The indirect effects of a greener EU agriculture on trade, land use and GHG emissions [1]

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Abstract

Environmental friendly agricultural production techniques have well known local benefits. They can also have indirect effects if they require intensification of deforestation somewhere else in the world. These indirect effects are well documented for biofuels production but not for the extensification of agriculture. Our aim is to quantify the environmental and trade effects of a greener European agriculture, measuring the displacement of crop production, accounting for important substitution and revenue effects. We add to Mirage-BioF, a global CGE model with an improved representation of land use, a specific representation of the European organic production technologies, based on micro-founded data, and of organic demand. If 20% of land devoted to maize, rapeseed, sunflower and wheat in Europe is converted to organic practices by 2020, as planned by some Member States, sizeable demand and production displacements will take place. The decrease in European production (-12.3 million tons for wheat, -4.3 for maize) is partially compensated by an increase of 0.8 Mha in the global cropland area leading to the emission of 117 million tons of CO_2eq. These preliminary results have to be balanced with the local benefits of organic farming but could help to optimize global environmental impacts of greener agricultural policies.

Key words: indirect land use change, organic farming, computable general equilibrium, EU agricultural policies

JEL classification: F11, F18, Q15, Q18, Q56

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1. Introduction

While making it possible to feed the EU population, European agriculture has generated several negative externalities over the last decades, affecting soil, water and biodiversity (EEA, 2010). Agriculture is responsible for a large share of the pollution of European surface water, aquifers and coastal seas by nutrients and pesticide residues (EEA, 2012). The combination of modern production techniques, the use of chemical inputs, the draining of wetlands and the uprooting of hedges has led to dramatic erosion in farmland biodiversity, as testified by the sharp decline observed in farm bird populations (EBCC, 2012). The long term sustainability of modern agriculture is questioned, given the risk that soil erosion and compaction and the decline in pollinators become limiting production factors (Jones et al., 2012; Klein et al., 2007; Bauer and Wing, 2010). Furthermore, these externalities generate economic costs of billion euros (Sutton et al., 2011b,a; Gallai et al., 2009; Allsopp et al., 2008; Boyles et al., 2011; Sumner and Boriss, 2006).

1.1. The disappointing attempts to 'green' EU agriculture

Such concerns and the related economic costs have led to a series of policy measures. Since 1992, Agri-Environmental Schemes (AES) have been introduced in the Common Agricultural Policy (CAP). They are designed to compensate farmers for voluntary actions protecting the environment that go beyond standard practice. While they have helped reducing some externalities, their cost-effectiveness has been found to be limited, mainly because of their high transaction costs (ECA, 2011). In parallel to the development of AES, those CAP subsidies that provided direct incentives to produce intensively have progressively been replaced by a more production neutral Single Farm Payment (SFP). The latter has been made conditional to good environmental practices. However, in practice, the conditions attached to the single farm payment have been lenient. And the impact of these reforms has recently been dampened by the higher prices for agricultural products. The recent CAP reform, the decision process of which ended in December 2013, actually failed to impose stricter environmental conditions on agricultural production. The principle that at least a share of a farmer's direct payment should be justified by environmental friendly production practices has been definitly established. But the new green payment that has been defined on this basis will have only an extremely limited impact on the ground (Matthews, 2013).

1.2. A more ambitious development of organic production?

Taking stock of the failure to make the CAP greener, there are calls for promoting a more radical reorientation of EU agriculture towards more environmentally friendly practices. Since a rather fuzzy set of this type of practices is proposed in the agro-environmental literature, we choose to focus on organic techniques, the specifications of which are defined by EU Regulations EC/834/2007 and EC/967/2008. The 2004 EU action plan for organic farming has not set a EU-wide target, but many Member States did it at their national level: France set a target of 20% of arable land grown organic in 2020 ; Ireland set a target of 5% in 2012 in a 2008-2012 Action plan; the 2007-2013 Austrian action plan maintains a target of 20% of organic land; the Plan of Long Term Development of organic farming of Slovenia set a target of 20% of organic land by 2015[2]. These national policies translate into an acceleration in the growth of organic agriculture in the EU. The EU-27 area under organic farming (including fully converted and

[2]Results of the European Commission funded research project ORGAP, http://www.orgap.org/

under conversion areas) increased by 7.4% between 2009 and 2010, by 42% between 2009 and 2006)[3], even if the total surface still accounted only for 5.1% of the EU Total Utilised Agricultural Area in 2010.

1.3. Local benefits vs. indirect effects

More focus on organic production would have several benefits. Organic production was found to result in higher soil organic matter content, less nitrogen and phosphor losses, less N_2O emissions, less energy use, lower eutrophication potential and a positive impact on biodiversity (Tuomisto et al., 2012; Mondelaers et al., 2009). Importantly, the rules governing organic farming leave little place for moral hazard, compared to the complex definition of terms of reference for agri-environmental scheme that often lead to windfall gains and information rents. Certification procedures have been successfully tested over several decades.

However, at a large scale, organic production might have some undesirable effects. In particular, there is a risk of indirect, international effects that can be paralleled with the well-known carbon leakage, i.e. the risk that, by making domestic production more costly or less competitive, an environmental measure leads to a displacement of production resulting in a less positive global environmental balance than expected. These effects have so far been poorly documented concerning a greening of the CAP. The European Commission's impact assessment of the CAP reform tends to focus on the direct, i.e. intra-EU effects (EC, 2011). Efffects on developing countries are documented in Cantore (2012). Recently, Britz et al. (2013) show that ecological set-aside, if implemented in the EU, would have some (limited) indirect consequences on greenhouse gases emissions in distant countries, such as Canada, through landuse chages. A much broader literature on the indirect effects of EU agricultural policies has been developed on the impact of biofuel policy (Taheripour et al., 2010; Britz and Hertel, 2011; Laborde, 2011; Havlìk et al., 2011). Even though results vary considerably across studies, large land use change effects have been measured when EU land is channelled into the production of energy crops (De Cara et al., 2012).

In a way that shows similarity with setting land aside or diverting it for non-food use, the mechanisms at stake in case of a large shift of EU agriculture towards organic production can lead to cross-market and cross-countries displacement effects. Recent studies have found significant yield gaps between organic and conventional production methods. Seufert et al. (2012) found in their meta-analysis an average organic-to-conventional yield ratio of 0.75, this gap varying according to crops (0.89 for oilseed, 0.74 for cereals, 0.63 for vegetables). Tuomisto et al. (2012) find a similar aggregate figure, with a standard deviation of 17% and Ponti et al. (2012) find that organic yields are on average 80% of conventional yields, with possible substantial variations (standard deviation of 21%). With sizeable differences in yields, an increase in the share of crops produced organically mays result in a decrease of the European food supply. New relative prices may change the EU agricultural trade balance, hence some macroeconomic impacts. This may also change net exports in the rest of the world. Depending on demand, the changes in prices may lead to put land in production, or to intensify current agricultural production outside the EU, and therefore to release greenhouse gases or to harm biodiversity. Depending on their extent, the negative impacts of the changes in land use generated by a major shift to organic farming might offset direct benefits (Roca, 2003). Since the pioneering work of Searchinger et al. (2008) it has often been argued that such indirect

[3]Eurostat *food_in_porg1* database

effects should be taken into account when assessing the Greenhouse Gases (GHG) emission consequences of substituting biofuels for fossil fuels. Because the price effects resulting from a more extensive agricultural production show some similarities with the channelling of feedstocks to the energy market, it is possible that rather similar LUC effects take place.

Such harmful consequences are not warranted, though. If, for example, the price effects are such that they trigger significant fall in demand, for example through shifts to a more vegetarian diets, indirect negative environmental effects would be minimal. The environmental effect of land displacement could be limited if expansion of production took place on unused degraded land rather than high natural value areas. In the case of a mandatory conversion or national targets on the share of land under organic production, it is likely that farmers would chose to allocate these lands where the yield gap and the economic costs of conversion are lower, or in the sectors where the price gap between organic and standard product is wider (fruits and vegetables, for example). The changes in the EU trade balance and the ILUC effects depend on how these effects will combine. Another key variable is the evolution of organic yields. Indeed, many authors consider that the yield gap can be significantly reduced with increased R&D in organic production techniques. The growth of the demand for organic products and a widespread use of organic techniques may increase the investments in research dedicated to organic farming and thus lead to a faster increase in organic yields. A reduced difference between the yields of organic and conventional methods would then result in a diminution of indirect negative effects. The overall consequences are therefore ambiguous and there is a need for quantification of the various mechanisms at stake.

2. Methodology

In addition to the impact on consumers, a shift to organic production also has an impact on the demand for intermediate consumption. A lower use of fertilizers and pesticides, a change in the demand for capital would modify the structure of the input industry. The induced changes in relative prices, production and trade in farm and non farm sectors depend on the substitution and complementarity between chemicals, capital and petroleum products (organic agriculture could require less treatments but more mechanical intervention e.g. for weeding, for example). In order to assess these effects it is important to take into account the new economic equilibria that would take place in what is sometimes called a 'systemic' Life Cycle Analysis (LCA) approach. A way to do so is to construct a General Equilibrium (GE) model in order to assess the impact of EU policies on a given product on third markets in third countries, accounting for a series of domino effects. This approach makes it possible to compare the current situation to a counterfactual one where the EU would have converted part of its agriculture into organic, while taking into account market adjustments, and supply and demand reactions in the different parts of the world.

Simulations rely on the framework developed under MIRAGE, a multi-country, multi sector recursive dynamic model. MIRAGE was originally developed to assess the impact of trade negotiations (Bchir et al., 2002; Decreux and Valin, 2007). Building on this framework, a specific version that distinguishes land allocation was developed to assess the LUC impacts of some specific policies, in particular the biofuel policies, by a team of modellers from the International Food Policy Research Institute, the International Institute for Applied System Analysis and the French Institut National de la Recherche Agronomique (see Laborde and Valin (2012)). The representation of land markets relies on a nested structure of constant elasticities of transformation, so as to account for the various possibilities of land substitution and expansion in each agro-ecological zone within each country. Land extension is endogenously calculated but also integrates an historical trend to track non-market-driven land-use change. The possibilities of substitution between crops have been refined, distinguishing agro-climatic conditions. The calibration of elasticities has benefited from a particular effort. A highly detailed database has also been built, introducing new sectors and recalibrating production technologies in the GTAP database (Narayanan et al., 2008) in order to ensure the consistency between values and volumes. This is of particular importance for our simulations, since physical linkages and substitutions play a critical role in the assessment of demand displacements and land use change.

Building on MIRAGE-Biof, we constructed specific demand and supply systems to explicitly represent the organic sector. A specific organic production technology was introduced, and consumers' preferences between conventional and organic products were also represented[4]. This required constructing a consistent set of social accounts that makes possible to represent the economic situation of organic products and the linkages with the production and consumption of non organic products, as well as the linkages with the other sectors.

Data availability is one of the main difficulties faced when building the new database. Characterization of the production technology in the organic sector runs into the lack of consensus regarding the yield gap with conventional agriculture. While some studies show that in experimental conditions it is possible for organic farming to reach yields that are similar to conventional production, it often depends on the ability to use more labour, hence some possible violation of the separability assumptions that are implicit in the functional forms used in GE models. And for certain agricultural productions, giving up chemical inputs (often used as a way to reduce production risk) generates more irregular output. Uncertainty also prevails on the ability of improving yields in organic production, since the there has been so far little research on organic farming or on agroecology compared to conventional agriculture. High rates of technical change in the organic sector are plausible in the future. We then choose to calibrate the production technology and the yield changes when shifting from standard to organic production on microeconomic data. We used data from the European Farm Accounting Data Network, which includes since 2000 an identifier variable for organic farms. The average organic to conventional ratio we obtained from Farm Accounting Data Network (FADN) for maize, rapeseed, sunflower and wheat is 0.68, which is a little bit lower than the average value of 0.74 found by Seufert et al. (2012) for cereals but seems nevertheless be in the range of the ratios they observed. To calibrate the area dedicated to organic crops, we used data from Eurostat, which reports areas under organic practices for many different crops. Data reported for recent years are accurate and are available for almost all European countries. MIRAGE-BioF model integrates an endogenous yield response to shock in fertilizers price and to increase in demand. This feature allows for an evolution of crop yields, including organic yields, depending on market evolution. The land supply constant elasticity of transformation tree of MIRAGE-Biof was amended to differentiate between organic and conventional land for each crop, adding an extra substitution level in the three. That is, the calibration reflects the current organic technology, rather than the one obtained if producers reduced the gap with

[4]Note that the use of a specific representation of the organic production technology, instead of a shock on factor productivity, is a key specification here. Indeed, it has been shown that the organic and conventional production technologies are not homogeneous (Mayen et al., 2010). Organic technology was introduced for maize, rapeseed, sunflower and wheat in the model.

potential yields obtained in experimental conditions, but accounts for the impact of prices on yields.

Calibration of the demand system also runs into limited data availability. Existing studies focus on final goods and not on rough products, mainly used as intermediary consumption, as it is the case for the crops we analyze. In our calibration of the demand system, organic and conventional crop productions are aggregated in a virtual good that is used by other sectors, by final domestic consumers and by foreign demand. Few econometric studies deal with the elasticity of demand for organic products, and they focus on very specific products aimed at final consumption. We used these estimates to choose the elasticity of substitution between organic and conventional production system, but the parameter lacks solid micro- foundations. This is why sensitivity analysis will be carried out on the simulations.

To calculate emissions from land use change, we rely on the guidelines for National Greenhouse Gas Inventories of the International Panel on Climate Change (IPCC, 2006), following Bouët et al. (2010). We use the Tier 1 methodology, which provides generic estimates of the carbon stocks in different climate zones (these climate zones are matched with the agro-ecological zones used in the Mirage-BioF model following Bouët et al. (2010)). We consider the emissions due to (a) the conversion of forest to other types of land (deforestation), (b) the cultivation of land. We compare the carbon stocks in forest biomass and in soils (forest + cultivated) in 2020 in our scenarios to the carbon stocks in 2020 in the baseline in order to estimate the carbon emissions due to land use change in our scenarios. At this stage, we consider only emissions of carbon, although nitrous dioxide releases are recognized to play a significant role.

2.1. Simulations

The scenarios we build are implemented on a baseline starting in 2004 and extended through 2020, in which we reproduce the present rate of adoption of organic farming in the European maize, sunflower, rapeseed and wheat sectors. We also include in the baseline the existent programs and announced commitments of biofuel policies (for details on biofuel programs included in the baseline, see Laborde and Valin (2012)) since they represent an important part of the agricultural demand of the next years. Precise data on consumers' preferences for each considered organic crop are not available but we used recent results estimating that the average market share for organic products in the EU is around 2% in 2010 (Agence Bio, 2012; Willer, 2012)(Eurostat data). After 2010, we consider a slight increase in the consumers' preferences for organic products: our hypothesis is that the market share of organic products will reach 5% by 2020, a value that is compatible with the historical trend.

In the policy scenario that we identify hereafter as the *ORG* scenario, the EU requires 20% of area cultivated for maize, rapeseed, sunflower and wheat to be under organic farming practices by 2020. We chose the rate of 20% since this figure is targeted in the organic action plans published by several European Member States (see above). We implemented the mandate progressively, in a linear fashion from 2010 to 2020, in each agro-ecological zone of EU. The 20% target is calculated as the ratio of the total organic land over the total land (conventional and organic) dedicated to the crops we focus on, rather than on each crop. At crop level, a share of land under organic practices greater than 20% is therefore allowed. Consumers' preferences are the same as in the baseline. To reach the policy target, the consumption of organic products is subsidised. Then, to ensure the budget neutrality of the policy, an equal cost tax is added on the total (conventional and organic) consumption of the considered crops, as recommended in Kretschmer and Peterson (2010).

3. Results

3.1. Supply and demand effects

A EU-wide mandate on the share of organic land is a strongly effective way to support the development of the organic sector: organic area and produced quantities are multiplied by 12 by 2020 in our ORG scenario with respect to the baseline. The implemented subsidies modify consumer relative prices of organic and conventional products. Therefore, the demand for organic products increases, followed by producer prices. Organic production raises, mainly through the expansion of the area dedicated to organic crops and, to a much lesser extent, through the increase in the use of other production factors. Conventional crop production increases in the ORG scenario, but less than in the reference scenario. This effect mainly comes from a decrease in the land used for conventional crops, even if this decrease is partially compensated by a slight raise in the use of fertilisers and other production factors. The total (conventional + organic) area dedicated to each crop is (almost) constant between the two scenarios in 2020, as shown in table 1. The main observed effect is the substitution of conventional crops by organic crops on the same land, which results in the expansion of organic area and a reduction of the conventional one, with respect to the reference scenario.

Table 1. Area and yield changes

	Area (10^3ha)			
	2010	2020		
Crop	REF	REF	ORG	% Var
Maize	9 934	9 835	9 824	-0.1%
Maize_norg	9 878	9 713	8 134	-16.3%
Maize_ org	56	122	1 690	1 285.5%
Rapeseed	4 678	4 591	4 565	-0.6%
Rapeseed_norg	4 661	4 560	4 210	-7.7%
Rapeseed_org	18	30	356	1 070.1%
Sunflower	3 680	3 603	3 601	0%
Sunflower_norg	3 647	3 532	2 689	-23.9%
Sunflower_org	33	71	912	1 178.6%
Wheat	26 449	26 051	26 120	0.3%
Wheat_norg	26 104	25 510	19 927	-21.9%
Wheat_org	344	541	6 193	1 044.7%
Total organic	451	765	9 151	1 096.6%

Organic yields being lower than conventional ones, the substitution in land uses translates into a negative supply shock in the affected sectors. This shock is significant: the European production of wheat decreases by more than 12 million tons and the maize production by 4.2 million tons. As a consequence, world prices are affected (+3% for maize, +2% for rapeseed, +2% for sunflower and +4.4% for wheat) and global demand and production are displaced.Table 2 displays the distribution of the change between supply and demand on each market. The decrease in the European supply is partially compensated by an increase in other regions' production. The increase in the world price due to the supply shock also leads to a demand displacement. In the case of wheat, the greater displacement comes from the livestock sector. Since the relative price increase of wheat is greater than the relative price increase of other crops, the livestock sector displaces its demand from wheat to maize, sunflower and rapeseed. Notwithstanding this displacement, the European demand for crops as feedstock decreases by 1.43%, the demand for proteins in animal meals increases by 1.45% and grazing plays a more important role. Indeed, the EU pasture area slightly increases in the ORG scenario. In the case of rapeseed and sunflower, the main demand displacement comes from the vegetable oils sectors and in the case of maize, it comes from the final consumption. The demand displacement is allowed by the elastic demand and helps to dampen the effect of the EU mandate on world markets and land use changes.

Table 2. Market balances (1 000 tons) in the ORG scenario, with respect to the reference scenario

	EU27	Brazil	USA	RoW	World	World Prices
Maize						
Supply	-4 266	779	751	1 326	-1 410	+3%
Final demand	-118	-5	-3	-682	-808	
Livestock demand	70	-209	-19	778	621	
Other demand	-299	-47	-501	-746	-778	
Rapeseed						
Supply	-807	1	-1	-56	-864	+2%
Final demand	0	0	.1	0	-1	
Livestock demand	21	0	2	34	57	
Other demand	-530	0	-1	-776	-920	
Sunflower						
Supply	-261	1	-1	-76	-337	+2%
Final demand	0	0	0	0	0	
Livestock demand	33	0	4	43	80	
Other demand	-166	1	-5	-494	-417	
Wheat						
Supply	-12 335	105	229	3 086	-8 919	+4.4%
Final demand	-182	-3	-4	-359	-549	
Livestock demand	-2 141	-7	-327	-4 565	-7 093	
Other demand	-913	-120	-20	-546	-998	

As a consequence of the decrease in the quantities produced, the change in prices and the demand displacement, the EU trade balance deteriorates, as shown in Table 3. The net trades of maize, rapeseed, sunflower and wheat respectively decrease by 57.8%, 17.2%, 44.9% and 26.7%. The production of rapeseed and sunflower oil also decreases and their imports raise. The demand for these oils is partially displaced to palm and soybean oils, which trade balances also decrease. Interestingly, EU trade balance of the cattle sector improves. As said before, livestock grazing develops in Europe and therefore producer prices of cattle augment relatively less in Europe than in other regions. Hence, European imports decline and exports increase leading to an improvement of the trade balance. The shock in the European supply does not change the ranking between regions exporting to Europe, even if the increase in exports is not perfectly homogeneous across exporters.

Table 3. European Union net trade in 2020 (1 000 tons)

	2008	2020		
Sector	REF	REF	ORG	% Variation
Maize	-2 685	6 782	2 862	-57.8%
Rapeseed	-2 123	-1 729	-2 027	-17.2%
Sunflower	-809	-286	-414	-44.9%
Wheat	10 062	34 116	25 017	-26.7%
Soybeans	-23 333	-26 255	-27 066	-3.1%
OilPalm	-2 665	-2 982	-3 051	-2.3%
OilRape	2	-60	-73	-20.9%
OilSoyb	-173	-602	-635	-5.5%
OilSunf	-322	-335	-360	-7.5%
PalmFruit	-65	-91	-93	-1,9%
Cattle	-273	907	936	3.2%

3.2. Land use changes and GHG emissions

Changes in demand and production lead to a change in land use across regions. Globally, through the changes in prices and production and demand displacements, the European target of 20% of maize, rapeseed, sunflower and wheat surfaces converted to organic production requires around 760 000 ha of land to be converted worldwide to grow new crops, as shown in table 4. The first source of land converted to cropland is pasture and to a lesser extent forest.

Assessing the global environmental impacts is difficult. Valuation of the ecosystem services gained and lost is not realistic at the global level, given the heterogeneity of these services and their valuation across regions and local specificities. A metric that is often used is GHG emissions. This approach faces severe criticisms (Tittonell, 2013). Clearly, this should not be the only criterion when assessing environmental impact, but it is a useful proxy for more energy use and more deforestation. Estimates on the case of the ORG scenario suggest that the related land use changes would emit around 116 million tons of CO_2 equivalent by 2020. We also computed the NDF, as defined in Plevin et al. (2010). We found an NDF of 0.09, meaning that the changes in relative prices induces 0.09 hectare of additional cropland to be put under cultivation anywhere in the world for each additional hectare of organic maize, rapeseed, sunflower or wheat in Europe. We can compare these estimates to other values found in the literature, for other policies: Laborde and Valin (2012) found a NDF value between 0.19 and 0.2 for the European biofuel policy and Plevin et al. (2010) consider values in the range from 0.25 to 0.8 for US corn ethanol.

4. Conclusion and extension

We show that a greening of the EU agriculture, which we modeled through a strong increase in the land dedicated to organic farming, has sizeable indirect effects in terms of price changes, demand and production displacement and land use change. Of course, our results

Table 4. Land use changes

	2008	2020	
		Area increase	Carbon emissions
	10^6 ha	10^3 ha	$MtoeCO_2$
Region and land type	REF	ORG	ORG
EU27			
Cropland	92.7	26	
Pasture	69.4	7	
SavnGrasslnd	19.6	-4	2.3
Other	51.6	-3	
Forest managed	147.5	-26	6
Forest primary	6.8		
World			
Cropland	1 257	759.5	
Pasture	1 245.1	-419.4	
SavnGrasslnd	3 414.7	-76	63.1
Other	2 843.5	-69.6	4.7
Forest managed	821.6	-182.3	45.5
Forestprimary	3 100.7	-12.1	3.2
Total			116.5

should be placed in a broader analysis framework. Indeed, the global negative effects we describe have to be balanced with the well known local benefits that organic farming practices generate. Therefore, indirect effects could be integrated in a Life Cycle Assessment (LCA) of the environmental impacts of organic crops. This kind of LCA for the organic crops are not numerous, LCA on organic products focus more on milk, vegetables or fruits. Nevertheless, Meisterling et al. (2009) conducted an hybrid life cycle assessment to compare the global warming potential of conventional and organic wheat in the US. They found that the global warming potential of 1 kg loaf of organic wheat bread is about 30g of CO_2 equivalent less than the conventional wheat loaf. Following the assumption of Meisterling et al. (2009), this figure correspond to a difference of about 45 g of CO_2 equivalent between organic and conventional wheat (and not bread) at farm gate. Making some (strong) assumptions, namely that the assumptions made by Meisterling et al. (2009) for the US wheat hold for the wheat produced in the EU and that these results can be generalized to the other organic crops we study (maize, rapeseed, sunflower), we can compare our results to the figure of Meisterling et al. (2009). We find that, in 2020, the production of organic crops in the ORG scenario exceeds by 38 million tons the production in the reference scenario. This surplus generates the emission of 116 million tons of CO_2 equivalent, through the land use changes it induces. In other words, 1 kg of organic crops would emit around 3 kg of of CO_2 equivalent more than 1 kg of conventional crops because of land use change. These 3 kgs more than compensate the 30 g of of CO_2 equivalent that Meisterling et al. (2009) found to be saved by organic production methods. Of course, this reasoning is not totally satisfactory. Indeed, the life cycle assessment made by Meisterling et al. (2009) only consider the energy and greenhouse gases tradeoffs between organic and conventional wheat productions and does not include considerations on eutrophication, human health, resource depletion, biodiversity, soil quality, rural development… Nevertheless, a good comprehension of the mechanisms at stake will be necessary to build policies that limit the negative global effects of the promotion of environmental friendly practices in agriculture, while enhancing the local benefits.

One of the next steps will be to improve the integration of our results in a life cycle assessment framework. We will also refine our results by improving the regional disaggregation of our model, in order to precisely track demand and production displacements across regions. Our work will be completed with an accurate sensitivity analysis on key parameters of the model. We will also include a more realistic representation of organic international markets. The EU is a net importer of organic products. Before authorizing imports, certification bodies must verify and label organic production methods in the exporter countries, following European regulations, on a case by case (product + country) basis. These procedures are difficult to represent in a CGE model but recently, the EU has signed trade agreements with some countries, recognizing that their organic production methods are equivalent to the European ones. In particular, in February 2012, a free trade agreement for organic products has been signed with the US. The incorporation of organic trade in our model would modify the effects on global price systems and thus on land use.

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