THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

BRIEFING

FEBRUARY 2013

# Vegetable oil markets and the EU biofuel mandate

## SUMMARY

An important question when estimating the indirect land use change emissions from biodiesel feedstocks is whether vegetable oils replace each other in the market, so that increased demand for one may result in increased production of another. In particular, it is important for the European Commission's estimation of iLUC factors whether palm oil production increases to meet EU demand for rapeseed oil biodiesel. Data from FAOstat show convincingly that since 2000, increasing rapeseed biodiesel demand has been met not only by increased rapeseed production and area but also by increased palm oil imports. Expansion in European vegetable oil production has been inadequate to meet biodiesel demand on its own, and palm oil imports have risen dramatically in the same period that biodiesel mandates have been introduced and ramped up. Prices of rapeseed oil, soy oil and palm oil are well correlated, suggesting that the markets for these oils are well connected. It has been argued that expanded rapeseed expansion will have a limited or zero displacement effect on other crops because it is a 'break crop' used in rotation with wheat. This contention is undermined by data clearly showing a large drop in the area of other break crops in parallel with increases in harvested rapeseed area.

The modelling of iLUC by IFPRI for the European Commission assumes that vegetable oil markets are fungible, and this assumption is well supported by the data. Based on consideration of FAO production and trade data, there is no reason to believe that IFPRI overestimates the role of palm oil in meeting EU food oil demand when rapeseed oil is displaced to biodiesel production, and there is therefore no reason to believe that the attribution by IFPRI of peat emissions to European biodiesel production is excessive.

# INTRODUCTION

Since the year 2000, the European Union's consumption of biodiesel has increased dramatically, from less than five hundred thousand tonnes in 2000 to just over ten million tonnes in 2010. Most European biodiesel is made from vegetable oil, so this rapid increase in demand has had a significant impact on European vegetable oil markets (for comparison, European rapeseed oil production in 2000 was only four million tonnes according to FAOstat). This leads us to the question of how the additional vegetable oil used for all that biodiesel was made available? Did European production increase, did imports go up or was it taken from other uses – and if it was some combination of these, in what proportions and which feedstocks were used?

This question becomes particularly important when we discuss the indirect land use change (iLUC) caused by expanding the biofuel mandate. Indirect land use change occurs when increased demand for agricultural commodities causes the agricultural frontier to expand into existing ecosystems. It doesn't matter whether the new production is actually used in a biofuel plant, or whether it just fills the gap in the market because existing production has been diverted – from an environmental point of view, the most important question is whether carbon emissions are caused by the land use change, and how big they are. Because we expect different vegetable oils to have different relationships with land use, working out which crops have expanded to meet additional vegetable oil demand is vital to quantifying the iLUC emissions. For example, the case of palm oil expansion is particularly stark, with around a third of new palm oil expansion in Malaysia and Indonesia occurring at the expense of peat ecosystems (Miettinen et al., 2012a, 2012b) and resulting in massive carbon dioxide emissions (Page et al., 2011).

In October 2012, the European Commission released a formal proposed that iLUC should be reported by biofuel suppliers under the Renewable Energy and Fuel Quality Directives, and suggested 'iLUC factors' to be used for different crop categories. The proposed emissions factors have been based on modelling by the International Food Policy Research Institute (IFPRI) using the 'Modeling International Relationships in Applied General Equilibrium' (MIRAGE) computational model. Because the modelling results suggest that biodiesel from oil crops is not a good GHG mitigation option for Europe, there has been extensive focus by stakeholders on the modelling, including the way that IFPRI treats vegetable oil markets in the model. In MIRAGE vegetable oils from different oilseeds are treated as being essentially fungible, meaning for instance that rapeseed oil could replace palm oil for any given application, and vice versa. In the IFPRI MIRAGE model, as in real life, palm oil is the cheapest available vegetable oil, and thus when demand for any other vegetable oil increases MIRAGE predicts that some of this increase in supply will come from palm oil. This idea of some degree of fungibility is consistent with our day-to-day experience (consider the number of processed food products at the supermarket that now have palm oil in) – but at the macro scale does an increase in rapeseed oil really drive an increase in palm oil demand (or soy oil, or sunflower oil etc.)?

## PRODUCTION INCREASE VS. IMPORTS

The first thing to ask is whether the biodiesel itself was produced in Europe or produced elsewhere and imported, and what feedstocks were used to make it. The lines on Figure 1 show data for European biodiesel production from the European Biodiesel Board (EBB), plus estimates of biodiesel imports to Europe taken from the US Department of Agriculture Foreign Agricultural Service (FAS). Clearly, the early years of the European biodiesel ramp up were characterised by rapidly expanding European production of biodiesel – but from 2006 foreign imports become an important element of ongoing growth. In 2008, we have also marked on the proportions of biodiesel coming from each feedstock according to the 2008 baseline in IFPRI MIRAGE's modelling of iLUC due to the EU biofuel mandate (Al-Riffai et al., 2011). Consumption of biodiesel from waste oil, sunflower and rapeseed matches up reasonably well with the volume produced in Europe, while it seems reasonable to assume that the soy and palm biodiesel was largely imported[1]. Historically, most biodiesel has been produced from rapeseed, but tropical feedstocks are predicted by Laborde (2011) to become increasingly important in the feedstock mix.

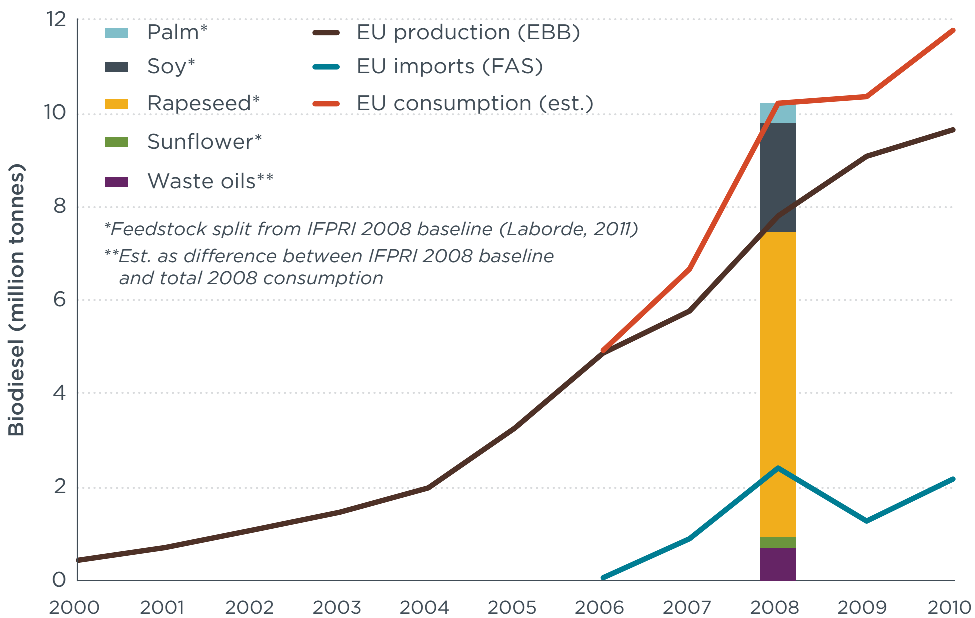


**Figure 1.** EU biodiesel production, imports and consumption 2000-2010, with 2008 feedstock mix (FAOstat, FAS, EBB)

1 Some soy and palm oil may also have been processed in European biodiesel plants.

## HOW LINKED ARE VEGETABLE OIL MARKETS?

Thinking in terms of domestic production and imports can be useful, but in the context of iLUC modelling the important question is not which feedstocks are being used for biodiesel, but which feedstocks are expanding overall to meet the extra demand for vegetable oil. In particular, when rapeseed oil is used for biodiesel, does that mean that more rapeseed oil gets produced, or that imports for food of other oils like palm oil increase?

Figure 2 shows that since 2000, rapeseed production has increased substantially, along with rapeseed harvested area. This fits with the accelerating introduction of biodiesel in the same period, and suggests that rapeseed area and production have indeed both responded to biodiesel demand. Sunflower, on the other hand, has shown relatively static production and area.

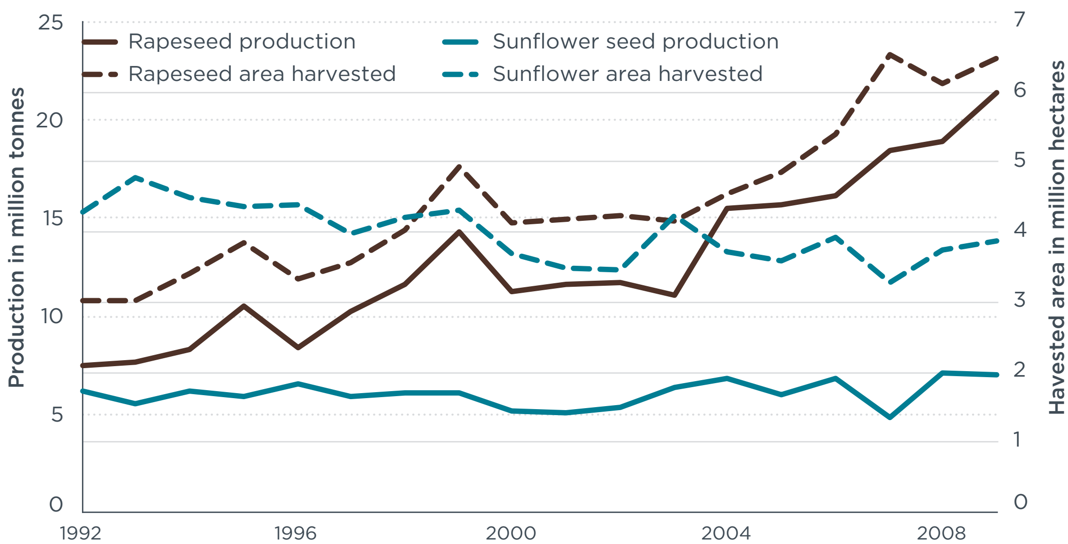


**Figure 2.** EU oilseed production and harvested area (FAOstat)

According to FAOstat, European rapeseed oil production has doubled from 2000 to 2010, an increase of 4.4 million tonnes, but this is still not enough additional vegetable oil to supply the full increase in demand for rapeseed biodiesel. According to the data shown in Figure 1, there was an 11 million tonne demand increase for biodiesel in that period, of which about 65% was rapeseed based – that would have required over 7 million tonnes of rapeseed oil. That suggests that even if all of the additional rapeseed oil went into biodiesel production, about 3 million tonnes of other vegetable oils would be needed to displace rapeseed oil in the market – or else that food consumption would have to fall to compensate.

***Interjection:*** *At this point, it's worth making a couple of caveats about the type of analysis that we're presenting here. In this briefing, we're using data largely from FAOstat to examine what has happened in EU and other vegetable oil markets since 2000, and compare that to demand for biodiesel. This can give us some useful insights into how causal relationships in the market* ***may*** *be behaving, but we should emphasise that it is not robust enough to draw rigorous causal connections. So, when we say that 3 million tonnes of vegetable oil needed to be 'replaced', this value is consistent with the data,* *but there may be other dynamics at work that we have not captured. For instance, it's possible that rapeseed consumption in food may have fallen sharply in this period for reasons unrelated to biofuel demand, allowing consumption to shift from the food sector to the biofuel sector. We would need additional evidence to categorically disprove such a hypothesis. Indeed, it is precisely because it is impossible to reliably quantify links between observed area expansion and demand increases across the globe that we fall back on economic modelling to provide estimates of iLUC emissions. In a model, it is possible to directly compare emissions in a scenario with biofuels to emissions in a counter factual with less or no biofuels, but of course in the real world there is no counterfactual available. What we have tried to present here is a narrative that provides a rational prima facie interpretation of the data that is available. We have highlighted key areas in which the data seems to be consistent with what we would expect if vegetable oils are indeed fungible, and drawn some simple comparisons between the historical data and the iLUC modelling with MIRAGE. Our narrative shows that the results of the iLUC modelling by IFPRI seem reasonable and fit with the patterns visible in trade and production data, and we would argue that any alternative explanation (in particular one purporting to support a hypothesis that vegetable oils are not fungible and vegetable oil markets are not well linked) would need to be carefully explained and supported with an analysis at least as robust and data supported as we have provided here.*

When we consider rapeseed alone we have an apparent shortfall in the market of three million tonnes of vegetable oil, so how is this excess demand being met – or is it not being met? Figure 3 shows that in the same period that rapeseed oil and biodiesel production were rising, the EU was reducing its vegetable oil exports and increasing imports. Indeed, from 2000 to 2010 as biodiesel consumption increased by 11 million tonnes, Europe's trade deficit in vegetable oil increased from about 1.5 million tonnes to 7.5 million tonnes, a change of 6 million tonnes. In Figure 4, we see clearly what this increasing deficit involved – a shift from being a net exporter of rapeseed and sunflower oil to being a substantial importer, and a large ramp up of palm oil imports. There has also been an increase in soy oil imports, but only to half a million tonnes in 2009; just one tenth of palm oil imports. Net EU palm oil imports rose by over 3 million tonnes in this period – which would be just enough, as it happens, to cover the apparent shortfall in rapeseed oil due to demand from the biodiesel sector.

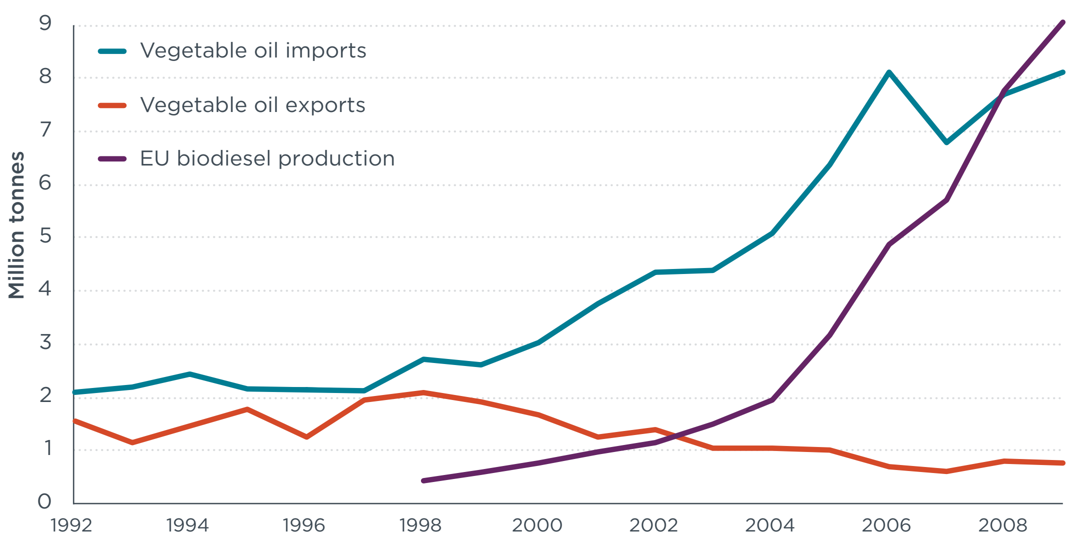


**Figure 3.** EU vegetable oil imports, exports and biodiesel production (FAOstat, EBB)*

** Vegetable oils included: sunflower, rapeseed, soy, palm, palm kernel*

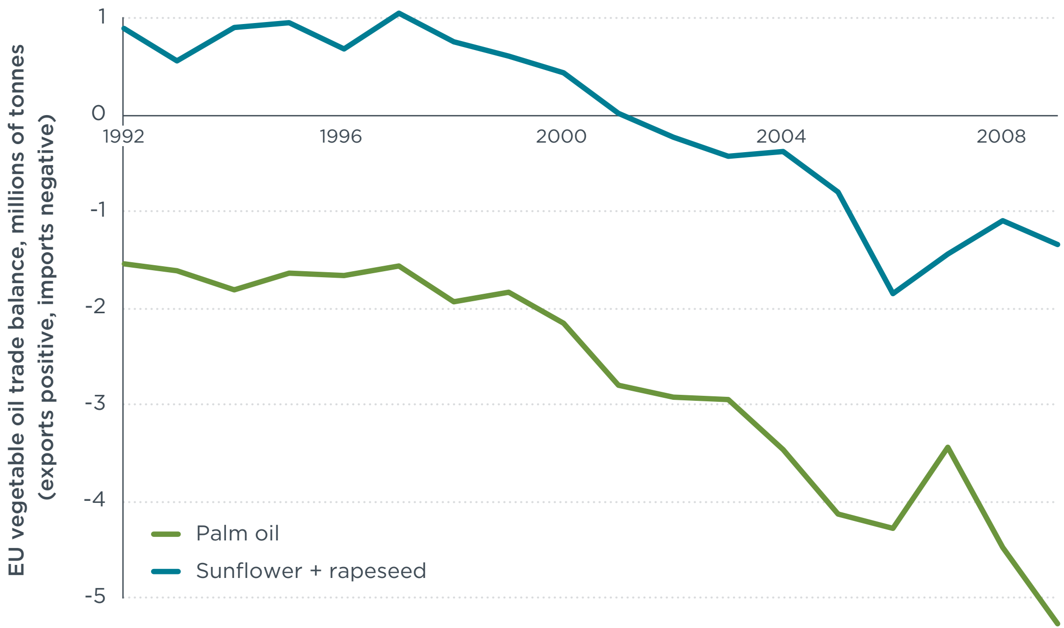


**Figure 4.** European trade balance for keyoils (FAOstat)

The data we have suggests that palm oil is not being directly processed into biodiesel in Europe (or at least not in volumes comparable to the amount of rapeseed oil used), but an obvious interpretation of the increase in palm oil imports is that they are being indirectly driven by biodiesel demand. Comparing the increase from 2000 to 2010 in European rapeseed oil production (4.4 million tonnes per annum) to the increase in palm oil imports (3 million tonnes per annum), we could hypothesise that something of the order of 40% of the increase in European rapeseed biodiesel demand may be being met indirectly through increased palm imports. This isn't a rigorous estimate that could or should be used directly in modelling work, but it gives some indication of the ballpark that it might be reasonable to work within. Certainly, the data strongly support the idea that vegetable oils are 'fungible' (i.e. that increased demand for one vegetable oil translates into a general demand increase across the market). For instance, in Figure 4, the graph for the trade balance in rapeseed and sunflower oils (largely grown in Europe) is remarkably well correlated to the graph for trade balance in palm oil, suggesting that the markets are well linked to each other. The data also seems to suggest that palm oil is the 'marginal' oil for Europe, the primary oil that is imported to meet any shortfall in domestic production.

Malaysia and Indonesia dominate global production and trade of palm oil, so we can be fairly confident that most of the palm oil imports to the EU comes from those countries. Figure 5 shows that Malaysia and Indonesia together account for 83% of palm oil production, while FAOstat data also show that they are the most export oriented of the major producers – Malaysia and Indonesia export 87% and 82% respectively of the oil they produce, while Nigeria, Colombia and Thailand export only 10%, 12% and 9% respectively of their domestic production. Similarly, European Commission trade data[2] shows that Europe spent 1.2 and 2.4 billion euro respectively

2 http://ec.europa.eu/trade/creating-opportunities/bilateral-relations/statistics/

on vegetable oil[3] imports from Malaysia and Indonesia in 2011, compared to 130 million euro to Thailand, 110 million euro to Colombia and recorded no imports from Nigeria. As noted above, palm oil expansion in Malaysia and Indonesia is strongly associated with land use change emissions from peat drainage, as well as deforestation and habitat destruction. It is therefore reasonable to conclude that there is a link from increased biodiesel demand in Europe, to increased palm oil production in Malaysia and Indonesia, to significant iLUC emissions in those countries.

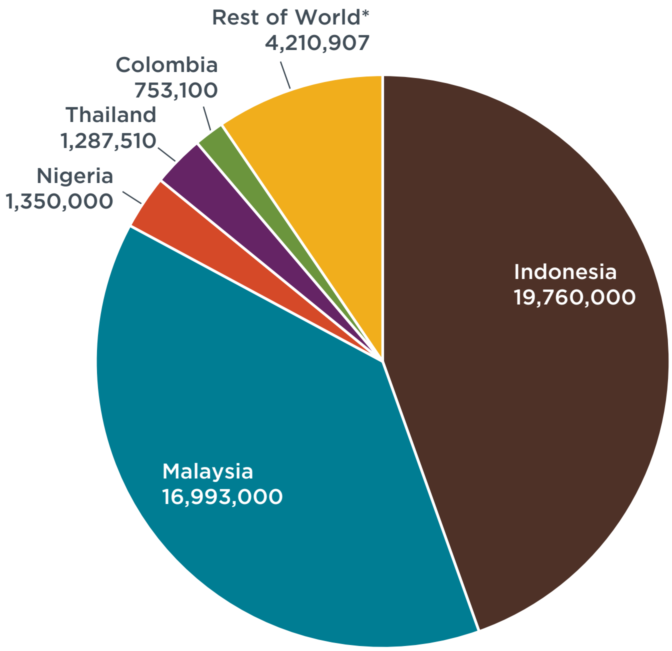


**Figure 5.** Global palm oil production (tonnes), 2010

** Production data for RoW includes countries processing feedstock grown elsewhere (e.g. Germany is reported as producing 640 kt in 2010, potentially from Malaysian or Indonesian feedstock)*

We have identified clear evidence that biodiesel demand has supported a significant expansion of rapeseed oil production in Europe, and an increased demand for palm oil from Indonesia and Malaysia, but there is a third piece in the puzzle as well. Despite the increase in European rapeseed oil production, exports of European oils have fallen since 2000 and been replaced by imports of rapeseed oil from outside the union, making Europe a net rapeseed oil importer (Figure 4). This suggests that there may have been an expansion of rapeseed area elsewhere – or of course a reduction in food consumption, or that rapeseed has been displaced in foreign markets by another vegetable oil, perhaps by more palm oil. Bauen et al. (2010) suggest that the most likely areas for rapeseed production to expand to meet increased European demand are Ukraine and Canada. India has been suggested as another possibility. Figure 6 shows that both Canada and Ukraine increased rapeseed exports, with Canada also significantly increasing rapeseed oil exports. India, on the other hand, shows no significant export growth – although palm oil imports increased substantially, this does not seem to have been required to replace exported material.

3 The full category is animal and vegetable oils, fats and waxes.

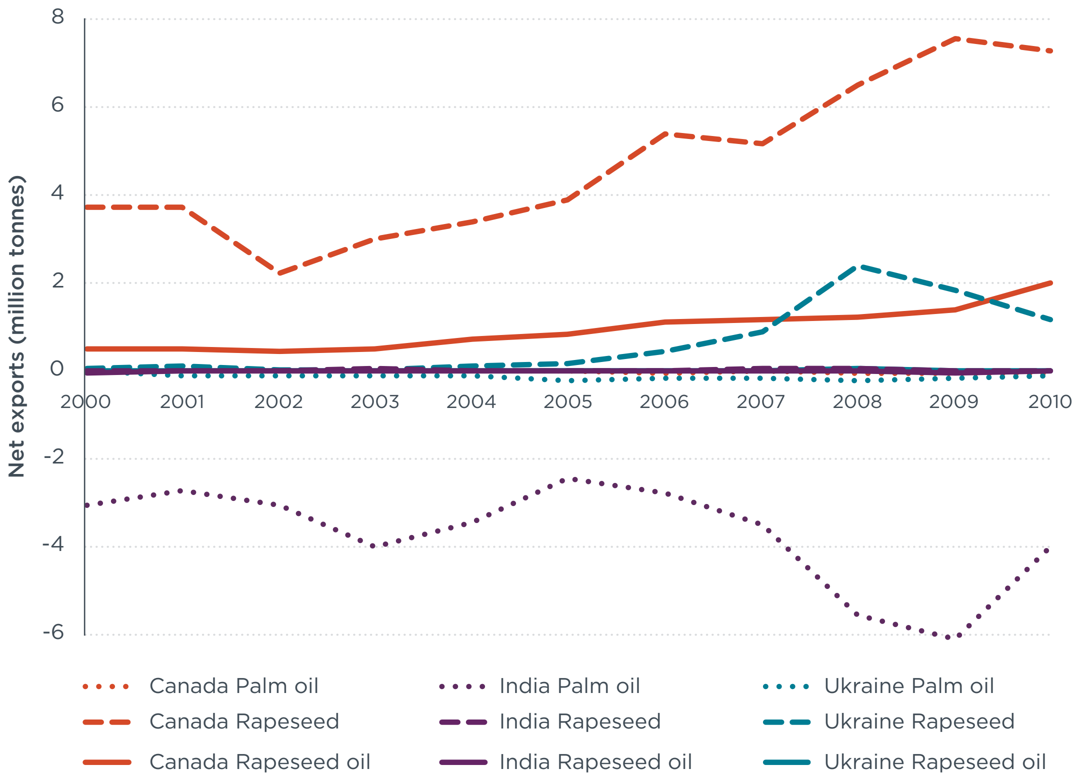


**Figure 6.** Trade balance in rapeseed, rapeseed oil and palm oil for possible exporter countries

The data on harvested area (Figure 7) show that not all of this increased production has come from increased yields – areas have risen, so the data is consistent with the possibility of land use change in the Ukraine and/or Canada being connected to European biodiesel expansion.

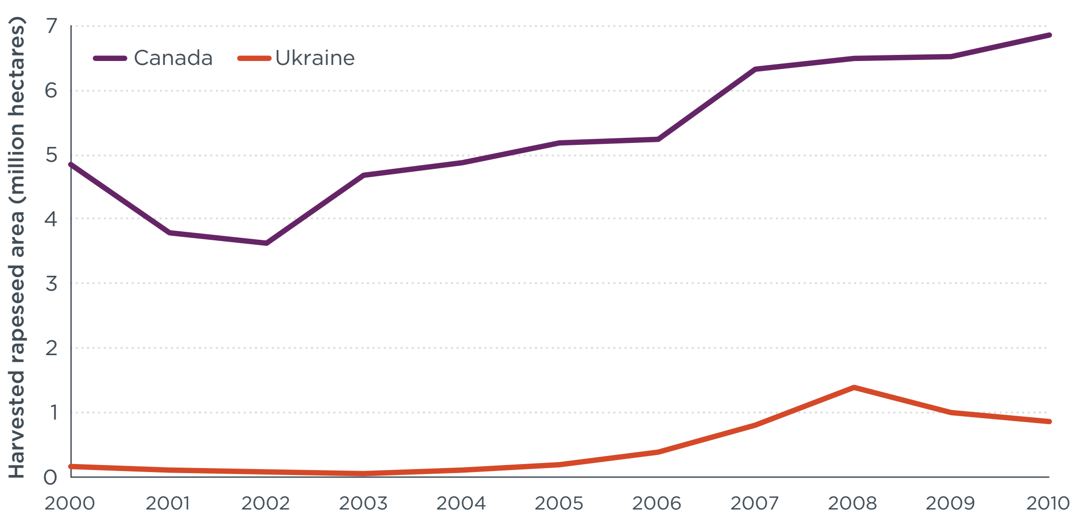


**Figure 7.** Harvested rapeseed area in Canada and Ukraine (FAOstat)

## VEGETABLE OIL PRICES

In the previous section we showed that the data on production and trade of oilseeds and vegetable oils seem to support the hypothesis that vegetable oil markets are well linked. Another thing one would expect to see in a well-connected market would be that prices of different vegetable oils would track each other relatively closely. For instance, if there were a poor rapeseed harvest in a well connected market we would expect not only the price of rapeseed to rise, but also the price of palm oil, soy oil and so forth. On the other hand, if different oils cannot readily displace each other, we would expect that the prices would behave differently – in that case, a poor rapeseed harvest would have little effect on palm markets.

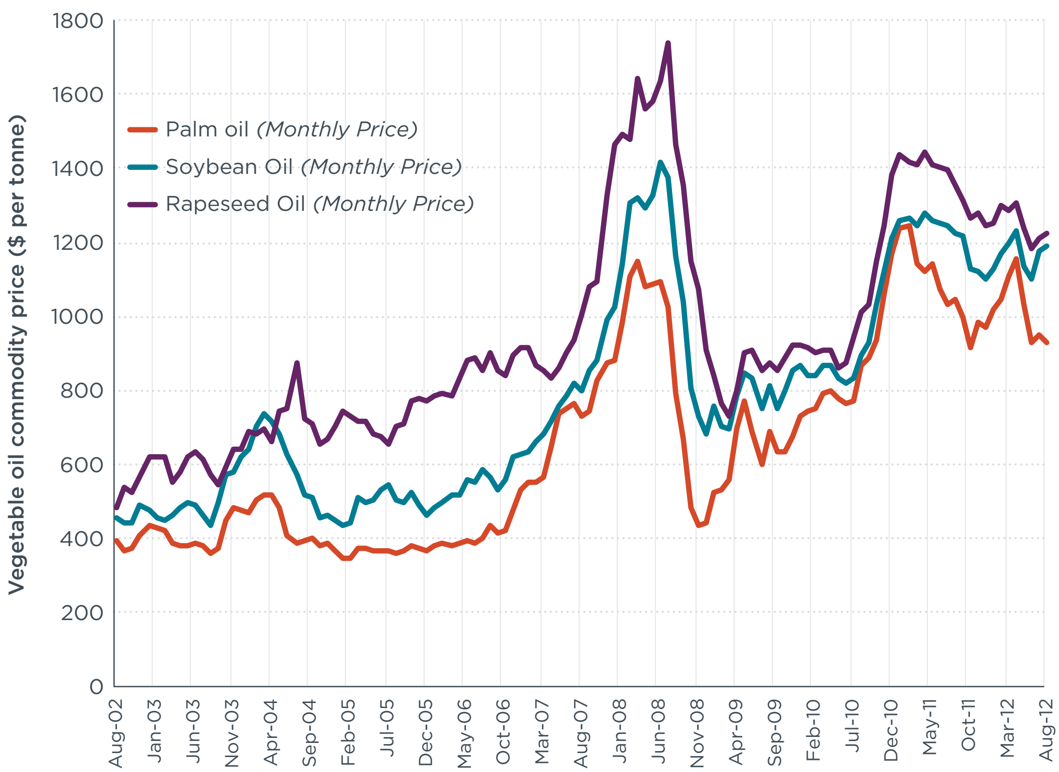


**Figure 8.** Vegetable oil commodity prices (World Bank)

Looking at the monthly price data in Figure 8, it seems clear that the prices of the key food oils (rapeseed, soy and palm) are well correlated with each other. The correlation coefficient between palm and rapeseed is 0.89, while over this period soy and palm are even more closely matched with a correlation coefficient of 0.97 (the maximum possible correlation coefficient is 1 for two sets of data moving completely in synchrony). Palm oil prices are consistently below rapeseed oil prices, but clearly they are subject to the same market pressures, strongly suggesting fungible products. If palm, soy and rapeseed oil were not fundamentally fungible, this price linkage would be a quite remarkable result.

## RAPESEED AND ROTATION

It has been suggested that it is an oversimplification of the agricultural sector to assume that an increase in rapeseed harvested area requires land use change, because rapeseed is generally grown in rotation. If an increase in harvested area of rapeseed really means an increase in the use of crop rotations (primarily for the existing wheat crop) rather than a displacement, then it has been argued that because crop rotation boosts average yields in wheat years and is considered good agricultural practice there will be less land use change than if rapeseed displaced an existing crop entirely.

According to 'UK Agriculture'[4], "Oilseed rape is always grown as part of a farm rotation and rarely returns to the same field more than one year in three. Other important break crops include potatoes, sugar beet, grass leys, peas and beans, all of which allow insects and fungal pests to die out between cereal crops." Given that rapeseed is generally grown as a break crop we might expect to see one of three things in the harvested area data when rapeseed expands:

1. As harvested rapeseed area increases, harvested wheat area reduces because rape is being put into continuous wheat as a rotational crop (this might also be accompanied by above-trend yield increases for the years wheat is grown);
2. As harvested rapeseed area increases, the area of other break crops diminishes because rapeseed is displacing break crops from existing rotations; or
3. Neither wheat area nor break crop area drops, suggesting that rapeseed is not entering a wheat rotation but being expanded as a monoculture against best practice, or is entering a non-wheat rotation.

Figure 9 shows the FAOstat harvested area data for rapeseed, wheat and the alternative break crops listed on the UK Agriculture website. We see that wheat area has been relatively static, though it did drop slightly (90 kha) from 2000 to 2010. Areas of other break crops, on the other hand, fell substantially in the same period: the total area for peas, beans, potatoes and sugarbeet declined by 2.5 Mha, while the area of rapeseed rose by 3 Mha. Again, correlation does not always imply causation, but these data are suggestive – they paint a picture of rapeseed replacing other crops in the rotation, and therefore displacing food production and causing indirect land use change if these lost crops are replaced elsewhere. Certainly, this data does not strongly support a hypothesis that rapeseed is entering the wheat rotation without displacement effects.

4 http://www.ukagriculture.com/crops/oil_seed_rape.cfm

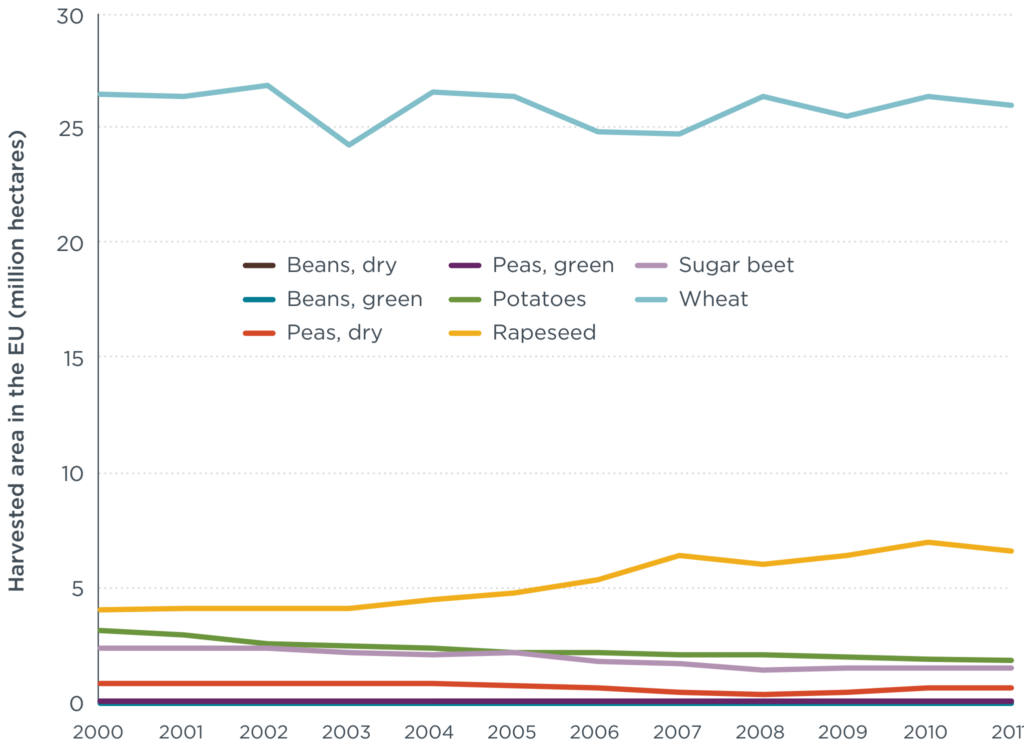


**Figure 9.** Harvested area of wheat and EU break crops (FAOstat)

## VEGETABLE OILS IN THE MIRAGE MODELLING

As noted above, MIRAGE treats different vegetable oils as fungible – one can replace the other in the model. The European Biodiesel Board (EBB) has led criticism of the IFPRI treatment of vegetable oil substitution in its MIRAGE modelling for the Commission, claiming in a position paper that, "the study assumes important substitutions effects between vegetable oils, which does not to correspond to the reality of the European biodiesel market (technical limitation on palm oil use for instance)." The EBB has implied that MIRAGE links rapeseed and other oil demand too strongly to palm oil supply, but this criticism seems to be ill founded. The trade and production data we've discussed above seem to suggest a reasonably clear narrative – increased demand for biodiesel has resulted in a combination of increased production of oilseeds in the EU, reduced exports of vegetable oil out of the EU and increased imports of vegetable oil including palm oil into the EU. This has almost certainly caused iLUC in Europe itself, in Southeast Asia, and in other countries linked to the vegetable oil market such as Canada. This narrative seems broadly consistent with the conclusions from the MIRAGE modelling, but let's take a moment to think through some of the details.

Laborde (2011) details the ratio in the MIRAGE modelling between increased demand for biofuel feedstocks and increase in the supply of those feedstocks – Table 1. For palm oil biodiesel, nearly the whole additional demand for biodiesel is accompanied by additional palm oil supply. Laborde explains that "any displacement of palm oil as a result of the increased demand for biodiesel production will have to be met by an additional supply of palm oil, the most competitive vegetable oil." Because palm remains consistently cheaper than other oils, consumers are unlikely to switch up to more expensive oils providing palm oil production can be increased. At the other extreme, when soy biodiesel demand increases, less than half is met by increased supply – 60 % comes from demand reduction, or other oils, probably primarily palm. Laborde explains, "This … does not mean that soybean oil disappears without being replaced. Instead, soybean oil is largely replaced by palm oil. This replacement explains why soybean noted the largest peatland effects (except palm)." Much of the value of the soy crop comes from soy meal rather than soy oil – a contrast to palm where the oil dominates the value of the crop. If vegetable oil prices increase without a corresponding increase in meal prices, this is a much less strong signal for soy expansion than for palm expansion. Again, the MIRAGE treatment seems to reflect reality.

Rapeseed falls in the middle – about 80% of rapeseed biodiesel comes from an increase in rapeseed production, but the other 20% comes from demand change and other oils, primarily palm oil. When we compared the increase in rapeseed oil production to the increase in palm oil imports to the EU based on FAOstat data, we found that perhaps 40% of additional rapeseed demand might be being met by palm oil. As we have noted several times, our naïve analysis of market changes gives a suggestion of what might be a reasonable value rather than rigorous transferable estimates. Still, the data is consistent with Laborde's modelling of vegetable oils as fungible and markets as well linked with palm oil playing a significant role in meeting increased demand for rapeseed oil for biodiesel. Indeed, if anything the FAOstat data suggests that Laborde may be underestimating the extent to which palm expansion will result from expanding biodiesel production rather than overestimating it. We therefore see no reason to believe that the attribution of peat emissions to the rapeseed biodiesel pathway by Laborde is excessive.

**Table 1.** How is additional vegetable oil demand met? (Laborde 2011)

| Feedstock | % of increased demand met by supply of that feedstock | % of increased demand met by palm oil/demand reduction/other oils |
|---|---|---|
| **Palm** | 97 | 3 |
| **Rapeseed** | 78 | 22 |
| **Sunflower** | 71 | 29 |
| **Soybeans** | 40 | 60 |

A review by the Kiel Institute of the IFPRI MIRAGE study, commissioned by the EBB (Delzeit et al., 2011), is also supportive of the conclusion that palm oil will be pulled into the market as rapeseed is increasingly turned into biodiesel. It comments that:

> *"The price competitiveness of palm oil leads to the substitution of non-energy uses of oils towards palm oil. However, since these demands cannot be met on current land areas devoted to palm oil production, there will be expansion, i.e. iLUC for palm oil plantations."*

The Kiel Institute review also supports Laborde's results that direct use of palm oil for biodiesel is likely to rise to 2020, noting that, "A recent study by Greenpeace Germany testing for biofuel admixtures in European filling stations found high shares of palm oil in the biodiesel shares (up to 80% in Italy), showing that this result is not unrealistic."

Indeed, it will become increasingly possible to use palm oil as a feedstock in the coming decade as hydrogenated vegetable oil processes such as that commercialised by Neste Oil make it possible to produce drop in ‘renewable diesel’ from palm, with no cold flow issues or blend limits.

A final detail in the Laborde modelling that seems consistent with the data we’ve looked at is a predicted reduction in the area for ‘vegetables and fruit’ in the EU. While the MIRAGE model does not have adequate resolution to distinguish between potatoes, peas and beans as break crops and other vegetable crops, there is a broad consistency between the prediction and the reduction in break crop area we see in the data.

## CONCLUSIONS

The MIRAGE modelling by Laborde (2011) has come in for criticism for assuming that there is a well connected world market for vegetable oils, in which one vegetable oil, in particular rapeseed oil, can be replaced by another, notably palm oil. Stakeholders have argued that the connection of rapeseed oil to palm markets is overstated, and thus that iLUC emissions from peat loss and deforestation in Southeast Asia have been unfairly attributed to the rapeseed oil biodiesel pathway. The evidence however, from data about global vegetable oil trade and production, tells a different story. In the past decade, the data suggest that the rise in the use of rapeseed oil for biodiesel has left a gap in the European vegetable oil market that has been filled by increased imports of palm oil. Far from MIRAGE overstating the connectivity between these markets, recent experience suggests that palm is indeed the world’s ‘marginal oil’, and that Laborde (2011) may even have underestimated the extent to which increasing EU biodiesel production could drive indirect land use change as forests and peatlands in Indonesia and Malaysia are replaced with palm plantations. The data also suggests, as is shown in the modelling, that the indirect effects may well result in land use change in other countries such as Canada as the price signal ripples through the global agricultural system. We also find no support in the data for the idea that rapeseed has entered the crop rotation without displacing other crops – rather, it seems likely that rapeseed expansion has been causing iLUC emissions and affecting food markets by displacing pre-existing break crops.

All in all, the treatment of vegetable oil markets by MIRAGE is reasonable and consistent with the evidence we have seen, and (as noted by Malins, 2012) reflects best practice in the field of CGE modelling. There is no reason on this score to believe that Laborde (2011) has exaggerated the likely magnitude of iLUC emissions.

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