Modeling Biofuels Expansion in a Changing Global Environment

by
May Peters, Agapi Somwaru, Jim Hansen, Ralph Seeley and Steve Dirkse

Names and affiliation of the authors:
May M. Peters, MTED/ERS/U.S. Department of Agriculture, mpeters@ers.usda.gov
Agapi Somwaru, MTED/ERS/U.S. Department of Agriculture,agapi@ers.usda.gov
Jim Hansen, MTED/ERS/U.S. Department of Agriculture, hansen@ers.usda.gov
Ralph Seeley, MTED/ERS/U.S. Department of Agriculture, seeley@ers.usda.gov
Steve Dirkse, GAMS Corporation, sdirkse@gams.com

Contributed Paper prepared for presentation at the International Association of Agricultural Economics Conference, Beijing, China, August 16-22, 2009.

Modeling Biofuels Expansion in a Changing Global Environment

by
May Peters, Agapi Somwaru, Jim Hansen, Ralph Seeley and Steve Dirkse

Abstract

This paper examines the impact of declining energy prices on biofuels production and use and its implications to agricultural commodity markets. It uses PEATSim, a dynamic partial equilibrium, multi-commodity, multi-country global trade model of the agriculture sector to analyze the interaction between biofuel, crop and livestock sectors. The ability of countries to achieve their energy goals will be affected by future direction of petroleum prices. A 50 percent decline in petroleum prices (absent of mandates) would result in rapid decline in biofuel use worldwide accompanied by a decline in feedstock and biofuel prices. About a 21 percent decline in U.S. cost of ethanol production is needed to make ethanol competitive with gasoline and to offset the effect of lower energy prices.

Key words: Biofuels, PEATSim, dynamic partial equilibrium model, energy prices

Modeling Biofuels Expansion in a Changing Global Environment

Introduction

Rapid changes in crude oil and agricultural commodity prices have increased the uncertainty about the effects of increased biofuels production on agricultural markets and the feasibility of achieving biofuel targets. As the previous year has demonstrated global commodity markets are constantly changing.

In the first half of 2008, agricultural crop and crude oil prices increased rapidly reaching record highs. This surge in crop and energy prices raised concern about the impact of high commodity prices on the poor and called into question the role of biofuels in reducing our dependence on fossil fuels, further stimulating the debate over “food vs. fuel” use for crops. Prices for these products in the latter half of 2008 have gone down just as quickly as they went up. In addition, the 2008 financial crisis is generating a slowdown in worldwide economies that is expected to lead to a significant contraction in global GDP.

Suddenly, the biofuels sector is confronted by a changed and uncertain economic environment. The high energy price environment that stimulated the biofuels boom may be transforming into a volatile energy price environment. Nevertheless, for now, government energy policy goals continue to influence the biofuel sectors in many countries of the world including the United States, EU, Brazil, Canada, Argentina, China, countries of the Former Soviet Union, Malaysia, and Indonesia as they continue to institute programs to promote biofuel production and pursue their biofuels use targets.

In the United States, the Energy Policy Act of 2005 mandates that renewable fuel use in gasoline (with credits for biodiesel) reach 7.5 billion gallons by calendar year 2012. The Energy Independence and Security Act (EISA) enacted on December, 2007 mandates the use of 36 billion gallons of biofuels by 2022, with as much as 15 billion gallons coming from corn-based ethanol by 2015 and subsequent years. In addition, factors such as blender tax credits and import tariffs; elimination of methyl tertiary butyl ether (MTBE) as an additive in gasoline blending; and other factors, have provided economic incentives for biofuel expansion.

Accordingly, this paper will examine the impacts of low energy prices on biofuels production and the implications it has for agricultural commodity markets.

Objectives of the Study

The effect of low petroleum prices on ethanol and biodiesel demand is expected to significantly influence global agricultural markets - prices, supply and use. For that reason, this study will analyze the effects and implications of the attainment of biofuels (alternative fuels) targets in major biofuel producing and consuming countries for global agricultural commodity markets. The specific objectives of this paper are:

- Capture the links between the market for biofuels, feedstock and biofuel by-products using the PEATSim Model;
- Analyze the impact of shifts in demand for ethanol and biodiesel and increased sources of biofuel feedstock on agricultural commodity production, prices and trade in the United States, EU, Brazil and rest of the world; and
- Evaluate the effects of a decline in petroleum prices on biofuels use and global agricultural markets.

We do this by specifying biofuel sectors in several key countries (United States, Brazil, and EU). These are the three major consumers and producers of ethanol and biodiesel. Since each country uses different feedstock sources, the challenge is to capture and properly model both the demand for biofuels and the supply response specific for each country. A "stylized" representation of biofuels production would fail to capture the complexity and interaction of biofuels production pattern. For this reason it is important that each country's production of biofuels be explicitly represented in order to capture their sectors/industries interaction effectively. The PEATSim model is capable of explicitly representing each country's biofuel sector.

Literature Review

Baker et al. (2008) developed a stochastic and dynamic General Equilibrium (GE) model and captures the uncertain nature of key variables such as crude oil prices and commodity yields. They show that the subsidies for corn ethanol, biodiesel and cellulosic ethanol need to be increased to raise their production.

Schmitz et al. (2007) used a welfare economic framework to address distributional issues and determined gainers and losers from ethanol production. The authors estimated the impact of ethanol subsidies on corn used for ethanol.

Gardner (2007) developed a vertical market model of ethanol, byproducts and corn to analyze social costs of ethanol subsidies or mandates. The study indicated that ethanol subsidies are unlikely to generate net social gains.

Gallagher (2006) indicated that without tariffs, both the United States and Brazil would exhibit periods of competitive advantage in producing ethanol from corn and sugarcane respectively. It indicated that a U.S. tariff free quota for ethanol imports from Caribbean countries often would be filled but the United States would also exhibit competitive export position in the ethanol market.

Von Lampe (2006) evaluated scenarios using the OECD's AGLINK model. The first scenario used a constant biofuel growth which assumed exogenous production and crop demand for biofuels at 2004 levels. The second scenario assumed biofuel growth rates for various countries in line with their policy goals. The third scenario incorporated adjustments of energy and fuel prices which affected the cost of agricultural production and the profitability of biofuel production. All of these scenarios result in increased grain prices and land used in the production of biofuels.

Elobeid et.al. (2007) provided the first comprehensive model of the biofuels economy. They analyzed the impact of liberalizing the U.S. ethanol market and removing the U.S. federal tax credit. The trade liberalization resulted in an increase in U.S. net ethanol imports which decreased corn demand for ethanol and corn price. Removal of U.S. tariff on ethanol and reduction of the blending credit increase U.S. imports of ethanol by about 137 percent. U.S. ethanol production falls by about 9 percent while production of ethanol in Brazil increases by slightly over 6 percent.

Tokgoz et.al. (2007) provided estimates of the impacts of higher oil prices, drought and removal of land from U.S. Conservation Reserve Program. The study filled some gaps and included work on equilibrium prices of co-products of the biofuel industries, most importantly distillers' grains. The study found that exogenous corn and sugar price increases reduce the production of ethanol, while increased prices for gasoline increase the production of ethanol.

Earlier studies had exogenous assumptions about the biofuel sector. Some recent studies have endogenized energy and biofuel production and demand; however, very few have addressed the impact of stronger biofuels demand on global agricultural markets nor dealt with declining energy prices. Many of the past and even most recent studies have economic assumptions of increasing gasoline prices and high income growth, but this economic environment has reversed/changed and could last for the rest of 2009 and into 2010 (Shane et al. 2009).

While most of the work done in the past had been based on assumed and exogenous levels of biofuels use, for this analysis, we extended the PEATSim model and incorporated detailed ethanol and biodiesel markets and link them to the domestic and international agricultural markets.

Methodology and Modeling Framework

Analysis of biofuels and agricultural markets is inherently a multi-sector problem because of the interactions between energy, farm inputs, crops, feed, food consumption, and trade. For these reasons, we use the Partial Equilibrium Agricultural Trade Simulation (PEATSim) model as a tool to analyze the complex facets of this problem.

PEATSim is a dynamic, partial equilibrium, multiple-commodity, multiple-region model of global agricultural policy and trade. The model accounts for simultaneous interaction between livestock and crops while maintaining identities such as supply, utilization and consumption. PEATSim contains major crop and oilseed markets, as well as oilseed product markets, sugar, livestock, dairy and liquid fuels (ethanol and biodiesel) markets. It also contains explicit representation of each country's domestic and trade policies pertaining to agricultural commodities**.**

PEATSim, unlike other trade models, has the unique ability to model different sets of production activities, interlinkages among various crops and livestock sectors, and interaction of producers, processors and consumers at a global level. The model's innovative and flexible specification gives it the capability to incorporate a variety of domestic and trade policy instruments.

The PEATSim model is written in GAMS (General Algebraic Modeling System) programming language utilizing PATH, a Mixed Complementarity Problem (MCP) Algorithm developed by Dirkse and Ferris (1995). MCP allows PEATSim to handle different production, consumption regimes and functional discontinuities. It also allows an endogenous determination of which regimes are active and what are the consequences of regime shifts**.** This means that PEATSim is able to handle discontinuous functional forms such as Tariff Rate Quotas, discontinuous demand issues created by mandates, targets, and other complicated policy instruments.

Model structure

PEATSim includes variables for production, area, yields, consumption, exports, imports, stocks, world prices, and domestic producer and consumer prices. Identities such as supply and utilization, consumption and its components (food, feed, fuel, crush, other) hold for all commodities and regions in the model. The behavioral equations have the same functional form (constant elasticity specification) for all countries/regions in the model. Constant elasticity functions were selected because of their ease of interpretation and well behaved properties. They can be viewed as first order approximations to underlying supply and demand relationships.

Country Coverage

PEATSim includes thirteen countries or regions: the United States, the European Union (EU25), Japan, Canada, Mexico, Brazil, Argentina, China, India, Australia, New Zealand, South Korea, and the Rest of the World (ROW).

Commodity Coverage

There are thirty-two agricultural commodities: 9 crops (rice, wheat, corn, other coarse grains, soybeans, sunflowers, rapeseed, cotton, and sugar); 10 oilseed, oil, and meal products (soybean, sunflower seed, rapeseed, and other oil); four livestock products (beef and veal, pork, poultry, and raw milk); six dairy products (fluid milk, butter, cheese, nonfat dry milk, whole dry milk, and other dairy products). In addition, there are three biofuel commodities and byproduct (ethanol, biodiesel, and distiller's dried grains (DDGs)).

Trade Block

The model balances supply and demand with the condition that world imports equal world exports. For commodity i in region r in year t, net trade (exports minus imports) is equal to:

$$NET_{irt} = PRD_{irt} – FOO_{irt} - FEE_{irt} - CRU_{irt} - FUE_{irt} - RMD_{irt} - OTH_{irt} - STK_{irt} ,$$

where:

PRD_{irt} = production of commodity i in region r in time t;

FOO_{irt} = food demand of commodity i in region r in time t;

FEE_{irt} = feed demand of commodity i in region r in time t;

CRU_{irt} = crush demand of commodity i in region r in time t (zero for all commodities except oilseeds);

FUE_{irt} = fuel demand of commodity i in region r in time t;

RMD_{irt} = processing demand of commodity i in region r in time t (zero for all commodities except raw milk);

OTH_{irt} = other use demand of commodity i in region r in time t; and,

STK_{irt} = net increase in ending stocks between years.

Equilibrium Condition.

Global market equilibrium requires that the sum of net trade across regions be equal to zero for each internationally traded commodity. Therefore, the market clearing condition requires:

$$\sum_{r \in \text{all regions}} NET_{irt} = 0 \quad \text{for i} \in \text{ traded commodities}$$

Supply/Production Block.

Production of grains, oilseeds, and cotton (PRD_{irt}) is the product of acreage harvested (AHV_{irt}) and yield (YLD_{irt}). Area harvested is specified as a constant-elasticity function of the crop's own producer price and the producer prices of other crops (PRP_{irt}). Yield is a constant-elasticity function of previous period yields and producer prices. Vegetable oil and meal production are specified as products of oilseed crush demand and extraction rates. Crush demand is specified as a function of lagged crush demand and the oilseed crushing margin (product value divided by seed value times yield). Livestock production is a function of lagged production and producer prices for livestock, and of a feed cost index. Production of dairy products is specified as a function of lagged production, lagged raw milk production, and dairy product prices. Stocks are functions of product prices. Biofuel production is a function of its price and of a feedstocks cost index.

Demand Block.

Total consumption of each commodity in the model is the sum of food demand (FOO_{irt}), feed demand (FEE_{irt}), crushing demand (CRU_{irt}), fuel demand (FUE_{irt}), processing demand (RMD_{irt}), and other use (OTH_{irt}). Food demand exists for all commodities except raw milk and oilseed meals. Feed demand is determined by the production of livestock in the model. Oilseed demand is for crushing, and the products are meals and oils. Fuel demand exists for biofuels such as ethanol and biodiesel. Since milk in its raw form is not consumed, there is a processing demand for raw milk to produce dairy products. Other use demand which includes seed use and waste is generally small.

Price Block.

Prices in the model are based on the world market clearing price (PWD_{irt}). Import prices (PIM_{irt}) are defined as:

$$PIM_{irt} = PWD_{irt} (1 + TRQ_{irt}) + TRANS_{irt} + DUT_{irt}$$

where:

PIM_{irt} = import price;

TRQ_{irt} = the *ad valorem* tariff;

$TRANS_{irt}$ = transportation cost; and,

DUT_{irt} = specific duties.

All prices in the model are linked through the domestic price and to the world reference price. As a result, they represent the levels which permit world market equilibriums to be achieved

Data

The data in PEATSim are from USDA Agricultural Projections to 2017 for area, yield, production, consumption, stocks, trade, and world prices. Dairy and sugar information from OECD and biofuel information from FAPRI supplements the dataset. Parameter values in the model are synthetic drawn from the literature and from other trade models.

Biofuel Sector in PEATSim Model

The PEATSim model has a fully operational endogenous biofuel sector with the United States, EU25 and Brazil's biofuel sectors built-in. The biofuel component of the model includes a detailed industrial use module as well as downstream industries related to biofuels. For the United States, PEATSim incorporates the use of DDG's (Distillers Dry

Grains) in livestock feeding to measure the effect of biofuel byproducts on the livestock industry.

Results and Analysis

The dynamic PEATSim model is calibrated to the 2009-2017 results from the USDA projections. Alternative hypothetical scenarios were simulated and sensitivity analyses were conducted. The shocks are introduced to the model to determine how production, consumption, trade and prices will react and adjust.

Base 2009-17 Model Run and Data

The USDA's long term projections were used as the base run of the model. The USDA's projections reflect a conditional, long-run scenario about what's expected to happen under a continuation of current farm legislation and specific assumptions. It assumes that there are no shocks due to abnormal weather, outbreaks of plant or animal diseases or other uncommon factors affecting global supply and demand.

Hypothetical Scenarios

The United States, Brazil and the European Union are major players in the biofuel sector. Brazil and United States together account for almost 90 percent of ethanol production worldwide, while the EU accounts for over 80 percent of global biodiesel consumption and production. There is continued emphasis on increasing availability of alternative fuel sources in these countries and globally. Although EU softened its targets, member countries still aim to increase the biofuel share of total transportation fuel to 5 percent by 2012 and 10 percent by 2020. In addition, Brazil continues to emphasize energy independence. Nonetheless, this expanding demand for biofuel will be occurring in an uncertain crude oil price environment as gasoline prices have been declining. If this represents a long term shift, then biofuels could be operating in a much more competitive environment with gasoline and diesel.

We modeled three hypothetical scenarios for this study, namely:

- Scenario 1 – shift U.S. ethanol demand curve by 20 percent. Under this scenario, the United States will achieve the 10 percent biofuel share to total transportation fuel demand by 2017. We will also add a twist to Scenario 1. We will increase U.S. corn yield and determine the corn yield (threshold yield) needed to fully offset the increase in corn price caused by the increase in ethanol demand
- Scenario 2 – simultaneous global biofuel demand increases (demand curve shifts), with 20% shift in U.S. ethanol demand, 20 % shift in Brazil's ethanol demand, and 10 % shift in EU biodiesel demand. The rationale for this scenario is the continued emphasis on increasing the availability of alternative fuel sources in these key biofuel countries in order to reduce dependency on fossil fuel and meet basic biofuel targets such as 10% biofuel share in transportation fuel in the United States., 5% biofuel share in transportation fuel in the EU25 and continued energy independence in Brazil.
- Scenario 3 – global biofuel demand increases as in Scenario 2 accompanied by 50 % reduction in gasoline prices. The recent drop in gasoline prices demonstrates that the high energy cost environment that stimulated the development of the biofuels sector may not last. A twist to this scenario is to determine the necessary shift in U.S. ethanol supply curve to keep U.S. ethanol use at global (Scenario 2) levels.

Each scenario was modeled by shifting the intercept in each relevant equation or by changing the technology parameter to change feedstock yields. All other equations and exogenous data (including macroeconomic information such as exchange rates and GDP) remain the same as in the base model run. All scenario results are reported as percentage deviations from the baseline or other specified levels.

Hypothetical Scenario 1

A 20 percent increase in demand for ethanol in the United States causes demand for ethanol feedstocks, primarily corn to increase. As a result, corn world reference price and U.S. corn producer price increase by 3 and 1 percent, respectively while U.S. corn production increases slightly—about one percent (Table 1). The slight increase in U.S.

corn production indicates that the potential for increasing corn plantings is low as opportunities for crop substitution and utilization of idle lands are limited. Opportunities for increasing corn production through crop substitution are limited by increased returns to other crops. Most of the adjustments in U.S. corn use come from a reduction in exports reflecting corn's high value as a livestock feed.

The high value of corn as a livestock feed keeps it in the United States, and as a result, U.S. exports of corn fall by 11 percent (Table 1). Despite this decline, the United States remains the biggest corn exporter. The increase in corn prices causes corn production in other countries to increase and leads to a significant increase in corn exports from other countries.

Increased prices of crops are partially offset by a decline in price of DDG's causing feed costs to increase slightly. The slight increase in feed costs causes U.S. livestock production to decline. U.S. exports of beef increase slightly as feed costs increase more in the rest of the world than in the U.S. putting rest of the world livestock producers at a slight competitive disadvantage relative to U.S. producers. This disadvantage reflects the availability of DDGs to U.S. livestock, particularly cattle producers which dampens the effect of the increased cost of corn on their production costs.

In addition, we conducted a modeling exercise to see how much corn yield needs to increase to offset the increase in demand for ethanol in the U.S. Increasing corn yields by 2.8 percent above current projected levels by 2017 would offset the projected corn price increase. If corn yield increases more than 2.8 percent, then, corn price starts to decline. USDA projections assume that U.S. corn yields will be increasing an average of 1.3 percent per year. This implies that corn yields will have to increase by 1.8 percent more per year than the 2.3 percent per year they grew over the last decade.

Hypothetical Scenario2

Scenario 2 deals with global expansion of ethanol and biodiesel use. The global demand shifts in this scenario result in the United States achieving the 10% gasoline blending limit. The EU25 also move close towards achieving biofuel voluntary targets of 5 % biofuels use in transportation by 2012. Lastly Brazil increases its ethanol use by 20 %, helping it maintain its energy independence.

Prices for feedstocks (corn, sugar, rapeseed), ethanol and biodiesel increase. As expected rapeseed oil production around the world expands (Figure 1). Rapeseed meal price declines. The increase in rapeseed oil production increases the supply of meal which is a co-product of the crushing process, driving its price down.

The effects of the increase in U.S. ethanol use are similar to the results described in the first scenario. In the EU25, production, prices and imports of rapeseed oil (RBO) increase (Table 2). RBO use increases by about 5 percent. RBO imports, however, are the major source of supply. RBO production increases by about 2 percent while RBO imports increase about 21 percent.

Hypothetical Scenario 3

This scenario deals with the same global ethanol and biodiesel demand shifts as in Scenario 2, but this time it is accompanied by a lower gasoline price. The 50 % reduction in price of gasoline causes biofuels use to fall significantly (Figure 2). Ethanol use in Brazil falls less than in the United States and EU, reflecting Brazil's lower costs of production which make ethanol produced in Brazil more competitive with gasoline.

The decline in biofuels use, in turn, causes world biofuel prices to fall substantially (Figure 3). A twist to Scenario 3 is to determine the reduction in the cost of U. S. production needed to keep ethanol competitive with gasoline in a low energy cost environment. We do this by shifting the U.S. supply curve for ethanol out until the ethanol produced under the Scenario 2 is met.   The decline in ethanol price needed to accomplish this goal will indicate how far the cost of producing ethanol will need to fall in order for it to remain competitive with low cost gasoline.

The U.S. ethanol supply curve needs to be shifted out by 38.5 percent to offset the effect of the 50 percent reduction in gasoline price on ethanol use (Figure 4). This translates into a 21 percent reduction in the price of ethanol. This indicates the difficulty in achieving U.S. ethanol targets in a low energy price environment.

Summary and Conclusion

The results of the analysis indicate that hypothetical increases in demand for biofuels would put upward pressure on agriculture commodity prices, particularly corn, sugarcane, and rapeseed, the major biofuel feedstocks in the United States, Brazil and EU, respectively. Increasing U.S. corn yield by almost three percent above current projected levels would offset the projected corn price increase from the 20 percent shift in U.S. ethanol demand.

A 50 % decline in gasoline prices would result in rapid decline in biofuel use worldwide accompanied by a decline in feedstock and biofuel prices. A substantial decline (about 21%) in U.S. ethanol production costs is needed to offset reduction in ethanol demand due to lower gas prices. This is necessary to make ethanol competitive with gasoline without a subsidy.

Supplying sufficient biofuels to meet energy targets and objectives will continue to have a major impact on agricultural commodity markets and trade. This impact will be lessened if yields for current ethanol feedstocks increase or more productive (greater ethanol yield per acre) feedstocks, such as switchgrass become feasible. At the same time the ability of countries to achieve their energy goals will be affected by future direction of gasoline prices. With high gasoline (energy) prices, use of biofuels will likely be limited only by the development of needed infrastructure (flex fuel vehicles and capacity to deliver biofuels from plant to retail outlets). At substantially lower gasoline prices the cost of converting feedstocks into biofuels will need to be substantially reduced or governments will have to subsidize their use to meet their energy targets and goals.

References

Baker, Mindy L., Dermot J. Hayes and Bruce A. Babcock. *Crop-Based Biofuel Production under Acreage Constraints and Uncertainty.* Working Paper 08-WP460. Center for Agricultural And Rural Development. Iowa State University . Ames, Iowa. February, 2008.

Dirkse, S. P. and M.C. Ferris. *MCPLIB: A Collection of Nonlinear mixed Complementarity Problems*. Optimization Methods and Software, 5 (1995).

Dirkse, S. P. and M.C. Ferris. *The Path Solver: A non-monotone Stabilization Scheme for Mixed Complementarity Problems.* Optimization Methods and Software, 5 (1995).

Elobeid, A and S. Tokgoz. *Removing Distortions in the U.S. Ethanol Markets: What Does It Imply for the United States and Brazil*?," Selected paper American Agricultural Economics Association Annual Meeting, Portland, OR, July 29-August 1, 2007.

Ferris, M.C. and J.S. Pang. *Engineering and Economic Applications of Complementarity Problems*. SIAM Review. 39 (669-713). 1997.

Gallagher, P., G. Schalel, H. Shapouri and H. Brubaker. *"The International Competitiveness of the U.S. Corn-Ethanol Industry: A Comparison with Sugar-ethanol Processing in Brazil,"* Agribusiness, Vol. 22(1): 109-134. 2006.

Gardner, Bruce. "*Fuel Ethanol Subsidies and Farm Price Support"* Journal of Agricultural and Food Industrial Organization. Vol. 5 (special issue), 2007.

Koizumi, T. and K. Yanagishima. *"Impacts of Brazilian Ethanol Program on the World Ethanol and Sugar markets: An Econometric Simulation Approach,"* Japanese Journal of Rural Economy. Vol. 7: 61-77. 2005.

Lampe, Martin von. *"Agricultural Market impacts of Future Growth in the Production of Biofuels"* Organization of Economic Cooperation and Development, Directorate for Food, Agriculture and Fisheries Committee for Agriculture, Working Party on Agricultural Polices and Markets, Paris France, February, 2006.

Interagency Agricultural Projections Committee. *USDA Agricultural Projections to 2017*. Long Term Projections Reports OCE-2008-1. Washington, DC: U.S. Department of Agriculture, Office of the Chief Economist, World Outlook Board, February 2008.

Schmitz, Andrew, Charles B. Moss and Try G. Schmitz. "*Ethanol: No Free Lunch"* Journal of Agricultural and Food Industrial Organization. Vol. 5 (special issue), 2007.

Shane, Mathew, William Liefert, Mitch Morehart, May Peters, John Dillard, David Torgerson and Bill Edmondson. *The 2008/2009 World Economic Crisis: What it means for U.S. agriculture.* Economic Research Service. U.S. Department of Agriculture, Washington, D.C. 2009

Tokgoz, Simla, A. Elobeid, J. Fabiosa, D. Hayes, B. Babcock, T. Yu, F. Dong, C. Hart, J. Beghin. "*Long-Term and Global Trade-offs between Bio-Energy, Feed and Food,*" Selected paper presented at the American Agricultural Economics Association Annual Meeting , Portland, Oregon. July 29-Aug.1, 2007.

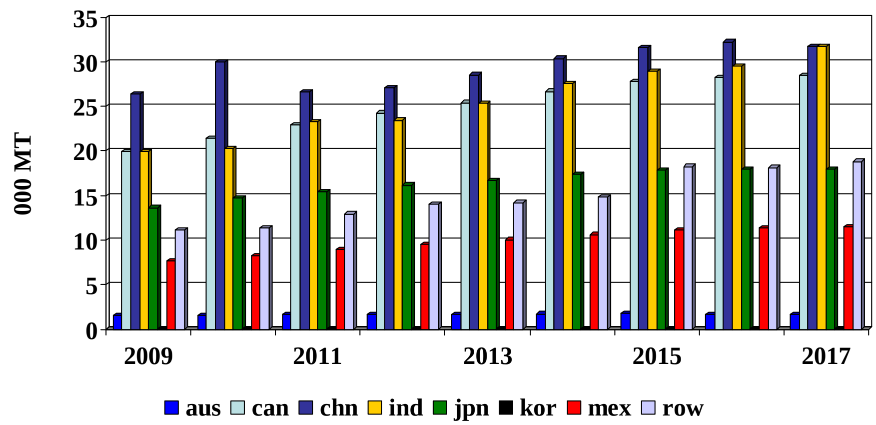
Table 1. Scenario 1A: Impact of a 20 % U.S. ethanol demand shift

Commodity	World Ref. Price	U.S. Production	U.S. Exports
	% change from base		
Corn	3.1	0.8	-11.0
Wheat	0.7	-0.1	-0.8
OCG	0.9	0.0	-2.0
Soybeans	1.0	-0.3	-0.6
Soy meal	0.6	-0.2	0.5
Soy oil	1.1	-0.2	-2.4
Beef	1.2	-1.1	0.4
Pork	0.8	-0.6	-1.3
Poultry	1.0	-0.6	-1.2

Table 2. Scenario 2: Impact of a global biofuel demand shifts, European Union Results

Commodity	World Ref Price	Imports	Production	Domestic Use
	Percentage Change from Base, %			
Rapeseed				
Seed	5.4	9.8	1.8	1.8
Oil	9.2	20.9	1.8	4.9
Meal	-2.8	2.9	1.2	2.1

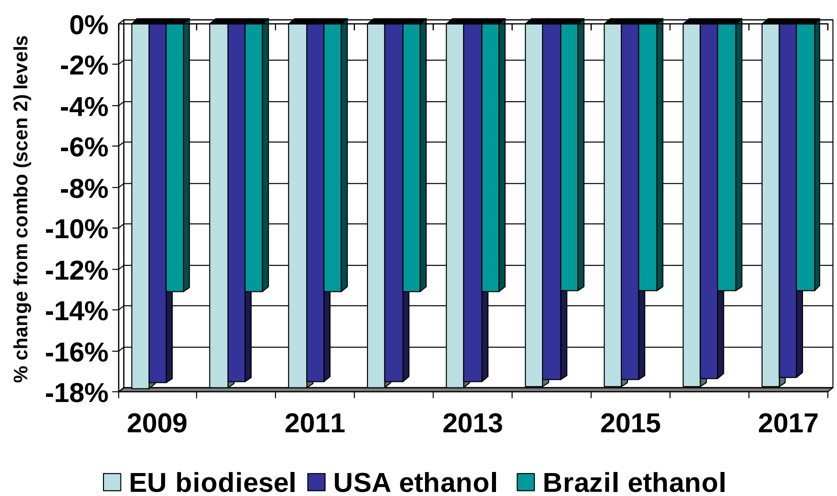
Figure 1. Scenario 2: Change in global rapeseed oil production with global biofuel demand shifts*



Source: PEATSim model results

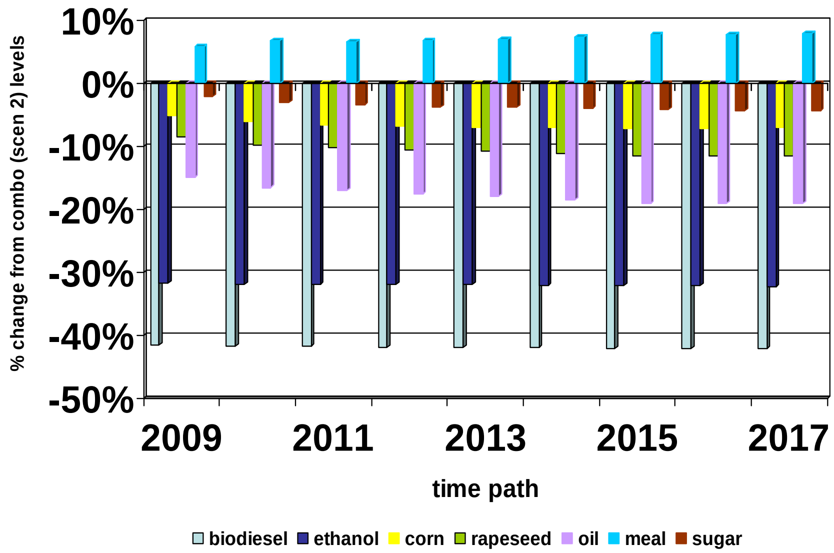
* excluding EU results

Figure 2. Scenario 3A: Change in Biofuel use with global demand shifts and decrease in price of gas



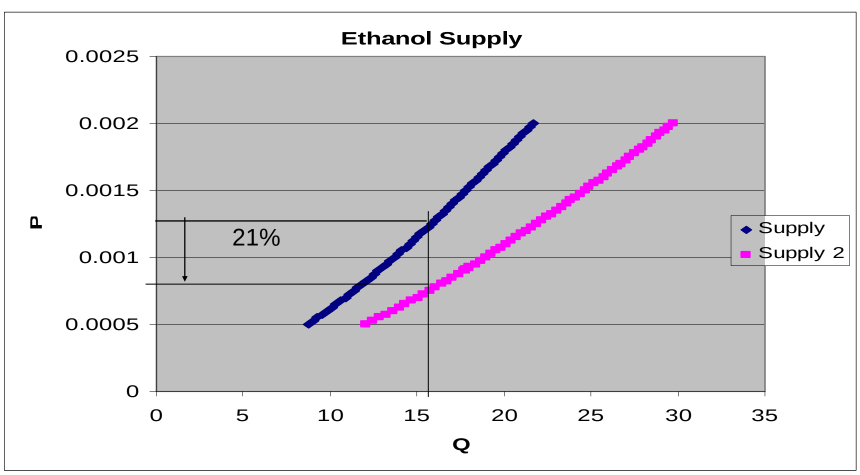
Source: PEATSim model results

Figure 3. Scenario 3A: Change in world prices with global demand shifts and reduction in price of gas



Source: PEATSim model results

Figure 4. Scenario 3B: Supply shift needed to keep ethanol competitive



Source: PEATSim model results