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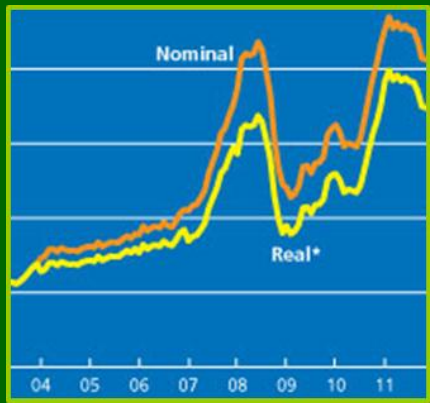

EU BIOFUEL USE AND AGRICULTURAL COMMODITY PRICES: A REVIEW OF THE EVIDENCE BASE

Report prepared for Action Aid

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Contents

EXECUTIVE SUMMARY

Biofuel mandates are being used in many parts of the world to encourage the substitution of fossil fuels in transport uses by renewable energy. Brazil has long had an extensive programme of producing bioethanol from cane sugar, the USA has massively expanded production of ethanol from corn and the EU's Renewable Energy Directive has led to a scale up in EU biofuel use, most notably of rapeseed biodiesel.

The European Commission will produce a report reviewing the social impacts of EU biofuel policy by the end of 2012. To support Action Aid in its participation in the debate about the future of EU biofuels policy, taking into account the social dimension, this report was commissioned to provide an independent review of the evidence base on the link between policy-driven EU biofuels demand and global agricultural prices – in particular through reviewing a selection of modelling based studies. The next step in the causal chain from agricultural prices to food price impacts, ie prices to consumers on the ground, whilst highly important lies outside the scope of the study.

The 10 per cent target for the use of renewable energy in transport set in the EU Renewable Energy Directive is anticipated to lead to a tripling of biofuel use in the EU in 2020 compared to 2008 levels, according to the National Renewable Energy Action Plans that all Member States have been required to produce. The plans confirm that the current dominance of biodiesel over ethanol in the European biofuel market will continue. The EU's target predominantly will be met by first-generation biofuels produced from traditional food and feed crops, translating into a significant additional demand for these crops. It is clear that this additional demand, alongside the growing global demand for food and biofuel demand elsewhere will increase agricultural commodity prices but by how much is the subject of continued debate. The uncertainty about the extent of price increases arises from a range of factors, including the prevalent interactions between different crops and livestock markets and between world regions and from the responses to price signals by consumers and producers. Yield increases stimulated by higher output prices is often suggested as a factor with the potential to mitigate price increases; another may be related to the rise of protein by-products as animal feed.

The complexities of interacting factors can only be captured in reasonably sophisticated economic models and we have reviewed a range of both partial and general equilibrium models for this report. Nonetheless, because of the wide variety in the context, scope and methodology of models used to analyse the effects of biofuel mandates, the results of analyses of the price effects range substantially. Consequently, it is often extremely difficult to draw comparisons between models.

In those modelling studies focusing on the impacts of EU (as opposed to global) biofuel policies, the most significant price increases are projected for oilseeds and vegetable oils, with increases in world prices by 2020 typically ranging between 8 to 20 and 5 to 36 per cent, respectively (see table below). Wheat prices are projected to increase by between 1 and 13 per cent and the majority of studies project increases of cereal / maize prices of up to 8 per cent and of sugar prices of up to 2 per cent. One model (ESIM) projects these increases to be 22 and 21 per cent, respectively. Many of the drivers of differences in results are those that have been under scrutiny in the indirect land use change debate. Consequently, the studies at the forefront in that debate can be expected to deliver the most robust results with regard to agricultural market impacts. This is most notably the IFPRI study, which projects increases in world rapeseed prices (anticipated to be the most significant feedstock for EU biofuel use in 2020) of around 11 per cent (Laborde, 2011). While looking at studies that model global biofuel policies does not allow singling out the EU policy impact, it is in some way a more complete scenario design, given EU policies in the real world do not take place in isolation but other countries have in place biofuel policies as well. At least some of the global studies estimate substantially higher price effects for ethanol crops such as wheat, other cereals and sugarcane.

Table: Summary of price effects per feedstock

Feedstock (group)	Range of price effects	Commentary
Studies that focus on the effects of EU biofuel policy		
Oilseeds	8 – 20%	
Vegetable oils	1 – 36%	
Oilseeds	9 – 20%	
Cereals / maize	1 – 22%	The ESIM model (Blanco Fonseca *et al*, 2010) projects an increase in maize prices of 22%. The remaining studies project increases in maize or cereal prices of ≤8%
Wheat	1 – 13%	
Sugar (cane/beet)	1 – 21%	The ESIM model (Blanco Fonseca *et al*, 2010) projects an increase in sugar prices of 21%. The remaining three models reporting results for sugar project price increases of ≤2%
Studies that analyse the impacts of global/multi-regional biofuel mandates		
Oilseeds	2 – 7%	
Vegetable oils	35%	OECD (2008) is the only ‘global’ study providing a figure for vegetable oils
Cereals / maize	1 – 35%	
Wheat	1 – 8%	
Sugar (cane/beet)	~10%	Timilsina *et al* (2010) is the only ‘global’ study providing a figure for sugar, 9.2 or 11.6% depending on the scenario

Source and notes: see section 5.3

In terms of options to deal with biofuel induced price increases: a reduction, or even abolition, of policy induced biofuel demand will reduce or prevent altogether agricultural market and hence price impacts due to biofuel *policy*. Depending on the development of oil and therefore fossil fuel prices on the one hand and feedstock prices on the other, the market might still drive increased biofuel use whenever it is price competitive with fossil fuels, rendering policy changes less or altogether ineffective. Unlike in the USA, where biofuels are promoted by a rigid mandate laying out annual targets for biofuel volumes consumed, EU biofuel targets are less specific, arising *de facto* from a wider renewable energy target. At present there is at least an element of flexibility afforded to Member

States in terms of how they choose to go about meeting the target. They are obliged to deliver a certain proportion of renewable energy in transport rather than to meet specific target volumes of biofuels. Consequently, policy can be adjusted in different ways – either by altering the target for renewables, setting more specific targets for different forms of renewable energy (eg from wastes), increasing the efficiency of transport vehicles etc. For example, EU policy that would encourage Member States to increase support for advanced biofuels produced from forestry and agricultural residues as well as renewable electricity while scaling back support for conventional biofuels produced from food and feed crops, would be a way of reducing pressure on agricultural markets. These alternative options for promoting renewable energy and increasing policy flexibility need further detailed consideration. More clarification could usefully be provided by the Commission regarding the scope of Member State autonomy to adapt their policies up to 2020.

This review assessed the impacts of biofuel use on agricultural *commodity* prices. The European Commission, as part of its reporting requirements in 2012, is required to judge the impacts of biofuels on *food* prices. This further step increases the complexity of the analysis substantially. Food supply chains involve an extremely wide range of plant and animal products with varying degrees of processing of agricultural commodities and varying proportions of staple foodstuffs in the diet. The vulnerability of consumers across the world to food price increases differs markedly between countries and across households, depending *inter alia* on income levels, household composition, and on the household status as net consumers or producers of agricultural and food stuffs. We are not aware of studies that use multi-household models, which would produce a better understanding of how commodity price rises induced by biofuels are transmitted to different population groups and allowing more solid estimates of the welfare impacts of biofuel policy. This gap should be closed in order to provide decision makers with a more complete evidence base feeding into the political review processes ongoing in 2012.

1 INTRODUCTION

In 2012, the European Commission (EC) will produce a report reviewing the social impacts of EU biofuel policy. Under Article 17 (5) of the Renewable Energy Directive (RED)[1], the EC is obliged to conduct this review into the impacts on 1) food affordability and availability; 2) land rights; 3) whether producer countries have implemented various International Labour Organisation conventions and 4) 'wider development issues'. To support Action Aid in its participation in the debate about the future of EU level biofuels policy, it commissioned IEEP to provide an independent review of the evidence base on the link between policy driven EU biofuels demand and global agricultural prices in particular through reviewing a selection of modelling based studies. The next step in the causal chain from agricultural prices to food price impacts, ie prices to consumers on the ground, whilst highly important lies outside the scope of the study. In Section 5 we provide a brief discussion of the complexity of the relationship between global agricultural and food prices.

This report is structured as follows: Section 2 gives a brief overview of EU policy driving biofuel demand and sets out what is currently known about the likely scale and nature of this demand to 2020. Section 3 outlines the major concerns and uncertainties in the discussions on biofuel use and agricultural and food price impacts or, in other words, the 'food versus fuel' debate. To separately analyse the effects of biofuel policy we have to understand the wider context of the high volatility in agricultural commodity prices experienced in recent years. Section 4 gives an overview of some of the most important factors shaping agricultural commodity prices. Section 5 reviews the results of a selection of modelling based studies examining the impacts of EU and global biofuel policies on agricultural markets and prices. Section 6 spells out some implications that might be drawn for policy on the basis of the modelling studies. Section 7 provides a brief conclusion.

[1] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

2 EU POLICY DRIVING BIOFUELS DEMAND AND OUTLOOK FOR THIS DEMAND TO 2020

In this section we briefly summarise the main dimensions of EU policy driving biofuels demand and provide an outlook for this demand to 2020 in terms of the overall scale of demand, as well as the nature of demand (ie what kind of crops will be used).

Biofuel use was first promoted in the EU by the 2003 'biofuel directive'[2], stipulating an indicative target for EU Member States of 5.75 per cent biofuel use in road transport fuels by 2010. There was limited progress towards this target in many Member States, leading to the introduction in 2009 of the new binding target in the Renewable Energy Directive constituted a significant further step. The Renewable Energy Directive calls for an EU-wide 20 per cent renewable energy share in gross final energy consumption to be reached by 2020. Apart from this overall target, the RED mandates a 10 per cent renewable energy share in transport to be met in each Member State by 2020. According to the National Renewable Energy Action Plans (NREAPs) which the Directive requires governments to prepare around 90 per cent of the transport target will be met by first-generation biofuels in 2020.

Box 1: First- and second-generation biofuels
Biofuels can replace conventional diesel (biodiesel) and petrol (bioethanol) as transport fuels. So-called first-generation biofuels are derived from food and feed crops. The crushing of different oil crops including rapeseed, soy, palm and jatropha (the latter not used for food or feed purposes) yields oils that are transformed into biodiesel through transesterification. Bioethanol is produced by fermenting the sugar components derived from sugar and starchy crops such as sugar cane and beet, wheat, rye and maize. Advanced or second-generation technologies are being developed that convert lingo-cellulosic material (including woody crops and forest and agricultural residues) into biofuel. These offer the possibility of utilising biomass which is less directly competitive for food and feed, and also capable of yielding a much higher energy return.

2.1 What is the current scale of EU demand for biofuels and how is this likely to develop to 2020?

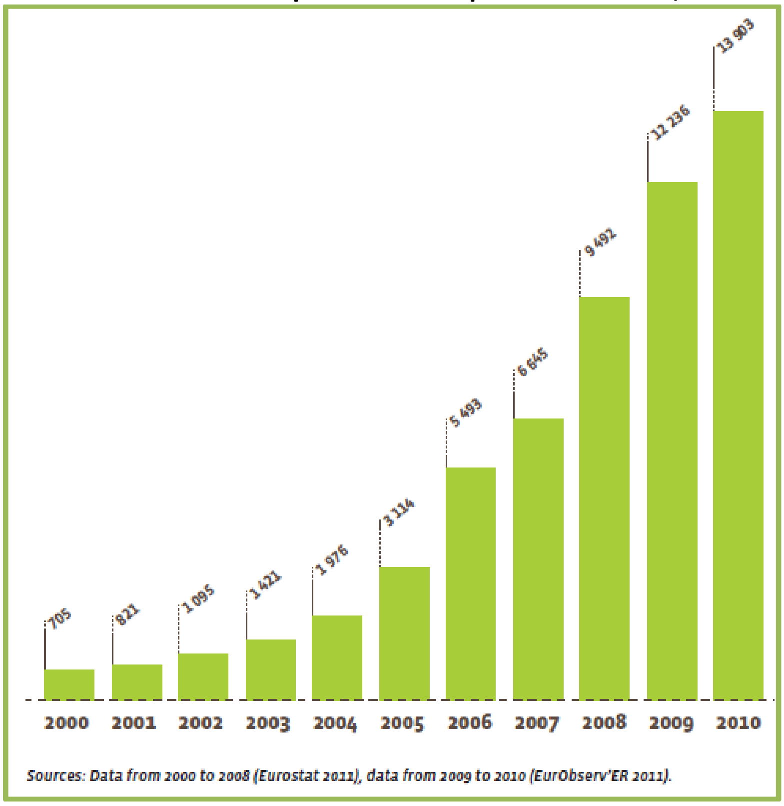
Figure 1 illustrates the development of EU biofuel consumption over the last decade showing the importance of EU policy in triggering uptake in the more recent years.

To give an idea about the breakdown of the aggregate position for the EU in Figure 1: the biggest biofuel consuming countries in 2010 were (in descending order) Germany, France, Spain, Italy and the UK. Biodiesel accounted for over three quarters of 2010 EU biofuel use. Germany, France and Spain lead EU biodiesel production in 2010 (EUROBSERV'ER, 2011). EU bioethanol production is dominated by France, Germany and Spain (2009 data)[3].

[2] Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport.

[3] http://www.biofuels-platform.ch/en/infos/eu-bioethanol.php

Figure 1. Development of biofuel consumption for transport in the EU 27, 2000 to 2010 (in mtoe)



Source: EUROBSERV'ER, 2011, p74

An outlook for future EU biofuel consumption is contained in the compendium of National Renewable Energy Action Plans (NREAPs) prepared by Member States[4]. Bowyer (2011) has analysed the Member States' NREAPs yielding the following observations, summarised in Table 1[5]. In order to meet the 10 per cent target:

- The 27 EU Member States will consume 29.6 Mtoe of biofuels in 2020. This translates into an increase in biofuel use between 2008 and 2020 of 19.5 Mtoe.
- The majority will be conventional first-generation biofuels, making up about 92 per cent of total predicted biofuel use or 27.3 Mtoe in 2020, equating to 8.8 per cent of the total energy in transport. Advanced or second-generation biofuels will not gain an important market share and are anticipated to account for only 0.7 per cent (2.1 Mtoe) of total energy in transport by 2020.
- Out of first-generation biofuels, 72 per cent are anticipated to be biodiesel and 28 per cent bioethanol; anticipated imports amount to 44 per cent of bioethanol and 36 per cent of biodiesel used in 2020 (see Table 1). Actual imported levels of feedstock could be even higher as it is unclear whether the figures for anticipated imports

[4] Member States subsequently are required to report on progress towards the binding renewable energy targets on a biannual basis; the first of these reports were due at the end of 2011. These can give an updated picture of the amount of biofuels Member State anticipate using in 2020. At the time of writing, not all reports had been submitted yet and it was beyond this study to analyse those already submitted.

[5] A detailed analysis of the NREAPs by Beurskens *et al* (2011) for the Commission yields additional information on biofuel pathways to 2020 in the different Member States (see tables on projected total bioethanol/bio-ETBE and biodiesel use in renewable transport over 2005-2020 on p178 and p184, respectively).

reported in the NREAPs also include imported feedstock for 'domestic' processing into biofuels or only refer to processed biofuels.

Table 1: The projected composition of EU biofuel consumption in 2020 according to NREAPs

Expected quantities of EU biofuels in 2020	Total Mtoe	Biodiesel		Bioethanol	
		Mtoe	*share*	Mtoe	*share*
Consumption	29.6	21.3	*72% of total biofuels*	8.3	*28% of total biofuels*
Imports	11.3	7.7	*36% of biodiesel cons*	3.6	*44% of ethanol cons*
Production	18.3	13.7	*74.4% of total biofuels*	4.7	*25.6% of total biofuels*

Source: Own compilation based on Bowyer (2011)

One question arising in this context is how EU Member States have derived their NREAP estimates, ie whether these are targets or predicted behaviours given certain signals and other assumptions and how accurate the estimates are expected to be. It seems reasonable to expect diverse answers to these questions across the different Member States, depending on the amount of resources, including modelling techniques, national authorities put into the elaboration of their NREAPs. NREAP estimates should reflect MS policies in place, including differentiated support for first-generation versus advanced biofuels versus renewable electricity in transport. This topic would merit further examination[6].

2.2 What kind of agricultural crops are currently used to meet EU biofuel demand and how is this likely to develop to 2020?

Tables 2 and 3 below show the shares of feedstocks for both EU biodiesel and bioethanol consumption in 2008 and 2020, respectively. For 2008, figures compiled under the 'Biofuel Baseline 2008' project by Ecofys *et al* (2011) have been used. Projections for 2020 are derived from one of the ILUC modelling studies prepared for the European Commission (Laborde, 2011).

Currently, rapeseed/oil dominates the market of biodiesel destined for EU consumption, amounting to over half of the total feedstock used. This is followed by soybean and palm oil with similar shares and a few feedstocks of minor importance. The resource base is more diversified for ethanol, with sugar cane and beet and wheat dominating current markets

Moving to projected feedstock shares in 2020 (table 3): rapeseed continues to dominate the biodiesel market, accounting for 57 per cent of the feedstock in 2020. Palm oil makes up another fourth of all feedstock used, with the remainder from soy and to a lesser extent sunflower. The market for ethanol destined for EU consumption is projected to be more heavily reliant on sugar cane in 2020 as opposed to 2008. Sugar cane is projected to account for almost half of all feedstock. This is followed by wheat, sugar beet and maize. These

[6] Work under the Biomass Futures project with the energy sector model RESolve contributes to this: www.biomassfutures.eu.

projections are derived from the IFPRI study (Laborde, 2011) whose scenarios are in line with the shares of and absolute volumes of biodiesel and ethanol Member States anticipate using in 2020. Taken together with accounting for observed usage of feedstocks in 2008 in the baseline, the 2020 figures should give a fairly good picture of the biofuel market in 2020 and the relative importance of different feedstocks. But of course the figures are not free from uncertainty and like any other results derived from the model depend on factors such as assumed (relative) crop yield developments and future crop demand from other sectors.

Table 2: Shares of feedstock for biofuels consumed in the EU in 2008

Biodiesel	% share	Ethanol	% share
Rapeseed/oil	55	Sugar beet	23
Soybean/oil	19	Sugar cane	23
Palm oil	16	Wheat	21
Tallow	5	Maize	13
RVO	4	Wine	8
Sunflower/oil	2	Rye	3
		Barley	1
		Triticale	0.4
		Other	8

Source: own calculation based on Ecofys et al, 2011, Tables 14 and 15
Note: RVO is recycled vegetable oil.

Table 3: Shares of feedstock for biofuels consumed in the EU in 2020

Biodiesel	% share	Ethanol	% share
Palm Oil	24	Maize	14
Rapeseed	57	Sugar Beet	18
Soy	15	Sugar Cane	46
Sunflower	6	Wheat	21

Source: own calculation based on Laborde, 2011, Table 3
Note: Percentages from Laborde’s Table 3 are recalculated taking the setting of biodiesel=100% and all ethanol=100% (instead of all biofuel=100% as in the original table). Percentages for biodiesel feedstock yield slightly over 100% when summed, due to rounding in the original table.

3 THE FOOD VERSUS FUEL DEBATE IN THE EU: A BRIEF REVIEW OF SOME OF THE MAIN DIMENSIONS

3.1 Why the Concern?

EU mandates and policy support for biofuels, and for biomass use for heat and electricity, generate additional demand for feedstocks and therefore for land on which to grow them, with consequences for land use both in Europe and globally (given the international nature of commodity markets). This situation gives rise to a series of unintended impacts and therefore raises doubts about the sustainability of the transport target, in particular whether it actually contributes to reducing GHG emissions from transport, a key underlying rationale for the whole policy. In this context, 2010 and 2011 have seen an intense discussion about the indirect land use change (ILUC) impacts of EU biofuel use[7]. While this discussion continues, the year 2012 increasingly will bring the social impacts of biofuel use on to the agenda given the Commission's reporting obligations. Already the impacts of biofuels on food prices has been fiercely debated in recent years particularly in the light of the agricultural commodity price spikes in 2007/2008 and again more recently in 2010/2011.

The demands placed on global land and food resources are already anticipated to rise in the coming decades due to a growing global population, income growth and continuing expansion in meat consumption. At the same time production of many crops is threatened by the consequences of climate change (see section 4). The additional pressure applied by a further sector, ie energy supply attempting to regain access to commodities and land to meet its needs will inevitably drive up the price of agricultural raw materials. This means that among others the cost of grains for different users such as the flour millers, brewers and animal feed compounders is raised. In turn, they will pass on their higher costs to final consumers of bread and other bakery products, drinks and other products and to livestock producers which will, in turn, raise meat and milk prices too. The outcome is that retail prices of food rise compared to where they would have been in the absence of the biofuels policies. The extent of this depends on the importance of the raw material costs in final product prices and the competitiveness of the food processing and retailing sectors.

The impact of increases in food prices on individual households depends very much on their composition and income. As spelled out in more detail in section 5 (Box 4), the share of income spent on food varies widely between low- and high-income households and is much higher in the former. Because of this, increases in food prices will have a lower impact on overall welfare and non-food expenditure in high-income groups. It may lead to reductions in saving rates or in the consumption of other, non-food goods or may lead to a switch from premium to discount food brands. In low-income groups, however, food price increases can lead to reductions in food intake or to a switch towards cheaper and less varied diets, risking malnutrition and/or undernourishment. Also, expenditure on schooling or health services may be reduced. The uneven effect of biofuel induced commodity price increases on low- and high-income groups becomes more pronounced due to the fact that the former rely more on staple foods which embody little processing. Therefore, sensitivity to any increase

[7] Some of the prominent studies addressing indirect land use change from EU biofuel use are: Bowyer (2011), Laborde (2011), Blanco Fonseca *et al* (2010) and Edwards *et al* (2010).

in commodity prices will be much greater in lower income families, whereas the diet of higher income groups primarily consists of processed food that has passed through a longer value-adding chain, so that commodity price increases have much smaller impact on retail prices. In short, policies which raise agricultural commodity prices, such as biofuel mandates, have a differentially larger impact on poor consumers.

3.2 Controversy over the fuel and food interaction

Central to the question of how the potential use of feedstocks for biofuels will impact on food prices is the extent of the growth in biomass production and the additional demand on land needed to enhance energy supply. Unfortunately, there is little agreement on the precise scale of additional land use demands anticipated from biofuel production. The most recent modelling results from IFPRI (Laborde, 2011) suggest global land use change generated by the increase in EU demand for biofuels associated with the RED would be between 1.73 and 1.87 Million hectares of additional cropland area[8]. This is just one illustration; other analyses have identified significantly larger and smaller estimates of the extent of land use change (see Edwards *et al*, 2010, for a discussion of the most important drivers of differences in results).

The consequences for agricultural commodity (and ultimately food) prices of this diversity are discussed in detail within the next sections. The primary sources of the disparities in estimates of the extent of biofuel impact on land and feedstock resources are summarised below:

- Differences in assumptions regarding feedstock usage to produce fuels, ie different crops yield dramatically different volumes of biofuel from one hectare of land. They range from an estimated 5470 litre/hectare (l/ha) for ethanol from sugarcane in Brazil and 4700 l/ha for biodiesel from Malaysian oil palm to 550 l/ha for biodiesel from US soy and 950 l/ha for wheat ethanol (FAO, 2008; see also Annex 1).
- Variable consideration of land demands and competition impacts associated with second-generation biofuels based on lingo-cellulosic material, combined with different assumptions regarding their market penetration in the medium to long term. It was originally assumed that the RED would drive expansion in these supplies ahead of 2020. However, analysis of Member State plans anticipates only 8 per cent of total biofuel demand by 2020 being delivered from such fuels, and moreover there remain uncertainties regarding the impact of wood fuel resources in terms of land and climate (Zanchi *et al*, 2010).
- Most of the growth in agricultural production in the twentieth century has come from increases in yields rather than an increase in agricultural area. It expected that this will remain true for the 21st Century. So a critical variable in explaining the impact on prices of a rise in the demand for food crops will be yield assumptions. These assumptions will differ between analyses. Yield growth has certainly slowed in the last decade for many crops and regions, however this in turn is highly dependent on some policy factors, especially agricultural research and development

[8] The average of these estimates equates to 1.1 per cent of EU Utilised Agricultural Area or 1.7 per cent of EU arable area (see Annex 1 for the sources of these total EU areas).

expenditures. The recent food price scares have stimulated policy change to increase publicly funded agricultural R&D in many regions, including the EU (see Foresight, 2011).

- Whether biofuels feedstock suppliers are directly competing for the same crops or varieties as food stuffs ie wheat varieties that are best suited for distilling, hence conversion to bioethanol, differ from those recommended for milling and flour production, or those often grown for animal feed (HGCA, 2010 and Nabim, 2012). There is, however, a question as to whether this would in reality limit the impact on wheat prices given that differing varieties of wheat are still digestible and are fit and used for human consumption in developing countries, it is simply that they are bred to meet different specialist needs in richer nations.
- The extent to which arable land use will expand in order to deliver additional demand generated by biofuels. Expansion in crop land could be ameliorated by developments in the use of by-products, particularly for animal feed, and the extent to which intensification of agricultural activities and yield increases for given crops are viable (see discussion below).
- The ability to deliver efficiency savings throughout the agricultural and food supply chain ie reducing waste in production and consumption phases, hence freeing up resources. The EU continues to debate whether to take action on food waste, which is anticipated to rise (if unchecked) to 40 per cent by 2020 in Europe (European Commission, 2011).
- Differing assumptions regarding the consequences of any expansion in the area of cropped land. A key question under debate is where would this expansion take place, in particular to what extent would this make use of 'degraded' lands, abandoned crop lands or what has become known as 'idle' land. The extent to which these categories of land are 'available' for use and economically productive has been questioned. For example, it has been reported that the Indian government has allocated 400,000 hectares of wasteland for jatropha cultivation to deliver biodiesel. However, these lands are often classified as Common Property Resources (CPR) and utilised for food, fuel and materials. Analysis has indicated that CPR contribute up to a quarter of poor household incomes with many of the poorest households dependent upon them (Oxfam, 2008). Moreover, while production of some biofuel feedstocks may be possible on degraded lands, inherent limitations mean such activities cannot compete economically with feedstocks produced on highly productive lands (FAO, 2008)

To illustrate the differences in the assumptions made in assessing the potential for biomass resources for energy, Table 4 offers an overview adapted from a recent study. This analysis by the UKERC (Slade *et al*, 2011) brings together key studies of global biomass potential for energy use illustrating the extensive range anticipated in terms of viable energy outputs from all forms of biomass. It also illustrates the different types of preconditions applied which explains this variation, ie the low band of estimates would rely on a combination of the use of residues, wastes and energy crops, moving from low to mid ranges implies a dominant role for energy crops and significant assumptions concerning changes to the agricultural system. The UKERC analysis, however, highlights three factors that are important in all studies when determining the contribution of biomass to energy and associated consequences for other sectors. These are: 1) the availability of land; 2) the productivity of the biomass grown on the land, ie the yield based on production conditions and conversion efficiency to biofuel products; and 3) the extent of competition from alternate uses of land, biomass and biomass waste materials.

Table 4: Exploring the variation in estimated biomass potential for energy

Global biomass potential (EJ[9])	*Essential Pre-conditions*
High band – over 600EJ	• Crop yields outpace demand: >2.5Gha[10] land for energy crops (includes >1.3Gha good agricultural land) • High or very high input farming, limited, and landless, animal production with dung recovery • Low population (<9bn)Vegetarian diet OR extensive deforestation / conversion to managed forestry • All residues a (< 100EJ constrained use, not included in all studies)
Upper mid- over 300 to 600 EJ	• Crop yields outpace demand: >1.5Gha land for energy crops (includes >1Gha good agricultural land) • Low population OR vegetarian diet OR extensive deforestation / conversion to managed forestry • All residues (< 100EJ constrained use, not included in all studies) ie agricultural, forestry and wastes
Lower mid – over 100 to 300 EJ	• Crop yields outpace demand: >1.5Gha land for energy crops (includes >1Gha good agricultural land) • Low population OR vegetarian diet OR extensive deforestation / conversion to managed forestry • All residues (< 100EJ constrained use, not included in all studies) ie agricultural, forestry and wastes
Low – up to 100 EJ	• Little or no land for energy crops (<0.4Gha total) • High meat diet OR low input agriculture • Limited expansion of cropland area AND high level of environmental protection • Agricultural residues (<30EJ, not included in all studies)

Source: adapted from Slade et al for UKERC, 2011, diagram page 64
Note: summary of the literature produced by UKERC surrounding the question of the extent of global biomass potential and the different pre-conditions that have to assumed in order to deliver different levels of energy supply. This illustrates that any expansion in bioenergy use implies trade-offs and that such shifts do not operate in a vacuum.

3.3 Determining the extent of biofuel land demands generated by the EU mandate – exploring yield, intensification and use of by-products

Fundamentally, the question of increased biofuel production impact on food relates to how easily current agricultural production can be expanded and in so doing, how efficiently the outputs can be used to meet multiple demands for food, feed and fuel. Expanding the area of agricultural land presents challenges in terms of environmental impacts; biofuels are in most cases promoted to help deliver greenhouse gas savings from transport. Hence it is necessary to minimise carbon dioxide emissions associated with land use change. Therefore,

[9] Ej – Exajoule – 10^{18} Joules ie a measure of energy available

[10] Gha – Global Hectares - The global hectare is a measurement of biocapacity of the entire earth. One global hectare is a measurement of the average biocapacity of all hectare measurements and biologically productive areas on the planet earth.

much of the debate has focused on the extent to which this can be minimised through the more effective use of existing resources, ie through increasing yields on existing land, intensifying production and putting by-products of biofuel production to use as animal feeds. It is argued that if more effective use can be made of existing resources land use change and food price consequences associated with expanded use of biofuels could be limited.

3.3.1 Turning by-products into usable co-products

The extraction of the energy content of wheat and maize and the oil from rapeseed and other oilseeds leaves an important protein by-product which is utilised in the animal feed compounding industry. In turn, this new source of animal protein can displace some of the need to grow protein crops domestically or import the protein from abroad. Different models of the kind examined in Section 5 will have incorporated this animal protein effect to different extents.

As of 2007, the EU livestock and poultry industries were consuming over 50 million tonnes of oilseed meal per annum, approximately 65 per cent of this was soybean meal with the remainder supplied primarily by rapeseed meal (25 per cent) and sunflower seed meal. Feed use is anticipated to expand to approximately 55 Million tonnes by 2020 (EC DG AGRI, 2011b). Analysis to date has focused on the ability of co-products to replace imports of soy based feeds, reducing overall demand for soy associated with animal feed. The main co-products are from the domestic production of wheat based bioethanol in the form of dried distillers grain with solubles (known as DDGS) and production of rapeseed in the from of rapemeal and glycerine[11]. DDGS from corn ethanol production is used extensively in animal feed, particularly in the US, however, the use of DDGS from wheat has been less extensive in Europe.

The Gallagher review (Renewable Fuels Agency, 2008) estimated that a greater supply and use of protein rich biofuel by-products could potentially lead to fewer crops being grown specifically for animal feed. This was considered particularly valuable, as protein crops have lower yields compared to cereals, meaning they require a relatively large land area in comparison. Analysis by CE Delft (Kampman, 2008) for the review estimated net land requirements per tonne of biofuel could be reduced by 60 to 81 per cent by making full use of this potential feed displacement effect. However, such displacement relies on a number of preconditions. The price of such by-products must be lower than for traditional feeds in order to promote a change from the status quo. This is because fundamental questions remain regarding the substitutability of such by-products, given that the extent and nature of the protein differs from traditional feeds. By-products from biodiesel in particular ie oil seed meals and glycerine, also can be potentially recycled to provide energy for the processing of biofuels, hence reducing the direct emissions from the production of the fuel. This offers a compelling competing use for such by-products.

[11] DDGS is a protein rich by-product of wheat ethanol production with approximately 0.3kg/kg produced. Rapeseed meal is protein rich and produced at a level of approximately 0.5kg/kg with glycerine produced at approximately 0.035kg/kg from rapeseed oil esterification.

Analysis for the pig (Jagger, 2008) and poultry (Acamovic *et al*, 2008) sectors in the UK has shown limitations on the ability to utilise DDGS from wheat, rapemeal and glycerine. Significant differences in terms of the nutrient content of DDGS have been noted in terms of the extent, quality and digestibility of the amino acids present. In addition, DDGS from wheat contains high levels of fibre, which may limit an animal's ability to take on sufficient quantities of feed. Only limited proportions of DDGS are, therefore, recommended within the feed mix. In the case of rapemeal, high levels of glucosinolates can be present, these compounds are known to have negative health consequences for animals consuming it at high volumes; the same holds for residues of methanol and salts (sodium or potassium chloride), likely to be present in biodiesel by-products. In addition, the metabolism of glycerol requires the activation of a specific enzyme and above certain thresholds of intake it is simply excreted rather than utilised by the animal.

3.3.2 Increasing Yield and the potential for agricultural intensification

Can we produce more crops on the same agricultural area, hence limiting the need to expand the area of arable land to deliver biofuel demand? In the past 40-50 years increases in production have largely been the result of higher yields from crops as a result of developments in crop breeding, in plant protection, weed and disease control and in mechanisation, rather than from expanded areas of agricultural land. For example, in the EU the area of agricultural land has remained relatively stable. However, on average crop yields have increased by around 29 per cent[12]. The Gallagher review estimated that high and low yield improvement scenarios result in approximately ±10% influence on total land demand for biofuels (Renewable Fuels Agency, 2008).

There is considered to be the potential to enhance crop yields, including within the range of feedstocks used for biofuel production – see figure 2. However, this potential is highly variable depending on location and determined by historic investment in the agricultural potential, ability to support research and development into yield expansion, the willingness of society and especially opinion influencers to accept new technologies in agricultural production, and the acceptability of the environmental impacts of increasing agricultural productivity. Analysis for the World Bank (2011) has combined assessments of potential for yield increase with an estimate of a country or region's ability to expand agricultural land. This provides a typology of the likely impact of expanded demand for agricultural commodities across the globe, given that EU biofuel demands will generate a footprint globally. Four different types of global regions are identified based on their projected ability to increase yield and/or increase the area of agricultural land. Given some uncertainties such as the precise availability of 'suitable' land given other uses and demand, this highlights some broad patterns, for example that there is little potential for expansion in production either based on yield or agricultural area in countries such as China, Vietnam or Western Europe. However, significant potential based on purely yield increase in countries such as Kenya, Malawi, Ukraine, Central America etc is noted (see Box 2).

The stimulation of yield increases, rather than the expansion of agricultural land, in response to the additional demands from biofuels should not, however, be assumed.

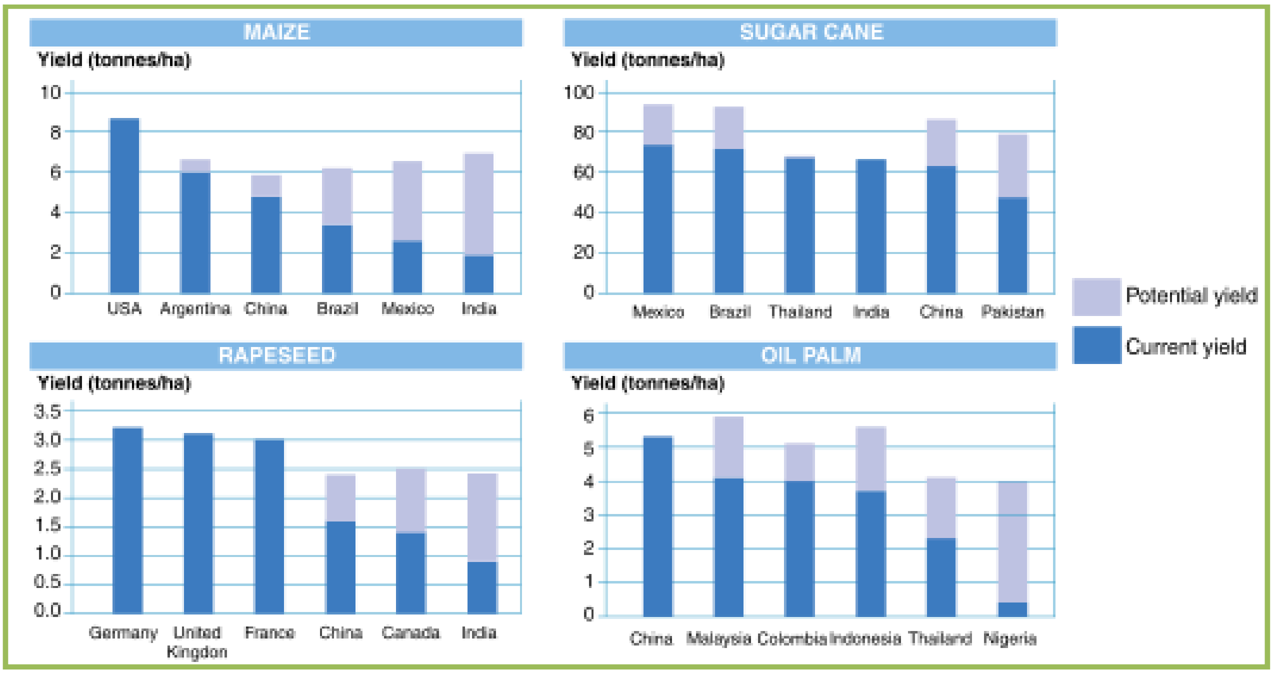
[12] Based on IEEP *et al* (unpublished), Interim report for the DG Environment Study – Land as an Environmental Resource, project code ENV.B.1/ETU/2011/0029.

Critically, the Gallagher Review (Renewable Fuels Agency, 2008) noted that advances in yield are dependent on three drivers:

- Public investment in research and infrastructure;
- Supportive legislative and trade agreements; and
- Private investment supported by profitability of production – which depend in turn on agricultural product and input prices.

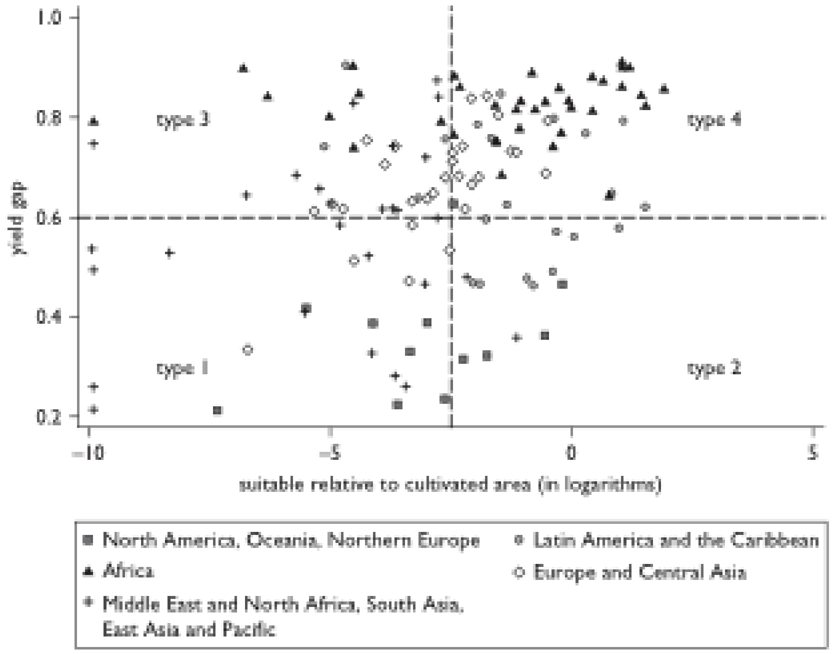
The FAO (2008), and others, believe that biofuels could provide a mechanism for reinvigorating investment in agriculture, in particular research and development. Analysis has, however, shown that crop productivity is higher in high-income countries than those with low or middle income. It is also telling that despite a significantly lower baseline in terms of productivity between 1992 and 2002, yield increases in low and middle-income countries were only marginally higher than in high-income countries. While biofuels could in principle stimulate yield increase, in practice this will be contingent on appropriate investments (UNEP, 2009).

Figure 2. Reviewing the potential for yield increases for four key biofuel feedstocks



Source: UNEP, 2009, p74

Box 2: Summarising the potential for agricultural expansion globally and providing a typology for the nature of this expansion



Type 1: Little Land for Expansion, Low Yield Gap
This group includes Asian countries with high population density, such as China, Vietnam, Malaysia, the Republic of Korea, and Japan, Western European countries, and some countries in the Middle East and North Africa with limited land suitable for rainfed production, such as the Arab Republic of Egypt and Jordan
Type 2: Suitable Land Available, Low Yield Gap
This group includes countries where land with reasonably well-defined property rights and where infrastructure access is fairly abundant and technology advanced, mainly in Latin America (Argentina, Uruguay, and central Brazil) and Eastern Europe
Type 3: Little Land Available, High Yield Gap
This group includes the majority of developing countries, including relatively densely populated areas in highland Ethiopia, Kenya, Malawi, the Philippines, Ukraine, Cambodia, and Central American countries (such as El Salvador) with limited land availability as well as Middle Eastern and North African countries where water availability constrains the expansion of agricultural production. Although there is little land available, large numbers of smallholders may be locked into poverty because the area cultivated remains far below the yield potential.
Type 4: Suitable Land Available, High Yield Gap
This group includes sparsely populated countries—such as the Democratic Republic of Congo, Mozambique, Sudan, Tanzania, and Zambia—with large tracts of land suitable for rainfed cultivation (in areas of sufficient precipitation) but also a large portion of smallholders who only achieve a fraction of potential productivity (figure 3.5). In some cases, such as Sudan, these areas are located in areas with political tensions and dispute. Labor supply often constrains expansion by smallholders, implying that not all potentially suitable land is used for crop production.

Source: World Bank, 2011, page xxxvi

3.3.3 In summary

The divisions within the 'food-fuel debate' lie partly in different interpretations of areas of genuine uncertainty and partly in the interests and positions of the participants. Clearly biofuel policies will add to other factors which have pushed up demand for certain commodities and there will be subsequent impacts on land use, but this will occur against a background of changes in market prices and national policies, giving rise to impacts which will vary considerably between countries and social groups within them. Generic effects at a global level are only one concern – local impacts are another.

4 THE ROLE OF VARIOUS KEY FACTORS IN DETERMINING AGRICULTURAL COMMODITY PRICES AND THEIR VOLATILITY

The purpose of this section is to give an overview of some of the important factors that influence agricultural commodity prices and commodity price volatility. This is to prepare the ground for the analysis in section 5 which examines what we know about the influence of policy driven EU demand for biofuels on global agricultural commodity prices. The purpose is thus to enable the reader to understand the 'normal' dynamics of agricultural commodity prices as a background to interpreting the analysis in section 5.

4.1 A little historical context

There is nothing new about using biomass to provide energy for transport. Indeed until one century ago, practically all transport 'fuel', apart from steam trains and ships, was the forage and grains fed to horses (or other draft animals). In many parts of the world this is still the case. Huge areas of land were liberated for food production in developed countries during the 20th century as general transport, as well as agricultural traction, switched from horses to utilise the internal combustion engine and fossil fuels. This is one reason why real agricultural commodity prices fell throughout the 20th century despite unprecedented population and economic growth and diet change. It is still the case that many developing countries use animals for transport and agricultural traction. Equally, traditional biomass energy in the form of wood, charcoal and animal manure continues to play an important role as a cooking and heating fuel in the developing world, making up around 90 per cent of all bioenergy use globally (for instance WBGU, 2009).

It is the development in more recent years and decades in industrialised and newly industrialised (most notably Brazil) countries that have started producing 'modern' forms of biofuels and bioenergy to displace fossil fuels in the internal combustion engines of road vehicles, as well as in electricity and heat generation, that represents a paradigm shift. These novel (at least in the sense of their scale) uses of agricultural biomass to produce energy constitute potentially a significant additional demand for agricultural commodities. This outward shift in demand for agricultural commodities must be expected to have some impact in raising agricultural commodity prices above where they would have been before the new energy demand came on stream. The question is therefore not *whether* there is an impact on agricultural commodity prices but how *big* it will be.

These questions lie at the core of the food versus fuel debate, introduced in the previous section, that became highly publicised in response to the 2007-08 agricultural price spike. As can be seen from Figure 3, this spike was not the end of the story. In the wake of the global financial and economic crisis taking off in 2008 and due to the strong supply response to the 2007-08 prices there was a surge in production with above-average harvests in 2008. Agricultural commodity prices dropped steeply from their 2007-08 highs. But the year 2010-11 saw a renewed price spike. The literature on agricultural commodity prices and their determinants has soared in response to these recent experiences. Any discussion on the role of the key agricultural market drivers is bound to refer to recent experiences, because the subsequent analyses provide useful explanations assessing the relative importance of different factors. One outcome of the compendium of analyses is that it is by now broadly established that biofuel demand was one amongst many factors explaining these spikes[13].

Box 3: The importance of price volatility

It is the volatility of prices as much, or arguably even more, as the level of prices that causes concern. The FAO *et al* (2011) work for the G20 focusing on agricultural price volatility bears witness to this fact. The most vulnerable households to high prices are likely to find it even more challenging to find ways of coping with the unpredictable nature of volatile prices. This is an aspect not accounted for in the models reviewed in the next section that are either only able to predict price changes in some target year, eg 2020, or include linear projections over time. In reality, agricultural markets will hardly follow such smooth paths towards reaching the higher price level, but will rather experience volatility that is difficult to predict. This unpredictability also makes it more difficult to adopt mitigating measures to compensate the most vulnerable for higher agricultural and food prices, for instance by means of emergency food aid. And, very importantly, the high prices create an environment of uncertainty not favourable for stimulating investment in agricultural development and hence increasing supply.

4.2 Key factors influencing global agricultural commodity prices

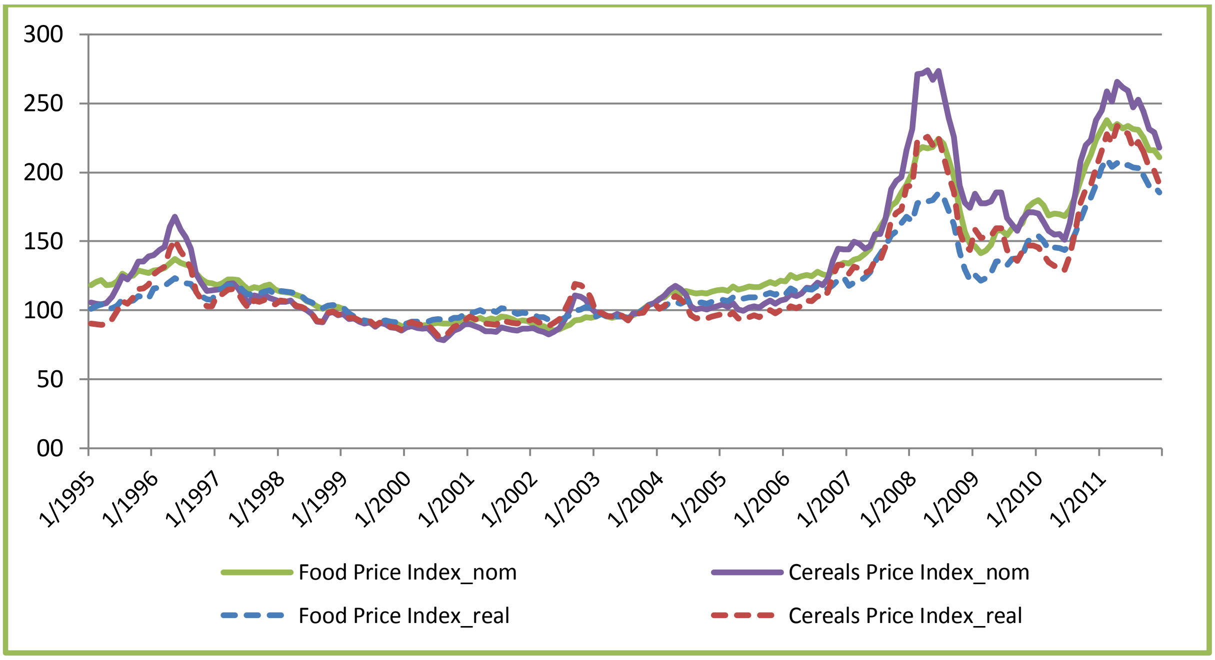
Understanding the dynamics of global agricultural commodity prices is complex as they involve a number of interlinked processes at different temporal and spatial scales. Here we simply provide an overview of some of the key factors to help understanding of the studies which model the specific contribution of biofuels policy. The principal factors in the recent commodity price spikes were:

- Population growth
- Income growth and associated changes in diets
- Weather conditions
- Changing climate
- Technological advances
- Crude oil and other energy prices
- Exchange rate movements
- Changes in the stock levels of agricultural commodities
- Trade policy
- Speculation and, more generally, financial market activity, and
- Biofuels policies

These will be considered first through their impacts on demand, then on supply, and then we consider other influences and the importance of price volatility as well as price levels. First we show two depictions of the dramatic price developments in the last decade.

[13] A recent analysis conducted by Ecofys *et al* for the European Commission adds to this discussion. The contribution of rising biofuel consumption in the EU to the 2007-08 cereal price increases is called 'modest', while it is shown to be 'significant in pushing up other food prices, notably prices of oilseeds and vegetable oils' due to the bigger share of biodiesel production and use (Ecofys et al, 2011, p143). At the same time, the authors note that the increase in global biofuel production in combination with harvest shortfalls (two factors that were found to be 'mutually reinforcing'), does 'explain a significant part' of the 2007-08 price increases (page iv).

Figure 3. Development of food and cereal price indices – nominal and real, 1995 - 2011

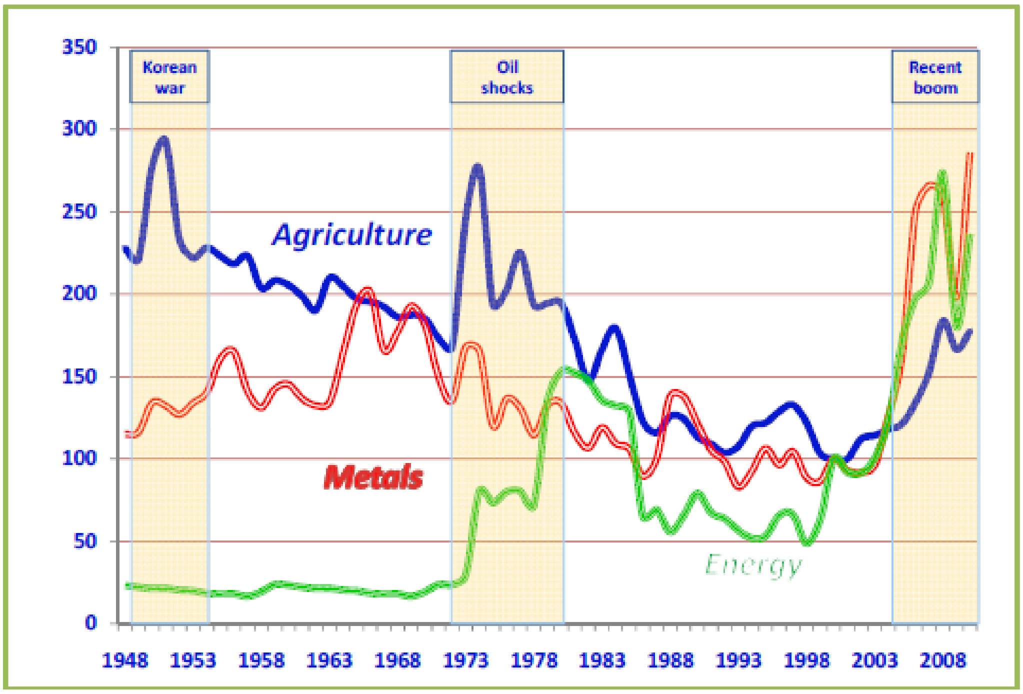


Source: http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/. The real indices are constructed by using the World Bank Manufactures Unit Value Index (MUV).

This FAO chart shows how the index of nominal international cereal and food prices had plateaued in the late 1990s, but started showing upward movement in 2006 before increasing more than two and a half-fold by the end of 2007. Following the 2009 slump they once again more than doubled before settling back. The indices in real terms showed lower, though almost as dramatic, changes.

Figure 4 below takes a longer perspective comparing the 2007-08 price spikes to the big price spikes of the 20th century, showing the contrasting story between agricultural commodity prices and energy (as well as metal) prices in the price spikes. In the 1950 price spike energy prices were stable. In the mid-1970s, the surge in agricultural prices preceded that in energy prices. The reverse was true in the recent spike.

Figure 4. Commodity Price Indices (Real, MUV-deflated, 2000=100)



Source: Baffes and Haniotis, 2010, p27
Note: deflated using the World Bank Manufactures Unit Value Index (MUV)

4.3 Factors influencing demand

The principal drivers of growth in food demand are population, incomes, changing diets and biofuels policies. **Population growth** leads to a sustained increase in demand for food and agricultural commodities. Similarly, **income growth**, especially of those living below or close to the poverty line, is expected to lead to absolute increases in the demand for food commodities. Furthermore, income growth itself is generally associated with changes in dietary patterns, particularly involving an increase in consumption of livestock products, meat and dairy produce (see Schroeder *et al*, 2010; Delgado, 2003). Expansion of livestock consumption, in turn, increases the demand for agricultural staples via increased animal feed requirements of energy and protein. The responsiveness of the demand for food commodities and any other goods to changes in disposable income is measured by the income elasticity and this elasticity is considerably higher in developing countries compared to high-income countries[14]. To these demographic and economic drivers of consumption growth more recently has been added, especially in N America and Europe, the policy driven shift in demand through **biofuel policy** providing strong incentives for consumption regardless of market prices**.** Note however that although it has been biofuels policy which has driven their recent expansion, if the trend towards high and rising oil prices persists this could make biofuels competitive with fossil fuels and encourage their expansion even if biofuels policies are phased out.

[14] Hertel et al (2008) have compiled income elasticities for 113 world regions as part of the Global Trade Analysis Project (GTAP). Looking at this dataset shows that for most OECD countries the income elasticities for the product category 'Grain-Crops' is well below 0.1 whereas it reaches close to 0.7 in least-developed countries (Table 14.5).

Looking at the past and anticipated importance of these factors, however, it should be noted that population growth has been slowing in recent decades, from 1.8 per cent over 1970-1990 to 1.3 per cent per annum over 1990-2010 and it is expected to slow further, with global population stabilising and even falling after the middle of this century (HM Government, 2010, quoting UN statistics). Also, according to analysis by the European Commission (EC DG AGRI, 2011a), growth in world demand has slowed down for most commodities in the 1997-2008 period compared to the three preceding 12-year intervals analysed. This pattern holds in particular for wheat, rice, total grains and total feed grains, while there has been (continued) strong growth in palm oil demand of around 9 per cent per annum over 1997-2008. It is further pointed out that both China and India 'have a history of effective self-sufficiency policies in the production of staple grains' (HM Government, 2010, p50). This limits the extent to which their markets are connected with other world regions and can hence exert influence on global market prices.

Other factors are likely to persist: looking at future pressures from increased demand, Abbott *et al* (2011) in analysing the 2010-11 price spikes note that the major drivers in 2011 were large and persistent demand shocks from biofuel policies as well as the demand derived from Chinese soybean imports to build up domestic stocks. These demands are expected to grow more slowly in the future, but will nevertheless persist to maintain US ethanol production and Chinese soybean stock levels. According to Abbott *et al*, this persistence is different from past demand surges over the last century, which were often more short-lived. In terms of the impact of past EU biofuel demand, a recent analysis has been conducted by Ecofys *et al* (2011) for the European Commission. They note that the contribution of rising biofuel consumption in the EU on the 2007-08 cereal price increases was 'modest', while it is shown to be 'significant in pushing up other food prices, notably prices of oilseeds and vegetable oils' due to the bigger share of biodiesel production and use (Ecofys *et al*, 2011, p143). At the same time, the authors note that the increase in global biofuel production in combination with harvest shortfalls, two factors that were found to be 'mutually reinforcing' does 'explain a significant part' of the 2007-08 price increases (page iv). The anticipated impact of future EU biofuels demand on agricultural markets is discussed in section 5.

4.4 Factors influencing supply

The classic determinants of agricultural supply are costs of production, technology and then uncontrollables such as climate, weather, pest and disease.

Although agriculture utilises a large part of the land area of most countries, and especially in developing countries it employs a significant proportion of the labour force, land rents and prices and wages are determined by, rather than determinants of, agricultural supply and prices. However, increasingly as agriculture modernises it becomes more dependent on variable inputs purchased from the rest of the economy, particularly energy and fertilisers (which are in turn energy intensive in their production).

Petroleum and natural-gas-derived fertilisers[15] make up an important share of production costs (for some crops, eg maize, more than for others, eg soybeans, see for instance HM Government, 2010, p36) as do other energy inputs for instance for machinery use and transport. Van der Mensbrugghe *et al* (2011) provide evidence for the strong response of many commodity prices to changes in energy prices. In the light of rising energy prices, this factor is expected to remain crucial. The rising energy and fertiliser prices have therefore raised agricultural costs, shifted up the agricultural supply curve with significant effect on agricultural prices. It is particularly this fundamental rise in agricultural costs which has lead the FAO and OECD to predict in each of their annual outlook publications since 2008 that agricultural prices will not return in the foreseeable future to their low levels at the beginning of this century (OECD/FAO, 2010). Likewise, the World Bank expects energy prices to be the major contributor to post-2015 increases in food prices (cited in Agra Europe, 2012).

More recently and as a result of increasing biofuel demand, a further **link has emerged between oil prices and agricultural output prices**. Rising oil prices raise the economic viability of biofuels compared to fossil fuels, all other things being equal despite the increase in their own production costs. Increased biofuel production increases the demand for biofuel feedstock, consequently raising their price until the competitiveness of biofuels with fossil fuels equalises. Schmidhuber (2007) has put forward the theoretical argument that biofuel markets establish this closer link between energy and agricultural markets, once oil prices has crossed a certain threshold making biofuels competitive. Empirical analyses have provided evidence for this link between the price levels for energy and different agricultural commodities as well as their volatility and it seems that this evidence is growing and becoming more compelling, based on literature collated by Hertel and Beckman (2011)[16]. At the same time, Hertel and Beckman concede it is still a recent phenomenon and caveat the existing evidence from econometric studies as '[suffering] from insufficient historical time series' (p9).

After production costs the next most important determinant of supply is the state of technology deployed in any farming system. This in turn is multi-dimensional depending on the biotechnology, biology, mechanical, chemical and management systems utilised. It embraces the genetic potential of plants and animals, the plant protection and animal health measures, the degree and type of mechanisation, and the sophistication and information used in management. The size and structure of farms also interacts with technology. These factors are highly variable across the world, and Europe, and are themselves developing all the time.

[15] EC DG AGRI (2008) provides time series of crude oil and fertiliser prices illustrating their co-movement and parallel spikes over 2007-08 (p20).

[16] Rapsomanikis and Hallam (2006) and Balcombe and Rapsomanikis (2008) study the sugar-oil-ethanol links and find evidence for threshold cointegration between price pairs. Evidence for a link between corn prices and oil prices is found by Tyner (2009) (as quoted by Hertel and Beckman, 2011). Du *et al*, 2009 (as quoted in Hertel and Beckman, 2011) tests for the existence of a link between the *volatility* of crude oil prices and of agricultural commodities (corn and wheat). No evidence is found for spill over effects from 1998-2006. Estimations using data for the more recent years (October 2006 to January 2009), however, 'indicate significant volatility spill over from the crude oil market to the corn market' (Hertel and Beckman, 2011, p7).

The simplest indicator of the net effect of technology is crop or animal yields per hectare or per animal. Yields of agricultural commodities themselves are highly variable from one year to the next depending on the **weather conditions** prevailing over the crop cycle. Indeed harvest shortfalls in particular of wheat in Australia, a major wheat producer and exporter, are mentioned as one of the more important reasons for the 2007-08 price spikes (Pfuderer and del Castillo, 2008; HM Government, 2010). Yield developments are expected to be influenced by a **changing climate**. However, the extent to which this will harm and benefit different world regions and the impact on world crop balances are not easily understood or projected (see for instance Msangi and Rosegrant, 2011, and Fischer, 2011).

The longer-term development of yields also depends on **technological advances,** realised over the decades to come. Bruinsma (2011, p262) illustrates the slowing trend in yield growth for major crops globally, which was 1.7 per cent per annum on average over 1961-2007 and is projected to be 0.8 per cent per annum for 2005/07-2050.[17] Similarly, European Commission analysis for 2010-2020 suggests that average yield growth will not be able to keep up with demand growth, even though the latter is expected to slow down over the period studied, therefore expecting further upward pressure on prices, which in turn, so the optimistic expectation, could speed up yield growth (EC DG AGRI, 2011b). However, there is considerable evidence to show close relationships between agricultural crop yield growth and expenditures on research and development in agriculture (see for instance Piesse and Thirtle, 2010). Private sector R&D effort is driven by economic returns, so rising agricultural prices might be expected to stimulate such activity. Public sector R&D is a political decision, and high-level global commitments have been made since the agricultural price spikes to significantly increase R&D on sustainable agriculture[18].

4.5 Other factors influencing international agricultural commodity prices

The **level of international stocks** in agricultural commodities is a major determinant of the extent to which markets can deal with, for instance weather related, supply shortfalls. In other words, stock levels affect the availability of supplies and therefore can have a major impact on prices especially in the short run. Stock levels can be affected by one-off events like a particularly bad harvest but also by persistent demand growth that exceeds growth of crop production. Another important factor are strategic decisions by countries to build up or reduce stocks. A frequently voiced concern is that information on international stock levels is poor and non-transparent, implying uncertainty about stock that may have repercussions for price expectations. Indeed falling stock levels have been suggested by many as an important influence for recent price spikes (FAO *et al*, 2011). Purchasers are naturally alarmed if stock levels are seen to be low, and will tend to bid up prices to ensure they can satisfy their market. Partly as a response to these concerns, the report prepared for the 2011 G20 meeting of agricultural minsters by several international organisations (FAO *et al*,

[17] He caveats these numbers by clarifying that such aggregate figures may hide variations between and within regions as well as between crops, but claims that the slowdown does reflect a pattern representative for most major crops.

[18] Exemplified by the European Commission in their proposals for the next 2014-2020 Multiannual Financial Framework to more than double agricultural R&D (June 2011, available at: http://ec.europa.eu/budget/biblio/documents/fin_fwk1420/fin_fwk1420_en.cfm).

2011) calls for an Agricultural Market Information System (AMIS) to improve information on stocks.

Pfuderer and del Castillo (2008) point at a negative correlation between stocks-to-use ratios and world prices. This is more closely analysed by the European Commission, revealing that maize and wheat prices 'are strongly and inversely linked to changes in stocks-to-use ratios'. This elasticity of price to movements in stocks is furthermore increasing, 'more than doubling since the mid eighties'. This development is particularly pronounced for wheat: Wheat prices historically changed by around 2 per cent in response to a 10 per cent change in the stocks-to-use ratio. But since the mid-1980s, the elasticity has increased to 14 per cent (EC DG AGRI, 2011a, p9). Soybean prices are much less responsive to stock changes attributed to traditionally low world stocks and the fact that soy is grown both in northern and southern hemisphere so that weather shocks can be balanced out. The responsiveness of sugar prices to stock changes has been increasing while no link between rice prices and stocks-to-use ratios is found (EC DG AGRI, 2011).

It is interesting to see how stocks have actually developed over time. HM Government (2010) show that the time series of wheat stocks-to-use ratios over the last decades reveals three low points that correspond to periods of spiking cereal prices in the early 1970s, mid-1990s (more modest rise in cereal prices compared to the other two periods) and more recently in 2007-08. On the other hand, Abbott *et al* (2011, following Headey and Fan, 2010) argue that the explanatory power of stock changes is reduced when considering the development of stocks-to-use ratios for the world excluding China, which has followed a stock-reducing policy in recent times especially for grains. They show that the argument that stocks continuously declined over the 2000s and hence running up to the 2007-08 price spikes holds for wheat, but not for soybeans, rice or corn. In a similar vein, EC DG AGRI (2011a) analysis suggests that 'available data (averaged out over 12-year intervals) show that for most commodities, actual stocks-to-use ratios have remained around long-term averages and in some cases they have even increased over time (from 1997- 2008)' (p10). Finally, it was mentioned above that recently political decisions in China to build up soybean stocks have triggered a surge in demand that contributed to the 2010-11 price spikes and is projected to be persistent so as to maintain stock levels (Abbott *et al*, 2011).

Trade policies and the resultant degree of integration of global agricultural commodity markets are important for price levels and volatility. Increased trade volumes, and a wider geographic range of sources for instance, can help smooth out supply shortages in one region by imports from another region. The prospect of exporting commodities sought on international markets may act as a stimulant to agricultural development. However, the recent periods of sharply increasing prices have witnessed reactions by governments in the form of trade measures, such as export restrictions, in an attempt to stabilise domestic crop supplies and moderate domestic food price inflation. Pfuderer and del Castillo, 2008 provide a list of measures imposed in a range of countries. The role of such measures is potentially powerful in certain markets; their impacts in 2007-08 were found to be most pronounced in the wheat and rice market, and export bans are cited as having altogether triggered the spikes in the latter market (HM Government, 2010). Martin and Anderson (2011) have estimated that trade barriers aimed at insulating domestic markets have contributed 45 and 30 per cent to the increases in rice and wheat prices in 2006-08, respectively. The impacts of export restrictions are likely to go beyond a short-term destabilising affect but may reduce incentives for production, hence 'muting the supply response and thereby helping to hold international prices higher for longer' (HM Government, 2010, p46). Their future relevance is hardly predictable, as it largely depends on decisions taken by individual governments and whether this triggers similar or even retaliatory measures by others.

The rising volume[19] of agricultural commodities subject to **speculation or more generally financial market activity** is frequently referred to as one of the culprits for higher and more volatile prices (a summary of such activities explaining both their function and effects is provided by van der Mensbrugghe *et al*, 2011, p196). However, empirical evidence for the influence of speculation is largely inconclusive. As the Agricultural Outlook summarises, '[most] researchers agree that high levels of speculative activity in futures markets may amplify price movements in the short term although there is no conclusive evidence of longer term systemic effects on volatility' (OECD/FAO, 2011, p16; Abbott *et al*, 2011, also summarise inconclusive evidence). A potentially important channel is the way in which speculative activity builds up expectations on future prices, which can increase inflationary pressures or volatility. But it is also pointed out in the context of the 2007-08 price spikes that the chain of causality has been the other way around in the sense that 'speculative flows into agricultural futures markets followed, rather than caused the price increases', and the same holds for price volatility (HM Government, 2010).

Finally agricultural markets can be disturbed by macroeconomic developments for example in **exchange rate movements.** Many agricultural commodity prices are denoted and traded in US Dollars. If the US Dollar depreciates against currencies of importing countries then these commodities look cheaper and the quantity demanded increases, adding to the other demand pressures. Of course if an importing country's currency depreciates against other major currencies faster than the Dollar then their imports will look more expensive. The US Dollar did indeed depreciate at the time of the 2007-08 financial crisis (see Figure 5 depicting the movement of the US Dollar exchange rate against the Euro). The future outlook is highly uncertain and depends on a range of macroeconomic conditions, many of which are well outside the sphere of influence of the US Federal Reserve, such as the future developments in China and in the Eurozone and hence the strength of the Euro. Both oil prices and exchange rates tend to be volatile. Therefore, because of their influence on agricultural commodity prices, they can be expected to contribute to price volatility in agricultural markets with potentially severe important implications for food security.

[19] More information on increasing volumes can be found in Torero, M 'Understanding the causes of food price volatility and mitigating its consequences', presentation given at Brussels Development Briefings on Food Price Volatility, 30 Nov 2011; available at: http://brusselsbriefings.net/past-briefings/no-25-food-price-volatility/.

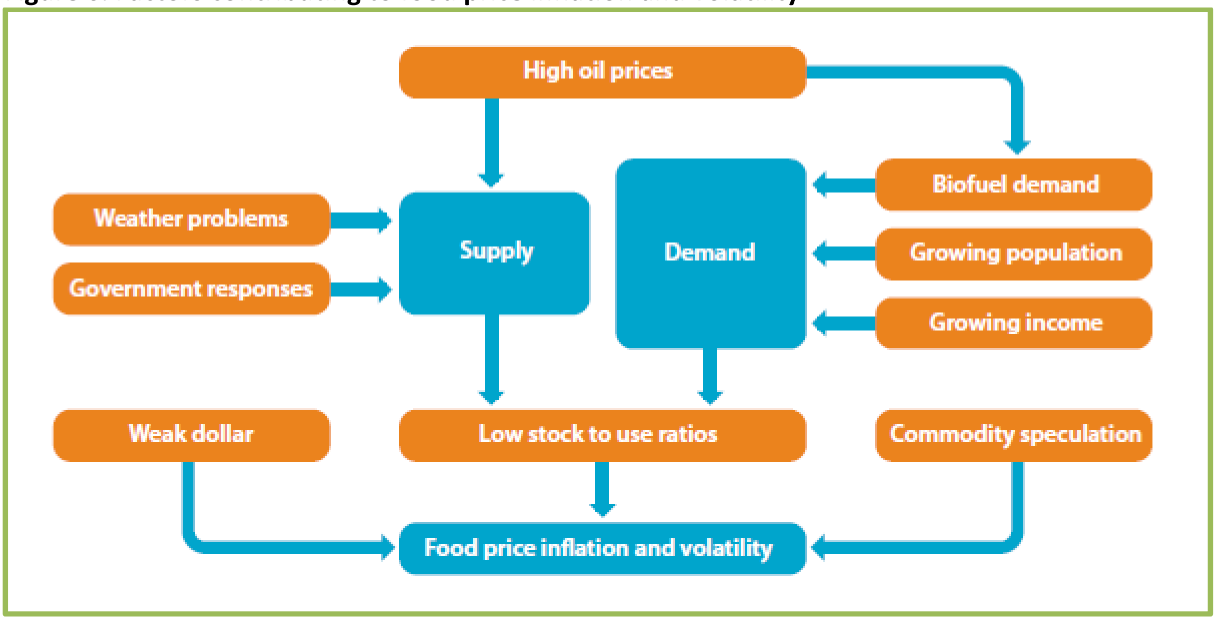
Figure 5. Euro/Dollar exchange rate

Source: http://www.oanda.com/currency/historical-rates/

4.6 In summary

Agricultural commodity prices are highly complex and influenced by a wide variety of factors which shift demand, supply or both, or directly impact on prices. This multitude of effects is neatly summarised in Figure 6 below. Biofuels policy is undoubtedly a significant factor, but not the only one of many causes of shifts in agricultural commodity markets. Because food is a fundamental human need, when markets exhibit volatility, especially in periods of shortage, markets can overshoot with dramatic, but thankfully usually short-lived doubling or trebling of prices in periods of weeks.

Figure 6. Factors contributing to food price inflation and volatility



Source: Committee on Climate Change, 2011, p41

5 THE ROLE OF EU BIOFUEL INCENTIVES ON AGRICULTURAL COMMODITIES PRICES TO 2020: A REVIEW OF SELECTED MODELLING STUDIES

The purpose of this section is to provide a review of the existing evidence base on the link between policy driven EU demand for biofuels on the one hand and agricultural commodity prices on the other. This is done through a review of selected modelling based studies. As noted earlier we will not be looking at the impact of biofuel prices on retail food prices as experienced at the national level. Essentially, hardly any models yield these results. Working out separately the consequences of increased agricultural commodity prices for food prices and the resulting welfare impacts for different groups of consumers is outside the scope of what can be achieved here. Box 4 spells out some of the factors involved determining the results of this pass-through and the associated welfare implications.

For the purpose of this report we have looked at a range of modelling studies that have been conducted in recent years using economic modelling tools, both partial and general equilibrium models. The studies reviewed include work based on models by international organisations such as the OECD and FAO, models in the hands of universities including the GTAP model (Global Trade Analysis Project, coordinated by Purdue University), an EU agricultural sector model CAPRI (developed mainly by University of Bonn) as well as work by the European Commission's Joint Research Centres (JRC). A lot of work on the agricultural market effects on biofuel use has been conducted in the USA looking at the implications of the US Energy Independence and Security Act (EISA), which was adopted in 2007. Given their regional focus not all of these studies are relevant in the present context and are therefore not included in the summary table in Annex 2[20].

In this section we first consider the role of models in understanding the impacts on agricultural markets of biofuels policy. Second, we set out our approach to reviewing the models and explain the main dimensions compared. Third, we set out the results of the review by considering each of the characteristics in turn. Fourth, and finally, we reflect on what the studies taken together indicate about the significance of EU biofuel policy on agricultural commodity prices.

5.1 The role of models and our approach to reviewing them

5.1.1 The role of models in understanding the agricultural market impacts of biofuel use

Because biofuel demand adds to an existing demand for agricultural commodities, many of which are traded on global markets, understanding the impacts of biofuel policies requires a methodology that can incorporate these interactions through international trade. Sophisticated economic models are needed in order to take a range of important economy-wide feedback effects into account, akin to the analysis of the land use change impacts from biofuel use (see for example Kretschmer, 2011). These include: impacts felt across agricultural sectors because of related markets (expressed by 'cross-price elasticities' that determine the extent to which an increase in the price of, for instance, wheat influences the

[20] Examples of studies focusing exclusively on the impact of US biofuel policy and therefore not considered include: Elobeid and Hart (2007), Hayes *et al* (2009), Rajagopal *et al* (2009), and Hertel and Beckman (2011).

demand for, for instance, corn); impacts on other economic sectors, most notably the energy and, in particular, the oil sector in the case of biofuels; international market impacts due to linkages established by trade flows; consumption response in the food and feed sectors.

This last point warrants some additional explanation: Reduced demand for food is likely to be the results of drops in real incomes due to the higher retail prices for food. This response is both real and an artefact of models. The fact that one of the modelled responses to increased biofuel demand is a reduction in food consumption has gained increasing attention in the ILUC debate. Using the GTAP model to study the land use change and associated emissions effects from US biofuel mandates, Hertel *et al* run an alternative scenario holding food consumption constant, so as to derive a 'food neutral ILUC factor', they find that emissions from ILUC 'per MJ of increased annual production capacity' increase by 41 per cent (2010a, p230)[21]. On this topic, Marelli (in Fritsche *et al,* 2012, p49) reports that substantial increases in crop production would occur when food consumption is not reduced, in other words pointing at an 'ILUC credit' due to reduced food consumption. As is stressed in several places in this report, the impacts in the real world will be much more complex than suggested by modelling results: a, for example, two per cent decrease in food consumption globally or on a country-level estimated by an economic model hides the fact that different population groups will be impacted to different extents.

Many of the models employed for this purpose have their origins in (agricultural) trade analysis and are either partial (PE) or general equilibrium models (the latter also denoted as CGE, computable general equilibrium models). The role of models is to capture the multitude of economic interactions of the kind summarised above and they do this by adopting a range of simplifying assumptions, for instance about the behaviour of economic actors such as producers and consumers. Most of the models used for analysing biofuel policies aim to run alternative scenarios and analyse the resulting impacts. They are usually not put forward as straight forecasting devices; a notable exception is the AGLINK-COSIMO model that is employed for providing projections for the OECD-FAO Agricultural Outlook. In order to make the models workable, economic sectors as well as countries are aggregated in to clusters of sectors and regions. The precise aggregation depends on the question at hand: for the analysis of biofuel policies, one can expect a more detailed disaggregation of the agricultural sector as well as a singling out of important biofuel producing and consuming countries. Making use of aggregation, together with typically linear dynamics over time, makes it practically impossible to derive reliable predictions such as the impact of EU biofuel use on wheat prices in country X at time T.

5.1.2 Key characteristics of interest

We have reviewed the models focussing on a selection of the key characteristics most relevant to the objectives of this study:

[21] The supporting online material disaggregates the differences in price effects between the two scenarios, which accounts for up to 0.8 percentage points for global export prices (this refers to their figure for coarse grains, changing from a 7.22 per cent to a 8.04 per cent increase in the scenario keeping food production constant, see Table S4 of the supporting online materials).

- Type of model, ie partial or general equilibrium models;
- Geographic and sectoral scope of the model;
- Whether and in which way crop land expansion is modelled;
- Whether and in which way biofuel by-products are modelled;
- Whether and in which way second-generation biofuels are modelled and what their assumed contribution to biofuel targets is;
- Which biofuel policy scenarios are modelled;
- Modelled (absolute) biofuel use in 2020 in the EU and globally;
- In which way agricultural price changes are reported.

The importance of some of these aspects in the food versus fuel debate has been introduced in section 3. The following paragraphs address the remaining characteristics and explain how all of them are treated in models, discussing whether these are significant consequences for the results obtained from running the models concerned. The list of characteristics can be found again in the summary review of all the models, presented in Table 5 where it forms the column headings. Annex 2 provides further information about the studies reviewed including more details on the modelling of biofuel technologies and land use (change).

Partial or general equilibrium models

An advantage of partial equilibrium models is that they entail a detailed representation of a specific economic sector, in the biofuel context this would be the agricultural sector, including the detailed representation of agricultural policies, of a broad range of agricultural processes and of different land uses. This detailed representation comes at the expense of a lack of representation of the remaining economy - that is often lumped together into a single entity. General equilibrium models, on the other hand, have the advantage of accounting for all economic sectors and world regions, thereby fully accounting for the economy-wide feedback effects mentioned before. Sectors as well as countries are grouped into aggregates in order to make the computation manageable. The disadvantage of this comprehensive representation of economies is typically a less detailed representation of individual sectors than found in partial equilibrium models (see also Kretschmer and Peterson, 2010, and Kretschmer, 2011).

The type of model used to examine a question will have implications for estimates of price effects. Kretschmer and Peterson (2010) point at the higher, and potentially unrealistically high, implicit supply elasticities in GE compared to PE models (as mentioned in Britz and Hertel, 2011[22]); higher elasticities imply more responsive supply in the face of a demand shock and hence lower price increases. Also, an element of discussion in the ILUC debate is that GE models tend to assume a more elastic food market, ie a more pronounced drop in

[22] Britz and Hertel (2011) (whose analysis is not included in the review tables because of their focus on a stylized scenario of a biodiesel-only quota) look at the relative performance of GTAP-only model runs and results from a couple model system including GTAP and CAPRI, in other words compare the results from a CGE model (GTAP) with a combined CGE-PE model system. They report an increase in EU oilseed prices of 48 per cent in the year 2015, while price changes for other crops are negligible due to scenario design. According to Britz and Hertel, the driver of higher price effects is the fact that production constraints and current policies in the EU are better represented through CAPRI; therefore the integrated system displays 'less domestic supply response and more imports of oilseeds and oils' than the CGE-only model run.

food consumption for a given increase in prices, see the discussion above. Gerber *et al* (2008) expect price effects to be higher for partial than general equilibrium models. This is in line with findings from a review of modelling studies by Timilsina *et al* (2010).

Out of the models reviewed, five are partial and five are general equilibrium models and one study employs a spread-sheet based approach for calculating price effects.

Geographic and sectoral scope of the model

Models differ according to their geographical and sectoral detail. The corresponding column in the table gives an idea about the number of regions and sectors the world is divided into in the models considered. As mentioned before the partial equilibrium models reviewed here tend to focus on the agricultural sectors, in which case the number of commodities is mentioned in the table.

Modelling of crop land expansion

The recent debate on Indirect Land Use Change (ILUC) has highlighted the considerable challenges and at the same time has done a good deal to advance the modelling of land use. The way in which production factor 'land' is modelled as well as the treatment of by-products (next point) are among the crucial assumptions in the present context, as has been argued in more detail in section 3. This implies that important insights in terms of agricultural price effects should be gained from the models that have been at the forefront of the ILUC debate. Allowing for land expansion and intensification of land use (for instance through increased fertiliser application but also through longer term yield response to higher prices) potentially reduces upward pressure on prices as a result of surging crop demand, a point that is *inter alia* made in Keeney and Hertel (2009). The way that different models deal with the issue of land expansion and yield response is addressed extensively in Edwards *et al* (2010; see also 'Box 2. Overview of the source of uncertainties' in Laborde, 2011, p24).

Table 5 below reports whether land model design is such that the area of cultivated land is 'allowed' to expand (or contract) in response to price levels or other market conditions. Five of the eleven studies explicitly mention and account for land expansion. The remaining studies do not provide any details, so that it cannot be determined if and in what way the expansion of cultivation is modelled. Annex 2 provides some further details about the way land is modelled.

Modelling of biofuel by-products

The importance of by-products when it comes to assessing the agricultural market response to biofuels and hence price impacts has been discussed in section 3. Evidence from modelling studies is provided by Taheripour *et al* (2010), who have found that in their scenarios of the implications of simultaneous EU and US biofuel policies, neglecting by-products may overstate price impacts by 30 to 40 per cent for some outcome variables.

In six of the eleven studies by-products are included in the modelling. One study explicitly mentioned that by-products were not considered, while it is not clear from the remaining ones.

Contribution from second-generation biofuels

The use of second-generation biofuels is often put forward as a way of reducing the pressures on land use and agricultural markets (see section 3) relative to supplies from food crops. However, EU Member States anticipate using only limited amounts of second-generation biofuels up to 2020 (see section 2) and therefore model scenarios that rely on a substantive share of second-generation biofuels should be gauged with caution.

Out of the studies reviewed, five do and another five do not include second-generation biofuels, with two studies not specifying any distinction between the two. Where second-generation biofuels are included, these are modelled in diverging ways; in some studies it is assumed that the land take requirement of supplying these biofuels is nil, while others assume proportionately lower feedstock and/or land use requirements than for first-generation biofuels. Annex 2 provides some further details on this.

Biofuel policy scenarios & Biofuel use in 2020

The models reviewed differ tremendously in the way biofuel (policy) scenarios are designed. As far as this information is available, we make clear in Table 5 what the assumptions are about biofuel use or its shares of the transport fuel market in the reference scenario and in the alternative policy scenarios. Key questions addressed are: 1) do the scenarios consider only EU biofuel use and policies or are global use and mandates included as well? 2) Where biofuel mandates are modelled as percentage shares of total fuel use, what absolute magnitudes, and therefore feedstock demands, are implied and how do these magnitudes change from reference to policy scenario? 3) What do different scenarios assume about the market penetration of second-generation biofuels?

Given the focus of this study on the effect of EU biofuel policy in 2020, there is a further key question about whether the model's assumptions about the total amount of biofuel use in 2020 and the increase between the reference use and the 2020 policy scenario use is in line with the volumes that the NREAPs predict. The comparison between the 2010 and 2011 IFPRI studies (Al-Riffai *et al*, 2010 and Laborde, 2011) on this point and others shows the importance of the amount of mandated biofuel use modelled in relation to the predicted results on indirect land use change.

Only five of the eleven studies actually give figures for the assumptions made on absolute biofuel quantities and these show a diverse picture of the scale of biofuel quantities modelled and especially in terms of the differences in biofuel use between reference and policy scenarios.

Reporting of price effects

Studies differ in the way they report price effects. A straightforward way of reporting the biofuel induced price impacts adopted in many studies is via a so-called 'comparative-static' analysis where prices in, for example, a 2020 biofuel policy scenario are compared to prices in a 2020 reference scenario. This is indeed the approach followed by the majority of the studies reviewed. Two of the studies in Table 5, however, report price changes over time, and these two different sets of results cannot be compared. One study (Davies, 2012) only reports price changes in a scenario where biofuel support is removed compared to a baseline of existing support, which cannot be compared to the other studies based on the information provided.

5.2 Results of the review

Given the range of different modelling characteristics that are important drivers in shaping the commodity price impacts that the models report as arising from greater biofuels production, the following two sub sections summarise the results with regard to the agricultural commodity price impacts of 1) EU biofuel policy (next section) and 2) global or multiregional policies (subsequent section)[23]. The results from all studies are summarised and tabulated below (Table 5) and in Annex 2. Table 5 is divided into two parts, with the first part reporting on studies that focus on the impacts on EU biofuel policies while studies in the second part model global, or at least multiregional targets.

Looking at the compendium of studies is useful in order to understand the magnitude of likely agricultural market impacts and how the models looking at these impacts have developed. In order to trace this development, we summarise the studies in chronological order. However, it should also be noted that insights from some of the earlier studies are not generally such as to address the question of how far the RED leads to increases in agricultural prices as, in the absence of the NREAPs, there was still considerable uncertainty at the time about the quantity of biofuels that would actually be used in the EU by 2020.

The compendium of studies indicates fairly wide ranges of results. Nonetheless, it is clear at the same time that the impacts of EU biofuel policies are more pronounced on the markets for biodiesel compared to ethanol feedstocks, while global impacts produce a more balanced or even reversed picture. Section 5.3 provides a summary of the impacts of EU biofuel policy on the prices of different feedstocks.

[23] Many of the earlier studies in Table 5 (and Annex 2) are also reviewed in Blanco and Fonseca (2010), to which those interested are referred to for further information. Further earlier reviews are provided by Gerber *et al* (2008) and Timilsina and Shrestha (2010). Gerber *et al* (2008) have conducted a review of biofuel induced food price effects as predicted by partial and general equilibrium models. The listed results show a highly varying picture difficult to interpret which is mainly due to the differences in assumptions, scenario and model designs and different ways in which results are reported.

Table 5: Summary of key model characteristics and results

Study and model	Model type	Geographical and sectoral scope	Crop land expansion	By-products included?	Contribution from 2nd-generation	Biofuel policy scenarios	Absolute biofuel use in 2020 policy scenario / FU (in increase	Absolute biofuel use 2020 policy scenario / increase world (in	In line with NREAP 2020 demand	Resulting per cent impact on world commodity prices, 2020 policy compared to 2020 reference, unless otherwise stated
Studies that focus on the effects of EU biofuel policy (differ in the extent to which global biofuel policies and use are included in the reference)										
EC DG AGRI (2007), ESIM	PE	Global EU+Turkey, USA & RoW, ag sectors	?	Yes	Yes	EU biofuel policy only *Baseline* with 6.9% biofuel share in 2020 *Policy* with 10% mandate for 2020 (2nd generation contributing 30%)	34.6 / 10.8	?	> / <	EU prices (apparently) over 2006-2020: Cereals 3 to 6% Sunflower seeds 15% Rapeseed 8 to 10% 'significantly higher' effects without 2nd-generation biofuels *Note these price rises are against an underlying assumed decrease in real prices*
Banse *et al* (2008), LEITAP	CGE	Global 32 regions 23 sectors	Yes	No	No	EU policy focus but global use accounted for (volumes not specified) *Baseline* w/o blending obligation *Policy* with 10% mandate for 2020	?	?	?	Oilseeds 8.5% Sugar 2.0% Cereals 6.0% Context: declining real ag prices
Edwards *et al* (2008)	No model Ad hoc calcs	EU27	-	-	No	EU 10% 1st generation mandate for 2020	?	?	?	Compared to no biofuel use, world cereal price 4% vegetable oils 24%
Blanco Fonseca *et al* (2010), AGLINK-COSIMO, ESIM, CAPRI	PE	Global (see Annex 2 for details on all models)	?	Yes	Yes	EU policy focus but global use accounted for (existing and announced policies modelled in all scenarios) *Counterfactual* no policy or support *Baseline* 10% mandate in 2020 (2nd generation, modelled as non land using, contribute 30%, implying a 7% 1st-generation share due to double counting)	~33.0 / 28.1 (Increase 2008 to 2020 baseline: 22.4)	~124.3 / 23	≈ / ≈	AGLINK-COSIMO: veg oil ~15%, small for ethanol feedstocks ESIM: Wheat 8, maize 22, sugar 21% Soybeans 0.5, rapeseeds 10, sunflower seeds 11% Veg oils palm 1, soy 17, rape 35, sunflower 36% CAPRI: Wheat 12.5, maize 8.0, sugar beet 2.0% Oilseeds 19.5, Vegetable oil 27.1%
Laborde (2011), MIRAGE-	CGE	Global 11 regions 43 sectors	Yes	Yes	No	EU policy focus but global use accounted for *Baseline* with constant 2008 blending of 3.3% *Policy* with 8.4% 1st-generation mandate	27.2 / 15.5	111.2 / 7.4 (=production)	= / ≈	Selected price changes for policy scenario: Wheat 1.01% Maize 0.74%

Study and model	Model type	Geographical and sectoral scope	Crop land expansion	By-products included?	Contribution from 2^{nd}-generation	Biofuel policy scenarios	Absolute biofuel use in 2020 policy scenario / increase EU (in	Absolute biofuel use 2020 policy scenario / increase world (in	In line with 2020 NREAP demand	Resulting per cent impact on world commodity prices, 2020 policy compared to 2020 reference, unless otherwise stated
Biof										Sugarcane/beet 0.88% Rapeseed 11.34% Rape oil 9.20% Palm oil 4.5%
Davies (2012) AGLINK-COSIMO	PE	Global All major commodities	?	?	?	EU policy but global use accounted for (see below for combined EU+US scenario) *Existing biofuel support* Baseline including biofuel support policies (2011 Agricultural Outlook projection) *Removing EU support* by abolishing import tariffs and tax incentives from 2011 onwards	?	?	?	Avg % change in 2011-2020 prices: Removing EU support vs existing biofuel support: EU prices: Wheat -7, veg oil -12, oilseeds -4% Global prices: Wheat -3, coarse grains -2, oilseeds -2, veg oil -5%
Studies that analyse the impacts of global (or at least multi-regional) biofuel mandates										
Rosegrant *et al* (2006), IMPACT	PE	Global 115 regions, 30 commodities	?	?	Yes	Global policies 1. Aggressive growth and baseline yields 2. Cellulosic biofuels as of 2015 3. Aggressive growth + cellulosic + increased yield growth Use of 2^{nd}-generation modelled by reducing demand for 1^{st}-generation biofuel feedstock	?	?	?	For scenarios 1, 2, 3: Cassava 135 89 54% Maize 41 29 23% Oilseeds 76 45 43% Sugar beet 25 14 10% Sugar cane 66 49 43% Wheat 30 21 16%
OECD (2008), AGLINK-COSIMO	PE	Global All major commodities	?	Yes	Yes	Global policies *No biofuel policy support* *Existing biofuel support* – world *Existing plus new policies* incl 50% met by 2^{nd} generation 2^{nd}-generation: on avg 50% of biomass from cropland, rest from crop residues (see note 15 in OECD, 2008, p91)	25.4 / 19.7 (2013-17 avg)	96.0 / 38.7 (2013-17 avg)	< / ≈	Avg % change in 2013-2017 world prices compared: No biofuel support vs existing support: Oilseed -3, Wheat -5, Coarse grain -7, Veg oil -16% Existing plus new policies vs no support: Oilseed 7, Wheat 8, Coarse grain 13, Veg oil 35%

Study and model	Model type	Geographical and sectoral scope	Crop land expansion	By-products included?	Contribution from 2^{nd}-generation	Biofuel policy scenarios	Absolute biofuel use in 2020 policy scenario / increase EU (in	Absolute biofuel use 2020 policy scenario / increase world (in	In line with NREAP 2020 demand	Resulting per cent impact on world commodity prices, 2020 policy compared to 2020 reference, unless otherwise stated
Fischer *et al* (2009a, b), IIASA model system	AGE	Global 34 regions 10 sectors (9 ag, 1 rest)	Yes	Yes	Depends on scenario	Global policies *Reference* biofuel use constant after 2008 *Policy* scenarios following World Energy Outlook, *WEO,* announced 2020 targets met Ambitious biofuels target scenarios, *TAR*, mandatory, voluntary and indicative targets are met 2^{nd}-generation from 'non-food' land (see Fischer *et al*, 2009b, p168-76 for details)	~25.9 / ~20.4 (WEO policy scenario)	94 / ~69.6 (WEO policy scenario)	< / ≈	WEO scenario no 2^{nd}-generation: cereals ~ 12, other crops ~9% TAR scenario: cereals ~ 35, other crops ~27% TAR scenario rapid 2^{nd}-generation: cereals ~ 15, other crops ~19%
Taheripour *et al* (2010), GTAP-BIO	CGE	Global	Yes	Yes	No	Global (focus EU and US policies, Brazil incl) US 15 billion gallon and EU 6.25% mandate in 2015 Separate scenarios with and without by-products	?	?	-	EU prices changes over 2006-2015, w/o and w/ by-products: Cereal grains 11.0 and 5.6% Other grains 11.9 and 8.7% Oilseeds 31.6 and 26.9% Sugarcane 10.7 and 7.8%
Timilsina *et al* (2010)	CGE	Global 25 regions 26 sectors	Yes	?	No	Global policies *Baseline* with already 5.4% biofuel share *Announced global targets* scenario (9% share) *Double global targets* scenario (announced targets doubled while the timing of their implementation is unchanged)	?	?	?	Prices changes announced, double targets: Sugarcane/-beet 9.2, 11.6% Corn 1.1, 3.7% Oilseeds 1.5, 3.1% Wheat 1.1 2.4% Other cereal grains 1.0, 2.3% Paddy rice 0.8, 1.6% Vegetables, fruit 0.7, 1.5% Livestock 0.4, 1.1% *Context of significant crop price increases over the baseline*

Source: Own compilation. Notes: Explanation of abbreviations: PE = partial equilibrium model; CGE = computable general equilibrium model; AGE = applied general equilibrium; ? = not specified. Column 'In line with NREAP 2020 demand': reports 1) whether biofuel use in 2020 is in line with NREAP projections for 2020, ie 27.2 Mtoe first-generation, 29.6 Mtoe all biofuels (first symbols) and 2) whether the increase in EU biofuel use is on line with the increase from the 'reference', taken to be biofuel use in 2008 prior to the adoption of the RED, to the NREAP 2020 biofuel use, ie roughly 19.5 Mtoe (Bowyer, 2011, based on NREAP and EurObserv'ER data).

5.2.1 Findings from studies focusing on the effects of EU biofuel policy

The **European Commission** analysed potential price increases as part of the impact assessment accompanying the climate-energy package of 2008[24]. The impact assessment acknowledged potential negative impacts but very much stressed the fact that increased prices would benefit food producers and could revitalise rural areas globally. It is claimed that '[the] market will have a full opportunity to adapt to the EU's target. The food security impacts of the EU policy, both positive or negative, are therefore likely to be relatively small' (p131). In concrete terms, the analysis suggests that 'the commodity price impact of the EU's own 10% biofuel target will be on a rather small scale, compared to the impacts of other policies at the global level. Implementation of the policy will cause cereal prices to rise by 3% to 6% compared to the 2006 level. The price of sunflower seed will increase by 15% and of rape seed by 8% to 10%, while prices of animal feed will fall due to the increased availability of biofuel co-products' (pp130-131). This quote refers to analysis by EC DG AGRI (2007), see Annex 2. The percentage changes reported refer to price increases over the projection period 2006-2020 accounting for biofuel policy in place; they do not refer to a comparison in the price level between baseline and policy scenario in the end-of-projection year (eg 2020). It should be noted in this context that more recent analysis by the European Commission recognises future EU biofuel use as increasingly driving future increases in EU cereal and oilseed use as well as area expansion for sugar beet cultivation (EC DG AGRI, 2011b).

An academic paper by **Banse *et al* (2008)** using a general equilibrium model has found price impacts that are rather at the lower end relative to the compendium of studies and results. The low price effects are surprising given that their model does not account for by-products accruing from biofuel production and replacing animal feed. One explanation for the relatively low price increases put forward by the authors is the fact that their modelling only includes EU biofuel policies instead of accounting for global mandates, which is an important aspect in the scenario design. Furthermore, the incorporation of the land supply curve allows for global land expansion in response to increased demand for crops and therefore land is a less limiting production factor. It should be noted that unlike other studies, it does not become clear from the paper what the absolute increase in biofuel use is between the policy and reference scenarios and the fact that only EU biofuel mandates are modelled is in line with the other studies reviewed in this section.

Analysis by the European Commission's Joint Research Centre (JRC), **Edwards *et al* (2008)**, does not rely on modelling but instead uses a more ad-hoc approach to calculating price effects. The study confirms that higher price increases can be expected for oilseeds and vegetable crops, a conclusion drawn by all of the studies focusing on the impacts of EU policy reviewed here. Given the stronger reliance of biodiesel use in the EU, this finding is not surprising. (Also OECD, 2008, modelling simultaneous EU and US policies, project the most pronounced increase for vegetable oil prices.)

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[24] Commission Staff Working Document SEC(2008) 85, VOL. II of 27.2.2008 'Annex of the Impact Assessment: Document accompanying the Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020', http://ec.europa.eu/energy/renewables/doc/sec_2008_85-2_ia_annex.pdf.

Blanco Fonseca *et al* (2010) present JRC analysis based on three partial equilibrium models, AGLINK-COSIMO, ESIM and CAPRI. The scenario results largely follow the predictions in terms of biofuel use as derived from the NREAPs, given this study was prepared for the European Commission to analyse and prepare the ground for potential legislation on ILUC. It should be noted, however, that the increase in biofuel demand from counterfactual to baseline scenario is considerably higher than the increase from 2008 biofuel consumption to 2020 NREAP demand for all biofuels, including second-generation. On the other hand, and arguably more important for explaining differences in global price effects, the increase in global biofuel consumption is considerably lower than, for instance, in Fischer *et al* (2009), a study that explicitly addressed global biofuel markets and policies, as discussed in the next section. The reason for the lower global consumption in Blanco Fonseca *et al* (2010) presumably is precisely because the scenario design focuses on the EU and (apart from EU policy), global biofuel policies are kept constant in the different scenarios. Despite this lower increase in supply in Blanco Fonseca *et al* (2010) compared to Fischer *et al* (2009), price increases in the former are higher. The extent to which the models in Blanco Fonseca *et al* (2010) allow for crop land expansion is not entirely specified, but it is mentioned that for instance AGLINK-COSIMO models land use change for selected countries only. Possibly, this may result in a less elastic cropland area response, explaining the higher price effects. Again, given the higher proportion of biodiesel in meeting EU biofuel demand, prices for biodiesel feedstocks, in particular vegetable oil increase more substantially than prices for ethanol feedstocks.

Further analysis based on the AGLINK-COSIMO model is provided by **Davies (2012)**, an economist at the UK Department for Environment, Food and Rural Affairs (Defra). The results from this study are not readily comparable to other studies because Davies compares scenarios conversely by only reporting price changes in a scenario where biofuel support is removed compared to a baseline of existing support. In qualitative terms, his results are in line with other studies and show the highest impact on vegetable oil prices. This holds for both changes in European and global prices, both of which are reported[25].

Finally, we have obtained data on price effects from the author of the often quoted 'IFPRI study', **Laborde (2011)**, the major study used by the European Commission in the preparation of its impact assessment on ILUC and which has been improved in the course of this process (the preceding study is by Al-Riffai *et al*, 2010). Using a general equilibrium model, Laborde finds again higher impacts on the markets for biodiesel compared to ethanol feedstocks. That said, as in Blanco Fonseca *et al* (2010), increased global biofuel use is accounted for but is kept constant across scenarios. In terms of the absolute magnitudes of global biofuel use in 2020, Laborde (2011) lies between the studies of Fischer *et al* (2009) and Blanco Fonseca *et al* (2010). Comparing the absolute increase in biofuel use in the EU from the 2020 reference situation to the 2020 policy situation, which potentially is of crucial importance for the extent of price increases, this increase is almost twice as high in Blanco Fonseca *et al* (2010) compared to Laborde (2011), ie 28.1 Mtoe compared to 15.5 Mtoe. This is because in the counterfactual scenario of Blanco Fonseca *et al*, biofuel use in the EU decreases from 2008 to 2020 because the scenario formulation assumes that biofuel

[25] Annex 2 adds results from a scenario that removes US policy support.

support measures are abolished altogether, whereas Laborde (2011) fixes 2008 biofuel consumption unchanged over the projection period in his reference scenario (this also implies that with regard to the increase of biofuel use from 2008 to the 2020 policy scenario, the two models diverge much less). This, together with the fact that the models in Blanco Fonseca *et al* are partial and not general equilibrium models, and an assumingly less sophisticated way of modelling land use change could explain that price increases in Blanco Fonseca *et al* (2010) tend to be higher than in Laborde (2011).

Table 6 shows differentiated EU and world average price impacts of enhanced biofuel use for selected feedstocks. These are percentage changes between the price levels in 2020 in a policy scenario compared to the price levels in 2020 in the reference scenario. In most cases, EU price impacts are larger in response to EU biofuel policy, except for sugarcane/beet and palm oil, both majorly or entirely imported feedstocks. Comparing the first and second sets of columns shows the scale of biofuel demand in influencing commodity prices. Two scenarios are illustrated. In the first, total EU biofuel demand in 2020 is derived from the estimates put forward by Member States in their NREAPs. This results in an 8.4 per cent share of biofuels in the total transport fuel market. The second scenario assumes higher use of advanced biofuels and renewable electricity and a correspondingly lower (5.7 per cent) share of conventional biofuels in the EU transport fuel market. It can be seen that the price impacts significantly increase between the two (note that the 2010 IFPRI study modelled a central scenario with a 5.7 per cent blending share).

Table 6: Commodity price effects from Laborde (2011) for selected sectors and world regions (comparison between 2020 reference and 2020 biofuel policy scenario)

	8.4% EU biofuel share in 2020		**5.7% EU biofuel share in 2020**	
	EU27	World	EU27	World
Wheat	1.48%	1.01%	0.73%	0.48%
Maize	1.09%	0.74%	0.52%	0.33%
Sugarcane/beet	0.01%	0.88%	0.01%	0.41%
Soybeans	2.64%	2.48%	0.94%	0.88%
Sunflower	7.06%	4.82%	2.56%	1.77%
Rapeseed	14.08%	11.34%	5.50%	4.27%
Palm oil	4.43%	4.53%	1.53%	1.55%
Rape oil	16.40%	9.20%	6.52%	3.56%
Soy oil	9.79%	7.30%	3.71%	2.69%

Acknowledgement: We thank David Laborde for sharing the data underlying this table, which is not reported in Laborde (2011). Please note that neither David Laborde nor IFPRI bear responsibility for the accuracy of the way in which the data are presented in this report.
Note: All results are for the business as usual version of the scenarios (as compared to a set of trade liberalisation scenarios also modelled). Price changes reported are for consumer prices.

Table 7 is meant to put the 'comparative-static' changes between the policy and the reference scenario in 2020 (Table 6) into perspective with the price changes observed over the projection period 2008 to 2020 in the policy scenario. This gives a better idea about the importance of biofuel induced price changes. We focus here on the 8.4 per cent 'NREAP' scenario only. The highest price changes over time are observed for the biodiesel feedstocks (with the exception of palm oil). Looking at world prices, biofuel policy contributes around 40 per cent to the observed increase in rapeseed prices of close to 30 per cent, for example. The contribution is more pronounced when looking at EU27 prices, rising to 46 per cent. The contribution of biofuels to the (limited) price increases in ethanol crops is small. The three-digit contribution to sugarcane/beet price increases can be disregarded given the extremely small increases over 2008 to 2020 barely exceeding zero per cent, which inflates the numbers for sugarcane/beet in the last two columns of Table 7.

Table 7: Price changes in the 8.4% policy scenario of Laborde (2011) and the contribution of biofuels to these price changes over time

	2008-2020 change policy scenario		**Contribution of biofuels to 2008-2020 changes**	
	EU27	World	EU27	World
Wheat	*8.64%*	*11.60%*	17.12%	8.71%
Maize	*5.31%*	*5.60%*	20.54%	13.22%
Sugarcane/beet	*0.01%*	*0.14%*	100.00%	612.92%
Soybeans	*11.94%*	*11.35%*	22.11%	21.84%
Sunflower	*15.22%*	*11.69%*	46.39%	41.25%
Rapeseed	*30.48%*	*28.62%*	46.19%	39.62%
Palm oil	*7.57%*	*7.91%*	58.49%	57.30%
Rape oil	*34.15%*	*25.77%*	48.02%	35.71%
Soy oil	*31.03%*	*25.71%*	31.55%	28.39%

Acknowledgement as for Table 6. Note: The contribution is calculated by dividing the comparative-static price change in 2020 for the 8.4 per cent policy scenario (from Table 6) by the change over time as in the first two columns of the present table.

5.2.2 Findings from studies analysing global biofuel mandates

Even though the scope of this study is on the impacts of EU biofuel policies on agricultural commodity prices, we deem it relevant to consider examples of studies that model multi-regional or even global mandates. While this does not allow singling out the EU policy impact, it is in some sense a more complete scenario design, given EU policies in the real world do not take place in isolation. In this context, we highlight the study by Hertel *et al* (2010b), analysing the effects of simultaneous EU and US biofuel expansion over 2006 to 2015 and comparing the effects on agricultural outputs and land use (but not on prices) to a situation where only one region's policy is modelled. The authors note the large impacts on global production and land use, especially because of expanding biodiesel use in the EU and less so due to ethanol expansion in the US. Importantly, they conclude that the combined effects are greater than the sum of the individual policies' effects, highlighting the pronounced land use change to arable cropping taking place in different regions.

Rosegrant *et al* (2006) is an example of an early study modelling global biofuel targets. The price effects found are particularly high. It should be noted, however, that this is compared to a baseline with 1997 as its base year and biofuel use is frozen at base year levels, when they were relatively small.

OECD (2008) looks at the joint impacts of the US and EU biofuel policies, based on which the authors conclude that there could be substantial agricultural market impacts. The most pronounced increases are found for vegetable oil prices.

The study by **Fischer *et al* (2009a)** investigates two sets of scenarios, both including projections for biofuel use and policies: 1) a set of scenarios based on World Energy Outlook 2008 (WEO) projections that assume that both China and the EU meet their targets for the year 2020 with a few years' delay while the US will have only attained 40 per cent of the targets laid out in the Energy Independence and Security Act by 2030[26]; 2) a set of biofuel target (TAR) scenarios that assume that all mandatory, voluntary and indicative targets for biofuel use in major developed and developing countries are met. Global biofuel consumption is about twice as high in the TAR scenarios, 189 Mtoe compared to 94 Mtoe in 2020 and thus much higher compared to modelling studies that only include the EU target. While the price effects found in the ambitious TAR scenarios are substantial, including increases in the cereal price index in 2020 by 35 per cent compared to the reference scenario, this change drops to 12 per cent in the less ambitious WEO scenario (with no availability of second-generation fuels). It is not clear how much oilseed or vegetable oil prices increase as these are not singled out but are included, so we assume, in the 'Other crops' aggregate, whose price increases by 9 per cent in the WEO scenario. Fischer *et al* (2009a) provide interesting additional information about the origin of the increased cereal supply to the biofuel sector. On average across the scenarios, they conclude that 66 per cent is derived from increased production, 24 per cent from reduced feed use (with the more significant reductions taking place in developed countries) and 10 per cent from reduced food use (with 75 per cent of the absolute cereal food consumption occurring in developing countries).

The results from **Taheripour *et al* (2010)** cannot be easily compared to other studies because the authors report changes over time (2006-2015) rather than comparisons between baseline and policy scenario at the end of the projection period. Their study modelling the simultaneous impacts of EU and US biofuel policy is, however, useful in showing the importance of taking by-products into account in the sense that price effects are, partly considerably, smaller in the scenario including by-products.

Results from **Timilsina *et al* (2010)** are summarised as follows. Their baseline includes a global biofuel share of 5.4 per cent, which increases to 9 per cent in the 'announced targets' scenario. In an alternative, more ambitious policy scenario, currently announced global targets are doubled. Absolute amounts associated with these shares are not specified, which makes a comparison to other studies more difficult. Nevertheless, the shares modelled are considerable while the price effects found are rather modest given the scenarios modelled. Also, while price effects double for some crops in the 'doubled targets'

[26] The WEO does not spell out 2020 biofuel use in the EU but 2030 use, when the EU is assumed to have met a 10% biofuels target, is predicted to be 25.9 Mtoe. This number falls short of the 29.6 Mtoe biofuel use (out of which 27.3 Mtoe first-generation biofuels, see Bowyer, 2011) predicted by the NREAPs for 2020.

scenario, this happens only in those cases where the effects were small in the first place. The only more pronounced price increase is found for sugarcane/-beet, with a 9.2 per cent increase, rising to 11.6 per cent in the 'doubled targets' scenario. One explanation could be that the general equilibrium model used allows for flexible adjustment to the increased demand for biofuel feedstocks across the economies, which makes the comparison with Fischer *et al* (2009a), employing a PE model, difficult. However, comparing the results to Laborde (2011), another general equilibrium model, it is rather striking that the increases from the 'doubled targets' scenario in Timilsina *et al* (2010) tend to be hardly higher. Having said this, sugar prices do increase more substantially than in Laborde (2011) but at the same time increases in oilseeds are considerably reduced.

Box 4: From global to local – from commodity to food prices

The 'food versus fuel' debate often revolves around the idea that the impact of increased demand for biofuel feedstocks directly affects consumer food prices. The link between increasing demand for biofuels and the final price of food to the consumer is, however, not the focus of the modelling studies examined here. Instead, the modelling studies reviewed for this paper analyse the impact of biofuel demand on price levels for agricultural commodities. The pass-through from agricultural commodity prices to consumer food prices in practice is much more complex and varied between markets and over time and any estimates thereon will be crude as they depend on a range of factors, including:

- Different use of staples in developed versus developing countries: A good example is corn, which is used for direct human consumption in a range of developing countries but is primarily a feed grain in developed countries;
- The scale of contribution of agricultural raw material costs to food production costs and hence prices. In many countries there is now a large gap between farm-gate and consumer retail food prices and an enormous multiplicity of food products. The extent of processing, storage and distribution varies considerably.

European Commission analysis exemplifies these points by commenting on the pass-through of commodity price increases to consumer prices in the EU in 2007-08. While headline and food inflation did increase, the contribution of agricultural commodity price increases to consumer food prices was moderate due to '(i) the appreciation of the euro; (ii) the declining share of agricultural raw materials in food production costs compared to energy and labour costs (mainly due to increased processing) and (iii) the low share of food in the total household expenditure (today an average EU-27 household spends around 14% of its total income on food)'[27]. The third point mentioned by the Commission is additional to the pass-through of commodity to retail prices and is crucial in determining the welfare impacts of rising commodity and food prices. The share of food expenditure out of total household expenditure varies between countries depending on income, age and composition of families. As a general rule, people with lower income levels and poorer countries tend to spend a higher proportion of their income on food, whereas this proportion decreases substantially in higher income groups (OECD/FAO, 2010; Ivanic *et al,* 2011)[28]. To exemplify this point: Wiggins *et al* (2008; adopted from Trostle, 2008) calculate the pass-through of a 50 per cent

[27] From p6 of Communication COM(2008) 321 final of 20.5.2008 from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on 'Tackling the challenge of rising food prices - Directions for EU action', http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0321:FIN:EN:PDF.

[28] In concrete numbers, Economic Research Service (US Department for Agriculture) analysis of 51 countries found that in high-income countries, on average 16 per cent of income was spent on food, whereas in low-income countries this average was 55 per cent (Meade and Rosen, 1997).

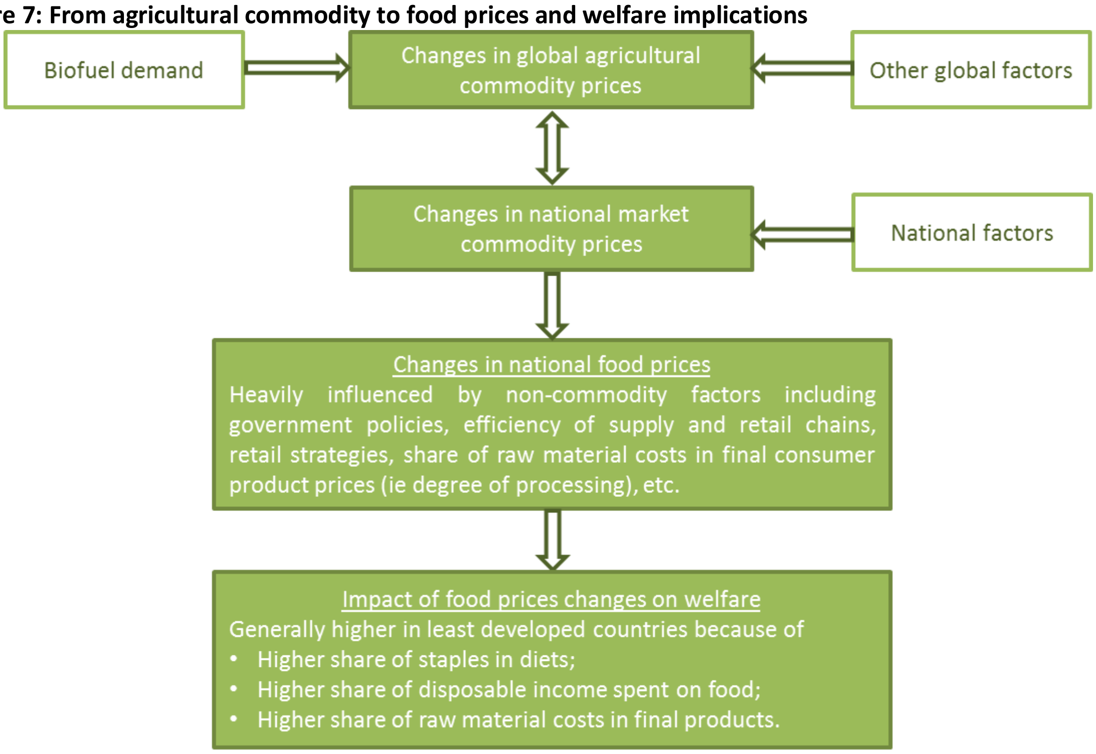
increase in the price of staples on illustrative food budgets in high- and low-income countries. They start from the assumption that a typical high-income-country consumer spends 10 per cent of her income on food, while this figure is 50 per cent in a low-income-food-deficit country. Based on assumptions on the share of staples in total food consumption as well as on the domestic pass-through of staples prices[29], the 50 per cent higher prices increase food expenditure as a share of total income to 10.6 per cent and to 60.5 per cent for the high- and low-income-country consumers, respectively. This underlines the greater impact of increases in staple commodity prices on households in developing countries.

Clearly the transmission of price changes from global to domestic markets differs between countries and regions[30], explained among others factors by:

- A country's food import dependency;
- Domestic policy measures aimed at delaying pass-through to domestic end-user prices, eg food subsidies. While these may ease the impact on food consumers, it may have unfavourable repercussions for producers in the sense of taking away the incentive to increase production in response to higher prices (Wiggins *et al*, 2008).
- Movements of the local currency exchange rate against the US Dollar;
- The distance between major centres of production and consumption, and the coast; and transport costs (HM Government, 2010).

These considerations are illustrated in a simplified way in Figure 7 below.

Figure 7: From agricultural commodity to food prices and welfare implications



Source: Own compilation

[29] A partial pass-through on staples of 60 per cent is assumed; the assumptions on staples as a percentage of total food spending are 20 and 70 per cent for the low- and high-income countries, respectively.

[30] Wiggins *et al* (2008, p29) review the degree of transmission of international prices for world regions with transmission found to be highest in Asia and lowest in Africa with Latin America showing a more diverse picture.

5.3 Implications for the significance of EU biofuel policy in relation to projected agricultural commodity prices by 2020?

Having looked at the compendium of studies, we provide an alternative representation of projected price impacts based on feedstock or feedstock groups in Table 8. This allows for a quick overview of the ranges found for the feedstocks that will be of particular importance in meeting the EU 2020 targets (see section 2.2).

Table 8: Summary of price effects per feedstock

Feedstock (group)	Range of price effects	Commentary
Studies that focus on the effects of EU biofuel policy		
Oilseeds	8 – 20%	
Vegetable oils	1 – 36%	
Oilseeds	9 – 20%	
Cereals / maize	1 – 22%	The ESIM model (Blanco Fonseca *et al*, 2010) projects an increase in maize prices of 22%. The remaining studies project increases in maize or cereal prices of ≤8%
Wheat	1 – 13%	
Sugar (cane/beet)	1 – 21%	The ESIM model (Blanco Fonseca *et al*, 2010) projects an increase in sugar prices of 21%. The remaining three models reporting results for sugar project price increases of ≤2%
Studies that analyse the impacts of global/multi-regional biofuel mandates		
Oilseeds	2 – 7%	
Vegetable oils	35%	OECD (2008) is the only 'global' study providing a figure for vegetable oils
Cereals / maize	1 – 35%	
Wheat	1 – 8%	
Sugar (cane/beet)	~10%	Timilsina *et al* (2010) is the only 'global' study providing a figure for sugar, 9.2 or 11.6% depending on the scenario

Source: Own compilation based on the preceding analysis

Note: Figures are rounded to full percentages. The ranges in this table do not include results from Davies (2012) because of a different reporting of price effects that cannot be compared to the other studies; Taheripour et al *(2010) for similar reasons (see Table 5); and Rosegrant* et al *(2006) given their results are considered outdated and therefore it does not seem sensible to compare them to the remaining studies.*

We conclude the following as to the likely impacts of EU biofuel policy on agricultural commodity prices in 2020 based on the evidence from models:

- Table 5 summarised the results of different studies and, just as importantly, the key modelling characteristics. It is clear that the compendium of studies provides a very *heterogeneous picture* from which it is very difficult to draw definite conclusions;

- The price changes projected into the future found in the studies reviewed here are all *positive, but not massive*, especially in comparison to the recently experienced global commodity price spikes. But they are not negligible either.
- Another rather robust result is that there is an important *difference in impacts between commodity groups*. Prices of oil crops, ie oilseeds or vegetable oils, depending on the study, are more affected than cereals and sugar prices as a result of EU policy. This is not a great surprise given that almost three quarters of EU biofuel use in 2020 is anticipated to be biodiesel. This picture is summarised in Table 8 above. This situation would be expected to change if in future the EU adopts a policy to mitigate ILUC, as is now being discussed. That would shift the EU biofuel demand in favour of ethanol rather than biodiesel and so potentially increase the impacts on the prices of the principal ethanol crops, such as sugar cane and maize.
- Probably one of the *more relevant studies* to look at is the recent study by Laborde (2011) that has been substantially improved in the course of preparing the evidence base for the European Commission's impact assessment on indirect land use change. Laborde shows pronounced increases for, among others, rapeseed oil, sunflower seeds and rapeseed. Focusing on the latter, the price increases in 2020 in the policy scenario compared to the reference scenario are 11.3 and 14.1 per cent for global and EU average prices, respectively.
- While these are clearly *significant impacts*, they do not translate to a large extent to other crop markets and neither does the range of models project substantial price effects for ethanol feedstocks given the relatively lower level of EU ethanol use in 2020. Price increases for the ethanol feedstocks wheat, maize and sugarcane/beet do not exceed 1.5 per cent in Laborde (2011). At the other end of the range, the partial equilibrium models ESIM and CAPRI (Blanco Fonseca *et al*, 2010) project increases of 8 and 12.5 per cent for wheat prices and 22 and 8.0 per cent for maize prices, respectively.
- Finally, we note that EU biofuel policies do not take place in isolation in reality and simultaneous biofuel support policies in several world regions multiply the pressure on agricultural market impacts including commodity prices.

6 IMPLICATIONS FOR POLICY

The modelling results summarised in section 5.3 indicate that estimates of the effect of the EU biofuels mandate on agricultural prices show a fairly wide range of values. In the studies focusing on the impacts of EU biofuel policy, the most significant increases are projected for oilseeds and vegetable oils, with increases in world prices typically ranging between 8 to 20 and 5 to 36 per cent, respectively. Increases in world rapeseed prices, which according to projections, are expected to be the most significant feedstock for EU biofuel use in 2020, are around 11 and 13 per cent in Laborde (2011), depending on the scenario. The ranges found leave a considerable degree of uncertainty. The welfare effects of higher international agricultural commodity prices (see the bottom part of Figure 7) are an even more complex subject, a detailed analysis of which is not attempted here. However, in order to understand the policy options for addressing the price changes identified in the models it is useful to highlight the following points.

From the perspective of (urban) food consumers, the higher agricultural raw material prices will in turn be transmitted down the food chain into higher retail food prices, which will diminish living standards (all other things being equal). The size of this impact on food price inflation is beyond any of the studies examined. Qualitatively it is expected that poorer countries and poorer households will bear a larger burden proportionately than richer households and countries.

It should, however, be noted that higher agricultural prices can be welcomed by rural households in the developing world which are agricultural producers. With higher prices – assuming such changes are transmitted back to rural areas and primary producers – their production will become more remunerative. The surplus dumping activities of developed country agricultural producers (like the USA and EU) have been criticised for reducing world prices and harming the interests of poor farming households in developing countries. Conversely, the same logic would presume that policies raising world prices would help the interests of these groups. It is, however, commonly asserted that while increasing prices hit net consumers of agricultural produce immediately, the supply response triggered by higher prices (that would produce positive welfare effects in agricultural communities) takes longer to materialise given crop growing cycles and investment costs. It may even be hampered altogether in the presence of high price volatility that makes investments more risky while at the same time increasing the vulnerability of the poorest households (Box 3).

The impacts of renewable energy policy on food prices are of course in addition to the direct higher price effects of the transport fuel itself, which will result from the biofuels mandate. Again as poorer families will tend to spend a higher proportion of their incomes on fuel as well as food, the differential social effect is compounded. None of the studies reviewed here is able to analyse these multiple effects on the household level. To do this, models need to account for different household structures distinguishing between characteristics such as urban, rural, land-owning. Such analyses of the micro level impacts of global price changes triggered by biofuel policy are badly needed in order to truly understand the costs and benefits of biofuel induced agricultural market impacts.

Ultimately the test of the policy is its efficacy and cost effectiveness in delivering its primary objective which, in Europe at least, is to displace fossil fuels, leading to lower emissions of greenhouse gases and thus mitigating harmful climate change. At the same time, this should not compromise other policy objectives, such as reducing poverty and hunger in the developing world. This study was framed to consider just one element of such an assessment, namely the effect on agricultural commodity prices. We have not explored the climate impact of EU biofuels policy, which requires taking account both of direct and indirect effects through indirect land use change, although this was a main focus of some of the studies reviewed here. It is clearly important to know if the commodity price raising effect of biofuels policy is a cost-effective route for mitigating climate change and if such mitigation is being achieved.

Finally, we offer some discussion of a selection of options for future EU biofuels policy that are 'on the policy makers' table' as put forward by different interest groups:

- Removal or reduction of the EU's 10 per cent target for renewable energy in transport;
- Enforcing stricter sustainability standards, including the removal of subsidies for unsustainable biofuels and/or the promotion of more sustainable biofuels;
- Making biofuel mandates more flexible.

Several prominent reports have called for a **removal of biofuel mandates and subsidies**. A paper prepared by ten international organisations to feed into the G20 discussions on agricultural market volatility under the French presidency (2011), FAO, IFAD *et al* (2011), recommended that 'G20 governments remove provisions of current national policies that subsidize (or mandate) biofuels production or consumption' (p27). A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (HLPE, 2011), calls for the CFS (Committee on World Food Security) to 'demand of governments the abolition of targets on biofuels and the removal of subsidies and tariffs on biofuel production and processing' (p13). IFPRI suggests as one of *seven steps to prevent recurring food crises* that 'public policies, particularly in the United States and the European Union, should aim to curtail and reform existing biofuel policies and subsidies to maximize environmental benefits while minimizing biofuel demand's possible contribution to the volatility of international and domestic food markets' (Fan *et al*, 2011, p3). Changing policy to reduce or abolish policy-driven biofuel demand could reduce or altogether eliminate agricultural commodity market impacts. However, the scale of the effect would be lessened in a market scenario with high oil prices (and a favourable ratio of biofuel output prices and feedstock prices), in particular given the production capacity already installed.

There are several reasons for removing biofuel support policies and agricultural market impacts would be a factor in the equation. The Commission has to report on the impacts on food prices and clearly there is currently a lack of understanding as to what extent the agricultural commodity price increases, already uncertain in themselves, would translate into retail price increases in different locations in the world and the effects this would then have on households, some of which are agricultural producers as well as consumers. Within the developed world which is imposing these biofuel policies, there are quite different effects for different consumers. Having said this, it is valid at this stage to make the link to the wider discussions on the sustainability of biofuels. The ongoing ILUC debate has questioned the ability of biofuels to reduce GHG emissions. Given the uncertainty about the ability of biofuels to contribute to one of their main underlying rationales, reducing GHG emissions in the transport sector, any further potentially harmful impacts will compound concern regarding their social acceptability, undermining the case for supporting policies.

The idea of **removing subsidies for unsustainable biofuels** and/or promoting more sustainable biofuels takes us into the more general debate on the environmental and social implications of biofuels. Whatever would be identified as unsustainable biofuels, removing support for those would reduce the pressure on the markets for the respective feedstocks. As examples of more sustainable biofuels, advanced biofuels produced from agricultural, forestry or other wastes are often cited. Once their environmental and social implications are better established[31], promoting the use of biofuels from such feedstocks could be an option to increase the GHG saving potential from biofuel use while at the same time reducing their impacts on agricultural markets and commodity prices. Volumes of these biofuels would be considerably lower than those from agricultural crops, at least in the shorter term.

With regard to **making biofuel mandates more flexible**, discussion is focused on the US situation. Unlike in the EU, the US Energy Independence and Security Act (EISA) mandates the use of quantities of biofuels (in gallons) on a yearly basis up to 2022. Several authors have pointed at the harmful effect of biofuel mandates in the sense that they add an inelastic demand to agricultural markets, which are generally considered already to be inelastic (because people do not generally change their consumption of food much in relation to its price) (Babcock, 2011; Hertel and Beckman, 2011; Meyer and Thompson, 2010; HM Government, 2010). With such inelastic demand small changes in production can have a disproportionate impact on prices, as seen in the price volatility of recent years. It could be argued that EU policy is from its outset more flexible. First of all, Member States are free to promote more heavily other forms of renewable energy in the transport sector, hence reducing the reliance on (first-generation and crop-using) biofuels. Also, the RED does not prescribe a stepwise roadmap on how to meet the targets by 2020. On the latter point, Member States are tasked with defining their own trajectory to 10 per cent in the form of the NREAPs and biannual progress reports. This could be seen as a 'softer', potentially more flexible, approach compared to the strict year-on-year targets contained in the US EISA. Nonetheless, changes to the timetable and to permit reductions in vehicle fuels consumption to be pursued in place of a specific renewable energy target for transport fuels would be means of adding further flexibility.

Finally, looking ahead, policy makers may have less influence over the amount of biofuels that will be used in future in the light of rising fossil fuel prices. If the competiveness of biofuels increases in the market with high oil prices (and favourable feedstock prices), the role of policy, be it in the form of subsidies, mandates or tax exemptions, diminishes. Hertel and Beckman (2011) cite Hertel *et al* (2010b), according to whom 'higher oil prices accounted for about two-thirds of the growth in US ethanol output over the 2001-2006 period. The remainder of this growth is estimated to have been driven by the replacement

[31] See eg Kretschmer et al (2012) for a summary of the environmental considerations surrounding the use of cereal straw for cellulosic ethanol production.

of the banned gasoline additive, MTBE, with ethanol in petroleum refining. In the EU, those authors estimate that biodiesel growth over the same period was more heavily influenced by subsidies. Nonetheless, they estimate that oil price increases accounted for about two-fifths of the expansion in EU biofuel production over the 2001-2006 period' (p6). Abbott *et al* (2011) make the same point, highlighting the 14 billion gallon production capacity already installed in the US, arguing that production would not fall with oil prices remaining high and producers being able to cover variable costs, even if changes were made to the RFS mandate. Likewise, the EU biofuel market is characterised by a structural overcapacity, meaning that the existing capacity provides much of that needed to meet the 2020 NREAP targets (Ecofys, 2012). Future policy scenarios need to take account of changing market conditions.

7 CONCLUSIONS

This report addresses one of the principal concerns in the current biofuel debate by providing a review of the evidence base on the impact of EU biofuel use on agricultural commodity prices up to 2020.

The 10 per cent target for the use of renewable energy in transport set in the EU Renewable Energy Directive is anticipated to lead to a tripling of biofuel use in the EU in 2020 compared to 2008 levels. These are the figures derived from Member States' National Renewable Energy Action Plans, which also suggest that the dominance of biodiesel over ethanol in the European biofuel market will continue. With almost exclusive reliance on first-generation biofuels produced from traditional food and feed crops, this increase in biofuel demand translates into a significant additional demand for these crops. In line with standard economic theory, increasing demand while holding all other things, most notably food and feed consumption, equal increases market prices. In the real word, 'all other things' are not kept constant but rather change according to complex interactions between markets for different crops, livestock and between world regions and according to responses to price signals by consumers and producers. In the food versus fuels debate, the use of by-products as animal feed and yield increases stimulated by higher output prices are two factors with a potential to mitigate price increases. Nonetheless, they are expected to increase over the period to 2020.

Partial and general equilibrium models are the primary tools of economists to study the impacts of biofuel use on agricultural markets. However, they differ in their assumptions about biofuels and in the way in which feedback mechanisms are taken into account. This, combined with differences in biofuel scenario designs, make the comparison of different model results a challenging task. The analysis in section 5 summarises the key characteristics from the relevant modelling studies reviewed here; we further classified models according to their focus on EU biofuel policy versus studies looking at the impacts of simultaneous targets in several world regions or globally.

From looking at the EU studies, it is clear that the impacts on biodiesel feedstock prices are more pronounced than those on ethanol feedstock. We suggest that those studies that have been refined to contribute to the debate on ILUC and whose results with respect to ILUC are used by a multitude of stakeholders can be expected to be more reliable than others in terms of assessing the impacts of EU policy on agricultural commodity prices. This is most notably the 'IFPRI study' by Laborde (2011), which projects oilseed price increases in 2020 in the policy scenario compared to the reference scenario of up to 11.3 and 14.1 per cent for global and EU average prices, respectively. Future EU legislation on ILUC may lead to a shift from biodiesel to more ethanol use with a corresponding shift of the agricultural market impacts from biodiesel to ethanol feedstocks.

In terms of policy options to deal with biofuel induced price increases, it is straightforward that a reduction or even abolition of biofuel demand would reduce or prevent altogether agricultural commodity market and hence consumer food price impacts due to biofuel *policy*. However, depending on the development of oil and therefore fossil fuel prices on the one hand and feedstock prices on the other, the market might still drive biofuel use whenever these are price competitive with fossil fuels, rendering policy changes less effective. Unlike in the USA, where biofuels are promoted by a rigid mandate laying out annual targets for biofuel volumes consumed, EU policies relating to biofuels are slightly more flexible and could be made more so. At present there is at least an element of flexibility afforded to Member States in terms of how they choose to go about meeting the target. They are obliged to deliver a certain proportion of renewable energy in transport rather than to meet specific target volumes of biofuels. Consequently, policy can be adjusted in different ways – either by altering the target for renewables, setting more specific targets for different forms of renewable energy (eg advanced biofuels), increasing the efficiency of transport vehicles etc. For example, EU policy that would encourage Member States to increase support for advanced biofuels produced from forestry and agricultural residues as well as renewable electricity while scaling back support for conventional biofuels produced from food and feed crops, would be a way of reducing pressure on agricultural markets. Alternative options for promoting renewable energy and increasing policy flexibility need further detailed consideration and clarification could usefully be provided by the Commission regarding the scope that Member States have to adapt their policies up to 2020.

Finally, it should be noted that this review assessed the impacts of biofuel use on agricultural commodity prices. The European Commission, as part of its reporting requirements in 2012, is required to judge the impacts of biofuels on *food* prices. This further step increases the complexity of the analysis substantially. Food supply chains involve an extremely wide range of plant and animal products with varying degrees of processing of agricultural commodities and varying proportions of staple foodstuffs in the diet. The vulnerability of consumers across the world to food price increases differs markedly between countries and across households, depending *inter alia* on income levels, household composition, and on the household status as net consumers or producers of agricultural and food stuffs. We are not aware of studies that use multi-household models, which would produce a better understanding of the impacts of enhanced biofuel use on different population groups and allowing more solid estimates of the welfare impacts of biofuel policy. This gap should be closed in order to provide decision makers with a more complete evidence base feeding into the political review processes ongoing in 2012.

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ANNEX 1: LAND REQUIREMENTS FOR BIOFUELS

In order to get an under understanding about the magnitudes of land used for biofuel production this annex presents 1) biofuel yields per hectare, 2) estimates of land required for EU biofuel consumption as well as 3) feedstock used for biofuel production in relation to global crop production. Table A1 summarises ***biofuel yields per hectare*** in different measures as well as their inverse, hectare requirements per Mtoe biofuel.

Table A1: Examples of biofuel yields per hectare[32]

	l/ha	toe/ha	ha/toe (=million ha/Mtoe)
Sugarcane ethanol (Brazil)	5470	2.75	0.364
Wheat ethanol (global)	950	0.48	2.095
Palmoil (Malaysia) biodiesel	4700	3.73	0.268
Soy biodiesel (USA)	550	0.44	2.293
Rapeseed biodiesel (EU)	777-1249	0.62-0.99	1.009-1.623
EU biofuels average*			0.590

Source: FAO (2008), Blanco Fonseca et al (2010); own conversion in tonnes of oil equivalent (toe) based on lower heating values (LHV) of 21.1 MJ/l for ethanol and 33.3 MJ/l for biodiesel.
*Notes: One litre of ethanol replaces 0.66 litre of gasoline; one litre of biodiesel replaces 0.91 litre of biodiesel. * Ecofys et al (2011), based on amount of biofuels consumed in the EU in 2008 and the total land estimated to be used for their production in 2008, see Table A2.*

Ecofys *et al* (2011) provide ***biofuel land use estimates*** for 2008 as summarised in Table A2. Using ecological-economic modelling tools, Ecofys et al (2011) show that 'the increase in biofuel production in the EU between 2000 and 2008 has led to an increased global agricultural land use of 1.3 Mha' (million hectare), falling short of the 3.6 million hectares estimated to be used for EU biofuel production in 2008. This shows that 'part of the land used for biofuels feedstock production became available through yield improvements of other crops, or at the cost of decreasing production of other crops' (p135).

With regard to **future land needs**: A simple calculation based on the average hectare requirement of 0.59 per tonne of oil equivalent biofuel together with an anticipated EU biofuel consumption of 29.6 Mtoe in 2020 yields a land requirement for EU biofuel use in 2020 of 17.5 million hectares globally. Note this represents a very crude estimate, as it neglects any yield improvements (which will reduce the land requirement) and does not account for potential shifts in biofuel pathways (could either reduce or increase the land requirement). To put the admittedly crude estimate in perspective: Current EU arable land amounts to 104 million ha, while the utilised agricultural area (UAA; includes arable land,

[32] Note this table serves as an illustration and the figures are crucially dependent on assumptions on crop yields, and conversion efficiencies. This becomes apparent in particular with regard to the figure above on wheat ethanol. While the FAO figure is based on global yield assumptions, a figure derived from a German source gives a much higher yield for wheat ethanol of 2760 litres per hectare (http://www.bio-kraftstoffe.info/kraftstoffe/bioethanol/rohstoffe/). This converts to a requirements of 0.721 hectares per tonne of oil equivalent.

permanent crops and permanent grassland) amounts to 170 million ha[33]. Extrapolated global biofuel land needs in 2020 for EU biofuel consumption are around 10 per cent of current EU utilised agricultural area or 17 per cent of 2007 EU arable area.

Table A2: Land use in EU 2008

	Million hectare for EU biofuel consumption in 2008
Gross land use	7
of which in the EU	*3.6*
of which in third countries	*3.3*
Net land use (accounting for co-products)	3.6

Source: Ecofys et al (2011)

Table A3 compiles data on the ***use of feedstock for biofuel production***. The figures refer to the quantity of a given feedstock used to produce biofuels in the EU. These are compared to global production of a given crop. The resulting shares are all relatively small, with noticeably differences between them, however. While vegetable oil use for biofuel production in the EU reaches 5.3 per cent, the share for wheat is negligible with 0.5 per cent.

Table A3: Use of feedstock commodities for biofuel production in the EU in 2007

	Use for biofuel production in EU (in 1000 tonnes)	**Global feedstock production (in 1000 tonnes)**	**Share of global production**
Wheat	2,851	591,833	0.5%
Sugar beet	9,281	244,237	3.8%
Vegetable oils	5,698	106,517	5.3%

Source: Based on OECD (2008, p78).
Note: The quantities of feedstock used for biofuel production in the EU (first column) may include imports and domestic feedstocks and are used to produce biofuels that may either be domestically consumed or exported.

[33] These are figures for 2007 and 2010, respectively, taken from: Eurostat statistical database (http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database); Eurostat (2011) EU-Agricultural census 2010 - first results, http://europa.eu/rapid/pressReleasesAction.do?reference=STAT/11/147&format=HTML&aged=0&language=EN&guiLanguage=en.

ANNEX 2: SUMMARY TABLE OF STUDIES REVIEWED

Study and model used	Scope and scenarios (geo – time – research questions)	Main results
Rosegrant *et al* (2006) *Short model description:* - Partial equilibrium. Uses IFPRI's IMPACT model[34] (International Model for Policy Analysis of Agricultural Commodities and Trade) - Biofuels modelled implicitly: 'The model contains three categories of commodity demand: food, feed, and other use demand. This study manipulates the "other use" demand category in order to reflect the use of commodities as biofuel feedstocks…' - Second-generation biofuels: cellulosic feedstock sources (crop residues and switchgrass) not represented, so use of second-generation biofuels modelled by reducing the demand for first-generation feedstock - No trade in biofuels - Biodiesel use only in the EU ✓ *Regions and sectors* 30 commodities accounting for 'virtually all of world food production and consumption'; 115 model regions ✓ *Modelling land* Not specified ✓ *Modelling by-products* Not specified	*Scenario description:* - Baseline scenario: Biofuel volumes frozen at 1997 (base year) levels - Policy scenarios: 1: Aggressive biofuel growth holding projected productivity increases for yields at baseline projection levels: biofuel shares (energy equivalent) in 2020 are: RoW 2%, USA 4%, China 8%, EU 10%, India 11%, Brazil 58% 2: Cellulosic biofuel as of 2015: crudely modelled by holding demand for conventional biofuel crops constant after 2015 3: Aggressive biofuels growth with productivity change and availability of cellulosic biofuels ✓ *Base year – model horizon* 1997 to 2020 ✓ *Absolute magnitudes of biofuel use (EU & global)* Not specified ✓ *Increase in magnitudes in scenarios* Not specified ✓ *NREAP demand considered?* No, not available at the time, but 10% biofuel share modelled (corresponding biofuel volume not specified)	✓ *Reporting of EU versus global price impacts?* No, only world prices ✓ *Differentiated reporting of commodity versus retail price impacts?* No, commodity level only ✓ *Comparator for price effects* Policy 2020 compared to baseline 2020 (not entirely clear from report) Price increases in 2020 compared to the baseline in scenarios 1, 2 and 3, respectively, for six crops reported are: - Cassava: 135, 89, 54% - Maize: 41, 29, 23% - Oilseeds: 76, 45, 43% - Sugar beet: 25, 14, 10% - Sugarcane: 66, 49, 43% - Wheat: 30, 21, 16%

[34] Model description available at: http://www.ifpri.org/sites/default/files/publications/impactwater.pdf

Study and model used	Scope and scenarios (geo – time – research questions)	Main results
EC DG AGRI (2007)[35] *Short model description:* - ESIM (European Simulation Model), partial equilibrium model for the agricultural sector[36] - biodiesel and ethanol demand up to 2020 based on energy projections of DG TREN's PRIMES model ✓ *Regions and sectors* Covers agricultural products; all EU Member States + Turkey and USA modelled as individual countries; remaining countries are aggregated as 'rest of the world'. ✓ *Modelling land* Not specified ✓ *Modelling by-products* Taken into account	*Scenario description:* - Policy baseline: 2020 situation under 2003 biofuels directive, expected to lead to a 6.9% biofuel share or 23.8 Mtoe biofuel consumption - New policy scenario: 2020 situation under a 10% biofuel target, leading to 34.6 Mtoe, ie an additional 10.8 Mtoe of biofuel use in 2020 - Penetration of second-generation biofuels: 30% of domestic biofuel production from second-generation, sensitivity runs lowering contribution; second-generation biofuels seem to be from (land-using) crops, but assumptions not specified apart from 'significantly higher energy per hectare' yields mentioned as a general remark - Agricultural policies as in 2007 and kept constant thereafter ✓ *Base year – model horizon* 20004/05 to 2020 ✓ *Absolute magnitudes of biofuel use (EU & global)* 'Baseline' versus 'new policy' in 2020: 23.8 Mtoe vs 34.6 Mtoe; global use not specified ✓ *Increase in magnitudes in scenarios* 10.8 Mtoe; global not specified ✓ *NREAP demand considered?*	✓ *Reporting of EU versus global price impacts?* No, reported prices appear to be EU27 prices ✓ *Differentiated reporting of commodity versus retail price impacts?* No, commodity level only ✓ *Comparator for price effects* Comparison over time 2006-2020 Price increases over 2006-2020[37]: - Cereals: 3 to 6% - Sunflower seeds: 15% - Rapeseed: 8 to 10% - Soy bean oil : 'significant' increases In the policy baseline (2003 directive) 'prices [in 2020] for agricultural raw materials would be similarly firm as under the 10% scenario [in 2020], however with slightly lower increases' (p7) No 2nd-gen biofuel production: 50% import share and 'agricultural prices would be significantly higher' (p9) Share of arable land used for biofuel production in 2020 with 10% target: 15%

[35] Results summarised in EC DG AGRI (2007) are cited in the annex of the impact assessment conducted by the European Commission in preparation for the 2008 climate-energy package: http://ec.europa.eu/energy/renewables/doc/sec_2008_85-2_ia_annex.pdf.

[36] According to EC DG AGRI (2007) the model is recursive-dynamic, while a short model description available at http://agrilife.jrc.ec.europa.eu/ESIM.htm states it is comparative static.

[37] Edwards *et al* comment on results for price developments over time in EC DG AGRI (2007): 'In 2007 OECD projected significant falls in inflation-adjusted world crop prices by 2020, whereas FAPRI projected a much gentler fall. [EC DG-AGRI 2007] bases its projection on OECD, so the rise in prices due to biofuels is partly masked by the overall fall in real prices in the background projection' (2008, p17).

Study and model used	Scope and scenarios (geo – time – research questions)	Main results
	No, not available at the time, but magnitudes modelled here are higher than biofuel consumption of close to 30 Mtoe (27.3 Mtoe first-generation) in 2020 according to the NREAPS	
Banse *et al* (2008) *Short model description:* - Computable general equilibrium model LEITAP, which is a modified version of the GTAP-E model - Biofuels not modelled as separate sectors but rather as intermediate inputs to the petroleum industry; therefore, trade in biofuels cannot be modelled - Second-generation biofuels not included ✓ *Regions and sectors* 37 regions and 23 sectors, with focus on the detailed representation of EU countries and other important agricultural market actors and on agricultural and energy sectors (see Banse *et al*, 2008, p122 for details) ✓ *Modelling land* Land availability determined by land supply curves representing the relationship between land supply and rental rates allowing for conversion of non-agricultural land into cropland; Allocation of land across different land covers and uses according to a nested CET function (see Fig 4, p124) ✓ *Modelling by-products* Not included	*Scenario description:* - 10% EU biofuel blending target by 2020 compared to a reference ('Global economy') scenario with no biofuel blending obligations - Declining real agricultural prices in the reference scenario as a result of the considerable degree of trade and agricultural market liberalization assumed as well as the inherent assumptions on productivity growth rates ✓ *Base year – model horizon* 2001 (GTAP 6) to 2020 ✓ *Absolute magnitudes of biofuel use (EU & global)* Not specified ✓ *Increase in magnitudes in scenarios* Not specified ✓ *NREAP demand considered?* No, not available at the time. 10% target modelled but associated quantities are not specified	✓ *Reporting of EU versus global price impacts?* No, only world prices ✓ *Differentiated reporting of commodity versus retail price impacts?* No, only commodity level ✓ *Comparator for price effects* Policy 2020 compared to reference 2020 World price increases between reference and policy scenario in 2020: - Oilseeds: 8.5% - Sugar: 2% - Cereals: 6% To note the development of prices over time: even in the policy scenario, sugar and cereal prices decrease from 2011-2020 (both by around 6-7%), while only oilseed prices increase (1-2%)
Edwards *et al* (2008) *Short model description:* - No modelling; acknowledge that modelling needed to take cross-feedstock effects into account - Calculations based on DG TREN fuel demand scenario calculating the amount of biodiesel and bioethanol	*Scenario description:* - 10% 1st generation ethanol and biodiesel use in EU in 2020, compared to no EU biofuel use in 2020 ✓ *Base year – model horizon* Looking at 2020 ✓ *Absolute magnitudes of biofuel use (EU & global)*	✓ *Reporting of EU versus global price impacts?* No, only world prices ✓ *Differentiated reporting of commodity versus retail price impacts?* No, only commodity level ✓ *Comparator for price effects* 2020 policy compared to 2020 no biofuel use

Study and model used	Scope and scenarios (geo – time – research questions)	Main results
needed for 10% shares biodiesel and 10% ethanol shares; calculating the amount of vegetable oil / cereals needed to meet this and the share of this demand out of total global supply in 2020 (based on FAPRI); combined with assumptions on long-term area response supply flexibilities to calculate price increases ✓ *Regions and sectors* Not applicable (EU focus) ✓ *Modelling land* Not applicable ✓ *Modelling by-products* No	Only partly specified, see below ✓ *Increase in magnitudes in scenarios* See above (reference assumes zero biofuel use) ✓ *NREAP demand considered?* No, not available at the time; mention that 10% of 2020 diesel demand is ~19.2 Mtoe (p9; no corresponding figure for ethanol mentioned)	Prices compared to no biofuel use in 2020: - 10% first-generation ethanol blend in EU gasoline would use, ~2.5% of world 2020 cereals, causing a world cereals price increase of at least 4%. - 10% first-generation biodiesel blend in EU diesel would use ~19% of world 2020 vegetable oils, causing a world price increase of at least 24%.
OECD (2008) *Short model description:* AGLINK-COSIMO, OECD-FAO partial equilibrium modelling system underlying the *Agricultural Outlook*. ✓ *Regions and sectors* Includes major temperate-zone agricultural commodities; extended to include sugar and sweeteners; Large developing country coverage through link to Cosimo ✓ *Modelling land* Not specified ✓ *Modelling by-products* Included (OECD, 2008, p125 for details)	*Scenario description:* - Counterfactual with no biofuel policy support - Baseline scenario incl existing biofuel support measures '[projecting] a substantial further growth in the production and use of both ethanol and biodiesel'. No second-generation biofuels - Policy scenario modelling the separate and combined effects of new policies (US EISA and EU RED) assuming a contribution to the target is met by second-generation biofuels (on average 50% of biomass for second-generation assumed to come from land otherwise used for food and feed production, rest from crop residues, see note 15 in OECD, 2008, p91) ✓ *Base year – model horizon* 2008-2017	✓ *Reporting of EU versus global price impacts?* No, only world market prices ✓ *Differentiated reporting of commodity versus retail price impacts?* No, only commodity level ✓ *Comparator for price effects* Comparison of average 2013-2017 prices in different scenarios Average 2013-2017 world market prices in counterfactual with no support compared to baseline: - Oilseeds: -3% - Wheat: -5% - Coarse grains: -7% - Vegetable oils: -16%

Study and model used	Scope and scenarios (geo – time – research questions)	Main results
	✓ *Absolute magnitudes of biofuel use (EU & global)* In policy scenario, 25.4 Mtoe in EU and 96.0 globally (2013-2017 average)[38] ✓ *Increase in magnitudes in scenarios* From counterfactual (no support) to policy scenario: 19.7 Mtoe in EU and 38.7 globally (2013-2017 average)[39] ✓ *NREAP demand considered?* No, not available at the time; 10% EU biofuel target in policy scenario (including second-generation biofuels) translating into absolute volumes and changes as above. Absolut magnitude lower then according to NREAP (29.6 Mtoe) but absolute increase very similar (19.5 Mtoe).	Average 2013-2017 prices of existing and new policies compared to counterfactual with no biofuel support: - Oilseeds: 7% - Wheat: 8% - Coarse grains: 13% - Vegetable oils: 35%
Fischer *et al* (2009a, b) *Short model description:* - Ecological-economic modelling approach, incorporating the FAO/IIASA Agro-ecological Zone (AEZ) model and the IIASA recursive-dynamic, applied general equilibrium 'global food system' model (focusing on agriculture but representing other sectors as well) - Results from the food system model are 'downscaled' to the spatial grid … for quantification of land cover changes' - Feedstock for second-generation biofuels (contribution depends on scenario) assumed to only use 'non-food' land (see Fischer *et al*, 2009b, p168-76 for details) ✓ *Regions and sectors*	*Scenario description:* - Reference scenario keeping biofuel use constant after 2008 - Several alternative scenarios including biofuel use as predicted by the World Energy Outlook (WEO) assuming that EU and China meet announced 2020 targets, while USA lag in meeting EISA mandates - More ambitious biofuels target scenarios (TAR) assuming that mandatory, voluntary and indicative targets for biofuel use in major developed and developing countries are met, with a resulting biofuel use about double and reaching a ~7% share in final consumption of total transport fuels globally (see Fischer *et al*, 2009, p15 for detailed summary of scenarios); ✓ *Base year – model horizon*	✓ *Reporting of EU versus global price impacts?* No, only world prices ✓ *Differentiated reporting of commodity versus retail price impacts?* Seem to be on commodity level effects ✓ *Comparator for price effects* Policy 2020 (2030) compared to reference 2020 (2030) Price increases compared to reference scenario (according to Fig3, p18): - WEO scenario without second-generation biofuels (WEO-V2): increase in cereal prices in 2020 ~ 12%, other crops ~9% - Biofuels target scenario (TAR-V1): increase in cereal prices in 2020 ~ 35%, other crops ~27% - Scenario with rapid cellulosic ethanol deployment (TAR-

38 Approximate figures based on information read from Figures 2.1 and 2.2 in OECD (2008, p65), reporting changes in biofuel use in the counterfactual scenario compared to the baseline as well as Figures 2.7 and 2.8 (p71) , reporting changes in biofuel use in the policy scenario compared to the baseline. Conversion from litres to Mtoe based on lower heating values (LHV) of 21.1 Megajoule per litre (MJ/l) for ethanol and 33.3 MJ/l for biodiesel.

39 As before.

Study and model used	Scope and scenarios (geo – time – research questions)	Main results
34 regions and 10 sectors (nine main agricultural sectors, one aggregated sector that represents all remaining activities) (for details see Fischer *et al*, 2009b, p134) ✓ *Modelling land* AEZ model represents land resources availability taking into account suitability and productivity parameters. Land conversion derived from land demand from world food system model together with constraints and criteria as contained in AEZ model (p136) ✓ *Modelling by-products* Included	2000; to 2020 and 2030 ✓ *Absolute magnitudes of biofuel use (EU & global)* EU biofuel use not specified, but underlying WEO projection is 25.9 Mtoe in 2020, thus falling short of NREAP prediction; global use in 2020: 94 = 63 + 31 Mtoe (developed world + developing world) ✓ *Increase in magnitudes in scenarios* Not specified; estimated to be 20.4 Mtoe for the EU and 69.6 globally[40] ✓ *MS NREAP considered?* 10% target part of biofuels target scenario, corresponding biofuel volume see above, falls short of NREAP projection, but absolute increase in line.	V3): increase in cereal prices in 2020 ~ 15%, other crops ~19% Price increases for coarse grains are largest due to maize ethanol production (Fig 4, p19). Large price drops for protein feed due to by-products.
Blanco Fonseca *et al* (2010) *Short model description:* integrated Agro-economic Modelling Platform (iMAP), a platform for the three partial-equilibrium, agro-economic models AGLINK-COSIMO, ESIM and CAPRI AGLINK-COSIMO: recursive-dynamic partial equilibrium model; includes first and second-generation biofuels, the latter exogenously included and assuming their production has no impacts on agricultural markets and land use ESIM: comparative static partial equilibrium model including first-generation biofuels	*Scenario description:* - Baseline scenario: meeting 10% biofuels target in 2020, with both first- and second-generation biofuels in the ratio 70:30 - Counterfactual scenario: no mandatory biofuel targets nor tax exemptions or other fiscal stimuli - Both scenarios assume that 'all countries outside the EU continue with their biofuel policies as already either implemented or announced at the start of 2009' (p.vii) - ESIM: 7% target in 2020 met by first-generation ✓ *Base year – model horizon* AGLINK-COSIMO model version 2009, ESIM: base year 2005; projection to 2020 ✓ *Absolute magnitudes of biofuel use (EU & global)*[41]	✓ *Reporting of EU versus global price impacts?* Only world prices reported ✓ *Differentiated reporting of commodity versus retail price impacts?* No, only commodity level reported ✓ *Comparator for price effects* 2020 baseline compared to 2020 counterfactual AGLINK-COSIMO: Based on Fig 3.2 and 3.3: very limited impacts on prices for ethanol feedstocks, more substantial for vegetable oils (no % change given, roughly in the order of +15% in the baseline compared to counterfactual based on inspecting Fig 3.3, p33)

[40] The reference assumes that biofuel use is frozen at 2008 levels. The authors cite the WEO 2008 to inform their scenario projections. The increases reported here are changes from biofuel use in 2006 to 2020, both according to WEO 2008. Given that biofuel use in 2008 exceeded use in 2006, these figures are overestimates (in the case of the EU, use in 2008 was 9.5 Mtoe according to http://www.eurobserv-er.org/pdf/biofuels_2011.pdf).

[41] The figures on absolute magnitudes are valid for AGLINK-COSIMO and CAPRI but some deviation with regard to biofuel use in the counterfactual scenario in ESIM, where biofuel use does not decrease from 2009 to 2020 but slightly increases (see Blanco Fonseca, 2010, p68).

Study and model used	Scope and scenarios (geo – time – research questions)	Main results
CAPRI: comparative-static, spatial, partial equilibrium model; biofuels not modelled as separate sectors; instead exogenous quantities of biofuels (from AGLINK) that are linked to corresponding cereals and vegetable oil feedstock requirements; CAPRI then models consequences for by-products and agricultural markets ✓ *Regions and sectors* AGLINK-COSIMO: 39 individual primary and processed products; 52 countries and regions ESIM: 43 individual primary and processed products; EU27 represented in detail, all other countries apart from USA and Turkey aggregated to 'rest of the World' region CAPRI: 47 individual primary and processed products; 28 regions ✓ *Modelling land* It is mentioned that land use change is modelled for 'selected countries only' in AGLINK-COSIMO and modelled at 'Member State level' in ESIM; in CAPRI land use change is modelled at NUTS 2 level within the EU but not outside of EU ✓ *Modelling by-products* Included in all (but based on exogenous biofuel demand in CAPRI)	In baseline scenario, EU use in 2020 is around 33.0 Mtoe, global use around 124.3 Mtoe (see below) ✓ *Increase in magnitudes in scenarios* Increase from counterfactual to baseline 2020 use: 28.1 Mtoe in the EU and 23 Mtoe globally Increase from baseline 2008-2020 use in the EU is 22.4 Mtoe, so close to NREAPs ✓ *MS NREAP considered?* AGLINK-COSIMO: 8.5% ethanol & biodiesel out of conventional petrol/diesel in 2020 (out of which 7% first- and 1.5% second-generation biofuels), yielding a 2020 biofuel demand of around 33 Mtoe, hence close to NREAPs[42]	ESIM: Increases in wholesale prices in 2020 baseline compared to 2020 counterfactual (no biofuel support) (Table 4.1, p71): - Wheat, maize, sugar: around +8, 22, 21%, respectively - Soybeans, rapeseeds, sunflower seeds: around +0.5, 10, 11%, respectively - Vegetable oils (palm, soy, rape, sunflower): around +1, 17, 35, 36%, respectively CAPRI: Price increases of selected crops in 2020 baseline compared to 2020 counterfactual (Table 5.5, p83): - Wheat, maize, sugar beet: +12.5, 8.0, 2.0% - Oilseeds: +19.5% - Vegetable oil: +27.1%
Taheripour *et al* (2010) *Short model description:* CGE model based on GTAP-E with agro-ecological zones	*Scenario description:* - Simultaneous 2015 EU and US biofuel mandates, ie 15 billion gallons of ethanol use in the USA by 2015 and a 6.25% biofuels share in transport in the EU by 2015 (as in	✓ *Reporting of EU versus global price impacts?* US, EU and Brazil price effects reported ✓ *Differentiated reporting of commodity versus retail price impacts?*

[42] Based on total demand of 49,435 million litres (from Table 3.5, p34) and lower heating values (LHV) of 21.1 MJ/l for ethanol and 33.3 MJ/l for biodiesel. The resulting split is 10.7 Mtoe ethanol and 22.4 Mtoe biodiesel. Global data derived from Tables 3.12 and 3.15 (p39 and p44, respectively).

Study and model used	Scope and scenarios (geo – time – research questions)	Main results
(AEZ) module but here in the GTAP-BIO (Taheripour *et al*, 2008) version including biofuel sectors and by-products ✓ *Regions and sectors* '28 sectors/industries, 30 commodities, and 18 regions comprising the major biofuel producers (including US, EU, and Brazil) as well as non-biofuel producers' (p279) ✓ *Modelling land* Competition for land between sectors modelled by including GTAP-AEZ land use module (Lee *et al*, 2005) that divides land use into 18 agro-ecological zones (AEZ) that with similar climate, precipitation and moisture conditions ✓ *Modelling by-products* Yes; it is the main contribution of the paper to augment the GTAP-BIO database to include by-products from biofuel production (DDGS and soil and oilseed meals)	Hertel *et al*, 2010b). - Separated scenarios with and without by-products. - Historical data validation for 2001-2006 so that the base year becomes 2006. ✓ *Base year – model horizon* 2006 (updated from 2001 from GTAP 6 database) to 2015 ✓ *Absolute magnitudes of biofuel use (EU & global)* Not specified ✓ *Increase in magnitudes in scenarios* Not specified ✓ *NREAP demand considered?* No, not available at the time and model horizon only up to 2015	Results for processed food and feed sectors reported (small changes within and across scenarios) ✓ *Comparator for price effects* Price changes are reported for 2006-2015 Some examples of changes in *EU prices* over 2006-2015 (see table 4, p283, for details), in the model run without and with by-products, respectively: Cereal grains: 11.0 and 5.6% Other grains: 11.9 and 8.7% Oilseeds: 31.6 and 26.9% Sugarcane: 10.7 and 7.8% Price increases in USA and to a lesser extent in Brazil also significantly affected by inclusion of by-products.
Timilsina *et al* (2010) *Short model description:* - Global dynamic computable general equilibrium model augmented with an explicit land allocation module - Separate biofuel production sectors (three types of ethanol, one for biodiesel) - Authors highlight higher Armington substitution elasticities between imported and domestic crops than in Keeney and Hertel (2008) - No second-generation biofuels included - Highlight US biofuel trade policy in line with existing tariff regime modelled ✓ *Regions and sectors* 25 regions and 26 sectors (not specified but as derived from figures and tables) ✓ *Modelling land* Land allocation module including AEZs and nested CET function or land allocation across land covers and uses	*Scenario description:* - Announced targets (AT) scenario: implementation of biofuel use targets globally consistent with what countries already have announced - ET: a doubling of the announced targets while the timing of their implementation is unchanged (eg 20% biofuel share in the EU by 2020) ✓ *Base year – model horizon* 2009 (updated based on historical data from GTAP 7 database with 2004 data) to 2020 ✓ *Absolute magnitudes of biofuel use (EU & global)* Not specified ✓ *Increase in magnitudes in scenarios* Not specified ✓ *NREAP demand considered?* No, but 10% target modelled for the EU in the AT scenario (corresponding volume of biofuel use not specified)	✓ *Reporting of EU versus global price impacts?* No, only world prices reported ✓ *Differentiated reporting of commodity versus retail price impacts?* Commodity prices but also effects reported for 'Processed food sector' ✓ *Comparator for price effects* Policy 2020 compared to baseline 2020 Important when assessing price effects: already a considerable biofuel penetration in the baseline, 5.4% share globally rising to 9% in the AT scenario. This together with high oil prices leads to significant increases in crop prices over the baseline. Changes in world crop prices (first figure for AT, second figure for ET scenario): - Sugarcane/-beet: 9.2%, 11.6% - Corn: 1.1%, 3.7%

Study and model used	Scope and scenarios (geo – time – research questions)	Main results
following earlier GTAP based studies (see Timilsina *et al*, 2010, Appendix B for details) ✓ *Modelling by-products* Not specified whether included		- Oilseeds: 1.5%, 3.1% - Wheat: 1.1% 2.4% - Other cereal grains: 1.0%, 2.3% - Paddy rice: 0.8%, 1.6% - Vegetables, fruit 0.7%, 1.5% Livestock: 0.4%, 1.1%
Laborde (2011) *Short model description:* Updated version of the global CGE model MIRAGE-Biof (Valin *et al*, 2010), including ethanol and biodiesel production factors based on a range of feedstocks singled out from the GTAP database (more detailed model description in Al-Riffai *et al*, 2010) ✓ *Regions and sectors* 43 sectors and 11 regions (database was compiled on a more detailed level of 57 sectors and 35 regions, including 23 sectors newly disaggregated from GTAP database) (see Al-Riffai *et al*, 2010, p39 for details) ✓ *Modelling land* Land resources are differentiated according to agro-environmental zones (AEZ). Land allocation between different covers and uses via nested CET function ✓ *Modelling by-products* Included	*Scenario description:* - Baseline scenario keeps biofuel blending constant at the 2008 rate of 3.3% over the projection period to 2020 (also implying a constant ratio of 83/17 biodiesel/ethanol share, leading up to 11.7 Mtoe EU biofuel consumption in 2020 up from 10.2 Mtoe in 2020 - Policy scenario including an EU first-generation biofuel consumption of 27.2 Mtoe in 2020, in line with the NREAPs, taking into account the NREAPs predicted biodiesel/ethanol ratio of 72/28 (translating into a share of 8.6%). - Further distinction between a 'trade policy status quo' scenario (BAU) and a free trade in biofuels scenario (FT) Previous Al-Riffai *et al* (2010) study modelled a 5.6% EU biofuel share in their central scenario. ✓ *Base year – model horizon* Reports development over 2008-2020 but uses GTAP 7 database with 2004 as base year ✓ *Absolute magnitudes of biofuel use (EU & global)* 27.2 Mtoe first generation land-using biofuels in 2020 policy scenario; world biofuel **production** is 111.2 Mtoe in Al-Riffai *et al* (2010) ✓ *Increase in magnitudes in scenarios* Additional EU consumption of 15.5 Mtoe (ie change from baseline 2020 to policy 2020; 17 Mtoe increase from baseline 2008 to policy 2020); increase in world **production** of 7.4 Mtoe from reference to policy	✓ *Reporting of EU versus global price impacts?* Results on price effects received from the authors split according to regions ✓ *Differentiated reporting of commodity versus retail price impacts?* 'Other food' sector included in data received from authors) ✓ *Comparator for price effects* Policy 2020 compared to baseline 2020 Study for the European Commission focusing in ILUC impacts, but results for price effects received from the authors, see Tables 6 and 7. Previous study by Al-Riffai *et al* (2010) on price effects (no figures or tables in the report): *'The model simulations show that the effect of EU biofuels policies on food prices will remain very limited, with a maximum price change on the food bundle of +0.5% in Brazil and +0.14% in Europe'* (p12)

Study and model used	Scope and scenarios (geo – time – research questions)	Main results
	scenario[43] ✓ *NREAP demand considered?* Yes, this is one of the major changes to the 2010 study	
Davies (2012) *Short model description:* Der analysis based on the OECD's AGLINK-COSIMO model, partial equilibrium modelling system underlying the *Agricultural Outlook*. Baseline is the 2011 Agricultural Outlook projections. ✓ *Regions and sectors* Covers the global agricultural sector ✓ *Modelling land* Not specified ✓ *Modelling by-products* Not specified	*Scenario description:* - Baseline scenario incl existing biofuel support measures, this is the 2011 Agricultural Outlook projection - Two separate scenarios: 1) Removing EU biofuel support by abolishing import tariffs and tax incentives from 2011 onwards and 2) Removing US biofuel support by abolishing import tariffs and tax credits for bioethanol from 2011 onwards and phasing out the Renewable Fuel Standard's quantitative mandate for bioethanol ✓ *Base year – model horizon* 2011-2020 ✓ *Absolute magnitudes of biofuel use (EU & global)* Not specified ✓ *Increase in magnitudes in scenarios* Not specified ✓ *NREAP demand considered?* Cannot be determine given the information on absolute volumes is not available	✓ *Reporting of EU versus global price impacts?* Yes, for the scenario that removes EU biofuel support ✓ *Differentiated reporting of commodity versus retail price impacts?* No, only commodity level ✓ *Comparator for price effects* Comparison of average 2011-2020 prices in different scenarios Average 2011-2020 prices in removing EU support compared to baseline with existing support (numbers refer to EU and world price impacts, respectively): - Oilseeds: -4, -2% - Wheat: -7, -3% - Vegetable oils: -12, -5% - Coarse grains: NA, -2% Average 2011-2020 world prices in removing US support compared to baseline with existing support: - Oilseeds: -6% - Wheat: -5% - Coarse grains: -12 to -14% - Soy: -7%

Source: Own compilation based on studies as referenced.

[43] Note that Laborde (2011) does not report world production or consumption of biofuels. Therefore, figures from the earlier study by Al-Riffai et al (2010) are reported here to get an idea about the magnitudes. Note, however, that Al-Riffai *et al* (2010) modelled a 5.6% EU biofuel share instead of the 8.6% share in Laborde (2011).