Indirect Land Use Analysis – *The Impacts of a Rise in U.S. Biodiesel Demand*

OVERVIEW

The aim of this report is to analyze the indirect land use impacts of a rise in demand for soybean-derived biodiesel in the U.S.

The analysis is divided into three sections:

1. Part A examines the indirect land use effects in Argentina and Brazil, the principal exporters of soybeans and soybean products outside the U.S. This section also considers the pressure to move soybean production into forest areas in Brazil.
2. Part B analyzes the response by the U.S. biodiesel manufacturing industry to fluctuations in soybean oil prices and its implications for soybean area in the U.S.
3. Part C presents analysis of the global framework linking vegetable oil prices to the consumption and production of soybeans and their use in biodiesel production.

BACKGROUND

Under the Renewable Fuels Standard (RFS2), the biomass-based diesel requirement has been set at 1.0 billion gallons in 2012. With biodiesel production in 2008 at 690 million gallons, output would need to rise by just 310 million gallons to meet the 1.0 billion gallon target. **If this additional volume were met solely using soybean oil, it would require just 1.1 million metric tons of oil, which is a negligible volume globally**. To put this into context, global vegetable oil production from the major oils[1] in 2008 was 107.2 million metric tons.

Assuming biodiesel yields of 65 gallons per acre, the production of 1.1 million metric tons of soy oil would require less than five million acres of land. To put this into perspective, total US farmland was estimated at 922 million acres in 2007.

In early May, the Environmental Protection Agency (EPA) published its proposals on the implementation of the RFS2. A key part of these proposals is its initial conclusions regarding the greenhouse gas (GHG) emissions of various biofuels. The RFS2 stipulates that conventional biofuels produced from corn must achieve GHG savings of 20%. However, advanced biofuels, including biomass-based diesel, must achieve savings of 50%.

EISA defines lifecycle GHG emissions as follows: "The term 'lifecycle greenhouse gas emissions' means the aggregate quantity of greenhouse gas emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes), as determined by the Administrator, related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gases are adjusted to account for their relative global warming potential."

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[1] Total includes palm oil, soybean oil, rapeseed, and sunflower oil.

The EPA's draft results suggest that, when *indirect* emissions are considered, soybean-derived biodiesel will achieve a reduction in GHGs of just 22%, preventing it from qualifying for the RFS2 as biomass-based diesel. However, if only *direct* GHG emissions are taken into account, soy-based biodiesel would easily meet the 50% GHG reduction target. The EPA's analysis of net GHG emissions suggests that the bulk of emissions from soy-based biodiesel are the result of international land use change. In their preliminary results, these account for over half of the total calculated GHG emissions.

The indirect land use change impacts of biofuels, also known as ILUC, relates to the unintended consequence of releasing more carbon emissions due to land use changes around the world induced by the expansion of croplands in response to the increased demand for biofuels. As farmers worldwide respond to higher crop prices in order to maintain the global food supply and demand balance, pristine lands are cleared and converted to new cropland to replace the crops for feed and food that were diverted elsewhere to biofuels production. Because natural lands, such as rainforests and grasslands, store and sequester carbon in their soil and biomass as plants grow each year, clearance of wilderness for new farms in other regions or countries translates into a net increase in GHG emissions, and due to this change in the carbon stock of the soil and the biomass, indirect land use change has consequences in the GHG balance of a biofuel.

However, measuring ILUC in practice is fraught with difficulty and there is no agreed methodology on how to do it. The European commission has opted to delay inclusion of ILUC into its biofuels directive until it has conducted further research into the concept. The Council of Ministers and the European Parliament have called on the European Commission to study the ILUC equation, and "if appropriate" to draw up a new law by the end of 2010.

The analysis conducted by the EPA assumes that biodiesel production will rise from 0.4 to 0.7 billion gallons. Yet with biodiesel production today just below 0.7 billion gallons, their analysis is based on assumptions which are out of date. This casts doubt over the validity of their findings and in particular on their claims regarding the indirect land use impacts of soy based biodiesel.

SUMMARY CONCLUSIONS

- **Our analyses, suggest that a rise in U.S. soy-based biodiesel demand is likely to have minimal indirect land use effects in Argentina, Brazil and the U.S., the principal producers of soybeans.**
- **Our analysis of the relationship between the price of oils and supply and demand suggests that a rise in demand for oils for biodiesel production is likely to result in only a very modest rise in soybean areas worldwide.**

LMC'S ANALYSES

Part A: Indirect Land Use Impacts in South America

This part examines the land use impact in South America of higher U.S. demand for soy-based biodiesel.

Argentina

Argentina is the world's largest exporter of soybean oil onto the world market, followed by Brazil. This point is illustrated in Table 1, which presents supply/demand for soybeans and soybean oil in the major producing and exporting countries. In 2007/08, Argentina produced 6.6 million metric tons of soybean oil, the bulk of which was exported. If all of this oil were converted to biodiesel it would equate to 1.9 billion gallons. Thus, the volume requirements of the US could be satisfied with little impact on Argentina's exportable surplus. Moreover, Argentina has no domestic biofuel requirement and therefore the industry is keen to find additional outlets for its oil.

- By using surplus oil and installing new biodiesel capacity or expanding the use of existing capacity, the country could easily increase its biodiesel output substantially *without increasing areas under soybeans*.

By the end of 2009, Argentine biodiesel capacity would exceed 850 million gallons (3 million metric tons), if all projects are completed on time, but this is approximately three times as large as output in 2008.

- This capacity could be comfortably supplied from local soybean oil output *without any need to expand local production of beans*.

- This suggests that the impact of a rise in demand for soy-based biodiesel in the U.S. would have little impact on the area planted to soybeans in Argentina, since Argentine processors could take the simple step of upgrading their soybean oil exports into soybean methyl ester.

Table 1: Soybean Supply/Demand for Major Producers, 2007/08 (million metric tons)

	Argentina	Brazil	EU-27	United States
Soybean Crush	34.6	31.9	14.9	49.0
Oil Equivalent (of the Crush)				
Production	6.6	6.1	2.7	9.3
Imports	0.1	0.1	1.0	0.0
Exports	5.8	2.4	0.3	1.3
Consumption	0.9	3.8	3.4	8.0

Brazil

Brazil is also a major producer of soybeans, and in 2007/08 processed 31.9 million metric tons (mt) of beans, equivalent to 6.1 million mt of oil. In 2007/08, the country exported 12.4 million mt of soybeans, equivalent to 2.4 million mt of oil or almost 690 million gallons of biodiesel.

- By using surplus beans, the country could increase its production of oil and of biodiesel *without expanding its area under soybeans*.

Increasing soy oil production would be relatively easy since the country already has ample oilseed crushing capacity.

Diagram 1 presents total Brazilian soybean crushing capacity split between utilized and spare capacity. The diagram reveals that not only has total installed capacity increased steadily in recent years, but also that utilization rates have declined.

- In 2007, spare capacity exceeded 20 million metric tons, more than sufficient to crush all of the country's soybeans currently exported unprocessed.

Soybean Cultivation is not Responsible for Deforestation

The EPA's analysis of indirect land use impacts is based on the assumption that an increase in demand for U.S. biodiesel results in an increase in the soybean area in Brazil and a loss of rainforest. However, as Diagram 2 reveals, area under soybeans has not increased in recent years. Over the same period, U.S. biodiesel production increased from 25 million gallons to 700 million gallons.

- **Therefore, the causal link suggested by the EPA between U.S. biodiesel output and Brazilian soybean areas, let alone the deforestation of the Brazilian rainforest, is not supported by the evidence from the past five crop years.**

While US biodiesel production has increased over the previous five years, deforestation in Brazil has declined. Figures from Brazil's National Institute of Space Research (INPE), show that deforestation fell from almost 10,600 square miles in 2004 to just over 4,600 square miles in 2008. In addition, a study carried out by the Soybean Work Group (GTS) in early 2009 found that since July 2006, only 2% of deforested area had been devoted to soybean cultivation. The principle uses were for cattle ranching and timber production.

It is not surprising that very little deforested area is used for soybean cultivation since the hot and humid climate of the Amazonas is less than ideal for soybean cultivation. While in recent years new soybean cultivars have been developed that are better adapted to the soil and climate of this region, yields are still below those achieved in the optimal soybean growing areas of Brazil such as in Mato Grosso. Any pressure to increase soybean production is likely to result in pressure to expand soybeans in higher yielding areas rather than in the Amazonas.

- **Very little deforested area in Brazil is used to grow soybeans. This is because the agronomic climate of the Amazonas is not ideally suited to soybean cultivation.**

In Brazil, Embrapa (the Brazilian Agricultural Research Corporation), estimates there are up to 100 million hectares (250 million acres) of savannah (Cerrado) suitable for the cultivation of soybeans, maize and sugarcane. However, it should be noted that the Cerrado is rich in biodiversity and conversion of this land to farmland would also result in substantial emissions penalties.

However, even if the Brazilian soybean area were to expand, it is far from clear that this would put pressure on forest or virgin Cerrado areas. There still exists considerable scope for expanding soybean cultivation into pasture land.

While cattle densities in Brazil have increased steadily, they are still low by international standards. Increasing Brazilian cattle stocking densities could free up additional land for soybean production. There are also synergies between cattle production and soybean production. Soybeans are grown in rotation with second-crop corn (the *safrinha*) in Brazil, and this may be used as feed on feedlots. In addition, the meal from soybean oil production can also be fed to animals. While cattle stocking rates have increased steadily in Brazil, the national average is almost exactly one head per hectare (roughly 2.5 acres per head). Diagram 3 reveals that in 2006 there were close to 170 million head of cattle on 170 million hectares.

ABIOVE, the vegetable oil producers' association estimates that by 2020, cattle per hectare will rise from 1.0 to 1.4. Even allowing for 1.1% annual growth in cattle numbers, this implies that area needed for cattle will drop from 172 to 139 million hectares, freeing up 33 million hectares (82 million acres) of pasture land for agricultural use. This is considerably more than the five million hectares we estimate would be needed if the RFS2 were met solely with soy based biodiesel.

- **Thus there is considerable scope to increase cattle stocking densities further and release land for soybean farming.**

Diagram 1: Brazilian soybean crushing capacity and utilization

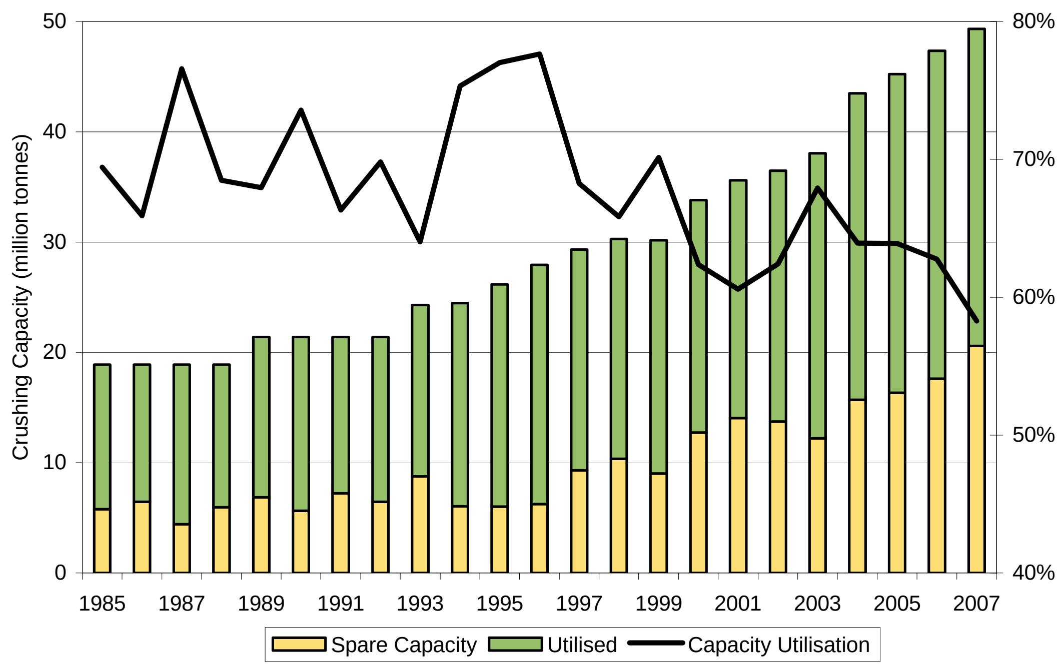


Diagram 2: Brazilian soybean areas and US biodiesel output, 2003/04-2008/09

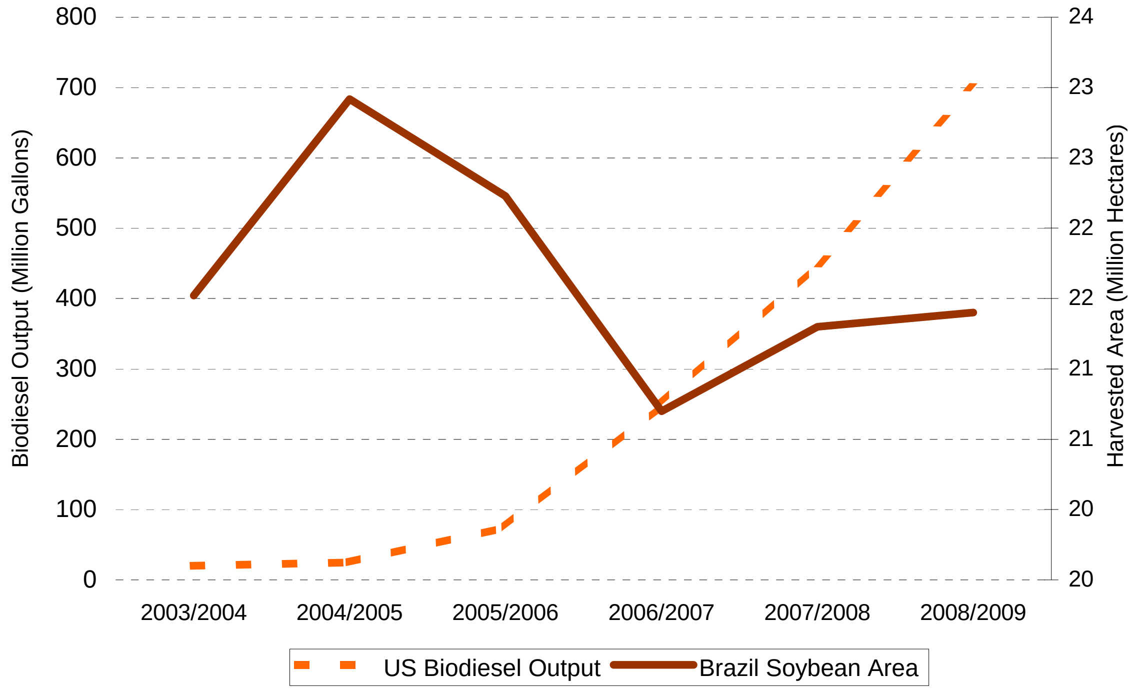
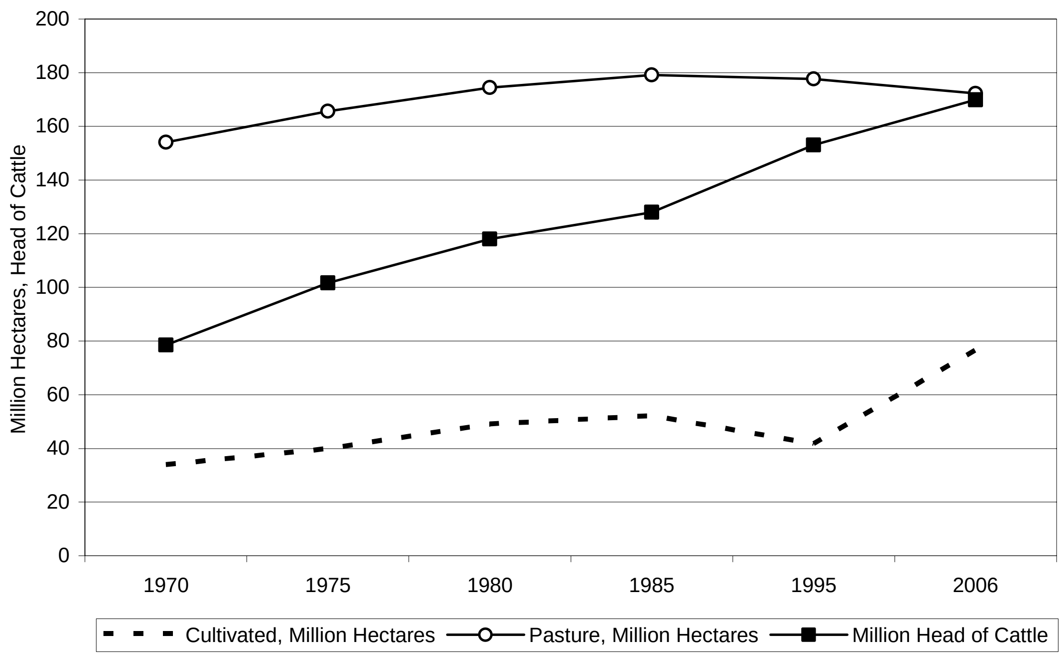


Diagram 3: The growth in cattle numbers and the pasture and cultivated areas from 1970 to 2006, total Brazil



Part B: The Impact of Changes in Soybean Oil Prices on U.S. Biodiesel Production

U.S. *soy-based* biodiesel production has declined in recent months, and peaked in mid-2007, *almost two years ago*. Meanwhile, *total* biodiesel output continued to grow, year-on-year, until the start of 2009, and the peak level of total U.S. output was in mid-2008. This is illustrated in Diagram 4, which implies that non-soy methyl esters have become increasingly important in biodiesel production.

A major part of the reason for the decline in soy-based output is that soybean oil became a relatively expensive raw material for producing biodiesel. Diagram 5 contrasts two curves. One plots the wholesale premium charged on soybean biodiesel over fossil diesel, after crediting biodiesel with the $1/gallon Federal blending credit. The other curve plots the processing margin calculated on soy methyl ester production in the Midwest.

In mid-2008, as well as in early-2009, soybean biodiesel became very expensive in relation to fossil diesel, and yet the processing margin on soy methyl ester production was negative in much of early 2008 and came under pressure again in early 2009. As a result, on simple financial grounds, biodiesel producers and users switched on a large scale to non-soy-based biodiesel, notably from animal fats and yellow grease.

The evidence of the behavior of the U.S. biodiesel market is very clearly that upward pressure on soybean oil prices in response to higher biodiesel demand leads rapidly to a shift towards the use of cheaper oils and fats, typically made from animal fats or recycled cooking oil. As a result, in several recent months, less than half U.S. biodiesel output has been produced from soybean oil.

Diagram 4: U.S. monthly biodiesel production – total volumes and the volume of soy biodiesel alone

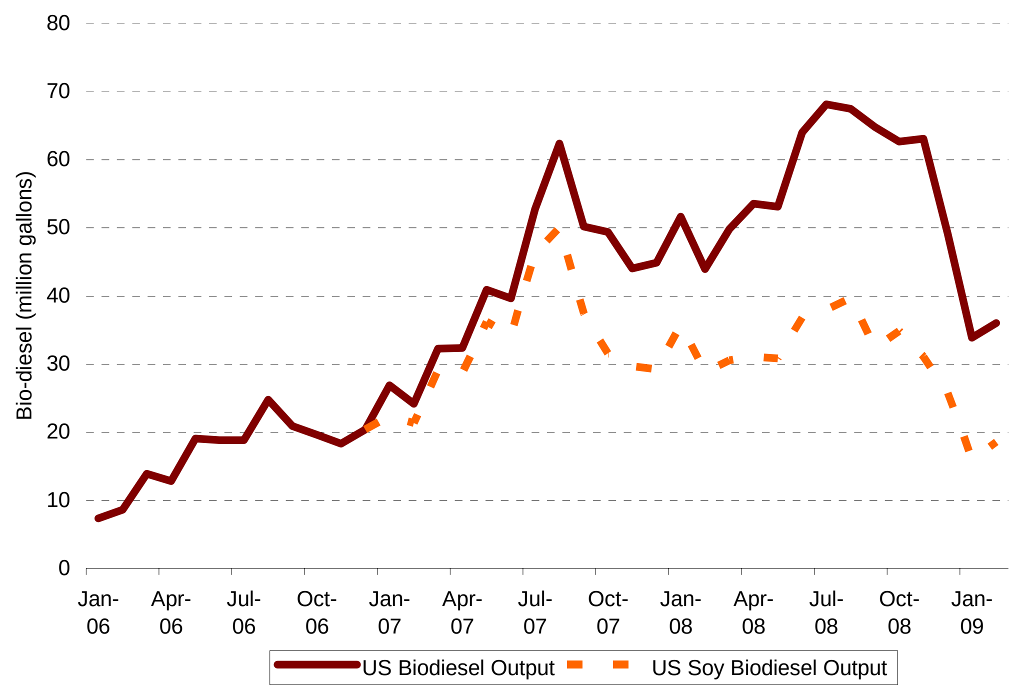
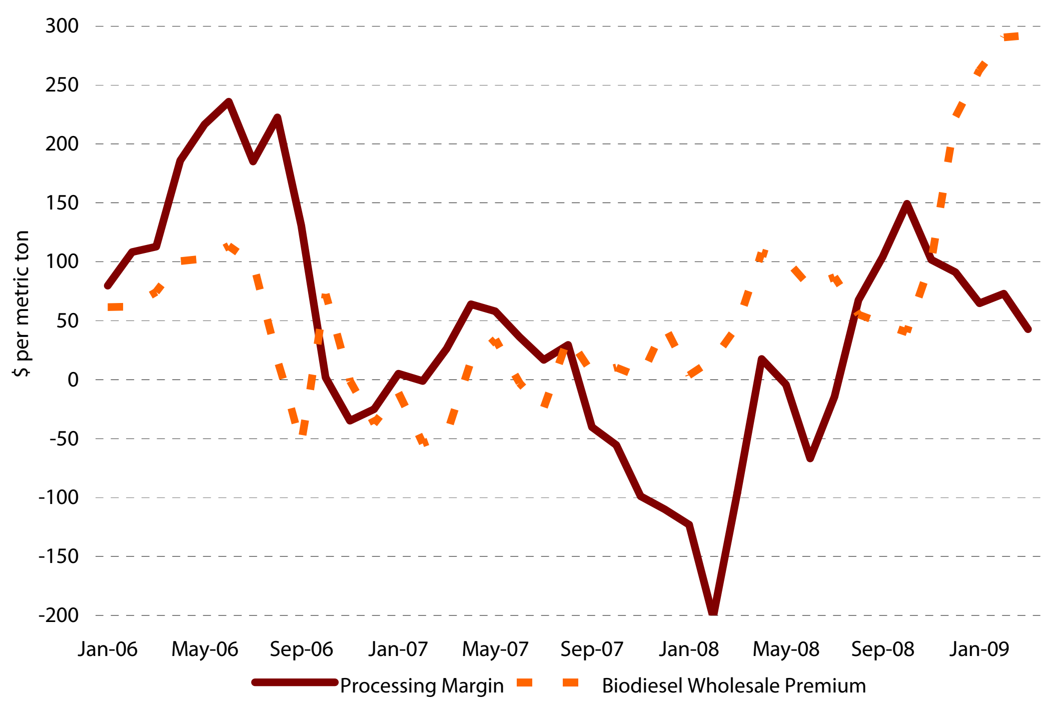


Diagram 5: Midwest premium (allowing for the $1/gallon Federal blending credit) for soy methyl ester over fossil diesel vs. processing margin on soy methyl ester



Part C: The Impact of U.S. Biodiesel Demand on Global Soybean Prices and Output

As has been explained above, both Argentina and Brazil could easily increase their production of biodiesel without increasing their areas under soybeans. In the case of Argentina, it would simply require a switch for soybean oil currently exported as oil to biodiesel plants (where more than enough capacity already exists) to be exported as biodiesel. For Brazil, there would need to be a switch for some of the soybeans exported as beans to domestic crushing plants, for processing and upgrading to biodiesel. Substantial surplus and unused crushing capacity exists, which could easily process the extra beans.

These two examples indicate that an expansion of biodiesel output could be achieved by using surplus world market oil and beans production. It is however, important to establish whether this would result in pressure to plant soybeans elsewhere or whether it would provide a stimulus for the production of other oil bearing crops, instead.

Methodology

The process by which increasing oils consumption feeds through to prices and then to production can be understood as a series of annual steps:

- Higher oil prices will inevitably feed through into oilseed prices.
- In the next round (i.e., in the next crop year), the output of oil-bearing crops will respond to this encouraging price signal, and there will be a knock-on effect upon the output of both oil and its co-product, meal, worldwide.
- The market will have to adapt to this increase in oil and meal supplies, and the form of its reaction will be a reduction in the prices of both products, in order to generate the necessary stimulus to demand that absorbs the extra supply.
- This price response for both oil and meal will feed through to seed prices and, once again, cause farmers to change their plantings for the following year.
- This sequence of demand changes, price changes and subsequent supply responses will continue over time, until the market eventually reaches a new equilibrium, in which the oil and meal supply matches the demand for both products at their new price levels.

The key questions then become, to what extent is the oil price rise transmitted to oilseed producers, and how do they respond?

As regards price transmission, this will be determined by the extraction rates and the relative prices of the oil and meal from each oilseed crop. The returns to a grower from an oilseed crop are indirectly composed of the return from the oil plus the return from the meal, after the processor and trader have taken their margins out of the final revenues from the sale of oilseed products.

Extraction rates

In addition to the price of oil and meal, the return to the grower is determined by the relative proportions of each product derived from the oilseed crop. These extraction rates differ significantly from crop to crop and have a crucial bearing upon the transmission of product prices to the producer.

Table 2 summarizes our assumptions regarding the average extraction rates for each oilseed crop. For soybeans and sunflower seeds, we assume that the hull is used for fuel; for oil palm, we assumed that 90% of the final marketed production consists of the combined palm and palm kernel oil output and 10% represents the palm kernel meal production.

Table 2: Worldwide average extraction rates for oilseed crops by weight

	Meal	Oil
Soy	76%	18%
Rape	60%	39%
Sun	42%	40%
Palm	10%	90%

Note: These are global average extraction rates. U.S. extraction rates are typically much higher.

The table allows one to compare the large amount of meal produced for each metric ton of oil from soybeans and the extreme contrast with oil palm. (Note that these figures are world averages, and the soybean extraction rates are pulled down by the poor performance of crushers in countries such as China and India.)

For every metric ton of oil produced from soybeans, over four tons of meal are produced. For oil palm, little over 0.1 metric ton of meal is produced for every ton of oil. This demonstrates that soybeans are planted for both their oil and protein bearing properties. This also suggests that soybeans would not be the crop of choice for a biodiesel producer because of the relatively low oil content of the beans.

Supply response of producers

The response of producers to any change in price is termed the *price elasticity of supply*. For a given percentage change in price, we can observe a given percentage change in the supply of the relevant product. Our analyses are based on supply elasticities from the USDA.

Demand response of consumers

As producers respond to price signals and increase, or decrease, their supply of oilseeds, so the supply of oilseeds available to crushers varies. Following an increase in prices, therefore, crushers will produce more oil from the increased supply of oilseeds. However, there is an important consequence of producing more oil, and that is an equivalent increase in the production of co-products, in this case, protein-containing oilseed meal.

As we can see from the extraction rates listed in Table 2, for soybeans, for every ton of beans that are crushed, meal production will rise on average around the world by 0.78 tons, while oil output increases by only 0.18 tons. Thus, a consequence of stimulating an increase in soy oil output is a proportionally larger increase in meal production.

World markets for vegetable oil and meal

It is important to recognize that the repercussions of an increase in production of soy oil in the U.S., or rapeseed oil in the EU, or palm oil in Malaysia, or even of animal fats or recycled cooking oil, are not insulated from the overall worldwide market for oil. As vegetable oils are traded freely across the globe and the different oils are close substitutes for one another, one can view the market structure for oil not so much as independent national markets, but rather as part of a single world market. In this way, a significant increase in U.S. soy oil or Malaysian palm oil demand and prices will affect the prices of all vegetable oils worldwide, irrespective of the agricultural raw material used in their production.

Similarly, oilseed meal is freely traded, and the meals derived from different agricultural raw materials are close substitutes for one another. Thus, a significant increase in U.S. soymeal production will have a downward effect on the price of the meal that is derived from sunflower seed in the EU. If this were not the case, opportunities and incentives would arise to substitute U.S. soy meal for EU sunflower meal wherever possible. The markets for individual oilseed meals should also, therefore, be recognized as parts of a single global market.

Price elasticity of demand

If increased supplies of oil and meal are not simply to weigh on the market as stocks, they will have to be absorbed by consumption. That is, demand will have to rise by the equivalent of the increase in supply to the market. In order to stimulate increased consumption, prices will have to fall. The extent of the price fall that is necessary to induce a rise in consumption sufficient to absorb all the additional production is determined by the *price elasticity of demand.*

Modeling supply and demand responses in world oilseed markets

Using the assumptions and elasticities, we have developed a model to illustrate the impact upon producers of an increase in biodiesel demand. The eventual outcome for producers will be felt following a repeated iterative cycle of responses in the oil, meal and seed markets.

The impact upon producers and the oil and meal markets is, therefore, determined by three main factors:

1. The oil and meal extraction rates from oilseeds;
2. The responsiveness of producers to price changes; and
3. The responsiveness of consumption to price changes.

Differences between crops in terms of the first two of these factors explain why the potential outcomes vary for different oil-bearing crops in response to the development of significant biodiesel programs.

The impact of biodiesel programs upon producers

Any impact of biodiesel programs upon the world markets for oilseed products is transmitted to producers through the prices that they receive for their oilseed output. The repercussions upon the seed prices differ from crop to crop, with the results depending upon the price signals in the world markets for oil and meal. Over time, the oscillations in the price will stabilize and converge upon a new equilibrium.

A boost of 5% to global vegetable oil demand generated by biodiesel output

Diagram 6 illustrates this effect for soybeans if there is an initial 5% boost to global oil demand for biodiesel, applying representative world market prices before the surge in commodity prices. A 5% boost to oil demand is roughly equal to 5.4 million metric tons. This is enough vegetable oil to produce 1.5 billion gallons of biodiesel. It is worth noting that this is almost five times the additional quantity required to meet the RFS2.

The initial shock to the markets provided by the increased demand for oil causes vegetable oil prices to rise by 7.6%. The impact on prices of fulfilling the RFS2 is likely to be much smaller, given that the volume requirement is just one fifth of that needed to raise global oils demand by 5%.

The time periods are not defined, but represent notional time periods over which price signals are transmitted and then acted upon in the seed, oil and meal markets. The diagram depicts a stabilizing process of interaction, with large initial fluctuations in price gradually dampened from one cycle to the next, until the soybean price converges upon a revised equilibrium.

The new equilibrium price for soybeans is approximately $4 per metric ton higher than the initial bean price. This represents an increase in the soybean producer price of a modest 1.75%. The outcome for a soybean grower contrasts with that for a palm oil producer. Diagram 7 illustrates the price outlook for palm oil producers in the wake of a 5% increase in global oil demand. The palm oil price rises by 17% as a result of the demand boost from biodiesel, as well as the re-establishment of oil price relativities between the major oils, most notably between palm and soybean oils.

Diagram 8 depicts the impact of a biodiesel-derived boost to vegetable oil demand upon meal prices. The incentive to expand soybean output is translated into an increase in meal supply without a corresponding rise in demand. Meal prices will have to fall to absorb the extra meal availability.

Diagram 6: Impact on Soybean Prices of 5% Rise in Total Oil Demand

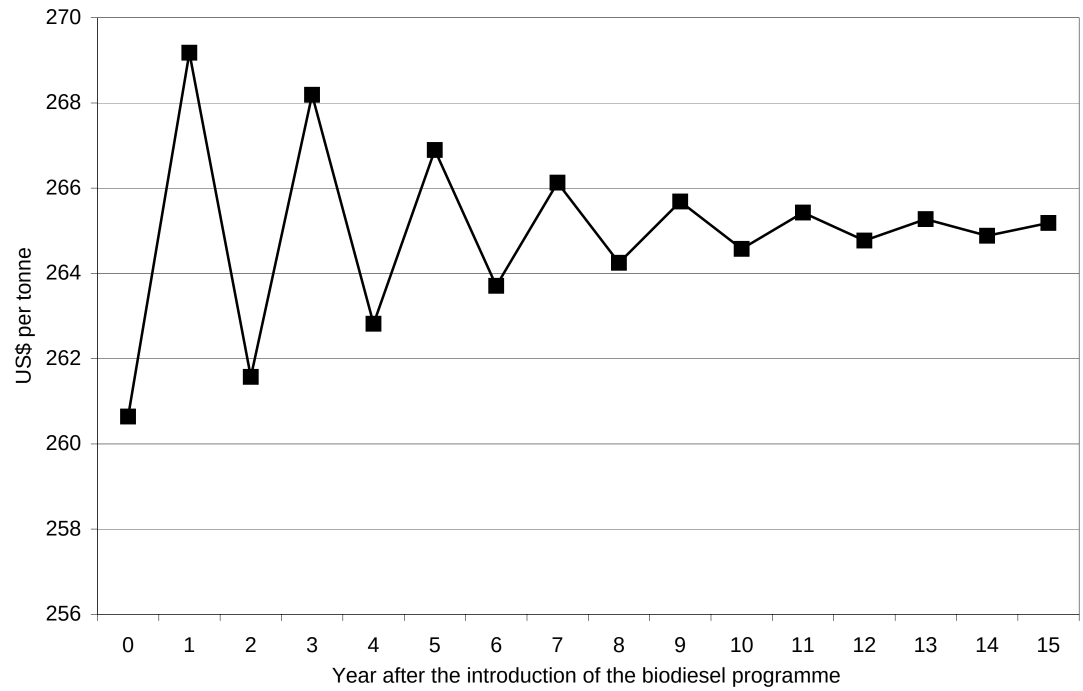


Diagram 7: Impact on Palm Oil Prices of 5% Rise in Total Oil Demand

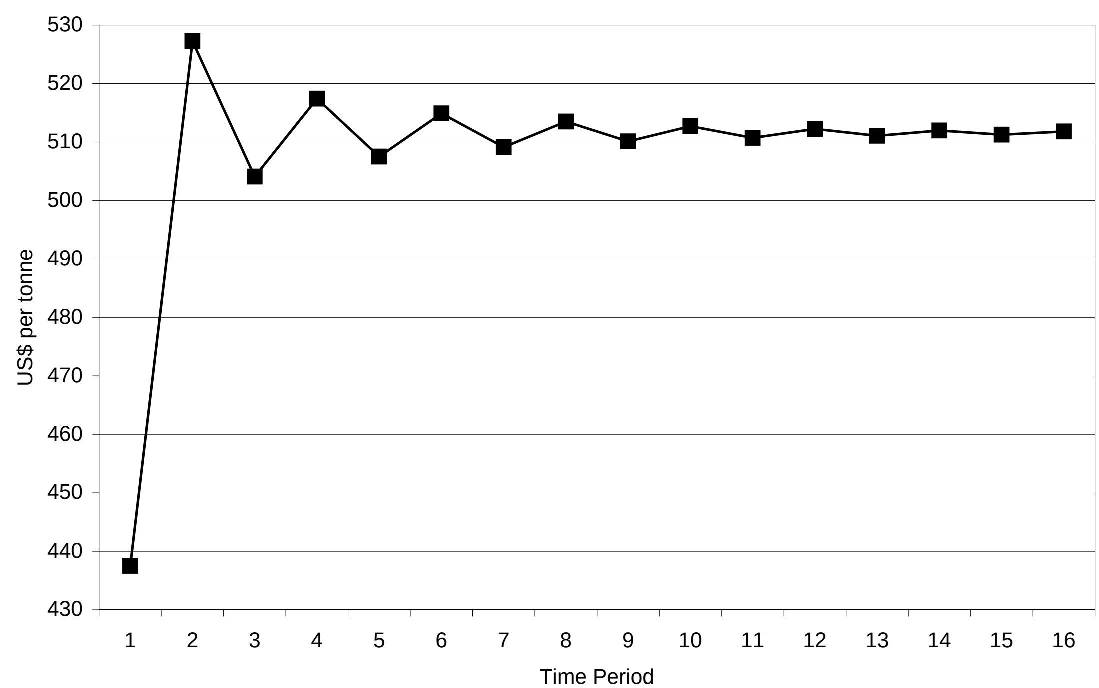


Diagram 8: Impact on Soybean Meal Prices of 5% Rise in Total Oil Demand

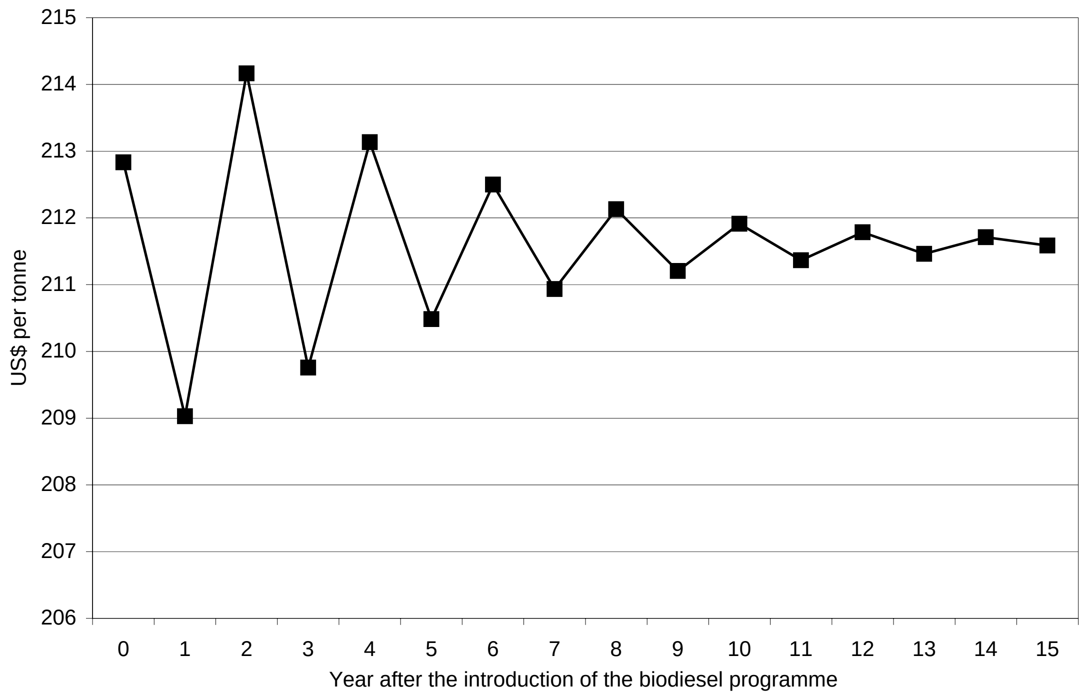


Table 3: Producer outcomes of a rise in oil prices following introduction of a biodiesel program using 5% of world oil output (prices in US$ per metric ton; outputs in '000 metric tons)

	Soy	Rape	Sun	Palm
Seed/Bean				
Initial Implied Price	260.6	379.0	302.3	402.6
Final Implied Price	265.2	337.9	317.6	469.4
% Increase in Implied Price	1.7%	-10.8%	5.1%	16.6%
Initial World Output	199,919	39,495	25,331	30,389
Final World Output	201,864	36,985	26,039	32,235
% Increase in Output	1.0%	-6.4%	2.8%	6.1%
Oil				
Initial Price	555.8	775.7	632.7	437.5
Final Price	586.2	671.3	671.3	511.8
% Increase in Price	5.5%	-13.5%	6.1%	17.0%
Initial World Output	30,938	14,021	8,752	30,389
Final World Output	31,239	13,130	8,997	32,235
% Increase in Output	1.0%	-6.4%	2.8%	6.1%
Meal				
Initial Price	212.8	127.5	114.7	88.2
Final Price	211.7	126.8	114.1	87.7
% Increase in Price	-0.5%	-0.5%	-0.5%	-0.5%
Initial World Output	132,448	21,598	9,718	3,884
Final World Output	133,737	20,225	9,989	4,120
% Increase in Output	1.0%	-6.4%	2.8%	6.1%

Note: It is assumed that the biodiesel program adds 5% to the initial level of world demand for vegetable oils.

Table 3 summarizes the initial and final prices that will face soybean, rapeseed, sunflower and palm oil producers, and it also lists the volumes of production that will occur at the revised equilibrium price.

A very important point to stress is that the simulation assumes that the supply response from the palm oil industry has been given time to occur. In practice, this will take a period of several years but, once it is over, the world market will increase its demand for palm oil substantially (by over 6%), which will eventually put downward pressure upon high cost vegetable oil producers, most notably of rapeseed oil. Palm oil is particularly helped in the simulation by the narrowing of its historical discount on soybean and other oils.

As biodiesel demand increases, palm oil, as the lowest cost vegetable oil, will be the greatest indirect beneficiary, as users for purposes such as food or the production of oleochemicals and biodiesel, will switch to the use of palm oil wherever possible, notably in the fast growing and highly populated countries of Asia.

The table demonstrates the limited long term impact of a biodiesel program on oilseed producers in terms of their overall output volumes:

- After all the repercussions have worked their way through the system, including in the oil palm sector, an initial boost of 5.0% to global oil demand is translated into an increase in vegetable oil production from all four crops included in the table of just 1.5 million metric tons. This represents a rise of only 1.8% from average production levels worldwide before the hypothetical boost to oil demand for biodiesel.

This disparity between the initial 5.0% boost to oil demand and the final 1.8% increase in crop output is explained predominantly by the low eventual rise in soybean production, which accounts for over two-thirds of total worldwide oilseed production, and which will suffer from the drop in meal prices, caused by the need to absorb the extra meal produced in conjunction with the additional soybean oil.

There would also be a decrease in rapeseed output, as its oil price loses the recent exceptional premium it has enjoyed while the market for biodiesel in the EU is assumed in the simulation adapts to the possibility of using other methyl esters for biodiesel. On the other hand, as noted above, palm oil output would increase by over 6%, spurred on by the rise in oil prices. In addition, oil palm benefits from its very low reliance upon meal credits, by comparison with other oilseeds.

Implications for world oil and meal markets

The results of the analysis described above suggest that, if a U.S. biodiesel program were to stimulate global demand for vegetable oil by 5.0%,

- The initial boost to the world price for oil would be 7.6%.
- U.S. soybean producers would eventually experience a price increase of only 1.7% for their beans, together with a modest 1.0% rise in total output.