Biofuels and Trade: World Agricultural Market Impacts

by
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Introduction

The United States has surpassed Brazil as the largest producer of ethanol in the world. The rapid expansion of biofuel production in the United States and the rest of the world increased the demand for feedstocks such as corn, soybean, rapeseed and sugarcane for biofuel. As Westcott (2008) shows, about a quarter of the total corn crop in the U.S. was used in ethanol production in 2007. The increased demand for corn might lead to increase cropland to corn from other competing crops such as soybeans, wheat, cotton, and other field crops. Satisfying the demand for biofuel is expected to impact agricultural global markets from the farm to markets - prices, supply, and use. This paper examines the impact of increased sources of biofuels on agricultural commodity production, trade patterns and input use. It also examines alternative hypothetical scenarios of increased demand for biofuels and supply response assumptions to assess their impact on the global agricultural markets.

The expansion of biofuel production and consumption is not limited to the United States. Increased crop-based production took place in Brazil over the last several decades, as Brazil used sugarcane as a feedstock to produce ethanol, and then used ethanol on a large scale to fuel vehicles. The EU has used rapeseed oil to produce biodiesel for fuel use in relatively large quantities over the last decade. Government policies are also influencing biofuel industries in Canada, Argentina, China, countries of the Former Soviet Union, Malaysia, and Indonesia. A number of developed and developing countries have instituted programs to promote biofuel production and consumption and have set targets for increasing the use of biofuels.

In the United States, the Energy Policy Act of 2005 mandated that renewable fuel use in gasoline reach 7.5 billion gallons by calendar year 2012. Prior to passage of the Energy Security and Independence Act (EISA) in December, 2007, projected growth in ethanol production in the United States was expected to exceed the 7.5 billion gallon mandate, more than doubling from 2005/06 levels within a few years. The EISA mandates the use of 36 billion gallons of biofuels by 2022, of which 15 billion must come from corn-based ethanol and 21 billion gallons from advanced or second generation biofuels. The latter should include 1 billion gallon of biomass-based diesel and 16 billion gallons of cellulosic biofuels.

The European Union (EU) is expected to increase the use of biodiesel in the future by having a voluntary mandate for their biofuels. The EU has a target to obtain 5.75 percent of transportation fuel from biofuels by 2010. EU policy has provided a per acre subsidy for the production of energy crops and individual member countries also offer tax credits on biofuels.

China provides a subsidy for producing fuel ethanol from corn. In 2007, China used approximately 3.5 million tons of corn to produce fuel ethanol. However, due to its food security policy, China is attempting to focus on ethanol production using nongrain feedstocks such as sweet potatoes and cassava. On the other hand, Brazil has implemented a major substitution of crop-based fuel for petroleum program. Brazil remains one of the largest producers of ethanol, nearly all of it made from sugarcane.

Canada has mandated that biofuels make up 5 percent of all transportation vehicle fuel by 2010. Meanwhile, Argentina has a system of differential export taxes resulting in a lower tax rates for biodiesel exports than the tax rates on feedstock exports such as corn or soybean oil. This provides an incentive for further investments in Argentina's already large crushing industry.

An analysis of these world-wide mandates call for an innovative way to capture the impact generated from the *demand-side* and analyze the linkages between upstream and downstream responses of the corn, corn-milling, ethanol and ethanol commingling with gasoline “complex”. Although the increase in biofuels use generates discrete or “discontinuous” demand, the *supply-side* has to be taken into account in the model as supply adjusts and responds. This calls for an innovative specification to capture the possible impacts at the farm level all the way to the global market.

We do this by augmenting our current model and incorporating a biofuel module that links the farm activities/sectors with downstream industries in key countries (the United States, Brazil, EU, China, Argentina and Canada). We further analyze the links and interactions between the markets for oil petroleum, biofuels, feedstocks, and the by-products of biofuel processing. We also assess the effects of both increased demand for biofuel and increased availability of feedstock due to technological innovation on the biofuel markets.

As different countries use different feedstock sources, the challenge is to capture and properly model both the demand for biofuels and 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- What we have learned so far

Baker et. al. developed a stochastic and dynamic general equilibrium (GE) model that captures the uncertain nature of key variables such as crude oil prices and commodity yields. They show that both the subsidy for corn ethanol, biodiesel and cellulosic ethanol needs to be increased to increase the production of these products. However, international trade is not present in the model. An international sector is needed to fully describe and analyze the domestic bioeconomy.

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.

Tyner, Hertel, et.al. (2008) used a CGE model in GTAP framework to assess the economic and environmental impacts of regional and global policies designed to stimulate biofuels production and use. The scenarios in the study include a hike in crude oil prices, replacement of MTBE by ethanol in gasoline additives, and subsidy for ethanol. They result in increased use of corn for ethanol production.

Earlier studies had exogenous assumptions about the biofuel sector. Relatively few studies have addressed the impact of stronger biofuels demand on agricultural sectors. Earlier studies have exogenous assumption about the bioenergy industry while recent studies have endogenized energy and biofuel production and demand.

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 a competitive export position in the ethanol market.

Von Lampe (2006) conducted 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 the policy goals as stated by the respective country governments. 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 bioeconomy. They analyzed the impact of liberalizing the U.S. ethanol market and removing the U.S. federal tax credit on the U.S. and international agricultural markets. The trade liberalization resulted in an increase in U.S. net ethanol imports which decreased corn demand for ethanol and corn price. Removal of the U.S. tariff on ethanol and reduction of the blending credit increased 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 the 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.

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. Continued growth in the use of food and feed products in the production of fuel has led to questions about short- and long-term market impacts. For these reasons, we use the *dynamic version* of the Partial Equilibrium Agricultural Trade Simulation (PEATSim[1]) model as a tool to analyze the complex facets of this problem that calibrates to the USDA baseline projections.

PEATSim (dynamic version) is a partial equilibrium multiple-commodity, multiple-region model of global agricultural policy and trade. The model accounts for

[1] The original version of the model, so-called ERS/WTO Penn State model, was developed by the Economic Research Service (ERS) at USDA, with the collaboration of Pennsylvania State University. Since 2004, the model has been augmented and improved and to date have a fully endogenous biofuel sector. The model has been converted from a comparative static to a recursive dynamic model with model equations parameterized to correspond to a yearly time-step

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 biofuel (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 both upstream and downstream, 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 the GAMS (General Algebraic Modeling System) programming language utilizing the PATH a *Mixed Complementarity Problem Algorithm* (MCP) developed by Dirkse and Ferris (1995) (see Appendix A). MCP allows PEATSim to generate a model with different production -consumption regimes and functional form discontinuities**.** This means that PEATSim is able to handle discontinuous functional forms such as Tariff Rate Quotas (TRQ), discontinuous demand issues created by mandates, targets, and other complicated policy instruments. It also allows for endogenous determination of which *regimes* are active and what are the consequences of *regime* shifts, such as "in quota" tariff to "over-quota" tariff. For example, PEATSIM endogenously determines in which segment of a "kinked" TRQ price and quantity solves and makes the need for the arbitrary *quota rent* allocation obsolete.

Model structure

PEATSim is a reduced-form model that captures the economic behavior of producers, consumers and markets in a global framework. It includes variables for production, acreage, yields, consumption, exports, imports, stocks, world prices, and domestic producer and consumer prices. Identities such as supply and utilization, consumption and its components 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. The model can be used for scenario analysis of a *base year* and simulate medium run scenarios as in "what-if' situation. It also can calibrate to each country's agricultural activities according to the USDA's long term projections and in this case it is used to perform simulations of the *USDA baseline*. 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 functions.

Country Coverage

PEATSim includes thirteen countries or regions: the United States, the European Union (EU-25), Japan, Canada, Mexico, Brazil, Argentina, China, India, Australia, New Zealand, South Korea, and the Rest of the World (ROW).

Commodity Coverage

There are thirty-five agricultural commodities: 13 crops (rice, wheat, corn, other coarse grains, soybeans, sunflowers, rapeseed, peanuts, cotton, cotton, other oilseeds, tropical oils, and sugar); 12 oilseed, oil, and meal products (soybean, sunflower seed, rapeseed, cottonseed, peanut, and other oilseed);), 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). There are three biofuel commodities and byproduct - ethanol, biodisel, and 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 values divided by seed values times yields). 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 price of the feedstocks used.

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} = tariff rate quotas;

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

DUT_{irt} = specific duties.

Data

The data in PEATSim are from the USDA Agricultural Projections to 2016 (USDA, 2007), for area, yield, production, consumption, stocks, trade, and world prices. Dairy and sugar information from OECD supplements the dataset. Parameter values in the model are synthetic, drawn from the literature and from other trade models such as ERS baseline projections model, European Simulation Model (ESIM), Food and Agricultural Policy Simulator (FAPSIM), OECD's AGLINK model, FAO's World Food Model, IFPRI's IMPACT model, Policy Analysis System-Economic Research Service (POLYSYS-ERS) model and the Static World Policy Simulation Model (SWOPSIM).

Biofuel Sector in PEATSim Model

The biofuel component of the model includes a detailed industrial use module as well as downstream industries related to biofuels. Specifically, for the United States it includes corn milling industry, the sugar complex and downstream blending gasoline industry. PEATSim also incorporates the use of DDG's (Distillers Dry Grains) in the feeding of livestock to measure the effect of byproducts on the livestock industry.

Policy Modeling Structure

Aside from trade policies, PEATSim is able to model domestic policies including price supports and loan rates specific to a country or region. Explicit representation of each country's trade and domestic policies is a unique feature of the model.

Results and Analysis

The dynamic PEATSim model has the capability of generating annual changes over a time path. The model's time path runs from 2008-2015. Once the model is calibrated to the 2008-2015 results from the USDA projections, alternative scenarios are simulated and sensitivity analyses are conducted. The shocks are introduced to the model to determine how the different agricultural sectors will react and adjust.

Base Model Run

As a starting point for discussion, the USDA's long term projections were used in 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. The Farm Security and Rural Investment Act of 2002, the Energy Policy Act of 2005 and the Agricultural Reconciliation Act of 2005 are assumed to remain in effect through the projection period. The base run does not include provisions of the Energy Independence and Security Act of 2007 or the 2008 U.S. Farm Act.

Scenarios

Since the United States is the biggest producer and exporter of corn, a primary feedstock for ethanol and livestock feed, three hypothetical scenarios focus on changes in the demand and supply of corn and how it will affect this country's domestic as well as global agricultural markets. Another hypothetical scenario focuses on rapeseed oil, a major feedstock for biodiesel production in the EU. Each scenario was modeled by shifting the intercept in each relevant equation. All other equations and exogenous data (including macroeconomic information such as exchange rates) remain the same as in the base model run. To increase ethanol demand, we shifted the ethanol demand equation by 15 percent. The same methodology was employed on the demand equations for biodiesel and the yield equation in the other scenarios. *All scenario results are reported as deviations from the baseline*.

We modeled three hypothetical scenarios for this study, namely:

- Scenario 1 – a hypothetical increase in ethanol demand of 15 percent in the United States. The rationale for this hypothetical scenario is a continued increase in the price of crude oil and a continued emphasis on increasing availability of alternative fuels by governments around the world.
- Scenario 2 – Scenario 1, accompanied by a hypothetical 10 percent increase in corn yield in the US. It is possible that a combination of increase in corn yields and an increase in ethanol demand will occur simultaneously. These two events may have offsetting effects. They will influence crops and livestock differently based on how they affect feed supplies and costs.
- Scenario 3 – a hypothetical increase in yield to offset the increase in the demand for ethanol in the US. We experimented with the model to see what increase in yield would result in no change in world price of corn, after we increased ethanol demand by 15 percent.
- Scenario 4 - a hypothetical increase in the use of rapeseed oil in biodiesel production in the European Union (EU). In the USDA baseline the EU was assumed to meet only three quarters of their mandate for biodiesel production. Under this a hypothetical scenario rapeseed oil use for biodiesel is increased by 1.4 to 1.7 million metric tons.

Scenario 1

We first look at a hypothetical 15 percent increase in ethanol demand in the US compared to the baseline scenario. This is the initial shock we introduce to the model. The increase demand for ethanol causes demand for ethanol feedstocks in the US, primarily corn to increase. As a result, corn price increases between 4 and 6 percent and corn production in United States increases slightly less than 1 percent (Table 1). The slight increase in corn production reflects the fact that relative prices do not change sufficiently to shift land out of other crops. This keeps acreage devoted to production of other crops from switching to corn. The increased demand for corn coupled with minimal increase in corn production leads to a tightening of stocks.

US corn use increases as a result of the increase in ethanol demand and the resulting increase in corn prices cause US exports of corn to fall around 25 percent, reflecting the importance of corn as a livestock feed. The high value of corn as feed keeps it in the US rather than being exported. Thus, U.S. share of world corn exports falls from 60 percent to 48 percent. Decline in U.S. exports leads to a 12 percent growth in corn exports from the rest of global market. Other countries besides the United States will collectively increase corn exports by 12 percent as their production increases in response to higher world corn prices.

Impacts on the rest of the US agricultural sector are fairly small. Soybean production in the United States declines slightly and soybean prices increase by less than 2 percent. Wheat production increases slightly while feed use of wheat increases by 7 percent. This reflects the increased value of wheat as a livestock feed due to increase in corn price. US wheat exports are affected somewhat more as US wheat exports decline moderately. US livestock production declines slightly. Beef, pork, and poultry production decline as feed cost increase. Some of this decline is offset by larger supplies of DDG's.

Scenario 2

This hypothetical scenario examines a combination of shocks (15 percent increase demand for ethanol accompanied by a 10 percent increase in corn yield). The increase in corn yields combined with increase in demand for ethanol leads to increased corn use, which is more than offset by increased production. Corn prices decline about 4 to 6 percent over the baseline period. As a result, corn increases its relative competitiveness in feed and export markets. US feed use of corn increase moderately while US exports of corn increase sharply (Table 2).

Production of other crops is largely unaffected by increase in corn yields. Corn area declines as yield growth offsets the need for land. Wheat and soybean area expand slightly as the price decline for these products less than the price of corn. The decline in feed demand for wheat and soybeans is caused by the decrease in corn prices and the increased in supply of DDGs. The decline in prices causes an increase in US exports of wheat and soybean oil.

The US livestock sector benefits from the lower grain prices. Beef production expands between 1 and 2 percent over the period. Poultry and pork production also increases about 1 percent because of the lower feed costs. These feed cost declines are a result of lower grain prices and lower DDG prices.

Scenario 3

In scenario 3 we performed a hypothetical experiment. We tested the model to determine what level of yield increase would be necessary to offset the 15 percent increase in ethanol demand. We changed yield levels until there was no change in the price of corn and therefore no change in livestock or trade in corn. A yield increase of 5 percent was enough to offset the increase in ethanol demand.

Scenario 4

The last scenario that we examine is a hypothetical increase in the amount of biodiesel used in the EU. Under the USDA baseline the EU did not meet its mandate for biodiesel production over the baseline period. In this analysis we examine the impact of increasing biodiesel use in the EU to mandate levels. This increase in biodiesel production was assumed to come from rapeseed oil (Table 3). These results show a rapid increase in the price for rapeseed oil over the period, from 23 to 25 percent. Soybean oil prices also increase as the vegetable oil complex rises from the increase in demand. Rapeseed oil production in the EU increases between 4 and 6 percent however rapeseed imports are a major source for this increase in EU production. Most of the increase in biodiesel production comes from increased imports of rapeseed oil and rapeseed. Rapeseed imports increase about 27 percent. Land limitation in the EU will limit their ability to expand biodiesel production from domestic sources.

Summary and Conclusion

The results of the scenario analysis indicate that the hypothetical increases in demand for ethanol would put upward pressure on agriculture commodity prices, particularly on corn, the major ethanol feedstock in the United States. Increases in yields of 5–10 percent were found to reduce the pressure on agricultural commodity prices. An increase in corn yields would increase supply of livestock feed without significantly reducing the production of other crops.

The base scenario, USDA baseline projections already include estimates of expected increase in corn yields so that a hypothetical 5-10 percent increase represents an increase in yields above the current expectations. Over the last ten years, US corn yields increased on average about 2.3 percent a year. Because the analysis was done using an intercept shift, the first year increases 10 percent with the growth rate for the remaining periods the same as in the baseline. An additional 10 percent growth in corn yield would imply a 1.7 percent greater annual average growth rate between 2008 and 2015.

Biodiesel production in the EU will have to be sourced from outside sources. There is a limited ability to domestically produce biodiesel.

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Appendix A. Mixed Complementarity Problem

A fundamental mathematical problem is to find a solution to a square system of nonlinear equations. There are two developed generalizations of nonlinear equations namely, a constrained nonlinear system which incorporates bounds on the variables, and the complementarity problem. The latter, adds a twist to the classic square system of non-linear equations. In its simplest form, the combinatorial problem is to choose from $2n$ inequalities a subset of n that will be satisfied as equations. These problems arise in a variety of disciplines including economics in computing Walrasian equilibrium, and in modeling the first order optimality conditions for nonlinear optimization programs.

The mixed complementarity problem is defined by a function $F: D \rightarrow \mathbf{R}^n$ where $D \subseteq \mathbf{R}^n$ is the domain of F and possibly infinite lower and upper bounds, l and u. Let $C := \{x \in \mathbf{R}^n \mid l < x < u\}$, a Cartesian product of closed (possibly infinite) intervals. The problem is given as

$$\text{MCP: find } x \in C \cap D \quad \text{s.t. } [F(x),\ y - x] \geq 0, \ \forall\, y \in C,$$

This formulation is a special case of the variational inequality problem defined by F and a (nonempty, closed, convex) set C. Special choices of l and u lead to the familiar cases of a system of nonlinear equations.

$$F(x) = 0$$

(generated by $l \equiv -\infty$, $u \equiv +\infty$) and the nonlinear complementarity problem

$$0 \leq x \quad \perp \quad F(x) \geq 0$$

(generated using $l \equiv 0$, $u \equiv +\infty$).

Table 1. Impact of a Hypothetical 15 percent increase in Ethanol Demand, deviation from the baseline							
USA	Year						
	2009	2010	2011	2012	2013	2014	2015
Corn							
Acres Harvested	0.46%	0.56%	0.58%	0.58%	0.56%	0.54%	0.51%
Yield	0.04%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%
Production	0.50%	0.60%	0.63%	0.63%	0.61%	0.59%	0.56%
Exports	-25.16%	-25.45%	-25.66%	-24.96%	-24.31%	-23.72%	-23.56%
Price	4.27%	5.28%	5.73%	5.90%	5.89%	5.79%	5.63%
Livestock Production							
Beef	-0.47%	-0.67%	-0.77%	-0.81%	-0.82%	-0.81%	-0.78%
Pork	-0.14%	-0.19%	-0.21%	-0.24%	-0.25%	-0.23%	-0.20%
Poultry	-0.13%	-0.18%	-0.20%	-0.21%	-0.21%	-0.20%	-0.17%

Table 2. Impact of a Hypothetical 15 Percent Increase in Ethanol Demand and a 10 Percent increase in Corn yield, deviation from the baseline

USA	Year						
	2009	2010	2011	2012	2013	2014	2015
Corn							
Acres Harvested	-0.49%	-0.64%	-0.65%	-0.63%	-0.63%	-0.64%	-0.64%
Yield	9.96%	10.99%	11.10%	11.11%	11.11%	11.11%	11.11%
Production	9.42%	10.28%	10.37%	10.41%	10.41%	10.39%	10.39%
Exports	26.15%	29.66%	28.63%	29.03%	29.17%	29.06%	28.89%
Price	-4.43%	-5.96%	-6.26%	-6.29%	-6.47%	-6.74%	-6.85%
Livestock Production							
Beef	1.20%	1.72%	1.88%	1.90%	1.94%	2.00%	2.04%
Pork	0.58%	0.80%	0.85%	0.82%	0.83%	0.87%	0.90%
Poultry	0.49%	0.67%	0.71%	0.70%	0.71%	0.74%	0.75%

Table 3. Impact of a Hypothetical Increase in Biodiesel Production to the EU mandate, deviation from the baseline

	Year						
	2009	2010	2011	2012	2013	2014	2015
Production	4.94%	5.30%	5.38%	5.46%	5.54%	5.61%	5.62%
Imports	42.61%	42.77%	42.42%	41.58%	41.02%	40.70%	40.31%
Use	12.41%	12.32%	12.29%	12.21%	12.13%	12.06%	11.95%
Price							
Rape Oil	22.52%	23.45%	23.80%	24.19%	24.54%	24.83%	24.85%
Soybean Oil	2.83%	3.49%	3.73%	3.85%	3.94%	4.00%	3.78%
Imports							
Rapeseed	27.00%	27.38%	27.56%	27.83%	28.14%	28.42%	28.20%