The Impacts of Energy Prices on Global Agricultural Commodity Supply

Getachew Nigatu, Kim Hjort, James Hansen, and Agapi Somwaru @*

Selected paper prepared for presentation at the Agricultural and Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 27-29, 2014.

This paper has not been previously presented in any other meetings.

@Nigatu, Hjort, and Hansen are economists with the Economic Research Service, USDA, and Somwaru is a consultant.

*The views expressed are the authors' and do not necessarily represent those of the Economic Research Service or the US Department of Agriculture

The Impacts of Energy Prices on Global Agricultural Commodity Supply

Abstract

This study assesses the role of energy prices in determining cross-commodity and cross-country projections of production costs, area harvested and production of four major commodities and ethanol and biofuels production. The analysis is conducted using a dynamic global partial equilibrium model of agricultural trade. By simulating changes in energy prices that might result as a consequence of changes in energy policy, we capture the link between the energy market and the agriculture-biofuels sector and present resulting changes in production in major production regions for corn, soybeans, wheat, and rice. Input costs will increase with higher energy prices, but decline slightly with lower energy prices. The projection indicates that higher energy prices will have significant impact on increasing ethanol production in Brazil while decreasing wheat production in the EU. Production in the US and India is relatively unaffected by change in energy prices.

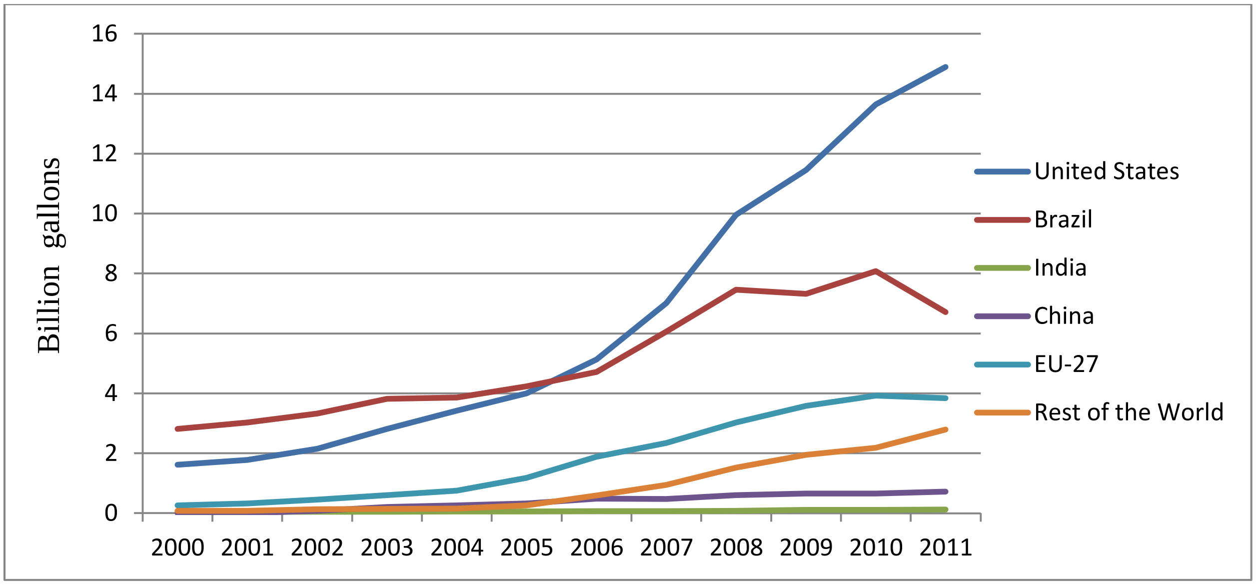
The Impacts of Energy Prices on Global Agricultural Commodity Supply

Introduction

The interaction between energy and agriculture has undergone a number of major structural transformations over the last few decades. As agricultural production becomes more mechanized, energy becomes one of its principal inputs as it affects the level and scale of many agricultural inputs. Some models suggest that the direct energy component of agriculture alone is four to five times higher than for manufacturing sectors (Baffes, 2013). As an energy-intensive sector, agriculture plays a big role on the demand-side of the energy equation. The sector is directly affected by high and volatile world oil prices that in turn affected the cost of agricultural production (Nazlioglu & Soytas, 2011).

Recently, however, the agricultural sector has become part of the energy-supply equation by providing feedstocks to produce biofuels. For instance, during 2007-2011, an average 20% of the 7,740 trillion British thermal units (tBtu) of renewable energy production in the United States was derived from biofuels but during 1981-1985, biofuels accounted for less than 1% of the 6,082 tBtu of renewable energy production. From 2007-2011, average annual U.S. fuel ethanol production exceeded 10.8 billion gallons, whereas during 1998-85, average annual ethanol production was around 370 million gallons. Global production of biofuels was over 29 billion gallons in 2011, six times the amount produced in 2000. As shown in Figure 1, the United States has been the leading producer of biofuel since 2006, followed by Brazil and EU-27 (EIA, 2014).

Figure 1 Global biofuel production from 2000-2011



Source: EIA (2014)

This transformation has occurred in response to environmental policy, price volatility and other behavioral changes (Beckman, Borchers, & Jones, 2013). In the US, the renewable fuel standards (RFS) have significantly increased demand for ethanol and biodiesel. The other structural transformation comes from supply-side technological advances that shift the comparative advantage of producing and then trading agricultural goods and biofuels, which subsequently generates cross-commodity and cross-country interactions. These structural shifts make global agricultural production and commodity trade more sensitive to world energy market shocks. At the same time, policies that are targeted to achieve environmental goals and to enhance energy security become more complex (Sands & Westcott, 2011). Evaluating energy-related costs across major agricultural producing countries can provide insights into the short-term impact of energy price changes on crop production patterns. It is also recognized that cross-country comparisons of production can be a useful tool for decision-makers considering production, investment, technology, trade or policy alternatives (AAEA, 2000; Schnepf, Dohlman, & Bolling, 2001).

This study assesses the role of energy prices in determining cross-commodity and cross-country projections of production costs, area harvested and production of four major commodities and ethanol and biofuels production. The analysis is conducted using the dynamic global Partial Equilibrium Agricultural Trade Simulation (PEATSim) model (Somwaru & Dirkse, 2012). By simulating changes in energy prices that might result as a consequence of changes in energy policy, we attempt to capture the link between the energy market and the agriculture-biofuels sector.

Literature Review

Over the last few decades, high energy prices increase the costs of producing agricultural products that yield food, feed, energy and fiber. Economic theory suggests that increasing crude oil prices directly affect agricultural prices through higher input and transportation costs (Gardebroek & Hernandez, 2013). A recent body of empirical research employing different methodologies on the nature of the relationship between petroleum and agricultural commodity prices suggests there is an indirect link of varying magnitude between the prices (Alghalith, 2010; Esmaeili & Shokoohi, 2011; Ciaian & Kancs, 2011). In contrast, Gohin and Chantret (2010) find a negative impact of petroleum prices on agricultural prices when employing a general equilibrium model with fully specified macroeconomic linkages.

Governments have devised many policy frameworks that are design to lessen the impact of higher energy prices. One approach is to insulate farmers from large fluctuations in input prices. India's well known and controversial fertilizer subsidy program is one example. Another avenue is to encourage the innovation and production of alternative sources of energy. Among the many alternative sources of energy, biofuels have become a primary emphasis for several governments and entrepreneurs. Biofuel production has had a tremendous impact on the interaction among agricultural practices, commodities and byproducts.

Recently, Sands & Westcott (2011) studied the impact of higher energy prices on agriculture using the Food and Agricultural Policy Simulator (FAPSIM)—a multi-commodity model of the U.S. agriculture sector—and Farm Level Partial Budget models. They found that higher energy prices increase production expenses and decrease net farm income, with the magnitude of the effect varying by region and commodity. Using National Agricultural Statsistics Service (NASS) data, Beckman, Borchers & Jones (2013) found that energy price shocks induce changes in production practices that reduce use of energy-intensive inputs. In particular, they reported that the response to higher energy prices varied by commodity in proportion to the use of energy related inputs like fertilizer.

Most research directed at determining the impact of petroleum prices on the agriculture and food sector has been at the global market level. Individual country impact analyses provide a multimarket perspective but without interaction with global commodity markets. This research extends the pool of energy-agricultural price linkage research by looking at energy price impacts on agricultural market outcomes in both regional and international markets. A significant advantage of this approach is that interaction between countries in the international market provides opportunities for reducing the impact of changes in petroleum prices within a region.

Methodology and Modeling Framework

In analyzing production-related dynamics, energy and agricultural markets are inherently a multi-sector problem because of the interactions among farm inputs, energy, crops, feed, food consumption and trade. For these reasons, we use the PEATSim model as a tool to analyze the complex facets of this problem. PEATSim is a dynamic, partial equilibrium, multi-commodity, multi-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 sugar, livestock, dairy and biofuel (ethanol and biodiesel) markets. PEATSim also accounts for domestic support and trade policies in most regions. As such, it is capable of modeling different sets of production activities, inter-linkages among various crops and livestock sectors, and interaction of producers and consumers at a global level. A detailed specification of the model is available in (Somwaru & Dirkse, 2012).

One shortcoming of PEATSim is that it does not include the costs of producing crops and livestock in producers' production decisions. That is, the current specification of the area harvested equation is:

$$1)\qquad \mathrm{AHV}_{i,r,t} = a_{i,r,t(1)}\mathrm{AHV}_{i,r,t-1}^{\lambda_{i,r}}\left[\prod_{i,j}^{n}\left(PPR_{i,j,r,t-1}\right)^{\varepsilon_{ij}}\right]$$

where $\mathrm{AHV_{i,r,t}}$ is area harvested of crop *i* in region *r* in year *t*; $\mathrm{a_{i,r,t(1)}}$ is a measure that captures the past interaction between the producer price and crop area; $\mathrm{AHV_{i,r,t-1}}$is lagged area of crop *i* in region *r*, $\lambda_{\mathrm{i,r}}$ is a partial adjustment parameter; $\mathrm{PPR_{i,r,t-1}}$ is the lagged own producer price; $\mathrm{PPR_{j,r,t-1}}$ is the lagged producer price of other crops j; and the $\varepsilon_{\mathrm{ij}}$ are own and cross price elasticities for crop area.

The above specification captures producers' evaluation of returns to alternative crops when making planting decisions. However, in addition to not having a cost component, the current equation imposes naïve expectations of prices. Therefore, we substitute expected revenue for lagged producer prices and add expected costs by modifying equation 1 as:

$$2)\qquad \mathrm{AHV}_{i,r,t} = a_{i,r,t(1)}\mathrm{AHV}_{i,r,t-1}^{\lambda_{i,r}}\left[\prod_{i,j}^{n}\left(ERT_{i,r,t}\right)^{\varepsilon_{ij}}\right]$$

where $ERT_{i,r,t}$ is expected returns to crop *i* in region *r* in year *t*. We define expected returns as:

$$3)\qquad ERT_{\mathrm{i,r,t}} = \left[\mathrm{EPPR_{i,r,t}}(1+\mathrm{g}_{i,r})\mathrm{YLD_{i,r,t-1}}\right]/\mathrm{ECST_{i,r,t}}$$

where $\mathrm{EPPR}_{\mathrm{i,r,t}}$ is expected producer price; $\mathrm{YLD}_{\mathrm{i,r,t-1}}$ is the yield of crop *i* in region *r* in year *t-1*; $g_{i,r}$ is the medium- to long-term[1] growth rate in regional crop yields; and $\mathrm{ECST}_{\mathrm{i,r,t}}$ is the expected cost of crop *i* in region *r* in year *t*. The term $(1 + \mathrm{g}_{i,r})\mathrm{YLD}_{\mathrm{i,r,t-1}}$ is a proxy for expected yield.

We assume that expected costs are a function of the price of petroleum in the current year and previous. The previous year price captures costs associated with inputs produced in the previous year and differences in cropping seasons which occur especially in the northern and southern hemisphere. The petroleum price, POIL, which is expressed in real U.S. dollars, is converted to local currency by multiplying it by the real exchange rate $\mathrm{REXR}_{\mathrm{r,t|t-1}}$ in region r in year t and t-1:

$$4)\qquad ECST_{i,r,t} = c_{i,r}\left(REXR_{r,t}POIL_t\right)^{\psi_{i,r}}\left(REXR_{r,t-1}POIL_{t-1}\right)^{\upsilon_{i,r}}$$

where $\psi_{i,r}$ and $\upsilon_{i,r}$ are elasticities measuring the transmission of changes in world crude oil prices to production costs for crop *i* in region *r*.

These changes yield the re-specified area equation as:

$$5)\qquad \mathrm{AHV}_{i,r,t} = a_{i,r,t(1)}\mathrm{AHV}_{i,r,t-1}^{\lambda_{i,r}}\left[\prod_{i,j}^{n}\left(\left\{EPPR_{i,j,r,t-1}(1+g_r)YLD_{i,j,r,t-1}\right\}/ECST_{i,r,t}\right)^{\varepsilon_{ij}}\right].$$

---

[1] A medium-term growth rate applies when technology affecting yields is in the process of changing, such as with introduction of new varieties.

The model is calibrated on 2012-2022 USDA agricultural projections for most commodities and, for those commodities not covered in the USDA baseline projections, on the 2013-2022 OECD-FAO Agricultural Outlook for all dairy products, sugarcane, sugar beets, sugar, and biofuels[2]. The model has a 10-year projection horizon.

Data Sources

Macroeconomic and demographic data such as GDP, GDP deflator, exchange rates, population, and population growth rates are those underlying assumptions employed in the USDA long term agricultural projections (OCE, 2013; OECD/FAO 2013).

Availability of production cost data for the regions in PEATSim is limited. Fortunately, cost data are available for five major agricultural producers and traders—Brazil, China, the European Union (EU), India and the United States (USA). Data for each of the regions were obtained from in-country sources. USA cost data are from USDA's Agricultural Resource Management Survey, while the Farm Accountancy Data Network of the European Commission's Directorate-General for Agriculture and Rural Development is the source for EU production costs. For Brazil, we use Custos de Produção collected by Companhia

[2] The model is not calibrated to 2014-23USDA and OECD-FAO agricultural projections because the updated OECD-FAO projections are not yet available. When they become available, PEATSim will be updated and calibrated to the new baseline projections.

Nacional de Abastecimento (CONAB). India's cost of cultivation data is taken from that reported by the Directorate of Economics and Statistics in the Ministry of Agriculture. China's production cost data are from the Ministry of Agriculture.

Petroleum-Production Cost Transmission Elasticities

Transmission elasticities for corn, rice, soybeans and wheat were estimated for each of the five regions. Due to limited production of rice and soybeans, EU production costs were collected only for corn and wheat. Data for all four commodities were available for the other regions. National average cost data were used for China, the EU and the US, with sample periods of 1995-2008, 1997-2011 and 1995-2012, respectively. State data were used to estimate transmission elasticities for Brazil and India. For both of these regions, sample periods and the composition of states for each commodity varied, reflecting changes in regional production. The elasticities were estimated using Ordinary Least Squares with cross-section Seemingly Unrelated Regression techniques for all regions expect the EU. The estimated elasticities are depicted in Figures 2 and 3 with more detail in Appendix Table 1.

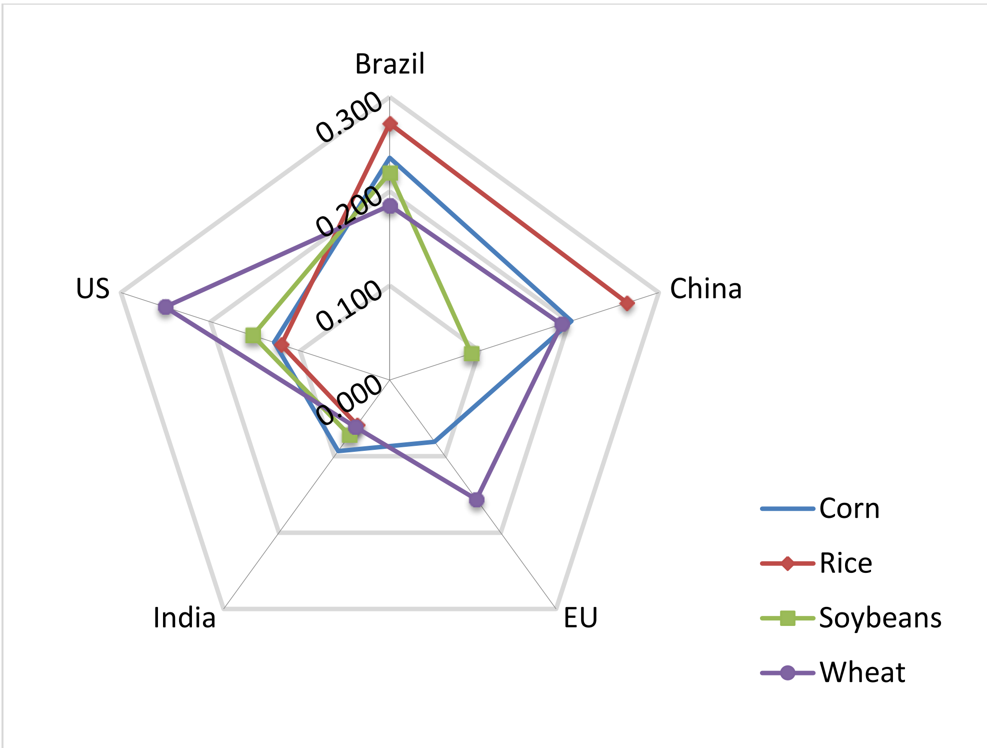
While the five focus regions are major world market players, there are other important producers and traders. To ensure that all regions responded to the energy price shock, we assumed values for cost elasticities for Argentina, Australia, Canada, Japan, Korea, Mexico, New Zealand, Russia and rest of world (ROW). The assumed values were chosen based on the estimated elasticities from our five focus regions and took into account the level of economic and agriculture sector development of the other regions. The assumed values are shown in Appendix Table 1.

In general, the transmission of current year petroleum price fluctuations—with the exception of rice in China—is highest for Brazil (Figure 2). Brazil and the United States have the highest corn and soybean cost elasticities. Costs of producing these two crops, which are major biofuels feedstocks,[3] are more sensitive to oil price changes than are other crops. On the other hand, China has the highest cost price elasticity for rice while the US has significantly higher cost elasticity for wheat compared to the other countries. The EU has relatively low cost elasticities, while the cost elasticities for India are uniformly low, which is to be expected given the government's policy of insulating producers from world energy price fluctuations.

Sensitivity to petroleum price shocks in the previous year is highest for Brazil, which is most likely due to the different cropping seasons relative to the other countries (Figure 3). Previous year petroleum-cost elasticities for the other major supplies are uniformly low, ranging from 0 in China to 0.11 in the U.S.

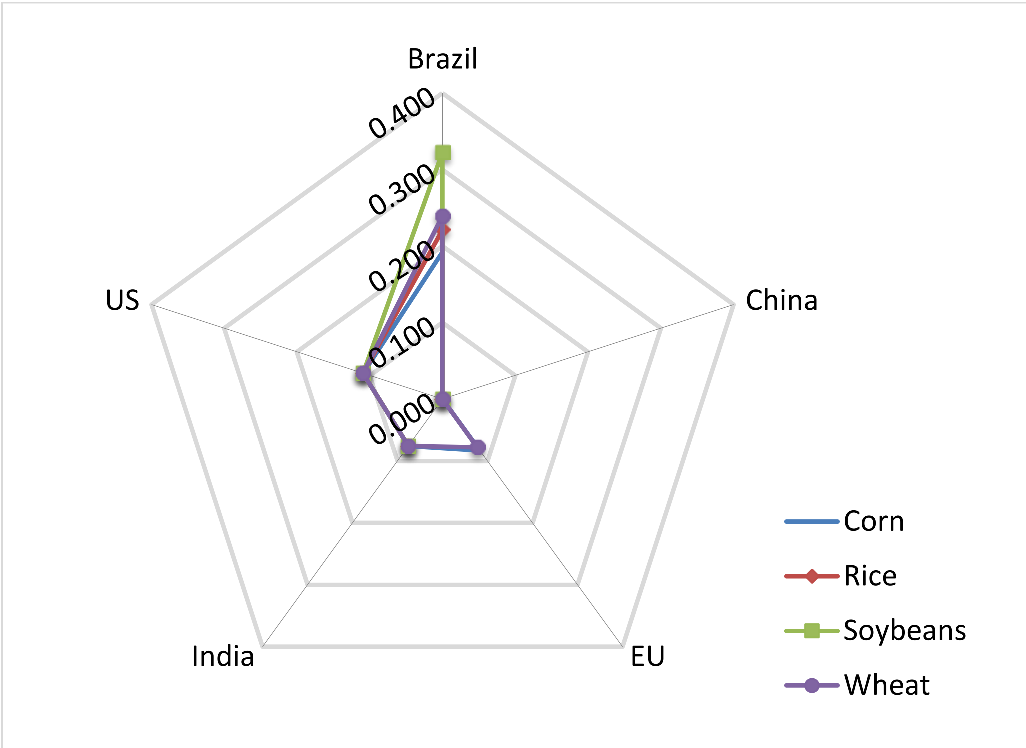
[3] At this time, limitations in cost data prevent inclusion of sugarcane--Brazil's sole ethanol feedstock--in the analysis.

Figure 2. Cost elasticities for current year oil price



Note: The cost elasticities measure the percent change in total variable cost of producing crop i in region r as a result of a one percent change in the current year's oil price.

Figure 3. Cost elasticities for previous year oil price



Note: The cost elasticities measure the percent change in total variable cost of producing crop i in region r as a result of a one percent change in the previous year's oil price.

Expected Prices

The mechanism for deriving expected producer prices will differ across countries and commodities. Producers in exporting countries will frequently base their price expectations on available information from futures markets. Price expectations for those commodities where futures markets do not exist may be based on futures prices of closely related commodities and/or on trends in domestic or regional prices. Similarly, producers in importing countries are more likely to develop price expectations based on trends in local or national market prices. Given that PEATSim is calibrated to the USDA and OECD-

FAO baselines, at this juncture we make the simplifying assumption that the expected price is equal to the previous years' producer price.

Simulation Scenarios

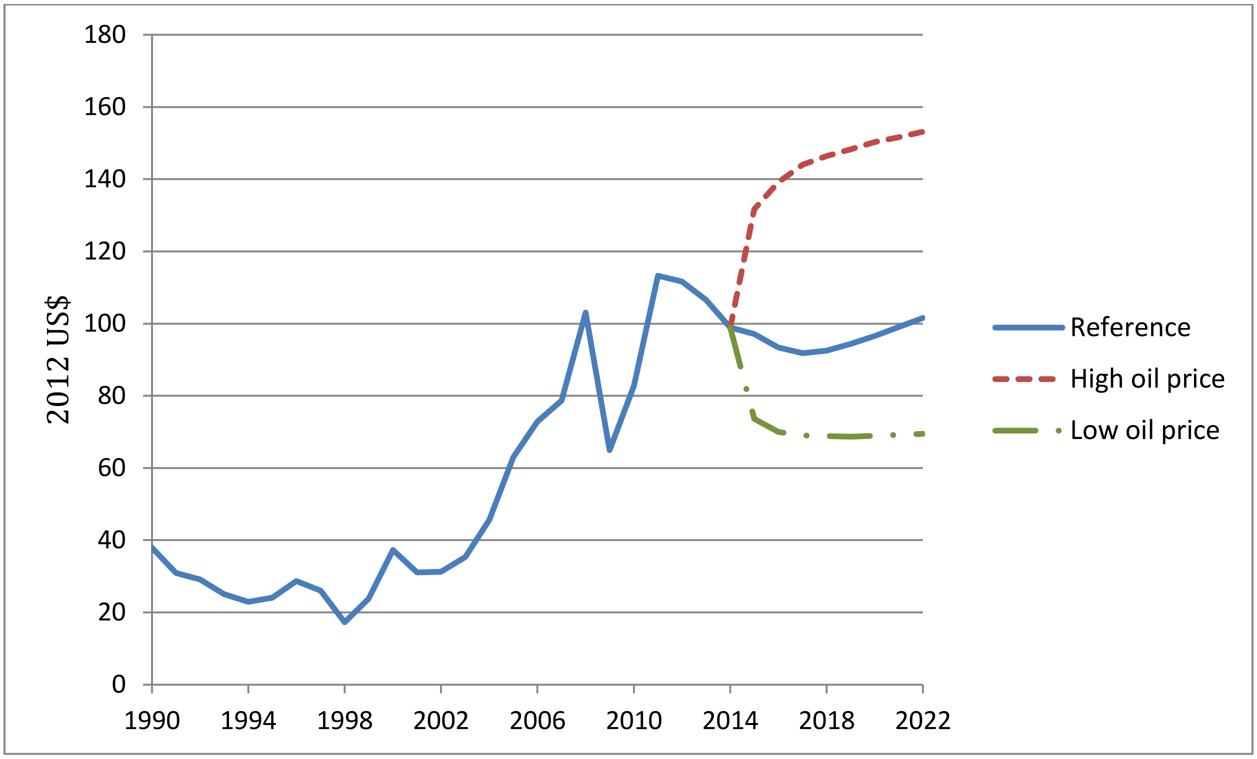
Based on the EIA Annual Energy Outlook 2014, we formulate three crude oil price scenarios for our analysis: Baseline, Scenario 1, and Scenario 2. As seen in Figure 4, it is expected that the baseline (reference) crude oil price will decline initially from a real value of $99 per barrel, to $92 per barrel in 2017 before it starts increasing to above $107 by the end of the projection period. The other two scenarios of low and high crude oil prices are constructed based on the assumption of a moderate decrease and sharp increase, respectively, in global energy demand after 2015. EIA's corresponding projections for U.S. gasoline and diesel prices are also used in the analysis.

Similar to EIA's low and high oil projections we introduce shocks to the price of crude oil, gasoline and diesel but we did not apply the same shocks as that of EIA[4]. We first introduce exogenously into the model the EIA low-oil and associated gasoline and diesel price projections to determine how production costs, area and production will adjust. Second we

[4] For the low-oil scenario, the price of gasoline and diesel decreases by 53 and 54 percent in each year of the simulation, respectively; in the high-oil scenario, the prices of gasoline and diesel increases by 53 and 48 percent in each year of the simulation, respectively.

shock the model by introducing exogenously the EIA high-oil price projections determine again the adjustment of our main variables of interest.

Figure 4. Brent Spot Crude Oil Prices in Two Scenarios



Source: EIA (2014)

Results

The PEATSim model includes full commodity supply and demand specifications with resulting world market clearing prices. At this time, we are introducing expected costs in the area harvested equation only while using assumed transmission elasticities for regions other than our five focus commodities. There are numerous other avenues by which energy prices affect agricultural markets such as yields, domestic and international transportation costs, and so on. We have not yet proceeded to the point where we can include such extended energy-costs in the pool of shocked variables. As a consequence of this omission, at this time we are only reporting production impacts. Since this is a work in progress, this and other issues will be addressed in the future.

Impacts of High and Low Oil Prices on Crop Production Costs

The high petroleum price scenario begins with a 37 percent price increase in 2015 which climbs to about 61 percent above the reference price in 2018 and then declines gradually to 49 percent above the 2022 reference price. The low oil price projection is more uniform, with crude oil prices falling 25 percent in 2015 and then gradually declining to 36 percent below the base price in 2022. Price shocks of these magnitudes have significant impacts on corn, soybean, wheat and rice production costs.

As expected given the high petroleum price transmission elasticities for Brazil, corn and wheat production costs are about 24 percent higher while rice costs are 28 percent and soybean costs rise further by 31 percent above base in 2022 (Figures 5-8). The increase in soybean costs is tied to expansion of cropped area in the center-west or frontier region of Brazil, where large tracts of land are multi-cropped. Producers in the United States, face a 12-20 percent increase in costs by 2022, with the highest increase for wheat and the lowest for rice and corn. . The largest increase in 2022 in EU production costs is for wheat at 12 percent while the increase in corn costs at about three-quarters that of wheat. Input cost impacts are quite modest in India, ranging from 9 percent for corn to 7 percent for wheat and rice. China's production costs for corn and wheat rise by a little more than 10 percent on average, with a 14 percent increase in rice expenses and a rise of about 5 percent in soybean production costs. Across all regions, the increase in soybean production costs relative to base 2022 average 21 percent and costs for the other three commodities rise by an average of 12 percent.

Figure 5. Change in Variable Costs from Base in 2022: Corn

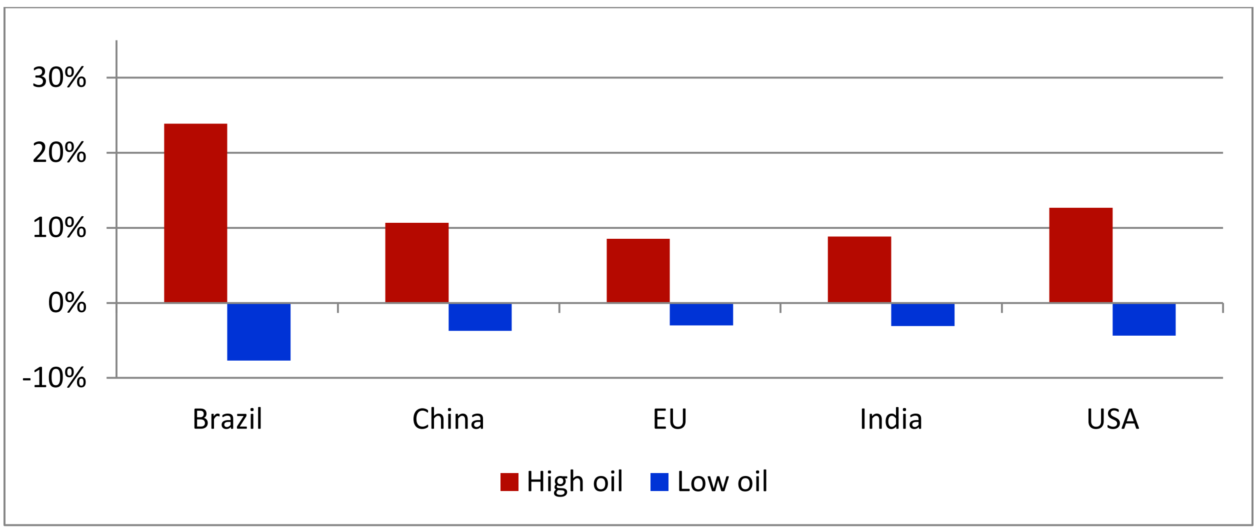


Figure 6. Change in Variable Costs from Base in 2022: Rice

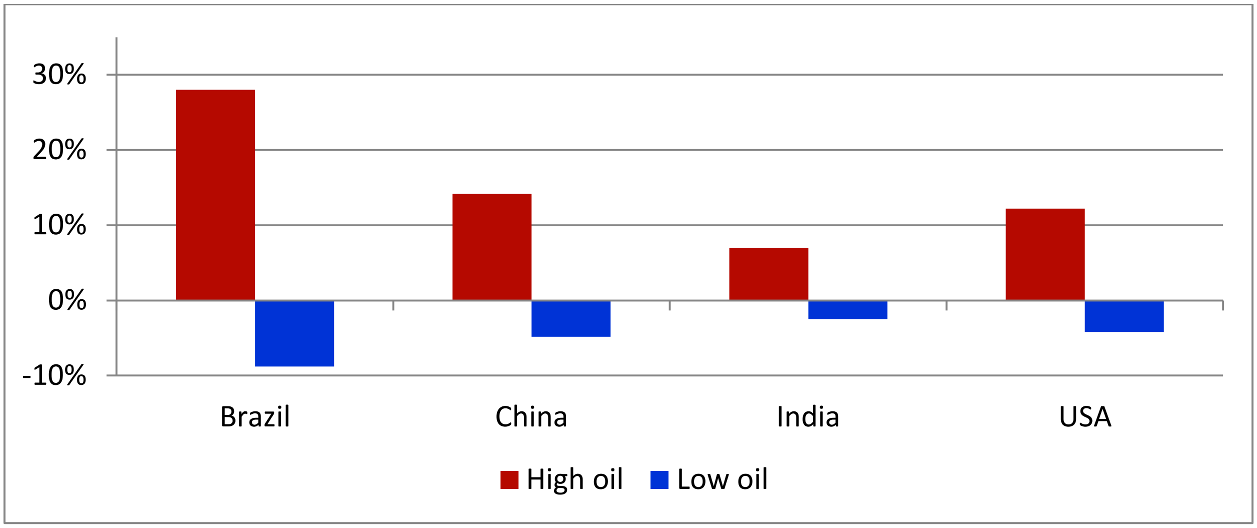


Figure 7. Change in Variable Costs from Base in 2022: Soybeans

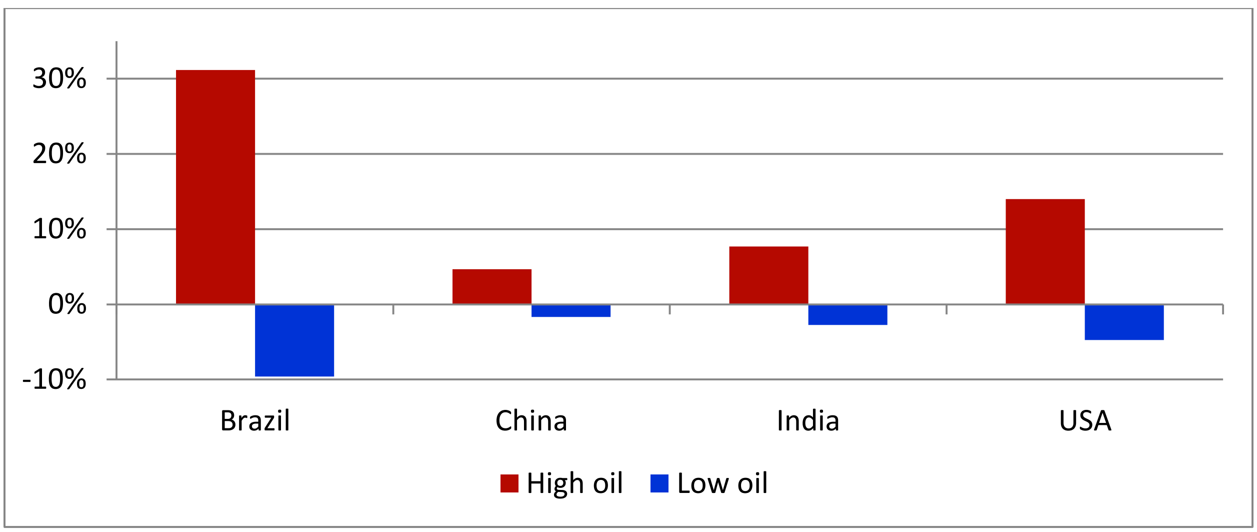
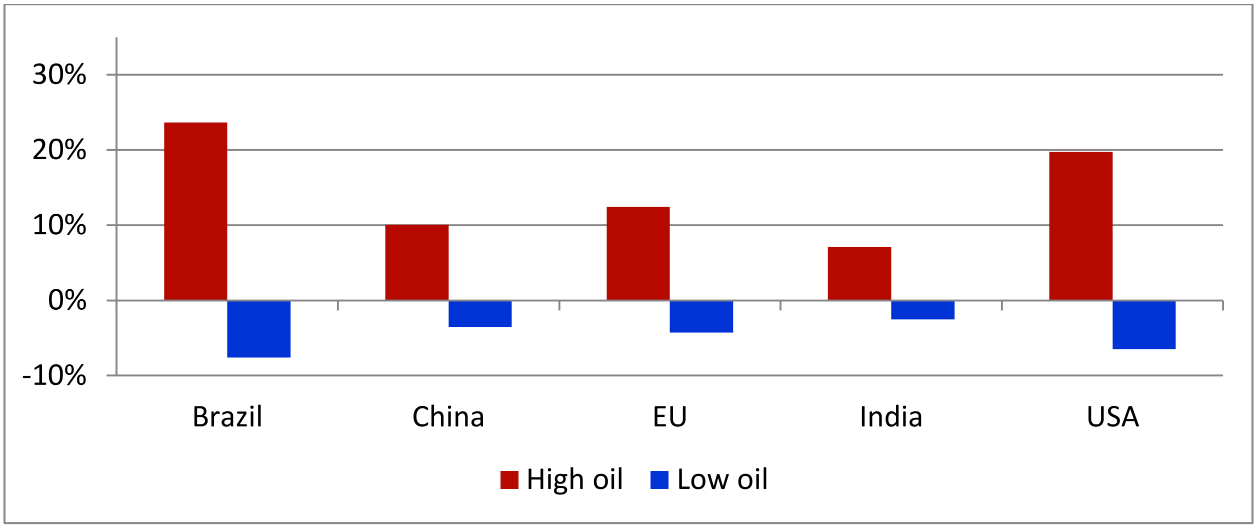


Figure 8. Change in Variable Costs from Base in 2022: Wheat



With lower petroleum prices, input costs decline in all five regions. Corn production costs fall by 3-8 percent with the smallest cost reduction in the EU and the greatest in Brazil. Soybean producers see the largest average cost decline of 21 percent, with Brazil topping out at 31 percent while China's cost reduction is a little under 5 percent.. Changes in wheat costs are similar to those of corn with an average decline of 4 percent. Costs of producing rice fall 9 percent in Brazil while China and United States see a 4-5 percent reduction and India's costs reduction is marginal at 2.5 percent.

Impacts of High and Low Oil Prices on Production

With high oil prices, total soybean and wheat production in the five focus regions declines by just under 1 percent, the most compared to other crops. The reduction in aggregate soybean and wheat production is 2 and 3 million tons, respectively, equivalent to about 2 percent of both world soybean and wheat trade. Aggregate production losses in corn and rice are minimal at 0.3 and 0.4 percent. Sugarcane production increases by 1 percent or 15 million tons. The bulk of the increase occurs in Brazil as ethanol becomes much more attractive to consumers than gasoline. The increase in sugarcane production boosts ethanol production by 0.5 percent with biodiesel production increasing by nearly the same amount.

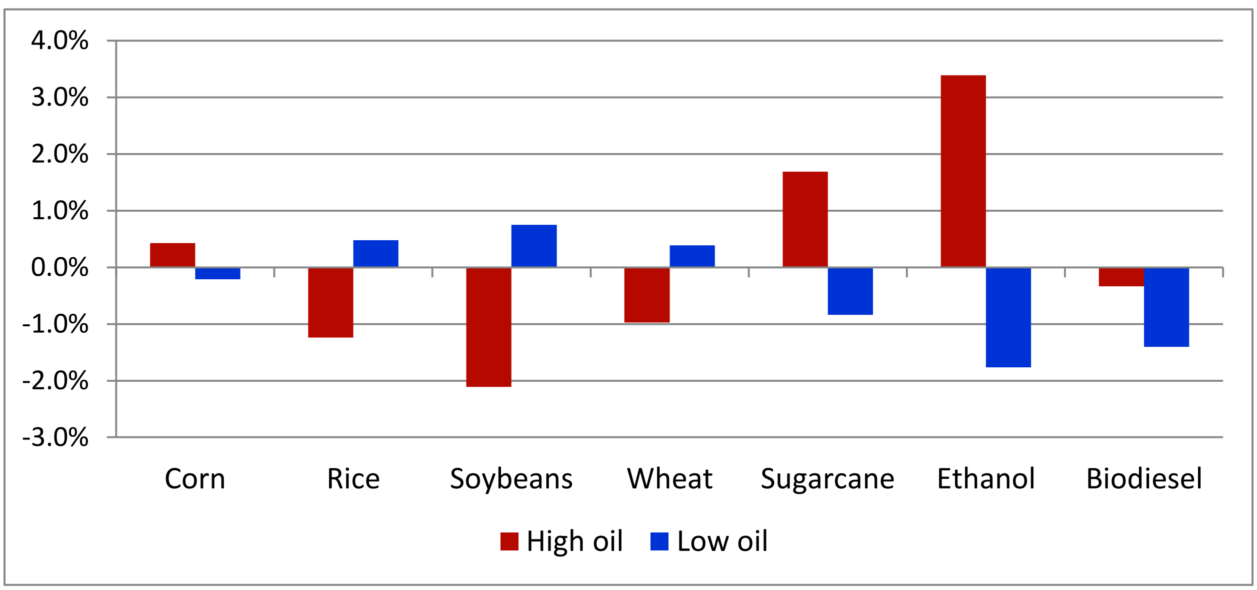
The production impacts with lower oil prices are, of course, the inverse of those with higher prices. However, because the magnitude of the reduction in petroleum prices is about half that of the increase in prices, the increases in corn, rice, soybeans and wheat production in 2022 relative to the base are 0.3 percent or less. The production of sugarcane, ethanol and biodiesel will fall by an average of 0.6 percent, mostly on the response to lower gasoline prices in Brazil. The greatest biodiesel production declines occur in the EU and the United States, the two regions with the largest production.

Brazil

Production of sugarcane, which is Brazil's sole ethanol feedstock, increases by 1.7 percent with high oil prices (Figure 9), which in turn yields a 3.4 percent increase in ethanol production. Consumers with flex-fuel cars—which can run on 100 percent ethanol—readily switch their fuel purchases from gasoline Corn production increases 0.4 percent, likely due to changes in relative profitability of alternative crops in the center-west (frontier) production region relative to the traditional southeastern production zone.

Of the remaining crops and biodiesel, soybean production declines the most at 2.1 percent with high oil prices. The decline likely occurs primarily in the frontier production region of Brazil where large land holdings require tractors, planters and harvesters, and in the case of agrochemical application, airplanes. Rice production declines by a little less than 100,000 hectares most likely due to energy associated costs of producing irrigated rice in the southeast. . Wheat production falls by about 1 percent. Wheat production in Brazil is about 4 percent of soybean production so the change is relatively insignificant.

Figure 9. Change in Production from Base in 2022: Brazil



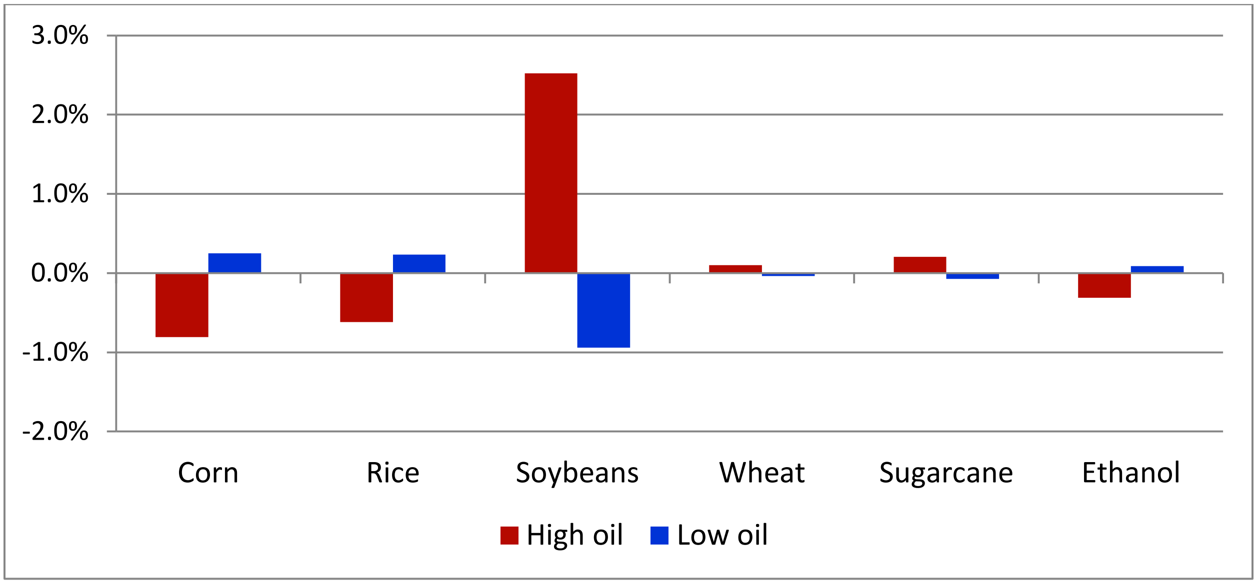
China

Under the high oil price scenario, increased energy costs result in higher cost for agricultural inputs such as fuel and fertilizers. Increasing production costs, related to oil prices, affects producers' planting decisions as crops requiring energy-related inputs become less profitable. The crops in China requiring higher energy-related cost, include corn and rice, most of these increase costs are associated with increased fertilizer expenses. By the year 2022, both corn and rice production are projected to decrease by 0.8 and 0.6 percent respectively (Figure 10). Soybeans production, which has lower input costs, will increase 2.5 percent by the year 2022. Both wheat and sugarcane will exhibit small increases in production, less than 0.2 percent. Under the low oil price scenario, lower energy costs result in low cost for agricultural inputs, which lowers the production costs. Farmers increase plantings of corn and rice which are now more profitable because of the lower input cost of fertilizers. By the year 2022, both corn and rice production are expected to increase by about 0.2 percent. Soybean production will decrease by almost 1 percent, which is less affected by energy costs. Both wheat and sugarcane will exhibit almost no change in production by the year 2022.

China's two major corn production areas include the Northeast, which accounts for about 40 percent and the North China Plain, which accounts for about 35 percent of total production. One of the major input costs for corn in China is fertilizer, which is directly related to energy costs. In Northeast China, the major substitute crop is soybeans. In the North China Plain, corn substitutes include wheat, cotton and some soybeans. Soybean production covers a large area from Northeast China, the North China plains, southern and southwest region. Soybean production is most concentrated in Northeast China, which accounts for over 50 percent of the production. The major alternative crop to soybeans in Northeast China is corn. Rice production is located in Northeast China, South and Southwest China. Japonica rice in Northeast China normally does not substitute with corn or soybeans. In southern and Southwest China, farmers produce two to three crops per year. Wheat production is mostly concentrated in the North China Plains and is the most mechanized crop. Cotton production is located in the North China Plains and in the West, Xinjiang province.

China maintains numerous government policies which affect trade, domestic prices, and cost of production. Direct subsidies are provided to grain farmers based on grain acreage, which began in 2004. These include payments to compensate input costs such as fuel and fertilizer. The Chinese government has attempted to minimize the impact of increasing fertilize prices by providing subsidies to grain farmers for increasing costs of fertilizer. Under our scenarios subsidies were not increased to offset the increased energy and fertilizer costs. Minimum prices are maintained for a number of commodities in major producing areas, which include selected grains, oilseeds and cotton. China maintains tariffs, tariff rate quotas, state trading, and value added taxes on a number of commodities. Tariff rate quotas are maintained on corn, wheat, rice, cotton, sugar, and wool. China's soybean trade is open to the world market with no trade barriers, and China has become the world's largest soybean importer.

Figure 10. Change in Production from Base in 2022: China

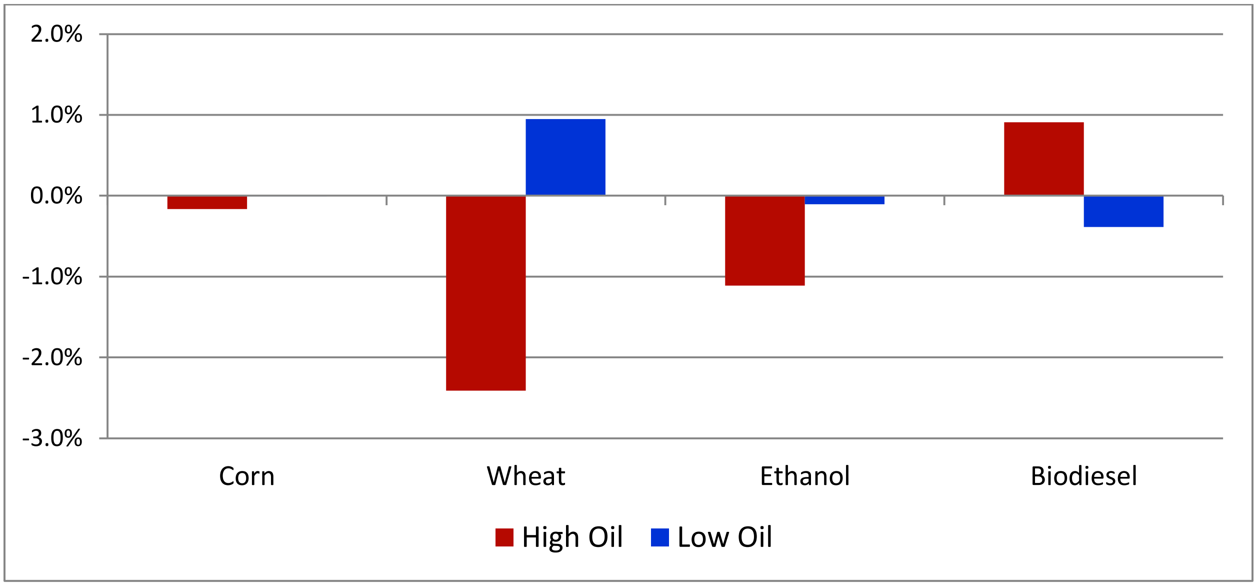


European Union

The EU wheat transmission elasticities are 0.157 and 0.078 for current and lagged petroleum prices. With high oil prices and relatively high cost transmission elasticities, EU wheat production declines by 2.4 percent or 3.6 million tons (Figure 11). The reduction in wheat supply likely translates into lower EU wheat exports, which in turn will raise international wheat prices. The shift away from wheat also means that supplies of crops that compete for land currently planted to wheat will increase. Producers are most likely to turn to rapeseed as an alternative crop, especially with increasing demand for biofuels.

With current year cost transmission elasticities half of those for wheat, corn reductions in corn area and production are minimal. Ethanol production declines as consumers reduce petrol consumption in response to significantly higher oil prices. Biodiesel production rises to offset higher energy costs.

Figure 11. Change in Production from Base in 2022: EU



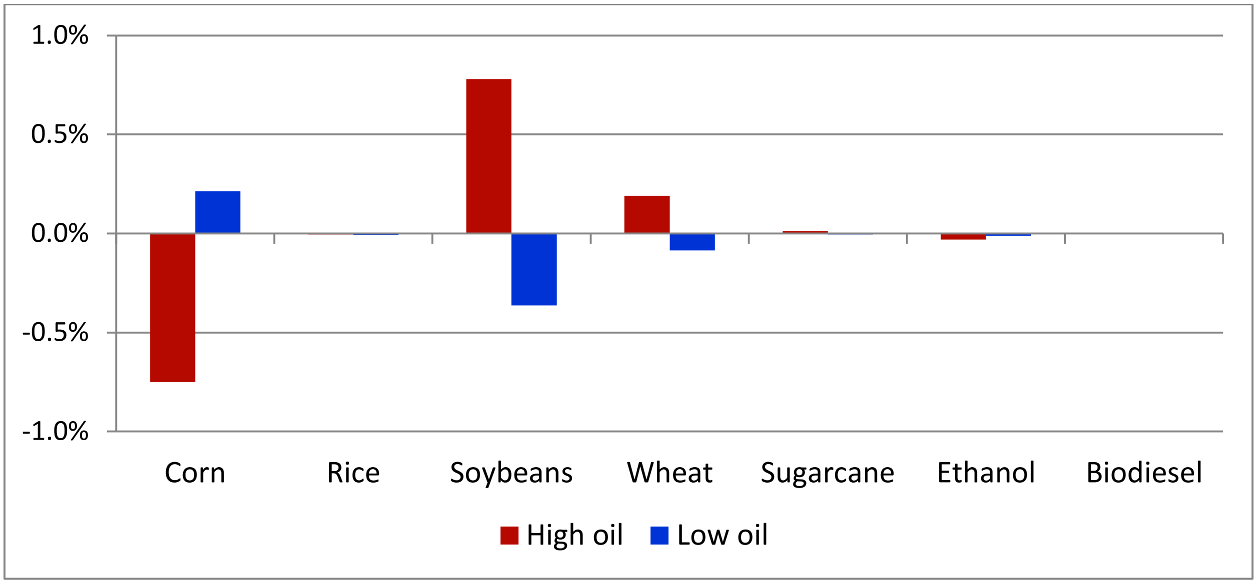
With low oil prices, wheat production in 2022 is 1.4 million tons (0.9 percent) higher than the base amount while corn production is virtually unchanged from the base. Ethanol production falls with lower petroleum prices due to reduced demand for blending. Biodiesel production also falls as domestic prices decline due to weak demand.

India

Petroleum-production cost transmission elasticities for India are very low, ranging from 0.59 for rice to 0.93 for corn for current year oil prices and 0.76 for previous year petroleum prices. As a consequence, adjustments to changes in world oil prices are small. The largest impacts with high oil prices are a decline in corn production and an increase in soybean production (Figure 12). Soybean production rises as higher world prices are fully transmitted to the domestic market. International wheat prices also rise by about the same margin as for soybeans. However, more than 90 percent of wheat area is irrigated, requiring electricity to pump ground water to the fields while only 3 percent of soybean area is irrigated. Wheat farmers therefore temper their response to higher world prices, yielding only a small increase in wheat production. Rice production is essentially unchanged.

Ethanol production, which is equivalent to about 2 percent of world production, declines 0.3 percent in response to lower world and domestic prices. Biodiesel production increases less than 0.1 percent. The production of sugarcane, which is the ethanol feedstock, rises slightly but the additional supply is used to produce sugar instead.

Figure 12. Change in Production from Base in 2022: India

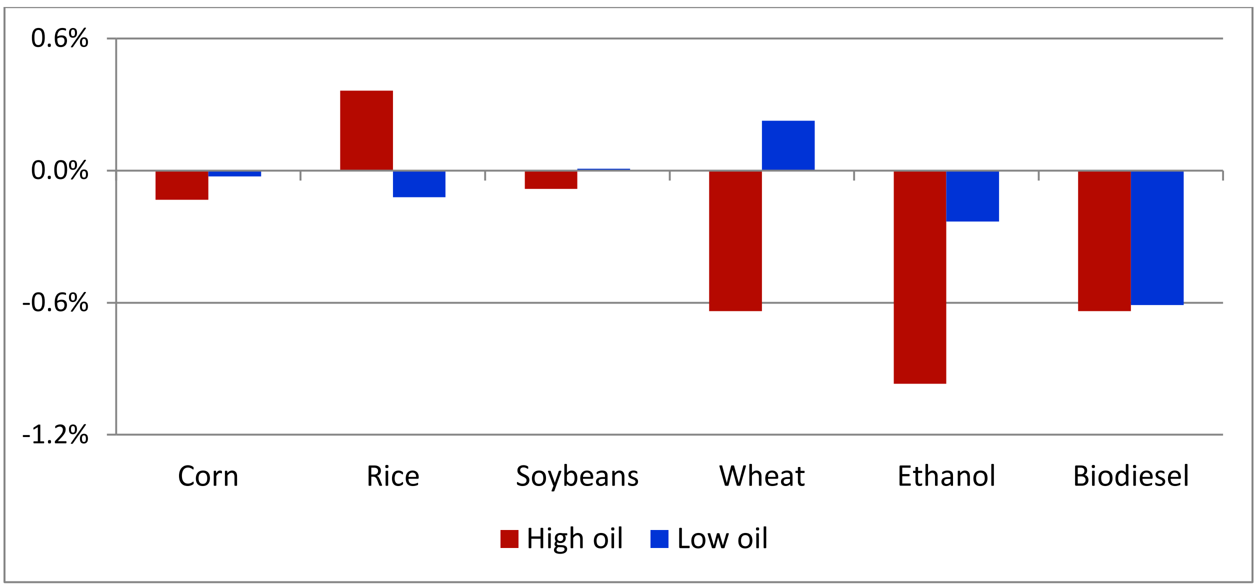


Corn production rises by 0.2 percent when petroleum prices fall. Both soybean and sugarcane production fall with lower domestic returns to production. Wheat, rice and biodiesel production are virtually unchanged with low oil prices.

United States

The projected high and low energy prices produce less than a 1 percent change in the production of major commodities in the United States by the year 2022 (Figure 13). Except for rice, U.S. producers are expected to decrease the production of other crops when they expect high energy prices and vice versa. It is projected that there is relatively little or no change in the production of corn and soybeans, the two most important feedstocks for ethanol and biodiesel production, respectively. In both energy-price scenarios, ethanol and biodiesel production are expected to decrease by less than 1 percent in 2022. This indicates that U.S producers will shift their feed composition or increase the export of these commodities as a response to change in energy prices. Hence, their production decision will be unaffected by change in energy prices. U.S. wheat producers are a bit more responsive to the changes in energy prices, reducing production by 0.6 percent with high oil prices. Despite U.S. rice production being energy intensive, rice production increases in response to a 2.5 percent increase in world prices due to high oil prices. Similarly, as world rice prices decline with lower oil prices, U.S. production falls.

Figure 13. Change in Production from Base in 2022: USA



Conclusions

This paper examines the potential impacts of energy price shocks on production of corn, rice, soybeans, and wheat, as well as biofuels and sugarcane as an ethanol feedstock using a dynamic multi-region, multi-commodity model. We model the impacts of EIA's baseline energy price projection as well as their low and high energy price projections.

We project that input costs will increase by more than 9 percent with higher energy prices, but will decline slightly with lower energy prices by 2022. As one of the biggest producers of biofuel, biofuels production in Brazil is expected to be affected by changes in energy prices. In facts, the projections indicate that as a result of higher energy prices, Brazil will increase its ethanol production by about 3.4 percent while the EU will decrease their wheat production by about 2.4 percent. Brazil will decrease the production of ethanol by about 2 percent based on the lower energy price scenarios. Unlike for Brazil, we find agricultural and biofuel productions in the US and India to be relatively unaffected by changes in energy prices. This could be because government policies and market mechanisms in these two countries are intended to reduce the impacts of changes in energy prices on the production of these commodities. Energy prices are expected to have an impact on Chines soybeans production.

Future research can consider the impacts of energy prices on other variables such as yields, where the primary linkages are likely to be via irrigation and fertilizer. The results reported here are likely underestimated due to two factors. The first is that the response to the energy price shocks is limited to corn, rice, soybeans and wheat, a condition necessitated at this point by data availability. The second factor is omission of yield response to energy price fluctuations, even if in the US at least, the yield is likely quite inelastic with respect to fertilizer price. Energy prices also immediately impact marketing costs and can also impact capital inputs and seed choices, but the latter impacts are likely more long run in nature. Future research can also address a more rigorous method of estimating cost elasticities in regions other than our five focus countries, and to expand the commodity coverage to include estimated transmission elasticities for sugarcane and cotton, along with assumed values for other commodities in PEATSim. Such work would provide a more complete picture of the scope and magnitude of energy price shocks on world agricultural markets.

References

AAEA. (2000). Commodity Costs and Returns Estimation Handbook. Ames, Iowa: A Report of the AAEA Task Force on Commodity Costs and Returns.

Alghalith, M. (2010). The interaction between food prices and oil prices. Energy Economics 32, 1520-1522.

Baffes, J. (2013). A framework for analyzing the interplay among food, fuels, and biofuels. Global Food Security, 2, 110-116.

Beckman, J., Borchers, A., & Jones, C. A. (2013). Agriculture's Supply and Demand for Energy and Energy Products. EIB-112, USDA/ERS.

Ciaian, P. & Kancs, D. (2011). Food, energy and environment: Is bioenergy the missing link? Food Policy, 36, 571-580.

EIA. (2014, March 20). Energy Information Administration, U.S. Department of Energy. Annual Energy Outlook 2014 with Projections to 2040. DOE/EIA-0383(2014). Retrieved from http://www.eia.gov/totalenergy/data/annual/index.cfm#renewable

Esmaeili, A. & Shokoohi, Z. (2011). Assessing the effect of oil price on world food prices: Application of principal component analysis. Energy Policy, 39, 1022-1025.

Gardebroek, C., & Hernandez, M. A. (2013). Do energy prices stimulate food price volatility? Examining volatility transmission between US oil, ethanol and corn markets. Energy Economics, 40, 119-129.

Gohin, A. & Chantret F. (2010). The long-run impact of energy prices on world agricultural markets: The role of macro-economic linkages. Energy Policy, 38, 333-339.

Nazlioglu, S., & Soytas, U. (2011). World oil prices and agricultural commodity prices: Evidence from an emerging market. Energy Economics, 33(3), pp. 488-496.

Sands, R., & Westcott, P. (2011). Impacts of Higher Energy Prices on Agriculture and Rural Economies . ERR-123, USDA/ERS.

Schnepf, R. D., Dohlman, E., & Bolling, C. (2001). Agriculture in Brazil and Argentina: Developments and Prospects for Major Field Crops. Outlook No. (WRS-013), USDA/ERS.

Somwaru , A., & Dirkse, S. (2012). Dynamic PEATSim Model Documenting Its Use in Analyzing Global Commodity Markets. TB-1933, USDA/ERS.

OCE (2013) Office of the Chief Economist, World Agricultural Outlook Board, U.S. Department of Agriculture. USDA Prepared by the Interagency Agricultural Projections Committee. Long-term Projections Report OCE-2013.

OECD/FAO (2013), *OECD-FAO Agricultural Outlook 2013*, OECD Publishing. doi: 10.1787/agr_outlook-2013-en

APPENDIX 1

Appendix Table 1. Petroleum-Production Cost Transmission Elasticities*

Region	POIL(t)				POIL(t-1)			
	Corn	Rice	Soy-beans	Wheat	Corn	Rice	Soy-beans	Wheat
Estimated								
Brazil	0.236	0.272	0.220	0.185	0.192	0.221	0.322	0.239
China	0.203	0.265	0.091	0.192	0.000	0.000	0.000	0.000
EU	0.081	--	--	0.157	0.083	--	--	0.078
India	0.093	0.059	0.073	0.062	0.076	0.076	0.076	0.076
US	0.129	0.121	0.153	0.251	0.109	0.109	0.109	0.109
Assumed								
Argentina	0.219	0.268	0.155	0.188	0.096	0.111	0.161	0.120
Australia	0.105	0.121	0.153	0.204	0.096	0.109	0.109	0.093
Canada	0.105	0.121	0.153	0.204	0.096	0.109	0.109	0.093
Japan	0.105	0.121	0.153	0.204	0.096	0.109	0.109	0.093
Korea	0.105	0.121	0.153	0.204	0.096	0.109	0.109	0.093
Mexico	0.219	0.268	0.155	0.188	0.096	0.111	0.161	0.120
New Zealand	0.105	0.121	0.153	0.204	0.096	0.109	0.109	0.093
Russia	0.219	0.268	0.155	0.188	0.096	0.111	0.161	0.120
Rest of world	0.035	0.040	0.050	0.067	0.032	0.036	0.036	0.031

Source: authors' estimates for Brazil, China, the EU, India and the United States.

Note: Due to data limitations, values for other regions are assumed as follows:
High income economies (Australia, Canada, Japan, Korea, New Zealand):
Average of the EU and US estimated elasticities
Middle income economies (Argentina, Mexico, Russia):
Average of the Brazil and China estimated elasticities
Rest of world:
One-third of the average of the EU and US elasticities

* The cost elasticities measure the percent change in total variable cost of producing crop i in a particular country as a result of a one percent change in the current (POIL(t)) and previous (POIL(t-1)) year's oil price, based on Eq. (4).