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List of Abbreviations

ACP	African, Caribbean and Pacific Group of States
CO_2	Carbon dioxide
DEFRA	Department for Environment, Food and Rural Affairs
EBB	European Biodiesel Board
EERE	Energy Efficiency & Renewable Energy. U.S. Department of Energy
FAO	Food and Agriculture Organization
FAEE	Fatty Acid Ethyl Ester
FAME	Fatty Acid Methyl Esters
FAPRI	Food and Agricultural Policy Research Institute
GTAP	Global Trade Analysis Project
IFPRI	International Food Policy Research Institute
MTBE	Methyl Tertiary Butyl Ether
OECD	Organisation for Economic Co-operation and Development
RFA	Renewable Fuels Association
UFO	Used Frying Oil
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
WRI	World Resources Institute

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1 Introduction

Permanent concerns about climate change mitigation, energy independence and high oil prices caused more interest in biofuel and raised support of government policies for their production. In recent years biofuels become economically competent to be a substitute for nonrenewable fuels, because of continuous rising crude oil prices. As the biofuel production has been increasing over the last 35 years in case of ethanol and over 20 years in case of biodiesel, but more expressively since 2001, the renewable energy source started to compete with the food crops for acreage.

Controversy press releases about biofuels impact on food prices initiate more concern about food price increases. This master thesis is aiming to give an overlook about factors which had an impact on food prices and try to give an understanding on these factors. At first there is an overview about biofuels, as there is a wide range of them. This master thesis concentrates only on bioethanol and biodiesel production globally and gives a summary of government's regulation in different countries as well highlights biofuel advantages and disadvantages. Next, leading biofuels manufacturer are presented and short story about existence of biofuels is given. Section third gives a clue how to understand food crises, as there are many causes of the crisis. Section fourth summary the studies, which evaluate the impact of biofuels on food prices and contains review of previous studies, which estimates effect of demand and monetary expansion and exchange rate movements on food crops. Section five includes author calculation of Granger causality test. Section six concludes the master thesis.

2 Biofuels

2.1 Definitions and Classifications

"Biofuel is produced from renewable biomass material, commonly used as an alternative, cleaner fuel source." Biofuels burn much cleaner as petrol and diesel and are considered carbon neutral, because they absorb the equal amount of carbon dioxide during their growth, as when they burnt.[1]

[1] Clean Energy Ideas (2011): http://www.clean-energy-ideas.com/energy_definitions/definition_of_biofuel.html viewed on May 10, 2011

Biofuels can be defined in many different ways, beginning from generation classification to physical state classification.

In generation classification biofuels are divided on biofuels the first, the second, the third and the fourth generation. The first generation is made from edible agricultural raw materials and biogas from the fermentation process. The second generation is manufactured from inedible biomass, primarily of cellulose and lignocellulose in biochemical or thermochemical processes. The third and the fourth generation use raw materials plants of high efficiency and genetically modified organisms from biotechnological processes. These biofuel provide significant reductions of CO_2 emissions in comparison to previous generation.

Biofuels we can also divide into virgin or waste biomass. Although in general biofuels are divided into: solid, liquid, and gaseous biofuels. Solid biofuels are the most common one and they are: refuse-derived fuel, briquettes, wood, industrial wastes etc. Liquid biofuels are divided into natural and synthetic. To natural biochemical liquefaction biofuel belongs biodiesel. To synthetic oxygenated liquid fuels belong bioethanol, biomethanol, and methyl tertiary butyl ether (MTBE). Gaseous biofuels are not so common in use as the other ones.[2]

This master thesis focus on liquid biofuels first generation; mainly bioethanol (ethanol) manufactured in distillation process of fermented sugar, corn, sugar beet, lignocelluloses (second generation) etc.; biodiesel from fatty acid methyl esters (FAME) and fatty acid ethyl ester (FAEE). Those are the monoalkyl esters of long-chain fatty acids manufactured from renewable commodities, such as vegetable oils, animal fats and microalgae (second generation).

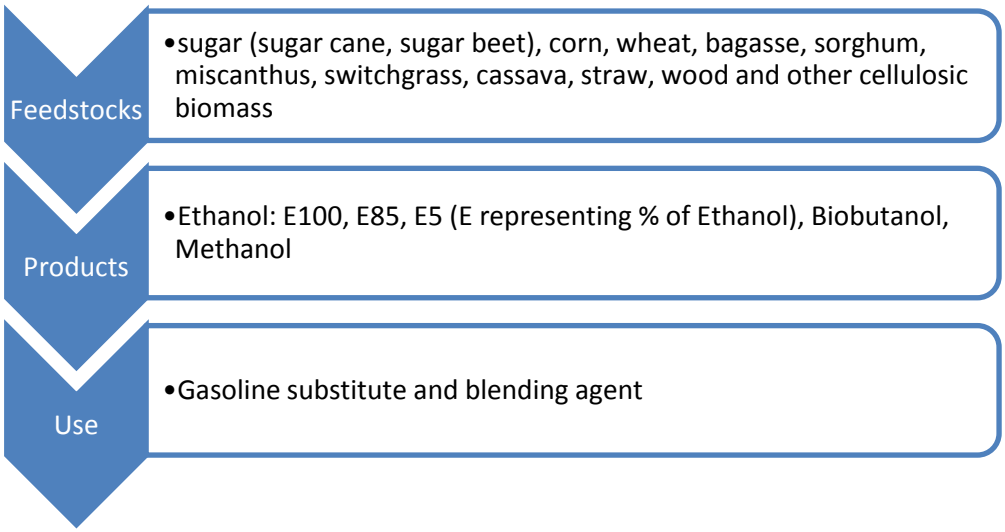
The most important is that cars can be refueled with biodiesel without any modifications on engine. Blend regulation in the European Union is now up to 5,75 percent. Most of the cars in European Union can tank biofuel blend, up to 10% and even higher.[3] On the contrary Brazilian bioethanol can be used only in flex-fuel vehicles, because blend for ethanol there is 85% of bioethanol and 25% of gasoline. As ethanol contains less energy per value than gasoline, the efficiency is about 25-30% fewer miles per gallon.[4]

[2] Petrou and Pappis (2009)
[3] Directive (2003/30/EC)
[4] The official U.S. government source for fuel economy information: http://www.fueleconomy.gov/feg/flextech.shtml viewed May 10,2011

Petrou and Pappis (2009) mention that ethanol can also be used as "fuel for electric power generation, in fuel cells (thermo-chemical action) and in power co-generation system, and as a raw material in the chemical industry." So ethanol has a very large usage rage.[5]

Figure 1 shows main feedstock, products and use of bioethanol.

Figure 1: Classification of Bioethanol[6]



There is a difference between ethanol from fermentation and synthetic process. It is worth to mention, that main outputs for industrial ethanol are solvent and about 60% are used for solvent applications in pharmaceuticals, toiletries and cosmetic, detergents and household cleaners, coatings and inks. Ethanol can be added to food and beverages. Though, much larger output for ethanol is as a fuel. Global estimation for fuel ethanol production is 73%, ethanol for beverage 17% and industrial 10%. In the United States, 92% fermented ethanol is used as fuel, 4% in food and beverages, and 4% as industrial solvents.[7]

Bioethanol as fuel is manufactured only from ethanol fermentation sources; it cannot be used from synthetic processes. "The major outlet of fuel ethanol in Europe is in ethyl tertiary butyl (ETBE), and also blending, whereby ethanol is used as a fuel oxygenate additive to gasoline and gasoline extender. A number of European methyl tertiary butyl

[5] Petrou and Pappis (2009), p:1056
[6] Data taken from Bloomberg (2011), viewed on March 20, 2011
[7] ICIS Homepage (2011a): http://www.icis.com/StaticPages/Ethanol.htm viewed: March 20, 2011

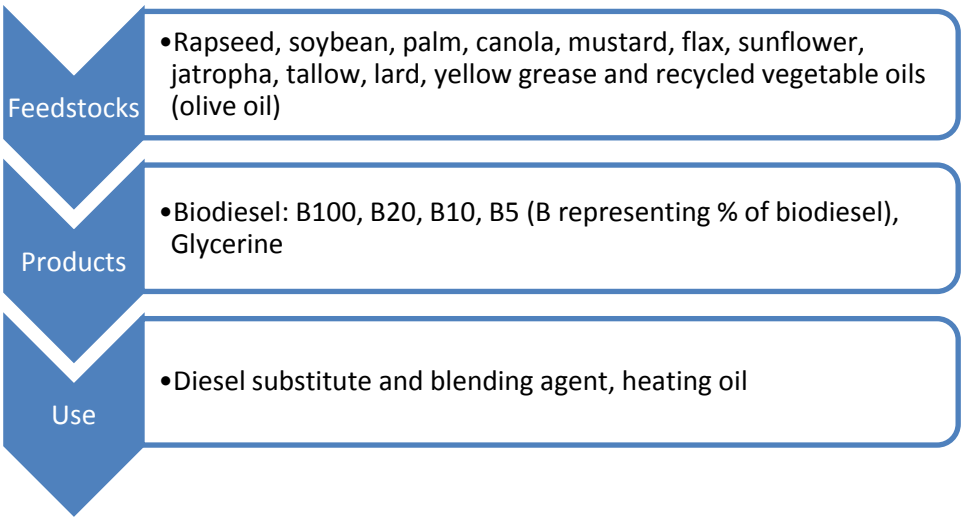
ether (MTBE) producers are in the process of switching from MTBE to ETBE and this has created new demand for fuel ethanol."[8]

In Asia ethanol is mainly produced in fermentation process. The important feedstock producers are India, which produce sugarcane, Thailand and Pakistan yield corn and China tapioca. The main production from ethanol in Asia are industrial chemical, another is for beverage. However countries like Thailand, China and India are rising fuel blending. Thailand produces mainly 10% ethanol blended gasoline. Shipments from Asia to Europe and the US have increased the fuel demand in these countries.[9]

The most efficient feedstock for ethanol production is sugar beet; France yields 714 gallons of ethanol per acre. On the second place is sugar cane, Brazil yields 662 gallons per acre. The third position is corn; U.S. produces 354 gallons per acre, which is a half of sugar beet ethanol production.[10] Figure 28, which can be found in annex, complied with help of different source as mention earlier, shows fast the same results, however on the third place is cassava, Nigeria yields 410 gallons of ethanol per acre; on the fourth place sweet sorghum, India yields 374 gallons per acre; fifth place corn, U.S. yields 354 gallons per acre; and on the sixth place wheat, France yields 277 gallons per acre.

Figure 2 shows main feedstock, products and use of biodiesel.

Figure 2: Biodiesel Classification[11]



[8] ICIS Homepage (2011a): http://www.icis.com/StaticPages/Ethanol.htm viewed: March 20, 2011
[9] ICIS Homepage (2011a): http://www.icis.com/StaticPages/Ethanol.htm viewed: March 20, 2011
[10] Global footprints (2011): http://www.globalfootprints.org/issues/local/transport/biofuels.htm viewed March 28, 2011 Project originally funded by EU and DfID (UK Department for International Development) with support from Tower Hamlets LEA
[11] Data taken from Bloomberg (2011), viewed on March 20, 2011

Biodiesel is a clean burning alternative fuel, manufactured from renewable resources, like vegetable oils but also used frying oils (UFO) or animal fats. Main feedstock is rapeseed, soy and palm oil. However as the Figure 2 shows, there are plenty other. Europe produce primary rapeseed methyl ester (RME), the United States - soy methyl ester (SME) and Asia, especially Malaysia and Indonesia - palm methyl ester (PME). Biodiesel contains no fossil fuel. However it is blended with petroleum diesel to create a biodiesel blend. In transport sector biodiesel is used pure or blended. Figure 2 shows blend possibilities for example 100, 20, 10 or 5 percent of biodiesel. In France and UK is common to use 5% biodiesel, because the vehicle manufactures' warranties cover use with 5% biodiesel blends. 100% biodiesel require EU quality standard EN 14214, which defines the requirements and test methods for fatty acid methyl ester.[12] The test made by motor producers in the European Union have performed in guarantees for blends with diesel oil up to 5-10%, 25-30% or even 100%.[13]

Biodiesel is manufactured in chemical process in which glycerin (a by-product used in soaps) is parted from the fat or vegetable oil. Biodiesel can also be made from alcohols, for example ethanol to produce FAME, but this type is not included in EN 14214.[14]

Increased usage of biodiesel in Europe is a result of Kyoto agreement, because that is how European Union wants to meet its emission reduction objective. [15]

The most efficient feedstock for biodiesel manufacturing are palm oil, from which production accounts 508 gallons per acre; coconut, with production of 230 gallons per acre; rapeseed with yield of 102 gallons per acre; soya beans – 56 gallons per acre.[16] Figure 29 compiled with help of other source, which can be found in annex, shows the same yields, but before soya beans are: peanut with 90 gallons per acre and sunflower with 82 gallons per acre.

[12] ICIS Homepage (2011b): http://www.icis.com/StaticPages/Biodiesel.htm viewed: March 20, 2011
[13] EBB (2011): European Biodiesel Board, 2003-2009. Invited by the European Commission. http://www.ebb-eu.org/biodiesel.php viewed: 24 March 2011
[14] ICIS Homepage(2011b): http://www.icis.com/StaticPages/Biodiesel.htm viewed: March 20, 2011
[15] EBB (2011): European Biodiesel Board, 2003-2009. Invited by the European Commission. http://www.ebb-eu.org/biodiesel.php viewed: 24 March 2011
[16] Global footprints (2011): http://www.globalfootprints.org/issues/local/transport/biofuels.htm viewed March 28, 2011 Project originally funded by EU and DfID (UK Department for International Development) with support from Tower Hamlets LEA

2.2 Regulations

Biofuels become a main topic of many countries policy schedules, since energy prices constantly rise, doubts about the future availability of non-renewable resources occur and environmental worries come into being.[17] In the late 1970s OPEC cut down the oil supply and the fuel prices rose significantly, that initiated accelerated interest in biofuels.[18]

To make biofuel competitive with petrol and diesel, many countries started to develop "consumption incentives (such as fuel tax reductions); production incentives (tax incentives, loan guarantees, and direct subsidy payments); as well as mandatory consumption requirements."[19]

The earliest governmental regulation for the US ethanol is the Energy Tax Act of 1978. That legislation "introduced the motor fuel excise tax exemption that gives ethanol blends of at least 10 percent by volume a 40 cent per gallon exemption on the federal motor fuels tax."[20] This tax exemption for ethanol increased to 60 cents per gallon under Tax Reforms Act in 1984. The excise tax exemption was replaced in 2004 through blender's credit; both regulations have the same implications. Recent tax credit accounts 51 cent per gallon till 2010. The biodiesel blender's tax credit in U.S. is 1 dollar per gallon. This tax is higher than for ethanol, because of higher source cost for biodiesel.[21] The 51-cent tax "will cost taxpayers more than $7 billion over five years, estimates the Congressional Budget Office."[22] The same was in EU during 2004. The Table 11 and 12 show that the subsidy for biofuels vary widely through countries. However in each country the subsidy for biodiesel is higher than for ethanol. It could be also due to the higher feedstock prices.[23] The widely difference in tax exemptions in EU countries is because each European country can determine independently their tax reductions amount and policy targets. The European Directive also not specifies which type of biofuel should be promoted and how high should be the investments grants.[24]

[17] Pfuderer and del Castillo (2008)
[18] Hertel et al. (2008)
[19] Pfuderer and del Castillo (2008), p.4
[20] Elobeid and Tokgoz (2008), p. 6
[21] Birur et al. (2008)
[22] Fortune (2006), http://money.cnn.com/magazines/fortune/fortune_archive/2006/02/06/8367959/index.htm viewed on May 10, 2011
[23] Tables 9 and 10 see in annex
[24] Al-Riffai et al. (2010)

The Energy Independence & Security Act of 2007 set a goal to reduce at least 20% annual petroleum consumption by 2015.[25] Elliot (2008) writes that 40% of corn production would be needed to achieve the goal of blending 15 billion gallons of biofuels with gasoline by 2015 that would substitute only 7% of gasoline consumption.[26] Many studies described later imply that this regulation is responsible for boost in food prices.

In recent years the EU has become a main producer of biodiesel, this was initiated through the tax credit given to biofuel by the EU member's states. The EU regulations allow member states differentiate taxation of energy products. So every state has different levels of tax subsidies for biofuels, but every state has the same goal. The first country, which implemented tax subsidies for biofuels, was Germany in 2002.[27] In 2003 the objective of the Commission Green Paper arrangements was "20% substitution of conventional fuels by alternative fuels in the road transport sector by the year 2020."[28] The members of the European Union have to assure minimum proportion of biofuels. "A reference value for these targets shall be 2%, calculated on the basis of energy content, of all petrol and diesel for transport purposes placed on their markets by 31 December 2005." And by 31 December 2010 it should be 5,75%.[29]

The Directive of the European Parliament wanted to decrease oil reliance, which amounted 98 percent, through usage of alternative fuels such as biofuels, these needed to be comply with the Kyoto Protocol. The European transport policy for 2010 indicates that CO_2 emissions from transport sector will increase by 50% in the period from 1990 to 2010.[30]

The EU directive which required 5,75% of biofuel use till 2010 induce 9,0 million ha of cultivated land occupation for biodiesel and 2,2 million ha for bioethanol. This amount of cultivable land represent 13,6% of the whole EU 25 acreage. This cultivated area was used before for food production.[31]

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[25] EERE (2011): U.S Department of Energy. Energy Efficiency & Renewable Energy. Federal Energy Management Program. Laws & Regulations. Available at: http://www1.eere.energy.gov/femp/regulations/eisa.html#rp viewed on: March 27, 2011

[26] Elliot et al. (2008)

[27] Birur et al. (2008)

[28] Directive (2003/30/EC), L123/43, http://www.ebb-eu.org/legis/JO%20promotion%20EN.pdf viewed: March 27, 2011

[29] Directive (2003/30/EC) Article 3 , L123/44, http://www.ebb-eu.org/legis/JO%20promotion%20EN.pdf viewed: March 27, 2011

[30] Directive (2003/30/EC)

[31] Petrou and Pappis (2009)

The progress in energy efficiency is a main objective of the EU and by 2020 it wants to achieve 20% of improvement. “The European Council of March 2007 […] endorsed a mandatory target of a 20% share of energy from renewable sources in overall Community energy consumption by 2020 and a mandatory 10% minimum target to be achieved by all Member States for the share of biofuels in transport petrol and diesel consumption by 2020.”[32] “The mandatory 10% target for transport to be achieved by all Member States should there be defined as that share of final energy consumed in transport which is to be achieved from renewable sources as a whole, and not from biofuels alone.”[33] Studies of the European Union have indicated that the 2010 EU directive goal will not be achieved, anyway the target have been achieved, but the demand for biofuels crops increased significantly and agricultural trade deficit rose.[34]

In the United Kingdom “[…] to try to meet these targets, the government has reduced the tax on biofuels by 20 pence a liter, while the EU is paying farmers an extra 45 Euros a hectare to grow them. […] Road transport in the United Kingdom consumes 37,6 million tones of petroleum products a year. The most productive oil crop which can be grown in this country is rape. The average yield is between 3 and 3,5 tons per hectare. One tone of rapeseed produces 415 kilos of biodiesel. So every hectare of arable land could provide 1,45 tones of transport fuel. To run our cars […] on biodiesel, […] would require 25,9m hectares. There are 5,7m in the United Kingdom. Switching to green fuels requires four and half times our arable area. Even the EU’s more modest target of 20% by 2020 would consume almost all our cropland.”[35]

Monbiot alerts, that if the same things happen in Europe as it happens in the United Kingdom, the effect on global food supply will be dramatic. It could come from net surplus to net deficit, and so to produce food for cars, not people.[36]

There is possibility that forestry or grasslands, which are not adequate for agriculture production, could be used for fuel production. However this will not bring environmental

[32] Directive (2009/28/EC) Clause 9, L140/17, http://www.ebb-eu.org/legis/OJ%20promotion%20EN%20updated06062009.pdf viewed: March 27, 2011
[33] Directive (2009/28/EC) Clause 18 , L140/18 , http://www.ebb-eu.org/legis/OJ%20promotion%20EN%20updated06062009.pdf viewed: March 27, 2011
[34] Hertel et al. (2008)
[35] The Guardian (2004): http://www.guardian.co.uk/politics/2004/nov/23/greenpolitics.uk viewed: March 20, 2011
[36] The Guardian (2004): http://www.guardian.co.uk/politics/2004/nov/23/greenpolitics.uk viewed: March 20, 2011

performance of biofuels. It is also important to take a note that, there is not much unused cultivated land left for a significant expansion for agricultural production.[37]

As the European Union promotes biofuel from domestic market and sets the regulations and certifications (for example EN 14214), that are needed for clean fuel production. The United States also care about that benefits do not arise for foreign markets and defined an ad valorem tariff of 2,5% on ethanol and additionally import duty of 54 cent per gallon. Very important trade regulation is the Caribbean Basin Economic Recovery Act (CBERA), which combine Central American countries with Caribbean countries. This Act establishes import ethanol regulations under the Caribbean Basin Initiative (CBI) and indicates free of duty charge for ethanol in the U.S. if is made from minimum 50 % of primary feedstock from CBERA. However the duty free imported non-CBERA ethanol cannot cross the amount of 60 million gallons that account for 7% of U.S. self-made ethanol.[38]

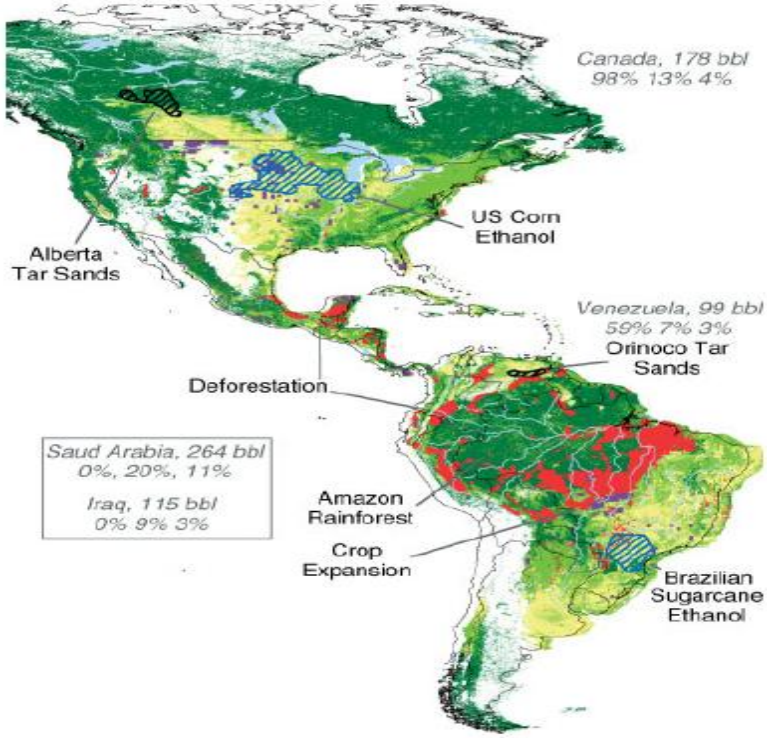
2.3 Pros and Cons

The primary advantage of biofuels is that they are renewable source of energy and they are substitute for fossil fuels, which are nonrenewable. Forest biomass is manufactured on 9.5% of the earth's surface, however correlates to 89% of the whole biomass. The problem which appeared with biofuel production is deforestation, which is caused through increased cultivated areas or for felling.[39] "Satellite imaging and field surveys show that Brazil alone has a deforestation rate of about $8x10^6$ ha/year. […] At mean net biomass carbon yields of 9,90 t/ha-year for tropical rain forest, this rate of deforestation corresponds to a loss of $79,2x10^6$ t/year of net biomass carbon productivity."[40] The indirect land use change (ILUC) hypothesis supports the thesis that "biofuel production competes for agricultural resources, this competition results in an increase in prices of agricultural products, and these price increases cause additional conversions of the world's grasslands and forests to cropland,"[41] which the Figure 3 shows. The biofuels life cycle impact assessment imply that the decision making process for the biofuels is

[37] Chakravorty et al. (2009)
[38] Elobeid and Tokgoz (2008)
[39] Petrou and Pappis (2009)
[40] Klass (1998), p.37
[41] Liska and Perrin (2009), p.321

not simple job, because environmental, economic and social impacts are not include in performance index.[42]

Figure 3: Competition between agriculture and forest reserves in the western hemisphere, and emerging biofuel and fossil fuel resources[43]



There is a concern about the energy balance from the biodiesel manufacture, caused through: byproduct energy content, which when comes out from the process then is taken into account, in other cases is not; another reason is a wide range of biomass types that varies in its property values, such as energy content or crop harvest; diverse cultivation methods for manufacturing process, for instance fertilization, tilling, collecting.[44]

Petrou and Pappis (2009) show how much the cost of production of various biodiesel resources differs in cost of production in 2004. They compared Spanish biodiesel cost and incomes, from mustard and used olive oil. For mustard biodiesel, they took such factors cost as: mustard procurement and oil extraction (0,47 euro/kg),

[42] Petrou and Pappis (2009)
[43] Liska and Perrin (2009), p.321: "Cropping systems(yellow,>30% of area), forest (green,>40% coverage), and overlap (light green). Deforestation (red) from 1980-2000 and crop expansion (purple) from 1980-1990. Country labels: petroleum reserves in 2009 in billion barrel (bbl), and percentages: reserves as tar sands, 2009 global reserves, and 2007 global production, respectively. Biofuels only comprise a portion of the designated areas. This stylized map was constructed with GIS data from the Millennium Ecosystem Assessment (www.millenniumassessment.org)."
[44] Petrou and Pappis (2009)

transesterification chemicals (0,16 euro/kg), power and water supply (0,01 euro/kg), biodiesel cleaning stage (0,04 euro/kg), labor (0,01 euro/kg), partial production costs (0,48 euro/kg), taxes (0,08 euro/kg), distribution (0,10 euro/kg); and incomes from: oil cake (0,17 euro/kg) and glycerin (0,04 euro/kg). Total cost of biodiesel from mustard account 0,66 euro/kg. For used olive oil biodiesel, they took other factors cost: olive oil procurement (0,15 euro/kg), filtration stage (0,03 euro/kg), transesterification chemical (0,13 euro/kg), power and water supply (0,01 euro/kg), biodiesel cleaning stage (0,04 euro/kg), labor (0,01 euro/kg), partial production cost (0,30 euro/kg), taxes (0,05 euro/kg), distribution (0,06 euro/kg); and incomes from glycerin (0,07 euro/kg). So total cost of biodiesel from used olive oil amount 0,41 euro/kg and is cheaper than biodiesel form mustard (0,66 euro/kg), the diesel (0,82-0,86 euro/kg) is expensive one. However if we add the tax to biodiesel which amount 0,33 euro/L, then biodiesel from mustard is the expensive one (0,99 euro/L; it's net thermal value is 37,25 MJ/kg) and not economical. Biofuel from used olive oil would be an alternative (0,74 euro/kg); 36,79 MJ/kg) for fossil fuel, but the amount of used olive oil on the market is very small.[45] To compare ethanol cost with biodiesel, other authors disclosed that total costs of ethanol production in Brazil was 1,10$ per gallon and of United States was 2,01-3,96$ in 2005. Brazil export more than 50% of its sugar and about 15% of ethanol production.[46] Petrou and Pappis (2009) estimate supply cost of ethanol manufacture from wheat and sugar beets in EU 27 and its breakdown and took such factor cost as: feedstock, co-product credit, subtotal feedstock, conversion, subtotal production, bending, and distribution. The European Biomass Industry Association assumes that ethanol manufacture from sugar or starch is not very big and cost and yields developments are not projected. "The ethanol's production cost is: 0,42 euro/L (20eros/GL) for ethanol produced from corn in the U.S.; 0,32-0,53 euro/L (15-20 euro/GJ) for ethanol produced from sugar beets in northwest Europe." So as we can see raw material costs varies between 50 to 80% of the final ethanol's cost. That's way ethanol prices are influence through commodity market price.[47]

There is another ethanol manufacture possible, which can be more efficient then the manufacture from common food commodity. The production from the lignocelluloses materials (second generation of biofuels) is cheaper and their global potential would be 442 GL of ethanol/year; their manufacture technology have enhanced energy

[45] Petrou and Pappis (2009)
[46] Birur et al. (2008)
[47] Petrou and Pappis (2009), p: 1061

enactment and produced ethanol can save up to 90% of CO_2 emissions compered to nonrenewable fuels.[48]

It should be considered that energy for biodiesel manufacturing comes into being from transportation of nonrenewable energy, the energy content of the nonrenewable fuel equal to 1 L of biodiesel account 32,3 MJ and input of nonrenewable fuel for transport and production process is 16% of its energy content. That means if diesel is substituted with biodiesel two third of fossil energy would be saved. It seems that biodiesel is not a perfect substitute for diesel and there is a need to make studies how to make biodiesel more efficient. The biggest problem of biodiesel economic efficiency is resource price.[49]

Many Authors imply that biodiesel is not practicable if there are no governmental subsidies. The main problem is that biofuel subsidies caused exceed demand for cultivated land. There is a concern that rising demand for cultivable area could deforest the Amazon's tropical forest or Malaysia's ancient forest.[50]

Biofuels promoters argue that detaxing renewable fuel develop agriculture and define food surplus. They mind that biofuels subsidy offset food subsidy and this inhibit food surplus and unequable competition to Africa, Asia and Latin America.[51]

The EU agricultural population and cultivable land development had declined in recent years, while practice of subsidizing has been cultivated. Petrou and Pappis (2009) show decline of acreage for production cereals, wheat, barley and sugar beet. The authors argue that cultivated land for these products is not compensated with expansion of acreage for rapeseed production.[52] However, they do not consider soya acreage, which is the second one of the main feedstock of biofuels.

The Table 1 below gives an overlook of the advantages and disadvantages of biodiesel and shows that there are more environmental drawbacks of biodiesel production than benefits.[53] Table 9, which can be found in annex, summarized not only biodiesel advantages and disadvantages, but the pros and cons of the biofuels in general.

[48] Petrou and Pappis (2009)
[49] Petrou and Pappis (2009)
[50] Petrou and Pappis (2009)
[51] Petrou and Pappis (2009)
[52] Petrou and Pappis (2009)
[53] Petrou and Pappis (2009)

Table 1: Summary of biodiesel pros & cons[54]

Category	Biodiesel advantages	Biodiesel disadvantages
Resources	It is saving fossil fuels	Biomass collection needs fossil fuels
Use	Simple in use, without any changes on engine*	
Engine	Has higher ignition point then diesel*	
Storage		Biodiesel can be stored up to six months without any problems, but for longer period stabilizing additives are needed*
Distribution	Distribution system for biodiesel does not need any changes for use of biodiesel as a transport fuel that is how it avoids costly infrastructure changes**	
Agricultural and energy sector	Positive impact on agriculture and greater energy independence**	Higher input prices for biodiesel production
GHG	Lower GHG emissions in relation to fossil fuels It is confirmed that 1 kg of biodiesel use, reduce nearly 3 kg of CO_2, conventional diesel contributed with 65-90% less than that**	But this hinge on how and where biofuels are produced[55]
Acidification		Bigger contribution to acidification in relation to fossil fuels;
Stratospheric ozone layer depletion		Higher NO_2 emissions in relation to fossil fuels
Eutrophication		Higher NO_x emissions in relation to fossil fuels
Human ecotoxicity	Lower suspended matter and SO_2 emissions in relation to fossil fuels	
Degradable ability	Biodegradable, toxicity of biodiesel is lower than that of diesel, and if pure and unadditivated, BASICALLY free of sulphur and aromatics*	

Petrou and Pappis (2009) shows how the net energy ratio (NER – "ratio of the produced bioethanol's energy content per energy amount consumed during its production ") varies according to different life cycle studies on ethanol manufacture from corn, over the years. In 1989, 1992 and 2005 the NER values were lower than 1, this means that from an energy aspect ethanol manufacture was not economical to produce. In other years NER values are higher then 1, however differ widely. That could be caused by: various corn lands, due to different climate; various extension methods, due to different climate and land economy; various harvest manufacture systems, due to different manufacture technology.[56]

The biofuels that are manufactured form food feedstock or from feedstocks that are grown on land that could grow food feedstock has two main cons, they are: high food

[54] Authors construction, developed on information taken from table: "Biodiesel Pros and Cons" from Petrou and Pappis (2009) extend with information from ISIC (*) and with information from EBB (**)
[55] Gibbs et al. (2008)
[56] Petrou and Pappis (2009), p.1060

prices and declined reduction in greenhouse gas emissions. There are a lot of other feedstocks, that could be used for biofuels production and that will not affect food prices. For example: crop residues, algae, municipal waste, jatropha. These feedstocks grown on degraded land and are by-products of edible oil fabrication.[57]

2.4 Biodiesel versus Bioethanol

"The use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in the course of time as important as the petroleum and coal tar products of the present time." Rudolf Diesel, 1912[58]

Rudolf Diesel was the first who constructed the engine, which was run on peanut oil. He presented officially the engine at the World Exhibition in Paris in 1900. This engine was then modified to "diesel-engine", which was run on cheaper by-product diesel fuel.[59]

Ethanol, as a fuel and liquor is known in form of Moonshine Whiskey since 15th Century in Scotland. In 1826 Samuel Morey designed an engine that could run on ethanol and turpentine. In 1876 Otto Cycle developed the engine that used alcohol and gasoline. Though first in 1908 corn alcohol called ethanol was used as fuel for the first car (Model T) of Fords Motor Company, after Henry Ford 12 years earlier engineered his first car, which used pure ethanol. In 1920's ethanol have been started to be added to gasoline, this was necessary for rise octane and reduce engine knocking.[60] "[…] in the 1920s, 25% of oil sales were non-petroleum related. It was only to disappear in the late 1940s."[61]

[57] Babcock (2008)
[58] Cyberlipid (2011): http://www.cyberlipid.org/glycer/biodiesel.htm viewed on May 1, 2011
[59] Diesel service and supply (2011): http://www.dieselserviceandsupply.com/Biodiesel.aspx viewed on May 1, 2011
[60] Fuel testers (2011): Fuel testers http://www.fuel-testers.com/ethanol_fuel_history.html viewed: on May 2, 2011
[61] Kayzer et al. (2008); p. 509

Figure 4: Fuel Ethanol Production since 1975 till 2010 in Million Gallons[62]

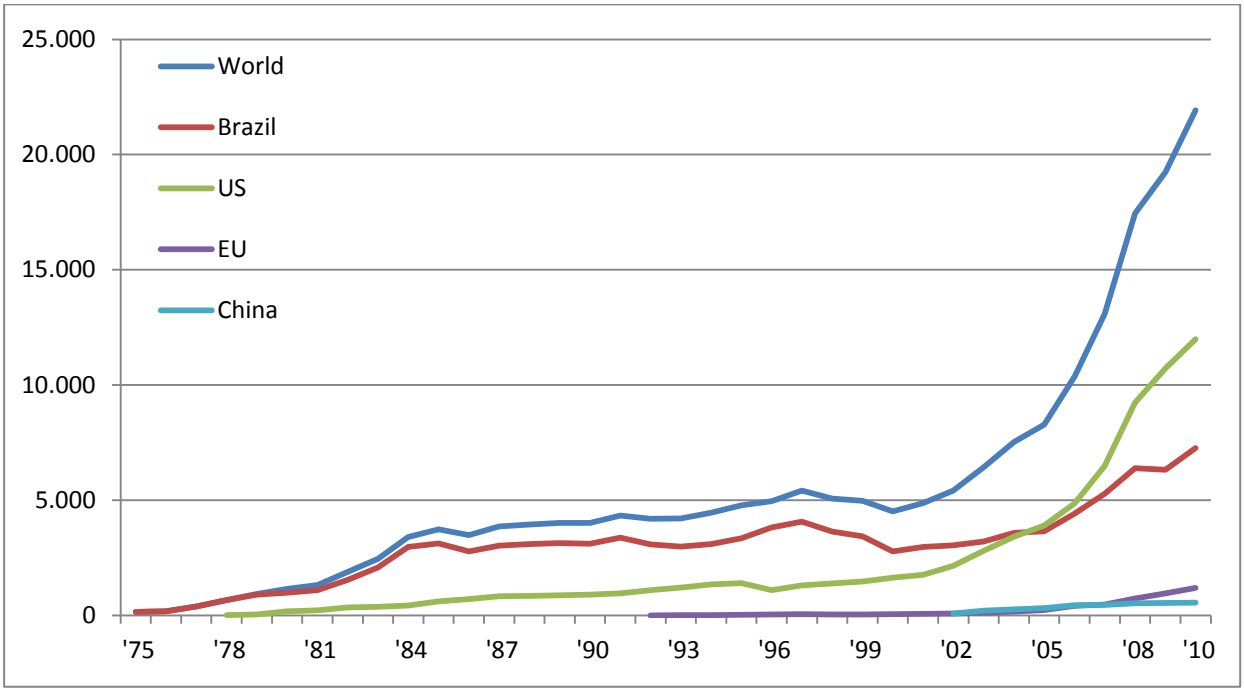
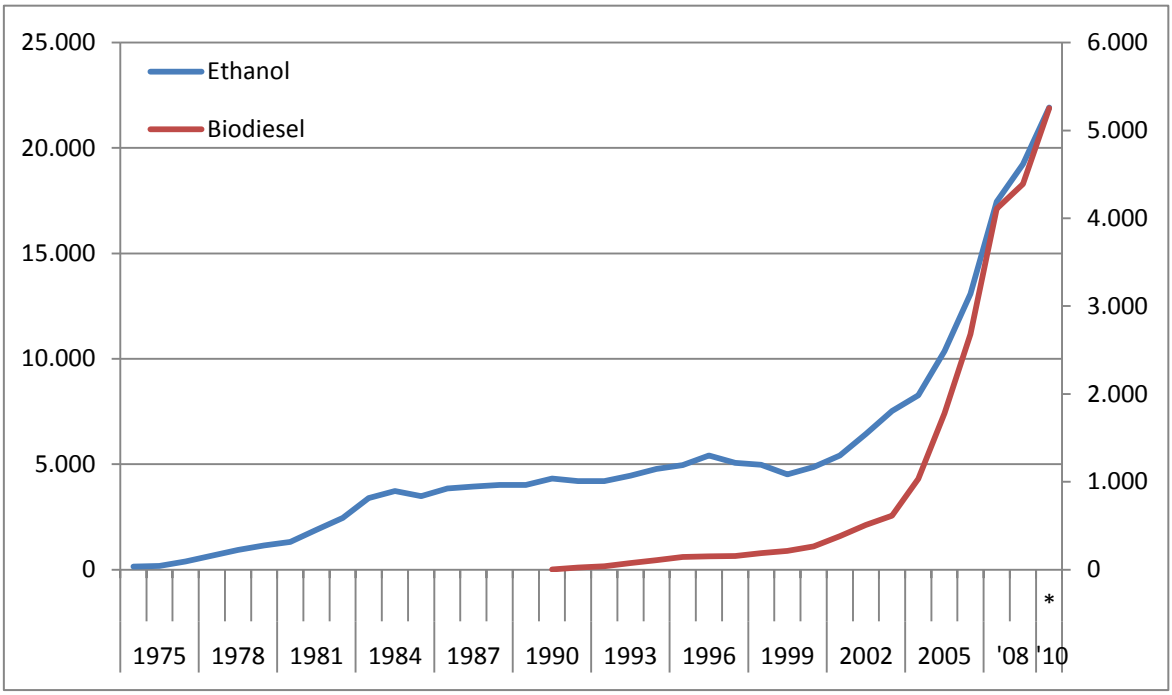


Figure 4 shows that, the large production of ethanol in Brazil and US began in 1970s. First fuel ethanol plant was built in Omaha, Nebraska in 1940's. U.S. Army built it.[63] But first in 2008 as the oil prices went up, biofuels began to be seen as important fossil fuel alternative. The 96 percent of whole biofuel production is ethanol and biodiesel accounts only of 4 percent. In 2008 US and Brazil were and are the main manufacturer of ethanol, with 90 percent of production. Yet the EU was and is a main manufacturer of biodiesel, with 80 percent of world biodiesel production in 2008.[64] In early 1970s Brazil was the main producer of ethanol from sugar cane on the world. The situation have changed in 2005, when the U.S. came to the same point of production and in 2007 achieved already 53% of ethanol production from corn. As Pfuderer and del Castillo (2008), also Birur et al. (2008) report, that since 1975 world ethanol production has increased significant at a compound growth rate of 10% per annum and from 2001 at 23% till 2006. Since 1991 the world biodiesel production has increased at the rate of 35% per annum, this is due to EU biofuel government incentives.[65]

[62] Authors construction data taken from: Earth Policy Institute (2011)
[63] Official Nebraska Government Website (2011) viewed May 27, 2011
[64] Pfuderer and del Castillo (2008)
[65] Birur et al. (2008)

Figure 5 shows the world fuel ethanol and biodiesel production at the world. We can observe that ethanol production, as already mentioned, started in late 70's and biodiesel first in early 90's. This was affect through governmental regulations.

Figure 5: World Fuel Ethanol and Biodiesel Production in Millions Gallons[66]



The U.S. fuel ethanol production rose from 175 million of gallons in 1980 to 13,230 million of gallons in 2010. In 2007 manufacture increased about 1,645 million gallons more to previous years, the next year was 2500 more and in 2009 was 1600 million gallons more, however in 2010 achieved over 2630 with amount of 13,230 million gallons.[67] In 2003 the production of ethanol increased due to replacement of MTBE, which has been polluting groundwater.[68] During the period from 2005 till 2008 US ethanol production nearly doubled and US biodiesel production achieved three-fold. Also prices of corn and soybean increased in line with biofuels production. This we can observe on Figure 6 and 7 below. As we will see in next section there are a lot of speculations if positive slop between production of biofuels and feedstock caused increase in food prices.

[66] Authors construction data taken from: Earth Policy Institute (2011)
[67] RFA (2011): Historic U.S. fuel ethanol production. Data set made available by Renewable Fuels Association. Available at: http://ethanolrfa.org/pages/statistics#A viewed: on March 24, 2011
[68] Fuel testers (2011): Fuel testers http://www.fuel-testers.com/ethanol_fuel_history.html viewed: on May 2, 2011

Figure 6: Annually World Ethanol Production (m gal) and World Corn Prices ($/mt)[69]

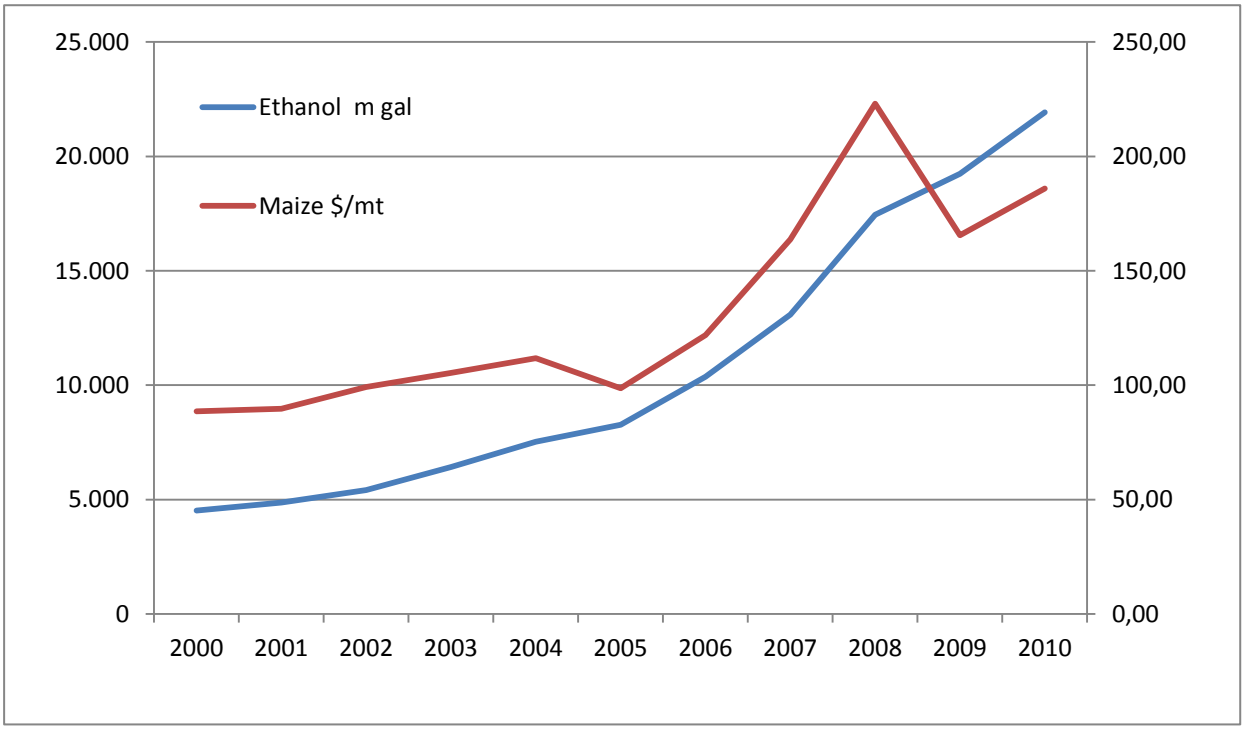
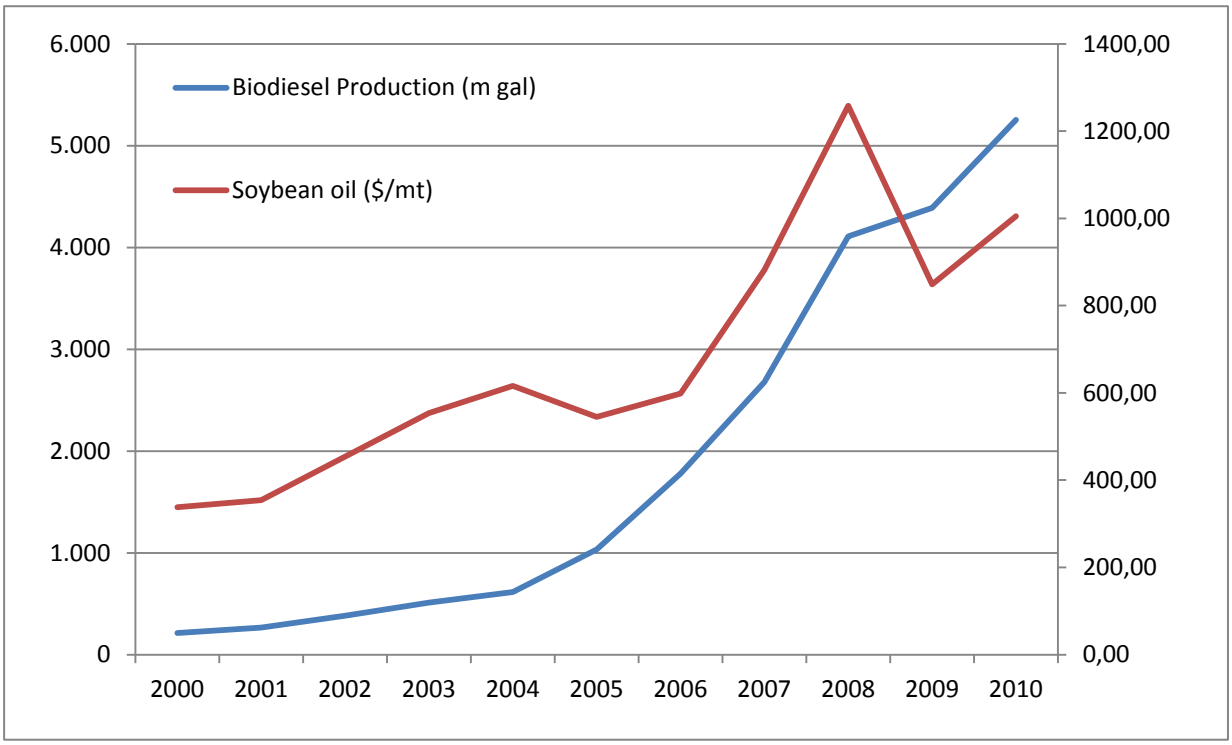


Figure 7: Annually World Biodiesel Production and World Soybean oil Prices[70]



[69] Authors construction data taken from Earth Policy Institute (2011) and World Bank Data (2011)
[70] Authors construction data taken from Earth Policy Institute (2011) and World Bank Data (2011)

Birur et al. (2008) shows in Table 10, which can be found in annex, the major drivers of ethanol boom in the U.S. and EU-27. He points the average crude oil and gasoline prices out and shows that the change 2001-2006 was 136% for crude oil and 77,5% for gasoline. He also present the share of MTBE to additives and the share of ethanol to additives, these change in 2001-2006 form 65% to 21% for MTBE and from 35% to 79% for ethanol. As already mentioned this was due to prohibition of MTBE use, because it's pollution of ground water, substituted with ethanol.[71]

In the past years biofuels production rose very fast in several regions of the world. The most common biofuels are ethanol, which is made from corn (US) or sugarcane (Brazil) and biodiesel from oilseeds (EU) or palm oil (Malaysia). For ethanol the main leaders on global biofuel market in 2006 were Brazil and United States, which together make up about 74 per cent of global production. Brazil is mainly producing ethanol from sugarcane, due to very good climate and land predisposition. As in United States is different climate and land, they produce ethanol from corn. After those two countries, on the ethanol market were China with 8, India with 4, the European Union with 3 and other countries with 11 per cent. The main leaders in 2006 for biodiesel were the European Union with 76 per cent of global production mainly from rapeseed and the United States with 20 per cent, with biodiesel from soybean. "Biodiesel is more important in the EU than ethanol because a much higher percentage of the automobile fleet is diesel. The U.S. fleet is predominantly gasoline, for which ethanol is a substitute. […] In the United States, biodiesel produced from plant materials has in recent years enjoyed a greater subsidy -$ 1 per gallon- than ethanol", to enhance biodiesel production. Nevertheless biodiesel is not profit-making because of high soy oil prices. The biodiesel production capacity of U.S. accounted 800 million gallons in 2008, but only one-third was produced. Because of the U.S. Renewable Fuel Standard by 2022 U.S. should achieve one billion gallons of biodiesel. Abbott et al. (2008) stress that it is very difficult to find out how strong is the impact of biodiesel growth on rise vegetable oil prices. Since 2004/05 EU produce biofuel from rapeseed, because of that 80% of rapeseed world usage was in the industrial sector. On the contrary during the same time and the same sector only 35% of world soybean oil have been used. As the EU is the main global manufacturer of biodiesel mainly from rapeseed, is seen also as the main contributor of

[71] Birur et al. (2008)

high vegetable oil prices.[72] Figure 8 demonstrate fuel ethanol production of leading countries at the world in 2010. The main producers are U.S. with 57% and Brazil with 35%. Figure 9 shows biodiesel production in five leading countries at the world in 2010. On the first place is U.S with 23% then Argentina with 21% on third place Germany and France with each 20% and on the fifth place Brazil with 16%. The both figures are projections.

Figure 8: Fuel Ethanol Production 2010 in Leading Countries at the World[73]

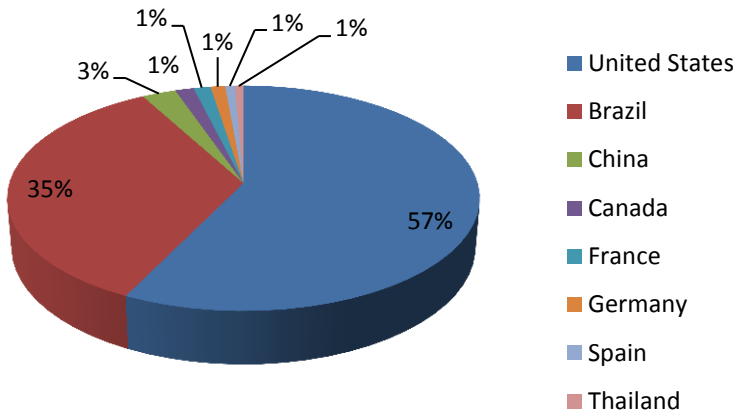
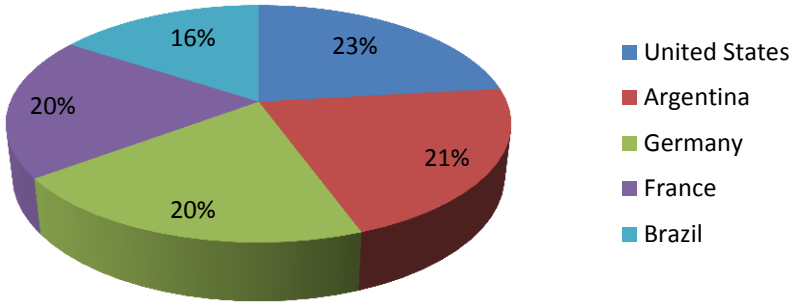


Figure 9: Biodiesel Production 2010 in Five Leading Countries at the World[74]



Biodiesel production in the EU began in 1992. Nowadays there are 120 plants in the EU, which manufacturing 6,100,000 tons of biodiesel annually. The most important are

[72] Abbott et al. (2008), pp. 41
[73] Authors construction data taken from Earth Policy Institute (2011); Data are projections
[74] Authors construction data taken from: Earth Policy Institute (2011); Data are projections

in Germany, Italy, Austria, France and Sweden. [75] "In the European Union in 2004, only about 0,4% of EU cereal and 0,8% of EU sugar beet production was used for bioethanol, while more than 20% of oilseed was processed into biodiesel. The annual growth rate between 2005 and 2007 was 53% and 44% for bioethanol and biodiesel, respectively."[76]

If we estimate percentage form the year 2006 in gallons, then at the first place in biodiesel production is Germany with 799 million gallons, then United States with 385 million gallons, the third France with 223 million gallons, the fourth Italy with 134 million gallons, the fifth United Kingdom with 58 million gallons, the sixth Austria with 37 million gallons, the seventh Poland with 35 million gallons, the eight Czech Republic with 32 million gallons and other countries with 227 million gallons. In ethanol production on the first place is the United States with 4 856 million gallons, the second Brazil with 4 763 million gallons, the third China with 1 083, the fourth India with 486 million gallons, the fifth France with 251 million gallons, the sixth Germany with 202 million gallons, the seventh Russia with 171 million gallons, the eight Canada with 153 million gallons, and other countries with 1 068 million gallons. To sum up the world ethanol production in 2006 accounted 13 033 million gallons and world biodiesel production accounted 1 929 million gallons.[77]

Recently Germany and France are the main producers of biodiesel production in Europe. Because of tax exemption the half of the EU biodiesel is manufactured in Germany.[78]

[75] EBB (2011): European Biodiesel Board (2003-2009). Invited by the European Commission. http://www.ebb-eu.org/biodiesel.php viewed: 24 March 2011
[76] Banse et al. (2008), p.3
[77] Birur et al. (2008)
[78] Banse et al. (2008)

PROALCOOL is a National Alcohol Program in Brazil, which started in 1974 and was initiated through oil crisis, is successful till today. Nevertheless in mid-1980s, when oil prices went down Brazil had economic troubles. Program was developed for independency of foreign oil. Ethanol is very good alternative for gasoline, when oil prices began to rise. Brazilian land accessibility and perfect climate for sugarcane agriculture, give this country comparative advantage in ethanol manufacturing. Public sector subsidies and tax breaks were the main factors, which helped the program started. In result farmers planted more sugar cane, investors built distilleries to convert the crop to ethanol and automobile industry designed cars, which are capable to run on 100% alcohol. Government's subsidies for distribution network allowed to get the fuel to gas stations and preserved alcohol prices low to attract future clients. In the 1990s, low oil prices and ethanol shortages, forced government to extract its subsidies and lift price control on ethanol. "Today, the price difference between gasoline mixed with ethanol and hydrated alcohol is defined by the Government (minus 30% for hydrated alcohol). The percentage of the mixture of ethanol with gasoline is set at 25%." Coordination between different kinds of Ministries was required for successful contribution of the project. By the mid-1980s nearly all new cars, which were sold in Brazil, tanked up ethanol. Today 40 percent of the fuel that Brazilians refuel is ethanol.[79]

After effective implementation of PROALCOOL program, which was mandatory, Brazilian government made this time incentive for biodiesel production and develop additional social certificates, which give producers tax incentives. These incentives develop into Brazilian Program of Technological Development for Biodiesel called PROBIODIESEL. With the 13th of January 2008 was obligatory to add 2% of biodiesel to diesel fuel, nevertheless addition increase to 5% in 2012. These compel the National Association of the Automotive Vehicles Manufactures to induce warranties for diesel engines that can be refueling with 2% biodiesel. The forecasts for demand are 800 million liters per year. In August 2005, Brazilian government create ruling, that biodiesel will be bought by the National Agency of Oil, Natural Gas and Biofuels (ANP).[80]

Kayzer et al. (2008): " in virtually all countries except Brazil biofuel production is far from profitable and fully relies on sizeable subsidies and quantitative restrictions in the form

[79] WRI (2011a): World Resources Institute http://projects.wri.org/sd-pams-database/brazil/national-alcohol-program-proalcool viewed: March 20, 2011
[80] WRI (2011b): World Resources Institute http://projects.wri.org/sd-pams-database/brazil/probiodiesel-brazilian-program-technological-development-biodiesel viewed: March 21, 2011

of minimum blending requirements that, moreover, make biofuel demand highly price inelastic hence contributing to price instability on food markets, to increasing malnutrition, and to inflation."[81]

3 How to Understand High Food Prices

Recent news reported that food prices overbid in December 2010[82] the levels prices of 2007-2008 crisis. The UN's Food and Agriculture Organisation said the boost in food prices did not caused a crisis, however the situation was serious, because the peak is yet not achieved. Still increasing food prices provoke fears about the follow-up the 2007-2008 crisis. The economist and Secretary of the Intergovernmental Group on Grains with the FAO said that the main causes for increasing prices was year of unpredictable and bad weather, which affect crop yields from Russia, U.S., Ukraine and Kazakhstan. But it is hard to say which factors influenced 2008 peak prices, which accrued in the summer at the end of the crop season. It is known that biofuels industry was evaluating and financial collapse was ruling. The most touched countries through the past crisis were Haiti, Bangladesh, Egypt and Cameroon. The high agricultural prices release the riots in these countries. The rise in food costs affects development economies of such companies like McDonald's and Kraft through increasing retail prices. High food prices account for increasing all-around inflation. According to FAO food price index, which include wheat, corn, rice, dairy products, oilseeds, meats, sugar, costs of these commodities increased sharply to 214,7 points, which account for 4,2 per cent from November 2010. Comparing the 2007-2008 food crisis, the index amounted 213,5 in June 2008. The FAO food index was first established in 1990, so it is difficult to show that the food prices were higher than the crisis of 2007-2008, in 1975. The rising prices of U.S. wheat are now the main topic, this is due to poor yields, which was affected through harsh, dry weather. Argentina will have a shortage in corn and soybean due to dry weather conditions and wheat yields from Australia will be delayed, because of heavy rains. Senior economist of the FAO said, when considering food security, rice and wheat are the critical agricultural commodities, but there prices are below the 2007-08 peak. The main factors behind the increase in the FAO food index are raising costs of sugar, oilseeds and meat.[83] Even president of France, Nicolas

[81] Kayzer et al. (2008), p. 509
[82] As the Article is from 5th of January 2011
[83] Financial Times (2011a): http://www.ft.com/intl/cms/s/0/51241bc0-18b4-11e0-b7ee-00144feab49a.html#axzz1MWg0SuQu , viewed on May 16, 2011

Sarkozy have said that food price volatility issue will be one of the G20 agendas. The World Bank has developed a crisis back up under the International Development Association, which found accounts for $49bn for the neediest countries. Also the World Meteorological Organisation and World Bank are trying to help and they working on improvement long-range weather forecasting and monitoring.[84]

Since 2003, international prices of commodities have risen sharply within few months or few years, depending on commodity. "The number of undernourished people in 2007 increased by 75 million, over and above FAO's estimate of 848 million undernourished in 2003-05, with much of this increase attributed to high food prices. This brings the number of undernourished people worldwide to 923 million in 2007, of which 907 million in the developing world."[85] "[…] Grave concerns are felt with respect to the impacts that food and fuel inflation may have on macroeconomic stability and economic growth, given that the first global commodity crises of 1974 coincided with an end to the "Golden Age" of post-War economic growth."[86]

"The period since World War II includes three distinct sub-periods. First, over the 20 years 1950-70, prices for rice, maize and soybeans declined relatively slowly, while wheat prices declined fairly rapidly. Next, following the price spike of the early 1970s, over the years 1975-90, prices for all four crops declined relatively rapidly. Finally, in the years 1990-2008 the period of rapidly declining food commodity prices ended."[87]

Over the period of 1990-2005 in comparison to previous three decades, we witness strike in the growth of land and labour productivity. Setting aside the world top 20 producers the slowdown in other countries is even higher. "Worldwide, land productivity grew at slower pace over the years 1990-2005 (1,82 per cent per year) than

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The Time (2011): http://ecocentric.blogs.time.com/2011/01/07/food-prices-hit-record-high-what-now/ , viewed on May 17, 2011

The New York Times (2011): http://www.nytimes.com/2011/01/06/business/global/06food.html?_r=2&ref=world , viewed on May 17, 2011

Reuters (2011): http://in.reuters.com/article/2011/01/06/idINIndia-53964720110106 , viewed on May 17, 2011

[84] Financial Times (2011b): http://www.ft.com/intl/cms/s/0/64ccfdae-1904-11e0-9c12-00144feab49a.html#axzz1MWg0SuQu viewed on May 17, 2011

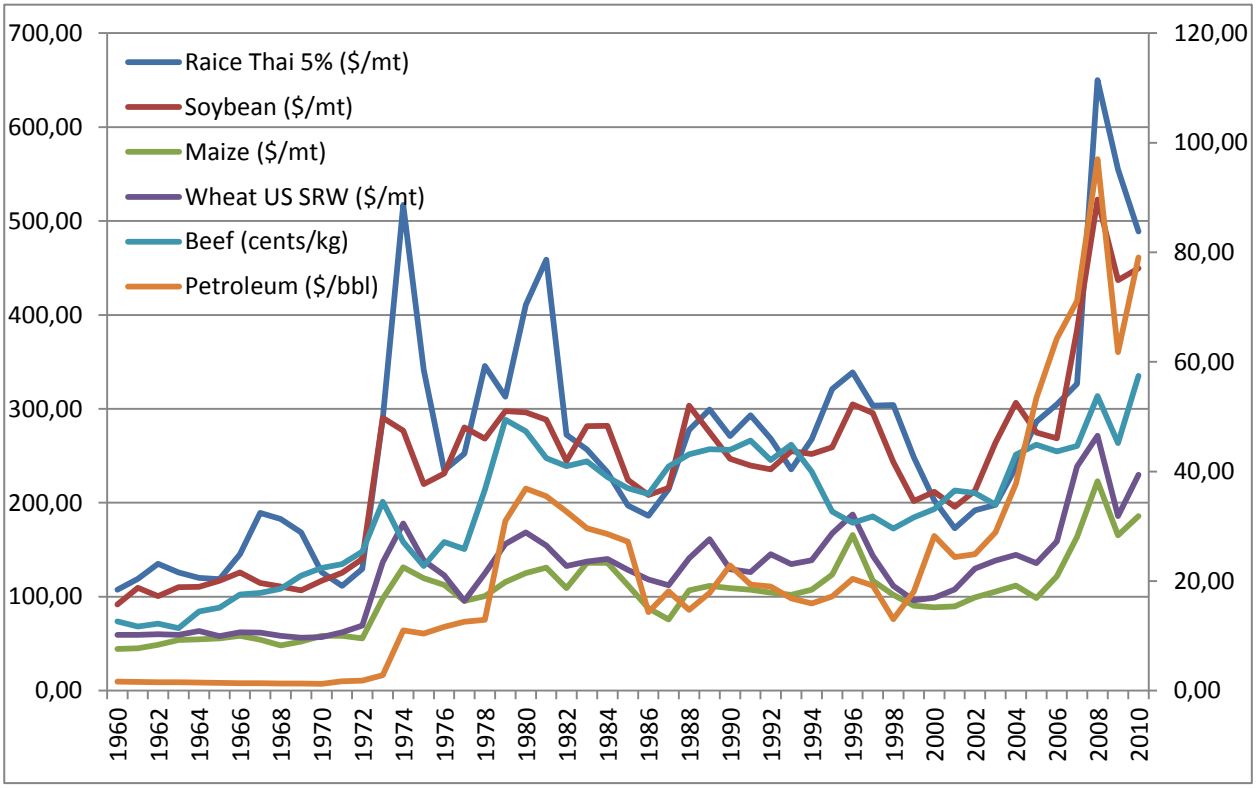
[85] Alston et al. (2010), p. 36

[86] Headey and Fan (2008), p. 375

[87] Alston et al. (2010), p. 37

over 1961-90 (2,03 per cent per year).” The investments in R&D are essential to avoid a long-term food price crisis.[88]

Figure 10: Annually Food Commodity Prices since 1960-2010[89]



The Figure 10 illustrates maize, wheat, soybeans, beef, rice and petroleum prices from 1960 to May of 2011 in the World. The Table 2 shows changes of real prices over particular periods of interest. Firstly what can be observed is that the price levels from May 2008 are higher as they were in the late 1970s or early 1980s and in case of soybean and rice even higher. Secondly, prices have increased very fast. In 1974 and 2008 crisis, rice prices reached 200% in the 1974, 255% in the 2008, wheat prices 160 % in 1974, and maize and soybeans 50 to 90%. “Thirdly, prior to the current price rise, the real prices of staple foods were at an all-time low after declining for the best part of 30 years.” Fourthly, prices of wide range of commodities have risen sharply. Fifthly, the time period of prices increases is different across commodities. Wheat and maize price boost emerged prior to 2008, however rice at first in 2008. Headey and Fan

[88] Alston et al. (2010), p. 38
[89] Authors construction data taken from World Bank Data (2011)

(2008) argue that long-run trends and the similarities of the 1974 crisis are important components of the 2008 crises.[90]

"The world has consumed more wheat than has been produced in six of the last seven years. Rice consumption has been higher than rice production in five of the last seven years." It is important to notice that rice and wheat are not used for biofuels production. There is no link between these feedstocks and biofuel, though there is a link with other food crops.[91]

Table 2: Percentage changes of prices across commodity groups in the 1974 crisis and 2008 (2000 USD)[92]

Commodity	% Change from:		
	1970–1974	2004–2008	01/08–05/08 (% 2004–2008)
Food			
Staple crops	148.4	101.9	61.7 (60%)
Wheat	159.8	81.4	23.6 (29%)
Maize	80.4	88.5	43.1 (49%)
Soybeans	88.0	52.9	47.9 (48%)
Rice (Thailand)	200.6	255.4	191.4 (75%)
Nonstaple crops	159.3	58.3	45.8 (79%)
Meat	24.5	4.5	10.7 (100%)
Beef (Brazil)	n/a	40.2	21.7 (54%)
Seafood	53.0	18.0	−5.7 (0%)
Other agricultural commodities			
Textiles	107.5	5.5	2.3 (42%)
Wood	34.7	13.2	4.5 (34%)
Cash crops	49.4	61.3	17.8 (29%)
Fertilizers	299.4	379.4	200 (53%)
DAP: U.S. GULF*	389.0	369.1	166.0 (45%)
Potash	475.3	381.8	193.5 (51%)
Metals	79.9	119.3	7.9 (6.6%)
Energy			
All energy	274.9	127.3	59.7 (47%)
Petroleum	325.0	182.8	65.7 (36%)
Coal	74.3	81.3	85.8 (100%)
Natural gas	n/a	98.5	38.9 (39%)
General prices			
U.S. GDP deflator	26.0	15.5	4.2 (27%)
USD per SDR	22.4	9.1	2.6 (28%)

[90] Headey and Fan (2008), pp. 376
[91] Babcock (2008), p.1
[92] Headey and Fan (2008), p.376; authors took the information from International Monetary Fund; "all commodity prices are deflated by the U.S. GDP deflator so as to be expressed in constant (2000 USD) terms."

The primary factor in 1974 food crisis was jump of oil price, however all energy prices have increased to 80-120% in 2008, also have the prices of metals and materials, and fertilizer in both crises.[93]

Headly and Fan (2008), but also Gilbert (2010) mention that there are a similarities between the 1973-1974 and 2005-2008 commodity price crises, as the price increases of agricultural commodities emerge from common increases in commodity prices, what was caused through U.S. trade deficits and frail monetary policies. In both crises oil prices reached peaks and ended with inception of recession. As there were similarities, there were also differences. The 1973-1974 crisis was shorter and grains prices led ahead of the rise in oil prices. The 2003-2008 commodity crisis was longer and increase in agricultural prices came at the end of the crisis.[94] Baffes and Hanidis (2010) go earlier in historic actions, and mention additionally to previous crisis the post-WWII period and Korean War. Each of the crisis was caused by a high constant economic growth and expansionary macroeconomic background, and then complied with slowdown. They point out that recent crisis was not affected through high inflation as 1970s crisis was.[95]

In 2008 prices of all food commodities have raised. Most of the commodities prices have reached a peak. The factors which drove high commodity prices were "[…] economic growth, international trade, currency markets, oil prices, government policies and bad weather."[96]

Baffes and Hanidis (2010) stress that impact of biofuels on food prices is not significant and point out new factor, which could have an effect on food commodity prices; the use of commodities by financial investors. They call it "financialization of commodities" – manager began to invest in commodities especially gold after 1970s crisis.[97]

Elliott el al. (2008) also mentions above factors and show them in Table 13. Trostel (2008) shows in Figure 30 when the drivers of higher food commodity prices had the

[93] Headey and Fan (2008)
[94] Gilbert (2010)
[95] Baffes and Hanidis (2010)
[96] Abbott et al. (2008), p. 5; also: Baffes and Haniotis (2010), Dewbre et al. (2008), Headey and Fan (2008), Pfuderer and del Castillo (2008), Trostle (2008), Zhang et al. (2009), wrote about this causes of the commodities price boost
[97] Baffes and Hanidis (2010)

impact (1996-2008 year line) and if these factors are from demand or supply side. Both tables can be found in annex.

As Abbott et al. (2008), Schnepft (2008) writes also that since mid-2007 raw materials prices such corn, barley, sorghum, oats, wheat, rice, soybeans, increased very fast. This had very bad impact for import depended developing countries. But there were also positive aspects of high commodity prices. Farmers of United States achieved best ever gains and government farm costs decreased, however the food price inflation stocked and costs of cattle and food for manufacturer rose. Very high volatility of primary product prices caused the risk and cost combined with sales promotion. "In particular, they have dramatically increased the cost of routine hedging activities (i.e., pricing commodities for purchase, delivery, or use at some future date) at commodity futures exchanges and as a result, have diminished "forward contracting" opportunities for grain and oilseed producers who are eager to take advantage of record high market prices."[98]

"Cooper and Lawrence (1975) argued that commodities were seen as a safe real asset in a period of unreliable monetary values." Other Authors "found that monetary expansion could raise agricultural prices relative to a more general price deflator."[99]

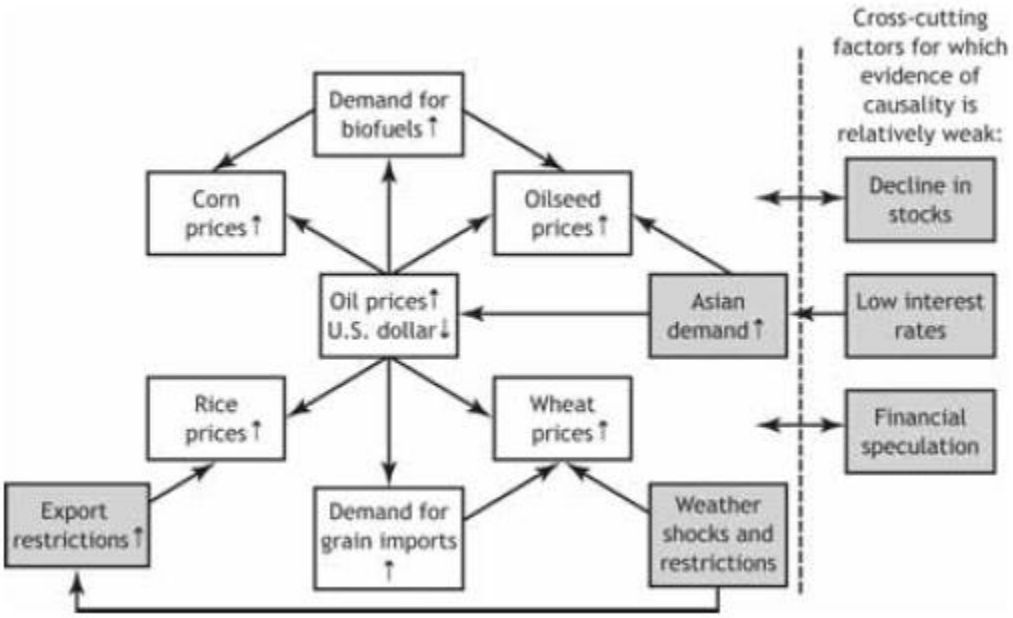
Abbott et al. (2009) writes "In the spring and early summer of 2008, the temperature of the rhetoric in the food-versus-fuel debate was skyrocketing right along with the prices of corn, soybeans and crude oil. […] Released in July 2008, What's Driving Food Prices? identified three major drivers of prices - depreciation of the U.S. dollar, changes in production and consumption, and growth in biofuels production. […] Today, just eight months later, the landscape is remarkably different. The 2008/2009 crop production was higher than forecast, quieting talk of inadequate supplies. Significant declines have occurred in crude oil, grain and oilseed crop prices. Biofuel production has slowed. The value of the U.S. dollar has appreciated. A global financial crisis and recession now dominate the news". In March 2009 Update report Tyner, Abbott and Hurt verified the main drivers of food prices and find out that the answers are not as simple as previous. "While the level of food prices has dropped, the forces driving those prices remain the same today as in July 2008, as does the need to understand how those forces work and interact." The July 2008 and March 2009 Update report confirm

[98] Schnepf (2008), p.3
[99] Gilbert (2010), p.46

that "[…] food prices are influenced by diverse and multiple factors generated by complex global economic issues."[100]

The three main factors of food crisis which Abbott et al. (2009) have already mentioned are also included in Headey and Fan (2010) general model that covers the key factor mechanisms of 2008 food crisis, which is shown in Figure 11 below.

Figure 11: A summary model of the principal causes of the crisis[101]



Financial speculation: "The potential significance of this trend is that nontraditional participants can now speculate on food price trends, because the value of a futures contract varies in relationship to the commodity prices in the current spot market, much as bond prices vary in response to changing interest rates. This variation affords speculators an opportunity to bet on futures contracts as a separate asset class quite apart from the spot prices of agricultural commodities in today's market."[102]

There is no doubt that the food prices increased sharply over the 2007/08 period. Depending on considered period the percentage of commodities vary widely, as the Table 3 shows. The IMF food Index rose 78,3% over the 3 years period till June

[100] Abbott et al. (2009), Preface
[101] Headey and Fan (2010)
"Boxes in gray denote weaker, crop-specific causes. The decline of the USD and the rise in oil prices are shown together because they are both universal factors, and because they may be causally related to each other."
[102] Headey and Fan (2010), p. 41

2008, however over 20 year average only by 2,1% at an annual rate. The more significant price increases can be observed due to the IMF Cereals, corn, wheat, soybeans, soybeans oil and rapeseed oil, they increased 4,7%, 4,5%, 2,4%, 4,3%, 5,7% over the same period.[103]

Table 3: Rise in Food Price – Period Ending June 2008[104]

	Weight	Percent Change (%)			
	(%)	12-months	2 years	3 years	20 year average
IMF food Index	100	44.4	55.4	78.3	2.1
IMF Cereals	22	73.2	119.7	169.3	4.7
Corn	6	74.5	162.1	194.3	4.5
Wheat	10	56.3	78.6	145.6	4.3
Barley	2	30.7	125.5	157.9	5.7
Soybeans	7	82.4	155.2	116.9	2.4
Soybean Oil	3	80.7	157.1	167.0	4.3
Rapeseed Oil	2	81.5	84.5	141.7	5.7
Sugar	5	19.4	-16.7	24.5	0.8
Beef	9	8.8	15.9	7.6	0.8

Headey et al. (2010) carry a commodity analysis of real food price trends, which included 50 countries, with help of FAO's Global Information and early Warning System dataset. The analysis show, that "the real monthly prices of commodities were significantly higher in 2008 than they were in the corresponding months of 2007. Prices were highest for potatoes (51%, only five observations, mostly from Latin America), followed by sorghum (27%, only nine observations), maize and rice (24%)." All commodities vary broadly in price changes, impaling "highly uneven transmission of international prices across countries."[105]

Headey and Fan (2010) shows with the help of Figure 33, which can be found in annex, the complex way of the commodity price formation. Mentioned already factors are also included in the Figure 33 and the direction of impact on the actual prices is shown.

3.1 Short-Term Factors in Food Commodity Prices

To short-term/cyclical problems belongs: adverse weather conditions, which causes changes in agricultural production; declines in stocks due lower than estimated harvests

[103] Baier et al. (2009)
[104] Baier et al. (2009),p. 23; authors took the information from International Monetary Fund's Primary Commodities Index
[105] Headey et al. (2010), pp.219

"have put upward pressure on prices due to the induced volatility and higher risk premium that lower stocks imply"; decline in international commodity trade due to exports ban in several countries (for example Argentina closed in 2007 wheat export so that the damages from the frosts could be estimated; in 2007 Ukraine limited export shipments of wheat, rye, barley and maize to 3000 tones, to complement domestic stock; Russia announced a higher export tax; Indonesia raised the palm oil export tax); inflow of speculative investments on commodity prices - "Financial investors have become more interested in investing in rising agricultural commodities, which have become increasingly attractive as a class of assets at a time when the dollar and stock markets are weak, and US interest rates are low". All of these factors had influence on higher commodity prices. Weather condition affected such countries as U.S, EU, Canada, Russia, Ukraine and Australia. The OECD-FAO Agricultural Outlook shows that Europe and Australia were over 60 million tonnes of supply shortfall.[106]

As other authors, Schnepf (2008), confirms that wheat and rice prices boost was short-term and was caused through the weather conditions. Under the assumption of normal weather, during two growing seasons the price situation should be back in norm.[107]

High commodity prices in agricultural markets are also caused through inelastic demand and unpredictable supply. The world wheat prices from 2008 were fast at the same level as in the 1995 and 1996. Though sugar prices gained there peak in 2003 and in early 2008 fell under production costs of all main manufacturer. There are a lot of different factors that have influence on commodity prices some of which are short-term and some of which are long-term.[108]

Gilbert (2010) differs between general and specific food prices explanation changes. He writes about averaging and substitution indicators. As he consider the averaging impact, he writes: "explanations of food price movements typically adopt a partial equilibrium, market by market, approach and focus on shifts in demand and supply curves. Supply shocks are generally seen as dominant with demand movements playing a less important role." The supply shocks are not as important as the demand movements are due to crops correlation.[109]

[106] Pfuderer and del Castillo (2008), p.14
[107] Schnepf (2008)
[108] Pfuderer and del Castillo (2008)
[109] Gilbert (2010), p.400

Figure 12: Price responses to idiosyncratic and common demand shocks[110]

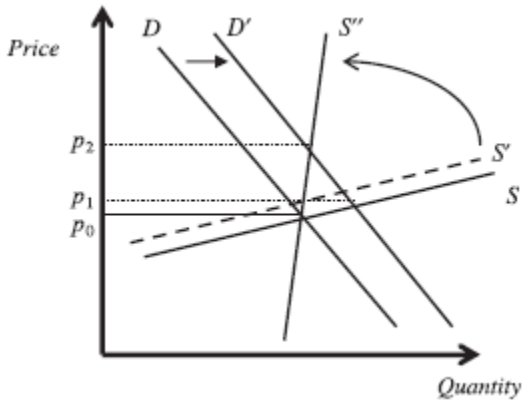
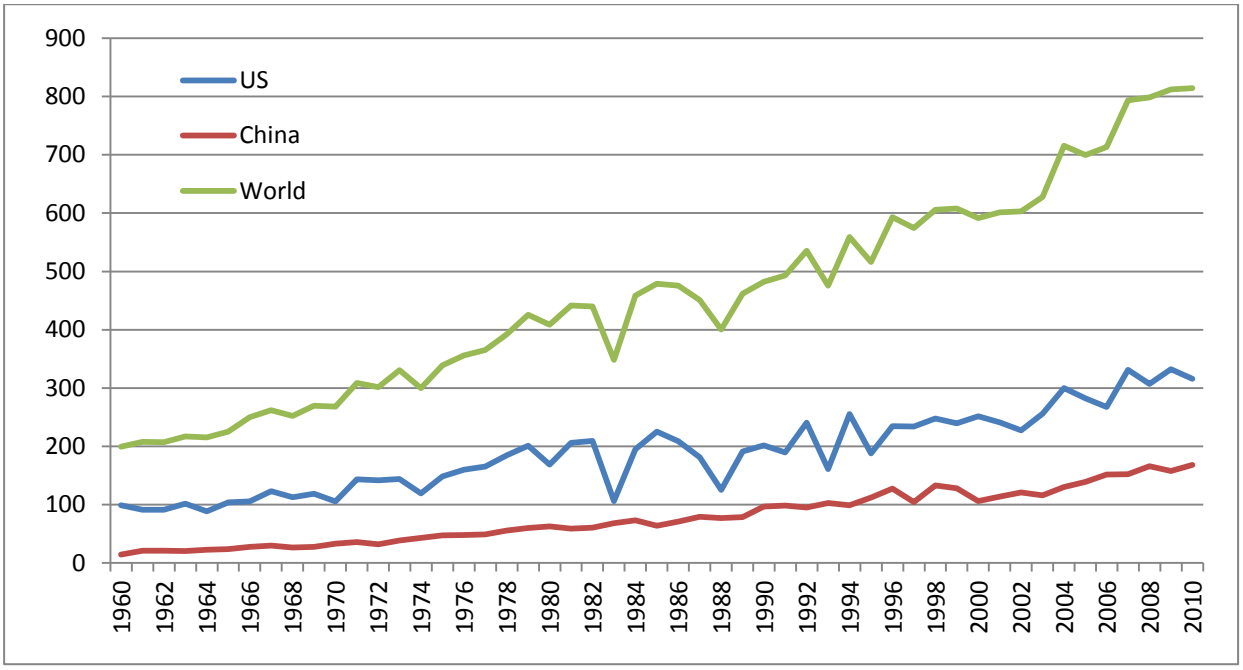


Figure 12 shows commodity-specific demand shock D -> D'. Supply is elastic and demand shocks induce the minor price increase. However if the situation changes and demand shock is common, that could be caused through output prices, which are used in one sector and moved to other. For example as grain inputs are used for feedstuff in meat fabrication. This we see in S to S' movement. If the supply S' moves to S'' it become less elastic. "In summary, common shocks will dominate movements in aggregate price indices at the expense of idiosyncratic shocks."[111]

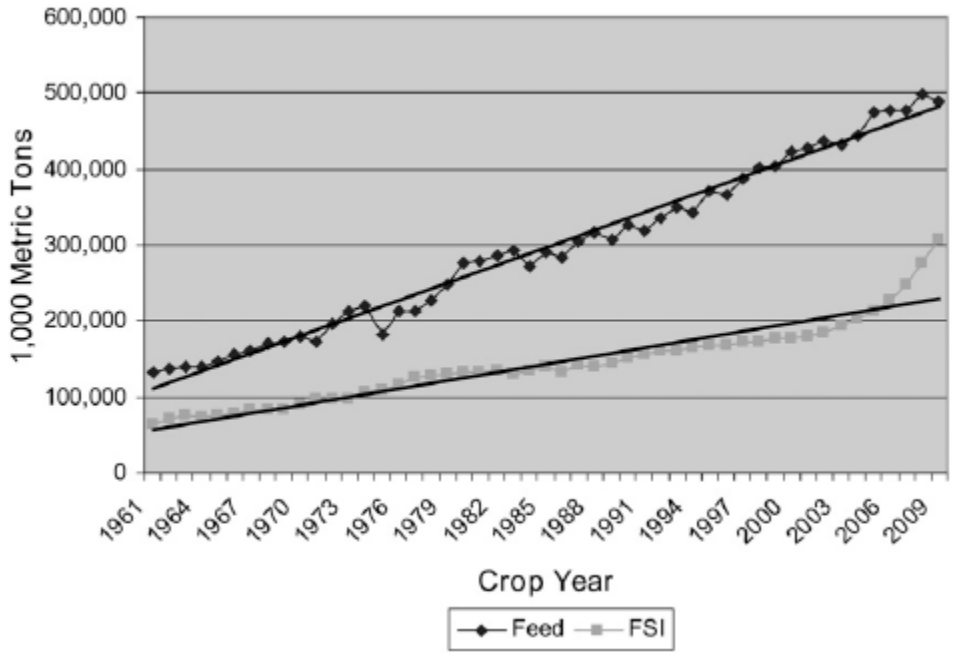
Figure 13: Corn Production in Million Tons 1960-2010[112]



[110] Gilbert (2010)
[111] Gilbert (2010), p.402
[112] Authors constriction data taken from Earth Policy Institute (2011)

As the Figure 13 and 14 show the corn production and its usage have constantly increased since 1961 till 2009. The usage of feed and food, seed and industrial has risen due to economic growth. In the long-run period the feed usage was greater than FSI, but it can be observed that since 2004 FSI has sharply increased by an average of 9,6% per year, however feed usage has increased by 0,73%. Since 2004 till 2008 total corn use has been accounted of 64 million metric tons for FSI and 34 million metric tons for feed.[113]

Figure 14: World Use of Corn - Feed and Food, Seed and Industrial (FSI)[114]



Stocks-to-use ratios are helpful to estimate supply and demand terms. “Calculated as the ratio of ending stocks to total consumption for a given crop year, they measure the percentage of carryover stocks available to meet demand during the next crop year.” From Figure 15 we can observe that stocks-to-use ratio for corn in 1989 has fallen from 46% to 13% in 2009. Due to this period the percentage of total corn-ethanol manufacture was very small, and it is not considered to be a cause of declined stock-to-use ratio. Corn usage for ethanol manufacture has increased from 10% in 2002 to 24% in 2008. The long-run reasons for declines in supply could be increasing usage of corn for feed, slowdowns in production of crop due to decreasing agricultural development,

[113] Harisson (2009)
[114] Harisson (2009), p. 495, author took the information from USDA Foreign Agricultural Service, Production, Supply, and Distribution Data, Sep. 2008

acreage transition, availability and increasing cost of irrigation. Since 2000 stock-to-use corn ratio decreased greatly from 27,8% to 13% in 2009, this is due to increased demand for ethanol from corn. In short-run period the growth in demand for corn is influenced through ethanol demand. Because of the shortage in supply, short run boost in ethanol impact significantly the prices.[115] The main driver of wheat price is the level of stocks at the end of the crop year.[116]

Figure 15: World Stock-to-Use Ratio for Corn[117]

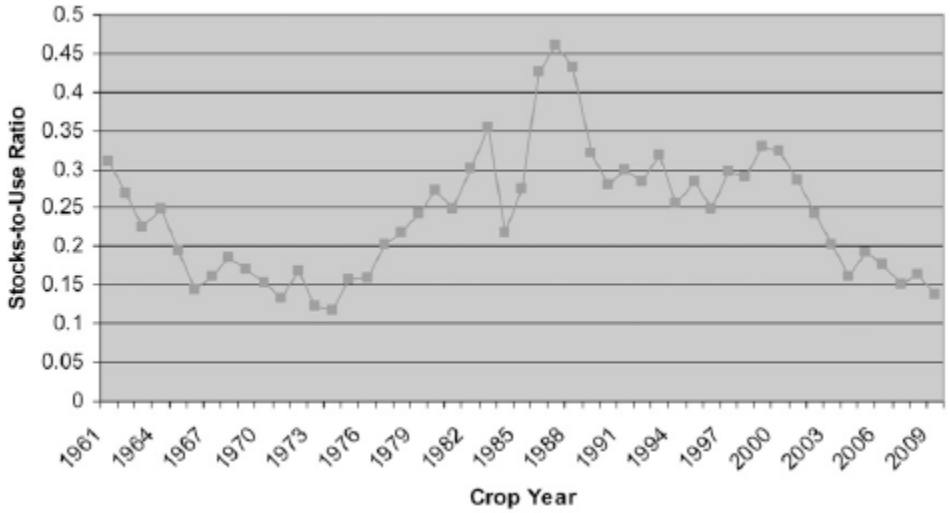


Figure 16: World Stock-to-Use Ratios for Soybean Oil[118]

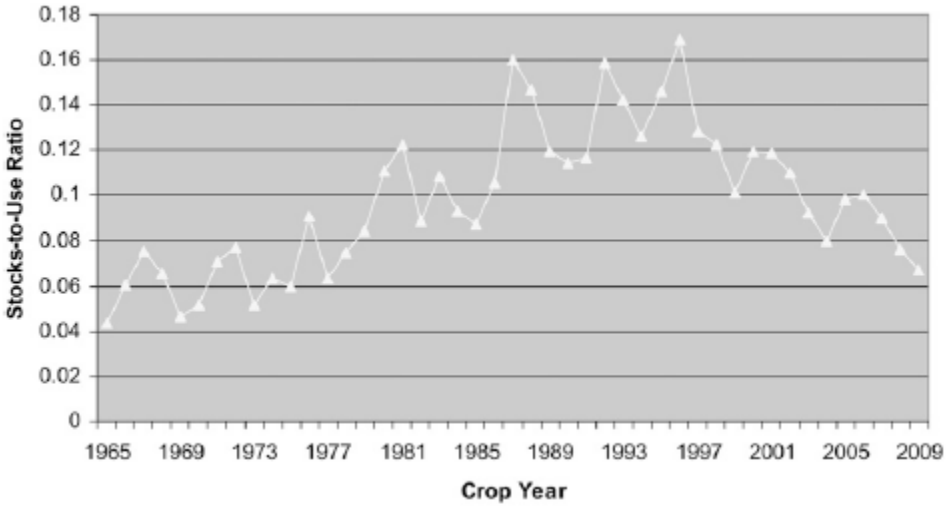
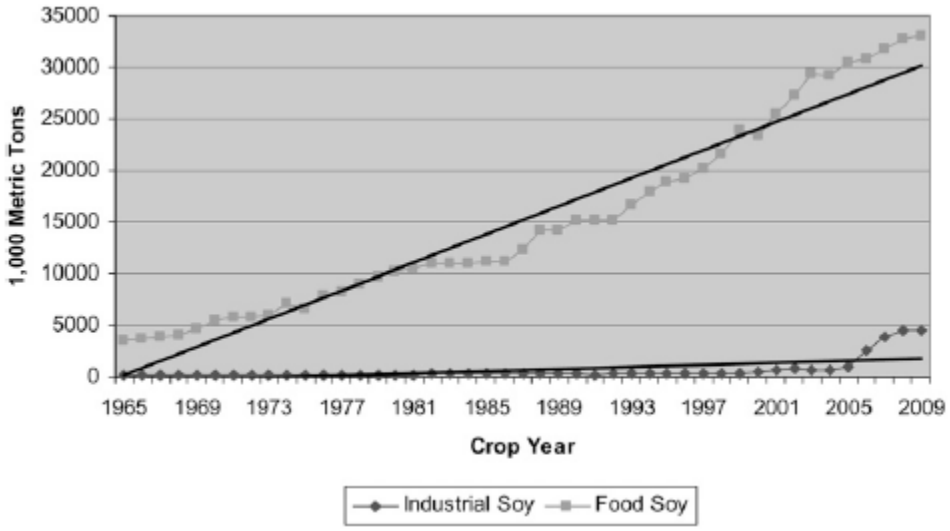


Figure 16 shows that world stock-to-use ratios for soybean oil declined from 17% in the mid-1990s to 6% in 2009. This is due to rising demand for soybean oil, which

[115] Harisson (2009), p.495
[116] Pfuderer and del Castillo (2008)
[117] Harrison (2009), p. 496, author took the information from USDA Foreign Agricultural Service, Production, Supply, and Distribution Data, Sep. 2008
[118] Harrison (2009), p. 497, author took the information from USDA Foreign Agricultural Service, Production, Supply, and Distribution Data, Sept. 2008

is growing more rapidly than its production. During the whole use of soybean oil has raised to 19% in 2005, supply has risen only by 15%. Soybean oil is mainly used as food ingredient and cooking oil and its usage has been constantly risen since 1965, as the Figure 17 shows. Its total usage for food is 89%. As we already know soybean is also used as raw material for biodiesel production and its total usage for it is only 11%.[119]

Figure 17: World Soybean Oil Usage[120]



"However, given the overall strength in demand growth, most market analysts predict that when commodity supplies eventually recover and prices moderate from current high levels, the new equilibrium prices will be significantly higher then has traditionally been observed during periods of market balance."[121]

Rapeseed is the main raw material for biodiesel production in Europe. Its usage as oil to total vegetable oil has risen from 8% in 2000 to 27% in 2008. In time period 2004-2008 industrial usage has risen by 80%, but food usage only by 20%.[122]

3.1.1 Crude Oil Prices

Abbott et al. (2008) mention that the impact of U.S. dollar exchange rate on commodity price is stronger and crucial than other studies assume. "The decline of the dollar is linked not only to higher demand for U.S. agricultural commodity exports, but also to higher oil prices. Some studies conclude that oil prices and rising production and

[119] Harrison (2009)
[120] Harrison (2009)
[121] Schnepf (2008) p.2
[122] Harrison (2009)

transportation costs have helped drive current commodity price increases." Higher crude oil prices have caused the rise in the cost of producing agricultural commodities through boost in the price of such inputs as diesel or fertilizer, but in the long-term period it is not confirmed.[123]

International markets set a price of oil in U.S. dollars. Decreasing dollar caused higher oil price, through two issues. "First, oil exporters must raise the dollar price per barrel to retain the same level of purchase power against appreciating non-U.S. currencies. Second, oil importers – whose currencies have generally strengthened against the dollar – drive the dollar price of oil higher when they bid the same price per barrel in their own currency." We should consider that U.S. is the biggest oil importer on the world, so oil import cost volatility cause the U.S. trade deficit and decrease economic activity.[124]

Gilbert (2010) confirmed the statement of Abbott et al. (2008) and writes that the combination of higher energy and transport costs raised U.S. production cost up to 20%. He implies that sharply up and down movements of oil prices had an impact on agricultural markets not only through supply, but also through demand for food commodities as biofuel primary product.[125]

Babcock (2008) confirms that the reason for high commodity prices is biofuel, which created a direct link between them and crude oil prices. High crude oil prices in the long run influence biofuel resource prices, despite of government incentives.[126]

"Macroeconomic studies showed that rising oil prices had larger macro impacts that rising food prices, but there is no doubt that poverty levels are highly sensitive to rising food prices even if rising fuel costs could also have had important effects."[127]

Not only high crude oil prices, but also the fact that it is non-renewable energy source, signal to find a substitute. The main substitutes for crude oil are biofuels. Feedstock, that are used for biofuel production, which are directly used for food production or are planted on land that would be producing food, imply the straight link between crude oil and food. Food prices are influenced through crude oil in terms of the energy used

[123] Abbott et al. (2008), p. 6
[124] Schnepf (2008), p.25
[125] Gilbert (2010)
[126] Babcock (2008)
[127] Headey et al. (2010), p.219

to plant the crop, food production, transport and store “but also in terms of the cost of raw ingredients such as grain, meat, milk, and vegetable oils.” There will be always a link between biofuel and food, because biofuel are produce from biomass and biomass needs land.[128]

3.1.2 Exchange Rates

Commodity prices show over sensitivity to exchange rate movements. There are two reasons for that, first one: “both exchange rate changes and commodity price movements have a business cycle component which may not be fully reflected by available demand-side variables. A second reason may be because causation runs in part from commodity prices to exchange rates.”[129]

3.2 Long-Term Factors in Food Commodity Prices

To long-term/structural problems belongs: increasing demand for meat and dairy products from developing economies caused through growing per capita income, which is combined with diets westernization, which increased demand for agricultural commodities; growing biofuel production, which influence mainly maize market in U.S. (wheat for biofuel production is very small, in 2007 only 0,6% globally was used for biofuels); higher oil prices influence the cost of inputs such as fertilizer, pesticides, fuels, heating and energy use. Due to the Sustainable Development Commission rise in oil price from $50 to $100 a barrel increased production cost up to 13% for crop. But higher oil prices can also cause faster development of biofuels; also low investment in research and agriculture sector, which was caused through long oversupplies, had delayed progresses in production, which had adverse influence on potential supply.[130]

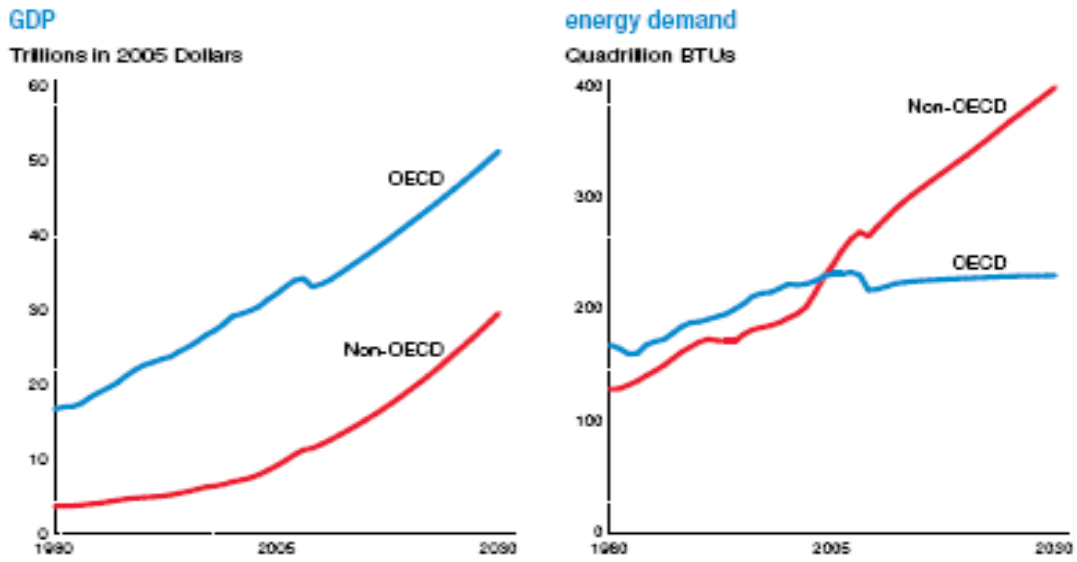
3.2.1 Growth in Production and Consumption

An increased growth in developing countries, such China and India, caused increased consumption in meat and feed grains for meat manufacture. As people can afford more, due to upturn of their incomes, the global demand for higher-value foods like meat and dairy product increased, which induce increased demand in raw materials used for feed livestock. The consequences of that were high commodity prices.[131]

[128] Babcock (2008), p.3
[129] Gilbert (2010), p.406
[130] Pfuderer and del Castillo (2008)
[131] Schnepft (2008)

From USDA projections is know that between 2008 and 2017 world economic growth will increase at a 3,5% average per year rate in comparing 2001-2007 with 2,9% per year. The economic growth in developing countries for 2008-2017 is expected at 5,8% per year.[132] And as we can see on Figure 18 it will increase even more.

Figure 18: Economic growth drives energy demand[133]



As already Schnepft (2008) also Abbott et al. (2008) writes that main attention due to very fast economic growth in developing countries determined China and India, because their dietary change from cereals to meat. Abbott et al. (2008) vary in this statement and says, that "world prices are formed by those who trade. China and India have both followed policies aimed at agricultural self-sufficiency, and neither are major traders of most agricultural commodities. However, China's rapidly growing oil imports have had an indirect effect on food prices by impacting world prices for crude oil."[134]

The agricultural productivity is not following the increasing demand for agricultural commodities. Increasing demand and stagnating productivity growth caused supply shortfall and in the end rising some commodity price. In 2006 and 2007 bad weather and crop disease compound low commodities prices situation. "The policy actions of some countries to isolate their domestic markets through export restraints made the

[132] USDA – United States Department of Agriculture (2011)
[133] ExxonMobile (2011) - Outlook for Energy a View to 2030 http://www.exxonmobil.com/Corporate/files/news_pub_eo_2009.pdf viewed: May 27, 2011
[134] Abbott et al. (2008), p. 5

situation even worse, particularly for rice. Increased investment in agricultural research is important, but will not provide a short-term solution."[135]

3.2.2 Increase in Biofuels Production

"Crude oil's strongest and most direct impact on food prices has been through its effect on the demand for biofuels." European Union and United States subsidies caused expansion of biofuels industry and its rising demand for corn and vegetable oils. In the past years increasing demand for ethanol has caused growing global demand for corn. Some of the reasons for high corn prices are: the ethanol blender credit or Renewable Fuel Standard, but high oil prices are the main cause.[136]

Due to new regulations global biofuels use will boost from 1 mb/d today to 4,4 mb/d in 2035. To the world's biggest biofuel manufacturer will still account U.S., Brazil, and the EU. "Advanced biofuels, including those from lignocelluloses feedstock, are assumed to enter the market by around 2020, mostly in OECD countries." To make renewable fuels competitive with imported oil, significant governmental support is needed in from of subsidies and incentives, because of high cost of biofuels production. In 2009 government spent $20 billion in part in the U.S. and the EU The projection of governmental support for 2010-2020 is estimated for about $45 billion annually and for 2021-2035 for $65 billion annually.[137]

4 The Impact of Biofuels on Food Price

Very fast growth in biofuel manufacture, especially ethanol, which is made from sugar or corn, causes the boost in food feedstock prices, through increased demand for sugar and corn, and change the acreage preferred usage. High prices of corn will have an effect on food prices and will shift corn and sugar to other crops, which will increase their prices. The negative effect of biofuels on food prices could be soothed through cellulosic biofuels production, which uses crop residuals, miscanthus, switchgrass and woody biomass. The second generation of biofuels is now developed to meet the targets of the Renewable Fuels Standard (RFS), which goal is to blend cellulosic biofuels with gasoline through 2007-2022 time periods. To help to achieve these targets

[135] Abbott et al. (2008), p. 5
[136] Abbott et al. (2008), p. 6
[137] World Energy Outlook (2010); p. 10

Food Conservation Energy Act (FCEA) of 2008 is also supporting this goal, through additional subsidies for cellulosic resources.[138]

Figure 19: Food crops demand and supply[139]

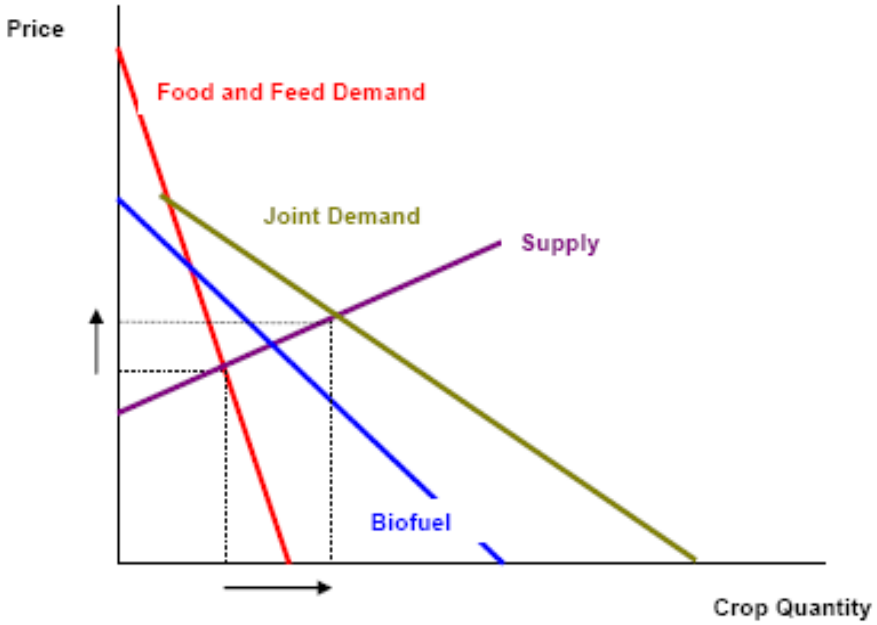
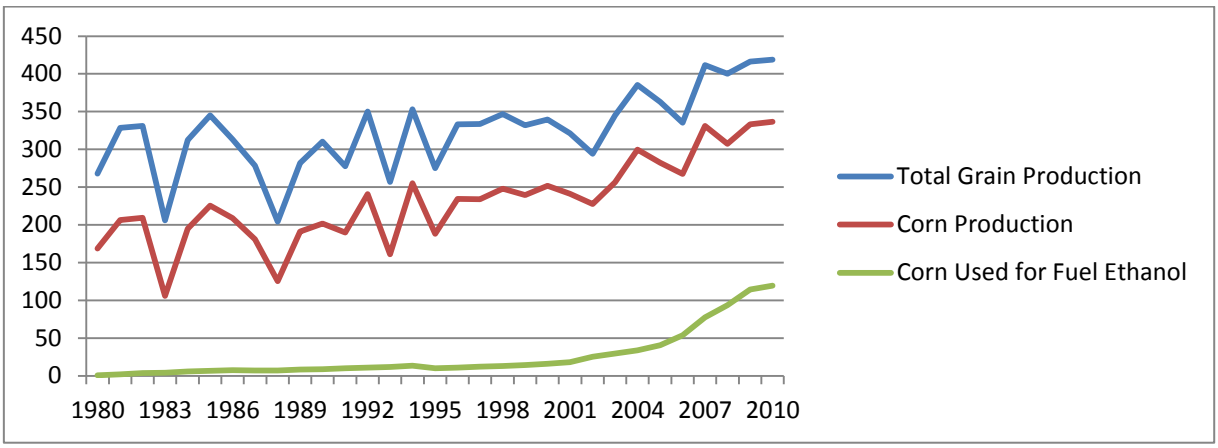


Figure 19 illustrates impact of biofuel demand on food and feed demand and their outwards movement, which will cause higher feedstock production and higher prices, however how strong it will be hang on supply curve, which movements depend on land and factors of production availability. As a result of trade obstacles and agricultural supports prices of commodities go under distortion. However inelastic demand and unpredictable supply affect commodities price once per year due to harvest. "Expected changes in supply and demand have much smaller impacts on prices then unexpected events such as bad harvests."[140]

[138] Chen et al. (2010)
[139] Pfuderer and del Castillo (2008), p.10
[140] Pfuderer and del Castillo (2008), p.7

Figure 20: Corn Production in million tons and Use for Fuel Ethanol in the United States, 1980-2010[141]



Corn and soybean are the food crops, so the link between food prices and biofuels exists, as the corn and soybean are used for biofuel production. Figure 20 shows that the corn production converted into biofuels, which is the main feedstock of U.S. ethanol increased from 5% in 1996 to above 25% in 2006 and is still increasing. The soybean production converted into biofuels, which is the main feedstock for biodiesel production for U.S. and South America, increased more rapidly from approximately 1% in 2002 to 18% in 2007.[142]

It is very difficult to say how much impact has biofuels on corn and soybean prices. However "Elobeid et al. estimated that a 30% increase in corn prices and the resulting increases in other commodities that compete with corn for land would increase U.S. at-home food expenditures by approximately 1.3%." Other author estimated that corn prices would go down by 13% in 2008/09, if federal biofuel policies would be removed. The FAPRI Institute assessed that government policies, such as Renewable Fuels Standard, the blenders tax credit, and the tariff on imported ethanol caused increase corn prices by mean of 16% in the long run.[143]

Diverse impact of biofuels on commodity prices is influenced through food basket definition and what is adopted into the relations between fuel and food prices. "The Council of Economic Advisors estimate that retail food prices increased only around 3% in 2007 due to ethanol production." Controversial other studies show that

[141] Authors construction data source: Compiled by Earth Policy Institute (2011) with corn used for fuel ethanol from U.S. Department of Agriculture (USDA), Feed Grains Database, electronic database, at www.ers.usda.gov/Data/FeedGrains, updated 14 July 2010; U.S. corn and grain production from USDA, Production, Supply and Distribution, electronic database, at www.fas.usda.gov/psdonline, updated 9 July 2010
[142] Babcock (2008)
[143] Babcock (2008), p.2

biofuel production is the main impact of increases in food prices and assume that U.S. will be the net importer of food instead of oil.[144]

Dufey (2006) underlines that in Malaysia palm biodiesel demand is increasing very fast so that government decided to reduce licensing new manufacturers. Malaysia signed the agreement together with Indonesia, that both countries will reduce palm oil output for biodiesel production by 40%. It is important to mention, that these two countries are responsible for 90% of global palm oil manufacture.[145]

Taheripour et al. (2011) constructed four panels Figure 31[146] (panel1 - without biofuel; panel2 - with biofuels but without byproducts; panel3 - with biofuels and their byproducts and panel4 - with biofuels and their byproducts with changes in final demand) and presented the links and effect directions between crop, food, feed, livestock and biofuel and their rivalry for land.[147]

4.1 Review over Economic Models

Recently the interest about biofuels raised, due to increased food prices. A lot of authors tried to find the links and impacts between them. This section includes short summaries of different studies, which shows the consequences of biofuel production on Greenhouse Gas emission, agricultural sector, land diversification, food and livestock prices. In the first section partial equilibrium models are described, in the second section general equilibrium models, as they are the progress of partial. In the third section interactive spreadsheet is discussed. And on the end there are shown other relevant economic models, which define the relation between biofuel and food.

The comparison and distinctions between the studies are demonstrated in three tables, which can be found in Annex. Every table is constructed as follow, in first column is the name of the authors study followed by what the study have estimated, then method which they used. Also new approaches are described and in the last column conclusions of the studies are summarized. All studies in the Table 14 are partial equilibrium models, in the Table 15 are general equilibrium models and in the last one Table 16 other economic models. The all three tables include different studies. It is difficult to compare the studies, because of the various goals of estimations of the

[144] Zhang et al. (2009), p.445
[145] Dufey (2006)
[146] Figure 31 can be found in annex
[147] Taheripour et al. 2011

studies. That is way the detailed conclusions and the estimated effect of the studies are included in tables, to give an overlook and simplest way to compare the studies.

Chakravorty et al. (2009) in their study made a review over economic models of Biofuels. They divided them on: models of the agricultural sector, models of agriculture and transportation, and these on partial equilibrium models and general equilibrium models. They estimated table which shows which study contains which factors, such as land-use deviations, economics of biofuels, government policy and environmental impact, the more interesting study form agricultural sector, which contain all four key factors, is the study from Schneider and McCarl (2003).[148]

The first study in Table 14 of partial equilibrium models is the study of Schneider and McCarl (2003), they researched economic prospective of biofuels in a greenhouse gas reduction. They used data on production and biofuel processing for switch grass, hybrid poplar, willow and traditional crop for livestock manufacture as well as afforestation of arable land contained them in U.S. Agricultural Sector Model. This model calculates at each carbon price level new market equilibrium and show agricultural raw material prices, regionally specific production, and welfare levels, environmental effects, input use and biofuel production. They found that if carbon prices are below $40 per ton of carbon, then there is no effect on biofuels and emissions mitigation through soil tillage and afforestation are more expensive. However if the carbon prices are higher than $70, biofuels take the lead in all agricultural reduction strategies.[149]

Chakravorty et al. (2008) with the help of extended Hotelling model, which includes equivalence between Ricardian land rent and the Hotelling rent for crude oil, find range of prices within, which biofuels are surrogate for oil and evidence that biofuel prices must lie within tangible range affected by acreage availability and the demands for food and energy. The influence of policies determines constant food production and agricultural prices for a period of time, if the demand for energy is high. The elimination of export subsidies on the domestic commodity and import tariffs for them induced decreased demand for food, but boost supply in biofuels. Also forecasts are possible on how agricultural subsidies impact the supply of biofuels.[150]

[148] Chakravorty et al. (2009)
[149] Schneider and McCarl (2003)
[150] Chakravorty et al. (2008)

Chakravorty et al. (2009) had studied to what extent biofuel boom indicates a reallocation of scarce land away from food to fuel production. They confirm what also the other authors assumed, that rising biofuel production have a major effect on food prices and deforestation due to land change. They point out that more research is needed to verify the effect of second generation biofuels technologies that would not causing deforestation as the first generation do.[151]

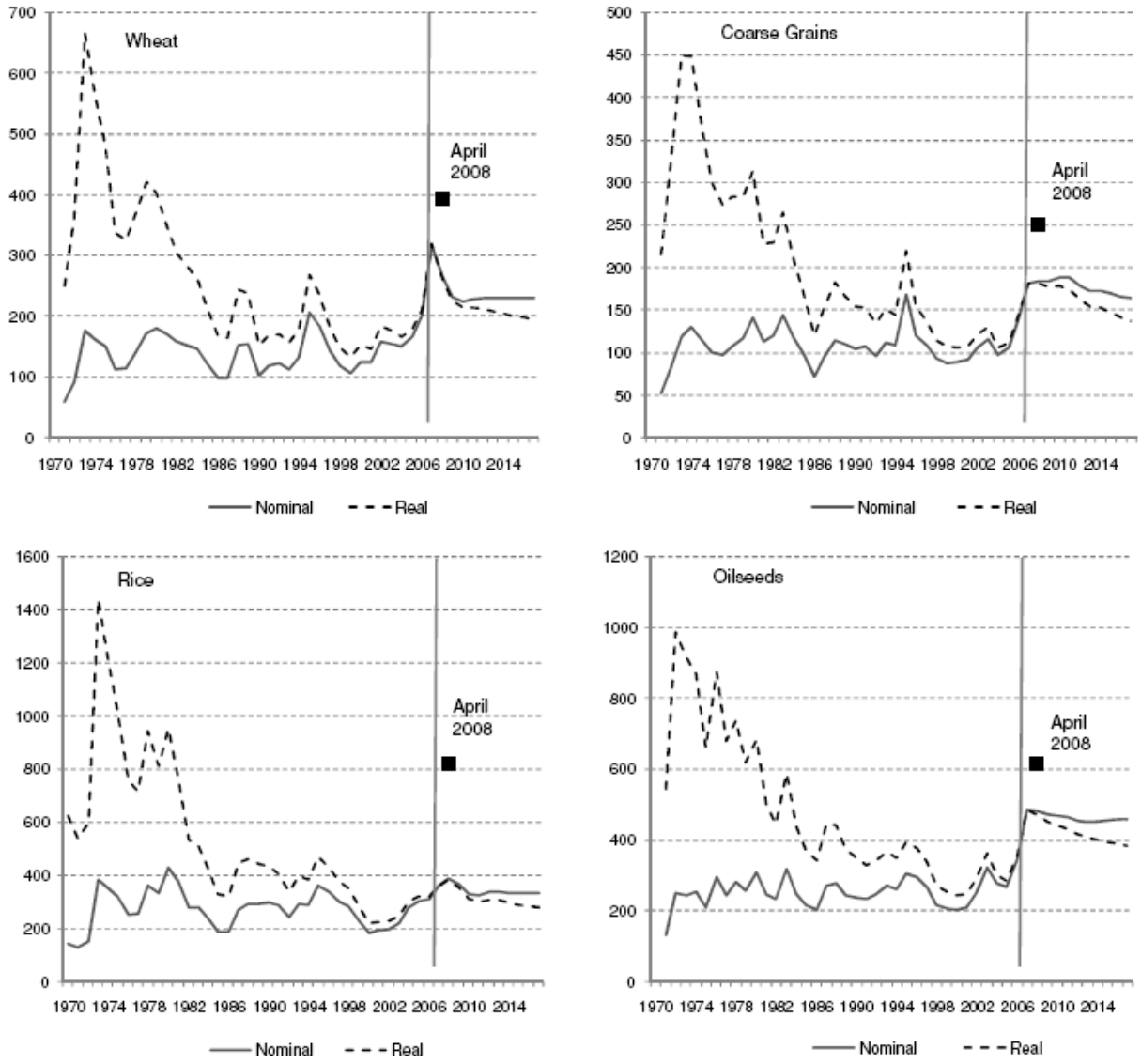
Elobeid and Tokgoz (2008) underline the significance of the impact of trade defaults on U.S. ethanol and estimate the effect of trade liberalization and exclusion of domestic defaults. They used multi-market international ethanol model based on 2005 market and regulations data to assess the effect of the U.S. tariff exclusion on trade, consumption, production and prices. Without supporting policies and mandates ethanol market, would not rise as fast as it does. Results shows that trade walls in the U.S. endangered the ethanol market and saved domestic prices strong. When the market becomes to be opened, the demand for ethanol from other countries increases, therefore world ethanol prices boost. The elimination of the U.S. tariffs causes for Brazil a profit, thus Brazil has comparative advantage of cost-effective ethanol manufacture. Brazil use CBI countries as indirect way for its ethanol to sale in the U.S. Without the U.S. tariffs Brazil would be able to export ethanol directly to the U.S. and CBI countries would notice great drop in their exports. The tariff abolition has an impact not only on ethanol industry, but also corn, by-products and sugar markets. The influence on demand for corn used for ethanol production, have their prices. The impact on other crop prices is also observed. This cause effects on the U.S. livestock, due to ethanol by-products prices and soy meal. Brazil is second after U.S. main world ethanol manufacturer. If the tariff, which now account 45 percent in ad valorem terms, would be removed, Brazil could turn high revenues. Because of that increased sugar-ethanol production would cause higher raw sugar prices and acreage expansion.[152]

While for farmers the discussion is simple in terms of food and fuel relationships. For the economists reality is more complex. There are a various factors that impact the relationship between increasing food commodities and food prices, these factors will keep up high food prices over the medium period. As other authors Dewbre et al. (2008) mention that such factors as rising biofuels demand, fast economic growth, weather disasters, high oil prices, weak US dollar, speculation and exports ban caused high food

[151] Chakravorty et al. (2009)
[152] Elobeid and Tokgoz (2008)

prices. In their study they measure these factors internationally and estimate implications changes for consumers with the help of AGLINKCOSIMO model, which is a global partial equilibrium model of world agricultural markets maintained by the OECD and FAO. The model determine the baseline forecasts for agricultural commodity supply, demand, trade and prices and "generate a 10-year baseline reflecting how markets could evolve given an extension of current policy, normal weather, trend yield growth, stable macroeconomic settings" but also petroleum prices.[153]

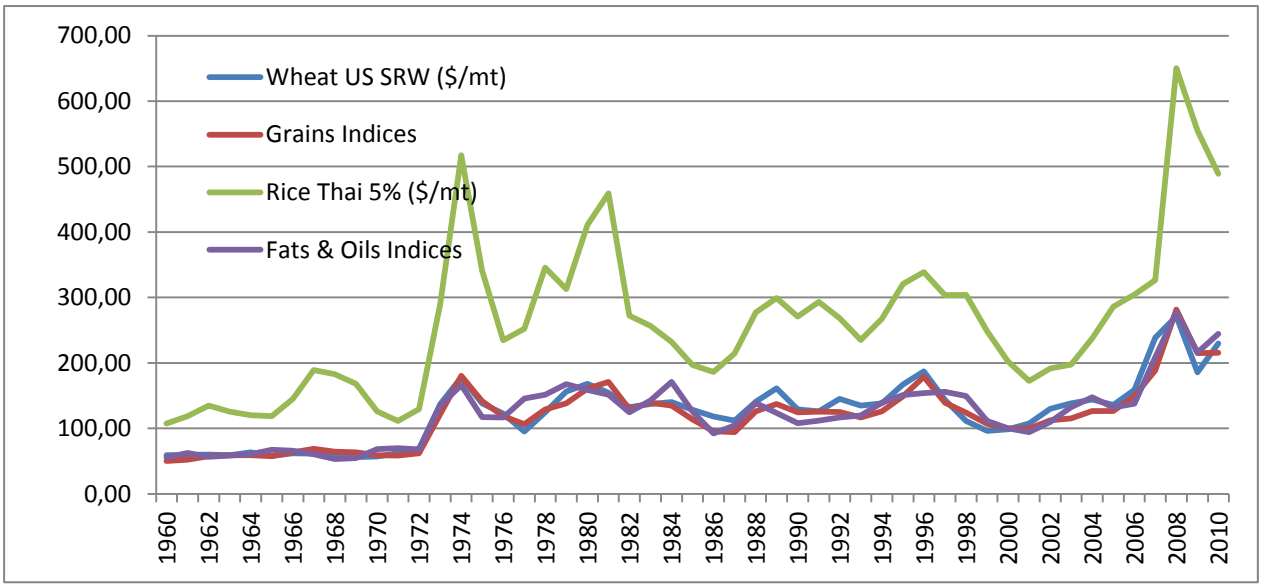
Figure 21: Food commodity prices, 1971-2007 with projections to 2017, U.S. dollar per tonne[154]



[153] Dewbre et al. (2008)
[154] Dewbre et a. (2008) reproduced the figure from OECD and FAO (2008); Note: Real prices deflated by U.S. GDP deflator; 2007=1; monthly price for April 2008. Dewbre et al. (2008), p. 395

Figure 21 illustrate forecast of yearly average world prices of wheat, coarse grains, rice, and oilseeds for 2008 till 2017. On the graph we have nominal and real prices. Nominal prices are less economically important due to long period time. Real prices include inflation so that the price of the good can express what could be bought instead at that time. Typically for these four graphs is high degree of price volatility, caused not through supply or demand, but short-run shocks. Volatility adjusted through policy interaction, move away risk from producers. As we compare last 40 years period prices increases in 2007/08 were not as high as they were in early 1970s, but nearly the same as in early 90s. What is most important to be observed that the high prices of 2007/8 will not last, as they didn't in earlier periods. The temporary factors driving high prices will disappear and demand and supply will react. "In particular, price signals are expected to cause productivity growth to regain its pace with demand growth."[155] Authors used baseline projections and alternative scenarios estimated for the 2008 OECD and FAO reports. If we compare the result with the Figure 22 below, we can see that prices of wheat, grains, rice and fats and oils were higher than in early 1970s and after declining in 2009 started to rise once again.

Figure 22: Annual prices for food commodities



FAPRI and IFPRI create global models that are only concentrating on agricultural level; however they do not consider scarcity of land resources in their studies. They construct partial equilibrium models to estimate impact of biofuels production on food prices, agricultural production, food security, and international trade, with projections till 2016

[155] Dewbre et al. (2008), p.395

or 2020. “The impact of the development of biofuels is explored by introducing an exogenous demand for transportation.” IFPRI model analyses tree scenarios: first concentrating on recent boost in biofuel manufacture, without second generation biofuels, second, with second biofuel generation, third includes development in crop productivity. Findings are matched to a benchmark model and not include biofuel production. As IFPRI consider three scenarios, FAPRI does only one, though assess expected effect of biofuel production on agricultural markets till 2016.[156]

Hayes et al. (2009) try to estimate the relationship between biofuels and world agriculture, with help of partial equilibrium model. They implied in their analysis the Renewable Fuels Standard of the Energy Independence and Security Act of 2007 for consent the link between fossil energy and biofuel sectors, to integrate the corn production for ethanol and to permit for demand side effects of cellulosic ethanol manufacture. They pointed out that ethanol market has substantial and longtime problems with distributions shortage, which is worsen through greater consumption. The subsidies of the Energy Independence and Security Act induce large discount in corn ethanol prices and cellulosic biofuel. The distribution shortage could be solved through market forces. The problem is that refiners and petroleum distributors could yield returns from low ethanol prices. They also highlight, that ethanol blender’s credit and biofuels consumption subsidy are very supportive for corn ethanol production. In case when energy prices are high and RFS is excluded corn ethanol production rise. “When energy prices are low then corn ethanol production responds to corn ethanol mandates. The combination of these two supports effectively provides a price floor for ethanol and for corn.” The impact between biofuels and food commodities are shown. The energy prices have an effect on biofuel prices and food commodities prices. The authors raise very tempting question, if OPEC market power has direct impact on the agricultural market and if biofuel market could rise to the size that could erode OPEC’s market power.[157]

4.2 Multi-market Equilibrium Models

Over the 2001-2006 period the GTAP-E model with biofuels and Agro-ecological Zones analyses the impact of biofuels on global changes in crop yields, use, commodity prices, trade and land use transformation. The study not only focuses on high oil prices and

[156] Chakravorty et al. (2009), p.5
[157] Hayes et al. (2009) p.17

governments incentives of US and EU, as main factors for biofuel boom, but also implies the importance of MTBE replacement by ethanol as gasoline additive in the US. They measured mainly elasticity's of energy substitution between biofuels and petroleum in US, EU and Brazil and estimated the share of feedstock in biofuels. Birur et al. (2008) stress that there are many studies containing partial equilibrium frameworks, but in recent years there is stream to use a CGE framework. However these studies does not include policy issues, linkages to other energy markets and land use deviations, which Birur et al. (2008) study do.[158]

Banse et al. (2008) calculates the global and trade-specific consequences of the Biofuels Directive (BFD) of the European Union with the help of a multi-region computable general equilibrium model, which considers endogenous land of supply. The conclusions point out that without obligatory petroleum blending regulations or subsidies, the goals of the directive would not be achieved in 2010 and will not be met in 2020. As the other authors they also stress that obligatory blending regulation boost demand for biofuel feedstock and has significant effect on agriculture on the world and in Europe. Global and European land use changes have negative impact on biodiversity. The development in agricultural sector could cool down the long-term process of falling real agricultural prices. The simulation to boost production in the European Union will raise the land prices and farm returns. The EU is not capable to produce the needed feedstock to achieve the BFD goals and this will cause also higher agricultural trade shortage. Because of increased needed amount of biofuels feedstock in the EU, import from NAFTA countries particularly from Brazil will raise. High feedstock prices decline biofuel consumption outside the EU, but globally biofuels use boost, crude oil demand decline, which decreases world oil prices. The authors assume that European import of biofuels, will be taken under liberalization and that will cause raise biofuel demand in Europe up to 50 per cent.[159]

Al-Riffai et al. (2010) adopted, in their global computable general equilibrium model, the Renewable Energy Directive (RED), which imply 10% of renewable energy in fossil fuel by 2020 and GHG emissions saving to 50% in 2017. The directive also indicates which land may be converted. Another regulation, which they adopted, is Fuel Quality Directive (FQD), which have the same sustainability goals as RED has, however includes 6% restriction on lifecycle GHG emissions from fuels in the EU by 2020. Under

[158] Birur et al. (2008)
[159] Banse et al. (2008)

the request of the European Parliament and Council, European Commission estimates the indirect land use change (ILUC), with help of the four studies. The study of Al-Riffai et al. (2010) is one of these. They focus mainly on assess the effect of changes in EU biofuels trade regulations on global agriculture and environmental sector. They considered only first generation of biofuels. “Analysis of ILUC effects by crop indicates that ethanol, and particularly sugar-based ethanol, will generate the highest potential gains in terms of net emissions savings. […] The model also indicates that ILUC emission coefficients could increase with the size of the EU mandate. Simulations for EU biofuels consumption above 5,6% of the road transport fuels show that ILUC emissions can rapidly increase and erode the environmental sustainability of biofuels.”[160]

With the help of global dynamic computable general equilibrium model (GDCGE) Timilsina et al. (2010) tries to answer the questions about long-term effects of boosted biofuel production. They explore the effect of increased biofuels production on food availability and their prices; find out the winner and losers of higher food prices and assess changes of agricultural production. On the basis of two scenarios they estimated effect of biofuels production and trade. The first scenario includes biofuel targets by countries, which should be achieved till 2020, some countries achieved this goals even earlier, for example U.S., Brazil, Malaysia or South Africa. In case of Brazil, the targets were already meet in 2009 and the study does not include extra governmental regulations until 2020. The second scenario doubles the first scenario targets in the same period. In result corn produced in Argentina and Brazil will replace the corn form U.S. and Brazilian soybean will replace U.S. soybeans. The same would be in case of Brazilian ethanol; it could be perfect substitute for any importing country, also U.S. Another essential trade regulation, which study follow, is U.S. biofuel trade regulation, which imply an ethanol ad valorem tariff of 2,5% or 54 cents/gallon. “If demand expansion pushes the U.S. price to the Brazilian price inclusive of the tariffs, then Brazilian imports take place and the U.S. price moves in tandem with the Brazilian ethanol price.” Important policy element in the study for the U.S. for freezing Brazilian ethanol imports over large price band is tariff restriction.[161]

Hochman et al. (2010) estimate the impacts of biofuel and food crisis on energy environment and agricultural field using classic Hecksher-Ohlin model. They use it

[160] Al-Riffai et al. (2010), p. 12
[161] Timilsina et al. (2010), p.19

to adopt household production in general equilibrium model. This model is a general equilibrium model of international trade. The model is established on David Ricardo's theory of comparative advantage by forecasting patterns of production and trade seating on the dotation of a trading region. Findings shows that globalization and capital flows boost demand for energy, which have an negative impact on food production and thus raise food prices. World Energy Outlook 2008 reported that China and India contribute to 51% of boost in demand for primary energy in 2006 till 2030. We witness that in China foreign direct and governmental investments rise and concurred to economic growth. This caused boost in demand for energy and China become a main oil importer. China decided to cut biofuel production due to higher food prices, caused through land use changes. Hochman et al. 2010 presume that for optimal global achievements emission tax and land-use tax are needed. They estimate that without taxes on land conversion, carbon tax could induce loss of welfare and land tax and carbon tax are imperfect substitute. These regulations could lower the factor price equalization theorem.[162]

Previous study estimates effects of biofuels on food prices. This study considers mainly livestock sector. As the very fast growth of biofuels has had also significant effects for the global livestock sector, through increasing prices of feed grains and oilseeds and large amount of biofuel by-products used as livestock feed rations. The study of Taheripour et al. (2011) assesses the impact of biofuel on global livestock sector. They observed, that decline in livestock production, caused through increases in the U.S and EU biofuels production, are not in these countries, but abroad, because of "the international transmission of grains prices which is offset locally by the lower cost of by-products". They divided livestock on non-ruminant and ruminant, and says that the production of firsts decline more significantly than the other, because we cannot add biofuels by-products to non-ruminant feed. This study confirms that biofuels subsidies increment cultivated areas, which come from reduced grazing lands. The main country manufacturers of biofuels will cut coarse grains exports and boost imports of oilseeds and vegetable oils, because these boost their exports of manufactured feed materials. The biofuels subsidies have not only influence on feedstock prices but also livestock prices, as biofuel by-products can substitute feed product. Biofuel by-products such as Distillers Dried Grains with Soluble (DDGS) can be used as animal feed and substitute expensive feed crops. The DDGS can be used for ruminants (dairy

[162] Hochman et al. (2010)

and beef) and is considered as important biofuel yield. The prices of DDGS would by very low, if the livestock could not absorb them. Biofuel and livestock sector rival for crop inputs. The mutual reactions of these industries and energy market and the rest of economy are more complex. That is way the authors developed the model to determine the substantial evaluation of effects of biofuel on global livestock sector and show the links between them in Figure 31. Land market connects the biofuel, crop and livestock sectors, since these rivals for the land. The DDGS are used also to substitute high crop prices. The U.S. DDGS production boost to 19,9 billion metric tons and exports have raise by 3,7 million metric tons in 2001-2008 period. Compering quantity shares of major feedstuffs in the U.S. livestock feed, corn has decreased from about 82% to 74% and DDGS has increased 1,3% to 10,3% during 2001-2008 period. The 16,2 million metric tons of DDGS has substituted 15,5 million metric tons of corn, during the discussed period. As the rapeseed is a main feedstock for biodiesel in EU, the main by-product is rapeseed meal, this has increased from 13,8% to 23,8%. Secondary feedstock for biodiesel production is soybean, this by-product (soybean meal) has decreased from 76,5% to 65,5%, during the 2001-2008 period. In the same time period the U.S. DDGS prices boost by 46% and corn prices boost by 84%. In case of EU in the same time period the prices of rapeseed meal has declined in relation to soybean meal and wheat. “This suggests that biofuel by-products can help to offset some of the adverse cost implications of the biofuels boom for the livestock industry.”[163]

Chen et al. (2010) in their research assessed an effect of biofuel policies and subsidies on food and fuel prices. They constructed a dynamic, multi-market equilibrium model, called Biofuel and Environmental Policy Analysis Model (BEPAM), which compute the impact of biofuels mandates on acreage usage between food and fuel feedstock and food and fuel prices in 2007-2022 period. They consider biofuels not only from corn but also from cellulosic resources and handle Crop Reporting District (CRD) like decision making unit where gains from primary product differ in costs of the resource and cultivable land availability. Food and fuel prices are endogenously and yearly and are used to update price outlooks, feedstock land and acreage use choices.[164]

[163] Taheripour et al. (2011), p.325,327
[164] Chen et al. (2010)

4.3 Interactive Spreadsheet

The paper of Baier et al. (2009) estimates the contribution of biofuels on feedstock, such as corn, sugar, wheat, barley, soybeans and rapeseed oil, and global food prices[165] with help of interactive spreadsheet[166] that give the possibility to choose the country (world, US, EU, Brazil, rest of the world – Argentina, Canada, China), time period, supply and demand elasticities, and the size of indirect effects. This are calculated over the time period of 2 years, with possibility of changing between 1 year and 2 years, ending June 2008. Through this wide range of feasibilities the authors show how sensitive are the results and how challenging is calculating the impact of biofuels on food prices. The authors argue that the boost in biofuels manufacture in the studied period has significant effect on corn, sugar, barley and soybean prices, however very small on food prices. However as we can see from the Table 4, 5, 6, 7 below in each table on the example of beef, there is no direct effect of biofuels production, but indirect share of price increase of corn and beef in each country.[167]

Table 4: Effect of increased Biofuel Production on individual Commodity Price Series Worldwide[168]

	Effect of Increased Biofuel Production on Individual Commodity Price Series					
	Direct		Indirect		Total	
	Pushed up Price (pp)	Share of Price Increase (%)	Pushed up Price (pp)	Share of Price Increase (%)	Pushed up Price (pp)	Share of Price Increase (%)
Corn	20,04	12,37	7,01	4,32	27,05	16,69
Sugar	12,17	-73,02	0,00	0,00	12,17	-73,02
Wheat	0,33	0,42	8,06	10,26	8,39	10,68
Barley	0,46	0,37	16,75	13,35	17,21	13,72
Soybeans	10,13	6,53	11,24	7,25	21,38	13,78
Soybean Oil	10,18	6,48	11,24	7,16	21,42	13,63
Rapeseed Oil	18,51	21,90	0,00	0,00	18,51	21,90
Beef	0,00	0,00	2,61	16,39	2,61	16,39

Table 4 shows the effect of increased biofuel production on individual commodity price series worldwide. As we can observe the highest pushed up price is for corn (20,4) and rapeseed oil (18,51). This is due to the fact that U.S. is the leading manufacturer of ethanol form corn and EU is the main manufacturer of biodiesel form rapeseed oil. However if we observe indirect pushed up price is for barley (16,75) and soybean oil (11,24) and in indirect share of price increase for beef (16,39).

[165] They also took beef under consideration
[166] This spreadsheet can be downloaded on: http://www.federalreserve.gov/pubs/ifdp/2009/967/default.htm
[167] Baier et al. (2009)
[168] Taken from spreadsheet which can be downloaded on: http://www.federalreserve.gov/pubs/ifdp/2009/967/default.htm

Table 5: Effects of U.S. Biofuels Production on Individual Food Prices

	Effect of Increased Biofuel Production on Individual Commodity Price Series					
	Direct		Indirect		Total	
	Pushed up Price (pp)	Share of Price Increase (%)	Pushed up Price (pp)	Share of Price Increase (%)	Pushed up Price (pp)	Share of Price Increase (%)
Corn	18,73	11,56	3,33	2,05	22,06	13,61
Sugar	0,00	0,00	0,00	0,00	0,00	0,00
Wheat	0,00	0,00	6,35	8,08	6,35	8,08
Barley	0,00	0,00	10,46	8,34	10,46	8,34
Soybeans	5,09	3,28	10,22	6,59	15,31	9,87
Soybean Oil	5,12	3,26	10,22	6,51	15,34	9,76
Rapeseed Oil	0,07	0,08	0,00	0,00	0,07	0,08
Beef	0,00	0,00	2,18	13,67	2,18	13,67

Table 5 shows the effect of increased biofuel production on individual commodity price series in U.S. As we can observe the highest pushed up price is for corn (18,73) and soybean oil (5,12), as the ethanol in U.S. is made from corn and biodiesel from soybean oil. By indirect pushed up price effect, as in previous table, is the barley (10,46) and in indirect share of price increase is beef (13,67).

Table 6: Effects of Brazils Biofuels Production on Individual Food Prices

	Effect of Increased Biofuel Production on Individual Commodity Price Series					
	Direct		Indirect		Total	
	Pushed up Price (pp)	Share of Price Increase (%)	Pushed up Price (pp)	Share of Price Increase (%)	Pushed up Price (pp)	Share of Price Increase (%)
Corn	0,00	0,00	0,76	0,47	0,76	0,47
Sugar	12,17	-73,02	0,00	0,00	12,17	-73,02
Wheat	0,00	0,00	0,30	0,38	0,30	0,38
Barley	0,00	0,00	1,33	1,06	1,33	1,06
Soybeans	1,17	0,75	0,00	0,00	1,17	0,75
Soybean Oil	1,17	0,75	0,00	0,00	1,17	0,75
Rapeseed Oil	0,00	0,00	0,00	0,00	0,00	0,00
Beef	0,00	0,00	0,07	0,44	0,07	0,44

Table 6 shows the effect of increased biofuel production on individual commodity price series in Brazil. As we can observe the highest pushed up price is for sugar (12,17) as Brazilian ethanol is made from sugar. By indirect pushed up price effect, as in previous tables, is the barley (1,33) and in indirect share of price increase is also barley (1,06).

Table 7: Effect of EU Biofuels Production on Individual Food Prices

	Effect of Increased Biofuel Production on Individual Commodity Price Series					
	Direct		Indirect		Total	
	Pushed up Price (pp)	Share of Price Increase (%)	Pushed up Price (pp)	Share of Price Increase (%)	Pushed up Price (pp)	Share of Price Increase (%)
Corn	0,15	0,09	2,25	1,39	2,40	1,48
Sugar	0,00	0,00	0,00	0,00	0,00	0,00
Wheat	0,25	0,31	0,86	1,10	1,11	1,41
Barley	0,46	0,37	3,55	2,83	4,01	3,20
Soybeans	2,94	1,89	0,36	0,23	3,29	2,12
Soybean Oil	2,95	1,88	0,36	0,23	3,31	2,10
Rapeseed Oil	18,45	21,83	0,00	0,00	18,45	21,83
Beef	0,00	0,00	0,19	1,20	0,19	1,20

Table 7 shows the effect of increased biofuel production on individual commodity price series in EU. As we can observe the highest pushed up price is for rapeseed oil (18,45). This is due to the fact that the EU mainly produces biodiesel from rapeseed oil. By indirect pushed up price effect, as in previous tables, is the barley (3,55) and in indirect share of price increase is also barley (2,83).

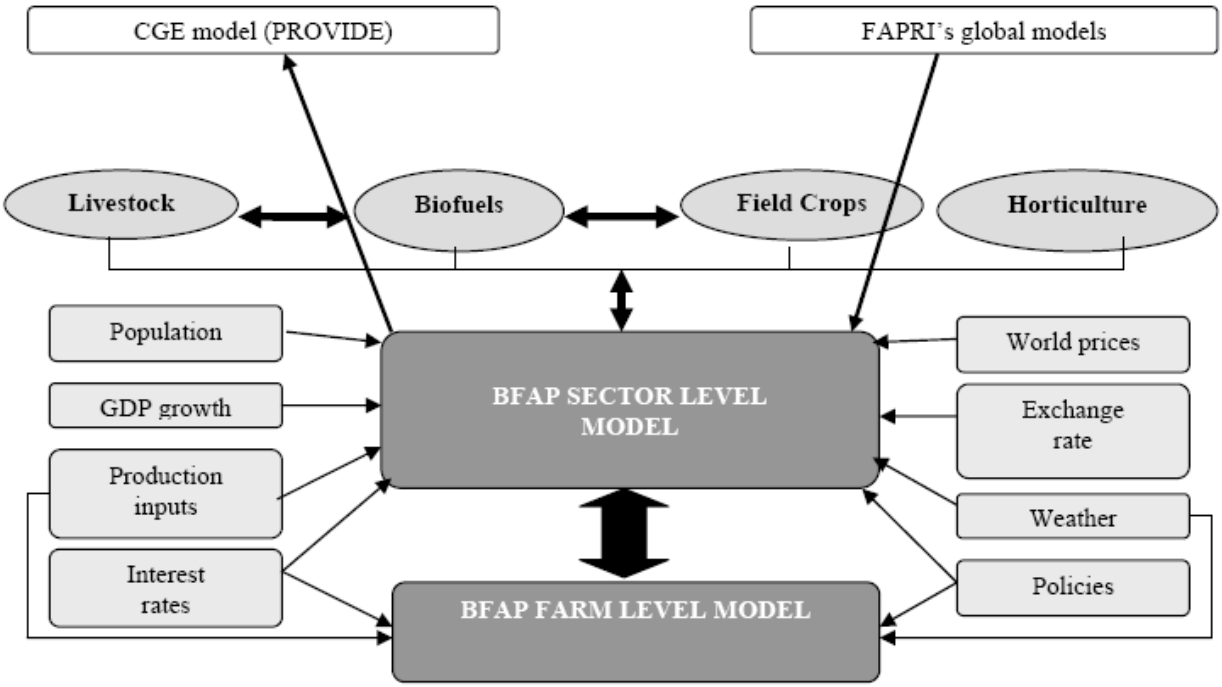
Over the June 2006 till June 2008, as the Table 4 shows, the worldwide biofuels manufacture pushed up corn, soybean oil, rapeseed oil and sugar prices by 27, 21, 18 and 12 percentage points in each case. In the case of corn, soybean and sugar prices the United States and Brazil accounts for the significant effect on these prices, in case of rapeseed oil is European Union. When we take U.S. ethanol and biodiesel production under consideration, then the prices of corn, soybeans are pushed up by 22, 15 percentage points in total. In the case of EU biofuels manufacture pushed corn and soybean prices up 3% points, but rapeseed by 18 percent. The US is mainly accountable for push up in corn prices, Brazil in sugar and EU in rapeseed oil. From the Tables above it is noticeable that biofuels had direct effect of commodities prices. The authors assessed that the boost in worldwide biofuels manufacture over 24 months period caused 12 percentage increase in the IMF's food price index, and respectively 7% by US, nearly 2% by EU, and almost 2% by Brazil. The authors emphasize that by computing impact of biofuels on food prices, elasticity's of supply and demand as also size of indirect effect and time periods play a very important role. They indicate that when ethanol has very significant effect on corn prices it has to be assumed that demand and supply curves are inelastic, which in their opinion is unrealistic due to the studied period. They argue that inelastic supply and significant indirect effect are inconsequent and these could misguide the reader. It is crucial to compare other studies and bring the differences to the light.[169]

4.4 Other Economic Models

Mayer et al. (2008) uses the Bureau for food and Agricultural Policy's (BFAP) sector model for simulation the effect of different cases of the possible biofuels industry and other related in South Africa during the period of 2007 and 2015. The BFAP sector model is combination of dynamic mechanism of econometric equations, which define relations across feedstock. This model includes six crops, five livestock and five dairy commodities and combines them with petrol, diesel, ethanol and biodiesel to give the simulation between them. Figure 23 demonstrate the associations between different industries and give a list of exogenous variables that could passible affect equilibrium in the market.[170]

[169] Baier et al. (2009)
[170] Mayer et al. (2008)

Figure 23: Basic structure of the system of equations for the BFAP model[171]



They present that absence of governmental support for biofuels has a significant impact in early phase on biofuels development and viability. The lack of imports tariffs give possibility for increase in biofuels production. They point out that 30% ad valorem import tariff increase the South African production of ethanol.[172]

The IFPRI policy brief includes the table of media reports on overseas land investments to secure food supplies in 2006-2009. In this table Africa plays a main role as a country in which the large investments from other countries are arranged. For example China invested in 2,8 million ha for biofuel oil palm plantation in Democratic Republic of Congo and in 2 million ha for biofuel from jatropha in Zambia. India spent 4 billion US dollar for flower growing and sugar estates in Ethiopia. Libya secured 100 000 ha for rice in Mali. This "large-scale land acquisitions may further jeopardize the welfare of the poor by depriving them of the safety-net function that this type of land and water use fulfills."[173]

As for consumers the food crisis has bad consequences, on the other hand farmers made a good deal. Tepe et al. (2009) used a two-factor asset pricing model; to measure the influence of biofuels policy on stock prices of sixteen companies in few agricultural inputs such seed, fertilizer, meat production and agricultural technology sectors.

[171] Meyer et al. (2008)
[172] Mayer et al. (2008)
[173] Braun and Meinzen-Dick (2009); p. 2

They found that corn prices increases have positive effects on excess stock returns for seed, fertilizer and farm equipment companies; however the effect on meat companies is adverse. There were statistical insignificance of result for meat production industry; over the study period one of the firms went into bankruptcy, because of the high corn prices. There are some speculations, which say, that agricultural industry would not grow so good without ethanol, which use major corn production. Corn futures markets are strongly dependent on corn biofuels legislation and demand of biofuels. Due to that fact company profitability and valuation will depend on corn prices. Prior supply shocks were the main issue affecting corn futures markets, because supply shocks are not stick, they can be refilled. Whereas supply shocks have long term impact on company profitability, stock price would have short term impact.[174]

In Germany after beneficial government policies, the manufacturers of biodiesel grew like the mushrooms after rain. Last year because of very high rapeseed prices few companies went into bankruptcy.

With the help of capital asset pricing model Gilbert (2010) shows why commodity prices peaks are better described by common indicators then by market once. He also calculates
on the basis of Granger causality test the impact of demand growth, monetary expansion and exchange rate movements over the time period since 1971 up to date. As already Zhang et al. (2009) mentioned Gilbert (2010) support the thesis that there is a not significant direct evidence that the demand of biofuels feedstock is the main key factor of the rising prices. But he exposed that index-based investment in agricultural future markets is the main indicator for food price increases.[175]

Zhang et al. (2009) emphasis that it is very important, when estimates the impacts of biofuels on commodity prices, to differentiate between short run and long rung factors. They used time-series prices on oil, gasoline, ethanol and corn, soybeans, wheat, sugar, rice to study the long-run co-integration of these prices at the same time with their multivariate short-run relations. The study show that there is no direct long-rung price effect between oil and gasoline on commodity prices and if any direct short-run relation. They assess that sugar prices have the modest impact on other commodity prices excluding rice in short-run price movements. Since sugar is the main feedstock

[174] Tepe et al. (2009)
[175] Gilbert (2010)

for ethanol production and biofuel production rises, it has a possibly impact on commodity prices in short-run. Sugar is a key factor of economic growth, since its production account 20% of GDP and employs 30% of the ACP workforce, so economic growth is parameter of short-run commodity price fluctuation. But in long-run time series rice is also influenced. “Overall, results support the effect of agricultural commodity prices as market signals which restore commodity markets to their equilibria after a demand or supply event (shock).” These lead to price inflation, however operating markets will try to abate these shocks. What is interesting in short and long time series corn prices are not affected by the price of ethanol, but through sugar, so there is no relation between U.S. ethanol and corn prices. Corn prices do not have any impact on other price commodity. On the contrary the corn prices are affected through soybean, sugar and rice prices. The thesis is that increasing biofuel prices caused high commodities prices through moving commodities from food to fuel manufacturing. However the study of Zhang et al. (2009) over the time-series does not support this thesis. High fuel prices are not directly causing inflated commodity prices. The main indicator for price inflation in commodities is high sugar prices, which is temporary, as competitive agricultural markets are decentralized. Microeconomic theory says that “competitive markets will efficiently respond to price signal. These transitory price impacts are caused by both crop yield and acreage response to shifts in relative agricultural prices.”[176]

5 Granger Causality Test

“The concept of Granger causality, put forward in Granger (1969), bears similarities with the concept of exogeneity in the sense that it allows us to draw inference on the dynamic impact of one variable on another. Such inference can be given an economically meaningful interpretation. This concept of causality draws upon the concept of forecastability. For example, for a bivariate series, the variable $y_{2,t}$ is said to be Granger-non-causal for $y_{1,t}$ if $E(y_{1,t}|Y_{1,t-1},Y_{2,t-1})=E(y_{1,t}|Y_{1,t-1})$, that is, the past of $y_{2,t}$ does not help in forecasting $y_{1,t}$. For the bivariate model, Granger non-causality of $y_{2.t}$ implies that $\Phi_{12}=0$.” The bivariate model:[177]

$$\begin{bmatrix} y_{1,t} \\ y_{2,t} \end{bmatrix} = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} a_{1,t} \\ a_{2,t} \end{bmatrix}$$

[176] Zhang et al. (2009), p.445, p.449
[177] Philip H. Franses (1998), p. 208

In this section Granger causality test is estimated with help of Eviews 6 (statistical, forecasting, modeling program) on long sample of monthly data from January 1991 to December 2010 for determining if one time series is useful in forecasting another. Through refining process of crude oil at 150°C we get gasoline. The gasoline is the product of petroleum and is blended with ethanol. The main feedstock in United States for ethanol is corn. For beef production corn is used as one of feed sources. The test is performed between: world petroleum crude prices (P) and U.S. Total Gasoline Retail Sales prices by Refiners (G); U.S. Total Gasoline Retail Sales prices by Refiners (G) and U.S ethanol prices (E); U.S. ethanol prices (E) and world maize prices (M) and world maize prices and world beef prices. The data are taken from World Bank Data (2011) and Official Nebraska Government Website (2011).

Figure 24: Petroleum and Gasoline prices 1991-2010[178]

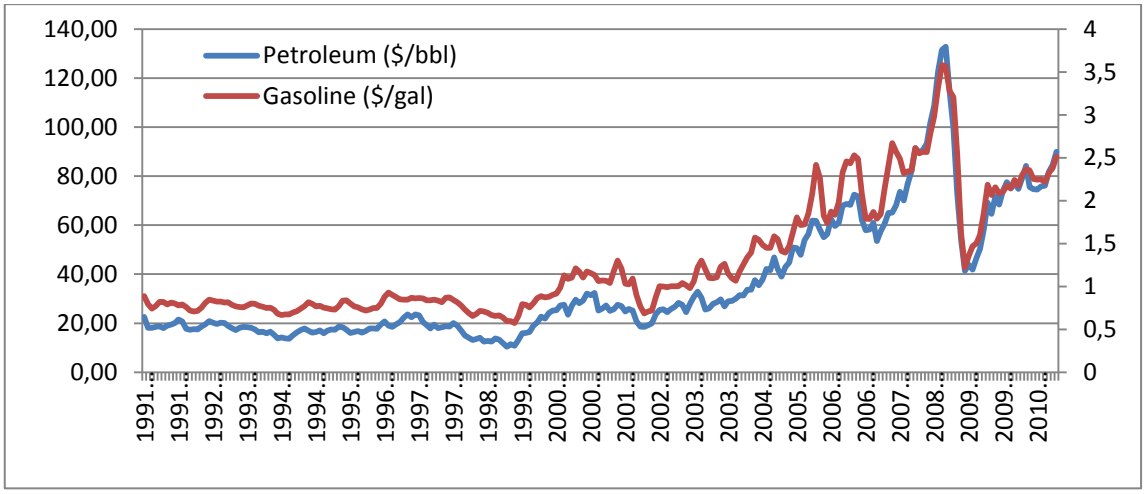
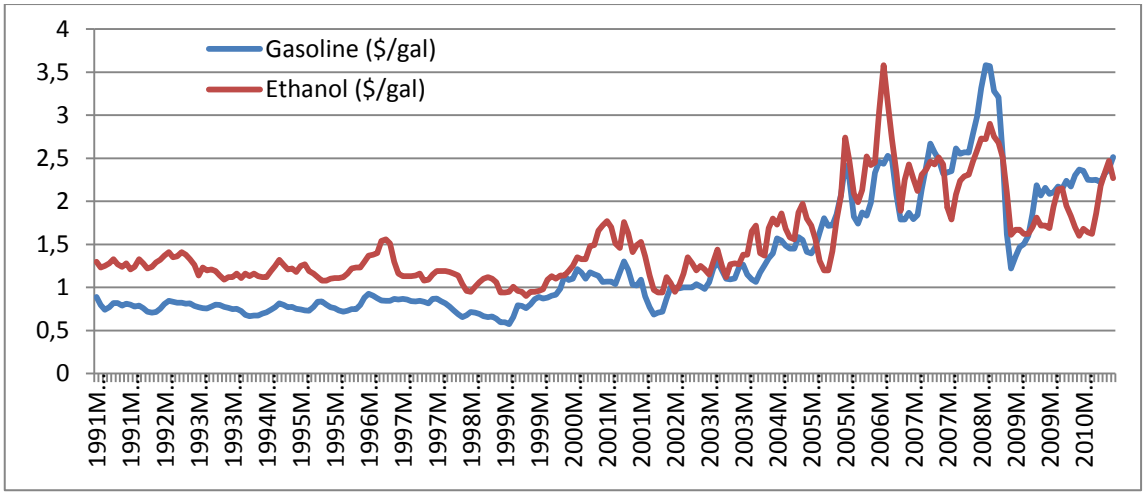


Figure 25: Gasoline and Ethanol prices 1991-2010[179]



[178] Data taken from: World Bank Data (2011) and Official Nebraska Government Website (2011)
[179] Data taken from: World Bank Data (2011) and Official Nebraska Government Website (2011)

Figure 26: Ethanol and Maiz 1991-2010[180]

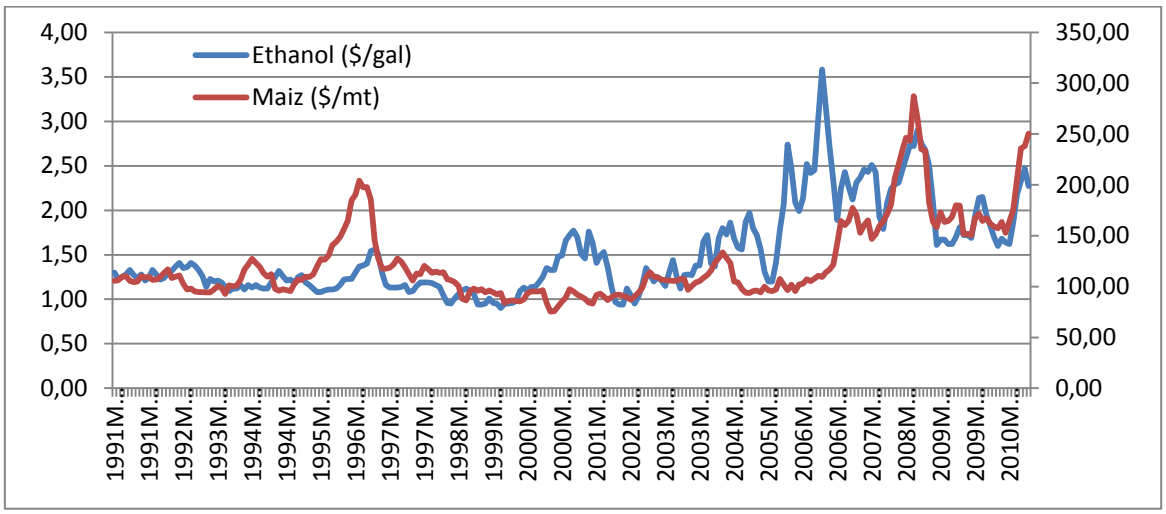
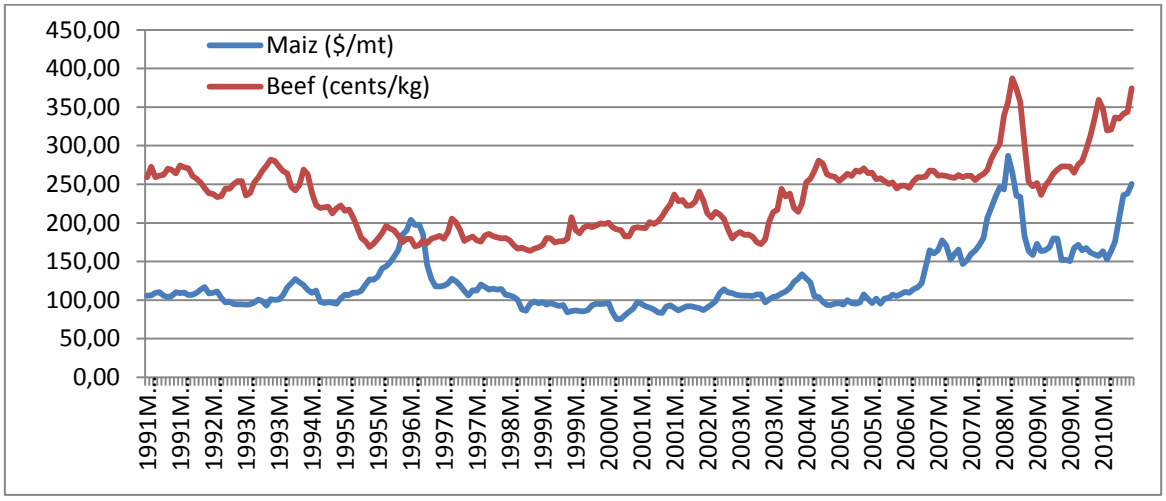


Figure 27: Maize and Beef prices 1991-2010[181]



From the figures 24, 25, 26 above we can see that there is a sharp escalation between 2003-2011 of the petroleum and gasoline, gasoline and ethanol, ethanol and maize prices. This happened due to the crisis. Figure 27 shows the prices of maize and beef. For Granger causality test we need non seasonal adjusted data. To proof if the data are non-stationary or not, the unit root test in Eviews 6 was estimated and shows that all data are non-stationary, that is way first difference was calculated and used in VAR model. If we want to get the appropriate results from Granger causality test the most important is the estimation of "Lag". With help of VAR Lag Order Selection Criteria in Eviews 6 the optimal number of lags was determined and differs depending on data included. The data sample of every pair compared is not divided in two periods (1991-

[180] Data taken from: World Bank Data (2011) and Official Nebraska Government Website (2011)
[181] Data taken from: World Bank Data (2011) and Official Nebraska Government Website (2011)

2001 and 2001-2011), because in case of the 10 years sample the test has a lower power and it's not able to distinguish a unit process from stationary process.

Campbell and Perron (2009) writes: "It turns out that for tests of the unit root hypothesis versus stationary alternatives the power depends very little on the number of observations per se but is rather influenced in an important way by the span of the data. For a given number of observations, the power is largest when the span is longest. For a given span, additional observations obtained using data sampled more frequently lead only to a marginal increase in power, the increase becoming negligible as the sampling interval is decreased […]. In most applications of interest, a data set containing fewer annual data over a long time period will lead to tests having higher power than if use was made of a data set containing more observations over a short time period. These results show that, whenever possible, tests of the unit root hypothesis should be performed using annual data over a long time period. This conclusion is reinforced by the fact that seasonal adjustment procedures often create a bias toward nonrejection of the unit root hypothesis […]."[182]

Null Hypothesis: LP has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.773605	0.8242
Test critical values:	1% level	-3.457747	
	5% level	-2.873492	
	10% level	-2.573215	

*MacKinnon (1996) one-sided p-values.

No rejection of the null hypothesis of unit root. LP (logarithmic transformed petroleum prices) has a unit root.

Null Hypothesis: LG has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.059341	0.7319
Test critical values:	1% level	-3.457865	
	5% level	-2.873543	
	10% level	-2.573242	

*MacKinnon (1996) one-sided p-values.

[182] Campbell and Perron (2009), pp. 153

No rejection of the null hypothesis of unit root. LG (logarithmic transformed gasoline prices) has a unit root.

Null Hypothesis: LE has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.991739	0.2904
Test critical values:	1% level	-3.457865	
	5% level	-2.873543	
	10% level	-2.573242	

*MacKinnon (1996) one-sided p-values.

No rejection of the null hypothesis of unit root. LE (logarithmic transformed ethanol prices) has a unit root.

Null Hypothesis: LM has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.405395	0.5794
Test critical values:	1% level	-3.457747	
	5% level	-2.873492	
	10% level	-2.573215	

No rejection of the null hypothesis of unit root. LM (logarithmic transformed maiz prices) has a unit root.

Null Hypothesis: LB has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.524050	0.5198
Test critical values:	1% level	-3.457747	
	5% level	-2.873492	
	10% level	-2.573215	

*MacKinnon (1996) one-sided p-values.

No rejection of the null hypothesis of unit root. LB (logarithmic transformed beef prices) has a unit root.

As already mentioned all the variables share a unit root process, the first difference is needed of all data for estimating a VAR model, because the VAR model have to be

estimated with stationary variables. On the end the granger causality test is proved for each pair with estimated optimal number of lag.

VAR Lag Order Selection Criteria – determine the optimal number of the lags. The optimum to perform the test is the smallest number of lag. The Schwarz information criterion is preferred in chosen the lag, because is most popular and effective as the other criterion.

LR – "the likelihood ratio (LR) test can pick the optimal lag order in the vector autoregressive model when the most applied information criteria (i.e. vector Schwarz–Bayesian, SBC and vector Hannan–Quinn, HQC) suggest two different lag orders. This lag-choosing procedure has been suggested by Hatemi-J (1999). The results based on the Monte Carlo simulations show that combining the LR test with SBC and HQC causes a substantial increase in the success rate of choosing the optimal lag order compared to cases when only SBC or HQC are used. This appears to be the case irrespective of homoscedasticity or conditional heteroscedasticity properties of the error-term in small sample sizes. This improvement in choosing the right lag order also tends to improve the forecasting capability of the underlying model."[183]

FPE – "Akaike's Final Prediction Error criterion provides a measure of model quality by simulating the situation where the model is tested on a different data set. After computing several different models, you can compare them using this criterion. According to Akaike's theory, the most accurate model has the smallest FPE."[184]

AIC – "The Akaike Information Criterion (AIC), (Akaike, 1974) is an objective measure of model suitability which balances model fit and model complexity, […] selection of the chosen model is then made by considering the minimum AIC=min(AIC(p)), than is the model with smallest AIC is chosen."[185]

SC – "The Schwarz information criterion (SIC,BIC,SBC), introduced by Schwarz (1978) as a competitor to the Akaike (1973,1974) information criterion (AIC), is one of the most popular and effective of the criteria used for model selection. Schwarz derived SIC to serve as an asymptotic approximation to a transformation of the Bayesian posterior

[183] Hatemi-J and Hacker (2009), Abstract
[184] See: http://www.mathworks.com/help/toolbox/ident/ug/bq5z7kv.html viewed on June 25, 2011
[185] Shittu and Asemota (2009), p. 410

probability of a candidate model. In large-sample setting, the fitted model favored by SIC ideally corresponds to the candidate model which is a posteriori most probable: i.e., the model which is rendered most plausible by the data at hand. The computation of SIC is based on the empirical log-likelihood and does not require the specification of priors."[186] Koehler and Murphree compare the AIC and SIC criterion and come to the conclusions that SIC is preferable to apply then AIC and leads to lower order models for forecasting.[187]

HQ – "The Hannan-Quinn Criterion for identifying an autoregressive model denoted by HQ(p) was introduced by Hann and Quinn (1979). The adjusted version of it can also be applied to regression models, […]. The best model is the model that corresponds to minimum HQ."[188]

VAR Lag Order Selection Criteria
Endogenous variables: DLP DLG[189]
Exogenous variables: C
Date: 06/23/11 Time: 13:13
Sample: 1991M01 2010M12
Included observations: 227

Lag	LogL	LR	FPE	AIC	SC	HQ
0	583.4903	NA	2.04e-05	-5.123262	-5.093086	-5.111086
1	628.5889	89.00526	1.42e-05	-5.485365	-5.394838	-5.448836
2	648.6047	39.14992	1.23e-05	-5.626474	-5.475595*	-5.565592
3	653.4349	9.362336	1.23e-05	-5.633787	-5.422557	-5.548553
4	658.9957	10.68072	1.21e-05	-5.647539	-5.375957	-5.537952
5	673.3532	27.32360	1.10e-05	-5.738795	-5.406861	-5.604855
6	679.0114	10.66830	1.09e-05	-5.753405	-5.361119	-5.595112
7	694.9939	29.85275	9.79e-06	-5.858977	-5.406341	-5.676332*
8	701.1949	11.47319	9.60e-06*	-5.878369*	-5.365381	-5.671371
9	702.6701	2.703455	9.82e-06	-5.856124	-5.282784	-5.624773
10	705.3731	4.905872	9.94e-06	-5.844697	-5.211006	-5.588993
11	708.7615	6.090142	9.99e-06	-5.839308	-5.145265	-5.559252
12	714.9111	10.94463*	9.81e-06	-5.858247	-5.103853	-5.553838

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

[186] http://myweb.uiowa.edu/cavaaugh/sic.pdf , viewed on June 25, 2011
[187] Koehler and Murphree (1988)
[188] Shittu and Asemota (2009), p 411
[189] DLP – first difference of logarithmic transformed petroleum prices; DLG – first difference of logarithmic transformed gasoline prices

Pairwise Granger Causality Tests
Date: 06/23/11 Time: 13:17
Sample: 1991M01 2010M12
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
DLG does not Granger Cause DLP	237	0.88691	0.4133
DLP does not Granger Cause DLG		9.08167	0.0002

DLG does not Granger Cause DLP 0,4133>0,05 no rejection of the H0 Hypothesis.
DLP does not Granger Cause DLG 0,0002<0,05 rejection of the H0 Hypothesis, that means for forecasting gasoline we should also consider petroleum prices.

VAR Lag Order Selection Criteria
Endogenous variables: DLG DLE[190]
Exogenous variables: C
Date: 06/23/11 Time: 13:18
Sample: 1991M01 2010M12
Included observations: 227

Lag	LogL	LR	FPE	AIC	SC	HQ
0	527.1377	NA	3.35e-05	-4.626764	-4.596588	-4.614588
1	560.0508	64.95628	2.60e-05	-4.881505	-4.790978	-4.844976
2	582.2076	43.33750	2.22e-05	-5.041477	-4.890598*	-4.980595*
3	585.1625	5.727512	2.24e-05	-5.032269	-4.821038	-4.947034
4	590.9827	11.17882	2.20e-05	-5.048305	-4.776724	-4.938718
5	596.8108	11.09148	2.17e-05*	-5.064413*	-4.732479	-4.930473
6	597.7678	1.804365	2.23e-05	-5.037602	-4.645317	-4.879309
7	600.2468	4.630256	2.26e-05	-5.024200	-4.571564	-4.841555
8	606.4132	11.40932	2.21e-05	-5.043288	-4.530300	-4.836290
9	607.2429	1.520468	2.28e-05	-5.015356	-4.442016	-4.784005
10	612.6527	9.818591*	2.25e-05	-5.027777	-4.394086	-4.772073
11	615.8128	5.679910	2.27e-05	-5.020377	-4.326334	-4.740321
12	621.1313	9.465585	2.24e-05	-5.031994	-4.277600	-4.727585

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

On the basis of the previous results (see SC) estimation of a VAR with two lags and the check for grange causality.

Pairwise Granger Causality Tests
Date: 06/23/11 Time: 13:18
Sample: 1991M01 2010M12
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
DLE does not Granger Cause DLG	237	0.21302	0.8083
DLG does not Granger Cause DLE		3.44094	0.0337

[190] DLG – first difference of logarithmic transformed gasoline prices; DLE – first difference of logarithmic transformed ethanol prices

DLE does not Granger Cause DLG 0,8083>0,05 no rejection of the H0 Hypothesis.

DLG does not Granger Cause DLE 0,0337<0,05 rejection of the H0 Hypothesis, that means for forecasting ethanol we should also consider gasoline prices.

VAR Lag Order Selection Criteria
Endogenous variables: DLE DLM [191]
Exogenous variables: C
Date: 06/23/11 Time: 13:19
Sample: 1991M01 2010M12
Included observations: 227

Lag	LogL	LR	FPE	AIC	SC	HQ
0	552.1170	NA	2.69e-05	-4.846846	-4.816670	-4.834670
1	577.2255	49.55331	2.24e-05	-5.032824	-4.942297	-4.996295
2	588.4651	21.98395	2.10e-05*	-5.096608*	-4.945730*	-5.035727*
3	590.8297	4.583487	2.13e-05	-5.082200	-4.870970	-4.996966
4	594.2204	6.512450	2.14e-05	-5.076832	-4.805250	-4.967244
5	597.4550	6.155739	2.15e-05	-5.070088	-4.738155	-4.936148
6	604.0327	12.40210*	2.11e-05	-5.092799	-4.700514	-4.934507
7	608.2109	7.804137	2.10e-05	-5.094369	-4.641733	-4.911724
8	609.4863	2.359831	2.15e-05	-5.070364	-4.557376	-4.863366
9	610.8190	2.442207	2.21e-05	-5.046863	-4.473524	-4.815512
10	613.2268	4.370133	2.24e-05	-5.032835	-4.399144	-4.777132
11	614.9393	3.078009	2.28e-05	-5.012681	-4.318638	-4.732625
12	618.1069	5.637448	2.30e-05	-5.005347	-4.250953	-4.700938

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Pairwise Granger Causality Tests
Date: 06/23/11 Time: 13:20
Sample: 1991M01 2010M12
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
DLM does not Granger Cause DLE	237	7.06632	0.0010
DLE does not Granger Cause DLM		1.85997	0.1580

DLM does not Granger Cause DLE 0,0010<0,05 rejection of the H0 Hypothesis, that means for forecasting ethanol we should also consider maiz prices.

DLE does not Granger Cause DLM 0,1580>0,05 no rejection of the H0 Hypothesis.

[191] DLE – first difference of logarithmic transformed ethanol prices; DLM – first difference of logarithmic transformed maize prices

VAR Lag Order Selection Criteria
Endogenous variables: DLM DLB [192]
Exogenous variables: C
Date: 06/23/11 Time: 13:21
Sample: 1991M01 2010M12
Included observations: 227

Lag	LogL	LR	FPE	AIC	SC	HQ
0	715.1143	NA	6.40e-06	-6.282945	-6.252769	-6.270769
1	735.6853	40.59823*	5.53e-06*	-6.428945*	-6.338418*	-6.392416*
2	739.3575	7.182677	5.55e-06	-6.426057	-6.275178	-6.365175
3	741.7927	4.720213	5.63e-06	-6.412270	-6.201040	-6.327036
4	743.4183	3.122269	5.75e-06	-6.391350	-6.119768	-6.281763
5	747.8086	8.355168	5.73e-06	-6.394789	-6.062856	-6.260849
6	751.5583	7.069888	5.74e-06	-6.392584	-6.000299	-6.234291
7	754.1867	4.909382	5.81e-06	-6.380499	-5.927863	-6.197854
8	757.1384	5.461408	5.87e-06	-6.371264	-5.858275	-6.164265
9	757.9957	1.571060	6.03e-06	-6.343574	-5.770235	-6.112224
10	759.7496	3.183326	6.15e-06	-6.323785	-5.690094	-6.068082
11	761.6269	3.374079	6.27e-06	-6.305083	-5.611040	-6.025026
12	763.5665	3.451949	6.39e-06	-6.286929	-5.532535	-5.982520

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Pairwise Granger Causality Tests
Date: 06/23/11 Time: 13:22
Sample: 1991M01 2010M12
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
DLB does not Granger Cause DLM	238	0.27573	0.6000
DLM does not Granger Cause DLB		0.35796	0.5502

DLB does not Granger Cause DLM 0,6000>0,1 no rejection of the H0 Hypothesis.

DLM does not Granger Cause DLB 0,5502>0,1 no rejection of the H0 Hypothesis.

The Zhang et al. (2009) assess that in the long-run (March 1989 through July 2008) on monthly price data oil prices are affecting gasoline prices which influence ethanol prices. Balcombe and Rapsomanikis (2008) studied the sugar-ethanol-oil relationship in Brazil. The effect was that in long-run oil prices drives ethanol and sugar prices Granger-cause ethanol prices.[193] In this paper granger causality test is estimated also with relation between crude oil and gasoline and gasoline and ethanol and estimate that during the period 1991 till 2010 for forecasting gasoline it is important to use petroleum data and for ethanol it is important to use gasoline and maize prices. In case of maize

[192] DLM – first difference of logarithmic transformed maize prices; DLB – first difference of logarithmic transformed beef prices
[193] Zhang et al. (2009)

and beef there is no causal relation. As there is direct effect between: crude oil prices and gasoline; ethanol and gasoline and maize, but no effect between maize and beef, there is an assumption that the indirect effect of crude oil and beef not exists, as also the indirect effect between ethanol and beef, also not exist, however direct effect between ethanol and maize exists.

Gilbert (2010) used quarterly data and run Granger causality test to assess the impacts of demand growth, monetary expansion and exchange rate movements over the period 1971-2008. He found, that effect of commodity prices changes "are seen as the result of largely idiosyncratic supply shocks", which not help to analyze the price boom, because the prices rise together. He argues that market explanations need a lot of factors and subsequent price responses to the crisis could be not appropriated.[194]

6 Summary

"Regardless of its contribution to rising food prices, corn ethanol is not making a significant contribution to the energy security and environmental goals set for it and the policies promoting it are costly to taxpayers and the environment."[195]

Since 1960 crude oil prices rise continuously, due to its shortage and achieved in July 2008 the highest till now price - 132,83$/bbl. After 2008 despite of short time price decreases, caused through speculations, oil prices began to rise once again and in April 2011 the price of crude oil barrel amounted 116,24 $/bbl.

"On the demand side, 99% of energy services in the transportation sector are currently provided by petroleum." Biodiesel and Bioethanol, which require cropland for production, amount only 1% of world renewable energy supply. They also account for 1,8% of the world's transportation fuels, with 90% of ethanol and 10% of biodiesel. By the year 2030 the world's liquids consumption will rise up to two-thirds.[196]

The analysts warn that in long time period we can observe steady upward trend for crude oil prices. That pushed developed countries, which consume huge amounts of petroleum to obligatory blending of diesel and petrol with blending agent. The most popular blending agents are ethanol for petrol and rapeseed ethyl ester for diesel.

[194] Gilbert (2010), p.419
[195] Elliot et al. (2008), p.3
[196] Chakravorty et al. (2009), p.3

The blending agents account for nonrenewable fuel vary widely through countries (1% in case of Australia and 5,75% in case of European Union)[197]. The blending agents are made form 100% agricultural production. In short time perspective blending agents blended with petrol or diesel should help to substitute petroleum. However as the Figure 32 shows the prices for blending agents in case of biodiesel are higher than crude oil prices.

There is definitely the linkage between biofuels and food, as the both are produce from the same feedstock. However the food prices are influenced through the variety of factors, which differ widely, taking into account time periods and macro/micro economics factor. Due to these numerous reasons for food price jump, it is very difficult to estimate the degree of this linkage. A lot of studies, which measured this impact, also vary wildly over time periods and methodologies.

Also important impact of the food price crisis is increasing acquisition of farmland in developing countries by other countries. Due to information from policy brief "China started leasing land for food production in Cuba and Mexico 10 years ago and continues to search for new opportunities to feed its large population."[198]

The journalists warn "If biofuels take off, they will cause a global humanitarian disaster." They do not harm, when used on small scale. In UK thousand greens refuel their cars with used chip fat.[199] The same can be observed in Poland. However rising crude oil prices cause rise of blending agent's prices, which have an effect on agricultural commodities prices. The farmers are cultivating these crops, which bring them highest returns. When yields from biofuels crop production will be higher than from crops for food or feed production, they will choose to yield crops for biofuel production. If the biofuels second generation, which would be the perfect substitute for petrol, diesel, bioethanol and biodiesel, will not enter the market soon the food prices (meet, dairy products) will still rise at the same time with crude oil prices.

However Timilsina and Shrestha (2010) argue that second generation biofuels developments are some hope, but need technical and economic support and still rival

[197] See Table 8 in annex
[198] Braun and Meinzen-Dick (2009), p. 1
[199] The Guardian (2004): http://www.guardian.co.uk/politics/2004/nov/23/greenpolitics.uk viewed: March 20, 2011

with food, because of land usage.[200] Ford is cooperating with VeraSun on campaign to promote E85 stations. In Canada Shell is running the first sizeable manufacture of cellulosic ethanol plant in Ottawa and Exxon Mobil has committed $100 million to Stanford University for exploration an alternative fuel topics.[201]

Biofuels should have been a solution to mitigating climate change and should achieve energy security. As we can observe from the summarized literature the opinion about that are divided. There is a potential in biofuels, however not in the first generation, because these compete with food, as the acreage is used for them and not for food. There are other possibilities for biofuels production, which are more appropriate. The accelerated investment in biofuels second generation would bring biofuels, which are more efficient and do not compete with food. There are already projects which are using this generation, but only on a small scale. Thus it is important to do more researches and investment in this direction. The European Union should start to promote these generation as the United States do, because the EU has less cultivated areas and in the long term it will cause rise in food prices.

“Biofuel may compete for renewable and nonrenewable resources and thus impact its sustainability and that of food.”[202]

[200] Timilsina and Shrestha (2010)
[201] Fortune (2006), http://money.cnn.com/magazines/fortune/fortune_archive/2006/02/06/8367959/index.htm viewed on May 10, 2011
[202] Zhang et al. (2009), p.445

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Annex

Table 8: Summary of biofuel targets[203]

Countries	Targets	Comments	Blending Mandates
Australia	1% by 2010 – or at least 350 million liters of ethanol or biodiesel		E2 in New South Wales, increasing to E10 by 2011 E5 in Queensland by 2010
Argentina	5 percent by 2009		E5 and B5 by 2010
Bolivia			B2,5 by 2007 and B20 by 2015
Brazil	An incorporation rate of 2 percent for biodiesel is compulsory, growing into 5 % by 2013.In 2006 all gasoline sold in Brazil must contain between 20- 25 % ethanol blend (by volume), 40% increase in production of Ethanol during 2005-2010	Focus is on ethanol from sugar cane	E22 to E25 existing; B3 by 2008 and B5 by 2013
Canada	Official target: 3,5% by 2010 (Ethanol)		E5 by 2010 and B2 by 2012; E7,5 in Saskatchewan and Manitoba; E5 by 2007 in Ontario
Chile			E5 AND B5 by 2008 but not obligatory
China	Biofuel development policies are aiming to increase ethanol production to 6 million tonnes by 2010 and 15 million by 2020. (By way of comparison, the US was expected to produce 24,6 million tonnes in 2007) 12 million metric tons of biodiesel by the year 2020. So 15% of total renewable fuels by 2020	Up until September 2007, the main biofuel produced was ethanol from maize. Since then China's government has announced an "Agriculture Biofuels Industry Plan" which implements a shift away from food grain ethanol feedstock to non-food crops inputs such as sweet sorghum and cassava	E10 in 9 provinces
Colombia			E10 and B10 existing
Dominican Republic			E15 and B2 by 2015
Germany	5,75% by 2010, 10% by 2020	The 2020 target is subject to the sustainability rules as well as the commercial availability of second generation biofuels	E5,25 and B5,25 in 2009; E6,25 and B6,25 from 2010 till 2014

[203] The table is author's construction based on: Pfuderer and del Castillo (2008), pp. 5 Table2: Summary of biofuels targets; Timilsina and Shrestha (2010), p.12 Table2: Biofuels Targets and Blending Mandates; Al-Riffai et al. (2010), p. 114 Table21: Current official targets on share of biofuel in total road-fuel consumption

Countries	Targets	Comments	Blending Mandates
India	The sugar mills are now permitted to convert cane juice directly into ethanol – previously molasses were the only permitted feedstock		E5 by 2008 and E20 by 2018; E10 in 13 states[204]
Italy	5,75% share of biofuels in transport by 2010; 10% by 2020		E1 and B1
Jamaica			E10 by 2009
Japan	The government has provided goals to use 500 million liters of fuel derived from biomass in fuel for transport by 2010, through promoting the use of E3. This would be a prelude to a national E10 blend standard by 2010 20% of total oil demand met with biofuels by 2030	Ethanol dominates biofuels in Japan. Currently, fuel-use ethanol is not made or used commercially in Japan while only about 200 kl of biodiesel is produced annually	
Korea			B3 by 2012
Malaysia	An objective has been adopted for biodiesel incorporation to reach 5 % by volume of standard diesel consumed	Biodiesel from palm oil	B5 by 2008
New Zealand	3,4% total biofuels by 2012		
Paraguay			B1 by 2007, B3 by 2008, and B5 by 2009; E18 or higher already exists
Peru			B2 in 2009; B5 by 2011; E7,8 by 2010
Philippines			B1 and E5 by 2008; B2 and E10 by 2011
South Africa			E8-E10 and B2-B5 proposed
Thailand	Its targets for biofuel use in 2010 equate to 2 % of projected energy needs 3% biodiesel share by 2011; 8,5 million liters of biodiesel production by 2012		E10 by 2007 and B10 by 2012
United Kingdom			E2,5/B2,5 by 2008; E5/B5 by 2010
Unites States	US Energy Bill was ratified in August 2005 and fixes the quantity of renewable fuels that must be consumed in 2012 at 7,5 billion gallons. 2,78% Ethanol by 2006. The 2007 Act requires 15 billion gallons fuel ethanol by 2015 and 36 billion gallons fuel ethanol by 2022 130 billion liters/year of biofuels nationally by 2022 3,4 billion liters/year by 2017 Pennsylvania	Note that under the new act, 21 billion gallons of the 36 stated by the act will need to be produced by advanced biofuels by 2022	E10 in Iowa, Hawaii, Missouri; and Montana; E20 in Minnesota; B5 in New Mexico; E2 and B2 in Louisiana and Washington State
Uruguay			E5 by 2014, B2 from 2008-2011 and B5 by 2012

[204] "Poor sugar cane yields in 2003 to 2004 forced India to import ethanol to meet state blending targets. It has postponed broader targets until adequate domestic supplies become available." Timilsina and Shrestha (2010), p.12 Table2: Biofuels Targets and Blending Mandates

Table 9: Summary of biofuel advantages and disadvantages[205]

PRO	CONTRA
+ Decline of the emissions of gases producing the greenhouse effect, especially CO_2 – biomass through their lives absorb CO_2 and emitted the same amount when biomass is burned ○ But that would mean that biomass used is 100% renewable – so in the same period biomass use rate must be equal to the new biomass cultivation rate ○ Cut and renewable biomass must absorb equal amounts of CO_2	− Enormous production of biofuel can cause the increase of gases contributing to the greenhouse effect ○ Usage of fossil transportation fuels for biomass collection, transportation and biofuels distribution ○ Deforestation or clearing of grasslands to be used for biomass cultivation
+ Reduced SO_2 emissions, because low content of biomass in sulfur ○ But because of supply system which uses nonrenewable fuels this advantage exist not any more	− Increased biofuel production increases food prices, due to change of usage of cultivated land from food to biomass
+ Biofuels input to the fossil fuels decomposition on the basis of NER – varies significantly	− Huge global demand of agricultural products, which is not satisfied
+ Positive impact of biofuels on regional development and sustainability	

[205] Author's construction based on: Petrou and Pappis (2009), pp. 1062

Figure 28: Bioethanol Yield in Gallons per Acre from Selected Crops[206]

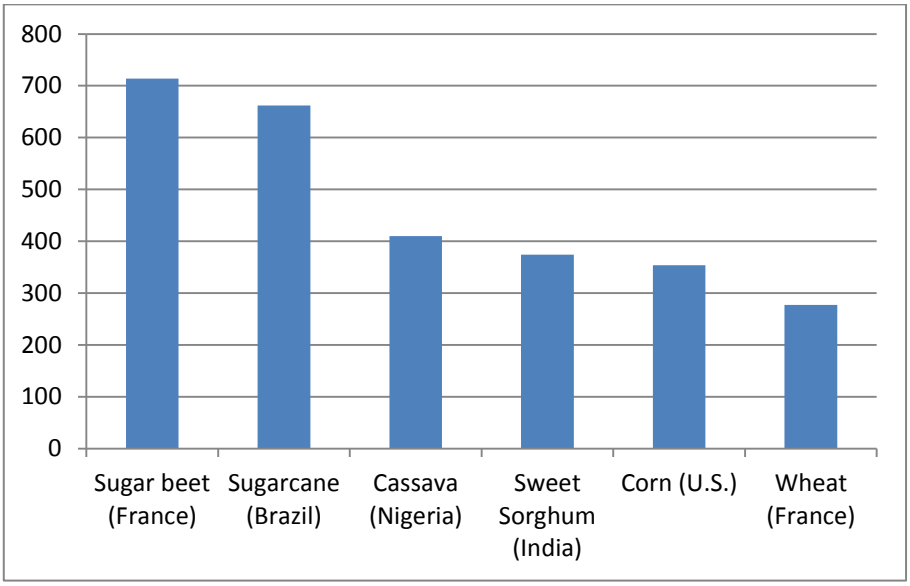
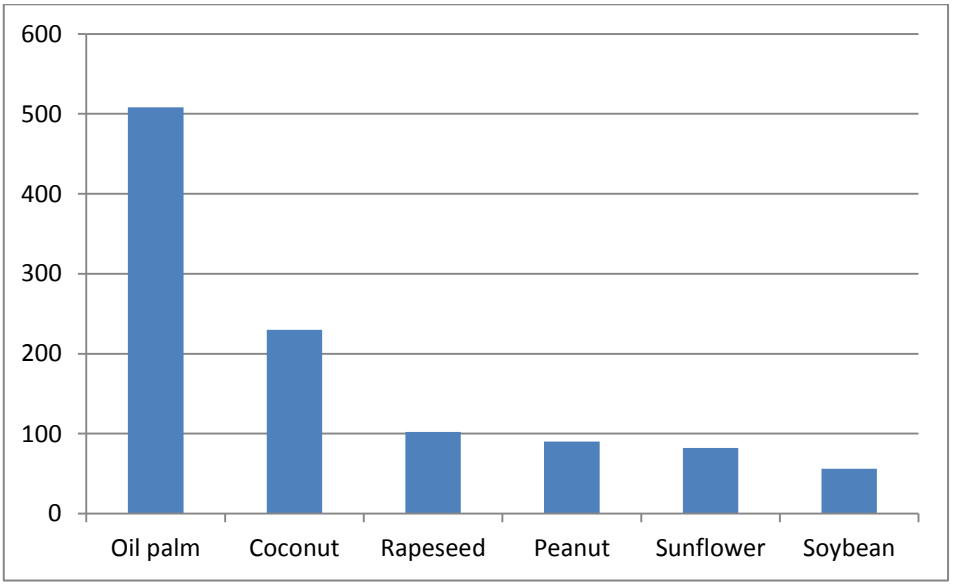


Figure 29: Biodiesel Yield in Gallons per Acre from Selected Crops[207]



[206] Author's construction data taken from Earth Policy Institute (2011) viewed on May 21, 2011 taken from Chapter 2, "Beyond the Oil Peak," in Lester R. Brown, **Plan B 2.0: Rescuing a Planet Under Stress and a Civilization in Trouble** (New York: W.W. Norton & Company, 2006).
Note: "Crop yields can vary widely. Ethanol yields given are from optimal growing regions. Biodiesel yield estimates are conservative. The energy content of ethanol is about 67 percent that of gasoline. The energy content of biodiesel is about 90 percent that of petroleum diesel."

[207] Author's construction data taken from Earth Policy Institute (2011) viewed on May 21, 2011 taken from Chapter 2, "Beyond the Oil Peak," in Lester R. Brown, **Plan B 2.0: Rescuing a Planet Under Stress and a Civilization in Trouble** (New York: W.W. Norton & Company, 2006).
Note: "Crop yields can vary widely. Ethanol yields given are from optimal growing regions. Biodiesel yield estimates are conservative. The energy content of ethanol is about 67 percent that of gasoline. The energy content of biodiesel is about 90 percent that of petroleum diesel."

Table 10: Majors drivers of Ethanol Boom in the U.S. and EU-27[208]

	Units	2001	2006	Change 2001-2006
Average crude oil price	*2006 $ / barrel*	25.29	59.69	**136.0%**
United States				
Average gasoline price[1]:	*2006 $ / gallon*	1.20	2.13	77.5%
Fuel ethanol oxygenate production:	*billion gallons*	1.76	4.86	3.10
MTBE oxygenate production:	*billion gallons*	3.26	1.29	-1.97
Additives = Ethanol + MTBE:	*billion gallons*	5.02	6.15	
Share of MTBE to additives:		65%	21%	-68%
Share of ethanol to additives:		35%	79%	125%
Decline in MTBE additive demand:	= 1/-1.97			0.51
Increase in ethanol additive demand (*-af*)	= ((0.51 -1)/1) *100			**-49.24%**
Ethanol:				
Average price	*$ / gallon*	1.48	2.58	74.3%
Federal Subsidy	$ / gallon	0.51	0.51	
ADV equivalent of subsidy[2]	%	1.34	1.20	**-10.9%**
Biodiesel:				
Average price	*$ / gallon*	2.45	3.23	31.8%
Federal Subsidy	$ / gallon	1	1	
ADV equivalent of subsidy[2]		1.41	1.31	**-7.0%**
EU-27				
Ethanol[3] :				
Average Price	$ / gallon	1.48	1.96	32.4%
Tax credit	$ / gallon	-	0.995	
ADV equivalent of tax credit[2]	%	1.00	1.508	**50.77%**
Biodiesel[4] :				
Average Price	$ / gallon	2.33	2.34	0.6%
Tax credit	$ / gallon	-	1.898	
ADV equivalent of tax credit[2]	%	1.00	1.812	**81.18%**

Note: [1] Gasoline prices exclusive of taxes.
[2] *Ad valorem* equivalent of federal subsidy in the US and tax credit in the EU-27.
[3] Ethanol price and the tax credit in the EU refers to France market.
[4] Biodiesel price and tax credits are production share weighted averages of major biodiesel producing countries in the EU-27.

[208] Table taken from Birur et al. (2008), p.42, Author took the information from EIA, EERE, Nebraska Ethanol Board, Lincoln, NE and Nebraska Energy Office, Lincoln, NE.

Table 11: Diesel and Biodiesel excise taxes in the European Union ($/liter)[209]

	GTAP Consumption weight	Diesel tax 2004 dollar/liter			Biodiesel tax exemption 2004 dollar/liter			Biodiesel tax 2004 dollar/liter		
		2005	2006	2007	2005	2006	2007	2005	2006	2007
AUT	0,015	0,371	0,368	0,368	0,397	0,409	0,403	-0,025	-0,041	-0,035
BEL	0,028	0,407	0,423	0,407	0,000	0,459	0,202	0,407	-0,036	0,204
BGR	0,003									
CYP	0,001									
CZE	0,012	0,411	0,435	0,435	0,384	0,409	0,411	0,027	0,026	0,025
DEU	0,200	0,583	0,583	0,583	0,583	0,508	0,000	0,000	0,074	0,583
DNK	0,009	0,502	0,501	0,501	0,037	0,434	0,440	0,464	0,067	0,061
ESP	0,079	0,365	0,365	0,374	0,335	0,335	0,335	0,030	0,030	0,040
EST	0,001									
FIN	0,005	0,396	0,396	0,396	0,000	0,000	0,396	0,396	0,396	0,000
FRA	0,176	0,517	0,517	0,531	0,409	0,409	0,310	0,108	0,108	0,221
GBR	0,160	0,304	0,304	0,342	0,000	0,000	0,322	0,304	0,304	0,020
GRC	0,012	0,859	0,857	0,879	0,397	0,360	0,358	0,462	0,497	0,521
HUN	0,012	0,409	0,399	0,399	0,422	0,422	0,422	-0,012	-0,022	-0,022
IRL	0,006	0,456	0,456	0,456	0,459	0,459	0,456	-0,002	-0,002	0,000
ITA	0,129	0,506	0,512	0,516	0,471	0,512	0,474	0,035	0,000	0,042
LTU	0,002									
LUX	0,002	0,339	0,345	0,360	0,057	0,062	0,000	0,281	0,283	0,360
LVA	0,002									
MLT	0,000									
NLD	0,027	0,453	0,453	0,460	0,000	0,384	0,378	0,453	0,068	0,082
POL	0,030	0,320	0,362	0,363	0,000	0,310	0,322	0,320	0,052	0,041
PRT	0,022	0,386	0,389	0,451	0,000	0,000	0,000	0,386	0,389	0,451
ROM	0,006									
SKV	0,006	0,466	0,482	0,482	0,434	0,434	0,476	0,032	0,048	0,006
SLK	0,003									
SWE	0,019	0,472	0,491	0,498	0,459	0,484	0,484	0,013	0,007	0,015
EU27		0,439	0,442	0,454	0,311	0,338	0,260	0,128	0,105	0,193

[209] Table taken from Al-Riffai et al. (2010), p.115

Table 12: Gasoline and Ethanol excise taxes in the EU ($/liter)[210]

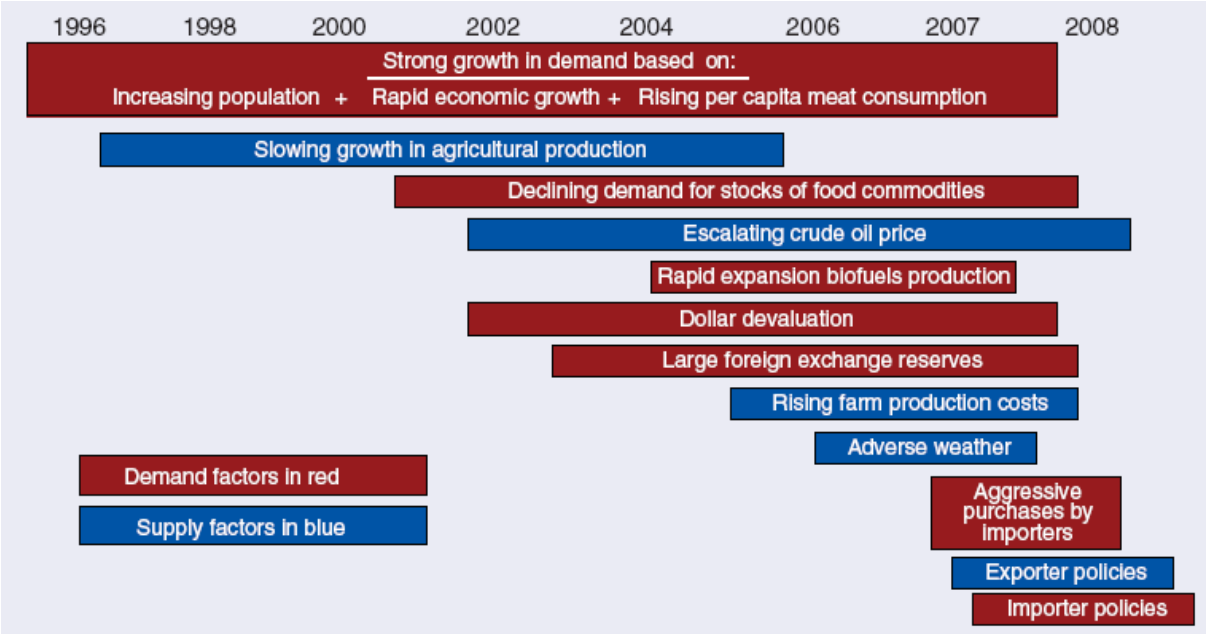
	GTAP Consumption weight	Gasoline tax 2004 dollar/liter			Ethanol tax exemption 2004 dollar/liter			Ethanol tax 2004 dollar/liter		
		2005	2006	2007	2005	2006	2007	2005	2006	2007
AUT	0,015	0,517	0,517	0,517	0,533	0,533	0,552	-0,016	-0,016	-0,035
BEL	0,028	0,682	0,734	0,734	0,000	0,732	0,438	0,682	0,002	0,296
BGR	0,003									
CYP	0,001									
CZE	0,012	0,489	0,518	0,518	0,372	0,037	0,037	0,117	0,481	0,481
DEU	0,200	0,812	0,812	0,812	0,806	0,806	0,123	0,006	0,006	0,690
DNK	0,009	0,672	0,677	0,677	0,347	0,347	0,000	0,325	0,330	0,677
ESP	0,079	0,491	0,491	0,491	0,459	0,459	0,461	0,032	0,032	0,030
EST	0,001									
FIN	0,005	0,729	0,729	0,729	0,000	0,000	0,000	0,729	0,729	0,729
FRA	0,176	0,730	0,730	0,753	0,471	0,471	0,409	0,259	0,259	0,343
GBR	0,160	0,367	0,367	0,410	0,000	0,000	0,000	0,367	0,367	0,410
GRC	0,012	0,859	0,857	0,879	0,347	0,347	0,358	0,512	0,510	0,521
HUN	0,012	0,498	0,486	0,486	0,508	0,508	0,513	-0,011	-0,022	-0,027
IRL	0,006	0,549	0,549	0,549	0,546	0,546	0,549	0,004	0,004	0,000
ITA	0,129	0,686	0,699	0,699	0,000	0,000	0,000	0,686	0,699	0,699
LTU	0,002									
LUX	0,002	0,548	0,548	0,573	0,097	0,099	0,000	0,451	0,449	0,573
LVA	0,002									
MLT	0,000									
NLD	0,027	0,826	0,828	0,842	0,000	0,620	0,626	0,826	0,208	0,216
POL	0,030	0,429	0,444	0,525	0,000	0,459	0,484	0,429	-0,015	0,041
PRT	0,022	0,670	0,692	0,723	0,000	0,000	0,000	0,670	0,692	0,723
ROM	0,006									
SKV	0,006	0,498	0,516	0,516	0,459	0,459	0,461	0,039	0,057	0,055
SLK	0,003									
SWE	0,019	0,660	0,668	0,678	0,682	0,682	0,657	-0,022	-0,014	0,021
EU27		0,605	0,610	0,625	0,325	0,372	0,214	0,280	0,238	0,411

[210] Table taken from Al-Riffai et al. (2010), p.116

Table 13: An Illustration of the Factors in the Food Price Crisis[211]

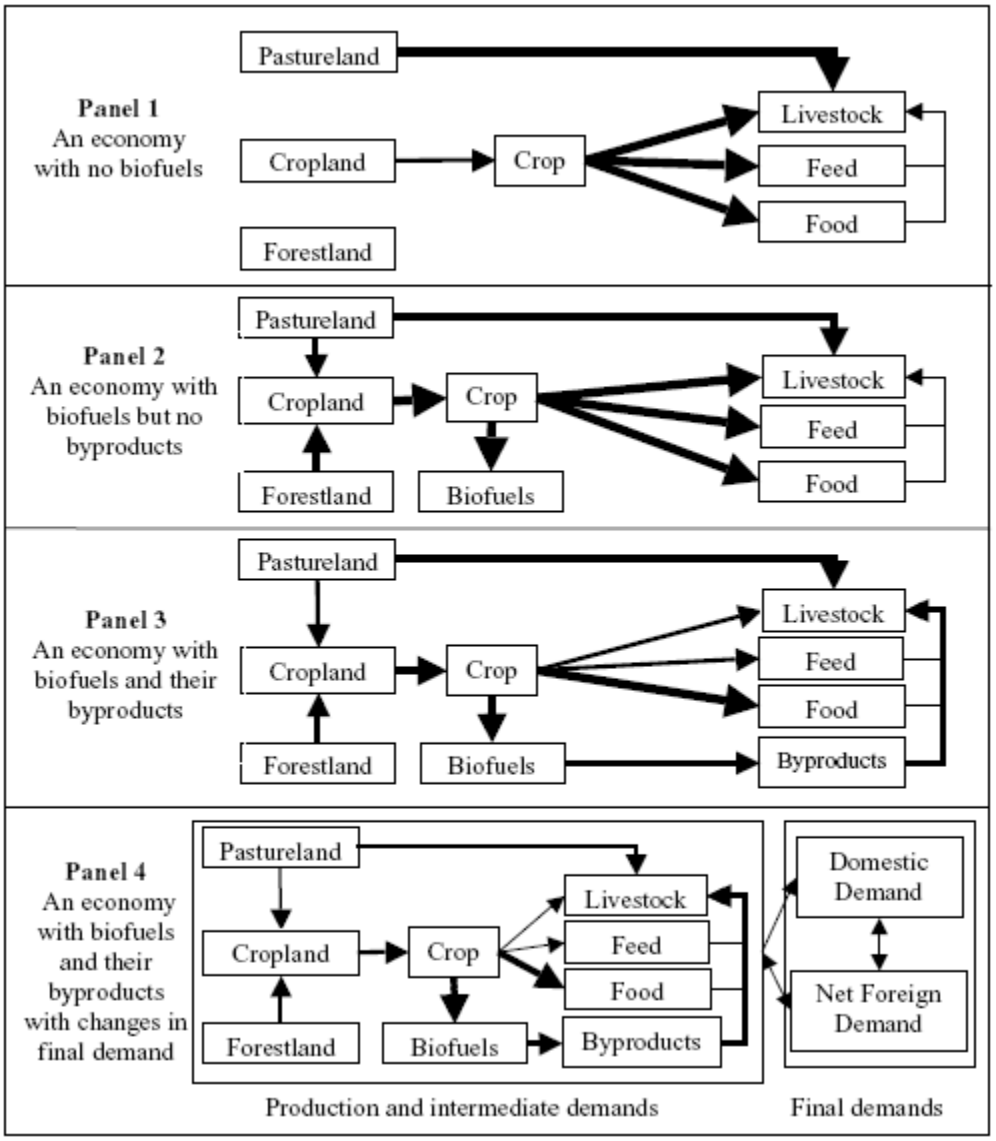
	Demand Side	Supply Side
Long run	Growth, rising incomes in developing countries leading to increased demand for meat, dairy products and indirect demand for grains	Inadequate investments in research and development, infrastructure, and extension services to increase productivity
Effect of long run trends: Demand growth > Supply growth = Declining stocks		
Recent, emerging	Biofuels demand	Rising energy, other costs
Short-run, cyclical	Financial speculation?	Adverse weather Bad policies, including export restrictions, hoarding and pre-emptive buying, price controls, untargeted subsidies

Figure 30: Factors contributing to higher food commodity prices[212]



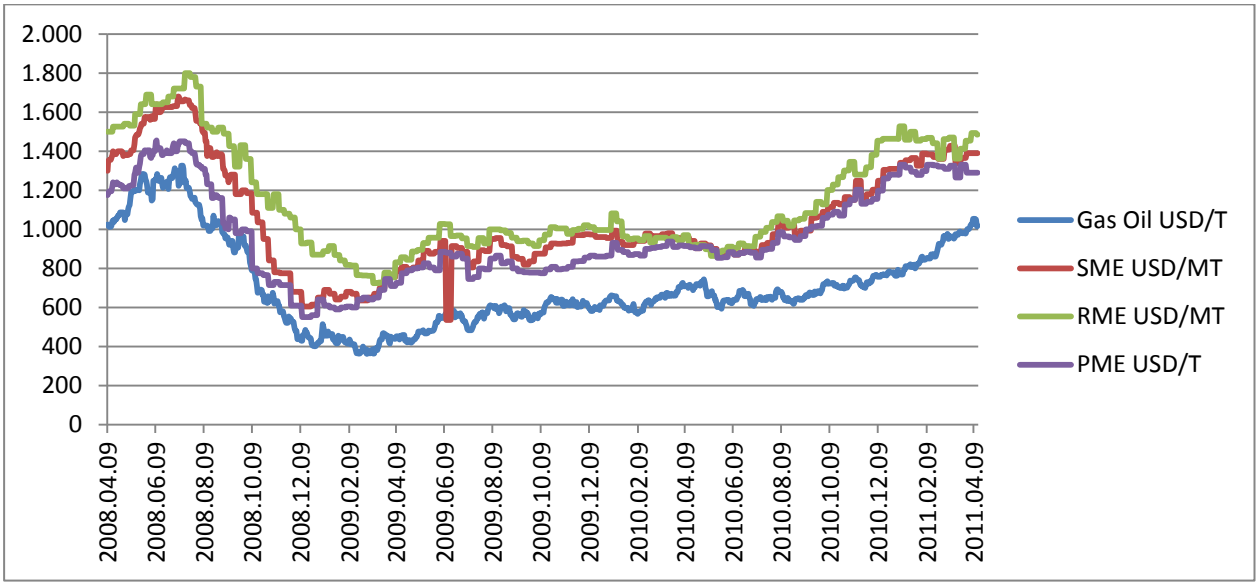
[211] Elliott et al. (2008), p. 7
[212] Trostel (2008), p. 6

Figure 31: Links between crop, food, feed, livestock, and biofuel industries and their competition for land in the presence and absence of biofuel by-products[213]



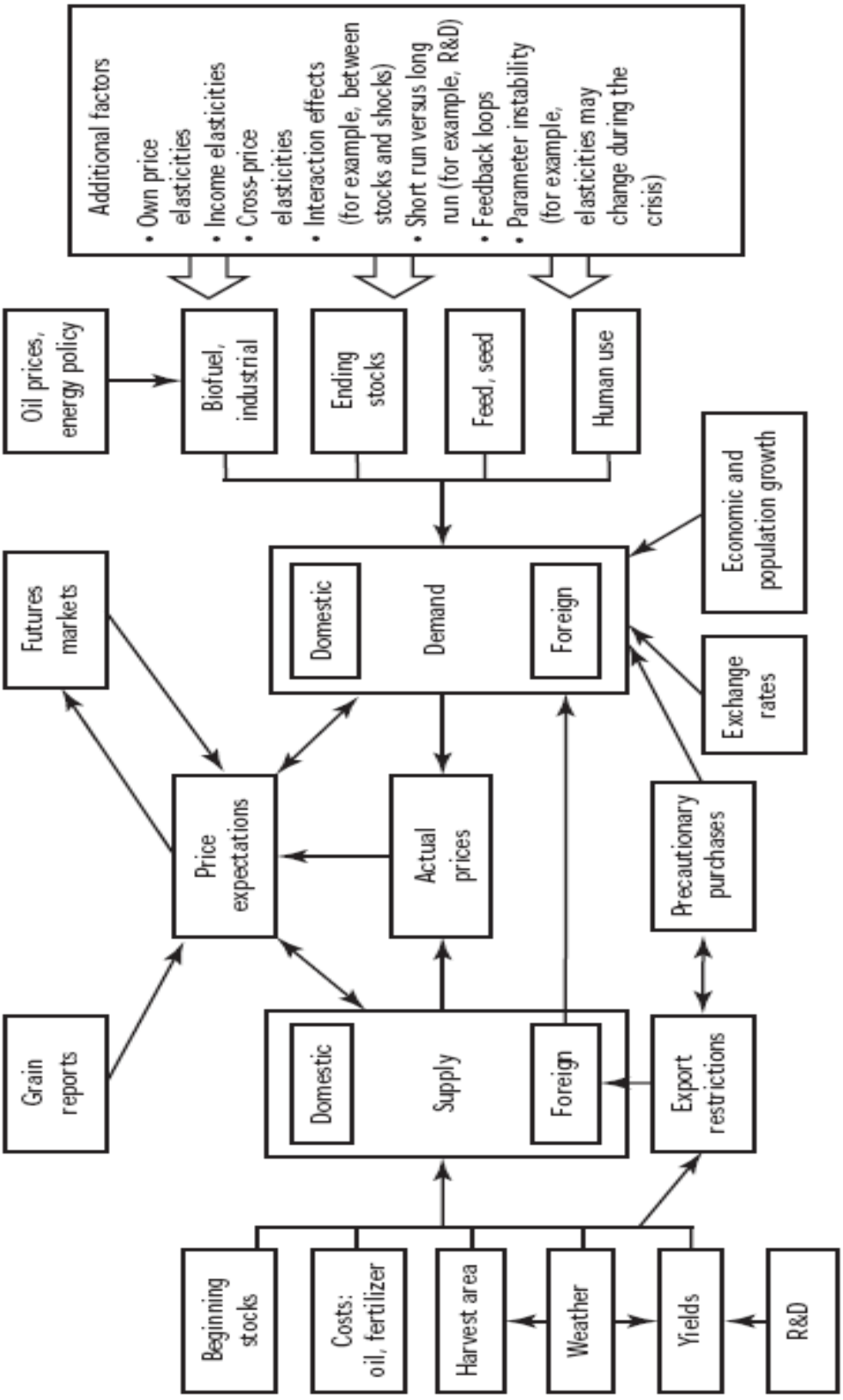
[213] Taken from Taheripour et al. (2011); For more interest in 4 panels description please see Taheripour et al. (2011), p.328

Figure 32: Daily prices of Gas Oil, SME, RME, PME from 09.04.2008-14.04.2011[214]



[214] Data taken from Bloomberg viewed on April 11, 2011; From Gas Oil we manufacture heating oil and diesel. Note: that the graphic clearly show, that without governmental subsidies the biodiesel would not be economical in comparison to diesel, as the blender agents (SME, PME, SEM) prices are higher than diesel prices.

Figure 33: The complicated nature of commodity price formation[215]



[215] Figure taken form Headey and Fan 2010; p. 5

Table 14: Partial Equilibrium Models - PEM

PARTIAL EQULIBRIUM MODELS - PEM				
Studies	**Estimation of:**	**Methods:**	**What's new:**	**Results:**
Schneider ad McCarl (2003)	Assess economic potential of biofuels in GHG reduction	Modified ASM with calculation and reduction of GHG emissions - U.S. Agricultural Sector Model – used to estimate the environmental regulations effects; developed already in 1970s; ASMGHG forecast land use and food commodity production in 63 U.S. areas and rest of the world	Integration of switch grass, hybrid poplar, and willow with traditional crop livestock production and processing and afforestation of cropland	Potential emission reduction regulation simulated through hypothetical carbon prices[216] If carbon prices are below 40$ per ton of carbon - no role of biofuels and emission mitigation through soil tillage and afforestation are more expensive If carbon prices are above 70$ - biofuels control all agricultural reduction strategies
Chakravorty et al. (2008)	With the help of this model the forecasts are possible on how agricultural subsidies impact the supply of biofuels. The elimination of export subsidies on the domestic commodity and import tariffs for them induced decreased demand for food, but boost supply in biofuels	Extended Hotelling model	Equivalence between Ricardian land rent and the Hotelling rent for the oil	They find range of prices within which biofuels are surrogate for oil; They evidence that biofuel prices must lie within tangible range affected by acreage availability and the demands for food and energy; The influence of policies determines constant food production and agricultural prices for a period of time, if the demand for energy is high;
Elobeid and Tokgoz (2008)	They calculate the impact of trade liberalization and exclusion of the tariff of ethanol imports in the U.S. from U.S. and Brazil	Behavioral equations for the production (consumption, ending stocks, and net trade). World ethanol price equating excess supply and excess demand. They use price transmissions equation's (price of ethanol is linked with world price through exchange rates and policy wedges)	Endogenize the prices of sugar and corn study expand previous analysis by Brazilian import liberalization	They discover that 24% boost in the price of world ethanol was cause through removal of trade distortions, during 2006-2015; additionally to the first assumption 51 cent per gallon tax credit to refiners entail 16,5% rise in world ethanol price. Repercussion for U.S: The prices of U.S. self-made ethanol decline by nearly 14%, because of 7% decrease in production and nearly 4% increase in consumption. The cheaper ethanol induces nearly 4% increase in its proportion in nonrenewable fuel consumption. U.S. net biofuel imports rise by nearly 200%. Repercussion for Brazil: Increased production by 9%. Decreased consumption by 3,3% Brazilians net export of biofuel rise by 64%. Increasing ethanol prices causes 5% boost in percentage of sugarcane.

[216] Every carbon level price have the new market equilibrium

Studies	Estimation of:	Methods:	What's new:	Results:
Dewbre et al. (2008)	Forecast for agricultural commodity supply, demand, trade and prices[217]	Experimental simulation with AGLIK-COSIMO model[218]		Baseline forecast 2008-2017: Wheat, coarse grains, rice, oilseeds - forecasted annual average prices for 2008 in baseline do not match the price peak for April 2008 – possible medium or long term market developments deflecting from short time issues influences these prices[219] Scenario results: Constant biofuel production 2007-2017: forecasted growth in biofuel increase world prices for coarse grains by 14% and world prices for vegetable oil by 18% Constant crude oil prices: maize and vegetable oil 10% lower and wheat 7% lower than baseline levels by 2017 Lower GDP growth in developing countries: wheat and coarse grain decrease slightly; vegetable oil 10% lower Stronger U.S. dollar exchange rates: wheat, coarse grain, vegetable oil 5% less than the baseline Higher crop yields: wheat 6%, maize 8% lower than baseline
Hayes et al. (2009)	Estimation of four scenarios for biofuels markets	Partial equilibrium model of the world agricultural sector for developing baseline; FAPRI model used for explore market impact and costs of actual and projected regulations over 10-year period	The model contain the new Renewable Fuels Standards; crude oil and biofuels markets; corn and ethanol production	First scenario (without biofuel subsidies when low energy prices): Wheat-9%,corn-18%,ethanol-12%,soybean-9%,soybean oil-17%, beef-3% Second scenario (no bottleneck in ethanol demand, when energy prices are high): wheat+20%,corn+51%,ethanol+38%, soybean+23,soyben oil-3% Third scenario(market force causing boost in ethanol demand due to high energy prices): Wheat+9%, corn+20%,ethanol+18%, soybeal+8%,soybean oil-4%,beef+3% Fourth scenario(reduction of biofuel tax subsidy when energy price high): biofuel production decrease and cause lower agricultural commodity prices; wheat+1%, corn+1%, ethanol+4%,soybean-0,5%,soybean oil-2%,beef-1%

[217] The results are reported in the annual OECD and FAO Outlooks
[218] The model was induce by the Organisation for Economic Co-operation and Development (OECD) and Food and Agricultural Organization of the United Nations (FAO)
[219] Please compare Figure 22 with Figure 10

Table 15: General equlibrium models - GEM

GENERAL EQULIBRIUM MODELS - GEM				
Studies	**Estimation of:**	**Methods:**	**What's new:**	**Results:**
Birur et al. (2008)	They recognize that ethanol from coarse grain and from sugarcane or sugar beet should be perfect substitutes in use, but they do not consider that in their study Measure the effects of biofuels[220] mandates for global agricultural markets, especially define the implication of biofuel production on them and acreage shift[221]	Model design on the McDougall/Golub GTAP-E	No imperfect substitutability between gasoline and ethanol; no CO_2 emissions module; They added new parameter – elasticity of substitution between fuel and biofuel in final demand	2001-2006 U.S. ethanol production boost from 1,7 billion gallons in 2001 to 7,1 billion gallon in 2006 (174%). Corn acreage has increased by 3,5%, production 11%. Brazil ethanol production 3,6 billion gallons in 2001 to 4,5 billion gallons in 2006 (24%). Sugarcane production increased 17%[222] Sugarcane ethanol from Brazil boost by 605% EU biodiesel raised from 288 million gallons to 1,47 billion gallons (410%). Oil seeds raised from 6,5% to 27,6%
Banse et al. (2008)[223]*	global and industry-sector-specific impacts of the BFD[224] (Improvement of the Eickhout and Prins 2008)	Global multi-region, multi-sector CGE[225]with endogenous [226]differentiation of land supply[227]; general equilibrium approach	Integration of the energy and land markets, with land use diversification	Without obligatory petroleum blending regulations or subsidies, goals of BFD would not be met in 2010 and will not be achieved in 2020 Reference scenario[228]: real world prices for agri-products[229] decrease and follow their long term trend BFD scenario: real price of oilseeds raise by 8% Crude oil price decrease by 1,5%, because of the BFD

[220] Biofuels – Biodiesel and Bioethanol
[221]They used for define the acreage diversification GTAP land use data base, which divide the land endowment into 18 Agro-ecological zones (AEZs) and describe biophysical growing condition and land usage for feedstock and forestry
[222] Historic boost is 32%
[223] Study develop further the EURUALIS project of Dutch Ministry of Agriculture, Nature and Food Quality
[224] BFD – the European Union Biofuels Directive; this study include ONLY this regulation do not consider OTHERS
[225] CGE – Computable General Equilibrium Model
[226] Land endogenously assumption imply that more land can be used for production, that restrain land and product prices
[227] To include land use changes and abandonment
[228] Reference scenario forecast the long-term trends global agriculture and food, which not consider current high price development in food sector
[229] Agro products – cereals, oilseeds, sugar

Studies	Estimation of:	Methods:	What's new:	Results:
Reilly (2008)	Analyze the effects of GHG reduction aims for second generation biofuels and acreage change; They find out if it's possible that cellulosic biofuel can fuel the world and what areas are competitive for this market. How second generation influence the food prices and land use. Also measure effects for carbon dioxide release from land diversification.	EPPA (Emissions Prediction and Policy Analysis) model – Global Land System Interactions They handle demand and supply, capital and investment, trade, regulations, technologies.	Cellulosic biofuels – second generation of biofuel	2015-2100 Without biofuel subsidies and GHG regulations cellulosic biofuels enter the market in 2035 and become a remarkable part of energy source. This is because of high oil prices (in simulation they increase to $100 in 2050 and $150 in 2100). With strong climate regulation they enter very soon, but this scenario does not treat the carbon effect on land diversification. Costs of second generation biofuels depend on acreage price. Biofuels have effect on land and food prices. With GHG regulation, Latin America and Africa would be main biofuels manufacturer and U.S. a net importer. Ag. Prices – 20% increase Land prices – 60% increase Ag. Output – 20% decrease
Al-Riffai et al. (2010)	Estimation of changes in EU biofuels trade regulations on global agricultural production and the environmental issue; Estimation of ILUC[230] impact and emissions of first generation of biofuels feedstock	Global Computable general equilibrium model (CGE) – modified version of the MIRAGE model;	Included Renewable Energy Directive (RED) and Fuel Quality Directive (FQD) Model changes - NEW modeling of energy demand – substitutability between different energy sources is possible Extended GTAP[231]database to individually identify ethanol, biodiesel, 5 additional crops, 4 vegetable oils, fertilizers, fuel sector; land use model for 2020	By 2020 5,6% biofuels blends in fossil fuel cause 17,8 Mtoe boost in EU consumption; Brazil's real income+0,06% due to EU bioethanol imports; world cropland boost by 0,07%(ILUC caused through EU regulations); emissions saving from biofuels 18Mt CO_2(but emissions from ILUC 5,3Mt – mostly from Brazil)=Global net balance 13Mt CO_2 savings in 20 years period; Impact of EU biofuels regulations: in Brazil on food bundle+0,5%, in EU +0,14% In Sub-Sahara Africa -0,12% of real income

[230] ILUC – Indirect Land Use Change
[231] GTAP – The Global Trade Analysis Project

Studies	Estimation of:	Methods:	What's new:	Results:
Timilsina et al. (2010)*	Effect of global expansion of biofuels on agriculture, land use and food supply; assess land-use at national, regional and global levels; effect of biofuel on rainforest, wetlands[232]	GDCGE[233] with land use and biofuel manufacture sector	Do not include second generation of biofuels or cellulosic biofuels	They show that biofuels would decrease GDP and food supply globally, especially India and Sub-Sahara Africa AT[234] scenario: world biofuel production and use: 64,5% or $38,8 billion (EU&EFTA $24,9 billion; Brazil $6,3 billion; U.S 0,2 billion) ET[235] scenario: 13,1% share of biofuels in transport sector; world biofuel production and use: 153,2% or $92,1 billion at 2004 prices (EU&EFTA $65,8 billion; Brazil $7,9 billion; U.S 0,8 billion) AT scenario: crude oil prices -0,8%; sugar cane&beet prices +9,2%; ethanol +2,8%; corn+1,1%; food prices +0,2%; gasoline and diesel -0,6% ET scenario: crude oil prices -1,7%; sugar cane prices +9,7%; ethanol +4,6%; corn+3,7%; food prices +0,5%; gasoline and diesel -1,4% Land changes due to biofuel production cause significant reduction in forest and pasture and deforestation in Brazil and Canada
Hochman et al. (2010)	Biofuel and global food crisis issues on energy and agri sector	Classic Hecksher-Ohlin model – general equilibrium model	Prototype of general equilibrium framework with household production; energy as ubiquitous factor in production; defines utilities	Higher demand for energy and higher energy prices; boosted demand for land, higher food prices

[232] Other studies argue that boosted production of palm oil for biodiesel cause deforestation in Indonesia
[233] Global dynamic computable general equilibrium model
[234] Biofuel targets by countries
[235] Doubled biofuel targets

Studies	Estimation of:	Methods:	What's new:	Results:
Taheripour et al. (2011)	Effect of biofuel U.S. and EU regulation on global livestock sector (extended GTAP model)[236]; links energy, biofuel, and agricultural markets	GEM 31 sectors, 33 commodities, 19 regions	Three level nesting structure for demand for livestock feeds; revision in the demand side of the model for animal feeds;	Full effect experiment[237]: 2001-2006 Boost production of coarse grains in U.S. (11.2%), sugarcane in Brazil 13,6%, oilseed in EU 32,6%, oilseed production in non-biofuel countries 6,3%; 2015 boost of the pastureland prices around the world (U.S. 17%;EU 29%), which cause higher crop prices; share of forest 23%, pastureland 77% conversion due to biofuels in EU; forest conversion in U.S. 36%, Brazil 27% First restricted experiment[238] -conclusion, when the food demand is fixed the U.S. economy have to manufacture more crops, convert more forest and pastureland Second restricted experiment[239]: -conclusion-crops and livestock increase more than under full effect Third restricted experiment[240]: -conclusion-16,9 million additional hectares for biofuels goal, 93% of this land is forest

[236] "In general, in the GTAP modeling framework, there is a competition between different industries to use primary inputs such as land, labor, and capital. In this framework producers select an optimal mix of primary inputs to maximize their profits, according to the prices of inputs." Taheripour et al. (2011), p. 328

[237] Multinational regulations program for biofuels are included

[238] Biofuels policies have no effect on final demands for food – demand for food is constant

[239] Demand for food is constant and the livestock manufacturer do not use biofuel by-products

[240] Demand for food is constant, livestock's manufacturers do not use biofuel by-products and supply of the land to the animal sector is perfect elastic – this eliminates competition between animal and biofuel crops.

Studies	Estimation of:	Methods:	What's new:	Results:
Chen et al. (2010)	Examine fuel, biofuel, food/feed feedstock and livestock markets. Gives simulation of U.S. agricultural and fuel markets and market equilibrium in feedstock sector, which contain trade with rest of the world. Sugarcane ethanol form Brazil and CBI countries. Focus on biofuel policy NOT trade.	BEPAM[241] - dynamic mulit-market; multi-period; food fuel price endogenous; nonlinerar mathematical programming model	BEPAM follow spatial[242] heterogeneity in feedstock and livestock production and feedstock imply Leontief function[243] Imperfect substitutability between gasoline and ethanol – biofuels prices are not simply demand driven, but also affected through production costs[244] Bioenergy crops – crop residual and perennial grasses; Ethanol from corn and cellulosic sources	2007-2022 Biofuel policy (without subsidies) would depend on corn ethanol to the max. level. Miscanthus would achieve 91% of biofuel target. Policies[245] induce 20% boost in area under corn and cause reduction in area under soybean and other crops. In 2022 the corn prices are 26% higher than in the BAU[246]

[241] Biofuel and Environmental Policy Analysis Model
[242] Spatial means that model uses the Crop Reporting District (CRD), which report about planting decisions taken under resource and land availability (1977 to 2007 from USDA/NASS) and current production development
[243] Linear function
[244] Chen et al. (2010) writes that Hayes et al. (2009) demonstrate that imperfect substitutability (ethanol-gasoline) in FAPRI model imply smaller effect of variance in crude oil prices on demand for biofuels and acreage use than in Tokgoz et al. (2007).
[245] In benchmark case
[246] In BAU (business-as-usual) is no biofuel policy in exception of import tariff, which is in all scenarios

Table 16: Economic models

ECONOMIC MODELS				
Studies	**Estimation of:**	**Methods:**	**What's new:**	**Results:**
Baier et al. (2009)	Estimation of impact of biofuel on commodity and global food prices	For estimation of direct impact of boost in biofuels on crops prices they used simply supply and demand equations. For estimation of indirect effect they used elasticity of supply and demand	Interactive spreadsheet - possibility to choose between: countries, time periods, supply and demand elasticity's and size of indirect effect)	Over 2007 and 2008 period biofuels production have significant effect on increases in corn 27%, sugar 12%, soybean 21% prices, but minor effect on global food prices index (12% - 60% of these was cause by U.S., 14% by Brazil and 15% by EU); 88% of the boost in global food prices are not from biofuel; U.S. ethanol and biodiesel production increased corn prices by 22%, soybean by 15%; EU biofuels production increase corn and soybean prices by 3%; Brazil ethanol production caused entire boost in the sugar prices
Mayer et al. (2008)	Simulation of economic feasibility of biofuel production in South Africa – no governmental subsidies are included at 2006 prices	BFAP - Bureau for food and Agricultural Policy's sector model – dynamic system of econometric equations, model simulates a dynamic equilibrium between all markets over time	African biofuels production	Study shows that without governmental subsidies biofuels are not economical; In 2006 sugar, maize, soybean, sunflower will not yield positive plant profit by making biofuels; Fuel market – biodiesel form soybean cost 336,45SA cents per liter; Human vegetable oil market – soybean oil cost 529,47 cents per liter; For simulation for the biodiesel production – vegetable oil sales should be diverted from the human vegetable oil market to biodiesel market; Plants profits: Sugar cane Eth.(-89,87 c/liter); Yellow maize Eth.(-101,80 c/liter); Soybeans biodiesel (-29,87 c/liter); Sunflowers biodiesel (-262,27 c/liter)[247]

[247] Under assumption that biodiesel sells at 100% of basic fuel price and bioethanol at 95%

Studies	Estimation of:	Methods:	What's new:	Results:
Tepe et al. (2009)	Estimation of effects of biofuels regulations on U.S. agriculture and food stock prices	Linear two-factor[248] equilibrium Asset Pricing Model	Conditional heteroskedasticity in stock returns is settled for GRACH model	Boost in corn prices – positive impact on excess stock returns for fertilizer, seed, machinery firms (biofuel producers positive returns); boost from $2 to $3,4 increase company value by 5% Boost in corn prices – negative impact on meat companies (meat producers losses)
Gilbert (2010)	Shows that food commodity price increases are explained by common factors then by supply shocks	Capital Asset Pricing Model		Demand for grains and oilseed – major factor for price boost Through index based investment in commodity future markets – monetary factors influenced boost in food prices (2007-2008) General level of commodity food prices – averaging factors (demand shock) Specific food crops - substitution between crops which is significant at the level of the individual crop price (supply shock) Common shocks cause fluctuations in aggregate price indices, because of individual shocks
Zhang et al. (2009)	Estimation of long run cointegration of fuels and agricultural prices together with their multivariate short run relations	Time-Series Model		No direct long run price associations between fuel and agri commodity prices BUT Direct short run association In short run: Sugar has an impact on all agri commodity prices (without rice) Boost in ethanol production have an effect on agri commodity prices
Lauring (2011)	Assess in long run period if crude oil prices have an impact on gasoline prices, if gasoline have an impact on ethanol, if maize have an impact on ethanol, and maize on beef prices	Granger Causality Test		World petroleum prices have an impact on U.S. gasoline prices U.S. gasoline and maize prices have an impact on U.S. ethanol prices Between world corn prices and world beef prices no causal relation was found

[248] S&P 500 and corn prices

Abstract (Deutsch)

Der andauernde Klimawandel sowie das damit verbundene Streben nach Energieunabhängigkeit, die Energieknappheit, das Gewährleisten einer nachhaltig andauernden Energieversorgung sowie die ansteigenden Rohölpreise führten bzw. führen nach wie vor dazu, dass das Augenmerk der Energiepolitik auf die Förderung von sog. Biokraftstoffen, sowie deren politisch geförderten Maßnahmen, gelegt wird.

Innerhalb der vergangenen 30 Jahre, haben sich Biokraftstoffe vermehrt zu Substitutionsprodukten entwickelt und könnten künftig als Ersatz für das immer teurer werdende Rohöl gelten. Die Ethanolproduktion kennt seit knapp 35 Jahren einen konstanten Anstieg, die Biodieselproduktion seit 20 Jahren, was Expertenmeinungen zufolge Einfluss auf die Nahrungsmittelpreise haben sollte.

Ausgehend von den eben erwähnten Prämissen, befasst sich diese Diplomarbeit mit der Darstellung der Zusammenhänge, welche sowohl die Produktion von Biokraftstoffen als auch andere Einflussfaktoren (Rohölpreise, Wechselkurse, Wachstum in Produktion und Konsumption) auf die Nahrungsmittelpreise haben und vice versa. Zu Beginn gilt es die verschiedenen Arten von Biokraftostoffen klar voneinander abzugrenzen und zu definieren. Folglich sind nur die beiden Typen Bioethanol und Biodiesel Teil der Analyse. Der zweite Teil der Auswertung umfasst die Darstellung sämtlicher politischer Maßnahmen, die den Rahmen zur Förderung biogener Kraftstoffarten bilden, die Analyse der Vor- und Nachteile biogener Kraftstoffarten sowie die Darstellung der weltweit führenden Biokraftstoffhersteller. Den Kern dieser Diplomarbeit bildet die Erörterung der bestehenden Zusammenhänge zwischen Kraftstoff- und Nahrungsmittelpreisen und welchen Einfluss biogene Kraftstoffe auf die Nahrungsmittelpreise haben. Hierzu wurde der „Granger Kausalitätstest“ herangezogen.

Letztlich lässt sich konstatieren, dass die bestehenden Zusammenhänge zwischen Nahrungsmittel- und Treibstoffpreisen das Nachfrageverhalten ebenso wie die Wechselkurse auf den Kapitalmärkten affektieren.

Abstract (English)

Permanent concerns about climate change mitigation, energy independence and high oil prices caused more interest in biofuel and raised support of government policies for their production. In recent years biofuels become economically competent to be a substitute for nonrenewable fuels, because of continuous rising crude oil prices. As the biofuel production has been increasing over the last 35 years in case of ethanol and over 20 years in case of biodiesel, but more expressively since 2001, the renewable energy source started to compete with the food crops for acreage.

Controversy press releases about biofuels impact on food prices initiated more concern about food price increases. This master thesis is aiming to give an overlook about factors which had an impact on food prices and try to give an understanding on these factors. At first there is an overview about biofuels, as there is a wide range of them. This master thesis concentrates only on bioethanol and biodiesel production globally and gives a summary of governments' regulation in different countries as well highlights biofuel advantages and disadvantages; specifies leading biofuels manufacturers and gives a short story about existence of biofuels. This master thesis gives a clue how to understand food crises, and what can cause these crises.

In the summary of the studies there is an evaluation of the impact of biofuels on food prices; estimation of effect of demand, monetary expansion and exchange rate movements on food crops. The master thesis includes also the calculation of the Granger causality test for petroleum, gasoline, ethanol, corn and beef prices to show what impact they have on each other. That was to prove the linkage between biofuels and food prices.

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Personal Data:

Nationality: Poland
Age: 29, born 9th April 1982
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Other languages:
German very good
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Technical skills:
Computer skills
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Artistic skills:
Photography, playing piano

Social skills:
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negotiation skills
teamwork

Organisational skills:
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Quick learner

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Other:
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Education:

Primary school:	1989 - 1997 in Szczecin
Lyzeum : Czarniecki-Gimnasium Nr. 6	1997 - 2001 in Szczecin
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Marina High School:	2001 - 2003 in Szczecin
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University of economics:	2003 - 2005 in Vienna
(Management Science)	
Vienna University:	2005 - 2011 in Vienna
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Professional Experience:

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BSM Diagnostica GmbH – pharmaceutical sales industry (Vienna, Austria)
Office Assistant – auditing of documents, accounting, cost accounting, payroll, filing, compiling statistics

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Med-Pro GmbH – pharmaceutical sales industry
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Arcturus GmbH – fuel retail industry
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Internship – order processing in import, export and working with freight forwarders

01.07.-01.08.2001
BGM Petrocargo GmbH – fuel retail industry
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