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Abstract

We analyze two puzzling results released by the California Air Resource Board who recently revises its land use changes and greenhouse gas emissions induced by biofuels. First the absolute reduction in the US average soya biodiesel estimate is much greater than the reduction in the US average corn ethanol one. Second the EU canola biodiesel estimate is twice the US canola biodiesel one. We find that these two puzzling results are mostly explained by some weak initial economic data. In both cases, the underestimation of the oilmeal production values biases upwards the carbon emission estimates. We then recall that any economic analysis is only worth the quality of the supporting data. The current focus on unobserved elasticity values to assess biofuel impacts is not sufficient.

Keywords: biofuels, land use changes, models, data

JEL classifications: Q11, Q57, C68

Une analyse des nouvelles estimations d'impacts environnementaux des biocarburants

Résumé

Nous analysons deux résultats surprenants publiés par l'Agence Californienne d'Environnement qui a révisé ses estimations d'impacts environnementaux des biocarburants. D'une part, la réduction absolue des impacts du biodiesel issu du soja est nettement plus grande que la réduction absolue des impacts de l'éthanol issu du blé. D'autre part, les impacts du biodiesel européen à partir de colza sont le double des impacts du biodiesel américain à partir de la même graine. Nous trouvons que ces deux résultats surprenants s'expliquent majoritairement par les données initiales utilisées. Dans les deux cas, la sous-estimation des valeurs de production de tourteau biaise les résultats à la hausse. Nous rappelons en conclusion que la pertinence d'une analyse économique appliquée dépend de la qualité des données économiques utilisées. L'accent porté ces dernières années aux valeurs des élasticités prix n'est pas suffisante.

Mots-clés : biocarburants, changement d'affectation des sols, modèles économiques, données

Classifications JEL : Q11, Q57, C68

Understanding the revised land use changes and greenhouse gas emissions induced by biofuels

1. Introduction

The Land Use Changes (LUC) and net GreenHouse Gas (GHG) emissions induced by the production of biofuels has been one of the most hotly debate over the past years. Biofuel productions have been promoted through many policy instruments in many regions, including the United States (US), Brazil or the European Union (EU), with the prospects of substituting oil imports, supporting farm incomes and mitigating climate change. However their efficiency with respect to this environmental objective is highly contested. The most controversial debate centers on the land use impacts and associated release of carbon into the atmosphere. These effects are not directly observed and are usually computed by using a combination of economic and environmental models. The results of these models depend on unobserved (and thus disputed) parameters, such as price elasticities in the former models and the Emission Factors (EF) for different land types/uses in the latter models.

This debate really starts with the publication of Searchinger *et al.* (2008) who report that the US corn ethanol program would increase rather than decrease carbon emissions. This results from major LUC from pasture and forest to arable crops. A very large economic and environmental literature then emerged trying to offer refined measures of these LUC effects for different biofuel pathways in different countries/regions and horizons. Several models have been developed and/or mobilized to compute these effects leading to contrasting results. Recent LUC assessments computed with economic models include Kavallari *et al.* (2014) with the MAGNET model, Wise *et al.* (2014) with the GCAM model, Escobar *et al.* (2014) using the GTAP-BIO model to name few recent ones. Many synthesis and policy implications have been derived (Malins *et al.*, 2014; Prins *et al.*, 2014; Tokgoz and Laborde, 2014; Panichelli and Gnansounou, 2015, again to name few recent references). They all agree that several modeling specifications contribute to the differences of results and that many parameter uncertainties remain. In particular, it is widely accepted that the disputed assumptions on crop yield responses have critical impacts on these results (for instance, Babcock and Iqbal, 2014; Gohin, 2014; Plevin *et al.*, 2015).

This abundance of results obtained with different modeling approaches is a priori useful to ensure their robustness and avoid serious omissions. However, when these results do not converge at all, it possibly adds confusion to stakeholders and policy makers who need to decide their investments or political supports. In that context, our contribution in this paper is to help understanding recent revised results reported by the California Air Resource Board (CARB, 2014a,b,c,d).

Four arguments justify our comparative analysis of the CARB results. First the CARB releases their first results in 2009 using a first version of the GTAP-BIO economic model and so-called "*Woods Hole*" EF. Then they update this economic model in several respects while maintaining its global structure. They also develop a new environmental model (the AEZ-EF model), in particular to take into account that both the biomass and soil carbon stocks vary significantly across Agro-Ecological Zones (AEZ). These updates are intended to take into account the major issues identified in the literature (such as the magnitude of the crop yield price elasticity or the carbon stock in peatland). Accordingly our focus on CARB results makes the comparative analysis more relevant and easier than a comparison of results released by models with different structures (and often mobilized once). Second, the former and latter CARB results have been extensively analyzed and reviewed by stakeholders, policy makers and academics. This extensive reviewing process was supported by the California administration because these results are directly included in the California regulations (and other US states as well, see CARB 2014d, annex I). The reviewing of academic reports and papers is generally much shorter and less expensive and thus possibly less detailed. While one may always argue that the CARB process does not provide full insurance about the quality of the reviewing process, we believe that these old and new CARB results deserve due consideration. Third the data, model equations and parameters underlying the different CARB results are fully documented and publicly available (at a small cost). Accordingly it is possible to get into the details and identify the crucial changes in the long list of changes (new disaggregation of products and activities, new economic data, specifications, parameters). In fact several changes were simultaneously introduced making the direct comparative analysis quite difficult. For instance, the new results show lower net GHG emissions and LUC while the reduced crop yield elasticities should lead to opposite results. Full access to all information allows us to explore the impacts of some of these changes. Last and not least, the revised CARB results are significantly different from the initial ones. We focus our attention on two puzzling results.

The first one is the huge absolute decrease of the average iLUC values for the soya biodiesel (from 62.0 to 29.1gCO2/MJ) compared to the corn ethanol one (from 30.0 to 19.8gCO2/MJ), both biofuels being produced in the US. The main changes introduced in the models do not seem to be biofuel and/or feedstock specific, so the difference of absolute results is a priori striking. This concern is shared with the US Renewable Fuels Association (RFA, 2014) who also wonders why the reduction in CARB's corn iLUC estimates is of a far lesser magnitude than the reduction in soya iLUC values. The second one is the different iLUCs estimated for the canola biodiesel produced in the US and the EU. In the preliminary results reported in CARB (2014b), the average iLUC of US canola biodiesel amounts to 10.4gCO2/MJ while the average iLUC of US+EU canola biodiesel amounts to 35.2gCO2/MJ. This suggests that the production of this type of biofuel in the EU induces much more iLUC that in the US. This is a priori surprising because the iLUC concept is global and that the biodiesel and related feedstock markets are not segmented. For instance, it would suggest that the EU biofuel policy can be justified provided that EU consumers buy imported biodiesel from the US.

Accordingly our precise objectives in this paper are to identify the crucial methodological changes that lead to these revised puzzling results and to assess if they represent real improvements leading to more consistent and robust results. Our paper is structured as follows. In the first section, we briefly recall the main characteristics of the modeling frameworks and the main changes that have been introduced. The second section is devoted to our first puzzling result and the third section to our second puzzling result. The last section concludes.

2. Modeling frameworks

The LUC and net GHG emissions of the biofuel productions are not directly observed and are generally computed in two major steps. In a first step, an economic model is used in order to assess the LUC induced by the policy. In a second step, these LUC are transmitted into an environmental model in order to compute the carbon emissions. Some other assumptions are also needed, such as the accounting period because most assessments use static approaches.

From the different economic models available at the end of the 2000s, the CARB staff considers that the GTAP economic model is the most appropriate to compute the LUC effects because it has a global scope, is publicly available and has a long history in modeling complex international economic effects. The GTAP framework combines a Computable General Equilibrium (CGE) model rooted in the Arrow Debreu neoclassical theory and a unique global database. This database is mainly made up of regional social accounting matrices (SAM). These SAM capture all economic flows between economic agents in value terms (in US dollars). They are derived from input-output tables and include the value of production and consumption of different commodities as well as the factor returns from different activities (capital, labor, land). The GTAP database ensures in particular that the regional SAM are consistent, which is a challenging task (Walmsley *et al.*, 2015). Accordingly this framework has been widely used for the global economic analysis of trade, poverty, energy, and environmental issues. Several changes were made in the late 2000s to the original GTAP framework to allow relevant biofuel analysis (such as introduction of coproducts in the list of individual commodities, of physical land use data in addition to land returns). These first changes lead to the GTAP-BIO framework that is based on the 2001 economic flows (the GTAP database version 6).

Following the publication of these first results, several stakeholders raised concerns on the iLUC methodology. This leads the CARB to define expert working groups in order to help refining and improving this methodology. Many expert recommendations have been integrated in the revised GTAP-BIO framework while main structural characteristics have been maintained (a static CGE model, perfect competition, producers maximize their profit, consumers their utility, prices ensure market equilibrium, neoclassical macroeconomic rules, etc). The revisions introduced in the GTAP-BIO model can indeed be gathered in two main types: economic data and behavioral parameters. As regards the changes in economic data, these include the use of the 2004 economic flows (the GTAP database 7) and the introduction of many new individual commodities. In particular three individual oilseed commodities (soya, canola, palm) are isolated from the former aggregated oilseed commodities (for all seeds, oils and meals). In the same vein, sorghum is isolated from the coarse grains aggregate. Also new are the distinctions of pasture land in the US and Brazil and of irrigated versus rain-fed crop technologies. As regard the behavioral parameters, their calibrated values have been updated to reflect more recent evidence or due to more flexible specification of production technologies and household preferences. In particular, the range of the yield price elasticity has been revised downwards which would lead, ceteris paribus, to increase LUC. To the contrary, the yield area elasticity has been revised upwards while the land transformation elasticities have been further differentiated between land use and regions.

The EF that are used to convert the LUC computed from the GTAP-BIO framework to net GHG emissions are also subject to some scientific uncertainties and hence to debates. In the 2009 modeling, the EF were taken from Searchinger *et al.* (2008) and did not vary by AEZ. However the biomass and soil carbon stocks vary significantly by AEZ, so it was considered that emission factors should be specific to each region/AEZ combination. Several other changes have been introduced in these EF, such as from the conversion of peatland.

3. On the US soya biodiesel relative to the US corn ethanol

Our objective in this section is to understand why the absolute reduction in CARB's US soya biodiesel estimate is much larger that the reduction in US corn ethanol estimate. As mentioned above, the numerous methodological changes leading to these revised results can be divided in three types: economic data, behavioral parameters and EF. The impacts of behavioral parameters on results have been extensively quantified, with the yield price elasticity being a very crucial one (see Plevin *et al.*, 2015). We then prefer to start our investigation with the economic data and EF.

3.1. Assessment

Thanks to the public availability of computer codes and databases of both (2009 and 2014) versions, we can deeply analyze the different results and can alternatively change the economic data, the parameter values and/or EF. Because the 2014 version is more detailed than the 2009 one, we start by aggregating the 2014 economic data (relating to the year 2004) to the commodity/region classification adopted in the 2009 economic data (relating to the year 2001) in order to implement it in the 2009 GTAP-BI0 model. Three technical issues appear during this aggregation process. First the new regional disaggregation does not nest perfectly the former one. However the behavioral parameters for the concerned regions share the same values, so the regional mapping does not matter. Second the new pasture land activity has no direct counterpart and is merged with the livestock activity. Third the 2009 version distinguishes crude and refined vegetable oils while the 2014 does not. So we need to create the data for the refined vegetable oil commodity and sector in this 2014 aggregate database in order to implement it in the 2009 GTAP-BIO model (otherwise this model will not solve as one sector/commodity is always null). We assume that the production of refined vegetable oil requires labor and capital in addition to the intermediate consumption of crude vegetable oil. We further assume that this refined vegetable oil is only sold for final consumption. Accordingly we remove the final consumption of crude vegetable oil and affect this value to the intermediate consumption by our new sector. This procedure ensures that the markets of these commodities are initially balanced. We initially assume that the labor and capital shares in the production costs of the refined vegetable oil represent 45% in all countries, which is taken from the 2001 economic database.[1]

We then introduce this new aggregated economic database for the year 2004 in the old GTAP-BIO model keeping default values for behavioral parameters (we use the version released in January 2010). We simulate an increase of the US production of biodiesel to 1 billion gallons and of the US production of corn ethanol to 15 billion gallons (taking into account that the US productions of biofuels in 2004 are larger than in 2001). We obtain new LUC and apply to them the old and the recent EF. Because perennial crops are no longer distinguished in the aggregated 2004 economic

[1] To check the impacts of these assumptions, we vary these shares between 5% and 45% and the results are not very sensitive to these assumptions. The reason is that the new sector is assumed to behave like other sectors in a perfectly competitive manner and thus perfectly transmit the price effects.

data (palm production is aggregated in oilseed production), the new carbon emissions are computed using only LUC among the pasture/forestry/crops categories. We also perform the same experiment and computations with the 2001 original economic database. The results of this first investigation are reported in table 1.

Table 1: iLUC values with 2009 behavioral parameters (gCO2/MJ)

	2001 economic data	*2004 economic data (aggregated)*
Biodiesel shock		
Old “Woods Hole” EF	60.9	32.4
New AEZ EF	59.0	16.8
Ethanol shock		
Old “Woods Hole” EF	30.4	33.7
New AEZ EF	23.8	22.9

We find that the choice of both economic data and EF by AEZ have great impacts on these results. In particular, the new economic data leads to significantly reduced iLUC values for the biodiesel and more limited variations for ethanol. The major difference occurs when the new EF are considered and we simulate the biodiesel shock (from 59 to 16.8 gCO2/MJ). We also find that the new EF always lead to reduce iLUCs values for both biofuels. This reduction can be very low (the case of the biodiesel shock with the 2001 economic data with the iLUC reducing from 60.9 to 59.0) as well large (again in the case of the biodiesel shock with the 2004 aggregated economic data reducing from 32.4 to 16.8).

Because the biodiesel shock leads to major changes, we pursue our investigation by looking more carefully the results of this scenario. The LUC obtained with the two economic databases for major countries are reported in table 2.

The LUC in the US are roughly of the same order with an increase of nearly 0.1% of arable crops. By contrast the impacts on other countries differ significantly. For instance, the arable crops area in Brazil increases by 115 thousands hectares (0.2%) when the 2001 economic database is used and by only 10 thousands hectares (0.02%) when the 2004 aggregated economic database is used. We even observe some opposite effects (China and India). Overall the global arable crop area increases much less with the 2004 aggregated economic data (272 thousands ha) compared to the original 2001 results (910 thousands ha). The impacts on world pasture and forestry areas are modified accordingly (roughly reduced by two thirds).

Table 2: LUC of the biodiesel shock

	USA	Canada	EU27	Brazil	China	India	Total
2001 economic data							
(1,000 ha)							
Arable crops	164.99	153.41	134.16	115.34	11.55	21.06	910.20
Pasture	-71.89	-63.23	-47.40	-73.76	-40.61	-5.62	-663.40
Forestry	-93.25	-90.21	-87.01	-41.58	28.97	-15.41	-246.95
(%)							
Arable crops	0.09	0.36	0.10	0.22	0.01	0.01	0.06
Pasture	-0.03	-0.31	-0.07	-0.04	-0.01	-0.05	-0.02
Forestry	-0.03	-0.03	-0.06	-0.03	0.03	-0.03	-0.01
2004 aggregated economic data							
(1,000 ha)							
Arable crops	171.36	27.91	12.76	10.34	-2.90	-8.08	272.34
Pasture	-45.73	7.58	-9.59	-22.27	-4.45	2.57	-182.25
Forestry	-126.06	-35.62	-3.17	11.92	7.34	5.50	-90.70
(%)							
Arable crops	0.10	0.07	0.01	0.02	0.00	0.00	0.02
Pasture	-0.02	0.04	-0.02	-0.01	0.00	0.02	-0.01
Forestry	-0.06	-0.04	0.00	0.01	0.01	0.03	-0.01

These LUC have been multiplied by different EFs to get the previous carbon emission results. It appears that the new EFs averaged over all AEZ are much lower than the initial EF ones for the the US and Canada. By contrast, these new average EFs are much higher for the EU and Brazil. These changes in the EFs do compensate when applied to the LUC obtained with the 2001 economic data. In other words, the reduced carbon emissions obtained in the US and Canada are compensated by the increased carbon emissions in the EU and Brazil. This explains the slight reduction at the global level (from 60.9 to 59gCO2/MJ). When the LUC computed with the 2004 aggregated economic data are used, we do not observe this compensation over regions because LUC in the EU or Brazil are much lower. In other words, most LUC are observed in the US where the EF have been revised downwards (roughly by half).

We then pursue our investigation trying to understand why the LUC outside the US are much reduced with the 2004 aggregate economic data. In that respect, we need to look at the drivers of the land decisions (supply and demand drivers). In a CGE model like the GTAP-BIO model and more generally in economic models where prices ensure market equilibrium, it is useful to examine price effects. They are reported in table 3 for selected commodities and regions, again with the two economic databases.

Table 3: Price effects of the biodiesel shock (in %)

Market price	USA	Canada	EU27	Brazil	China	India
2001 economic data						
Veg Oil	14.60	1.47	0.58	0.50	0.50	0.26
Oil meals	-44.26	0.66	-0.33	0.50	0.55	0.10
Oilseeds	2.89	0.85	0.57	0.67	0.45	0.23
Coarse grains	0.58	0.37	0.27	0.39	0.12	0.13
Other grains	0.41	0.31	0.25	0.39	0.09	0.14
2004 aggregated economic data						
Veg Oil	16.37	4.67	0.72	1.17	1.12	0.40
Oil meals	-13.59	-7.31	-2.46	-2.25	-1.09	-1.50
Oilseeds	1.17	0.13	-0.02	0.00	-0.02	-0.38
Coarse grains	0.26	0.07	0.01	0.01	0.00	0.00
Other grains	0.16	0.07	0.01	0.02	0.00	0.00

As expected, the biodiesel shock leads to an increase of vegetable oil prices. The US price increase of this commodity amounts to around 15% in both cases. This price increase is only partially transmitted to other countries due to the trade modeling where commodities from different origins are assumed to be imperfect substitutes (the so-called Armington approach and the disputed Armington elasticities already discussed in the literature). In both cases, we observe a slight increase of the vegetable oil price in all countries. Other things being equal, these price increases stimulate the production of vegetable oils and simultaneously of the oilmeals. As expected, this in turn leads to price decreases for this commodity. These price effects are very different across the two economic databases. The US oilmeals price decrease by as much as 44% when the 2001 economic database is used, by only 14% when the 2004 aggregated economic database is used. Above all, the oilmeals price effects are different in the other regions. They roughly slightly increase with the 2001 economic database which is quite unexpected. By contrast, they more significantly decrease with the 2004 aggregated economic database and thus are closer to the US price effect, which is more intuitive.

These different oilmeals price effects explain the different oilseeds price effects and by extension the main agricultural price effects. These price effects are positive (around 0.4% in the EU/Brazil for instance) when the 2001 economic database is used. They are null or even negative (the Indian oilseeds price) when the 2004 economic database is used. Accordingly we follow our investigation by focusing on the oilmeals markets, trying to understand the unexpected results mentioned above.

3.2. The oilmeals data

We identify two surprising features in the 2001 economic database. First there is no trade of oilmeals between countries. Second the production of oilmeals is null in some countries (China) while the production of vegetable oils is positive. At this stage, we suspect that this absence of trade may explain the different oilmeals price effects mentioned above. The intuition is the following. When there are no trade flows initially, the applied Armington approach with CES functions excludes that some trade flows materialize after the scenario. Accordingly the oilmeals price in the different countries can evolve in different directions because merchants are not able to exploit the price wedges. That is, potentially importing countries (such as the EU) are not able to import cheaper oilmeals (from the US for instance) and similarly potentially exporting countries (such as the US) are not able to export its cheaper oilmeals. To the contrary, when there are initially trade flows (the 2004 aggregated economic database), consumers (animal feed industries) are allowed to buy their oilmeals from different regions, hence limiting the price wedges. We also suspect that the absence of oilmeals production in some countries matters as well by reducing the "co-product effects" already discussed in the literature.

In order to confirm our intuitions, we decide to revise the 2001 economic database by correcting these two features. This is not an immediate task because data changes must be made such as initial balances (commodity market equilibrium and budget identities) are respected. Let's start with the corrections applied to oilmeals production values. In each region, we increase these production values by using the output shares of oilmeals production in the oilseed crushing sectors as observed in the 2004 aggregated economic data. We apply these new shares to 2001 production values of vegetable oils, assuming that these values are correct. We ensure that the crushing sectors accounting identities are satisfied by increasing their capital returns. Indeed the expert working groups hired by the CARB have also pointed out the fragility of these capital returns. We ensure that the oilmeals commodity markets are still initially equilibrated by increasing their domestic use by the livestock industries. In turn the regional values of livestock productions are increased. We ensure that these commodity markets are equilibrated in each region by increasing their domestic use by the livestock processing industries. Again the regional values of processed livestock productions are increased. Finally we assume that the final consumptions of this commodity by regional households are increased by the same absolute amounts. All these changes are needed to ensure an initial consistent economic database. In particular household expenditures (in processed livestock) and receipts (capital returns from the crushing sectors) are increased by exactly the same amounts. It should be noted here that, while the revisions may be important for some regional oilmeals markets, there are quite marginal for processed livestock markets because oilmeals contribute to a limited extent to the production costs of these products.

The corrections needed to introduce trade flows of oilmeals in the 2001 economic database are also numerous. We start using the values of bilateral trade flows of oilmeals observed in the 2004 aggregated economic database for 4 regions (US, EU, Brazil, China) and assume no transport costs for simplification. The introduction of these trade flows changes the trade balance for these regions. We then modify the trade flows of the manufactured good among the four countries to restore their initial trade balance. We then modify the intermediate uses of these two goods by the livestock sectors to ensure the market balance and without destroying the budget identities for these sectors.

We do not claim that our revised 2001 economic data perfectly fit the economic flows observed in that year. As mentioned above, the construction of consistent regional SAMs is a tremendous task (Walmsley *et al.*, 2015). Rather we believe that the revised 2001 economic data are certainly closer to the reality and are more comparable to the 2004 economic data used in the revised CARB analysis. Hence it is appropriate for our comparative analysis.

We perform the same biodiesel and ethanol shocks using this revised 2001 economic data. We report in tables 4 and 5 the price and LUC effects of the biodiesel shock.

Table 4: Price effects of the biodiesel shock using the revised 2001 economic data (in %)

Market price	USA	Canada	EU27	Brazil	China	India
Veg Oil	30.83	1.39	1.96	4.86	-0.21	0.29
Oil meals	-27.90	-0.53	-6.40	-3.29	0.63	0.03
Oilseeds	2.03	0.34	0.06	0.03	-0.06	0.22
Coarse grains	0.30	0.14	0.04	0.10	0.03	0.12
Other grains	0.21	0.13	0.05	0.11	-0.01	0.11

Table 5: LUC of the biodiesel shock using the revised 2001 economic data

	USA	Canada	EU27	Brazil	China	India	Total
(1,000 ha)							
Arable crops	73.60	80.00	22.69	29.64	-0.34	21.79	467.50
Pasture	81.34	-59.62	-11.30	-26.03	-20.06	-4.69	-310.76
Forestry	-154.85	-20.38	-11.58	-3.57	20.39	-17.06	-156.68
(%)							
Arable crops	0.04	0.19	0.02	0.06	0.00	0.01	0.03
Pasture	0.04	-0.29	-0.02	-0.01	-0.01	-0.04	-0.01
Forestry	-0.05	-0.01	-0.01	0.00	0.02	-0.03	-0.01

The nature of impacts does not change with the revised 2001 economic data (comparison of table 4 with table 3). For instance, we always observe in the US an increase of the vegetable oil price and a decrease of the oilmeals price. The magnitudes of these impacts are different, in particular in regions that now trade oilmeals. The market prices of oilmeals now decrease in the EU and Brazil (by respectively 6 and 3%). While these price decreases are much lower than the one observed in the US (by 28%), a result that may hurt traders, the differences are lower than those obtained with the original 2001 economic data. In these two regions and in the US as well, we observe higher price effects on vegetable oil prices. This is explained by our revisions on oilmeals production values. The higher the share of oilmeals in the crushing sector receipts, the higher must be the increase of the vegetable oil prices in order to induce production response.

The variation of the vegetable oils and meals prices are transmitted to the oilseeds price by the crushing sectors assumed to be perfectly competitive. We now find more limited increases of oilseed prices. They are indeed close to those obtained with the 2004 aggregated economic data. In particular, the oilseed prices don't really change in the EU and Brazil. By extension, production response is more limited, land competition across crops is less severe and price effects of other agricultural commodities are also muted.

With lower agricultural price effects, the LUC are also revised downwards. For instance, the arable crop expansions in the EU and Brazil are lower than 30 thousand hectares (roughly a fourth of initial results) and are closer to the results obtained with the 2004 aggregated economic database. We also observe a huge decrease in the expansion of arable crops in the US and Canada that, if combined, also come near the 2004-based results.

It remains to examine the new impacts on the iLUC values. We report them for the two biofuel shocks in table 6 with the different EF. We also provide the last revised CARB results that are obtained with different behavioral parameters.

Table 6: iLUC values using the revised 2001 economic data and CARB revised results (gCO2/MJ)

	CARB initial results (2011)	*2001 revised economic data*	*CARB revised results (December 2014)*
Biodiesel shock			
Old "Woods Hole" EF	62.0	43.7	
New AEZ EF		32.8	29.1
Ethanol shock			
Old "Woods Hole" EF	30.0	30.6	
New AEZ EF		23.8	19.8

We find that our revisions of 2001 economic data focused on oilmeals have great impact on the iLUC values of biodiesel. Using the old EF, it amounts to 43.7gCO2/MJ (compared to 60.9 with the original 2001 economic data) because the LUC are reduced. Using the new EF, this reduction is amplified to 32.8 gCO2/MJ due to the regional EF effects (with lower average EF in the US for instance). We also find that our revisions of 2001 economic data have nearly no impacts on the iLUC values of ethanol (using both types of EF). The oilmeals co-product effect is logically relatively less important in the ethanol case, which can also be explained by the fact that the DDGS market was less significant than the soya meal market in the beginning of the 2000s.

To conclude this first investigation, we find that the revised 2001 economic data leads to iLUC values very similar to the last ones reported by the CARB and introduced in the new contemplated regulations. This does not mean that we are able to exactly reproduce them by just changing the oilmeals values in the 2001 economic database. As mentioned before, there are many other changes that have been implemented in the CARB analysis, including the calibration of behavioral parameters. Rather our comparative analysis shows that economic data alone can greatly explain why the absolute reduction in CARB's soya biodiesel estimate is much larger that the reduction in corn ethanol estimate. Oilmeals economic data used in the revised CARB analysis are more relevant than in the first CARB analysis. On this aspect we thus argue that the revised CARB results represent real improvements leading to more consistent results.

4. On the US vs EU canola iLUC values

The preliminary results reported in September 2014 provide puzzling figures for canola biodiesel (CARB, 2014b). The canola biodiesel produced in the US induces less iLUCs than the canola produced in the US+EU (an average of 10.4 vs 35.2gCO2/MJ respectively). While one can conceive that the biodiesels produced from different vegetable oils lead to different iLUC values, this is much more unexpected when the same feedstock is used and when there are no major trade frictions on this market. In the subsequent publications, the CARB no longer makes this distinction and only reports US canola biodiesel iLUC values (an average of 14.5 gCO2/MJ).

4.1. Assessment

We thus start our new investigation by using the last available version of the GTAP-BIO economic model, the latest version of the AEZ-EF environmental model. We perform a canola biodiesel production shock of the same amount (400 million gallons) in these two countries. The results obviously depend on the behavioral parameters. 30 sets of parameters are retained by the CARB. We initially retain two of them, the first one with “low price elasticities” and the eighth with “average price elasticities”. The iLUC results of this first step are reported in table 7.

Table 7: iLUC values for Canola biodiesel (gCO2/MJ)

	EU27	US
Parameter set 1 (low price elasticities)	46.8	20.5
Parameter set 8 (average price elasticities)	27.2	13.8

Our US iLUC results are not exactly the same as those reported by the CARB but are very close. This is also true for the LUC, possibly due to subsequent minor revisions in the GTAP-BIO framework. Above all, our first step confirms the preliminary CARB results of a significant difference between the iLUCs values. Roughly the EU values are twice the US ones. The absolute difference is larger when the low price elasticities are considered. We pursue our investigation with this set of parameters, looking again first at the LUC impacts.

The world arable crop land increases by 208 thousand hectares with the EU shock, by only 97 thousand hectares with the US shock. The LUC impacts are thus crucial to understand the above difference of iLUC values. Table 8 reports the LUC impacts for some commodities in selected countries (table 8).

Table 8: LUC of canola biodiesel in the two countries

Land use (ha & %)	USA		EU27		Canada		South-Africa	
The EU27 shock								
Rapeseed	14,689	4.34	421,311	9.25	93,085	1.91	799	1.14
Soybean	-49,569	-0.17	-3,977	-1.03	-4,098	-0.35	-1,093	-0.10
Coarse grains	15,493	0.05	-84,439	-0.25	-10,733	-0.16	13,589	0.03
Wheat	33,442	0.17	-100,937	-0.38	-32,757	-0.35	4,275	0.15
Other agri products	27,863	0.07	-134,187	-0.35	-28,781	-0.28	84,749	0.12
Total arable crops	4,209	0.00	20,908	0.02	14,036	0.04	105,433	0.06
The US shock								
Rapeseed	200,304	59.22	46,157	1.01	301,904	6.20	726	1.03
Soybean	-336,809	-1.13	-965	-0.25	-15,685	-1.34	-3,375	-0.30
Coarse grains	59,710	0.18	-13,243	-0.04	-30,659	-0.45	5,116	0.01
Wheat	4,072	0.02	-253	0.00	-122,891	-1.31	3,092	0.11
Other agri products	80,495	0.21	-20,077	-0.05	-90,400	-0.87	26,166	0.04
Total arable crops	2,164	0.00	4,338	0.00	33,528	0.10	33,306	0.02

We find as expected that the canola areas increase in all countries. The soybean areas decrease in all regions as well due to the induced oilmeals competition. The impacts on other crop areas depend on the considered countries. For instance, the EU coarse grains area decreases in the two scenarios which is quite intuitive (land competition). To the contrary, the US coarse grains area increases in the two scenarios which is less intuitive but theoretically possible (cross price effects). In fact most of the US canola biodiesel shock seems to be “transmitted” to the Canada. The Canadian arable crop area increases more with the US shock than the EU shock. If we sum the arable crop areas of these three countries, the impacts are quite similar for the two shocks (around 40 thousand hectares). On the other hand, the impacts on other countries, especially South Africa, are far apart. The South African arable crop area increases by 105 thousand hectares with the EU shock and only by 33 thousand hectares with the US shock. It even appears that these South African results explain most of the different iLUC values obtained above.

The biggest absolute land impacts are surprisingly observed for the “other agricultural product” which includes wine, fruits, vegetables and some fodder crops. The South African area allocated to the activity increases by 85 thousand hectares with the EU shock, by 26 thousand hectares with the US shock. In the EU shock, this seems to be related to the major decrease for this area in the EU (134 thousands hectares). To the contrary, the area devoted to this activity significantly increases in the US following the US shock (by 80 thousand hectares), compensating to a large extent the decline observed in Canada (90 thousand hectares).

The story line of the previous results can be the following. An increase of the US canola biodiesel production favors the Canadian canola production at the expense of many crops, including fruits and vegetables. These commodities must be produced elsewhere, mostly in the US due to the land availability following the soybean contraction. By contrast, an increase of the EU canola biodiesel production favors it own production to the detriment of many crops, including fruits, vegetables and wine. These commodities are now more produced in South Africa, as EU consumers are initially importing and thus valuing these products. The South Africa crop yields are lower than the US ones, leading to the greater global LUC computed above.

While one may contest this literal interpretation of previous results, we stress that these results are theoretically plausible. In fact there are many cross market effects included in a CGE model and the GTAP-BIO model is fully consistent with the Arrow Debreu neoclassical theory. However one can be concerned with their empirical plausibility. The CARB results have been extensively analyzed by US experts/stakeholders, we prefer to focus on the EU results assuming that the 2004 US figures are correct.

4.2. The EU land data

We start trying to understand the significant decrease of the EU “other agricultural product” area following the EU shock. It decreases more than the EU cereal areas. This is theoretically plausible but more debatable empirically. Even if we cannot use direct observations on EU land uses to infer the biodiesel LUC, there is no evidence that the fruits, vegetables, wine and some fodder crops (hay) have significantly decreased in the recent years following the rapeseed area expansion.

It is worth here to briefly recall the modeling of the land uses and markets in the GTAP-BIO model. In fact, the major issue that all economic modelers face when dealing with land decisions is related to the measurement of the quality of land (see Gurgel *et al.*, 2007 or Valin *et al.*, 2013 for a more detailed discussion of this issue). It is widely accepted that the land is a heterogeneous asset (a wine field can be different from a wheat field), that some attributes/qualities of these fields can be altered (depending on farmers’ investment for instance). However the quantification of this heterogeneity and its evolution are challenging. There have been many efforts in the GTAP-BIO framework to deal with these challenges, resulting in the introduction of AEZ data per crops and technologies in all regions. The possibility to change the attributes of fields has also been recognized by allowing land mobility across activities. This is technically captured by the specification of land transformation functions and the calibration of corresponding elasticities. The intuition of this specification can be explained with the following example. Let’s suppose that the relative price of one crop increases generating higher relative land returns. Arable crop farmers may then decide investments to make more land suitable to this activity, implying that there is less land available to other activities pursued by these farmers. The amount of investment obviously depends on the initial relative quality of land that the farmers want to reallocate. This investment is possibly null when the reallocation involves only arable crop activities, possibly high when it involves the conversion of pasture land into arable crop lands for instance. The total physical amount of land (measured in hectares) remains the same but the average quality of land has changed. There is a difference between the physical hectares and the so called “effective” hectares that take into account their endogenous productive qualities (see Golub and Hertel, 2012). While there is a one-to-one correspondence between physical hectares, this is not true for the “effective” hectares. They should be weighted by their productive values, which are measured in a static context by their land returns. The higher the initial land returns from one activity, the easier is the shift of that land to the other activities. It implies that, other things being equal, the transformation of one hectare of high quality (for instance devoted initially to the wine production) into an arable crop activity induces more arable crop area that the transformation of one hectare of low quality (for instance devoted initially to pasture).[2]

The principles of this land modeling are sound. However its implementation and impact on results greatly depend on the initial availability of land returns for the different activities in the different AEZ, on the investment made by farmers to modify the physical properties of their lands. Unfortunately this type of information does not exist for all countries, in particular in the EU countries. Accordingly it is first necessary to calibrate these land returns in the database, which is again a delicate task. In particular this should take into account the land subsidies provided by the farm policies and their capitalization in the land returns. Table 9 reports the values of these land returns for selected activities in the EU.

Table 9: EU initial land data

	Wheat	Coarse grains	Rapeseed	Oth agri products	Total arable crops
Harvested area (1,000 ha)	26,002	31,095	4,495	33,287	115,729
Share (%)	22.5	26.9	3.9	28.8	100.0
Land returns ($/ha)	147	126	235	1,112	499
Share (%)	6.6	6.8	1.8	64.1	100.0
Land unit subsidy ($/ha)	89	66	129	681	301
Land subsidy (bio $)	2,309	2,046	579	22,679	34,887
Share (%)	6.6	5.9	1.7	65.0	100.0

These values are summed over all AEZ and for the predominant rain fed technology. The land returns are made of the market returns and the land subsidies. We observe two striking data features. First the land return generated by the other agricultural product activity is much higher than the other arable crops activities (1112$/ha, which is more than 5 times higher the return from arable crop activities). Second this land return is significantly made by subsidies (681$/ha). The total land subsidies given to this sector are higher than 22 billion dollars, roughly two thirds of CAP land subsidies. This last figure is clearly not supported by EU budget data. CAP land

[2] In mathematical terms, let's consider a farmer (country) with a fixed amount of total land that can be allocated among three activities. Let's assume that the relative land return to the first activity marginally increases following a biofuel shock. The farmer wants to benefit from this opportunity and to increase the land allocated to this activity. The GTAP-BIO modeling of the land market implies that at the margin:

$$dl1 = -\frac{p2}{p1}dl2 - \frac{p3}{p1}dl3$$

with p the vector of land returns and dl the vector of land use variations. If p2 is larger than p3, then one hectare from activity 2 generates more hectare suitable to activity 1 than one hectare of activity 3. It is thus easier to increase the land allocated to the first activity by reducing the land allocated to the activity 2.

subsidies are mainly provided to arable crops (cereals/oilseeds) and not to fruits, vegetables or wine. It should be recognized that this “other agricultural products” activity also includes some fodder crops (hay on arable land) but these activities certainly do not benefit from greater unitary CAP land subsidies. In addition to the land subsidy amounts, we are also concerned with the land return values (1112$/ha). As far as we understand the construction of the GTAP databases, these returns are determined as a fixed share of production values for all activities. Without doubt, the production values of one hectare of fruits, vegetables or wine are much higher than the production values of one hectare of cereals or oilseeds. However the structure of their production costs is certainly different as well, with more labor or capital for instance. The true return to land (and to other factors) in these activities is unknown but it is highly doubtful that one “marginal” hectare of this type of land can be transformed into 5 hectares of cereals or oilseeds. Even if we can conceive that some wine fields have great returns, their “massive” transformation to oilseed production following a biofuel shock is more suspect. The transformation of vegetable (potatoes) areas to arable crop areas is certainly more likely but their land values are certainly closer to each others.

We thus suspect that these questionable EU land data values can partly explain the huge decrease of physical hectares of “other agricultural product” area and by extension the high iLUC values for the EU canola biodiesel. The US land data values do not exhibit the same differences between sectors. To check this intuition, we modify the EU land data values in the following way. We assume that, in each AEZ, the per hectare land values and subsidies are the same for all crop activities (we do not include here pasture, forestry). When we aggregate over all AEZ, some small differences appear between these crop activities. Our revised EU land data for selected commodities are reported in table 10.

Table 10: Revised EU land data

	Wheat	Coarse grains	Rapeseed	Oth agri products	Total arable crops
Harvested area (1,000 ha)	26,002	31,095	4,495	33,287	115,729
Share (%)	22.5	26.9	3.9	28.8	100.0
Land returns ($/ha)	508	475	519	515	499
Share (%)	22.9	25.6	4.0	29.7	100.0
Land unit subsidy ($/ha)	307	287	313	311	301
Land subsidy (bio $)	7,979	8,924	1,409	10,361	34,887
Share (%)	22.9	25.6	4.0	29.7	100.0

We do not change the figures on harvested areas as they are derived from “official” statistics. We only change the values of factor returns. As expected the unitary land returns or direct subsidies are quite similar across sectors because they are all present in the main AEZ. In order to introduce these revised EU land data in the GTAP-BIO framework, we need to ensure the budget balances of the different sectors. We adjust their capital/labor returns to ensure them. Fortunately, these modified returns remain positive, which is important in the steady case approach of the static GTAP-BIO model.

We perform the two canola biodiesel shocks with the EU land revised economic database and the parameter set 1 with low price elasticities. The LUC impacts are reported in table 11.

Table 11: LUC of canola biodiesel in the two countries with revised EU land data

Land use (ha & %)	USA		EU27		Canada		South-Africa	
The EU27 shock								
Rapeseed	16,846	4.98	376,770	8.28	105,436	2.17	916	1.30
Soybean	-47,443	-0.16	-4,641	-1.2	-4,491	-0.38	-859	-0.08
Coarse grains	11,438	0.04	-121,833	-0.36	-13,296	-0.2	8,361	0.02
Wheat	63,641	0.31	-157,437	-0.59	-26,738	-0.28	7,797	0.27
Other agri products	2,386	0.01	45	0.00	-41,585	-0.40	36,123	0.05
Total arable crops	3,720	0.00	17,327	0.01	16,129	0.05	59,503	0.03
The US shock								
Rapeseed	200,460	59.27	41,583	0.91	302,869	6.22	738	1.05
Soybean	-336,891	-1.13	-1,024	-0.26	-15,738	-1.34	-3,346	-0.30
Coarse grains	58,749	0.18	-19,990	-0.06	-31,026	-0.46	3,853	0.01
Wheat	9,724	0.05	-13,445	-0.05	-121,166	-1.29	3,710	0.13
Other agri products	75,274	0.20	4,605	0.01	-92,449	-0.89	14,915	0.02
Total arable crops	1,938	0.00	3,032	0.00	33,674	0.10	21,705	0.01

As anticipated, the revised EU land data modify the results. Let's start with the EU shock. We now find that the EU expansion of canola area mainly leads to a larger reduction of cereal area while the impact on the area of other agricultural products is now nil. By extension, the South African LUC impacts are reduced, by roughly one half. The larger reduction of the EU wheat is compensated by a larger increase in the USA. In this scenario it remains a more limited shift of fruits and vegetable areas between Canada and South Africa.

We also find that the revised EU land data significantly modify the results of the US canola biodiesel shock (comparison of table 11b and 8b). Again the impact on the EU area of other agricultural product broadly disappears, hence limiting the expansion of the South African corresponding area. Still the LUC impacts with our revised EU land data remain greater for the EU shock. In turn, the iLUC value for the EU shock decreases to 35.2 gCO2/MJ (hence by 11.6) while the one for the US shock decreases to 16.9 gCO2/MJ (hence by 3.6).

4.3. The EU canola meal data

The previous investigation on the EU land data partly explains the different iLUC values. But they still remain significantly different, inviting us to explore other possible explanations. In the former section, we found that the oilmeals economic data were critical. We thus turn our attention to these data.

As mentioned above, most of the US canola biodiesel shock is "transmitted" to Canada where the canola production is historically much higher. We compare the Canadian and European canola data. We observe that the share of canola meals in the total receipt of the EU canola crushing sector is much lower than the Canadian one (16.6% and 28.9% respectively). The EU figure is quite low when compared to the "real" data. That is, when we use the production quantities from Eurostat publication and the market prices from Oil World publications, we find that this EU share at the industry level is 24.3%.

This leads us to revise the EU oilmeals data. We again assume that the EU canola oil production value in the GTAP database is correct. In fact this value includes the marketing costs when selling food products to final consumers. Hence the GTAP consumer value is higher than the firm value computed above with "real" data. The difference amounts to 36%, which seems a reasonable marketing cost share. The marketing cost of oilmeals is a priori lower than for vegetable oils. We assume (using French statistics on wheat marketing/transportation costs) that the oilmeal marketing cost represents 10% of the firm oilmeal price. We apply this ratio to the real data. In concrete terms, these assumptions lead us to increase the EU canola meal production by 30%. As in the previous section, we ensure the consistency of the revised economic database by increasing the intermediate use of this commodity by the livestock sector and so on. To be complete, table 12 reports the results of the two shocks with the revised data on EU canola meal only.

The impacts of this data revision on results are modest in the EU shock, nearly nil in the US shock. As expected, the increased EU value of canola meal production implies a greater "co-product" effect of the EU biodiesel shock. We find a slightly larger increase in the EU canola area to the detriment on other oilseed areas. The soybean areas decrease more, in particular in the US easing the land competition. The increase of the South African arable crops area is reduced by 11 thousand hectares. This translates into an iLUC value for the EU canola biodiesel of 39.6 gCO2/MJ (hence a decrease by 7.2). By contrast the iLUC value for the US canola biodiesel is unchanged.

Table 12: LUC of canola biodiesel in the two countries with revised EU canola meal data

Land use (ha & %)	USA		EU27		Canada		South-Africa	
The EU27 shock								
Rapeseed	14,812	4.38	426,719	9.37	93,244	1.92	777	1.10
Soybean	-63,744	-0.21	-4,929	-1.27	-4,449	-0.38	-1,348	-0.12
Coarse grains	17,962	0.06	-74,891	-0.22	-10,756	-0.16	13,801	0.03
Wheat	33,351	0.16	-98,183	-0.37	-33,041	-0.35	3,807	0.13
Other agri products	30,051	0.08	-128,592	-0.33	-28,841	-0.28	78,839	0.11
Total arable crops	3,282	0.00	19,604	0.02	13313	0.04	94,023	0.05
The US shock								
Rapeseed	200,372	59.24	49,824	1.09	302,383	6.21	731	1.04
Soybean	-336,671	-1.12	-1,004	-0.26	-15,685	-1.34	-3,362	-0.30
Coarse grains	59,666	0.18	-13,660	-0.04	-30,740	-0.45	5,136	0.01
Wheat	4,184	0.02	-992	0.00	-123,061	-1.31	3,112	0.11
Other agri products	80,542	0.21	-20,997	-0.05	-90,541	-0.87	26,610	0.04
Total arable crops	2,164	0.00	4,448	0.00	33,602	0.10	33,793	0.02

4.4. The EU internal trade data

Some previous experience with the GTAP approach leads us to examine the impact of EU internal trade data (Femenia and Gohin, 2009). In a nutshell, the EU member states trade with each other, states of the US certainly as well. These internal trade flows are captured in the GTAP database only for the EU case. There are some methodological debates in the GTAP community on the modeling of these internal trade flows. The current practice is to assume a two level approach. In the first level, the consumers are assumed to arbitrate between domestic products and the aggregate of foreign products. In the second level, consumers arbitrate between the different foreign products. The Armington elasticities applied at the second level are twice those of the first level. The EU internal trade flows are introduced in that second level. This implies that the EU import elasticities are much higher than the US ones. Table 13 reports the initial elasticities for selected commodities in both regions.

Table 13: Trade elasticities

	Armington elasticities (first level)	US import elasticity	EU import elasticity With intra trade	EU import elasticity Without intra trade
Rape oil	3.3	1.5	6.1	3.2
Oth agr prod	2.5	2.0	3.2	2.1
Wheat	4.5	4.1	6.9	4.1
Coarse grains	1.3	1.3	2.2	1.2

It appears that when the EU domestic price of agricultural/food products increases by 1%, it induces much larger EU imports from third countries than in the US case. For instance, the EU rape oil imports increase by 6.1% compared to "only" 1.5% in the US case. This suggests that the EU biofuel shock is more "easily" transmitted to third countries and hence higher LUC in these third countries. When we remove the EU internal trade in the GTAP database, the EU initial import elasticities are much more comparable to the US ones.

We thus build a new revised database where we remove the EU internal trade. We did that for all agricultural and food commodities first, then for all commodities. Results are basically similar. When we remove these trade data, we remove in the same time the transportation/marketing costs. We correct the values of intermediate use/final uses accordingly to ensure equilibrium in all markets. To be complete, table 14 reports the results of the two shocks with the revised data on EU intra trade only.

We again find that this data revision mostly change the results of the EU shock, more marginally those of the US shock. In particular the LUC induced by the EU shock are in general lower in absolute values. Price transmissions to third countries are generally lower. For instance the "other agricultural production" price increase in the South Africa following the EU shock is now limited to 0.09% (compared to 0.12% initially) and more comparable to the US shock effect (0.03%). These LUC impact translate into an iLUC value for the EU canola biodiesel of 36.1 gCO2/MJ (hence a decrease by 10.7). By contrast the iLUC value for the US canola biodiesel slightly increases to 20.8gCO2/MJ.

Table 14: LUC of canola biodiesel in the two countries with revised EU trade data

Land use (ha & %)	USA		EU27		Canada		South-Africa	
The EU27 shock								
Rapeseed	11,735	3.47	353,875	7.77	74,895	1.54	635	0.90
Soybean	-40,911	-0.14	-3,548	-0.92	3,306	-0.28	-865	-0.08
Coarse grains	12,549	0.04	-70,300	-0.21	8,605	-0.13	10,024	0.02
Wheat	27,801	0.14	-85,951	-0.32	-26,400	-0.28	3,705	0.13
Other agri products	21,530	0.06	-108,040	-0.28	-23,282	-0.22	62,849	0.09
Total arable crops	3,253	0.00	19,598	0.02	11,143	0.03	78,753	0.04
The US shock								
Rapeseed	202,857	59.97	24,763	0.54	320,163	6.58	902	1.28
Soybean	-334,424	-1.12	-876	-0.23	-15,964	-1.36	-3,279	-0.29
Coarse grains	58,417	0.18	-7,212	-0.02	-33,139	-0.49	4,525	0.01
Wheat	5,401	0.03	2,918	0.01	-129,795	-1.38	3,291	0.11
Other agri products	78,628	0.20	-11,605	-0.03	-96,302	-0.92	23,724	0.03
Total arable crops	2,372	0.00	3,647	0.00	35,842	0.11	31,586	0.02

4.5. Synthesis

Up to now, we proceed revision by revision, using a set of parameters. Table 15 reports the effects of combined revisions for the two parameter sets.

Table 15: Revised iLUC values for Canola biodiesel (gCO2/MJ)

	EU27	US
Parameter set 1 (low price elasticities)	22.5	18.1
Parameter set 8 (average price elasticities)	14.1	12.9

It appears that the iLUC effects are nearly additional (the impacts of the three revisions made simultaneously are very close to the additions of the three individual impacts). This makes sense because the revisions are made in very different data. The iLUC values from the two canola biodiesel shock are much more similar. To conclude this second investigation, we find that the economic data are again crucial. We do not claim that these final values are the true values, nor that these should strictly equal. Indeed they are unobservable. We just claim that it is possible to understand some striking differences, looking at initial economic data that are more observable.

5. Concluding comments

The iLUC effects of biofuels are highly disputed. They are not directly observable and are simulated using both economic and environmental models. These models depend on unobserved parameters, such as price elasticities in the economic models that are eventually identified with econometric methods using past observations. Then the iLUC debate rapidly turns to be an elasticity debate. Many econometric efforts are currently underway in order to better quantify the price responses of the farm sectors in different countries (for instance, Scott, 2013; Smith *et al.*, 2014; Koutchade *et al.*, 2014 to name few recent efforts). These original researches are very welcome in order to feed debates such as the iLUC one but other agricultural issues as well (how to produce more food with less damaging environmental impacts).

In this iLUC debate, our analysis of the revised CARB iLUC results recalls a very trivial point: the simulated results also greatly depend on the initial data (see for instance Mercenier and Yeldan, 1999). Indeed (price) elasticities are “multiplied” to economic data to compute the LUC effects. We illustrate this by looking at two puzzling results provided in the revised CARB results.

It appears in both cases that the oilmeals data have significant impacts. This is typically a kind of data where the collaboration between stakeholders and modelers can easily take place to improve the quality of assessments.[3] More generally, in an “ideal” world, the economic models developed to compute impacts such as iLUC values should be built on time series data that are accepted by all parties and that are long enough to allow econometric identification of crucial behavioral parameters. Like Babcock and Carriquiry (2010), we believe that the economic models are useful and that greater efforts can be made to demystify them if they are to be really used for policy advices and decisions. In that respect, the GTAP framework underlying the CARB assessment is exemplary, even if we find some puzzling figures. The transparency of procedures allows external analysts to perform robustness checks. We certainly do not claim that the revisions we introduce in the economic data make our results the final ones. Rather we believe that our revised results are more consistent on the two dimensions that we analyze. Further investigations of CARB results may reveal other data issues. Before launching new investigations, we believe that economic models should not be used to deliver just one value (the LUC in this case). At the minimum the price impacts for main commodities in main regions should be provided. Price figures (initial values and impacts) can facilitate the dialogue between all parties.

[3] Funny enough, the oil meal data used by Laborde (2011) to compute the iLUC values of EU biofuels with the Mirage-BioF model have also been questioned by EU stakeholders. The canola meal crushing coefficient is considered too low.

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