelling ensures that in the case of large price or quantity changes specified behavioural equations are still consistent with the underlying profit maximisation assumption. On the contrary the linear or double log specifications often adopted in partial equilibrium analysis may lead to inconsistencies in large shocks as they do not satisfy integrability properties. Second is the joint and consistent estimation of impacts on product and primary factor markets. On the contrary the EC evaluation for instance relies on two modelling frameworks which require hard job to reconcile. On a one hand a partial equilibrium model is used to simulate the impacts on agricultural markets and prices with some given macro economic assumptions (on the GDP, GDP price index, labour costs, …). On a second hand an input output model is used to simulate these macro economic effects, including employment effects, where agricultural prices are assumed to be fixed. The CGE model used in this paper includes both frameworks and thus is better appropriate to simultaneously assess production and employment effects.

On the other hand CGE models are usually criticized on the ground that they are too aggregated and thus unable to represent the internal complexity of sectors/policies. This argument does not apply to our CGE model already used for CAP reform analysis and with a product coverage very similar to the ones in agricultural partial equilibrium models.[3] More precisely our CGE model distinguishes 32 agricultural products, 31 farm processed products, 10 farm input goods and finally only 2 goods/services for the rest of the economy (see table 1). We built the underlying Social Accounting Matrix relying mostly on Eurostat databases and FEOGA/WTO notifications as far as the agricultural sectors are concerned and with the GTAP database otherwise.[4]

2.2. The supply module of EU farm products

The impacts of the EU bio-fuel policy on the whole farm sector first depend on its capacity to increase the domestic production. In our model the domestic supply of farm products is specified in an original way thanks to

---

substitution between the different energy sources at the production and consumption sides, the government intervention, …) is presently underrepresented. In the same vein, the EC evaluation study reveals that the employment/macro-economic effects are very sensitive to the assumed fossil oil price and may pass from positive to negative.

[3] The overall structure of this model is fully detailed in Gohin (2004) and the last version in Gohin and Bureau (2006).

[4] In particular we use the input-output SPEL database for 1995 (Weber, 1995). Unfortunately this database is not updated and accordingly our model is still calibrated using 1995 technical coefficients. At first sight, it would be preferable to use more updated input output tables like the last GTAP version for 2001. However the latter retains less farm and food products and moreover is built on the initial assumption that input output coefficients have not changed since 1995. Finally it must be stressed that the definition of the benchmark situation is much more crucial when simulating future policies than the calibrated point.

the detailed coverage of farm and food products. For instance the feed module, which is at the heart of the interaction between arable crop and livestock activities, captures the technological relationship between energy rich and protein rich ingredients. Rather than the standard Constant Elasticity of Substitution (CES) function we use a latent separability approach to represent the substitution patterns between these ingredients and calibrate the structural parameters using production elasticities from Mahé and Munk (1987). The allocation of primary factors of production also plays a significant role in this interaction between arable crop and livestock activities. As far as land is concerned, we adopt an imperfect mobility structure specified with a two level Constant Elasticity of Transformation (CET) function with a first level between pasture land and arable land and a second level between all different arable land uses. The set aside land usable for energy crop production is modelled as a fixed percentage (the set aside rate) of the aggregate arable land. We also assume an imperfect mobility of labour and capital across agricultural and non agricultural sectors. In order to represent the multi-product nature of agricultural firms and simultaneously avoid the allocation labour and capital (overhead expenses as well) to each farm enterprise, we specify a revenue function in the same vein as Peterson et al. (1994). This allocation is again governed through a latent separability approach where structural parameters are calibrated so as to get a desired supply elasticity matrix (Gohin, 2004). Finally the availability of domestic production to satisfy the bio-fuel demand will also depend on the possibility to eventually increase yields per hectare (if land supply is not sufficient). In CGE models these yields are endogenously determined and depend on the substitution patterns between land and other inputs, including chemicals and fertilizers (mineral and organic). A new latent separability structure determines these patterns.

2.3. The demand module of EU farm products

By increasing demand of agricultural products, the bio-fuel policy is likely to affect other demands, notably for food consumption. At the demand side, our model assumes that these farm productions are mostly processed domestically by food industries according to fixed proportions technologies (cereal exports are obviously a notable exception). For instance oil seeds are processed by the oil and fat industry into vegetable oils and meals with linear technological relationships. The food products are then traded or sold domestically to food retailers and then to consumers. At the final demand level, household preferences are specified with a new latent separability structure so as to reflect the characteristics of food consumption. For instance we assume high substitution between vegetable oils, intermediate substitution between them and other animal fats (butter) and finally limited substitution between all fats and other food products.

2.4. The trade module of EU farm products

The expected positive impacts of the EU bio-fuel policy on the whole farm sector also depend on the evolution of trade flows. In our model we start with the traditional (CES) Armington specification for differentiated products like poultry meat or cheeses. On the other hand most products are defined at a so detailed level that we assume that imports and exports are of the same quality (for instance, corn, sugar, oilmeals, …). The position of the EU as a net exporter or importer on the world market depends on the relative position of domestic supply and demand and for some products on the existence of trade regulations. As an example the EU simultaneously import and export sugar due to the complex import policies (with tariff rate quotas). The trade flows that will take place also depend on the “net” capacity of foreign producers to supply the European markets. In that respect we assume that the EU is a major player on world food markets and thus the net import supplies of farm/food products are positively sloped functions with respect to the corresponding world prices. In most single country CGE models the net import supply functions are (log linear) reduced forms that depend only on the price of the concerned product (for instance, de Melo and Tarr, 1992):

$$M_i = M_i^0 . \left(\frac{PW_i}{PW_i^0} \right)^{\varepsilon_i} \quad \forall i \tag{1}$$

where superscript 0 relates to the initial data point and other notations are usual ones. Such specification assumes a constant price elasticity which is the default assumption in non CGE models. However such specification does not allow the country to pass from net importer to net exporter. Moreover such specification imperfectly captures the substitution relationships at work in foreign countries between products (for instance between vegetable oils) while they are acknowledged in multi-country models.[5] Ideally one should develop a multi country model with detailed coverage of all products but such project is confronted with data availability. The solution adopted in this paper is to improve the specification of CGE type net import supply functions as follows in the case of vegetable oils. We assume the existence of one leading product (the soya oil) and world prices of other vegetable oils are linked to the world price of this product through the log linear relationships:

$$PW_{ioil} = PW_{ioil}^0 . \left(\frac{PW_{iloil}}{PW_{iloil}^0} \right)^{\pi_{ioil}} \quad \forall ioil \tag{2}$$

---

[5] Tthis is still imperfect even if one adds an exogenous price index in this function to reflect the homogeneity of trade functions with respect to prices.

where ioil is the index of vegetable oils excluding soya (rape, sunflower and palm oils) and iloil is the index of the leading vegetable oil (soya). In this equation π_{ioil} is the price transmission elasticity which carries all substitution relationships (at the production and consumption level) in foreign countries. If this elasticity equals one this implies that the world prices of all vegetable oils perfectly move together because there are perfectly substitute in some regions. We calibrate these elasticities to 1.5 based on the simulation results of Dronne and Gohin (2005) derived from a multi-country partial equilibrium model focused on the oilseed complex. These price equations are introduced in the model while the previous import supply specification (equation 1) is removed for these vegetable oils. We also modified the import supply function of the leading soya oil as follows:

$$M_{iloil} + \sum_{i=ioil} M_{ioil} = \left(M_{iloil}^{0} + \sum_{i=ioil} M_{ioil}^{0} \right) . \left(\frac{PW_{iloil}}{PW_{iloil}^{0}} \right)^{\varepsilon_{iloil}} \tag{3}$$

The world price of soya oil is determined by the net trade flows of all vegetable oils. Accordingly the elasticity parameter is reduced (from 10 to 5) because it intends to capture only expansion/contraction effects and no longer substitution effects between vegetable oils. This new specification of import supply functions allows the EU to eventually become net importer/exporter of some oils and simultaneously better capture the substitutions operating in foreign countries. We basically implement the same trade specification for the group of oil meals (with soya meal as the leading product and including the CGF). Finally we assume that there is perfect substitution abroad between sugar and bio-ethanol (the price transmission elasticity is equal to one in equation 2). However we implement a linear (rather than log linear) version of equation (3) because, following the sugar reform and the contemplated bio-ethanol demand, the EU may pass from a net exporter to a net import of the composite “sugar + bio-ethanol”. The linear version allows this switch.

3. The no bio-fuel benchmark

3.1. Main assumptions

The quantitative impacts of any policy critically depend on the situation that would prevail in its absence. In that respect the recent observed years are not very adequate benchmarks for the following reasons. Firstly the production/consumption/trade of bio-fuels have already started in some EU countries (significantly in Germany and Sweden). Secondly the EU bio-fuel directive fixes the target of a 5.75% market share for bio-fuels in the overall transport fuel supply for the 2010 year. Moreover the EC analysis of current market development concludes that this target is very unlikely without new measures at that horizon. Thirdly the last wave of CAP reforms (during 2003-2005) is likely to alter the equilibrium of agricultural markets and revenues.

Accordingly we define a benchmark situation aimed to project the EU economy to 2015 with the following main assumptions. At the supply side we assume that farm inputs productivities increase by 1.25% in the cereal sectors, by 1% in other arable crop sectors and 0,75% in livestock sectors. Primary factor productivities in other sectors, including food industries, also increase by 1% annually. At the consumption side we suppose that butter consumption decreases each year by 0,5%, compensated by an equally increase of vegetal oils. At the trade side we use the FAPRI projections of world prices made in 2005 (without new bio-fuel policies around the world) in order to calibrate the evolution of the parameters of the net import supply functions. Regarding macroeconomic conditions, we assume that the euro stabilizes at 1.2 against the US dollar. Labour and capital endowments increase by respectively 0,2% and 1% annually. On the other hand, farm land decreases by 0,25% per annum.

Last main assumptions concern the evolution of agricultural policy instruments. We obviously introduce the CAP reforms of 2003 and 2005 with the (partial) decoupling of direct payments, the reduction of intervention price of dairy products and sugar. We assume a fixed 10% mandatory set aside rate. Finally we assume that the new single farm payment has a limited production effect (due to wealth, dynamic and capital market imperfections effects) calibrated to a 7.5% market price support in case of arable crops.[6] Even if the EU does offer to lower import tariffs and stop export subsidies in the context of WTO negotiations, we don't introduce these changes in the baseline because this offer is conditional and moreover the other evaluations of the bio-fuel policy are also based on such assumption. On the other hand we assume that C sugar exports are no longer feasible following the WTO panel ruling on European sugar. Finally we assume in this benchmark that the EU demand for bio-fuel is null, as well for domestic production and trade.

3.2. Main characteristics of the benchmark

EU cereal markets are characterised by significant unsubsidized export of soft wheat to the world market (17.4 MT) while the corn market is protected from out-of-quota imports by an import tariff (table 2) Compared to recent statistics, yields per hectare moderately increase to reach 6.9T/ha for soft wheat (6.6T/ha over the 2001-2004 period) and to 9.3T/ha for corn (8.7T/ha) because the CAP reforms dampen the effects of exogenous technical changes. Soft wheat area stabilizes at 13.5 Mha, a level again very comparable to recent statistics. On

---

[6] The impacts of this new agricultural policy instrument are still uncertain. Our 7.5% figure is in the lower range of figures found in the literature (between "small" in Fabiosa et al. (2005), 6% in the OECD analysis and up to 30% in Bienfield et al., 2004)

the other hand our projection of sugar beet area is fairly lower due to the 2005 sugar reform and the WTO ruling on the C sugar production. Despite the significant cut in the intervention prices, the EU production does not collapse; in fact average EU production costs are projected at 376€/T. The domestic price remains higher than the world price and the domestic production is also higher than domestic consumption, so that the EU still uses some export subsidies for that sector.

As far as the vegetable oil complex is concerned, the rapeseed area is projected at 2.1 Mha which is a much lower level than recent campaigns. However when we take out rapeseed grown on set aside land for energy uses our projected figure makes sense. We project the EU to be a small net importer of rapeseed while a significant importer of sunflower seed and soya. The net trade situation is very similar for oil meals with the EU importing 18 MT of soya meal (table 3). On the other hand the EU is projected to be a net exporter of rape oil as well soya oil. But imports of palm oil outweigh the previous exports such that the EU is a net importer of all vegetable oils. Again the huge reduction of the butter intervention price has a negative effect on domestic production and positive effect on the domestic consumption (table 4). However these two effects are not sufficient to resolve EU butter market imbalance and the EU price is still higher than the world price. As a consequence butter export subsidies are still positive. On the same table one can observe that the EU is projected to be a net importer of beef (307 mT) with some out-of-quota imports. On the contrary our model suggests that the EU will be a significant net exporter of pork and finally a small net exporter of poultry meat.

4. The EU bio-fuel policy experiment

4.1. Assumptions

The 2003 EU bio-fuel directive sets out only indicative targets and leaves each Member states the initiative to implement appropriate policy instruments (tax exemptions on bio-fuels, tax surcharge on non-renewable fuels, bio-fuel obligations…). Through the CAP the EU also supports the bio-fuel sector when allowing growing bio-fuel crops on set aside land and furthermore by granting an area-constrained 45€/ha direct payment to energy crops grown on non set aside land. Because the 2003 directive target is not mandatory, it is presently far from evident that the EU bio-fuel consumption will reach it (without new policy rules). That depends on the policy support the EU member states will grant it which in turn depends on the overall efficiency of this policy. Our evaluation gives one piece of response to this vast question by assessing the impacts on the farm sector as well as the production costs of a given use of bio-fuels.

At the demand side our assumptions are mostly derived from the EC evaluation. In particular we assume that EU member states ensure a EU25 bio-fuel consumption of 18.4 Mtoe in 2015.[78] Based on the farm land availabilities we assume that 75% of this new demand (13.8 Mtoe) will be addressed to the EU15 farm sector. Then the share of bio-diesel is 55% (7.6Mtoe) and of bio-ethanol 45% (6.2 Mtoe). Adjusting for the energy content of bio-fuels we finally assume that the new demand of vegetable oil is equal to 8 MT and the new bio-ethanol demand equals 7.3 MT.

At the supply side we first assume that only first-generation bio-fuels will be competitive in 2015 by methodological convenience. The new demand for vegetable oils may be fulfilled by domestic/imported rape/soya/palm oil. The substitution possibilities between these different oils in bio-diesel production can not be derived from past evolutions. In this paper we assume that all bio-diesel demand will be satisfied by (domestic/imported) rape oil. This is a priori an extreme assumption which likely bias the result in favour of positive impacts on EU farm revenues. However this potential bias is much reduced by the fact that there are still some technological constraints in the use of soya/palm oil for bio-diesel production. Above all we assume significant substitution elasticities at the EU food consumption as well as at the foreign net supply functions between these vegetable oils so that their prices will not diverge that much. The arbitrage between domestic and imported vegetable oils is almost free (with only a 6% ad valorem tariff rate on imported bio-fuels/vegetable oils).[9]

In the same vein the new demand for ethanol may be satisfied by imported and/or through the processing of different raw materials. In this paper we assume that 1 MT of ethanol will always be made from domestic out-of-quota (previously C) sugar beet.[10] This assumption intends to reflect technological constraints for the processing of perishable sugar beets and the fact that European farmers were formerly internationally competitive in producing C sugar. The remaining 6.3 MT of ethanol are either imported either made from the processing of soft wheat depending on their domestic prices.

---

[7] This 18 Mtoe figure is a very crude estimate derived from an assumption of 320 Mtoe consumption of oil for transport multiplied by a 5.75% blending ratio.

[8] In our CGE model this shock is introduced as a new public demand which is financed partly externally, partly by lower public investment. In a variant we assume that this new public expenditure is entirely financed by new household taxes. Impacts on the farm markets and sectors are unaltered; more generally macroeconomic closures have very limited impacts on sectoral effects (see, for instance, Kilkenny and Robinson, 1990).

[9] Our model is not designed to determine where oilseeds will be crushed. Like Dronne and Gohin (2005) we safely assume that trade of oilseeds is unchanged and all trade adjustments operate on vegetable oils and oil meals.

[10] In our CGE model this shock is introduced as a public demand of 1.82 MT of out-of-quota sugar to account of the energy content of sugar and ethanol content. This production does generate pulp by-products used in animal feeding.

The domestic production of ethanol with soft wheat is a new activity introduced in our model. We calibrate the input-output coefficients of this new activity using medium run unit production costs computed by the OECD (2006).[11] We thus make the other heroic assumption of constant returns to scale ethanol processing technologies. In the initial stage of development, firms will likely experience increasing returns to scale. However we assume that the projected volume of production allows firms to exhaust them. Moreover this assumption is consistent with the assumption made on other food processing industries.[12] Finally the production costs will be evolved with the prices of soft wheat, wheat bran and DDGS by-products. The latter is assumed to have the same role as CGF in animal feeding.

Bio-ethanol can also be imported and will compete the domestic production if its domestic price, net of the specific tariff of the 243€/T, is lower or equal to the price of domestic bio-ethanol. The future world price of bio-ethanol is also highly uncertain. In recent years it fluctuates between 270$/T to 700$/T for several reasons. In particular it partly depends on the fossil oil price because there are some substitutions operating in foreign countries (Brazil for instance) between these two commodities. The evolution of the brasilian real also had some effects on trade flows and world prices. In medium term projections it is important to abstract from short term effects and concentrates on structural determinants. According to OECD production cost estimates Brazil is able to produce bio-ethanol from sugar cane at 276$/T. According to Elobeid et al. (2006), a 60$ per barrel crude oil price translates into a 462$/T bio-ethanol price which is roughly the level in last FAPRI projections (Fabiosa, 2006). In this paper we will use the latter as our starting point. We furthermore assume that the world price of bio-ethanol will evolve with EU imports, if any, by specifying a joint net import supply function with sugar (see modelling section). This specification implies that greater imports of bio-ethanol by the EU contribute to increase the world price of both sugar and bio-ethanol because there are some substitutability between these two productions in foreign countries (notably Brazil).

Our last assumption lies on the possibility to grow energy crops on set aside land. We assume that for agronomic reasons only half of mandatory set aside is available for arable crop cultivation. We also assume that the Blair House limit on oilseeds production cultivated on set aside has no market effects because farmers are allowed to

---

[11] In the short run the net unit production cost is 585€/T. Smeets et al. supporting study (2005) argue that with larger plants capital costs could be cut by half, leading to a 50€ reduction of unit production costs. We thus use the initial estimate of 535€/T.

[12] When comparing the recent evolution of vegetable oil/oilseeds/oil meals prices, Dronne and Gohin (2005) point out that the fat processing industries may capture part of the biofuel benefits by not transmitting food price increases to farm prices. With increasing returns to scale this “imperfectly competitive” behaviour can be economically motivated. Nevertheless we assume that in the medium run both the coexistence of farm cooperatives and private firms on a one hand, the increased volume of production on a second hand will deter from such behaviour.

grow cereals/sugar beet on set aside land. Finally we check ex post if the bio-fuel domestic production requires more than the "re-cultivated" set aside land and the energy area limit benefiting from the 45€/ha specific payment. If yes, then we assume that this energy crop payment is a pure transfer to farmers without any market effects. If not, we specify it as a input subsidy to soft wheat use in bio-ethanol production.

4.2. Results

a- on the bio-diesel sector

The new demand of rape oil for bio-diesel production (8MT) is considerable with respect to the initial domestic demand (2.5MT). Our model suggests that this new demand will be partly satisfied by larger domestic production (2.3 MT or 68.9%) and mostly by imports (Table 3). The EU becomes a net importer of rape oil of 4.4 MT compared to a initial net exporting position of 0.9 MT. Finally food use of rape oil decrease by 0.3MT because the domestic (and world) prices considerably increase (47.9%). Indeed the final world price amounts o 843$/T, a level never reached in the last decade. However this figure makes sense when compared to the even higher last FAPRI price projections (Fabiosa, 2006). The decrease of rape oil food consumption (11%) is significant but finally limited by the fact that the prices of other vegetable oils increase quite similarly. For instance we estimate that the world price of soya oil increase by 33.9%. As expected soya oil food consumption increases (by 8.4%) but total vegetable oil consumption decreases by 2.7%.

At the supply side, the increased production of rape oil induces a proportional increase of rape meal. These additional by-products are partly sold on the domestic market and mostly sold on the world market thanks to a significant price decrease (12.4%). In fact the EU becomes a net exporter of rape meal (by 1.9 MT). Due to substitutions operating in both the EU and foreign countries, the world prices of other meals also decrease (4.3% in case of soya meal). Our reduced-form specification of net import supply functions implies quite surprisingly that EU import of soya meal does marginally increase. The explanation is that substitutions between the different oil meals are larger in foreign countries than in the EU. Most importantly the net EU trade situation of all protein rich feed ingredients improves by 21.5% as expected.

These oil and meal price effects lead to a significant price increase of oilseeds, by as much as 42.6% for rapeseed so that the final price reaches 291€/T (table 2). It appears that production increases mainly through an expansion of areas (1.6 Mha) and very marginally by an increase of yields (0.4%) because three opposite effects interact. On the positive side the output price increase favours the intermediate consumption of variable inputs (like fertilizers and pesticides) and hence yields per hectare: applications of these variable inputs per hectare slightly increase (for instance by 8% for pesticides). On the negative side our model assumes that the additional land devoted to rape production is less productive due to the decreasing marginal productivities: in more technical words, this means that previously set aside lands were in average of lower quality for arable crop productions. Moreover the increase rapeseed production also requires more labour and capital allocated to this sector to the detriment of other farm (and non farm) sectors. According to our modelling assumptions this is only possible with higher returns to these factors because they are imperfectly mobile. Our simulation indeed suggests that the unit price of the labour/capital bundle for rape production (78.5%) increases more than the land unit price in that sector (24.8%) and consequently the labour/capital mix becomes a “limiting” factor for yield growths (table 6). More intuitively this means that more workers/farm managers and capital investment must be engaged in farm production and they must be paid significantly for that. More land is also required to satisfy the bio-fuel production but the possibility to cultivate set aside land softens the competition on this factor. Hence land is relatively less scarce and by consequence yields per ha tends to decrease on that ground (more on this point in the sensitivity analysis).

We finally underline that the EU sunflower sector also expands (the production by 28.6%) despite to the huge increase of the rape seed sector. In fact the production price of sunflower seed basically follows the rapeseed price because their oils/meals are good substitutes. This positive own price effect dominates the negative cross price of rapeseed.

b- on the bio-ethanol sectors

In our experiment we assume that 1MT of bio-ethanol will be made with EU sugar beet (or equivalently 1.8 Mt of out of quota sugar). In that respect the main contribution of our model is to compute the production costs of this volume. As said earlier, the unitary production cost of sugar equals 376€/T in the benchmark, hence a level slightly lower than the new intervention price. In order to secure their production quota, we assume that the sugar sector (both the sugar beet farmers and sugar processing firms) still cross subsidizes the out-of-quota production as in the past (Gohin and Bureau, 2006) and that the bio-ethanol demand allows them to sell this additional production. However the cross subsidy level is much lower than previously because it is assumed to be a linear function of the gap between the intervention price and the unit production cost. Moreover additional production of sugar beet and sugar implies higher production costs (again to the decreasing marginal productivity of land) as well as higher production of by-products (sugar beet pulp). Quite surprisingly we find a stability of the sugar beet pulp domestic price. This is an energy rich feed ingredient which is modelled as a net substitute to cereals and a net complement to protein rich ingredients. The price decrease of the latter (see above) and the price increase of the former (see later) both contribute to increase the domestic use of sugar beet pulp in feed rations and hence to stabilize its price. All these effects combine to a final out-of-quota sugar production cost of 334 €/T and an ethanol (made from sugar) production cost of 608€/T (table 4). This production cost is slightly lower than the net of tariff imported bio-ethanol.

The remaining demand for bio-ethanol is fully supplied by the domestic production. Production costs of bio-ethanol made from soft wheat (592€/T) is projected to be again lower than imported ones, despite considerable increases of the domestic price of soft wheat (11.3%). The demand of soft wheat for bio-ethanol production represents 21MT or equivalently 27.3% of initial total domestic demand. It appears that this demand "only" increases by 19.5% (15 MT) because there are simultaneously reductions of the feed (11.6% or 4MT) and food (4.6% or 2 MT) demands. Domestic production of soft wheat significantly increases (by 5.4% or 5 MT). However the market balance of soft wheat is mainly obtained by a huge reduction of soft exports to the world markets (by 58.2% or 10 MT). The shock on the soft wheat market is proportionally lower than the one on the rape market and accordingly price effects are lower. The processing of soft wheat to bio-ethanol induces an increase of wheat bran and DDGS productions. In our modelling framework we assume that the former is an energy rich feed ingredient while the latter has a composition very similar to CGF and hence a net substitute to other protein rich feed ingredients. Accordingly the price of wheat bran slightly increases as the sugar beet pulp (2.6%) while the price of CGF (DDGS) decreases by 14.8%. Finally imports of CGF become marginal.

The positive effect on the soft wheat market has obviously some impacts on other cereal markets. For instance the increase in the area devoted to soft wheat production is partly compensated by a decrease of corn area. On this market the main effect is a corresponding decrease of domestic production which is partly compensated by higher out of quota imports because the gap between the domestic and world prices rise.

c- On the downstream livestock sectors

As expected the experiment leads to an increase of cereal prices and a decrease of the price of some by-products. The final effect on the price of livestock feed rations depend on the initial shares of these feed ingredients as well as the possibility to change these compositions. Our model results show that the first effect dominates. For instance the production costs of compound feed slightly increases (by 0.7%). This feed cost effect is even reinforce in cattle sectors because the production costs of fodder (on both arable land and non arable land) also increase (due to the competition on land uses). Quite surprisingly our model suggests that all animal/meat productions will marginally expand (from 0.5% for pork to 0.9% for beef). Three marginal effects concur to this result. Firstly the domestic price of animal fats increases following those of vegetable oils. Consequently for a given animal price and prices of the other processing inputs, the meat industry may sell meats at a lower price and hence stimulate domestic consumption. Secondly we earlier explain that arable crop production requires more pesticides and fertilizers. The substitution possibilities between organic and mineral fertilizers are far from complete and hence there are additional demand for organic ones. For instance, we evaluate an increase of organic nitrogen domestic price by 7.2%. This effect also does support the livestock sectors and productions. Finally our labour/capital mobility modelling allows for cross-subsidization between farm activities. For instance we evaluate that the labour/capital unit price in the pig sector decreases by 6.7% (table 6). Intuitively this means that (mixed) farmers get less rewards for the pig production but nevertheless earn more on their farms thank to their arable crop activities (more on this point in the sensitivity analysis).

These additional productions of meats lead to marginal increases of domestic consumptions (at most 0.2% for pork). In fact they are mainly exported (for pork and poultry) or displace out-of-quota imports (for beef). Finally the impact of this experiment on the dairy sector are as expected very limited, in part because milk production is constrained by milk quotas. We observe a slight increase of butter consumption (1.9%) due to a substitution effect with vegetable oil consumption. This consumption increase mainly allows to reduce subsidized exports of butter.

d- <u>On the whole farm sector</u>

Our experiment leads to an increase of almost all farm productions. This increase of overall farm production is feasible because yields per hectare slightly increase and above all because energy crops are allowed on previously set aside land. We estimate that 2.8 Mha return to farm production and that overall 5.5 Mha are dedicated to bio-fuel production.[13] This is much larger than the maximum area eligible to the energy crop direct payments.

As expected the bio-fuel policy allows to support farm incomes. The agricultural value added increases by 3.2% or 3.2 billions €. This supplement income transmits in higher land values (19.2% or 0.8 billions € because land unit price increase as well the volume of productive land), higher production quota rents (43% or 0.2 billions €), higher capital rewards (3,3% or 0.7 billion €) and finally higher farm labour remuneration (2.5% or 1.5 billions €). This is this latter increase of labour remuneration that explains the increase of farm employment. In this

---

[13] This is based on the assumption that EU farmers will fulfill food consumption of rape oil. On the other hand, if we assume that all domestic rape oil production is sold for bio-fuel production and that the food consumption is imported, then total area for energy uses reaches 6.9 Mha.

central experiment, farm job creation amounts to 42 000 units (or 1.3% of initial level). This figure is significantly lower than the EC estimate of nearly 200 000 job creation. Our tentative explanation is the following. In our modelling framework, we assume that the EU governments inject 10.5 billions € in purchasing bio-fuel.[14] The benefit to the EU farm sector (in terms of value added) is "only" 3.2 billions € which is quite low compared to a decoupled program. Around 4.8 billions € are bypassed to foreign agents (with lower cereal exports and higher vegetable imports) and 2.5 billions € cover processing costs (of soft wheat to bio ethanol). Accordingly "only" 30% of the public inflow does really support farm incomes and only half of this farm labour. On the other hand, nearly 45% of the public inflow goes externally. By comparison, the EC evaluation study assume that 27% of bio-fuel demand will be imported. Here lies probably the main source of difference.[15]

4.3. Sensitivity analysis

As usual all previous figures depend on our modelling assumptions. In this paragraph we test their robustness to three critical assumptions. The first is on the land available in the EU for energy crop productions. The second is the capacity of the EU farm sector to attract labour and capital from the non agricultural sectors and hence to respond to the surge on domestic demand. The last sensitivity test is about the fossil oil world price and related world bio-ethanol price.

a- to the set aside rate

In our central experiment we assume that for agronomic reason energy crop production is possible on only half of set aside land. In this alternative we assume that it is possible to cultivate all set aside land. Results are given in the third lines of tables 3 to 7. In a nutshell main results are basically equal to our central estimates. The additional cultivated areas are much less productive than previous ones, such that average yields decrease. Elobeid et al. (2006) also get limited effects of the addition of Conservation Reserve Program (CRP) area.

b- to the mobility of labour and capital to farm sectors

In our central results it appears that agricultural productions are partially constrained by the availability to attract labour and capital. Let's now assume a very long term horizon where these two primary factors of production are perfectly mobile between all activities. This is a very extreme assumption usually not adopted in other CGE simulations. However it is interesting to give an upper bound to the farm impacts. Before analysing these results,

---

[14] Again we emphasize that we do not evaluate the welfare efficiency of the bio-fuel policy.

[15] The EC evaluation study assumes that bio-fuel consumption will amount to 23.1 Mtoe but 20% will be made from second-generation bio-fuels. So our experiments are very comparable in the definition of the shock.

this modelling alternative implies that the domestic supply of farm products is more sensitive to price shocks and the main limiting factor is then land. Results are given in the fourth lines of tables 3 to 7.

As expected, the supply response by EU farmers are now much larger. For instance the domestic rape oil production increases by 175% (69% in our central estimate) and the EU is a net importer of “only” 1 MT (4.4T in our central estimate). The evolutions on the soft wheat market are less significant: production increases by 9.1% (rather 5.4%) and exports decrease by 46.2% (rather 58.2%). On the contrary some sectors evolve less favourably (sunflower seed) due to increased competition in both food demand and land uses. Interestingly the impacts on livestock sectors are stable with similar production increases. In fact all indirect effects on these sectors that we previously identify simultaneously change and the net effect is null. For instance the price of feed-stocks increase less or decrease more. On the other hand the unit cost of labour and capital used in these sectors no longer declines.

Are farm incomes better supported in this alternative? The response is unambiguously yes but by a rather limited amount. In this alternative the leakages of the bio-fuel benefit to the world markets are clearly lesser. But the increased EU farm production requires more inputs (for instance the expenditures on chemical inputs increase by 0.8 billion € compared to the central estimates) and above the support is much more capitalised in land values. Finally we find that farm job creation amounts now to 55000 (compared to 42000 in the central case).

c- to the fossil oil and bio-ethanol world prices

Our central estimates are based on the assumption that the world price of bio-ethanol is equal to 462$/T when the world price of oil is equal to 60$ per barrel. All economic studies recognize that there are great uncertainties about the evolution of these two prices, even at the 2015 year horizon. In the EC evaluation study the oil price is assumed to vary between 48$ and 70$ per barrel. In this sensitivity analysis we assume this oil price to stabilize at 45$ per barrel and by consequence that the world price of bio-ethanol (without any EU imports) is 346$/T. We finally assume that EU governments will fully arbitrate between all types of bio-ethanol due to increased competition represented by potential imports.

As expected this alternative assumption has a major impact on the bio-ethanol sectors: domestic production made from sugar beet disappears, the one from soft wheat amounts to only 4.3 MT and now imports totalize 3MT (hence 40% of domestic demand). The specific tariff of 243 €/T on bio-ethanol obviously prevents more massive imports. As a result the domestic production of soft wheat expands less than in the central case. In the same time soft wheat exports decrease by a smaller amount while there are no additional imports of corn.

Basically the additional EU imports in terms of bio-ethanol are partly compensated by higher net trade positions in cereals and by a much lesser extent in vegetable oils. Impacts on the livestock sectors are very similar to the central estimates. Finally the effective agricultural support of the EU bio-fuel policy is logically more limited with 35 000 farm job creation.

Concluding comments

The European indicative bio-fuel policy is presently highly disputed as an efficient mean to tackle both the EU energy security and the climate change issues. On the other hand there is no doubt that, if fully enforced, it will support the EU farm sector as a provider of bio-fuel raw materials. The purpose of this paper is to offer a numerical evaluation of this potential benefit with a farm-detailed computable general equilibrium model. Two side effects may indeed lower the expected positive direct effect on the EU arable crop sector. Firstly this new (policy supported) demand may be satisfied by imports. Secondly downstream (livestock) sectors may suffer from an increase of their production costs. In our standard case the simulation results suggest that most of the bio-diesel demand will be satisfied by (marginally taxed) imports while the bio-ethanol mostly by domestic production (thanks to significant import taxes). This share between imported/domestic bio-fuel is logically quite sensitive to the assumptions on world prices and on the EU farm supply responses. On the other hand all simulations reveal that downstream livestock sectors are not negatively affected. Finally the positive farm income effect is also robust to these assumptions due to compensating cross market effects. The transfer efficiency of this policy is nevertheless invariably limited; as a consequence the EU bio-fuel policy can not be justified only on that ground.

There are obviously several extensions to this paper that one may contemplate to better address this vast bio-fuel issue. For instance, with the same model, it will be interesting to investigate trade policy shocks on the new bio-fuel markets compared to “old” agricultural markets. In terms of model improvements we believe that the priorities are firstly to develop an energy module in order to allow more insights on the global welfare effects and secondly to enlarge the model in both country coverage (extension to enlargement to new EU member states and main players on the world markets and product coverage (introduction of second-generation bio-fuel products).

References :

Bienfield J., Donnellan T., Hanrahan K., Hart C., Westhoff P. (2004). CAP reform and the WTO: Potential Impacts on EU agriculture. FAPRI-UMC Report 08-04.

De Melo J., Tarr D. (1992). A General Equilibrium Analysis of US Foreign Trade Policy. The MIT Press, Cambridge.

Dronne Y., Gohin A. (2005). Le développement des utilisations non alimentaires de l'huile de colza dans l'UE : quels impacts sur les marchés et prix mondiaux ? *OCL*, 12(5), pp. 344-357.

Fabiosa J.F., Beghin J.C., Dong F., Elobeid A., Fuller F.H., Matthey H., Tokgoz S., Wailes E. (2005). The Impact of the European Enlargement and Common Agricultural Policy Reforms on Agricultural Markets: Much Ado about Nothing? CARD Working Paper 05-WP382, www.card.iastate.edu

Fabiosa J. (2006). World sugar and ethanol markets. FAPRI 2006-2016 Preliminary Outlook. Power point presented at the Pluriagri Conference, Paris, November.

EC (2007). Bio fuels Progress Report. Commission staff working document accompanying the COM (2006) 845 final

Elobeid A., Tokgoz S., Hayes D., Babcock B., Hart C. (2006). The Long-Run Impact of Corn-Based Ethanol on the Grain, Oilseed, and Livestock Sectors: A Preliminary Assessment. CARD Briefing paper 06-BP 49.

Gohin A. (2004). Etude prospective d'évolution à moyen terme des organisations communes de marché de la viande bovine, du lait, du sucre et des grandes cultures sur la base d'une modélisation en équilibre général de l'agriculture européenne, 233 p. Available at www.agriculture.gouv.fr/spip/ressources_r3.html

Gohin A., Moschini G. (2006) Evaluating the Market and Welfare Impacts of Agricultural Policy in Developed Countries. Comparison of Partial and General Equilibrium Measures. *Review of Agricultural Economics*, 28(2), 195-211.

Gohin A., Bureau J.C. (2006). Modelling the EU sugar supply to assess sectoral policy reforms. *European Review of Agricultural Economics*, 33, 223-247.

Kilkenny M., Robinson S. (1990). Computable General Equilibrium Analysis of Agricultural Liberalization: Factor mobility and Macro Closure. Journal of Policy Modeling, 12(3), 527-556.

Mahe L.P., Munk K. (1987). Impact of Changes in Agricultural Policy Measures based on Results of an Agro-Feed Model. Background paper for EC Commission Study: Disharmonies in EC and US agricultural policy measures.

OECD (2006). Incidences de la croissance de la production des biocarburants sur les marches agricoles. AGR/CA/APM(2005)24/FINAL

OECD (2004). Analysis of the 2003 CAP Reform. http://www.oecd.org/dataoecd/62/42/32039793.pdf

Peterson E., Hertel T. and Preckel P. (1994). A General Equilibrium Framework for the Food Marketing System. *European Review of Agricultural Economics*, 21, 37-57.

Smeets E., Junginger M., Faaij A. (2005). Alternative developments in biofuel production across the world. Consultant report to the OECD secretariat.

Weber G. (1995). SPEL System: Methodological Documentation (Rev 1), Vol 2: MFSS. Theme 5, Series E, Luxembourg: Eurostat.

Table 1 : Product and sector coverages

Sectors		Commodities
AGRICULTURE		
Sector	*Agricultural sub-sectors*	
Agriculture	Soft wheat	Soft wheat
	Barley	Barley
	Maize	Maize
	Rape	Rape
	Sunflower	Sunflower
	Soya	Soybean
	Protein crops	Protein crops
	Sugar beet	A&B Sugar beet, C sugar beet
	Fodder	Fodder on arable land
	Grass	Grass
	Poultry	Poultry, Organic nitrogen, Organic phosphate, Organic potassium
	Pigs	Pigs, Organic nitrogen, Organic phosphate, Organic potassium
	Laying hen	Eggs, Poultry, Organic nitrogen, Organic phosphate, Organic potassium
	Dairy cows	Bovine cattle, Raw milk, Calves, Dairy cows, Organic nitrogen, Organic phosphate, Organic potassium
	Suckling cows	Bovine cattle, Calves, Suckling cows, Organic nitrogen, Organic phosphate, Organic potassium
	Beef calf	Beef calf, Organic nitrogen, Organic phosphate, Organic potassium
	Calf rearing	Bovine cattle, Heifers, Bulls and Steers, Organic nitrogen, Organic phosphate, Organic potassium
	Heifers	Bovine cattle, Dairy cows, Suckling cows, Organic nitrogen, Organic phosphate, Organic potassium
	Bulls and Steers	Bovine cattle, Organic nitrogen, Organic phosphate, Organic potassium
	Sheep and goats	Sheep and goat milk, sheep and goat animals
	Fruits vegetables	Fruits, potatoes and vegetables
	Other agricultural activities	Other agricultural products
FOOD PROCESSING		
Meat industry		Bovine meat, Pig meat, Poultry meat, Veal, sheep and goat meats, Carcass meals, Animal fats
Dairy industry		Butter, Skimmed milk powder, Cheese frow cow, cheeses from sheep and goat, Whole milk powder, fluid milk, Other dairy products
Compound feed industry		Compound feed
Cereal processing industry		Grains bran, Corn gluten feed, iso-glucose, Other cereal processed products, bio-ethanol
Oilseed crushing industry		Rape oil, Sunflower oil, Soybean oil, Rape cake, Sunflower cake, Soybean cake, palm oil
Sugar industry		A&B Sugar, C sugar, Sugar beet pulp, Molasses
AGRICULTURAL STATIONERIES		
Mono product sectors supplying:		Mineral nitrogen, Mineral phosphate, Mineral potassium, pesticides, veterinary products, fish meals, other energy rich feed, other protein rich feed, other feed ingredients, seeds
OTHER SECTORS		
Food retail trade		Food retail trade services
Other sectors		Other products and services

Table 2 : Impacts of the EU bio-fuel policy on the arable crop markets

	Soft wheat	Corn	Rapeseed	Sunflower	Sugar beet/ Sugar
Area (Millions ha)	13569 4.5% 10.5% -0.4% 3.1%	3934 -2.9% 2.0% -9.5% -1.4%	2131 76.2% 84.7% 166.0% 80.5%	1534 29.2% 38.1% -1.6% 32.6%	1554 13.4% 15.9% 7.3% 0%
Yields per ha (T/ha)	6.9 0.9% -3.9% 9.5% -0.1%	9.3 0.4% -4.3% 8.4% -0.4%	3.4 0.4% -5.1% 10.4% -0.8%	1.5 -0.4% -4.5% 7.5% -1.2%	59.8 -0.4% -2.5% 5.4% 0%
Production (Millions T)	93545 5.4% 6.3% 9.1% 3.1%	36640 -2.5% -2.3% -2.0% -1.8%	7207 76.6% 79.6% 194.2% 79.8%	2324 28.6% 31.9% 5.8% 31.0%	13877 13.0% 13.0% 13.0% 0.0%
Total demand (Millions T)	76833 19.5% 19.7% 21.2% 12.9%	38941 -2.0% -2.1% -1.7% -1.7%	8400 68.9% 71.6% 174.2% 71.7%	4854 13.2% 14.6% 2.8% 14.2%	13095 14.0% 14.0% 14.0% 0.2%
Net exports (Millions T)	17413 -58.2% -54.6% -46.2% -41.3%	-2500 5.0% 0.6% 1.7% 0.0%	-469 0% 0% 0% 0%	-2115 0% 0% 0% 0%	430 -7.4% -7.4% -7.4% -6.4%
Domestic prices (€/T)	107 11.3% 10.6% 9.0% 8.0%	132 6.4% 6.0% 6.1% 5.2%	204 42.6% 41.7% 19.2% 42.6%	219 34.2% 33.5% 14.4% 34.4%	404 0.0% 0.0% 0.0% 0.0%
World prices ($/T)	128 11.3% 10.6% 9.0% 8.0%	96 0.6% 0.1% 0.2% 0.0%	245 42.6% 41.7% 19.2% 42.6%	263 34.2% 33.5% 14.4% 34.4%	281 0.1% 0.1% 0.1% 11.8%

The first lines are the benchmark levels. The second lines give the impacts of the EU bio-fuel policy with our standard modelling specification. The last three lines report the results of the sensitivity analysis to 1) set aside obligation, 2) to the degree of mobility of labour and capital and 3) to the assumption on oil and bio-ethanol world market prices.

Table 3 : Impacts of the EU bio-fuel policy on the vegetable oil product markets

	Rape oil	Rape meal	Soya oil	Soya meal	Palm oil
Production	3357	3955	2180	9647	-
	68.9%	68.8%	-0.1%	-0.1%	
	71.7%	71.5%	-0.1%	-0.1%	
	174.4%	174.0%	-1.9%	-1.9%	
	71.5%	71.5%	-0.1%	-0.1%	
Total demand	2485	4478	2021	26671	3631
	310%	23.4%	8.4%	3.4%	-6.2%
	310%	23.6%	8.2%	3.1%	-6.2%
	314%	31.4%	5.1%	3.9%	-3.7%
	310%	17.9%	8.2%	2.7%	-6.2%
Net exports	905	-62	125	-18001	-3631
	-584%	-3062%	-117.5%	5.3%	-6.2%
	-574%	-3238%	-113.1%	4.8%	-6.2%
	-204%	-9999%	-100%	7.0%	-3.7%
	-573%	-3710%	-112.5%	4.2%	-6.2%
Domestic prices	483	110	462	175	464
	47.9%	-12.4%	33.9%	-4.3%	38.9%
	47.1%	-12.8%	33.4%	-4.5%	38.2%
	23.2%	-16.7%	16.2%	-5.8%	18.8%
	47.1%	-9.5%	33.4%	-3.2%	38.4%
World prices	570	129	546	207	548
	47.9%	-12.4%	33.9%	-4.3%	38.9%
	47.1%	-12.8%	33.4%	-4.5%	38.2%
	23.2%	-16.7%	16.2%	-5.8%	18.8%
	47.1%	-8.2%	33.4%	-3.2%	38.4%

The first lines are the benchmark levels. The second lines give the impacts of the EU bio-fuel policy with our standard modelling specification. The last three lines report the results of the sensitivity analysis to 1) set aside obligation, 2) to the degree of mobility of labour and capital and 3) to the assumption on oil and bio-ethanol world market prices.

Table 4. Impacts of the EU bio-fuel policy on the ethanol markets

	Quantity (mT)	Domestic Price (€/T)
Ethanol from domestic wheat	-	-
	6300	592
	6300	590
	6300	590
	4270	575
Ethanol from domestic sugar beet	-	-
	1000	608
	1000	605
	1000	581
	0	-
Imported ethanol	-	-
	0	628
	0	628
	0	628
	3030	575
Domestic demand	-	-
	7300	594
	7300	592
	7300	589
	7300	575

The first lines are the benchmark levels. The second lines give the impacts of the EU bio-fuel policy with our standard modelling specification. The last three lines report the results of the sensitivity analysis to 1) set aside obligation, 2) to the degree of mobility of labour and capital and 3) to the assumption on oil and bio-ethanol world market prices.

Table 5: Impacts of the EU bio-fuel policy on the animal products markets

	Pork	Poultry meat	Beef	Butter	Compound feed
Production (Millions T)	19150	8888	6507	1846	121032
	0.5%	0.6%	0.9%	0.0%	0.8%
	0.6%	0.7%	1.1%	0.0%	0.8%
	0.2%	0.1%	1.0%	-0.1%	1.5%
	0.5%	0.5%	0.8%	0.0%	0.7%
Total demand (Millions T)	18273	8728	6821	1505	121032
	0.2%	0.0%	0.1%	1.9%	0.8%
	0.2%	0.0%	0.1%	1.8%	0.8%
	0.1%	0.0%	0.2%	0.9%	1.5%
	0.2%	0.0%	0.1%	1.9%	0.7%
Net exports (Millions T)	841	128	-307	342	-
	6.9%	6.8%	-12.5%	-6.6%	
	7.9%	7.9%	-15.1%	-6.4%	
	3.4%	1.3%	-11.9%	-3.5%	
	6.4%	6.0%	-11.2%	-6.4%	
Domestic prices (€/T)	2648	2823	3811	2462	257
	-1.2%	-1.2%	-0.4%	0.0%	0.7%
	-1.4%	-1.4%	-0.5%	0.0%	0.6%
	-0.6%	-0.2%	-0.4%	0.0%	0.2%
	-1.2%	-1.1%	-0.4%	0.0%	0.6%
World prices ($/T)	3177	3864	1927	1701	-
	-1.2%	-0.7%	-0.9%	2.7%	
	-1.4%	-0.8%	-1.1%	2.6%	
	-0.6%	-0.2%	-0.4%	1.4%	
	-1.2%	-0.6%	-0.8%	2.6%	

The first lines are the benchmark levels. The second lines give the impacts of the EU bio-fuel policy with our standard modelling specification. The last three lines report the results of the sensitivity analysis to 1) set aside obligation, 2) to the degree of mobility of labour and capital and 3) to the assumption on oil and bio-ethanol world market prices.

Table 6: Impacts of the EU bio-fuel policy on the agricultural primary factors markets

	Wheat sector	Rapeseed sector	Pig sector	Milk cows sector	All farm sectors
Labour/capital unit price (index)	1 14.6% 16.3% 0.0% 10.7%	1 78.5% 82.2% 0.0% 80.2%	1 -6.7% -7.7% 0.0% -5.5%	1 -0.6% -0.7% 0.0% -0.3%	1 1.2% 1.4% 0.0% 1.0%
Labour/capital use (Millions € equivalent)	6359 4.9% 5.6% 9.6% 2.7%	784 60.2% 62.8 185.0% 63.5%	5609 0.5% 0.6% 0.2% 0.5%	17507 0% 0% 0% 0%	107251 1.1% 1.3% 1.7% 0.9%
Land unit price (€/ha)					42 19.2% 4.5% 81.3% 13.8%
Value added (Millions €)					85644 3.8% 3.6% 5.3% 3.0%
Labour (000 persons)					3179 1.3% 1.5% 1.7% 1.1%

The first lines are the benchmark levels. The second lines give the impacts of the EU bio-fuel policy with our standard modelling specification. The last three lines report the results of the sensitivity analysis to 1) set aside obligation, 2) to the degree of mobility of labour and capital and 3) to the assumption on oil and bio-ethanol world market prices.