Energy xxx (2010) 1–7

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Biofuels versus food production: Does biofuels production increase food prices?

Amela Ajanovic*

Energy Economics Group, Vienna University of Technology, Gusshausstr. 25-29/373-2, 1040 Vienna, Austria

ARTICLE INFO

Article history:
Received 11 September 2009
Received in revised form
10 May 2010
Accepted 11 May 2010
Available online xxx

Keywords:
Biofuels production
Food price
Costs

ABSTRACT

Rapidly growing fossil energy consumption in the transport sector in the last two centuries caused problems such as increasing greenhouse gas emissions, growing energy dependency and supply insecurity. One approach to solve these problems could be to increase the use of biofuels.

Preferred feedstocks for current 1st generation biofuels production are corn, wheat, sugarcane, soybean, rapeseed and sunflowers. The major problem is that these feedstocks are also used for food and feed production.

The core objective of this paper is to investigate whether the recent increase of biofuels production had a significant impact on the development of agricultural commodity (feedstock) prices. The most important impact factors like biofuels production, land use, yields, feedstock and crude oil prices are analysed.

The major conclusions of this analysis are: In recent years the share of bioenergy-based fuels has increased moderately, but continuously, and so did feedstock production, as well as yields. So far, no significant impact of biofuels production on feedstock prices can be observed. Hence, a co-existence of biofuel and food production seems possible especially for 2nd generation biofuels. However, sustainability criteria should be seriously considered. But even if all crops, forests and grasslands currently not used were used for biofuels production it would be impossible to substitute all fossil fuels used today in transport.

1. Introduction

For the largest part of human history passenger and freight transport has been based on different types of renewable energy. Most important energy carriers were cereals (for e.g. feeding horses) based on renewable solar energy.

In recent years, the interest in fuels based on renewable energy has been increasing all over the world, mostly due to the problems, which are currently accompanying the use of fossil energy for providing individual automotive mobility, such as:

- growing consumption of fossil fuels;
- increasing greenhouse gas emissions;
- accelerating import dependency especially from politically unstable countries.

The core objective of this paper is to investigate whether the current increases of biofuels production had a significant impact on the development of agricultural commodity (feedstock) prices. The most important impact factors like biofuels production, land use, yields and feedstock and crude oil prices are analysed.

1.1. Recent trends in biofuels production

Currently, global production of biofuels is relatively low, but continuously increasing. This increase is supported by the fact that many countries have set goals to replace a part of fossil fuels by biofuels. In the European Union 5.75 percent of the energy used for transportation should be biofuels by the year 2010 [1]. By 2020 10% of energy used in transport should be from renewable energy source, biofuels in practical terms.

In 2007 total production of biofuels amounted to 62 billion litres, which is equal to 1.8% of total global transport fuel consumption in energy terms. The highest share of biofuels in total transport fuels demand in 2007 was in Brazil and the USA, 20% and 3% respectively, see Fig. 1.

Yet, the major feedstocks currently used for biofuels production are directly or indirectly used for food production and there are claims that biofuels production increases significantly the prices of feedstocks and thereby of food (e.g. [4–6]). The major feedstocks for biofuels are corn, wheat, barley, sugarcane, rapeseed, soybean

* Tel.: +43 1 58801 37364; fax: +43 1 58801 37397.
E-mail address: ajanovic@eeg.tuwien.ac.at

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doi:10.1016/j.energy.2010.05.019

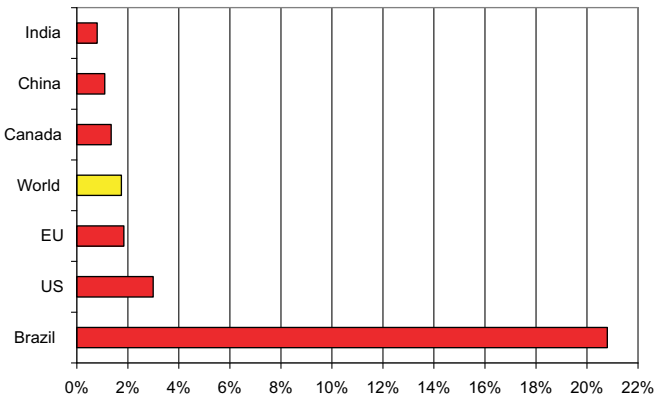

Fig. 1. Share of biofuels in total road-fuel consumption in energy terms, 2007 [2,3].

and sunflower. Depending on climatic factors the preferences for these feedstocks differ by regions.

The shares of different feedstocks in bioethanol and biodiesel production in the European Union in 2008 are shown in Fig. 2.

In EU-25 wheat is the major feedstock for bioethanol production. In 2008 70% of total European bioethanol production was based on wheat. On the second place is barley, followed by corn and rye.

The biodiesel production in the EU is based on rapeseed oil. Only 3% of biodiesel in the EU is produced from sunflower oil and 18% from soybean oil.

In the USA bioethanol production is mostly based on corn, see Fig. 3. In 2008 other feedstocks have been used for only 3% of total bioethanol production. Biodiesel production in the USA is based on soybean oil, 82% and canola oil, 13%.

The biodiesel production is currently very low in Brazil. On the other hand bioethanol production is very high and completely based on sugarcane.

It is currently under international discussion if and to what extent biofuels production affects feedstock prices. There are basically two different opinions:

- Using crops for fuel is the driving factor for an increase of food prices. The food price increase in the last few years has been mainly explained as a result of the expansion of biofuels, which reduced the availability of food supply at the international market and increased food prices (e.g. [4,8–13]).
- Rising feedstock prices are primarily due to other factors such as oil price developments, financial speculation and recent strong economic growth of China (e.g. [14–17]). The oil prices are seen as the long-run drivers of biofuel prices [18].

In the USA the share of fuel cost in total production costs of bioethanol from corn have increased 1% between 2002 and 2007, while fertilizer costs have increased 8%, see Fig. 4.

The majority agrees that biofuels are pushing up price of food, but estimates of how much vary widely.

2. Method of approach

The method of approach applied in this paper is based on the following two categories of research:

(i) the fundamental relationship between quantities produced, costs of production and resulting market prices.
(ii) a review of the most important literature contributions on the "food versus fuel" discussion.

Fig. 5 depicts the basic economic principle of how prices for specific commodities come about under different market conditions.

In years with high agricultural yield increasing demand for feedstocks for biofuels production does not have significant impact on food prices. But in the years with low agricultural yield food price increase could be significant due to biofuels production, see Fig. 5.

The current biofuels production is relatively low, mostly due to high biofuels costs. Biofuels are generally not competitive with fossil fuels without subsidies with Brazil being the only exception. Their cost is dependent on lots of factors, such as feedstock price, conversion costs and implemented policy measures.

3. Results

In this chapter I present the most important results of my analysis related to the recent development of total biofuels production, cost of biofuels, land resources, land use, yield, as well as recent development of feedstock and oil prices.

I compare the quantity of biofuels production with the feedstock prices. Moreover I discuss the impact of land areas used for feedstock production and the specific yields. Finally, a comparison of the volatility of feedstock prices and other possible impact parameters like the world oil price is conducted.

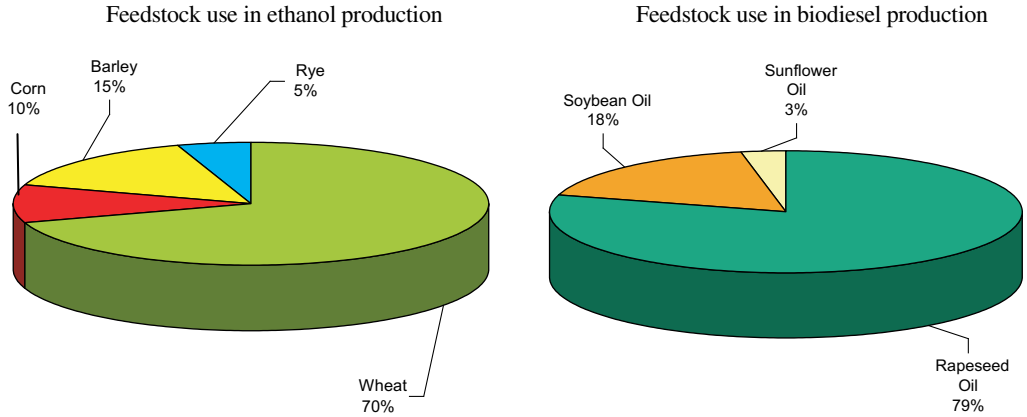

Fig. 2. EU-25: Feedstock use in biofuels production in 2008 [7].

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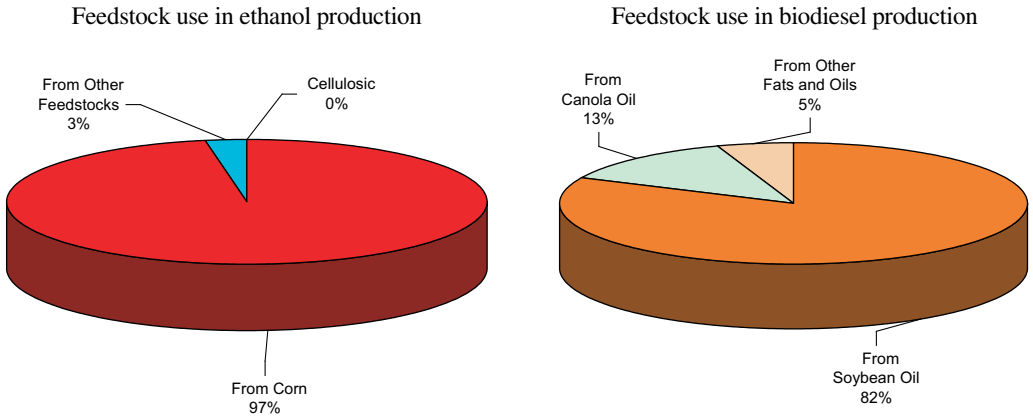

Fig. 3. USA: Feedstock use in biofuels production in 2008 [7].

3.1. Biofuels production

Global production of biofuels amounted to 62 billion litres (or 36 million tonnes of oil equivalent (Mtoe)) in 2007, which is equal to 1.8% of total global transport fuel consumption in energy terms. Brazil and the United States together account for almost three-quarters of global biofuels supply.

Ethanol production is rising rapidly in many parts of the world in response to climate change and higher oil price, which is making ethanol more competitive, especially in combination with government incentives.

Recent trends in ethanol production are shown in Fig. 6. As shown, global bioethanol production tripled from its 2000 level and reached 52 billion litres (28.6 Mtoe) in 2007.

Total production of biodiesel worldwide was about 7.6 Mtoe (10.2 billion litres) in 2007. This is very little compared with ethanol production. The largest part of biodiesel, about 60% is produced in the European Union; on the second place is the USA.

Recent trends in biodiesel production are shown in Fig. 7.

3.2. Land resources, yield and water demand

More than 99.7% of human food comes from the terrestrial environment, while less than 0.3% comes from oceans and other aquatic ecosystems. Most of suitable land for biomass production is already in use. Worldwide, out of the total 13 billion hectares of land area on earth the percentages in use are: cropland, 11%; pasture land, 27%; forest land, 32%; urban 9%; and other 21%. The remaining, 21%, is mostly unsuitable for crops, pasture or forest because the soil is too infertile or shallow to support plant growth, or the climate and region are too cold, dry, steep, stony, or wet. Thus, most suitable land for production is already in use [20–22].

Currently, the use of biomass covers about 13% of the global primary energy demand. Biomass supply potential is very dependent on the land availability, crop yields, population growth, food demand, economic development, food production efficiency and competing biomaterial products [23].

According to the FAO, a lack of land is not forecasted for the time period until 2030. Suitable land for rain-fed crop production is almost three times larger then currently used capacities [24].

In 2006 about 14 million hectares of land (about 1% of the world's available arable land) are used for the production of biofuels and by-products. Given that 1% of global transportation fuels are currently derived from biomass, increasing the share to 100% is clearly impossible unless fuel demand is reduced, land productivity is dramatically increased, large areas of pasture are converted to arable land or production is shifted from conventional sources of biomass to new ones, such as crop residues or trees and grasses that can be grown on non-arable land. The large-scale use of biofuels will probably not be possible unless second-generation technologies based on ligno-cellulosic biomass that requires less arable land can be developed commercially [25]. According to the IEA, biomass potential from all sources in 2050 could be between 1000 and 26 200 Mtoe. The share of the world's arable land used to grow biomass for biofuels is projected to rise from 1% at present to 2.5% in 2030 in the Reference Scenario and 3.8% in the Alternative Policy

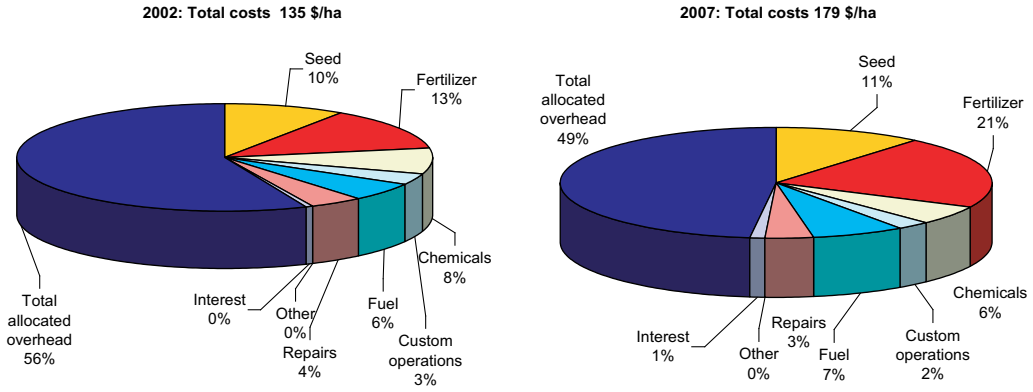

Fig. 4. Cost of bioethanol from corn in USA, 2002 versus 2007 [19] (Fuel includes lubricants and electricity. Total allocated overhead includes labour cost, capital recovery, land, taxes & insurance and overhead).

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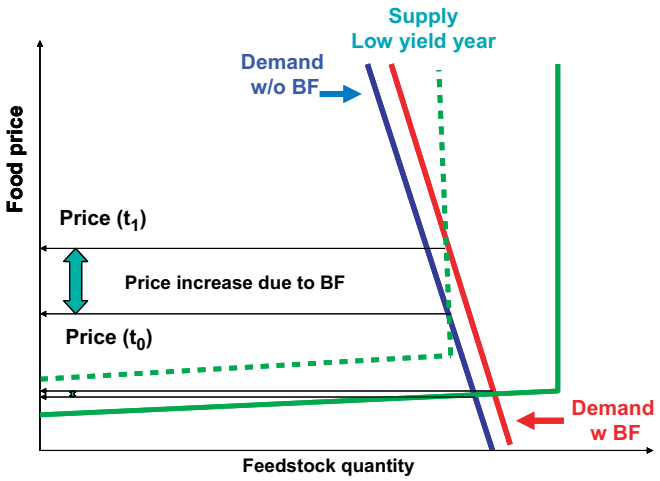

Fig. 5. Short-term supply and demand for feedstocks from crop areas.

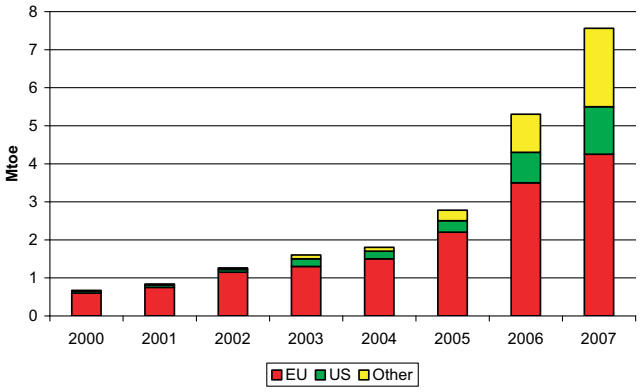

Fig. 7. Recent trends in biodiesel production [2,3].

Scenario, on the assumption that biofuels are derived solely from conventional crops [25].

The future land requirements for biofuels production in Reference (RS) and Alternative Scenario (AS), as well as in Second-Generation biofuels case (SG) are shown in Fig. 8.

In case of additional land use due to biofuels production the impact on biodiversity has to be considered with high priority. Conversion of natural ecosystems induces high losses of biodiversity [26]. In addition, any forest or grassland that is lost to make way for cultivation of feedstock oil, starch or sugars crops causes an enormous one-off release of carbon dioxide, and the ongoing production of artificially fertilized crops releases nitrous oxide, a GHG almost 300 times more potential than carbon dioxide [27].

Land use competition for production of food and fuel is recently discussed by Rathmann et al. (2010) [16]. With the start of fuel-ethanol production in Brazil, land and sugarcane became incorporated as inputs in the fuel production chain, in competition with food production. Attracted by higher returns than those obtainable from traditional activity, many farmers shifted to energy agriculture, resulting in the systematic substitution of other crops by sugarcane. The shift from soybeans to sugarcane in Brazil and from wheat to corn in the USA in the past could be noticed, causing a rise in prices and decline in stock of these agricultural commodities [28–30].

On the other hand, other arguments could be find in the literature such as that there is no effective competition for land use between food and fuels, that largest part of the lands used for biofuels have been otherwise marginal and the competition has been mitigated by a continuing increase in agricultural productivity [31–39]. Some of the reasons for this position are increased agricultural productivity, use of marginal lands (except in Europe), existence of land available to be incorporated, a result of agricultural policies in European countries, forcing farmers to keep fallow land, incorporation only of pasture lands and the promising development of second-generation biofuels [16].

According to Rathmann et al. [16] a shift of areas traditionally used to food production to fuel has contributed to the increase of food prices in the short run, but this change cannot yet be called significant. This is not the only factor determining this trend, nor will it last in the long-run.

In the following figures the most important features regarding worldwide areas harvested, yield and production of major feedstocks are documented. In the period between 2000 and 2007 the total worldwide area harvested for soybeans, rapeseed, sunflower, sugarcane, maize, barley and wheat has increased. The increase ranges from 1% for wheat to 28% for soybeans, see Fig. 9.

In the same period yield improvement has been significant: 3% for wheat, 10 for sugarcane, 7% for rapeseed, 5% for soybeans and 17% for maize. The only exception is barley. In 2007 yield of barley was for 1% lower than in 2000, see Fig. 10.

Due to the increase in area harvested and yield, total production has increased as well, see Fig. 11.

Beside land, water is a key driver of agricultural production. Actually, agriculture is the largest user of water among human activities. At the same time that means that biofuels production requires significant amount of water as well. Impact of biofuels production on water resources largely depends on making

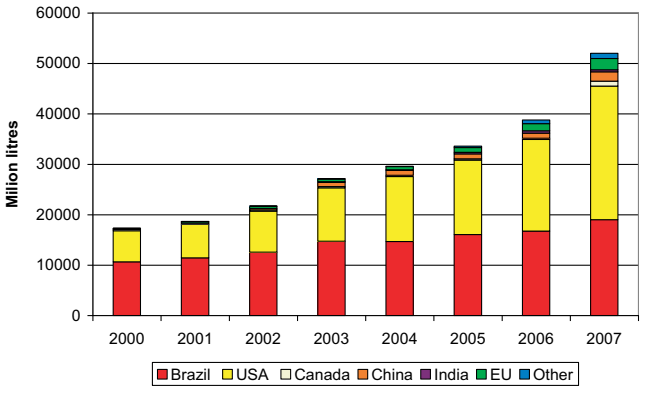

Fig. 6. Recent trends in bioethanol production [2,3].

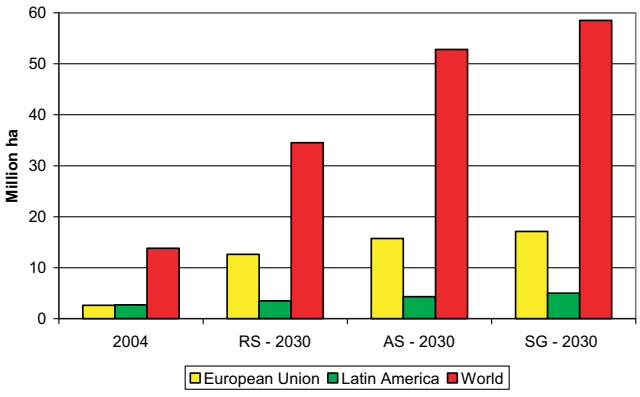

Fig. 8. Land requirements for biofuels production [8].

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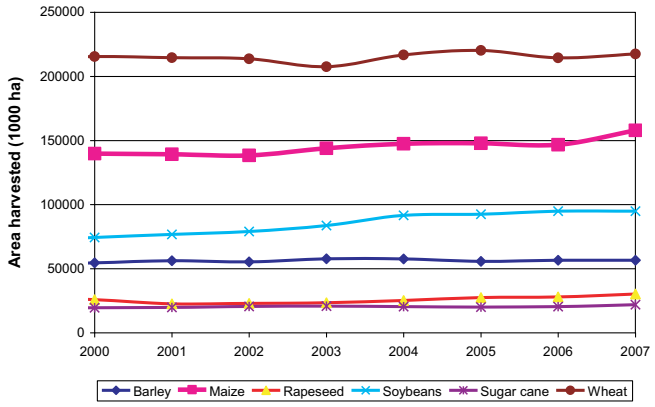

Fig. 9. Total worldwide areas harvested for major feedstocks used for biofuels production [40].

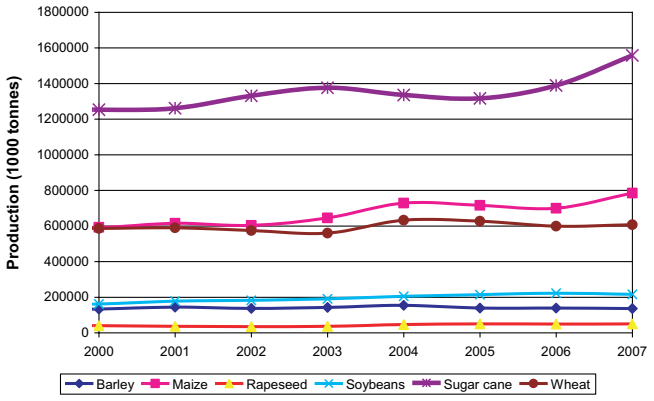

Fig. 11. Total worldwide production of major feedstock also used for biofuels production [40].

appropriate choice of suitable feedstocks to be cultivated and appropriate management practices. To reduce water competition with food production producing biofuel feedstocks under irrigated conditions should be discouraged and feedstocks appropriate for rain-fed cultivation should be used [26]. Increasing biofuels production will also impact water quality due to the use of agro-chemicals and through harmful substances produced in feedstock processing and conversion.

Bioethanol production in the USA reports a wide range of water use, usually from 3.5 to 6.0 gallons of water per gallon of ethanol produced [41].

3.3. Feedstock prices

Due to the rising trend in international food prices and its acceleration in 2008, the discussion about impact of biofuels production on food prices has been very intensive in 2009. According to various studies (e.g. [4–6]) biofuels were considered to be the main driver of increasing feedstock prices. Other impact factors, such as droughts in Australia, poor crops in the EU and Ukraine in 2006 and 2007, higher demand from China and India, or the development of the world crude oil price, were not considered as very significant.

According to Zhang et al. [42] rising fuel prices are not directly causing increasing agricultural commodity prices. They believe that sugar is a driving force in determining the direction of other agricultural commodity prices. It is also the largest input for world ethanol production, and its price is a leading economic indicator, especially when emerging markets dominate world economic growth or contraction. Unfortunately, EU and USA sugar quotas and tariffs have resulted in price erosion for developing sugar-producing countries.

Therefore according to Zhang at el (2010) [42] there is no direct long-run price relations between fuel and agricultural commodity prices.

In Escobar et al. (2009) [17] the poverty, in terms of income, access to education, agricultural resources, technology and credit lines for food production, is seen as the main reason for food insecurity. In most of the countries that suffer from food insecurity the rural development, including biofuels production, is an important path towards the reduction of poverty and food insecurity. However, considering that the amount of agricultural land is limited, it is necessary to define the fraction of farmland that could be used for the sustainable production of biofuels. The use of farmland and grains that could be consumed by humans for biofuel production is already sending warning signals in some places of the world.

However, price volatilities are becoming a more and more "normal" feature of commodity markets, including agricultural products. The price surge in 2008 is already the 5th such event witnessed in grain markets since the oil crisis of 1973, despite the long-term declining trend of agricultural prices. In fact, recent prices for all major agricultural commodities still remain, in real terms, below their comparative levels of either 1973 or 1979 oil crises [43].

It has to be stated that hunger and poverty have existed long before the biofuels production. Especially, the globalization model

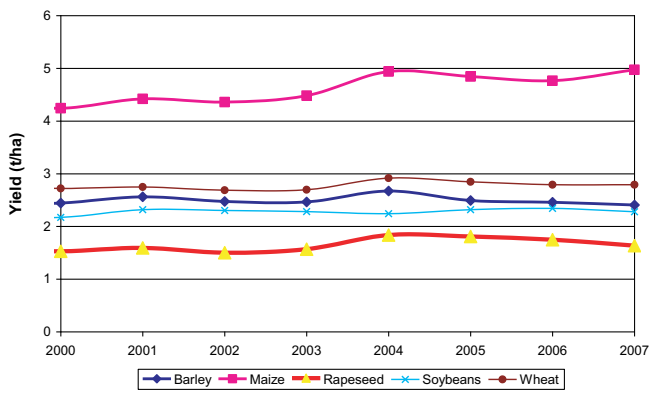

Fig. 10. Average yield of feedstocks worldwide average over period 2000–2007 [40].

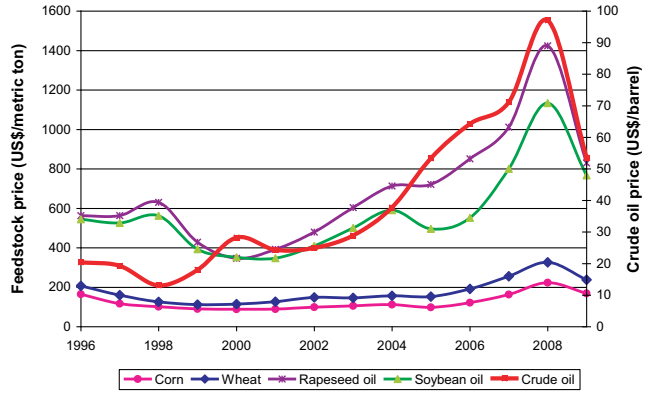

Fig. 12. Development of the crude oil price and feedstock prices for period 1996–2009 [47].

that prioritizes cash crop exports over food self-sufficiency has helped make developing countries very vulnerable to volatile global food prices [44]. Due to the globalization and increasing economic integration it can be noticed that "the rich getting richer and the poor getting poorer" [45]. The fact is that there is more food per capita now than there was ever before. But, unfortunately in some countries malnutrition still exists while in others there is over-consumption of food and other resources.

Corn and wheat are very important feedstocks for bioethanol production. Yet, as has been shown in previous figures, bioethanol production has been rapidly increasing, especially in the last ten years.

And in spite of the increasing use of wheat and corn for biofuels production, it can be noticed that their prices have been relatively stable in the period between 1996 and 2006. In the period between 2006 and 2008 these commodity prices have increased more than 50%. But after the price spike in 2008, in July 2009 corn and wheat prices were again at the same level as in 2006, as well as 1996.

Fig. 12 illustrates the high volatility of the prices of rapeseed oil and soybean oil in the period between 1996 and 2009. Between 1998 and 2000 these commodity prices have been decreasing, and the lowest price was reached in 2000. After 2000 prices of rapeseed oil and soybean oil are rapidly increasing, reaching the highest prices in 2008. Until July 2009 price of rapeseed oil has decreased about 40% and price of soybean oil about 30%.

Over the same period biodiesel production was continuously increasing-without remarkable volatilities, see Figs. 6 and 7.

The development of crude oil price and major agricultural commodity prices is shown for the period between 1996 and 2009 in Fig. 12.

Looking at this figure, it is obvious that the volatility of commodity prices is linked to the development of the crude oil price. The oil price has risen countinuosly since about 2002. With the drop of the oil price after 2008, all feedstock prices have also decreased significantly. Hence, there is a clear correlation between oil prices and the prices of agricultural commodities.

Oil price increases impact feedstock prices not only because of transportation expenses, but also in terms of how much farmers have to spend on oil and the price of fertilizer. One reason is likely, that energy costs are a significant part of fertilizer, farming and food distribution costs.

Yet, the other, from our point of view, much more compelling reason is undoubtedly that virtual demand for different commodities—better known as speculation—is an increasingly important impact parameter, see Haas et al. [46].

Summing up, feedstock and straightforward food price increases over the period 2002–2008 have been driven by a combination of rising oil price, unfavorable weather conditions (e.g. droughts in Australia and other countries), increase in demand from developing countries and also biofuel production.

The sharply price spike of agricultural prices in 2007/2008 is caused by a complex mix of factors such as increasing costs to farmers due to high fuel and fertilizer prices; neglect of agriculture in many developing countries over recent decades; the reduction in food stocks held by many developing countries; supply disruptions caused by drought in some agricultural exporting countries; rising demand in large developing countries that have experienced growth in household incomes; the decline of the dollar, the currency in which many commodities are priced on global markets [48]; and from our point of view due to a high correlation with speculation in the oil market.

Yet, the volatility of feedstock prices cannot be explained to a large extent by relatively low but continuously increasing biofuels production.

4. Conclusions and outlook

The major conclusions of this analysis are:

(i) with respect to the impact of forced biofuels production on feedstock price development:
- Naturally, the use of feedstocks for biofuels production will in principle increase feedstock prices—mainly due to increases in feedstocks demands and corresponding higher marginal costs. (This is justified from an economic point of view if there are no severe distortions due to subsidies.)
- In addition, very cheap (feedstock) prices are not a target in any market per se. The goal should rather be prices, which reflect the actual marginal production costs. This is currently not the case in many countries because of agricultural subsidies (e.g. in Europe) and international trade restrictions (e.g. in the USA). But farmers need a certain market price level to have an incentive to grow feedstock. Hence, a more intensive competition due to feedstock use for biofuels could finally lead to an over-all "healthier" market.
- Within the period 2000–2009 the increase or better the volatility of feedstocks prices has not been only the consequence of continuously increasing biofuels production. Yet, by far the largest part of these volatilities was caused by other impact parameters such as oil price and speculation.
- That leads to the ultimate conclusion that the argument, that recent increases of biofuels production has a significant impact on feedstocks prices, does not hold.

(ii) with respect to sustainability issues:

There are also problems of environmental benignity, sustainability and social implications with respect to biofuels production.

Environmental problems such as soil erosion and water pollution from fertilisers and pesticides could become worse with increasing biofuels production. The fact is that even if all available crops, forests and grasses were used for biofuels, we could not become independent of fossil fuels.

(iii) with respect to future technological developments:

For the future, the switch to 2nd and 3rd generation biofuels could at least relieve this problem, because not only food-competitive crop areas pose the resource base for them. Meadows, pasture, wood, straw, wood residues from industry and other lignocellulose feedstocks (e.g. woody and herbaceous plants such as perennial grasses and fast growing tree species) could also become part of the resource base. 2nd generation biofuels also have higher energy yield with modest use of agro-chemicals and higher GHG reduction potential. Therefore, the question whether a forced biofuels production will increase food prices will then be obsolete.

The only problem is that these biofuels are still in the developing stage and may become commercially available only in the next 10–20 years [26].

Acknowledgement

The author wishes to thank Professor Reinhard Haas for helpful comments and suggestions in improving the quality of this work.

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Please cite this article in press as: Ajanovic A, Biofuels versus food production: Does biofuels production increase food prices?, Energy (2010), doi:10.1016/j.energy.2010.05.019