Analyzing the Impacts of Biofuel Mandates on World-Wide Grain, Livestock, and Oilseed Sectors

Richard Stillman, Jim Hansen, Ralph Seeley,
Dave Kelch, Agapi Somwaru, and Edwin Young

United States Department of Agriculture, Economic Research Service,
Market and Trade Economic Division, Washington, DC

Selected Paper prepared for presentation at
DOMESTIC AND TRADE IMPACTS OF U.S. FARM POLICY: FUTURE DIRECTIONS AND CHALLENGES
Washington, DC, November 15-16, 2007

Questions or comments can be addressed to Richard Stillman, Jim Hansen, and Dave Kelch at USDA/ERS/MTED 1800 M St. Rm S5205, Washington D.C. 20036; (202) 694-5265, 694-5321, and 694-5151; stillman@ers.usda.gov, jhansen@ers.usda.gov, dkelch@ers.usda.gov,

Analyzing the Impacts of Biofuel Mandates on World-wide Grain, Livestock, and Oilseed Sectors

Richard Stillman, Jim Hansen, Ralph Seeley, Dave Kelch, Agapi Somwaru, and Edwin Young

Increased use of agricultural products in the production of biofuels has contributed to rapid increases in grain prices in the U S and the world. Agricultural commodity market prices increased dramatically in 2006 and remained at high levels in 2007 in part because of the increased demand for biofuel feedstocks. Corn prices rose from below $2.00 in the beginning of the 2006, to well over $3.00 by the end of the year. This price rise occurred even with the third largest corn crop in U S history. A large corn crop in the United States in 2007 has eased corn prices slightly but supplies remain relatively tight.

Construction of new ethanol plants continued at a strong pace, 16 percent in 2006, but expansion in ethanol production capacity grew faster, 27 (Renewable Fuel Association, 2007). Demand for corn used in ethanol production increased by 23 and 31 percent in crop marketing years 2005 and 2006 respectively. Total corn used for ethanol production was 1,605 million and 2,125 million bushels in the 2005 and 2006 marketing years, which was 14.2 and 18.6 percent of total corn use for ethanol production in the United States, respectively (USDA, 2007).

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. However, factors such as, high oil prices combined with blender tax credits and import tariffs; elimination of methyl tertiary butyl ether (MTBE) as an additive in gasoline blending; State programs; and other factors, have provided economic incentives for a biofuel expansion

that exceeds the Act's mandate. Projected growth in ethanol production in the United States is expected to more than double from 2005/06 levels within a few years (USDA, 2007).

The expansion in biofuel production and consumption is not limited to the United States. Major substitution of crop-based fuel for petroleum took place in Brazil. In the last several decades the Brazilian government supported the use of sugarcane to produce ethanol on a large scale to fuel vehicles. The European Union supported the use of rapeseed oil to produce biodiesel for fuel use in relatively large quantities over the last few years. The EU is expected to increase the use of biofuels in the future by introducing a mandatory level of production. Government intervention is critical to the development of biofuels and is spurring biofuel industries in Canada, Argentina, China, countries of the Former Soviet Union, Malaysia, Thailand, and others.

We use the Partial Equilibrium Agricultural Trade Simulator (PEATSim) to test the model's ability to analyze the expansion of biofuel production in key countries. Using PEATSim, we examine the effects of mandated biofuels policies as well as different tariff policies in world biofuel markets and on agricultural commodity markets. We look at the cross country and cross commodity impacts of the growth in the biofuel markets.

More specifically, we analyze the impacts of biofuel induced demand on commodity production, use, and prices across commodities and countries. Continued growth in the use in food and feed products coupled with demand for grains in the production of biofuel has led to questions about the short- and long-term market impacts of energy on food crops. In addition, byproducts from biofuel production have changed the landscape of feed and livestock industry. We design scenarios that help understand these complex phenomena and their impacts on agriculture and agricultural trade.

We construct three scenarios that evaluate the effects of a change in use on agriculture in the three main biofuels-producing countries in the world, the United States, Brazil, and the EU:

1. Examine the impact of the US exceeding the projected level of ethanol production by 10 percent in 2010. Holding EU biofuels at the projected levels.

2. Examine the impact of the EU exceeding the projected level of biodiesel production by 10 percent in 2010. Holding US biofuels at the projected levels.

3. Examine the combined impact of the US, the EU, Brazil, and China all exceeding the projected levels of biofuels by 10 percent.

Literature Review

Relatively few studies have addressed the impact of stronger global biofuels demand on agricultural sectors. The earlier studies had exogenous assumptions about the bioenergy industry, while recent studies have endogenized energy and biofuel production and demand. Research studies include those by Koizumi and Yanagishima, 2005: Gallagher et al., 2006: von Lampe, 2006; and Elobeid and Tokgoz, 2007.

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

The von Lampe 2006 study 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 final scenario incorporated adjustments of energy and fuel prices, which affected the cost of agricultural production, and the profitability of biofuel production.

The study by Elobeid and Tokgoz (2007) 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. According to Elobeid and Tokgoz removal of the 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. The resulting reduction in corn demand for ethanol is about 250 million bushels of corn.

Additional detailed studies on ethanol and the impacts on global agricultural markets included the 2007 study by Tokgoz *et al*, although that study did not include trade liberalization. Tokgoz *et al*. provided estimates of the impacts of 1) higher oil prices, 2) a drought, and 3) removal of land from the U.S. Conservation Reserve Program.

Partial Equilibrium Agricultural Trade Simulator

The Partial Equilibrium Agricultural Trade Simulator (PEATSim) is an applied partial equilibrium, multiple-commodity, multiple-region model designed for use in analyzing domestic agricultural policy and international agricultural trade policy. 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 Penn State University (Stout and Abler).

PEATSim is a reduced-form model that captures the economic behavior of producers, consumers and markets in a global framework. The behavioral equations have the same functional form all regions in the model and the model calibrates each country's agricultural activities to the world projections in 2010. The strength of PEATSim is its ability to handle TRQ's (Tariff Rate Quotas) while accounting for simultaneity between livestock and crops. PEATSim also is able to model domestic policies including output payments, price supports,

and loan rates. This model has been developed to analyze trade policy and has been developed further too specifically analyze the impacts of policy changes in the ethanol sector.

PEATSim includes twelve countries or regions: the United States, the European Union (EU-25), Japan, Canada, Mexico, Brazil, Argentina, China, Australia, New Zealand, South Korea, and the Rest of the World (ROW). 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); and six dairy products (fluid milk, butter, cheese, nonfat dry milk, whole dry milk, and other dairy products). PEATSim 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 countries/regions in the model.

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

$$NET_{ir} = PRD_{ir} - FOO_{ir} - FEE_{ir} - CRU_{ir} - RMD_{ir} - OTH_{ir} - STK_{ir,}$$

Where PRD_{ir} is production, FOO_{ir} is food demand, FEE_{ir} is feed demand, CRU_{ir} is crush demand (zero for all commodities except oilseeds), RMD_{ir} is processing demand (zero for all commodities except raw milk), OTH_{ir} is other use demand, and STK_{ir} is the net increase in ending stocks between years. Global market equilibrium requires that the sum of net trade across regions be equal to zero for each internationally traded commodity:

$$\sum_{R=\text{all regions}} NET_{ir} = 0 \text{ for i traded commodities}$$

We will present a brief over view of the structure of the model for a detailed description, see Stout and Abler.

Production of grains, oilseeds, and cotton (PRD_{ir}) is the product of acreage harvested (AHV_{ir}) and yield (YLD_{ir}). Area harvested is specified as a constant-elasticity function of the crop's own producer price and the producer prices of other crops (PRP_{ir}). 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.

Total consumption of each commodity in the model is the sum of food demand (FOO_{ir}), feed demand (FEE_{ir}), crushing demand (CRU_{ir}), processing demand (RMD_{ir}), and other use (OTH_{ir}). 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. Since milk in its raw form is not consumed, there is a processing demand for raw milk to produce dairy products. Other use demand has been small, but with the growth of the biofuels sector, this demand is a rapidly growing area. Until we have fully incorporated the behavioral biofuels sector in the model, this will be the variable that will be shocked to assess the impact of the three scenarios.

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

$$PIM_{ir} = PWD_{ir}(1 + TAR_{ir}) + TRANS_{ir} + DUT_{ir}$$

,

where PIM_{ir} is the import price, TAR_{ir} is the *ad valorem* tariff, $TRANS_{ir}$ is the transportation cost, and DUT_{ir} are specific duties.

PEATSim is solved in GAMS (General Algebraic Modeling System) using Mixed Complementarity Programming (MCP). This software, developed by the GAMS

Corporation, allows for discontinuous functional forms, resulting from TRQ's. PEATSim uses MCP specifically to solve TRQ problems, and is unique in that it can address both the domestic policies associated with biofuel issues, as well as border measures and trade effects.

Data and Assumptions

The comparative static version of PEATSim is used in this analysis. The policy set for all regions in the model includes *ad valorem* tariff-rate quotas (TRQ's), producer and consumer subsidies, and production quotas for commodities (an example being the EU dairy quota). The data in PEATSim are from the USDA Agricultural Projections to 2016, including data for area, yield, production, consumption, stocks, trade, and world prices. The model's base year is 2010. The year 2010 was chosen to incorporate some of the ethanol and biodiesel growth, and to eliminate some of the base year problems that can occur in static models.

Once the model is calibrated to the 2010 results from the USDA projections, alternative scenarios are simulated by changing the exogenous demand variable for other use (OTH_{ir}) for the appropriate commodity to reflect the assumed change in biofuel production. An example is the increase in US corn used for the production of ethanol by 10 percent in the first scenario. These assumptions are determined by using standard conversion factors for biofuels production from the corresponding feedstock.

Rapid growth in the ethanol sector has resulted in a projection of over 10 billion gallons of corn-based ethanol in the USDA long term projections for the year 2010. This amount of ethanol requires 4 billion bushels of corn in its production, and accounts for about 31 percent of the corn use.

An important international assumption in the USDA projections was that the EU does not meet its goal of providing 5.75 percent of their fuel needs by 2010. The projections assumed that the EU would meet about two-thirds of this mandate. We will examine the impact of the EU's expanding the production of biodiesel in 2010 by 10 percent through the use of rapeseed oil. This assumption is based on the ability to grow rapeseed in Europe, and the reluctance of

the EU to use tropical oils for environmental reasons. Rapeseed production increased by 10 percent (about .9 million metric tones), from a base of about 9 million metric tons.

For ethanol related simulations the model was adjusted to reflect the use of the byproduct from corn based ethanol, Distillers Dried Grains Soluble (DDGS). For every pound of corn used in the production of ethanol, about one-third of a pound of DDGS is produced. A pound of DDGS can substitute for a pound of corn in beef cattle rations, with lower substitution rates for other livestock. Given different substitution factors, when the scenarios were run, one-fourth of the corn used to produce ethanol resulted in an increase in the DDGS fed, dampening the impact on corn prices in the analysis.

Scenario Descriptions

The analyses presented below are three model simulations for 2010 based on changes in the assumptions used in the USDA Projections to 2016. The first scenario examines the impacts on US agriculture if the United States expands its ethanol production by 10 percent (an additional 400 million bushels of corn). In the second scenario, we examine the impact of the EU exceeding their projected level of biodiesel production by 10 percent. This increase will bring the level of biofuels production to about 74 percent of the mandated levels. We will then examine what happens if four of the major biofuel producing countries expand their biofuels production by 10 percent. We increase the use of corn in the US, rapeseed in the EU, sugar in Brazil, and corn in China. We will focus on the livestock impacts and the impacts on South American traders to illustrate important cross-commodity relationships and cross-country interactions.

Results

When the demand for corn used in ethanol is increased by 10 percent in the US, producer prices for corn increase about 3.6 percent. This increase in prices results in acreage moving toward corn and away from soybeans and other crops (Table 1a). World prices for all grains

and oil seeds increase as ethanol production expands. Higher corn and soybean prices reduce the production of meat. US beef, pork, and poultry production fall by less than one-half of one percent. Livestock prices rise for all meats as a result. Prices increase because of reduced levels of livestock production in this scenario. Meat production also declines in all of the other countries in the model (Table 1b). Higher demand for corn used in ethanol production reduces US corn exports as well. Brazil, Argentina and China all expand production of corn. Increases in production and exports by other countries replace about half of the reduction in US corn exports. Consumption declines account for the other half.

An additional scenario using PEATSim examines the situation where the EU expands biodiesel production by 10 percent. The increase in the amount of biodiesel produced for use in the EU comes from several sources. The EU increases its production of rapeseed by about 3 percent, and increases domestic production of rape oil by about 5 percent (Table 2a). The expansion of biodiesel use is made up by reductions in rapeseed and rape oil exports. The exports of rapeseed and rape oil decline to almost zero. The structure of the model sets either exports or imports as a residual; therefore, the model will reduce the residual trade component first. In all likelihood some increase in imports would occur. The net impact on world price would not change a great deal if EU imports increase.

Production of wheat and corn in the EU declines, as prices for rapeseed and soybeans increase more than these grains. The impact on the EU livestock sector is slight (Table 2b). Reduced protein meal prices (rape meal prices decline by a little over 5 percent) benefit livestock producers slightly (mostly pork and poultry). The impact on the United States and other countries is minor as soybeans and soy oil prices increase, but not nearly to the extent of rapeseed products. Production of rapeseed in the United States is minor compared to that of soybeans.

Finally we examine the impact of expansion of biofuels production in the US, Brazil, China, and the EU. World corn prices increase over 4 percent as a result of increased biofuels production (Table 3a). Corn and rapeseed production increase the most in this scenario. However increased demand for corn and rapeseed is greater than the increase in production.

Production of other grains and oilseed decline as land is bid into the production of rapeseed and corn. Overall U S livestock production declines slightly more in this scenario than in scenario 1 (Table 3b). These livestock changes may seem small in size but they have an impact on farm income. EU pork and poultry sectors again benefit from reduced protein meal prices (rape meal prices decline by 5 percent).

Conclusion

The overall results of the scenarios analyzed in this paper show that the increased production of biofuels has an impact on other crops, the livestock sector, and across different countries. Livestock producers and consumers face lower supplies and higher prices. The increase in biofuels production in Brazil, China, the EU, and the US has the largest impact on the U.S. agriculture sector. Reduced exports in the world market increase corn prices over 4 percent. Corn production increases in all countries and regions in the model, to meet increased biofuel and import demand. However the increase in production does not offset the decline in exports. Production of other crops in all countries also declines. Higher feed costs result in livestock production declining in most counties.

These scenarios are initial experiments using PEATSim to analyze the impact of biofuels production on world agricultural prices and production. Further work is needed to develop a fully endogenous biofuel sector in the model. This work is ongoing, and will be a part of the dynamic version of PEATSim, which is in the development stage. The full interaction between the grain, ethanol, and energy sectors will improve the results provided in this type of analysis. Nonetheless, results presented here are representative of market effects of expanding biofuel production.

References

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.

Gallagher, P. G. Schamel, 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.

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 Policies and Markets, Paris France, February 1, 2006.

Renewable Fuels Association *Industry Statistics: Ethanol Industry Overview* accessed on October 9, 2007, available at: http://www.ethanolrfa.org/industry/statistics/

Stout, James, and David Abler. "ERS/PENN STATE TRADE MODEL DOCUMENTATION." Department of Agricultural Economics and Rural Sociology. Oct. 2004. Penn State University. 12 Sept. 2007 http://trade.aers.psu.edu/pdf/ERS_Penn_State_Trade_Model_Documentation.pdf.

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

USDA Agricultural Projections to 2016. USDA. Washington, DC: USDA, 2007.

U.S. Department of Agriculture. *World Agricultural Supply and Demand Estimates*, WASDE-450, September 12, 2007, available at: http://www.usda.gov/oce/commodity/wasde/latest.txt

Table 1a. Impact of an 10 percent increase in US ethanol production.

Percent Change

US Crop Results	Rice	Wheat	Corn	Soybeans	Cotton	Sugar
Production	-0.38	-0.09	0.89	-0.30	-0.61	0.12
Consumption	0.05	0.52	3.46	-0.18	-0.03	0.01
Exports	-0.86	-0.82	-12.24	-0.55	-1.03	0.07
Imports	-0.01	-0.01	-0.04	-0.01	-0.01	-0.53
World price	0.82	0.90	3.65	1.11	1.45	0.55
EU Crop Results						
Production	0.17	0.08	0.12	0.29	-0.10	0.00
Consumption	-0.05	-0.12	-0.24	-0.14	-0.03	0.09
Exports	0.54	1.79	0.43	0.25	0.01	-0.56
Imports	-0.29	-0.06	-9.34	-0.16	0.05	0.00
World price	0.82	0.90	3.65	1.11	1.45	0.55
Brazil Crop Results						
Production	-0.04	0.01	1.43	-0.15	0.08	0.06
Consumption	0.00	0.00	-0.49	-0.19	-0.03	0.02
Exports	0.56	0.13	27.71	-0.08	0.33	0.08
Imports	0.49	-0.01	-2.54	-0.27	-0.01	0.00
World price	0.82	0.90	3.65	1.11	1.45	0.55
Argentina Crop Results						
Production	0.12	0.15	2.15	0.17	0.22	0.05
Consumption	0.00	0.00	-0.67	-0.16	-0.03	0.01
Exports	0.17	0.23	3.13	1.61	1.45	0.27
Imports	-0.61	-0.14	-2.97	-0.27	-0.01	-0.07
World price	0.82	0.90	3.65	1.11	1.45	0.55
China Crop Results						
Production	0.00	0.00	0.92	-0.37	0.02	-0.01
Consumption	0.01	0.08	-0.48	-0.10	-0.02	0.02
Exports	0.66	0.14	50.76	0.25	0.01	0.07
Imports	3.75	0.90	-2.72	0.13	-0.14	0.33
World price	0.82	0.90	3.65	1.11	1.45	0.55

Table 1b. Impact of an 10 percent increase in US ethanol production.

Percentage Change

United States Livestock Results	Beef	Pork	Poultry	Milk	Butter	Cheese	Nonfat Dry Milk	Whole Dry Milk	Other Dairy Products
Production	-0.33	-0.47	-0.40	-0.14	-0.20	-0.24	-0.20	-0.67	-0.02
Consumption	-0.32	-0.42	-0.47	-0.14	-0.19	0.03	0.16	0.13	-0.02
Exports	0.40	-0.82	0.16	0.00	0.00	0.00	-2.51	0.00	0.00
Imports	0.00	-0.24	-0.30	0.00	0.00	7.68	0.00	9.33	0.00
World price	1.42	0.73	1.01	1.08	1.70	0.95	0.60	0.63	1.13
EU Livestock Results									
Production	-0.08	0.08	0.17	0.00	0.00	0.03	0.00	-0.26	0.02
Consumption	-0.14	-0.18	-0.16	0.00	0.02	0.04	0.06	0.08	0.02
Exports	0.28	4.50	3.50	0.00	-0.21	-0.09	-1.04	-0.50	0.00
Imports	-0.73	-0.42	-0.37	0.00	-0.06	-0.05	-0.04	0.00	0.00
World price	1.09	0.73	1.01	0.00	0.30	0.81	0.71	0.70	0.00
Brazil Livestock Results									
Production	-0.31	-0.17	-0.17	0.05	0.06	0.09	0.06	0.09	0.05
Consumption	-0.08	0.17	-0.02	0.05	0.06	0.05	0.05	0.05	0.05
Exports	-1.33	-1.36	-0.51	0.00	-11.63	2.22	0.19	0.59	0.00
Imports	-1.03	0.00	0.00	0.00	0.00	-0.19	-0.54	-0.19	0.00
World price	1.09	0.73	1.01	0.00	0.30	0.81	0.71	0.70	0.00
Argentina Livestock Results									
Production	-0.24	0.00	-0.19	0.15	0.06	0.31	0.06	0.20	0.03
Consumption	-0.03	0.00	0.00	0.15	0.07	0.01	0.02	0.02	0.03
Exports	-1.16	0.00	-1.78	0.00	-0.10	2.87	0.20	0.31	0.00
Imports	-1.03	0.00	-0.94	0.00	0.00	-0.26	-0.23	-0.23	0.00
World price	1.09	0.73	1.01	0.00	0.30	0.81	0.71	0.70	0.00
China Livestock Results									
Production	-0.02	-0.03	-0.20	-0.09	0.00	0.00	0.00	-0.34	-0.02
Consumption	-0.01	0.00	-0.13	-0.09	0.00	0.00	0.04	0.02	-0.02
Exports	-0.53	-5.05	1.01	0.00	0.00	0.00	0.20	0.24	0.00
Imports	-1.02	-0.82	3.04	0.00	0.00	0.00	0.04	2.91	0.00
World price	1.09	0.73	1.01	0.00	0.30	0.81	0.71	0.70	0.00

Table 2a. Impact of a 10 percent expansion in EU biodiesel production

Percentage Change

US Crop Results	Rice	Wheat	Corn	Soybeans	Cotton	Sugar	Rapeseed	Rape oil
Production	-0.09	0.03	0.00	0.09	-0.12	0.07		
Consumption	-0.01	-0.07	-0.01	0.08	-0.01	0.00		
Exports	-0.17	0.15	0.06	0.10	-0.20	0.02		
Imports	0.00	-0.01	0.00	0.00	-0.01	-0.39		
World price	0.32	0.52	0.33	0.42	0.51	0.19		
EU Crop Results								
Production	0.03	-0.15	-0.05	0.04	-0.13	0.00	2.55	5.08
Consumption	-0.01	-0.20	-0.04	0.10	-0.01	0.01	5.08	14.08
Exports	0.22	0.30	0.12	0.09	0.00	-0.03	-31.19	-98.16
Imports	-0.03	-0.05	0.23	0.10	0.09	0.00	-8.65	-15.82
World price	0.32	0.52	0.33	0.42	0.51	0.19	9.00	18.79
Brazil Crop Results								
Production	0.03	0.11	0.00	0.14	0.09	0.03		
Consumption	-0.01	-0.03	-0.03	0.11	-0.01	-0.01		
Exports	0.22	0.08	0.44	0.20	0.32	0.05		
Imports	-0.44	-0.18	-0.26	-0.10	0.00	0.00		
World price	0.32	0.52	0.33	0.42	0.51	0.19		
Argentina Crop Results								
Production	0.06	0.12	0.03	0.14	0.09	0.02		
Consumption	-0.01	-0.02	-0.03	0.10	-0.01	-0.01		
Exports	0.09	0.19	0.05	0.30	0.57	0.14		
Imports	-0.24	-0.08	-0.28	-0.10	0.00	-0.02		
World price	0.32	0.52	0.33	0.42	0.51	0.19		
China Crop Results								
Production	0.00	-0.18	-0.03	-0.01	-0.01	-0.02		
Consumption	0.00	-0.03	-0.02	0.04	-0.01	0.00		
Exports	0.24	0.08	-0.34	0.10	0.00	0.02		
Imports	0.62	1.55	-0.27	0.07	-0.01	0.18		
World price	0.32	0.52	0.33	0.42	0.51	0.19		

Table 2b. Impact of a 10 percent expansion in EU biodiesel production

Percentage Change

US Livestock Results	Beef	Pork	Poultry	Milk	Butter	Cheese	Nonfat Dry Milk	Whole Dry Milk	Other Dairy Products
Production	-0.01	-0.05	0.02	0.02	0.03	0.03	0.03	0.06	0.02
Consumption	-0.02	0.02	0.02	0.02	0.03	0.01	0.01	0.01	0.02
Exports	0.02	-0.73	0.05	0.00	0.00	0.00	0.15	0.00	0.00
Imports	-0.04	0.00	0.00	0.00	0.00	-0.42	0.00	-0.62	0.00
World price	0.11	-0.01	0.00	0.00	0.05	0.03	0.04	0.03	0.00
EU Livestock Results									
Production	0.02	0.08	0.03	0.00	0.01	-0.01	0.01	-0.02	0.00
Consumption	0.00	0.02	0.02	0.00	0.00	0.00	0.01	0.01	0.00
Exports	0.01	1.15	0.13	0.00	0.03	-0.12	-0.04	-0.04	0.00
Imports	-0.30	0.01	0.01	0.00	-0.01	0.00	0.00	0.00	0.00
World price	0.11	-0.01	0.00	0.00	0.05	0.03	0.04	0.03	0.00
Brazil Livestock Results									
Production	-0.01	-0.03	0.04	0.01	0.01	0.01	0.01	0.01	0.01
Consumption	-0.02	0.06	0.06	0.01	0.01	0.01	0.01	0.01	0.01
Exports	-0.01	-0.33	0.01	0.00	0.49	-0.14	0.01	-0.05	0.00
Imports	-0.10	0.00	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00
World price	0.11	-0.01	0.00	0.00	0.05	0.03	0.04	0.03	0.00
Argentina Livestock Results									
Production	-0.05	0.00	-0.04	0.00	0.02	0.00	0.02	0.01	0.01
Consumption	0.00	0.00	0.04	0.00	0.00	0.01	0.01	0.01	0.01
Exports	-0.25	0.00	-0.65	0.00	0.23	-0.09	0.06	0.00	0.00
Imports	-0.10	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00
World price	0.11	-0.01	0.00	0.00	0.05	0.03	0.04	0.03	0.00
China Livestock Results									
Production	0.00	0.04	0.03	0.02	0.00	0.00	0.00	0.04	0.01
Consumption	-0.01	0.03	0.02	0.02	0.00	0.00	0.01	0.01	0.01
Exports	0.32	1.11	-0.02	0.00	0.00	0.00	0.01	0.01	0.00
Imports	-0.09	0.04	-0.52	0.00	0.00	0.00	0.01	-0.22	0.00
World price	0.11	-0.01	0.00	0.00	0.05	0.03	0.04	0.03	0.00

Table 3a. Impacts of a 10 increase in biofuels production in EU, US, China, and Brazil

Percentage Change

US Crop Results	Rice	Wheat	Corn	Soybeans	Cotton	Sugar	Rapeseed	Rape Oil
Production	-0.51	-0.07	0.92	-0.20	-0.82	2.32		
Consumption	0.05	0.48	3.41	-0.10	-0.04	-0.09		
Exports	-1.15	-0.74	-11.78	-0.42	-1.38	0.37		
Imports	-0.01	-0.02	-0.04	-0.02	-0.02	-12.80		
World price	1.26	1.55	4.28	1.73	2.20	3.03		
EU Crop Results								
Production	0.22	-0.07	0.08	0.39	-0.24	0.00	2.72	5.16
Consumption	-0.07	-0.34	-0.30	-0.05	-0.05	0.11	5.16	14.18
Exports	0.83	2.34	0.59	0.39	0.02	-0.65	-29.88	-98.29
Imports	-0.37	-0.12	-9.79	-0.07	0.15	0.00	-9.46	-16.73
World price	1.26	1.55	4.28	1.73	2.20	3.03	9.93	20.10
Brazil Crop Results								
Production	-0.03	-0.01	1.49	-0.04	0.12	1.41		
Consumption	0.00	-0.03	-0.56	-0.08	-0.05	12.57		
Exports	0.86	0.23	29.44	0.02	0.47	-4.94		
Imports	0.34	-0.04	-3.00	-0.42	-0.02	0.00		
World price	1.26	1.55	4.28	1.73	2.20	3.03		
Argentina Crop Results								
Production	0.20	0.29	2.30	0.36	0.34	1.05		
Consumption	-0.01	-0.02	-0.75	-0.06	-0.04	-0.13		
Exports	0.28	0.45	3.35	2.17	2.25	7.82		
Imports	-0.94	-0.25	-3.46	-0.41	-0.02	-0.38		
World price	1.26	1.55	4.28	1.73	2.20	3.03		
China Crop Results								
Production	0.00	-0.18	0.97	-0.39	0.02	0.58		
Consumption	0.01	0.05	-0.05	-0.06	-0.03	-0.14		
Exports	0.99	0.23	37.30	0.39	0.02	0.36		
Imports	4.75	2.55	-3.25	0.22	-0.18	-7.07		
World price	1.26	1.55	4.28	1.73	2.20	3.03		

Table 3b. Impacts of a 10 increase in biofuels production in EU, US, China, and Brazil

Percentage Change

US Livestock Results	Beef	Pork	Poultry	Milk	Butter	Cheese	Nonfat Dry Milk	Whole Dry Milk	Other Dairy Products
Production	-0.37	-0.55	-0.39	-0.13	-0.18	-0.23	-0.18	-0.65	0.00
Consumption	-0.36	-0.43	-0.49	-0.13	-0.17	0.05	0.19	0.14	0.00
Exports	0.45	-1.55	0.29	0.00	0.00	0.00	-2.52	0.00	0.00
Imports	0.00	-0.26	-0.33	0.00	0.00	7.76	0.00	9.22	0.00
World price	1.31	0.79	1.10	0.00	0.39	0.91	0.82	0.80	0.00
EU Livestock Results									
Production	-0.07	0.18	0.22	0.00	0.01	0.03	0.01	-0.30	0.02
Consumption	-0.15	-0.18	-0.15	0.00	0.03	0.05	0.08	0.10	0.02
Exports	0.32	6.17	3.96	0.00	-0.19	-0.24	-1.16	-0.58	0.00
Imports	-1.10	-0.44	-0.40	0.00	-0.07	-0.06	-0.05	0.00	0.00
World price	1.31	0.79	1.10	0.00	0.39	0.91	0.82	0.80	0.00
Brazil Livestock Results									
Production	-0.35	-0.21	-0.14	0.06	0.08	0.11	0.08	0.11	0.07
Consumption	-0.09	0.26	0.05	0.06	0.08	0.06	0.06	0.06	0.07
Exports	-1.42	-1.84	-0.55	0.00	-12.19	2.18	0.22	0.59	0.00
Imports	-1.23	0.00	0.00	0.00	0.00	-0.22	-0.56	-0.22	0.00
World price	1.31	0.79	1.10	0.00	0.39	0.91	0.82	0.80	0.00
Argentina Livestock Results									
Production	-0.30	0.00	-0.24	0.17	0.09	0.33	0.09	0.23	0.04
Consumption	-0.03	0.00	0.05	0.17	0.08	0.01	0.02	0.02	0.04
Exports	-1.44	0.00	-2.61	0.00	0.21	2.99	0.31	0.35	0.00
Imports	-1.23	0.00	-1.03	0.00	0.00	-0.29	-0.26	-0.26	0.00
World price	1.31	0.79	1.10	0.00	0.39	0.91	0.82	0.80	0.00
China Livestock Results									
Production	-0.02	0.00	-0.18	-0.08	0.00	0.00	0.00	-0.34	-0.01
Consumption	-0.02	0.04	-0.12	-0.08	0.00	0.00	0.04	0.03	-0.01
Exports	-0.27	-4.67	1.08	0.00	0.00	0.00	0.23	0.27	0.00
Imports	-1.21	-0.86	2.95	0.00	0.00	0.00	0.05	2.96	0.00
World price	1.31	0.79	1.10	0.00	0.39	0.91	0.82	0.80	0.00