www.defra.gov.uk

The Impact of Biofuels on Commodity Prices

Economics Group, Defra

April 2008

Department for Environment, Food and Rural Affairs
Nobel House
17 Smith Square
London SW1P 3JR

Tel: 020 7238 6000
Website: www.defra.gov.uk

Information about this publication and copies are available from:

Economics Group
Defra
Nobel House
17 Smith Square
London, SW1P 3JR

Email: economics@defra.gsi.gov.uk

This document is available on the Defra website.

Published by the Department for Environment, Food and Rural Affairs

The Impact of Biofuels on Commodity Prices

Simone Pfuderer[1] and Maria del Castillo [2]

April 2008

Summary

- Global biofuel production has seen a three fold increase over the last 20 years.

- Price spikes are common in agricultural markets due to a combination of relatively inelastic demand and volatile supply. Historical data (using 1987 as the base year) shows that world wheat prices were at similar level to present levels in 1995 and 1996, less than the 2007 peak in nominal terms but 15 percent higher in real terms. Sugar prices peaked in 2003 and in early 2008 fell below production costs of all major producers (including Brazil).[3]

- Other things being equal, biofuel production should put upward pressure on cereal, oilseeds and sugar prices. However, a closer look at recent price developments suggests that there are a number of factors affecting current commodity prices some of which are cyclical and some of which are structural in nature:

Short-term/cyclical factors

i. Adverse weather conditions affecting agricultural production in many parts of the world explain some of the recent commodity price increases.
ii. Reductions in stocks due lower than expected harvests have put upward pressure on prices due to the induced volatility and higher risk premium that lower stocks imply.
iii. International commodity trade has been limited due to the imposition of export restrictions in various countries, putting upward pressure on commodity prices.
iv. There is some debate about the impact of the influx of speculative investment on agricultural commodity prices. Whilst some analysts argue that this influx had no impact on prices, others think that it has contributed to recent price rises.

Longer-term/structural factors

v. Growing demand from emerging economies has increased demand for agricultural commodities.
vi. Rising biofuel production, mainly in the US has had a discrete impact on commodity prices and most notably the maize market.

[1] Economist – Agricultural Economics Unit, Defra
[2] Assistant Economist – Agricultural Economics Unit, Defra
[3] FO Lichts International Sugar and Sweetener Report (2008), 4th January 2008.

vii. Higher oil prices have an impact on the agricultural industry. The Sustainable Development Commission suggests that an increase in oil price from $50 to $100 a barrel could cause an increase in production costs of 13 percent in commodity prices for crops and 3-5 percent for livestock products.
viii. Historically low levels of investment in agriculture and agricultural research have slowed down improvements in productivity with a negative impact on the supply potential.

- The changes in agricultural prices have historically not been fully reflected in consumer prices.

- Several studies have attempted to evaluate the future impact of biofuel production on commodity prices; results should be interpreted with caution as work on models that combine agricultural and biofuel markets is still at an early stage.

- Second generation biofuel production has the potential to reduce land requirements and increase productivity.

Introduction

The purpose of this note is to review the existing research on the impact of biofuels on commodity and food prices.

Over the last few years the rise in energy prices, the political tensions in some oil producing regions, the uncertainties surrounding the future availability and access to non-renewable resources and environmental concerns have made biofuels rise to the top of many countries' policy agendas.

The public policy debate about biofuels has become increasingly polarised. Some point towards the potential impact of biofuels on food security and it has been suggested that biofuels expansion could result in significant implications for world hunger.[4] Gidley (2007), for example, argues that in Mexico, tortilla prices have increased by up to 400 percent as a result of maize being diverted to ethanol production in the US.

The issues around the impact of biofuels on commodity prices are complex and it is important to try to separate the facts from speculation. This note first summarises trends in biofuels production and trade. Second, it tries to assess the impact of biofuel demand and other drivers on current commodity prices. The following sections summarise available information on the impact of current high crop prices on food prices in developed and developing countries as well as the livestock sector. This is followed by a discussion of currently available projections of demand of food commodities for biofuels production and of the limitations of such projections. In the final section, a short overview of the Malthusian trap is provided.

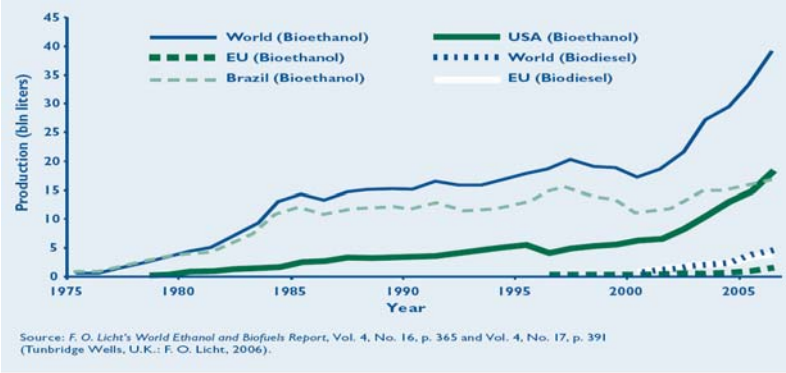
[4] Monbiot, G. (2004) 'Feeding the Cars not People' The Guardian 22 November 2004
Brown, L.R. (2006) 'Starving the people to feed the cars' Washington post, 10 September 2006.

1. Trends

There are two main types of liquid biofuels produced from land-based energy crops:

- bioethanol is an alcohol that can be derived from sugar or starch crops (e.g. sugar beet, sugar cane or maize) by fermentation;
- biodiesel can be derived from vegetable oils (e.g. rapeseed oil, soy or palm oil) by reaction of the oil with methanol.

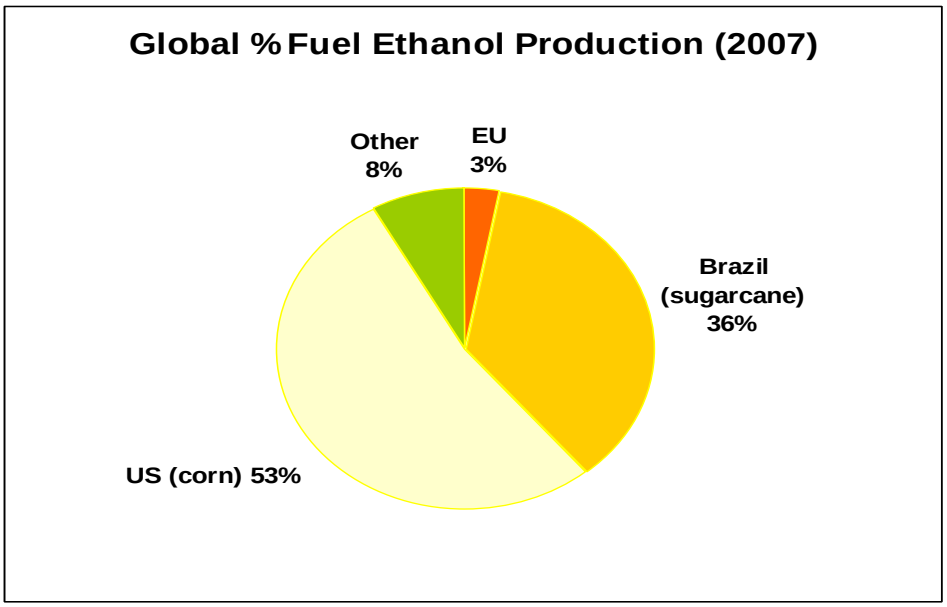
Figure 1: World Biofuel Production



The first large-scale schemes for biofuels production began in the early 1970s (in Brazil and the US), but only recently have biofuels been given important worldwide consideration as a fossil fuel alternative.

Ethanol makes up most of the total biofuel production, with 96 percent of total biofuel production being ethanol and 4 percent biodiesel. Production of biofuels is highly concentrated with Brazil and the US accounting for almost 90 percent of the global ethanol production. The EU on the other hand produces relatively more biodiesel, accounting for more than 80 percent of world biodiesel production.

Figure 2: Global Fuel Ethanol Production (2007)



Source: F.O. Licht

At present, the international trade in biofuels is somewhat limited (see table 1). Some of these limitations can be explained by trade distortion in both the importing and the home producing countries. Brazil is the largest world exporter of ethanol and the US and Japan the largest importers. The projections seem to suggest that the flow of biofuels should increase in the coming years as countries engage in policies aiming to diversify their energy sources.

Table 1: World Ethanol Trade

Ethanol Trade (Million Gallons)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Brazil	928	647	719	779	856	940	1,007	1,072	1,137	1,198	1,255
China	42	8	5	-8	-33	-52	-72	-90	-106	-121	-133
EU-25	-71	-124	-129	-145	-154	-182	-193	-205	-219	-232	-244
India	-118	-152	-147	-152	-164	-171	-179	-185	-189	-193	-195
Japan	-171	-196	-209	-222	-235	-246	-258	-269	-281	-292	-302
S. Korea	-75	-84	-90	-96	-103	-110	-116	-123	-129	-135	-142
U.S	-679	-237	-286	-288	-295	-300	-306	-311	-316	-322	-327
ROW	23	17	15	11	6	1	-5	-11	-18	-25	-33

Source: FAPRI Agricultural Outlook 2007

2. The policy context

Currently, many countries around the world provide support to biofuels so that they can compete with petrol and diesel. Such support includes consumption incentives (such as fuel tax reductions); production incentives (tax incentives, loan guarantees, and direct subsidy payments); as well as mandatory consumption requirements. For example:

European Union

In 2007, the EU agreed a conditional minimum target of 10 percent for the share of biofuels in overall EU petrol and diesel consumption by 2020, subject to sustainability of production, commercial availability of second-generation biofuels, and amendment of the Fuel Quality Directive to allow adequate levels of blending. In January 2008, the EU Commission published its proposals for the biofuels sustainability rules to determine the structure and the composition of biofuels usage in the community. In these proposed rules the Commission set a minimum value of 35 percent of GHG savings, which biofuels must achieve in order to count towards the biofuels target. The sustainability criteria are still under negotiation.

United States

In 2005, the Energy Policy Act was passed. The legislation set a target of 7.5 billion gallons of renewable fuels to be used by 2012. Since then, a new "Energy Independence and Security Act 2007" has been agreed. The new act requires 15 billion gallons fuel ethanol by 2015 and 36 billion gallons fuel

ethanol by 2022. However, under the new act, 21 billion gallons out of the 36 citied will need to be produced from advanced biofuels.

Brazil

For over three decades, Brazil has been the global leader in the production and use of sugar cane based ethanol. All gasoline sold in Brazil must contain between 20 and 25 percent ethanol blend (by volume).

Table 2: Summary of biofuels targets

Countries	Targets	Comments
EU	5.75 percent by 2010, 10 percent by 2020	The 2020 target is subject to the sustainability rules as well as the commercial availability of second generation biofuels
Australia	1 percent by 2010 - or at least 350 million litres of ethanol or biodiesel	
Japan	The government has provided goals to use 500 million litres of fuel derived from biomass in fuel for transport by 2010, through promoting the use of E3. This would be a prelude to a national E10 blend standard by 2010	Ethanol dominates biofuels in Japan. Currently, fuel-use ethanol is not made or used commercially in Japan while only about 2000 kl of biodiesel is produced annually
China	Biofuel development policies are aiming to increase ethanol production to 6 million tonnes by 2010 and 15 million by 2020.[5] (By way of comparison, the US was expected to produce 24.6 million tonnes in 2007)	Up until September 2007, the main biofuel produced was ethanol from maize. Since then China's government has announced an "Agriculture Biofuels Industry Plan" which implements a shift away from food grain ethanol feedstocks to non-food crops inputs such as sweet sorghum and cassava
USA	US Energy Bill was ratified in August 2005 and fixes the quantity of renewable fuels that must be consumed in 2012 at 7.5 billion gallons. The 2007 Act requires 15 billion gallons fuel ethanol by 2015 and 36 billion gallons fuel ethanol by 2022	Note that under the new act, 21 billion gallons of the 36 stated by the act will need to be produced by advanced biofuels by 2022
Argentina	5 percent by 2009	
Brazil	An incorporation rate of 2 percent for biodiesel is compulsory, growing into 5 percent by 2013. All gasoline sold in Brazil must contain between 20 and 25 percent ethanol blend (by volume)	Focus is on ethanol from sugar cane
Thailand	Its targets for biofuel use in 2010 equate to 2 percent of projected energy needs	

[5] F.O. Licht (2007). World Grains Markets Report, September 2007.

Malaysia	An objective has been adopted for biodiesel incorporation to reach 5 percent by volume of standard diesel consumed	
India	In 2007, the government rolled out its new biofuel policy which stated: the mandatory ethanol blend will rise from E-5 to E-10 by October 2008 and that sugar mills are now permitted to convert cane juice directly into ethanol – previously molasses were the only permitted feedstock	

3. The relationship between biofuels and recent changes in commodity prices

Context: The market

Agricultural commodities have traditionally been subject to price distortions due to highly protective trade barriers and farm subsidies. Although there has been a reduction in trade distorting support measures, agricultural markets remain subject to significant levels of government interventions.

Price spikes are common in agricultural markets due to a combination of relatively inelastic demand and volatile supply. In the short term, supply of cereals and oilseeds cannot adjust to unexpected changes in supply or demand because in general there is only one harvest per year. The price is the main instrument to balance the market in the short term. In the medium term, supply is fairly responsive which can lead to large price swings following shortages. Expected changes in supply and demand have much smaller impacts on prices than unexpected events such as bad harvests. The expected production increase for 2007/08 demonstrate the supply responses to shortages in the previous year.

World grain production is fairly concentrated and a significant fraction of production is traded across regions (around 17 percent). The five major exporters are Argentina, Australia, Canada, the EU and the US.

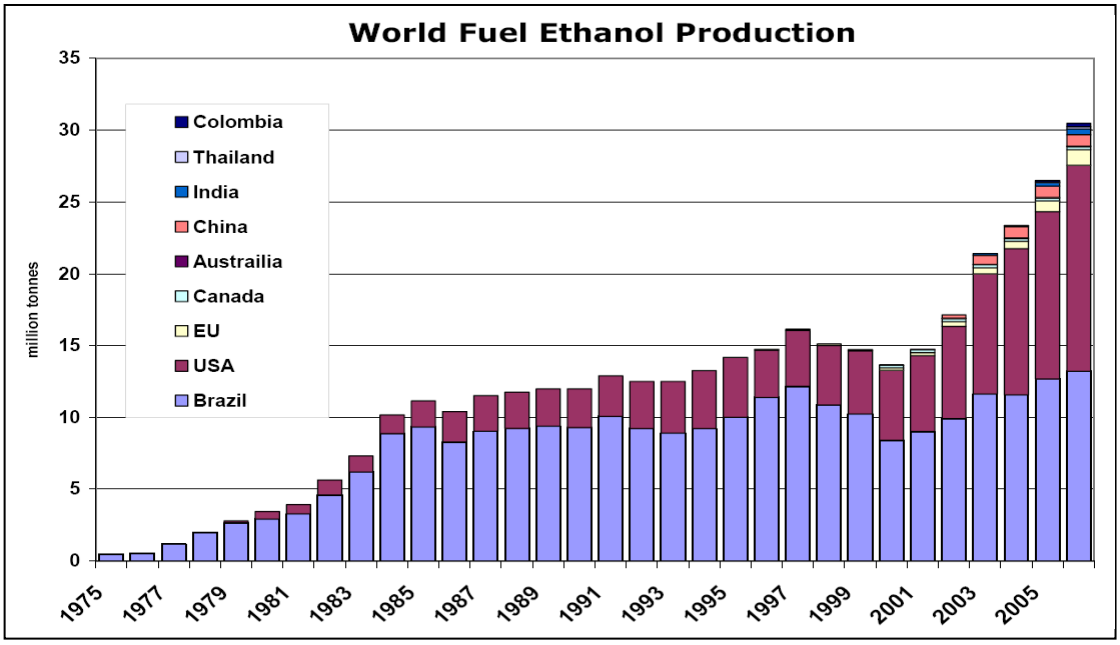
Wheat (million tonnes)				
	2004/05	**2005/06**	**2006/07**	**2007/08 (estimate)**
Production	628	620	592	604
Trade	110	110	110	104
5 major exporters	86	80	80	76
US exports	28	27	25	33
Maize (million tonnes)				
	2004/05	**2005/06**	**2006/07**	**2007/08**
Production	713	695	698	966
Trade	76	79	88	97
5 major exporters	70	76	80	90
US exports	47	51	56	62
Total Grains (million tonnes)				
	2004/05	**2005/06**	**2006/07**	**2007/08**
Production	1649	1602	1572	1659
Trade	212	215	221	228
5 major exporters	164.7	161.8	165.1	174.9
US exports	81	84	85	103

From the table above one can observe that if there are disruptions in supply in any of the five major exporters it would result in global market impacts.

Sugar and cereal prices

Sugar cane and maize are currently the most important feedstocks for the production of bioethanol. This section describes recent developments in sugar and cereal prices and explains the drivers behind the price movements. Brazilian sugar based ethanol dominated the market up until 2005. In 2007 Brazil accounted for 36 percent of world ethanol production (down from 42 percent the previous year).

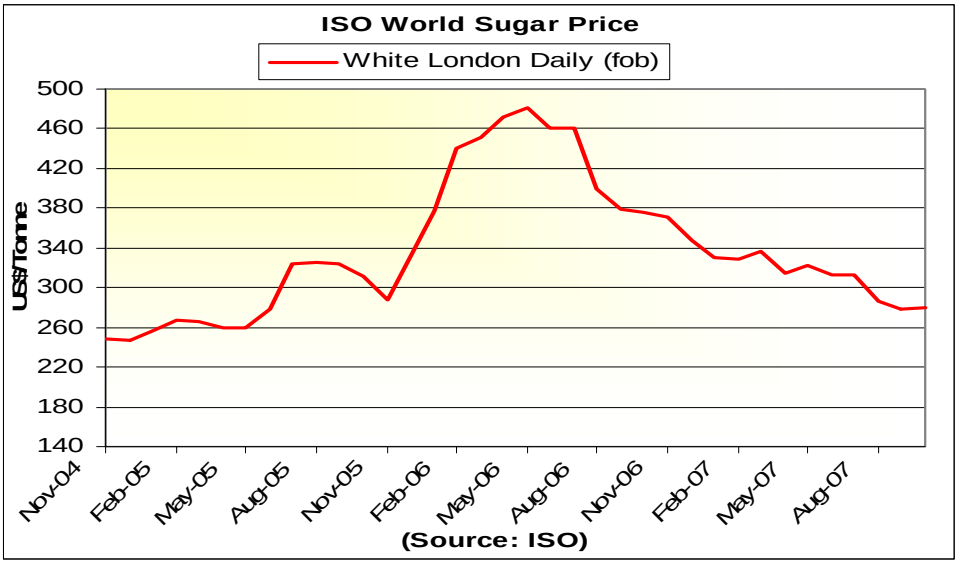
Figure 3: World Ethanol Production



Source: F.O. Licht

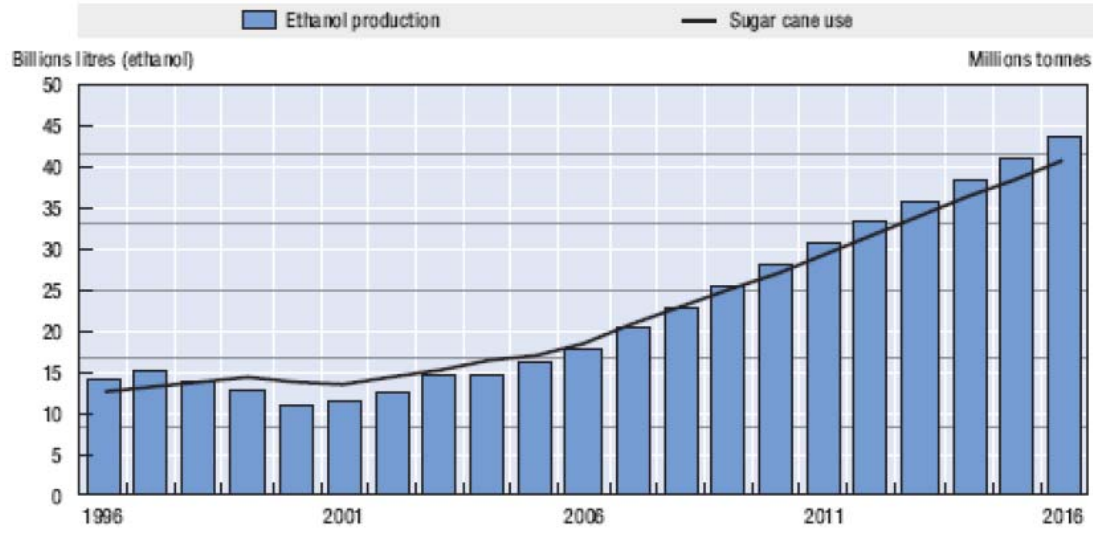
While other commodity markets are booming, sugar has underperformed in the last year. Having strengthened since 2003, world prices surged in late 2005 and early 2006 under the pressure of tight global supplies and high oil prices, reaching a 25 year high in 2006 but then fell back again later in the year and have continued to declined throughout 2007 due to large oversupply of sugar on the market.

Figure 4: World Sugar Price



Sugar prices have declined despite reduced EU exports, continuous growth in demand for food and from ethanol producers (see figure 5). More than half of all sugar cane grown in Brazil, the largest sugar exporter, is destined for the production of fuel alcohol.

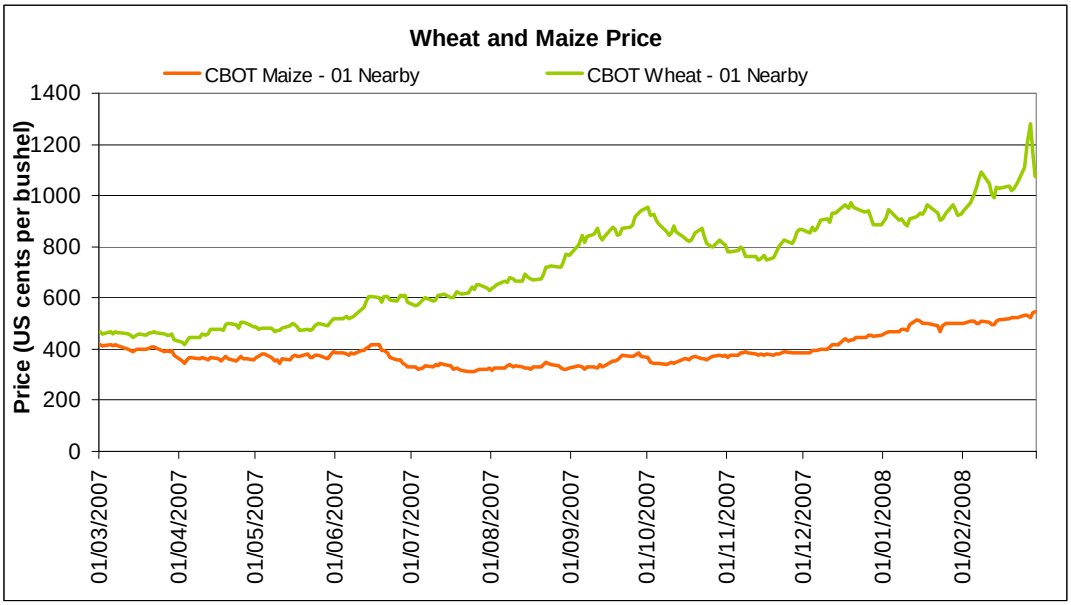
Figure 5: Growth in Brazilian Sugar-Cane Ethanol Production



Source: OECD and FAO Secretariats.

In contrast to sugar, world cereal prices have risen sharply in the last year. Wheat and maize prices increased by 136 and 31 percent respectively in the week ending 17 March compared to the equivalent week in 2007 (see figure 6).

Figure 6: CBOT Wheat and Maize Price

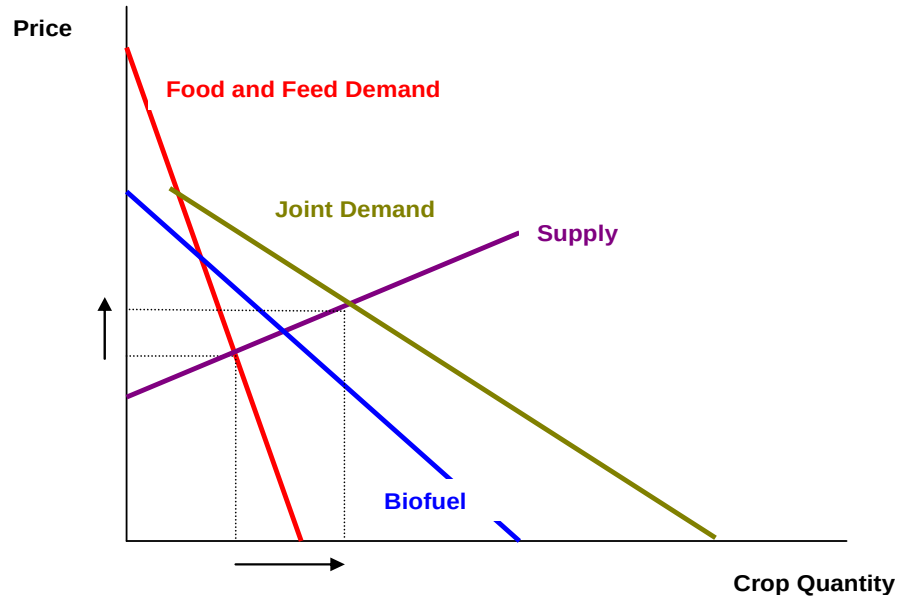


Source: HGCA

Other things being equal, additional demand for biofuels can be expected to put upward pressures on the prices of the soft commodities which are currently used to make them (see figure 7). It has been suggested that biofuels are the force behind the latest increases in the cost of basic staples, causing some of the recent food riots around the world.

The figure below describes how a new biofuel demand will shift the food and feed demand curve outwards, resulting in higher feedstock output but also higher prices. The scale of the change in both price and output will depend on the shape of the supply curve, which will shift over time as land availability and other factors of productions become available.

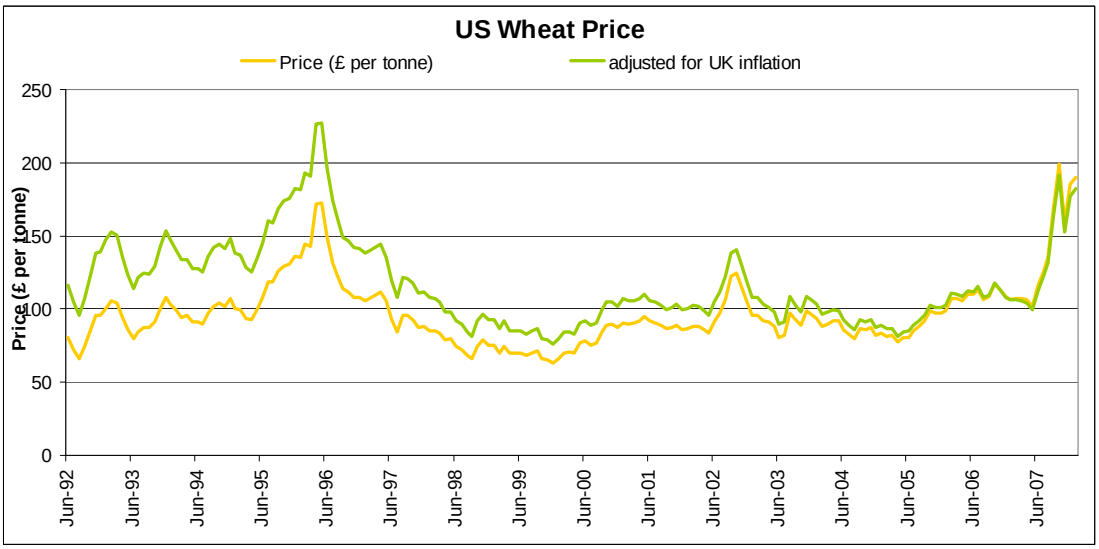
Figure 7: Food crops' demand and supply



A closer look at both the recent price spikes and the relationship between commodity and food prices is needed before concluding that recent price increases have been driven by higher biofuel demand. There are a number of factors that have affected cereal prices over the last year, some of which are cyclical or shorter term and induce volatility into the market and others that are longer term and structural in nature (such as the expansion of the biofuels industry or increased demand from emerging economies).

Historical data (using 1987 as the base year) shows that world wheat prices were at similar levels to present levels in 1995 and 1996, less than the 2007 peak in nominal terms but 15 percent higher in real terms. Note that the peak was short-lived with prices dropping quickly, mainly because farm output rises in response to higher prices from one harvest to the next. This section will take a closer look at each of the factors that have contributed to high cereal prices.

Figure 8: Nominal and Real Wheat Prices



Source: ONS and HGCA

Shorter-term/cyclical factors

i) The weather

Weather-related losses in production have occurred in a number of countries and regions over the last year. The regions that have been worst affected include the US, the EU, Canada, Russia, Ukraine and Australia. For example, wheat production in Australia has more than halved in the last year alone as it declined from 25.4 million tonnes in 2005/06 to 10.6 million tonnes in 06/07 and remained far below expectation in 07/08 with an estimated production of 13.1 million tonnes.[6] Its share of world wheat exports have consequently declined from 14 percent to under 9 percent,[7] which in turn have had an

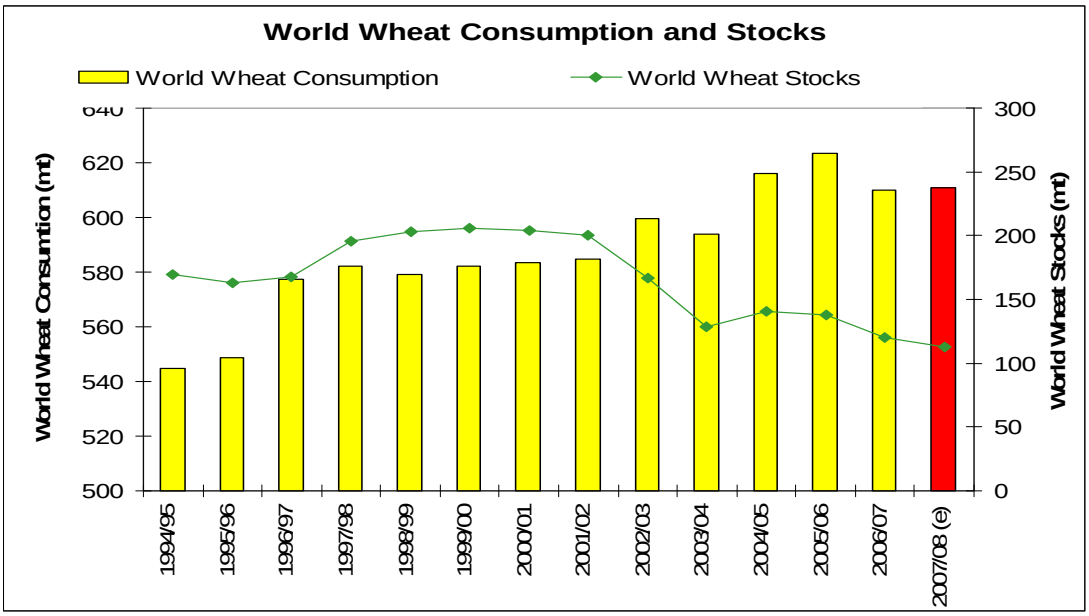
[6] Figures from IGC Grain Market Report, 28 February 2008.
[7] Calculations from IGC Grain Market Report, 28 February 2008.

impact on world wheat prices. The OECD-FAO Agricultural Outlook[8] suggests, for example, the combined cereal supply shortfall of North America, Europe and Australia was over 60 million tonnes.

Whereas the effects of adverse weather tend to be relatively short-lived (but recurrent), the impact of global warming may however give rise to more enduring climate change and to more frequent occurrences of extreme weather events leading to potentially greater agricultural price variability in the future.

ii) Stocks

Figure 9: World Wheat stocks and consumption



Source: International Grain Council

A fundamental driver of the cereal price is the level of inventories at the end of the crop year. Ending stocks are viewed by the industry as the "buffer" stocks available to incorporate increases in demand or reductions in supply in the following year. Low stocks increase the perceived risks and therefore lead to higher prices. World stocks for wheat and maize are at exceptionally low levels, for example the wheat stocks to usage ratio has fallen from 35 percent in 2000/01 to an expected 19 percent for 2007/08 (see figure 9).

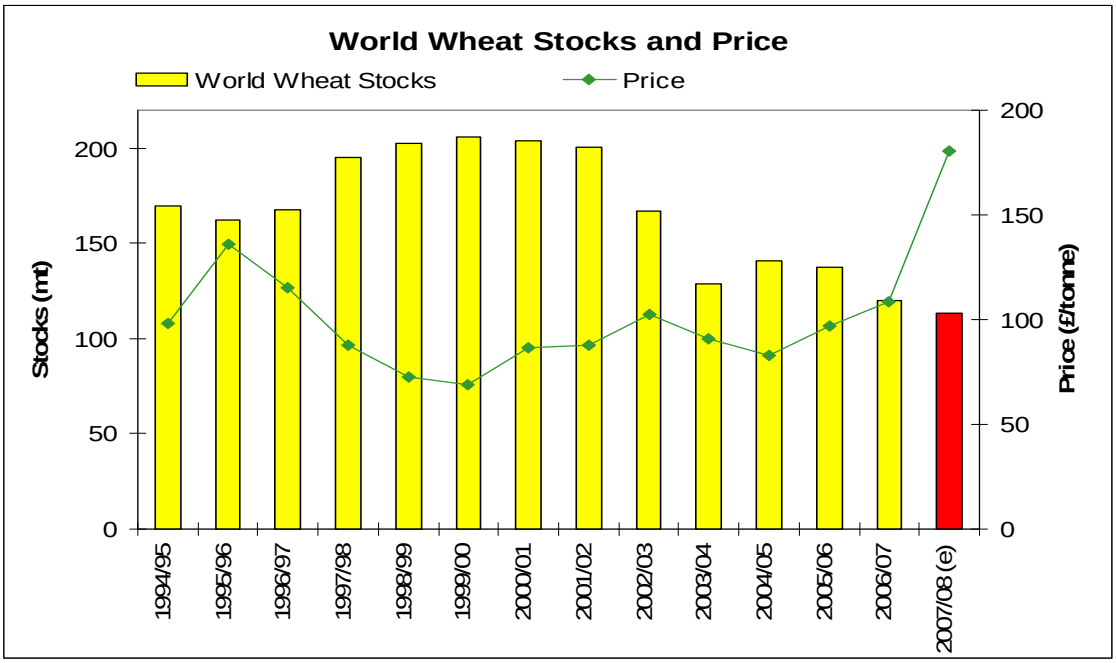
There is a negative correlation between stocks as a percentage of consumption and world prices. Over the last decade or so, stocks to usage ratios have followed a downward trend. Figure 10 shows that when wheat stocks are at their highest, as between 1998 and 2001, wheat prices tend to be at their lowest. This year, as a result of the bad harvest, world cereal stocks in the main exporting countries are at low levels. For example, the EU public stocks of cereals fell from a peak of 17.4 million tonnes in 2004 to 14.6

[8] http://www.oecd.org/dataoecd/6/10/38893266.pdf

million tonnes in 2005 and 2.2 million tonnes in 2006. By autumn 2007, all intervention stocks were either sold or committed for sale.

Reductions in stocks have also taken place as a result of more efficient trade systems and reductions in protectionist policies.

Figure 10: World wheat stocks and prices



Source: International Grain Council

iii) Export restrictions

Over the last few months, as a response to global shortages and bad harvests several countries have adopted restrictions on their supply to world markets, thus adding further pressure on cereal prices. For example:

- In Argentina, the government temporarily closed its wheat export registry in November 2007 in order to assess crop damage from the frosts in wheat farming areas and to assure that enough wheat would be available for the local market. At the end of January, traders were allowed to apply for a licence to export wheat. However, the Agriculture Secretariat restricted the volume of wheat to be exported in 2007/2008 to 2 million tonnes, with a monthly limit set at 400,000.[9] The government closed the registry again in February and has recently

[9] F.O. Licht (2007), 'World Grain Markets Report', February 7, 2008

announced that the re-opening of the registry due on 17th March will be postponed to 8th April 2008.[10]

- In June 2007, Ukraine's government imposed prohibitive grain export quotas, limiting shipments to 3,000 tonnes each for wheat, rye, barley and maize in a bid to replenish domestic stocks. Export quotas have now been extended until the end of March 2008.[11]

- Russia introduced a higher export tax for wheat of 40 percent or no less than €105 from the end of January.[12]

- Kazakhstan's minister of agriculture has recently announced the government's wishes to limit exports of wheat in order to curb domestic inflation. Although the export tariffs have yet to be imposed, the prices of top quality wheat jumped 25.25 percent the day the announcement was made.[13]

- The Indonesian government raised the palm oil export taxes in June 2007 to 6.5 percent (from the previous 1.5 percent). It was followed by an increase to 7.5 percent in September and to 10 percent in November 2007. This means a significant tax burden considering the already high export prices. A further announcement in 2008 stated that the government is determined to raise the export tax to 15 percent once fob export prices for palm oil reach US$ 1100.[14]

iv) Influx of 'hot money' and speculation into agricultural markets

Commodity markets, including agricultural commodities, have recently seen an inflow of 'hot money' from various investors. Financial investors have become more interested in investing in rising agricultural commodities, which have become increasingly attractive as a class of assets at a time when the dollar and stock markets are weak, and US interest rates are low. There are estimates that around $42 billion[15] will be moved into the US commodity markets in general, during the first quarter of 2008. One view is that non-commercial investors (e.g. speculators) take positions that follow fundamental price movements, rather than drive them. And certainly, as a class, speculators have an essential role to play in providing liquidity in the market to allow hedgers to manage various commercial risks thereby facilitating improved the price discovery. However, others take the view that some of the price increases in February and March 2008 for many agricultural

[10] Reuters (2008) 'Argentina posterga reapertura exportaciones de trigo' 29th February 2008 http://lta.reuters.com/article/domesticNews/idLTAN2915344320080229
[11] F.O. Licht, 'World Grain Markets Report', September 2007 and November 2007
[12] International Grains Council, 'Grain Market Report', 24 January 2008
[13] Financial Times, 'Wheat in biggest one-day rise as price soars to 25percent to record high', 26 February 2008
[14] Oil World Weekly (2008), 8 February 2008
[15] F.O. Licht, 'World Grain Markets Report', January 2008

commodities can be attributed to an influx of money from institutional investors.[16]

Longer-term/structural factors

v) Emerging economy demand

Another factor cited as responsible for high cereal prices is the growing per capita income in emerging economies across the world, which would put upward pressures on demand. Higher income is associated with the westernisation of diets and thus leads to higher demand for relatively resource intensive foods (such as meat and dairy products). Furthermore, the income elasticity (which measures the responsiveness of the quantity demanded of a good to the change in income) of food products in emerging economies is higher than in developed economies. For instance, the income elasticity of demand for food in countries such as Brazil and Egypt is double that of France and the UK.[17]

Different studies conclude that emerging economies have increased their food demand as per capita income has increased. However, there is little evidence of a significant acceleration in recent years. Indeed, for China and India overall food demand seems to be rising somewhat more slowly than in the mid-1990s.[18]

vi) Biofuels

High cereal and oilseed prices have been associated with a reduction in the available supply for food due to biofuel production (for instance, a senior UN official called the increasing use of crops for fuel rather than food a crime against humanity[19]). Other things being equal, additional demand for biofuels would push the price of cereals and oilseeds (two of the main feedstocks). However, it is important to put the overall price effect into perspective. Whereas wheat prices have seen the most dramatic rise amongst all the cereals, the use of wheat for biofuels production is modest (in 2007 1.4 percent of wheat was used for biofuels in the EU and 0.6 percent globally[20]). It is therefore unlikely that biofuel demand for cereals in the EU has contributed to the price increases. By contrast, the US projected ethanol use of maize almost doubles between 2005/06 and 2007/08, and it is forecast to exceed 4 billion bushels (or 100 million tonnes) in 2009/10, reaching almost 38 percent of total US domestic maize use. Analysis by the European Commission suggests that cereal price increases "were further reinforced by the bioethanol boom in the US, which influenced the market only punctually and most notably

[16] See for example: International Sugar Organization Market Report and Press Summary, February 2008 and F.O. Licht's International Coffee Report 4th March 2008
[17] USDA http://www.ers.usda.gov/Data/InternationalFoodDemand/Index.asp?view=IEB#IFD
[18] UBS Investment Research (2007) 'What's up with food prices'
[19] BBC News, World Warned on Food Price Spiral, 11 March 2008.
[20] Figure based on IGC estimates of wheat production of 603 million tonnes and biofuel demand of 3.4 million tonnes.

in the maize markets".[21] There is some evidence of the impact of increased bioethanol production on the soybean market, suggesting a trade-off between maize and soybean production. For instance, in 2006 farmers responded to market signals by reducing maize acreage in favour of soybean, and the reverse happened in 2006-07, suggesting that increased demand for maize due to increased ethanol production may have had an indirect effect on the price of soybeans (see table 3).

Table 3: US Planted Acreage

US Planted Acreage (million Acres)

	2005	2006	2007	2008
Corn	81.8	78.3	93.6	90
Sorghum	6.5	6.5	7.7	8.3
Oats	4.2	4.2	3.8	3.7
Barley	3.9	3.5	4	4
Feed Grains	96.4	92.5	109.1	106
Winter Wheat	40.4	40.6	45	46.6
Spring Wheat	14	14.9	13.3	12.6
Durum	2.8	1.9	2.1	2.6
All Wheat	57.2	57.3	60.4	61.8
Rice	3.4	2.8	2.8	2.7
Soybeans	72	75.5	63.6	69
All Cotton	14.2	15.3	10.8	9.1
Sunflowers	2.7	2	2.1	2.1

Source: Informa Economics

In the EU, the main feedstock for biodiesel is rapeseed. EU production of biodiesel is estimated to have used 4.1 million tonnes in 2004 or the equivalent to around 20 percent of the EU-25 total oilseed production. The resent raise in palm oil production has been associated with the boom in biofuel production, however at present only 1 percent of palm oil is used for biofuels. There will have been some indirect impact as more rapeseed is used for biodiesel but overall, the use of vegetable oils for biodiesel remains small compared to other uses.

Expectations about the increase of cereal and oilseed use in future might have had an impact on prices though and might have inflated commodity prices. In market fundamentals though the impacts of increased biofuels demand in the current market are small relative to the weather related factors outlined above. In 2006/07, for example, the combined cereal supply shortfall of North America, Europe and Australia was over 60 million tonnes, nearly

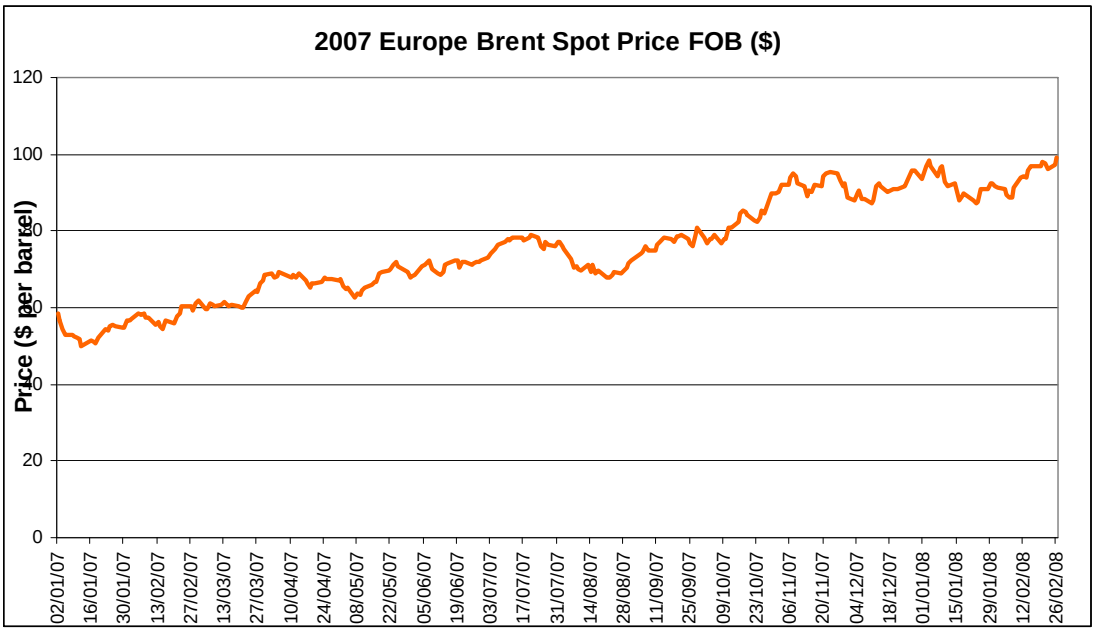
[21] European Commission (2007), 'Prospects for Agricultural Markets and Income in the European Union 2007-2014'

four times larger than the 17 million tonnes increase in cereal use for ethanol in these countries.[22]

vii) Oil prices

Structurally high prices of oil could, other things being equal, reduce overall supply of cereals and place upward pressures on prices as they affect production costs.[23] Oil prices have increased by almost 70 percent in the last year.

Figure 11: Brent oil prices



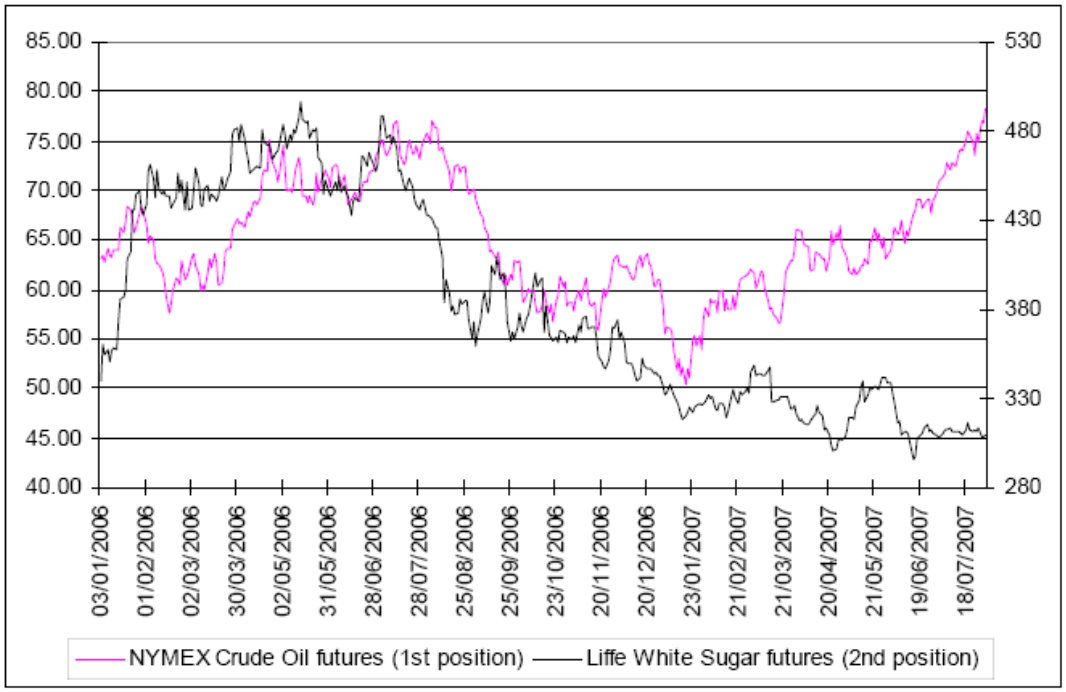
Source: EIA

Higher oil prices may have significant impacts on the agricultural industry for two main reasons. Firstly, higher oil prices will increase the costs of inputs such as fertilizers and pesticides as well as fuels, heating and energy use. Second, the biofuel sector may develop significantly as a result of improved market returns. In this context, land may be taken out of food production to grow biofuels or commodities may be directed to different markets other the traditional feed and food uses, adding further pressure on cereal prices. Finally, while some studies seem to suggest that grain prices have become increasingly correlated to oil prices one must not forget the recent perceived correlation between sugar and oil prices. Sugar cane based ethanol is currently the only competitive alternative to petrol and Brazil is the largest exporter of sugar and the largest producer of sugar cane based ethanol. Therefore, the correlation should be strongest for sugar. The sugar market highlights the danger of assuming that, as an increasing percentage of a

[22] http://www.oecd.org/dataoecd/6/10/38893266.pdf
[23] Sustainable Development Commission (2007) '$100 a Barrel of Oil, Impacts on the sustainability of food supply in the UK'

given commodity is used in the production of biofuel, it will slavishly follow the price of crude oil. Feed and food uses still dominate cereals, sugar and oilseed markets and there are too many factors affecting agricultural and soft commodities to make this a close relationship (see figure 12).

Figure 12: Relationship between Sugar and Oil Prices



Source: Liffe

A study recently published by the Sustainable Development Commission concludes that oil prices will impact directly and indirectly on farm production costs. This varies between and within commodities depending on the production system. Moving from $50 to $100 for a barrel of oil would increase production costs of livestock products by between 3 and 5 percent and crops by 13 percent of commodity price.

viii) Under-Investment in Agriculture

The cereal and oilseed markets have only recently emerged from decades of oversupply and low prices which also meant low levels of investment in agriculture and agricultural research. For example, The World Development

Report 2008: Agriculture for Development concludes that in many countries there was “serious underinvestment in R&D and in innovation systems more generally”.[24] The lack of investment has slowed down improvements in productivity with a negative impact on the supply potential.

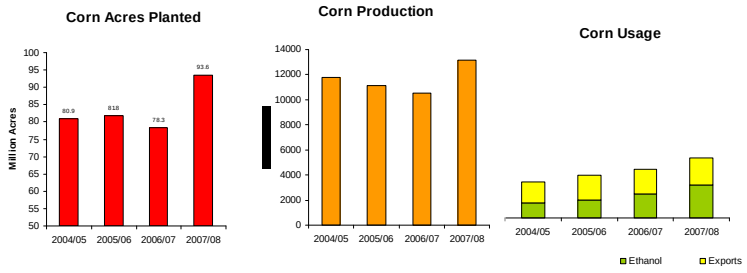
Case Study: Current US Maize Market

It has been suggested that increased ethanol production has caused maize prices to increase substantially since 2006. However, though ethanol production has been one factor, the reasons for increased maize prices are more complex and need to be put into perspective.

There are linkages between the maize market and the soybean market as these crops can be grown on the same land. In spring 2006, price signals in the futures markets gave farmers the incentive to plant more soybeans, and the acreage planted to maize fell by 3.5 million acres. Combined with relatively flat yields, maize production fell to 10.5 billion bushels. Price signals from the soybean market reduced maize production and thus put upward pressure on maize prices.

Whilst US maize production fell by 1.3 billion bushels in two years usage of maize increased. The usage of maize in ethanol production expanded from 1.3 billion bushels in 2004/2005 to 2.1 in 2006/07. The ethanol industry was not the only source of additional demand as the US maize exports, which were 1.8 billion bushels in 2004/05, rose to 2.1 billion bushels in both 2005/06 and 2006/07 and it is forecast to increase by almost 2.4 billion bushels in 2007/08.

Figure 13: US maize Supply/Demand, Crop Years 2004/05- 2007/08



Source: USDA

US Maize Balance Sheet

[24] World Bank, World Development Report 2008 – Agriculture for Development, p. 14.

	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09
Planted Acres	79.5	80.2	77.4	79.6	75.7	78.9	78.6	80.9	81.8	78.3	**93.6**	**88.9**
Harvested Acres	72.7	72.6	70.5	72.4	68.8	69.3	70.9	73.6	75.1	70.6	**86.1**	**81.8**
Yield	126.7	134.4	133.8	136.9	138.2	129.3	142.2	160.4	148.0	149.1	**153.0**	**160.0**
Beginning Inventories (Sep. 1)	883	1,308	1,787	1,718	1,899	1,596	1,087	958	2,114	1,967	1,304	**2,117**
Production	9,207	9,759	9,431	9,915	9,503	8,967	10,089	11,807	11,114	10,535	**13,168**	**13,083**
Imports	9	19	15	7	10	14	14	11	9	12	**10**	**10**
Total Supply	10,099	11,085	11,232	11,639	11,412	10,578	11,190	12,776	13,237	12,514	**14,482**	**15,209**
Feed & Residual	5,479	5,469	5,665	5,842	5,864	5,563	5,795	6,158	6,155	5,598	**5,700**	**5,400**
Food/Seed/Industrial	1,805	1,846	1,913	1,957	2,047	2,340	2,537	2,686	2,981	3,488	**4,290**	**5,500**
Of Which: Ethanol for Fuel	481	526	566	628	706	996	1,168	1,323	1,603	2,117	**2,900**	**4,100**
Domestic Use	7,284	7,316	7,578	7,799	7,911	7,903	8,332	8,844	9,136	9,086	**9,990**	**10,900**
Exports	1,507	1,983	1,937	1,941	1,905	1,588	1,900	1,818	2,134	2,124	**2,375**	**2,150**
Total Use	8,791	9,298	9,515	9,740	9,815	9,491	10,232	10,662	11,270	11,210	**12,365**	**13,050**
Ending Inventories (Aug. 31)	1,308	1,787	1,718	1,899	1,596	1,087	958	2,114	1,967	1,304	**2,117**	**2,159**
Stocks/Use	14.9%	19.2%	18.1%	19.5%	16.3%	11.4%	9.4%	19.8%	17.5%	11.6%	**17.1%**	**16.5%**
Futures Price ($/Bu)	2.57	2.16	2.10	2.09	2.15	2.37	2.64	2.12	2.23	3.54	**3.55**	**3.25**
Farm Price ($/Bu)	2.43	1.94	1.82	1.85	1.97	2.32	2.42	2.06	2.00	3.03	**3.25**	**2.85**

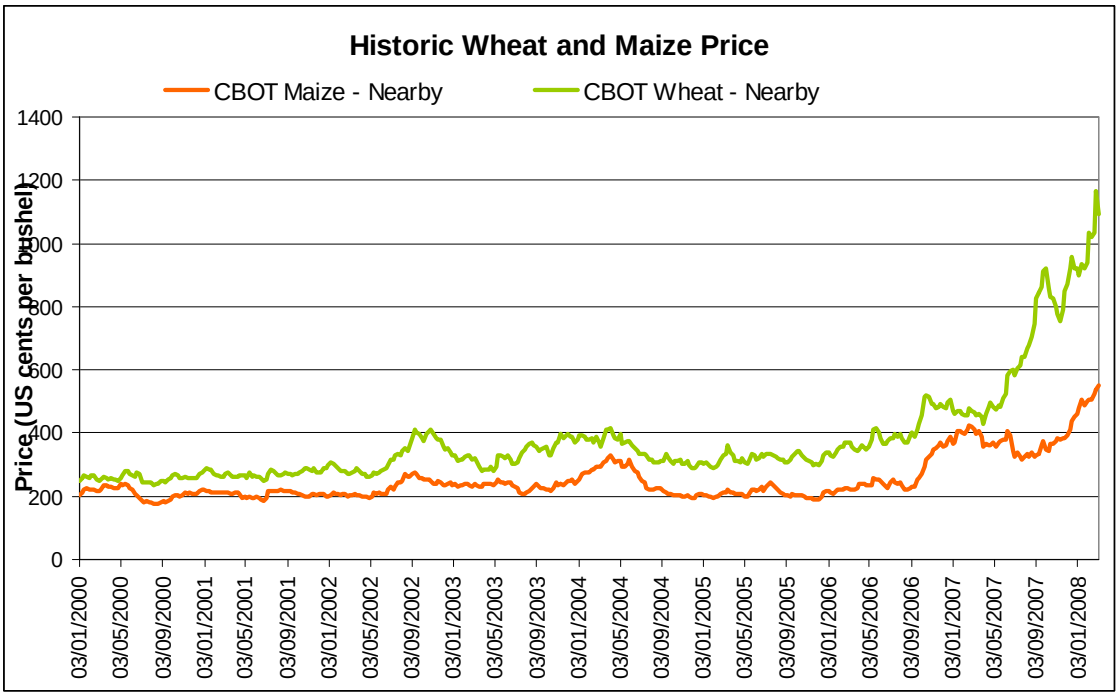
Source: USDA, CBOT (history), Informa Economics (forecast)

The US is the largest supplier of maize and by looking at the table above, one can see that its share as a global exporter has been growing over the last few years thus suggesting that to date, bioethanol production has not had a substantial impact on world maize exports.

Finally, more recently, while maize prices have experienced an increase of around 30 percent, one of the most dramatic rises in the commodity markets has been seen in wheat prices which more than doubled (136 percent) in the week ending 17 March compared to the equivalent week in 2007. Figure 13 bellow suggests that wheat prices may be driving maize prices upwards. Traditionally, the price difference between maize and wheat has been narrow (the ratio of wheat to maize was 1:1.3 in 2000). Wheat has become relatively more expensive compared to maize (current ratio is 1:2.18) and therefore some substitution in the feed market from feed wheat to maize can be expected, further increasing demand for maize.

These factors influencing supply and demand combined led to increased maize prices.

Figure 14: Historic Wheat and Maize Price



Source: HGCA

4. How do high cereal prices influence consumer food prices?

This section's aim is twofold: first to examine the degree of transmission of price changes along the supply chain (between the producer and consumer) and second to look at the impact of higher agricultural commodities on consumers in developing countries.

Studies undertaken by the European Commission assert that prices in agriculture are more volatile than consumer prices even on an aggregate level. Over the last seven years agricultural producer prices tended to slightly decline in nominal terms and more strongly in real terms, while food prices increased both in real and nominal terms. More importantly, consumer prices for bread increased by 2 percent between 2006 and 2007 compared to a 45 percent increase in producer prices for the same period. The main reason for this is the fact that the share of cereals in bread production costs is around 5 percent. Thus only extreme and prolonged peaks in prices could lead to slightly higher consumer prices. Similar changes can be observed for many agricultural commodities – see table 4.

Table 4: Producer prices comparison

Changes in producer prices			
	1st semester 2007/ 1st semester 2006	August 2007/ Aug-06	August 2007 1st semester 2007
Wheat	45%	78%	40%
Maize	30%	50%	37%
Poultry	21%	30%	10%
Pigs	-8%	-10%	12%
Beef	-2%	-1%	-1.50%
Butter	5%	46%	34%
SMP	32%	76%	35%
Cheese	0%	18%	15%
Rapeseed oil	-4%	n.a.	n.a.
Changes in consumer prices			
	1st semester 2007/ 1st semester 2006	August 2007/ Aug-06	August 2007 1st semester 2007
Bread	2%	4%	2%
Poultry	4%	6%	2%
Pigs	-2%	-2%	2%
Beef	0%	0%	0%
Butter	4%	32%	24%
SMP	22%	53%	25%
Cheese	0%	9%	8%
Rapeseed oil	-2%	n.a.	n.a.

Source: European Commission

The European Commission identifies several reasons why large fluctuations of agricultural producer prices do not lead to large effects on consumers. First, the share of agricultural raw materials in food production costs tends to decrease with degree of manufacturing; more important factors affecting the final goods are labour, capital and energy prices. Second, food-supply chains tend to have competitive structures and in some food sectors and countries the structures may restrain the transmission of primary commodity price changes to consumers. Third, increasing household incomes causes consumer behaviour to change and food costs as a proportion of incomes have been on a downward slide since World War Two. Finally, as discussed below, food prices changes tend to have a smaller effect on consumers in developed countries as the share of income designated to food is relatively small as a proportion of total disposable income (and consumers tend to buy less-processed food).

Figure 15: Consumer Price Index

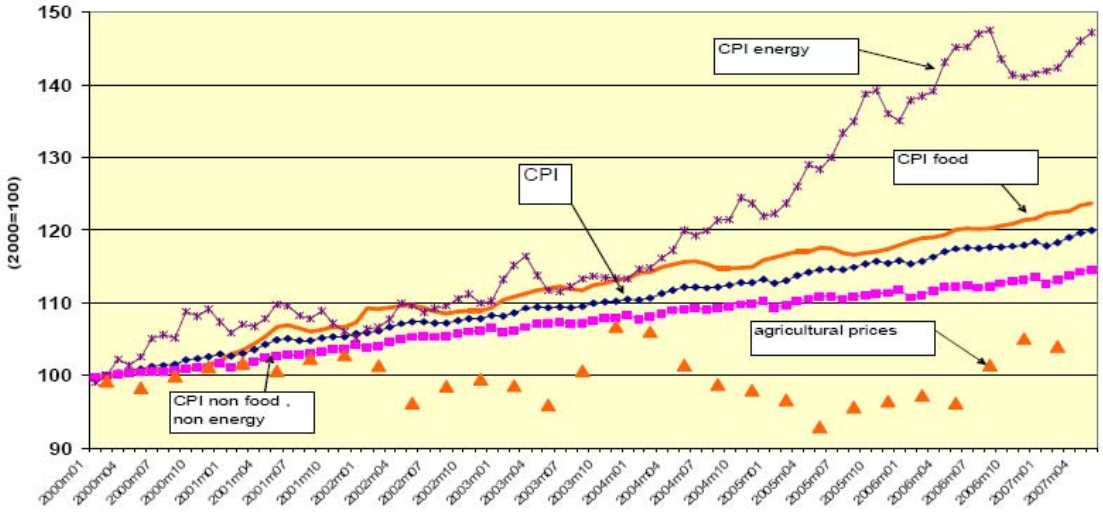


Figure 14 demonstrates that agricultural prices tend to fluctuate around a moderately stable trend whereas the Consumer Price Index (CPI) for food has risen steadily.

The Centre for Agricultural and Rural Development at Iowa University utilised a multi-product, multi-country, deterministic partial equilibrium model to evaluate the impact of US ethanol production and its impact on planted acreage, crop prices, trade and retail food costs. The study concludes that ethanol expansion will cause a retail food price increase; it predicts that in the long run, general food prices will increase between 0.7 percent and 1.8 percent more than they otherwise would have.[25]

Impact of higher commodity prices on the livestock market

Higher feed prices are likely to put upward pressures on the livestock prices. Previous Defra analysis[26] suggest the following:

Pigs and Poultry: intensive livestock producers are likely to be worst hit by increases in feed costs as feed makes up a significantly larger proportion of total costs. Feed accounts for around 60 percent of the total costs associated with pigmeat production. In the poultry sector feed makes up roughly half the total costs for conventional egg and broiler production. The compound poultry feed price was £176 per tonne in the period of July to September 2007 compared to £150 over the same period in 2006. According to the NFU an increase of £10 per tonne of feed increases the cost of chicken meat production by approximately 2p/kg of live-weight.

Beef and Lamb: feed costs are generally a smaller proportion of total costs for most beef and lamb producer than for example dairy.

[25] Tokgoz, S., Elobeid, A., Fabiosa, J., Hayes, D., Babcock, B., Yu, T., Dong, F., Hart, C. and Beghin, J. (2007), 'Emerging Biofuels: Oulook of Effects on US Grain, Oilseed, and Livestock Markets'. Centre for Agricultural and Rural Development, Iowa State University.

[26] http://statistics.defra.gov.uk/esg/publications/Monthly%20brief/Annex%201%20Food%20and%20farming%20brief%20-%20impact%20of%20high%20commodity%20prices.pdf

Dairy: feed costs make up a significant proportion of total costs for dairy cows.

Several studies have concluded that despite the recent increase in feed costs, the marketing bill (i.e. input costs from transport, labour, processors, etc) has a stronger relationship with the food Consumer Price Index than does the cost of feed. While an increase in feed prices will affect certain industries – for example, causing livestock and poultry feeding margins to be lower than they otherwise would have been, the statistical evidence does not reveal a direct transmission of higher feeding costs into consumer prices (see figure 14).

Impact of higher commodity prices on developing countries

Three of every four poor people in developing countries live in rural areas and most depend on agriculture for their livelihoods.[27] Promoting agriculture is therefore imperative for meeting the Millennium Development Goal of halving poverty by 2015. At present, evidence that biofuels are leading to food price increases is only circumstantial (Mayat 2007, Gidley 2007, Blas 2007).

The FAO estimates that developing countries' import bills will increase by 10 percent between 2007 and 2008 and some recent reports have attributed this increase to increased biofuel production but as set out in section 3 of this paper, biofuel demand has not been the main driver behind the current increase in commodity prices. It is also worth mentioning that while the import bill has increased, the export bill has also risen.

Of the main staples – rice, wheat and maize, only maize is currently used in significant quantities for ethanol production but wheat has experienced the largest price increase. The prices of these grains tend to move together, indicating that they are substitutes in some markets. Thus at the global level, at least, consumers should respond to any shortage in the supply of maize by increasing consumption of rice or wheat. Moreover, Hazel et al. (2005) argue that there is an imperfect transmission of world prices to domestic prices.[28]

Higher commodity prices are likely to have various effects on developing counties, and the effects will vary according to the different economic, social and environmental conditions. Whether those effects are positive or negative will depend on the local situation and would require case-by-case analysis.

Countries that have the largest endowment of under-utilised lands are in the developing world, especially in Latin America and Africa. Putting the land into production will require a type of infrastructure that usually crowds in with other forms of investment (such as transport, sanitation and water facilities). Biofuel production has the potential to make those infrastructure investments socially profitable and thus to promote overall economic development.

[27] World Bank (2008), 'Agriculture for Development - World Development Report 2008'
[28] http://www.passlivelihoods.org.uk/site_files%5Cfiles%5Creports%5Cproject_id_371%5CBiofuels,%20Agriculture%20and%20Poverty%20Reduction.pdf

In order to analyse the impact of bioenergy on food security, the FAO has recently developed an analytical framework which allows governments interested in entering the bioenergy sector to calculate the effect of their policy decisions on the food security of their country on the basis of inputting country-specific scenarios. This framework will provide the tools to assess the potential costs and benefits of biofuels for developing countries.

5. Implications of future increased energy crop demand

Commodity market models are not yet designed to model biofuels as endogenous factors. Work is under way by international research organisations (such as the OECD) to develop models that bring together biofuels production, trade and the interrelationship between biofuels and commodity markets. A study for the International Energy Agency "Bioenergy and biomass trade: Evaluation of models' suitability for analysing international trade of biomass and bioenergy products" gives more details on the limitations of current models.[29]

Some of the difficulties encountered by current models relate to the fact that they mostly rely on historic data. Biofuel production and trade are a relatively new phenomenon and as such the market for both biofuels and feedstocks has not yet been developed and most of the information needed to get a clear understanding of its development is currently not available. Some of the available models concentrate on modelling the impact of biofuels policy via mandates rather than consumption per se. Some of the obstacles relate to the lack of trade data for fuel ethanol and the unknown elasticities that are currently policy dependent.

In theory, in the longer term, increased demand for biofuels could potentially have a significant impact on crop patterns. Below an account is given of recent analytically oriented research on the extent to which higher biofuel production would result in an increase in commodity prices.

A recent OECD study suggests that the three OECD regions, the US, Canada and EU15, would require between 30 percent to 70 percent of their respective current crop area if they are to replace 10 percent of their transport fuel consumption by biofuels, assuming unchanged production technologies, feedstock shares and crop yields, and in the absence of international trade of biofuels or use of marginal fallow land. Brazil on the other hand, would only require 3 percent of its land in order to replace 10 percent of its transport fuel. For the world as a whole, 9 percent of cereals, oilseeds and sugar land would be required in order to achieve a 10 percent biofuels share of transport fuel. Whilst these figures are indicative rather than definitive, they reinforce the message that international trade, rather than national self-sufficiency is likely to be the key to achieving renewable energy obligations.[30] Finally, the OECD-FAO outlook suggests that increased feedstock demand for biofuel production may keep prices above historic equilibrium levels during the next 10 years.

[29] http://www.bioenergytrade.org/downloads/solbergetal.modelingbiomasstrade.pdf
[30] OECD (2006), 'Agricultural market impacts of future growth in the production of biofuels' http://www.oecd.org/dataoecd/58/62/36074135.pdf

For example, the wheat price is projected to be around $250 and $180 between 2007 and 2016 or between 18 and 25 percent higher than the average for 2001/02 and 2005/06 but significantly lower than prices in early 2008 which were over $350/tonne. The report points out that there are a number of uncertainties in relation to biofuel markets and how important they will prove to be in underpinning prices in agricultural markets in the future.

The OECD study estimates that the commodity price impacts of higher oil prices and increased demand for biofuels (relative to constant biofuel production) are likely to be more significant for vegetable oil (20 percent) and sugar (60 percent) than for cereals (4 percent). However, recent decrease in world sugar prices despite increasing oil prices and bioethanol production suggest that the relationship is not straightforward. The assumptions underpinning the model used in this analysis are: no trade in biofuels, that all biofuel is produced from food feedstocks and constant technologies for the projection period.

EUCAR, CONCAWE and JRC evaluate the effect of a 5.75 percent EU biofuels target on cereal and oilseed prices using the FAPRI food commodity prices in 2012. The analysis report argues that reaching the EU biofuels directive target of 5.75 percent replacement would represent an additional demand of 9 percent of 2012 world oilseeds supply, assuming a 5.75 percent share of biodiesel in diesel consumption. From market flexibility indicators, they conclude that the world price would then increase by between 6 and 16 percent. The extra cereals needed to produce a 5.75 percent share of bioethanol in petrol consumption would only represent 1.5 percent of the projected world cereal production, thus the cereals market would only be marginally affected.[31]

Defra has done some preliminary analysis in order to assess the impact of increased biofuel production on the cereals market at the EU15 level. The analysis has been carried out using the OECD Aglink model. It is assumed that the EU will not meet the 5.75 percent target in the Biofuels Directive; instead an incorporation rate of 4.2 percent will be met in 2010. Cereal consumption was altered in the model to include a 4.2 percent incorporation rate, thus consumption and production of cereals will increase compared to the baseline. The results show that wheat consumption is projected to increases by 6 percent in 2010 and coarse grain consumption increases by 8 percent by 2010 compared to the baseline. Similarly, wheat prices increase by 5 percent and coarse grains by 7 percent in 2010 compared to the baseline. Furthermore, the assumptions in the model are similar to those of the OECD study; in addition, it assumes the same elasticity of demand for biofuels and other industrial uses, absence of trade in biofuels and constant technology.

The European Commission carried out a set of simulations in order to analyse the impact of increased biofuel demand. One of the simulations assumes that the market share of biofuels increases to 5.75 percent in 2010

[31] EUCAR, CONCAWE and JRC (2007), 'Well-to-Wheels Analysis of Future Automotive Fuels and Powertrains in the European Context'

and a regulated market prevails. The results suggest that half of the projected biofuel demand of the EU25 in 2010 could be served by domestically grown feedstocks: through increased production driven by price increases for cereals (6 to 11 percent) and oilseeds (5 percent to 15 percent), shifts in consumption and reductions in exports. Increasing production of feedstock would be reached by expanding cereal and oilseed production by 4.1 million hectares, or around 4 percent of the total arable land of the EU25. The additional production of cereals and oilseeds would contribute 21 percent to the biofuel demand. The usage of sugar beet in the most productive regions could contribute an additional 4 percent. In total, 25 percent of biofuels needs in 2010 could be served by increasing production of EU feedstocks under these assumptions. The second simulation assumes a 5.75 percent market share as well as a deregulated market where all tariffs on biofuels and feedstocks are phased out. The analysis suggests that 27 percent of EU biofuel demand will be served by domestic production, mainly due to increased oilseed production caused by higher oilseed prices (5 to 12 percent). The phasing out of tariffs on biofuels and feedstocks would cause cereal prices to decline (-15 to -20 percent) due to the substantial increase in imports.[32]

Further analysis by the European Commission assessing the impact of the 10 percent by energy biofuel target for 2020 indicates that prices for agricultural raw materials in the EU would increase by 3 to 6 percent for cereals and 5 to 18 percent for oilseeds. The likely increase would have a relatively smaller impact on food prices – given the share of raw-material costs in the price of most foods.

Koonin (2006) estimates that biofuels could supply 20-30 per cent of global fuel demand in an environmentally responsible manner without affecting food production.[33]

Research to assess the impact of biofuel production on agricultural markets and the economy more generally using General Equilibrium Models, such as GTAP, is also under way.[34]

When interpreting the results of any of the studies, it is important to understand the scenarios modelled, the assumptions made and the limitations of the model used.

6. The potential of second-generation biofuels

Many uncertainties remain for the future of biofuels. One of the biggest uncertainties is the extent to which the land intensity of current biofuel production can be reduced. For instance, the amount of biofuel that can be produced from an acre of land varies from 100 gallons per acre for EU

[32] Commission of the European Communities (2006), Communication from the Commission, 'An EU Strategy for Biofuels – Impact Assessment'
[33] Koonin, S., (2006) 'Getting serious about biofuels' Science 311 (5760): 435, 27 January 2006. In ODI (2007), 'Natural Resource Perspective', June 2007. http://www.odi.org.uk/Publications/nrp/NRP107.pdf
[34] For some strands of research see the website of the 10th annual GTAP conference https://www.gtap.agecon.purdue.edu/events/conferences/2007/program.asp

rapeseed to 400 gallons per acre for US corn and 660 gallons per acre for Brazilian sugarcane.[35]

Second-generation biofuel production has the potential to reduce land requirements and increase productivity. Cellulosic ethanol could be made by breaking down the cellular material that gives plants rigidity and structure and converting the resulting sugar into ethanol. Cellulose is the world's most widely available biological material, present in wood chips and wood waste as well as in crop residues such as maize stover, bagasse and sugar cane trash. A few pilots are planned to start operating this year. Brazil for instance will bring the country's first pilot plant for the production of cellulosic ethanol into service.

In addition the "Energy Independence and Security Act 2007" requires 36 billion gallons fuel ethanol by 2022. However, of its total, 60 percent has to come from advanced biofuels. The Renewable Fuels Standards also requires the US to produce a 16 billion gallons of cellulosic biofuels by 2022.

Similarly, in 2007 the EU agreed a target of 10 percent for the share of biofuels in overall EU petrol and diesel consumption by 2020. The new target is conditional upon sustainability of production and commercial availability of second-generation biofuels.

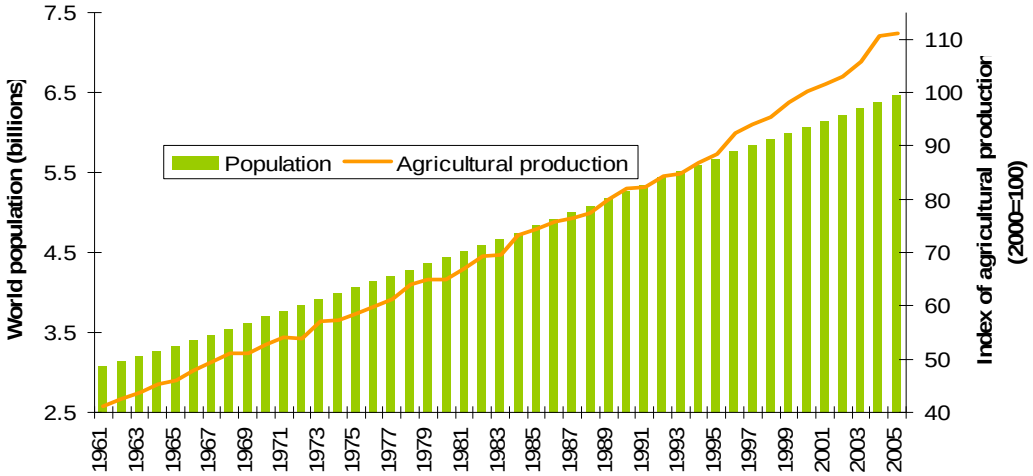
7. Back to Malthus?

Malthusian arguments about capacity are increasingly a part of the biofuels debate. Malthus argued in 1798 that land is finite and that its productivity can, at best, increase only arithmetically or linearly (1,2,3,4 etc.), while population increases geometrically (1,2,4,8, etc.); so the increase in population tends to outrun the increase in food supply. Consequently, most people would be condemned to live in misery and poverty with wars, epidemics and famines serving to slow down the growth of the population.

Currently, growth in agricultural production is higher than population growth and it has been since the early 1990s. Chaturvedi (2006) suggests that population growth and increasing demand for both biofuels and food will put extraordinary pressure on the land.

[35] USDA

Figure 16: World population and agricultural growth



Source: Sustainable Development Commission Report

Others argue that there is potential to increase sustainable production of biofuels feedstocks. The IKAR – a Russian based agricultural institute – estimates that as many as 10 million hectares in Russia, Ukraine and Kazakhstan that were used for grain production in the early 1990s could easily be brought back into production. These three countries also have the potential to increase productivity/yields capacity.[36] Similarly, the FAO estimates that 23 million hectares of arable land have been withdrawn from production in recent year in Eastern Europe and the CIS region.[37]

Hausmann (2007) asserts that there are more than 700 million hectares in 95 countries that are of good quality un-cultivated land. He also argues that today's oil production (depending on assumptions about productivity) represents the equivalent of some 500 million to 1 billion hectares of biofuels. So the production potential of biofuels is in the same ball park as oil production today.[38]

Conclusions

The development of biofuel programmes in developed and developing countries is closely linked to the potential expansion of feedstock production and to the impact that this expansion may have on production structure of the producing countries and on global agricultural markets.

This paper concludes that recent increases in cereal prices appear to have more in common with poor harvests and consequently lower stocks than they do with structural change in demand.

Different studies have attempted to estimate the future impact of increased biofuel production on commodity prices. The OECD suggests that effects of

[36] IKAR (2007) 'The Role of the CIS in Meeting Growing demand for Feedstock'
[37] AgraFacts 14/03/2008
[38] Hasusmann, R. (2007) 'Biofuels can match oil production' Financial Times, 6 November 2007

global demand for biofuels are likely to be more significant for vegetable oil and sugar. However, recent decreases in world sugar prices despite increasing oil prices and bioethanol production suggests that the relationship is not straightforward. While such studies provide a useful benchmark they assume that all biofuels is produced from food-crops, no trade in biofuels and constant technology.

More research is needed and is being carried out to improve the understanding of the biofuel demand on commodity prices. Work is already under way to improve the models that are used to assess the impact of biofuel demand on agricultural commodity markets (for example by OECD and researchers using general equilibrium models).

The Government has commissioned the Renewable Fuels Agency (RFA) to consider some of the existing evidence gaps around biofuels use and production. The RFA-led review will examine the impacts of rising demand for biofuels upon land use and specifically effects upon the net greenhouse gas (GHG) savings, taking into account potential direct and indirect land changes. The review will aim to put the impacts of biofuels into perspective, by quantifying the extent to which demand for biofuels is adding to pressure on available land resources and driving increasing food commodity prices and food insecurity for the most vulnerable members of society.

More research is also needed in order to understand the potential costs and benefits of biofuel production on food security and agricultural development more generally under different policy options (e.g. regarding the incentive to use by-products either for animal feed or energy).