

# **The Role of Biofuels and Other Factors in Increasing Farm and Food Prices**

*A Review of Recent Developments with a Focus on  
Feed Grain Markets and Market Prospects*

Written by Keith Collins, Ph.D. (economic advisor,  
Keith J. Collins LLC) as supporting material for a review  
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## Executive Summary

**Farm and Food Price Increases.** Farm-level prices have increased sharply over the past two years. The index of prices received by farmers for all farm products increased by 34 percent over the period January 2006 through May 2008. The index of prices received for feed grains and hay, led by surging corn prices, increased by 144 percent over that period. High prices for farm products have led to significant retail food price increases, rising 4.9 percent during 2007, the highest increase in 17 years.

**Factors Behind the Increases.** Many factors are contributing to higher farm-level and retail food prices. They include: (1) strong global economic growth, thereby increasing demand for U.S. commodities; (2) the declining value of the dollar, although recent real trade-weighted exchange rates suggest that the weakened dollar has been less important to corn and other key crops; (3) reduced supplies of some crops, such as wheat and rice, due to adverse global weather; (4) higher energy prices that have increased farm production costs and food processing and distribution costs; (5) changing foreign agricultural policies that insulate countries from higher global prices; (6) increased investment by index funds and other managed investments that probably have increased price volatility but are not likely to have sustained effects; and (7) biofuels, particularly corn-based ethanol. Biofuels have been a major factor for feed grain and livestock markets, with corn used in ethanol rising from 2.1 billion bushels in 2006/07 to an expected 4.0 billion in 2008/09. This increase in corn for ethanol production exceeds the entire expected increase in total corn demand over this period.

**Role of Ethanol.** The expected increase in corn used as a feedstock in ethanol plants from 2006/07 to 2008/09 is equivalent to the production of corn on about 12 million acres. The increase in corn demand due to ethanol is rising faster than growth in corn yields per acre. So long as that situation continues, corn will have to attract acreage from other crops to meet its expanding demand. This shift will mean higher prices for all crops that compete, directly or indirectly, for acreage with corn. The market projects a continually tight corn supply and demand balance for the next several years, evidenced in current high cash prices and futures prices for the next several years.

This paper reviews various studies that have examined the relationship between corn used in ethanol production and corn prices. They suggest increased corn demand for ethanol could account for 25 to 50 percent of the corn price increase expected from 2006/07 to 2008/09. Another analysis presented in the paper suggests that ethanol could account for 60 percent of the expected increase in corn prices between 2006/07 and 2008/09 when market demand and supply are inelastic with respect to price—i.e., a period when stocks are very low, feed use is slow to respond, export demand is strong due to foreign agricultural policies, and acreage is very constrained.

**Ethanol drivers.** There are two important factors that have increased the price of ethanol. First, high crude oil prices and correspondingly-high gasoline prices have helped establish the current level of ethanol capacity. Second, Federal biofuels policies are encouraging continued ethanol production even with record-high and steadily rising corn prices. The ethanol tariff limits U.S. access of foreign supplies; the tax credit enables ethanol producers to pay the equivalent of up to \$1.43 more per bushel for corn used as feedstock; and the Renewable Fuel Standard (RFS) mandates steady, undeviating annual increases in ethanol demand. These requirements must be met regardless of what happens to the prices of oil, ethanol, or corn. The RFS is likely to be an increasingly important factor in determining the direction that ethanol and corn prices will take over the next several years. The rate-of-return received by ethanol plants has been declining over the past year as corn prices have increased, and ethanol prices, excluding the tax credit, have declined to a level that reflects their energy (BTU) value relative to

gasoline prices. Without Federal biofuels incentive programs, it is increasingly likely that the RFS levels of ethanol production would not be realized with this year's expected decline in corn supplies.

**Extraordinarily Low Feed Grain and Oilseed Stocks.** With Federal biofuels programs assuring future expansion of corn for ethanol production, the corn and soybean supply/demand balance is expected to be very tight. Unless quantities demanded for exports, feed, seed, and food uses drop below the recent average levels and/or acreage expands beyond similar levels, corn and soybean inventories will fall to historic lows. These reserves provide the industry with a cushion to protect against low yields and adverse weather. Without sufficient reserves, any disruption will result in significant price increases, placing all users at substantial business risk, including livestock and poultry producers and many ethanol plants.

**Food Price Effects.** The increase in farm-level prices has contributed to higher retail food prices, which were up 6.9 percent at a seasonally-adjusted annual rate during the first 4 months of 2008. This increase compared with a 4.9 percent increase during 2007. Food price increases have exceeded forecasts, and many studies offer various conclusions about the causes for these increases and the prospect of future food prices. Higher energy prices, overall inflation, and biofuels are major contributors to recent food price increases. This latter factor – biofuels – is likely to have more of an impact over the next few years as meat production slows due to higher feed costs.

One way to gauge the potential increase in food prices due to biofuels is to estimate the increase in costs for livestock producers and other U.S. users of feed grains and oilseeds. If these costs are fully passed on through the food chain, they eventually will be reflected in higher retail food prices. For example, assume, as this paper suggests, that 60 percent (or \$20 billion) of the expected increase in feed grain and oilseed product costs between 2006/07 and 2008/09 is accounted for by biofuels. These increases, in turn, translate into increased U.S. personal consumption expenditures on food, over a 2-3 year period, of 1.8 percent. While 1.8 percent may, on its face, appear small, it must be viewed in the context of the long-term annual average increase in food prices of about 2.5 percent per year. Thus, the increase in retail food prices due to biofuels is estimated to be 23-35 percent above the normal increase in food prices that would occur over 2-3 years. Accordingly, biofuels is now becoming a significant factor in higher food prices.

**Policy Options.** There are several global options for addressing extraordinarily low commodity stocks and higher farm and food prices. Governments could take actions to increase worldwide food production and increase investment in agricultural research and adoption of biotech seeds and other technologies. U.S. Federal biofuels policy could also be reconsidered.

As discussed, with ethanol plant margins declining over the past two years and corn prices soaring, tax credits and the RFS mandate will increasingly keep ethanol production capacity expanding, plant utilization high, corn prices rising, livestock producers under stress, and pressure on food price inflation. Government support for corn-based ethanol ensures a permanent, significant, and increasing demand for corn. These policies interfere with the normal price rationing function of markets when supplies are short. This is the situation today with production being reduced by flooding and excess moisture. In this “short-crop” environment, biofuels policy, including the RFS mandated use, causes even higher corn prices, eliminates the need for ethanol producers to adjust production based on market conditions, and shifts that burden to other users of corn (e.g., the livestock sector), and puts continuing pressure on retail food prices.

Therefore, the Federal Government should give serious consideration to whether (1) biofuels programs should be permitted to intervene significantly in corn and soybean markets, or (2) consumers, acting through market forces, should be the primary mechanism for allocating crops between food and fuel uses, with Government-supported biofuels programs functioning only as a safety net for biofuel producers.

## **The Role of Biofuels and Other Factors in Increasing Farm and Food Prices**

### ***A Review of Recent Developments with a Focus on Feed Grain Markets and Market Prospects***

#### **Introduction**

Global grain market prices have increased sharply over the past two years. The increases have caused food protests and riots, threatening government stability in many developing countries. In the United States, the index of prices received by farmers for all products increased by 34 percent from January 2006 to May 2008 (U.S. Department of Agriculture (USDA), National Agricultural Statistics Service). The index of prices received for feed grains and hay, led by surging corn prices, increased 144 percent over that period. The large increases have raised questions about the causes, effects on market participants, impacts on food prices, and the likely direction of commodity and food prices for the future.

Many factors are contributing to higher farm-level and retail food prices. Rising demand for corn and vegetable oils for biofuel production have been identified as an important cause, generating controversy over the magnitude of the effects on farm and food prices. Expanding biofuel production increases the demand for corn and vegetable oils, increases prices of products that use them as ingredients, and increases prices of other crops that compete with corn and oilseeds for acreage. This paper reviews the factors affecting commodity and food price increases with a focus on biofuels and corn.

The search for more diversified U.S. energy supplies and stronger farm and rural incomes led to Federal programs to increase the production, distribution, and use of biofuels. Advances in corn and ethanol production technologies and improving technical and economic efficiencies of converting biomass into ethanol, have been a basis for increased Federal tax credits, loans, loan guarantees, grants, research, and tariffs for, and mandatory use of, biofuels. Rising oil prices, weather problems, and strong export demand for U.S. crops have combined with Federal biofuels programs to tighten the production/use balance of corn and increase corn prices well beyond recent projections of market analysts.

The surge in corn demand has been reducing the quantity of corn available in storage at the end of the marketing year to low levels. Carryover stocks are now expected to reach historically low levels, setting up the possibility of severe corn market imbalances in 2008/09 that will likely eliminate any disaster reserve and continue to push farm-level corn prices well beyond previous record highs. In such a tight market environment, the price effects of a sharp increase in demand for biofuels will be amplified, compared with a market that has more readily available supplies. These major market changes are occurring while corn ethanol use is just only slightly above one-half the level of use mandated for 2015 by the Renewable Fuel Standard (RFS) under the Energy Independence and Security Act of 2007 (EISA).

As farm-level prices have increased over the past two years, retail food prices have increased. During 2007, the Consumer Price Index (CPI) for food increased 4.9 percent (December 2007 over December 2006), compared with an increase of only 2.1 percent during 2006 (U.S. Department of Labor (DOL), p. 5). The 2007 increase was the highest in 17 years. And, food prices continue to increase, with the food CPI up 6.9 percent at a seasonally adjusted annual rate for the first 4 months of 2008. While a series of events have caused the recent increases in food prices, DOL notes, "Price increases for food can be attributed primarily to increases in ethanol production, exports, and energy prices" (DOL, p. 5). Because

biofuels affect prices for animal feeds, much of their impact on food prices has yet to be realized. As biofuel expansion continues, animal producers will reduce production and increasingly pass on higher feed costs to consumers in the form of higher prices for meats and other animal products.

### The Road to Record-high Corn Prices

Prior to the 1970s, when the Former Soviet Union began importing large quantities of grain, farm-level corn prices were fairly stable and averaged between \$1 and \$1.50 per bushel annually. Since then, corn prices have been higher and more variable, typically setting new highs that last for one year and then pulling back as temporary demand surges pass, or, more usually, as production increases following weather-reduced production.

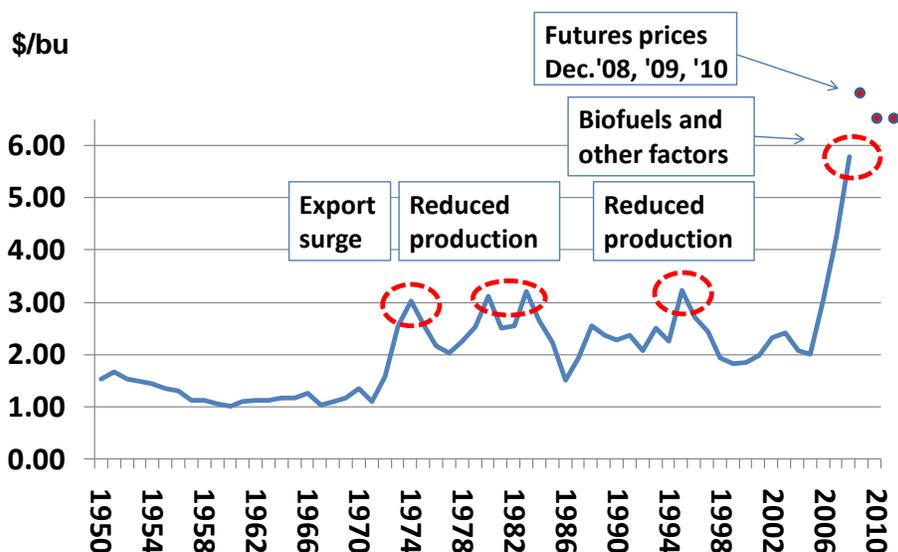
Figure 1 illustrates the price history and includes USDA projections and futures prices as of June 10, 2008 (USDA, WASDE). During the 1974 crop year as global grain demand increased sharply, season-average corn prices received by farmers set a then-record high of \$3.02 per bushel. Two years later, however, prices averaged \$2.15, a decline of nearly 30 percent.

In the 1980 crop year, the next record-high corn price was set at \$3.11 per bushel when weather reduced corn yields. Again, two years later, corn prices averaged \$2.55, nearly 20 percent lower.

In 1983, low yields again pushed corn prices to another record high at \$3.21 per bushel. But prices declined 30 percent to \$2.23 two years later.

In 1995, the next record-high corn price was reached at \$3.24 per bushel, as weather again reduced production. This record prevailed until 2007. But three years after the 1995 record was achieved, corn prices had fallen 40 percent to \$1.94 per bushel.

**Fig. 1. U.S. Corn Season-Average Farm Price**



This pattern of a sharp rise in corn prices followed by a rapid decline now appears to have ended. Corn farm prices reached a near-record high of \$3.04 per bushel for the 2006 crop year and are estimated by USDA to average a new record-high of \$4.35 per bushel for the 2007 crop year. During May 2008, the U.S. average farm-level corn price was \$5.12 per bushel. In February 2008, USDA forecast that the U.S. average corn price for the 2008 crop year would set yet another record high of \$4.60 per bushel (Ash). By June 2008, USDA had raised its 2008 crop year forecast of the U.S. average corn farm price to \$5.80 per bushel.

Other forecasters also see continued high corn prices. The Food and Agriculture Policy Research Institute (FAPRI) projected in early March 2008 that the corn farm price for the 2008 crop year would average \$3.90 per bushel (FAPRI). In April 2008, the ProExporter Network, a consultant to the grain and ethanol industry, issued a farm price forecast for the 2008 crop year of \$6.00 per bushel (ProExporter Network), which incorporated the lower-than-expected 2008 planting intentions for corn reported in USDA's Planting Intentions survey released on March 31, 2008.

### **Key Factors Affecting Corn and Other Crop Prices**

It is impossible to give precise estimates of the impacts of each of the many factors affecting corn or other major crop prices. Many recent studies have reviewed developments in markets and identified key factors (e.g., Trostle, Schnepf). This section identifies the major contributors to grain and oilseed price increases.

**Expanding foreign incomes.** Strong foreign economic growth has raised demand for U.S. exports and contributed to higher corn, other grain, and oilseed prices (von Braun, 2008a). During 2003-2007 global economic growth was unusually strong with the annual average real GDP rising 4.6 percent (IMF), compared with 3.2 percent in the prior 5 years. In emerging and developing economies, annual average real GDP increased 7.3 percent, compared with 4.1 percent in the prior 5 years. Emerging middle classes, changing diets, and high income elasticities of demand for food in emerging and developing economies all contributed to strong demand for food such as meats and grains.

**The declining value of the dollar.** A weaker U.S. dollar has contributed to higher corn, other grain, and oilseed prices by helping to maintain U.S. export demand in the face of higher commodity prices. For example, between 2001 and 2007, the nominal value of the dollar declined against the Euro by 35 percent (USDA Economic Research Service (ERS), 2008b). However, some discussions of the role of the weaker dollar have not taken account of all factors related to the dollar's depreciation.

A different picture emerges when the foreign exchange value of the dollar is adjusted for the relative rates of inflation in the United States and other countries that buy grain and oilseeds from the United States. For example, the ERS index that averages the inflation-adjusted currencies of countries that import U.S. corn (weighted by each country's share of U.S. corn exports) was down from over 113 in 2002 (the peak year in the 2000s) to about 107 in 2007, a depreciation of 5 percent. Between 2005 and 2007, the period of greatest corn price increases, the real corn export-weighted exchange rate actually increased 2.6 percent. The real corn exchange rate index, when weighted by the currencies of U.S. competitors in the global corn market, was down 19 percent between 2002 (the peak year in the 2000s) and 2007. But between 2005 and 2007, the real corn competitor-weighted real exchange rate was down 1.5 percent.

Thus, during a period when corn prices sharply increased, the real corn exchange rate changes were small in comparison. There is little doubt that over time the declining value of the dollar has increased export demand for corn and contributed to corn price increases, but the impact is not as large as suggested by the nominal depreciation against currencies such as the Euro.

**Higher prices for other crops.** The price of one grain or oilseed is affected by changes in the prices of other grains or oilseeds. For example, corn substitutes with sorghum, barley, and oats in feed rations. Prices of the four feed grains move closely together, but since corn dominates total feed grain supply and demand, changes in the markets for the other feed grains have only small effects on corn, but changes in the corn market have a large effect on the other feed grains. Oilseed meals can serve as a complement and substitute for corn and therefore affect corn prices. However, high oilseed prices were not the major cause of high corn prices. Reduced corn production in 2006 and stronger demand for corn increased corn prices, which led to a large shift from soybean acreage into corn acreage in 2007. That shift was a major factor which drove up soybean and soybean product prices. Demand for soybean oil for biodiesel also contributed importantly to the oilseed price increase.

**Increased U.S. animal numbers.** U.S. animals that consume grain have increased in recent years and have increased the demand for grain and oilseeds for feed use. The index of grain consuming animal units (U.S. animal numbers weighted by their share of grain consumption) was up 5.3 percent from 2005 to 2007. This suggests that, other things equal, feed and residual use of feed grains would be up 5.3 percent during this period, or about 325 million bushels for corn, which would have a fairly small price effect.

**Weather effects.** During the past several years, adverse weather has contributed to commodity price increases. The World Bank suggests that the price effects were not major noting, "Other developments, such as droughts in Australia and poor crops in the E.U. and Ukraine in 2006 and 2007, were largely offset by good crops and increased exports in other countries and would not, on their own, have had a significant impact on prices" (World Bank, p. 1). However, global weather effects on production appear most notable for wheat but less so for rice and minimal for corn. For corn, foreign production has increased from 415 million tons in 2005/06 to 446 million tons in 2006/07 to an estimated 458 million tons in 2007/08. U.S. corn yields have been close to trend levels during these years.

**Changing foreign agricultural policies.** Changing foreign agricultural policies have contributed to global commodity price increases. Numerous countries are reported to have taken actions to insulate their domestic markets from high commodity and food prices. For example, the International Food Policy Research Institute notes, ". . . China has banned rice and maize exports; India has banned milk powder exports; Bolivia has banned the export of soy oil to Chile, Colombia, Cuba, Ecuador, Peru, and Venezuela; and Ethiopia has banned exports of major cereals. Other countries are reducing restrictions on imports: Morocco, for instance, cut tariffs on wheat imports from 130 percent to 2.5 percent; Nigeria cut its rice import tax from 100 percent to just 2.7 percent" (von Braun, 2008b, p. 2). Generally, these actions include reducing import barriers, subsidizing domestic consumption, and halting or taxing exports. These actions prevent reductions in consumption that would otherwise be caused by higher prices, and they reduce supplies available to world buyers. The effect of the actions is to transmit increased prices and price volatility to countries that are not insulating their markets. For U.S. grain and oilseeds, the effect is primarily felt through U.S. exports being higher and less responsive to price changes than they would be otherwise.

**Higher energy prices and U.S. farm production costs.** Increases in farm production costs can raise commodity prices. U.S. average corn operating costs increased from \$186.37 per acre in 2005 to \$229.61 per acre in 2007, mainly due to higher energy costs (USDA ERS, 2008a). While higher production expenses, if sustained, are most likely to have longer term effects on commodity or food prices, several adjustments may partly offset their market price effects. First, higher costs reduce producer returns and the reduction may be reflected in lower farm land prices and rents. Second, producers may make production adjustments that lower input costs. Third, increases in productivity will also offset higher production costs per acre. For example, corn yield per planted acre increased slightly between 2005 and 2007, making the operating costs \$1.25 per bushel in 2005 and \$1.52 per bushel in 2007, an increase of 22 percent or \$0.27 per bushel over two years. Fourth, higher energy prices can also contribute to lower farm-level prices by raising transportation costs to markets, such as ocean shipping costs. These distribution costs can be partly passed back to producers as wider basis or lower farm prices than would otherwise be the case.

**Increased financial investment in commodity markets.** Open interest in agricultural contracts on commodity exchanges has increased, but new futures market participants seem unlikely to be a major cause of persistently higher grain prices. Activity by money managers, such as index funds, has increased sharply. This has raised concerns that new players in the market have increased crop price levels and volatility. The Commodity Futures Trading Commission (CFTC) held an all-day hearing to examine the performance of futures markets in price discovery and hedging (CFTC). While there has been less efficient convergence between futures and cash markets for some contracts at some times, there is no clear indication that new investors are responsible for sustained higher corn prices. Futures and cash markets still generally converge and the hearing identified some actions that could improve convergence and basis predictability. CFTC is continuing to review this issue and accepted comments from the public through May 7, 2008.

A recent Government Accountability Office (GAO) review of increased managed-money investments in crude oil is instructive for crop markets. GAO notes that the views of market participants and other experts are mixed, with some arguing large speculative purchases could lead to higher prices, while others believe speculative activity does not have significant price impacts. GAO states, "Still others told us that while speculative trading in the futures market could contribute to short-term price movements in the physical markets, they did not believe it was possible to sustain a speculative "bubble" over time, because the two markets were linked and both responded to information about changes in supply and demand caused by such factors as the weather or geographical events." (GAO, 2007b, p. 13).

In agricultural as in energy markets, if new investors on the long side are bidding up prices well beyond the fundamentals of physical supply and demand, there is an opportunity for arbitrageurs to take short positions and physically deliver against futures contracts, which would move futures prices toward fundamentals of the market. The increased activity in futures markets is a reaction to tightening fundamentals and higher commodity prices and price volatility. Investors and traders are not creating the environment that is increasing farm prices; they are reacting to the opportunity presented by tight markets to invest funds to earn a return as prices move higher, due to the factors identified in this section.

**Expectations of ever tighter markets.** Expectations of even tighter markets in the future are likely being reflected in current prices, especially for corn and soybeans. The very sharp increases in corn cash and futures prices in late 2007 and early 2008 may also reflect expectations by market participants that there will not be quick relief from tightening supplies. While global wheat production is expected to be

much higher in 2008/09, and wheat prices likely lower with a return to global trend yields, the corn market is moving toward increased tightness in 2008/09 (USDA, WASDE). USDA expects that another large increase in corn use in ethanol and reduced corn acreage during 2008/09 will lead the second lowest level of stocks relative to consumption in 49 years. The average U.S. corn price received by farmers is forecast at \$5.80 per bushel. Although soybean stocks are expected to increase in 2008/09 with higher production, soybean prices are forecast to increase yet again. It is likely that corn, soybeans, and wheat prices are all being affected by the expectation that corn and soybeans will compete intensely for limited acreage in 2009. In addition, expectations that stocks levels will be inadequate to deal with a moderate to severe drought may also add to current corn price increases by causing current supplies to be held back from the market in expectation of higher prices in the future.

**Steady increases in biofuel production.** Many media stories and other articles have cited biofuels as a major factor in commodity price increases. For example, one review concludes: “While biofuels have thus far had little impact on crude oil prices, they have already had large effects on prices of commodities used as feedstocks for biofuels, as well as for competing crops. For example, maize prices rose by about 60 percent from mid-2005 to mid-2006, largely because of the increased use of maize for ethanol production in the United States. This prompted a huge shift of land from wheat into maize in the following season, which contributed to a sharp increase in wheat prices. Vegetable oil prices have also increased because of their stepped-up use for biodiesel production in Europe and the United States, with palm oil prices up 48 percent in the last year and soybean oil prices up 25 percent” (World Bank, 2008).

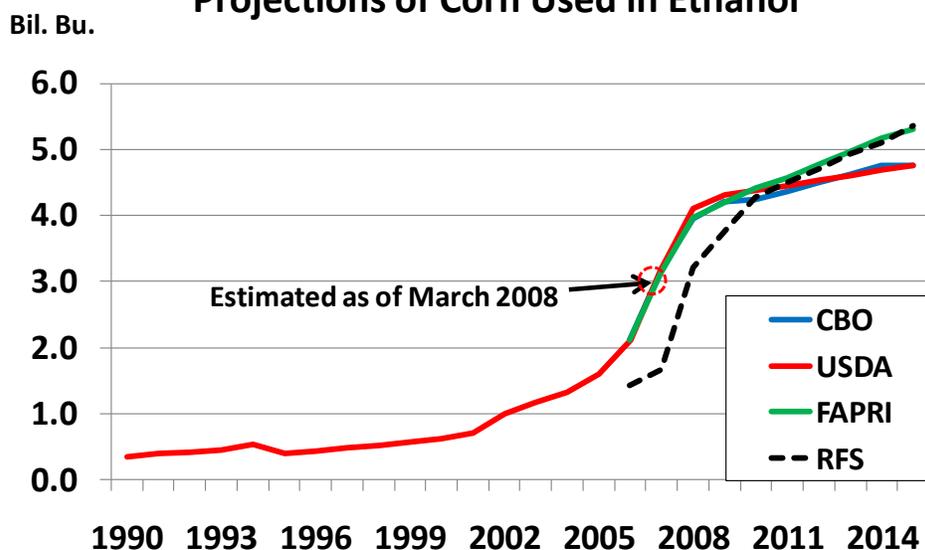
One way to illustrate the importance of biofuels in the U.S. corn market relative to other global factors is to compare foreign corn consumption and production relative to U.S. corn used in ethanol production. Table 1 indicates that the corn deficit (domestic consumption minus production) in foreign countries has increased over the past two decades. The difference between foreign consumption and production signals the need to import corn from the United States and use up foreign corn stocks, or both. After a sharp rise in the early 2000s, this difference has been relatively steady in recent years. However, the increase in ethanol use (measured as 70 percent of the U.S. corn going to ethanol plants to account for coproducts used as feed) has grown much more sharply than the need for U.S. corn in foreign markets.

	1989/90- 1993/94	1994/95- 1998/99	1999/00- 2003/04	2004/05- 2008/09	2006/07	2007/08	2008/09F 1/
<b>Foreign production</b>	292.7	337.8	362.6	437.6	445.5	457.7	477.2
<b>Foreign domestic consumption</b>	333.4	378.5	420.2	489.5	497.3	511.9	526.1
<b>Difference</b>	40.7	40.7	57.6	51.9	52.0	54.2	48.9
<b>70% of U.S. corn demand for ethanol</b>	6.9	8.4	14.4	42.8	37.6	53.3	71.1

1/ USDA, World Agricultural Outlook Board, 2008

Biofuel demand for corn is currently only a little more than half the RFS level for non-advanced biofuels mandated by EISA for 2015, thus assuring steady and large increases in corn demand for ethanol in coming years (Figure 2). The next section more closely examines biofuels, in particular ethanol.

**Fig. 2. Current USDA, Congressional Budget Office and Food and Agricultural Policy Institute Baseline Projections of Corn Used in Ethanol**



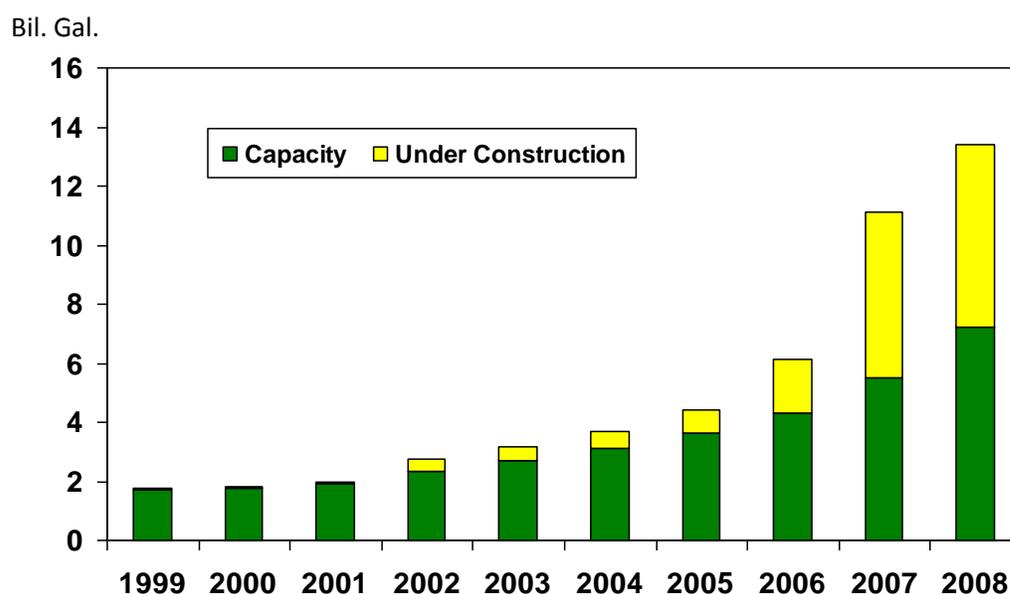
### The Evolution of Ethanol as an Increasingly Important Factor in Farm Prices

**Slow ethanol growth from 2000 to 2004.** By 2004, corn used in ethanol had increased to a then record-high 1.323 billion bushels. This growth reflected the benefits of the \$0.51 per gallon tax credit, steady gains in ethanol production efficiency, and higher oil prices. These factors spurred investment in ethanol plants. But the growth in corn use in ethanol between 2000 and 2004 could readily be accommodated by a market where annual increases in corn productivity were exceeding the increase in corn used in ethanol. Between 2000 and 2004, corn used in ethanol increased an average of 174 million bushels per year. However, corn production over the period, due entirely to increases in yields per acre, rose by an average of 473 million bushels per year. By the end of the 2004 crop year, corn carryover stocks amounted to over 2.1 billion bushels, consistent with long-term average carryover levels. However, the production increase included the unusually high yield in 2004. With a normal yield, production increases would have been slightly less than total demand, suggesting a small reduction in stocks and a small price increase due to corn demand increases due to ethanol and other factors.

**Expansion quickens.** The pace of ethanol expansion began to accelerate during the 2004-2005 period. While the tax credit for ethanol blending traces to 1978, the acceleration of corn ethanol production in the mid 2000s was also stimulated by increasing crude oil prices, which in 1999 began an advance to a new higher level. Refiner acquisition costs for crude oil rose from about \$11 per barrel in early 1999 to over \$31 by November 2000, focusing Federal policy attention on renewable fuels. The new President in early 2001 created the Energy Policy Development Group, chaired by the Vice President, which produced a report advocating increasing energy supplies including renewable energy. While there was no immediate legislative action on the President's energy policy report, the context for ethanol was defined: biofuels were going to be a part of any newly enacted national energy policy. However, the Energy Policy Act of 2005 initiated unprecedented mandates for ethanol consumption.

**Ethanol emerges as major demand force.** From 2006 to 2008, ethanol is the primary force behind the rise in corn prices and the reason corn prices are likely to remain at high and volatile levels for several years. The evidence for this conclusion is in the changing supply and demand balance sheet statistics for corn. By early 2005, crude oil prices exceeding \$50 per barrel combined with existing and prospective new renewable energy programs to pull new investment steadily into ethanol plants (Figure 3). This raised ethanol production, increased corn used in ethanol production, and drove corn prices and the prices of related major crops to unexpectedly ever-higher levels. During the 2004 crop year, corn used in ethanol accounted for 12 percent of total use of corn; in 2005, 14 percent of total corn use; and by 2006, 19 percent of total corn use. USDA's current forecast for the 2007 crop year is that corn used in ethanol will account for 23 percent of total corn use, and USDA projects that in 2008 corn used in ethanol will rise to 32 percent of total corn use.

**Fig. 3. Ethanol's Rapid Capacity Growth**



Source: Renewable Fuels Association. January 1 of each year.

**Productivity cannot meet demand growth; more acres needed.** One implication of the rapid growth in corn use in ethanol is the need for substantially more corn acreage to support this new demand and still meet U.S. and global food and animal feed needs. This land requirement is illustrated by the implied acreage needed to satisfy this new corn demand. Between 2006/07 and 2008/09, corn use in ethanol is expected by USDA to increase from 2.1 to 4.0 billion bushels. This 1.9-billion-bushel increase is equivalent to the production on over 12 million harvested acres (with trend yields). Annual increases in corn use in ethanol are now rising more rapidly than the annual increases in corn productivity.

With corn used for ethanol expanding faster than corn productivity growth, ever more land is needed for corn ethanol. This pressure on land will continue until corn productivity is growing as fast as the growth in total corn demand, including corn used in ethanol. However, such a steady state appears to

be a few years away. EISA mandates the use of 12.0 billion gallons of biofuels by 2010 that, practically speaking, means crop-based biofuels like corn ethanol. If 95 percent of that is made from U.S. corn (a reasonable assumption), about 4.1 billion bushels would be needed. Corn was used in ethanol production in early 2008 at about a 2.8-billion-bushel annual rate (assuming 2.8 gallons of ethanol per bushel of corn). That means corn used in ethanol production must increase by 1.3 billion bushels over the next 2-3/4 years, or an average of 470 million bushels per year. Even assuming that 30 percent of the corn used in ethanol plants ends up as coproduct animal feeds, 330 million more bushels would be needed each year just for the ethanol produced. This increase is well beyond the normal annual increases in corn production due to trend increases in corn yields.

**More corn acres raise the prices of other crops.** As ethanol has expanded, corn stock levels have declined and corn prices have increased. Higher corn prices reflect lack of supplies, the need to ration short supplies among alternative users, and the need for more corn acres. In 2007, corn planted area reached nearly 94 million acres, the highest level in over 50 years. As the corn market has tightened, so too has the soybean market; soybean oil is used for biodiesel and soybean acres are pulled into corn production. Soybean prices have now increased sharply and are limiting the additional soybean acres that can be shifted to corn. Wheat acreage is expected to be up in 2008, but persistently high corn and soybean prices will limit future wheat expansion, holding wheat prices higher than otherwise.

**Overall acreage is limited.** In addition, there is only a limited acreage of cropland pasture that could be converted to soybean and corn production. While some crop acreage is expected to be released from the long-term Conservation Reserve Program (CRP) through the normal expiration of contracts and the 32 million acre cap put in the CRP by the 2008 Farm Bill, the quantity of acres that may return to crop production is still likely to be limited. In the fall of 2008 only 1.3 million acres under long-term contracts will expire and be available for 2009 production, and in the fall of 2009, 3.9 million acres will expire and be available for 2010 crop production. While the conversion of most of these acres to crop production would help augment tight supplies over a several year period, most of these acres are in areas that produce more wheat than corn or soybeans.

### **Quantifying the Importance of Ethanol in Determining Corn Prices**

The effects on agricultural and food prices of all of the factors identified in the previous sections cannot be quantified with precision. Econometric models, simulation models, expert judgment and other approaches may be able to estimate the relative contribution of some of the factors on corn and other major crop prices, but results will vary. In this section, two approaches are used to illustrate the relative importance of ethanol in the recent increases corn prices.

**Approach #1: Imputing price effects based on other studies.** The first approach is to draw on the results from recent corn market projections that have examined exogenous shocks to the corn market and estimated the impacts on ethanol production, corn use, and corn price. For example, recent studies have estimated the impacts of eliminating the tax credit, eliminating the biofuel mandate under EISA, and increasing oil prices by \$10 per barrel. Table 2 summarizes some recent studies and shows the effects on ethanol and corn.

<b>Study</b>	<b>Effect measured</b>	<b>Change in corn use in ethanol</b>	<b>Change in corn use in ethanol (1)</b>	<b>Change in corn price</b>	<b>Change in corn price (2)</b>	<b>Percentage increase in corn price per one percentage point increase in corn use in ethanol (2) ÷ (1)</b>
		mil bu	Percent	\$/bu	Percent	Percent
<b>USDA baseline, 2007</b>	Tax credits and tariff v. credits and tariff expire; effect averaged over 2010-11	+488	+13.77	+0.25	+7.68	0.56
<b>McPhail &amp; Babcock</b>	EISA v. no EISA for the 2008 crop year	+378	+14.63	+0.35	+7.04	0.48
<b>Tokgoz et al., CARD, July 2007</b>	Increase of \$10 per bbl in crude oil price; long term effect	+5,806	+115.82	+1.27	+40.32	0.35
<b>FAPRI Baseline</b>	Tax credit v. no credit; effect averaged over 2011-17	+590	+13.14	+0.14	+3.68	0.28

The last column of the table shows for each study how much the corn farm price increases on average for each percentage point increase in corn used in ethanol. The impacts on price differ because the models and approaches differ, and the time periods over which the effects are measured differ. They suggest that a 10-percent increase in corn used in ethanol would increase corn prices by 2.8 percent to 5.6 percent over various time periods.

These multipliers may be used to make a rough estimate of the effect of expanded corn use in ethanol production. For example, corn used in ethanol was 2.1 billion bushels in 2006/07; and USDA forecasts an increase to 4.0 billion bushels in 2008/09, up 89 percent. Using the above table, the implied percentage changes in the price of corn due to the increase in corn use in ethanol would range from 25 percent to 50 percent. These multipliers, then, suggest an increase actual average corn farm price of \$3.04 per bushel in the 2006/07 to a range of \$3.80 to \$4.55 in 2008/09.

If the price of corn averages \$5.80 per bushel in 2008/09 (mid-point of the USDA forecast as of May 2008), these results suggest corn ethanol could be accounting for 28 to 55 percent of the price increase since 2006/07. Most of these analyses project lower prices for 2008/09 than currently being experienced, estimate market adjustments over a long period, or have stock levels that do not reflect current very markets. When stocks relative to use are extremely tight as they are today, a given increase in demand, such as one due to ethanol expansion, has a much larger price effect than during a period of high stocks relative to use. The current environment of high prices and low expected stocks

suggests the current ethanol-corn price relationship is more likely to be near or above the upper end of the range of these studies.

**Approach #2: Using a simple analytical model.** Another approach to illustrating the role of ethanol in affecting corn prices is to use a mathematical example based on elasticities of supply and demand (Table 3). The approach uses equations to represent the U.S. corn market. There are equations for U.S. corn feed demand, corn export demand, corn demanded for ethanol production, and corn supply. Each demand component is specified as a function of corn price and exogenous factors that shift demand. The supply of corn to the market is taken to be production plus the change in stocks and is also specified as a function of the price of corn. The equations can be mathematically expressed in terms of elasticities of supply and demand and the percentage change in the shift factors. See the Appendix for a more complete discussion of this approach.

The model could be used to simulate the percentage change in corn price from 2006/07 to 2008/09 due to shifts in each corn demand component and yield changes over that period. However, these shifts cannot be observed, and determining them irrespective of price changes is difficult. Part of this difficulty is knowing which supply and demand elasticity to use. This selection problem stems from the fact that the corn market is moving toward a historically tight supply and demand balance in 2008/09 with constraints on acreage, limited export response to price changes due to foreign policies, and an unusually limited supply of stocks available to meet demand. Thus, elasticities are likely moving toward smaller than historical average values, which magnifies the price effect of any demand or supply shift.

Instead, the approach used with this model is to start with the tight 2008/09 market and work back in time. The model is used by taking USDA 2008/09 forecasts as the starting point and answering the question: what would corn price be in 2008/09 if corn used in ethanol had remained the same as quantity used in ethanol in 2006/07?

Table 3 shows the results of the calculations. Price elasticities of demand and supply are used that reflect the current tight markets and limited changes in demand that have occurred in the face of dramatic price increases.

Variable	2008/09 forecast value	Price elasticity	Percent change	Percent change in corn farm price due to change in variable
Supply	11,735	0.15		
Feed and residual use 1/	6,350	0.2		
Ethanol use 1/	2,800	0.15	-47	-29
Other food, seed & industry use	1,360	0		
Exports	2,000	0.5		
Average farm price (\$/bu.)	5.80			4.13

1/ Ethanol use is reduced and feed and residual use is increased by 30 percent of the 2008/09 forecast of corn going to ethanol plants to account for coproducts of ethanol production being used as feed.

Had corn used in ethanol stayed at the 2006/07 level, the resulting demand and supply changes suggest 2008/09 corn prices 29 percent below the current expected price, or an average price of \$4.13 per bushel. This means that the increase in corn used in ethanol since 2006/07 is estimated to increase corn

prices 40 percent, or from \$4.13 per bushel to an expected \$5.80 in 2008/09. Alternatively, the increase in corn used in ethanol since 2006/07 is estimated to account for about 60 percent of the \$2.76 increase in corn prices from \$3.04 per bushel in 2006/07 to \$5.80 in 2008/09. This approach does not identify the role of each factor in getting to a record high corn price but simply examines what might happen to prices if ethanol demand for corn was at a much reduced level.

No model however simple or complex can account for precisely what factors caused the increase in corn prices in the last couple of years. However, the projection models reviewed earlier and this simulation model indicate that biofuel demand for corn has been a significant factor in determining corn prices, particularly in an environment of tight supplies, and will continue to be so with the biofuel production increases mandated and expected over the next several years.

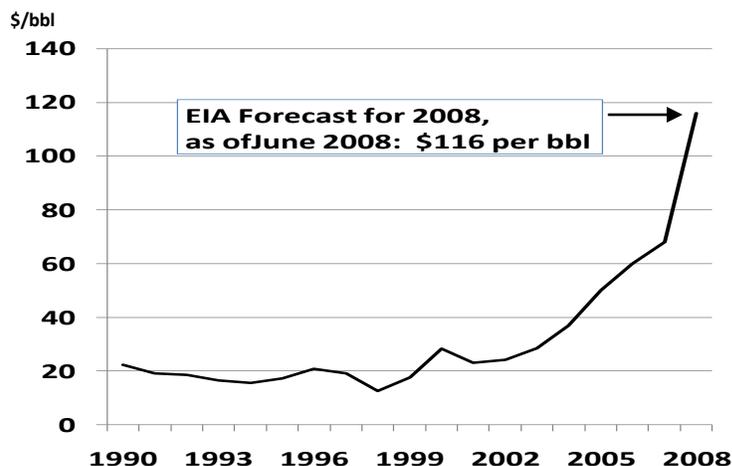
### **Factors Causing the Expansion in Ethanol Production**

While it is difficult to explain quantitatively what each factor contributed to the increase in corn or other commodity prices, the reasons for the expansion of ethanol production are also hard to quantify. Factors include current and expected ethanol prices, corn prices, ethanol production costs, and government policy.

**Oil prices.** Oil prices have risen sharply during the 2000s (Figure 4), pulling up gasoline and ethanol prices. With ethanol prices rising faster than corn prices in the mid-2000s, the increase in ethanol plant margins spurred investment in production capacity. Higher oil prices generally enable ethanol plants to pay more for corn, which is illustrated by the following example.

If the price of crude oil increases by \$10 per barrel and 42 gallons of gasoline can be derived from it, then the marginal increase in the value of the gasoline in a barrel of oil would be \$0.24 per gallon ( $\$10/42$  gallons per barrel). Because ethanol is worth two-thirds of gasoline based on energy value, ethanol would be worth \$0.16 per gallon more (0.67 times \$0.24). With 2.8 gallons of ethanol produced per bushel of corn, the value of corn in ethanol would be worth \$0.45 per bushel more ( $\$0.16$  times 2.8 gallons per bushel). If 30 percent of corn can be sold as coproduct feeds at the same value as corn, then an ethanol plant can pay \$0.64 per bushel more for corn ( $\$0.45$  divided by 0.7).

Consequently, a \$50 per barrel increase in crude oil prices, from \$80 to \$130 per barrel, could result in \$0.80 per gallon higher ethanol prices ( $\$0.16$  times 5) and \$3.20 per bushel higher corn prices ( $\$0.64$  times 5). While this example shows how crude oil prices have been an important incentive to produce ethanol, they are highly volatile and provide no guarantee that ethanol markets will be profitable in the future.

**Fig. 4. Refiners Acquisition Cost of Crude Oil**

**Tax preferences and tariffs.** Prior to 2005, current and expected oil prices and corn prices, along with Federal tax credits and state subsidies were the primary incentives to expand ethanol production. The \$0.51 per gallon tax credit enabled blenders and refiners to pay \$0.51 more for ethanol than they sell ethanol for in the retail market. Thus, the ethanol plant receiving up to 51 cents more per bushel than in the absence of the credit could pay up to \$1.43 per bushel more for corn (\$0.51 per gallon times 2.8 gallons per bushel and now after the recent reduction, \$0.45 times 2.8, or \$1.26) (Elam). The tax credit, combined with higher oil prices, enabled ethanol plants to cover operating and capital costs, and has been a powerful force on corn prices by spurring investment in ethanol production. FAPRI estimated that removal of the tax credit at the end of 2010 would reduce corn prices by \$0.14 per bushel (3.6 percent) on average during 2011-2017. In an analysis of effects during 2008/09 alone, McPhail and Babcock (2008a) estimated that removal of the credit in 2008/09, in the absence of a mandate, would reduce corn prices by \$0.82 per bushel (16.5 percent). In a later analysis, McPhail and Babcock (2008b) estimated that removal of the credit in the presence of the mandate and tariff in 2008/09 would reduce corn prices in that year by \$0.21 cents per bushel (3.5 percent), and removal of the credit in the absence of the mandate and tariff would reduce corn prices by \$0.85 per bushel (14.5 percent).

**Renewable Fuel Standard (RFS).** The Energy Policy Act of 2005 (EPACT), with its RFS mandate to use 7.5 billion gallons of renewable fuels by 2012, likely contributed in some limited way to establishing the current ethanol capacity, despite mandated use levels being below current and expected production at that time. EPACT was important because it provided a Federal government commitment to ensuring expanded biofuel consumption and reducing risk for ethanol firms by putting a floor under ethanol production. EPACT was also notable for eliminating the oxygenate requirement in reformulated gasoline markets and not providing liability protection for the controversial gasoline additive MTBE, which led to the replacement of MTBE by ethanol (Anderson et al.).

In contrast, EISA sharply increased the mandated levels of biofuel use such that the mandates are no longer floors but targets that can be achieved only through ethanol industry expansion (Appendix table). Several studies have attempted to estimate the effects on corn prices of the EISA mandate. Babcock and McPhail (2008b) estimated that removal of the RFS mandate in 2008/09 would decrease corn prices by \$0.23 per bushel (3.9 percent) for 2008/09. In another approach, de Gorter and Just estimated that if

ethanol production in 2015 was 12 billion gallons, with no mandate in place, then a mandate that raised production to 15 billion gallons would increase corn prices by 15 percent in that year. Anderson et al. estimated that a one-quarter reduction in the mandate would reduce corn prices by about \$0.30 per bushel and a one-half reduction in the mandate would reduce corn prices by \$0.50 to \$0.60 per bushel in a few years.

With current ethanol production running at slightly above half the mandated level for 2015, the effects of the mandate are now being built into current and out-year futures prices. Corn futures ranged from \$5.50 to over \$6 per bushel for corn delivered in late 2008, 2009, and 2010 even before the recent flooding in June. The EISA mandate raises expected ethanol prices because it ensures blenders and refiners will have to bid up ethanol prices if ethanol plants reduce output below the mandate in the face of higher corn costs or lower ethanol prices. Even if actual or expected ethanol production is above the mandated level in any year, the mandate raises expected future ethanol prices. It does this because it ensures higher corn demand for ethanol than might occur without the mandate in years when corn production or oil prices are low, assuming the mandate is not waived. This risk mitigation increases investment in ethanol production and hence ethanol output, even if ethanol production is above mandated level.

**Federal biofuels programs taken together.** The tax credit, tariffs, and RFS collectively lessen a number of risks facing ethanol producers, and as a result, generate ethanol investment, ethanol production, and higher corn and other agricultural commodity prices. Risks that are mitigated by biofuels programs include:

- Lower ethanol prices, caused by lower gasoline prices, caused by lower crude oil prices.
- High corn prices caused by unexpected demand, low corn production, or both.
- Low ethanol coproduct feed prices.
- High operating costs caused by increases in energy costs, labor costs, interest rate, or other raw material costs.
- Unexpectedly high plant construction and expansion costs.
- High transportation costs.
- Infrastructure problems creating ethanol distribution bottlenecks.

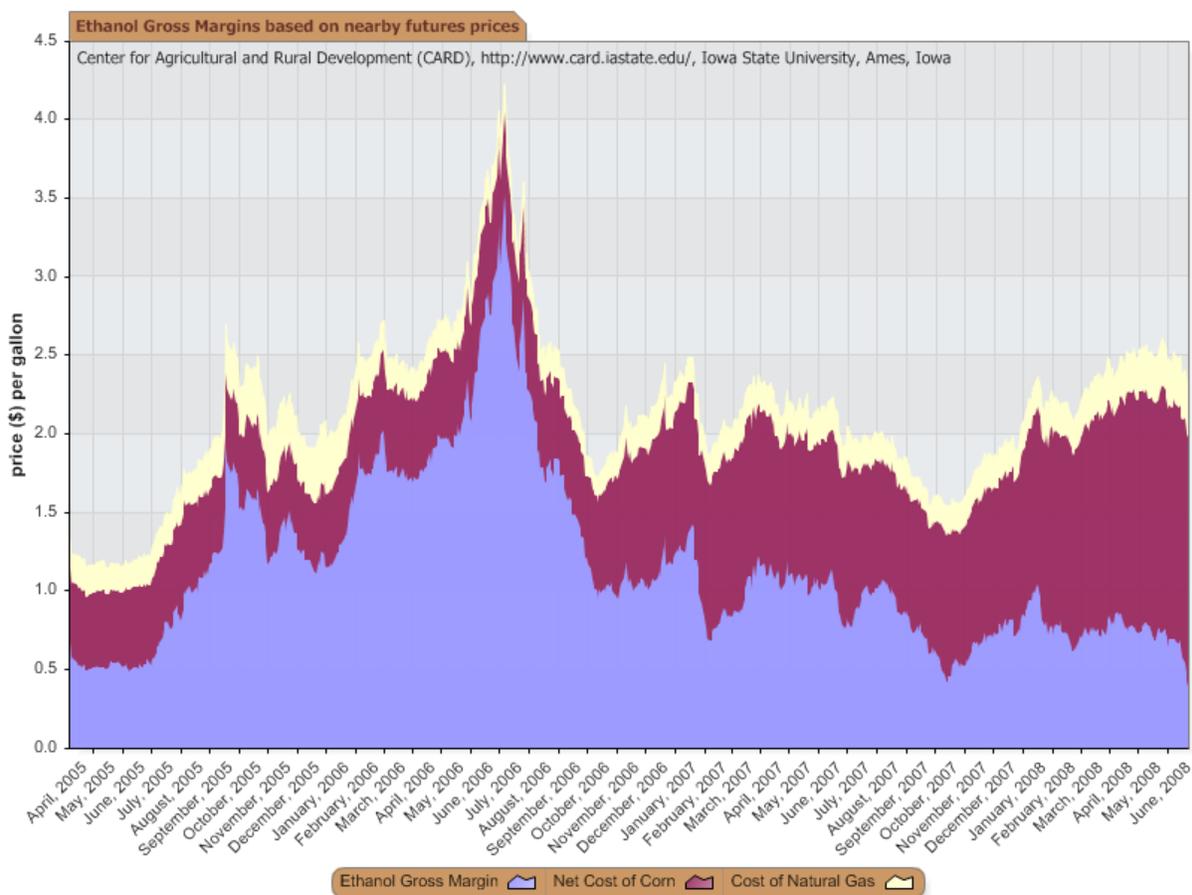
The tax credit raises ethanol prices and enables ethanol plants to pay more for corn. The tariff restricts ethanol competition from foreign sources and supports ethanol prices. The RFS mandate changes expectations about future corn demand and the ability of corn production to meet that demand. The once uncertain increase in corn demand due to biofuels, contingent primarily on strong, but highly volatile oil prices, is now a certain increase in demand due to the RFS, regardless of oil or corn prices. The mandate makes the demand for corn by ethanol plants highly inelastic with respect to price changes when corn prices are high and crude oil prices low. This feature reduces the normal ability of high corn prices to reduce demand and ration short supplies across users. In combination, these biofuels programs help ensure that corn stocks are reduced to historically low levels and kept low for several years, because of limited ability to expand corn production as fast as corn use in ethanol.

### **Current Ethanol Economics**

**There is no assurance RFS levels would be met without the mandate.** In 2008, ethanol faces several challenges. Ethanol futures prices for August 2008 were in the range of \$2.50 per gallon during mid

May, fell to about \$2.30 in early June and then increased to about \$2.80 in mid June. Corn prices have continued to increase, with cash market prices recently over \$6.50 a bushel in Central Illinois and futures prices well over \$7.00. Ethanol margins have been declining since 2006 (Figure 5 from Center for Agricultural and Rural Development, Iowa State University). Plant operating and expansion costs are rising and some plants have reportedly slowed or halted expansions. Distributing ethanol is now more costly because remaining blend markets are outside the Midwest, and ethanol must be transported longer distances, with transportation cost averaging 13 to 18 cents per gallon compared with 3 to 5 cents for petroleum fuels (GAO, 2007a). In this environment, the tax credit and the RFS mandate are helping to maintain investment in ethanol production capacity and production. Without these policies, ethanol prices would likely decline to their energy-equivalent value to gasoline, some ethanol plants would have negative margins and reduce capacity use or cease operating, and corn prices would decline.

**Fig. 5. Ethanol Gross Margins**



### The Supply/Demand Challenge Facing Corn and Soybean Markets

This section examines the adjustments that corn and soybean markets likely face during the next 3 marketing years. Balance sheets for 2009/10 and 2010/11 are constructed based on the May 9, 2008 official USDA forecasts for production and carryin stocks for 2008/09 (Tables 4 and 5). Demand components are not forecast for each year; rather they are simply taken to be the most recent 3-year averages for feed, food, industrial, seed, and export demand for corn and crush, exports, and other for

soybeans. This is a “business as usual” case that provides no growth in demand, except for corn and soybeans used in biofuels. Ethanol demand for corn is assumed to expand as projected under the March 2008 FAPRI baseline, which incorporates EISA. Soybean crush for all years is assumed to be constant at the USDA forecast for 2008/09. Direct corn feed use is reduced in 2009/10 and 2010/11 to account for increased use of ethanol feed coproducts. Soybean and corn harvested acreage in 2009 and 2010 are assumed to be the average of 2007 and the USDA’s 2008 forecast of harvested acreage. In addition, the 2009 corn and soybean acreage are each increased by one quarter of the acreage under Conservation Reserve contracts that expire in 2008, and the 2010 acreages are each increased by one quarter the acreage under Conservation Reserve contracts that expire in 2009. Corn and soybean yields are as projected in the USDA baseline.

Item	2005/06- 2007/08 Avg.	2008/09 1/	2009/10	2010/11
Harvested acreage (mil. ac.)	77.4	79	83	84
Yield (bu./ac.)	149.4	148.9	157.3	159.3
Production (mil. bu.)	11,574	11,735	13,056	13,381
Feed and residual use (mil. bu.)	5,968	5,150	5,440	5,370
Ethanol use (mil. bu.)	2,240	4,000	4,186	4,418
Exports (mil. bu.)	2,236	2,000	2,236	2,236
Other (mil. bu.)	1,370	1,360	1,370	1,370
Carryover stocks (mil. bu.)	1,568	673	497	484
Stocks-to-use (percent)	13.4	5.4	3.8	3.6
Avg. farm price (\$/bu.)	3.13	5.80	--	--

1/ USDA, World Agricultural Outlook Board, 2008; midpoint of price forecast

Item	2005/06- 2007/08 Avg.	2008/09 1/	2009/10	2010/11
Harvested acreage (mil. ac.)	69.6	73.8	69	70
Yield (bu./ac.)	42.3	42.1	42.6	43.0
Production (mil. bu.)	2,945	3,105	2,939	3,010
Crush (mil. bu.)	1,795	1,840	1,840	1,840
Exports (mil. bu.)	1,056	1,050	1,056	1,056
Other (mil. bu.)	145	172	145	145
Carryover stocks (mil. bu.)	383	175	73	42
Stocks-to-use (percent)	12.8	5.7	2.4	1.4
Avg. farm price (\$/bu.)	7.36	11.75	--	--

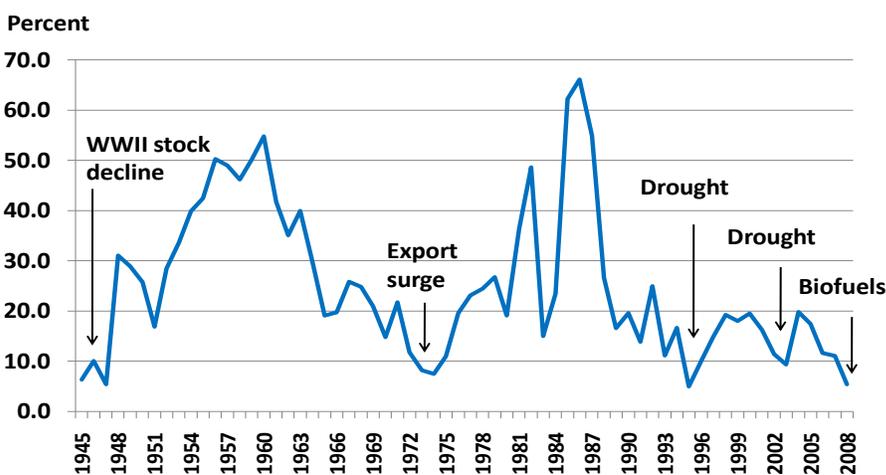
1/ USDA, World Agricultural Outlook Board, 2008; midpoint of price forecast

The examples presented in Tables 4 and 5 indicate that even with no growth in demand for feed and exports above the most recent 3-year average levels, yields above recent levels, and acreage assumed to be above the average level of the past two years, corn and soybean carryover stocks as a percentage of use would fall steadily by 2010/11 to record low—impossibly low—percentages (Figure 6). Stock levels undoubtedly will be higher than in these examples, but much more production or rationing of use, or both, will be needed to bring them to an average level and to a level that could withstand adverse

weather in any of these 3 years. The current futures market corn and soybean prices reflect sustained tight markets as implied in these examples (Figure 7).

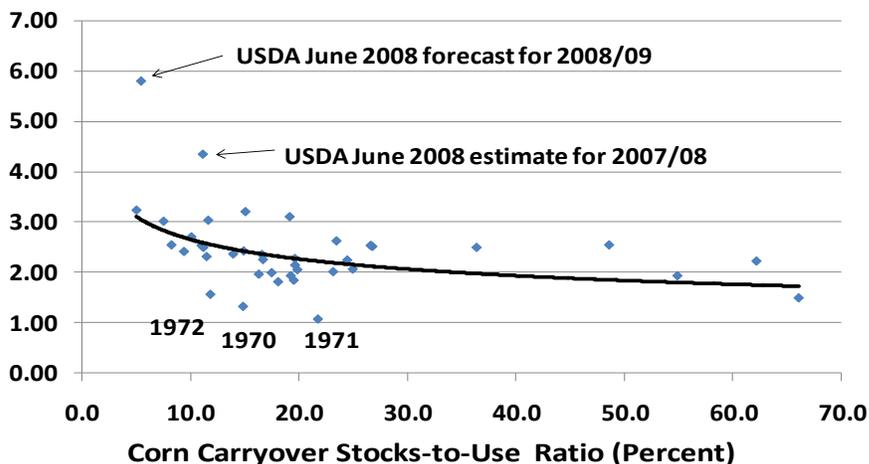
**The importance of having adequate stocks.** Evidence of increasing farm-level and retail food prices can be seen in “stocks-to-use ratios.” In the agricultural industry, a prime indicator of price is the relationship of inventories of corn and other coarse grains (barley, sorghum, oats, and rye) to the use of those grains. The stocks-to-use ratio is the inventory that remains after harvest and sale of an annual crop, divided by the year’s total use of the crop. During the period 1980 through 2004 (the year prior to enactment of the Energy Policy Act of 2005), the U.S. stocks-to-use ratio for corn averaged 24 percent. This number meant that there was sufficient inventory in the market that would provide a substantial cushion for the industry. The 24 percent represented approximately three months consumption of corn. Thus, if there was a drought or another adverse event, U.S. and foreign consumers had three months supply to draw upon, and price increases would be limited.

**Fig. 6. U.S. Corn Ending Stocks: Share of Total Use**



**Fig. 7. Corn Price v. Stocks/Use**

Corn Price, \$/bu



In contrast, today, the corn stocks-to-use ratio is expected to drop to 11.1 percent for 2007/08, or a little over one month's supply of this essential product. In 2008/09, it is expected to drop to 5.4 percent, only 20 days of supply and the second lowest level in 49 years of records. There is little prospect of a return to the historical ratio because demand for corn is increasing, and the market is tight. Simply stated, the U.S. and global grain economies are at risk. The delayed plantings and the excess precipitation this spring in the corn belt are proving that there no longer is any cushion or insurance, anywhere in the world, against disruptions in feed supplies due to production shortfalls in the United States. Prices are spiking significantly and if production prospects worsen, there would be further significant price increases for corn, which would have a devastating effect on the purchasers of that product.

Those less concerned about current high prices would argue that more acreage will be planted as land comes out of the CRP and that technology is likely to boost yields above these trends. That may work out over longer term but does not solve the problems of the next 2-3 years.

Over the next 2-3 years, biofuel use of commodities will continue to grow; added lands from CRP contract expirations will help but add only limited amounts to production; foreign economic growth and foreign policy decisions will likely cause continued strong demand for U.S. corn and soybeans; and weather may reduce corn yields in one or more of these years.

### Biofuels and Food Prices

**U.S. retail food and farm prices are related.** In the United States, average annual changes in the Consumer Price Index (CPI) for food have generally reflected changes in prices received by U.S. farmers (Table 6). However, the relationship has weakened over time as the farm share of the retail dollar has declined from 32 percent in 1970 to about 20 percent before the recent increase in farm prices. In the 1970s, overall inflation averaged 7.1 percent per year, while the food CPI averaged 8.1 percent and the index of all farm prices averaged 9.1 percent. During the 1980s, smaller increases in farm prices aided in limiting food price increases. In the 1990s, farm prices actually declined 0.8 percent annually, while prices for all items and food increased 3.0 and 2.8 percent, respectively. Between 2000 and 2006, the average annual increases in the overall CPI, the CPI for food, and in farm prices were all similar, rising between 2.5 and 3.0 percent per year. In 2007, the index of all farm prices increased 18 percent and the CPI for food rose 4.0 percent.

	<b>1970-1979</b>	<b>1980-1989</b>	<b>1990-1999</b>	<b>2000-2006</b>	<b>2007</b>
<b>CPI-All Items</b>	7.1	5.6	3.0	2.8	2.8
<b>CPI-All Food</b>	8.1	4.6	2.8	2.5	4.0
<b>Prices Received by Farmers for All Farm Products</b>	9.1	1.2	-0.8	3.0	18.0

Sources: Bureau of Labor Statistics (CPI) and USDA NASS (farm prices).

Food prices are rising rapidly and the 4.0 percent year-over-year increase in the food CPI for 2007 masks a larger change within the year and larger increases in certain food groups. When food prices are accelerating, the change during the year will be larger than the year-over-year annual increases. For December 2007, the increase in the food CPI from the previous December was 4.9 percent. Food prices

during the first 4 months of 2008 increased at a seasonally adjusted annual rate of 6.9 percent, following the 4.9 percent increase during all of 2007. The food CPI increase during 2007 was the highest in 17 years.

**Recent projections have been underestimating food price increases.** Most forecasts of retail food price increases have been underestimated over the past two years. For example, USDA's initial forecast released in their 2007 baseline called for an increase in the food CPI of only 1.9 percent in 2007, compared with the actual increase of 4.0 percent. FAPRI's 2007 baseline forecast that the food CPI would rise 2.9 percent in 2007. Studies released in early 2008 increased forecast levels but, again, viewed food prices as generally low in 2008 and declining thereafter. USDA's baseline issued in February 2008 projects that the increase in the CPI for food would be 3.2 percent for 2008, and food price increases would decline to 2.2 percent by 2011. FAPRI also projects annual retail food price increases will decline over the long term, with food prices rising 3.7 percent in 2008 and increasing by only 1.9 percent by 2010. USDA's long term baseline has underestimated food price for each of the past 4 years in a row, and it appears that will happen again in 2008.

A challenge with forecasting food prices in the current environment is the sustained and pervasive increase in commodity prices that buyers are facing. Food pricing is a dynamic process. When crop price increases are modest and perceived to be temporary, livestock producers and other users may restrain from adjusting production or increasing their prices. However, when crop price increases are widespread, large, and perceived to be long-term, then larger and more rapid increases in meat and other food prices are likely to occur. These factors may lead to larger-than-expected increases in retail food prices over the next couple of years.

**USDA has been increasing food inflation forecasts.** USDA has been revising its forecasts monthly and now forecasts the year-over-year midpoint increase in the CPI for food for 2008 will be 5.0 percent above 2007, with a likely range of 4.5 to 5.5 percent. That would be up from the 4 percent increase in 2007 and the 2.4 percent increase in 2006. In explaining its CPI for food forecast for 2008, USDA notes several factors that are likely to pressure retail food prices in the future (Glauber). First, higher energy prices are increasing food processing, marketing, and retailing costs, and if maintained, these costs will be passed on in higher retail prices. Second, although USDA believes that food price inflation will moderate over the next few years, they caution that expansion of biofuels will keep corn and soybean prices at historically high levels and livestock producers will reduce production, leading to higher retail prices for beef and pork.

**Studies show mixed effects of biofuels and corn prices on recent and prospective food price inflation.** A number of studies have drawn various conclusions about increasing food prices and the major causes. These fall roughly into four groups.

First, some conclude that there is little evidence that food prices are being increased by ethanol-induced corn prices or that the effects are small relative to other factors, such as energy prices and labor costs (Informa Economics, Anderson et al., Urbanchuk). Second, others explain that the effect of higher feed grain prices are currently small but further increases may be realized in the market over time as livestock markets adjust and pass on their higher costs (Anderson et al., Glauber). Third, some make estimates regarding the effect on food prices, assuming that these higher feed costs are fully reflected in livestock product prices (Tokgoz et al., Leibtag, USDOE and USDA). Tokgoz compared the corn price of \$1.90 a bushel (referred to as a no ethanol case) with \$4.42 a bushel (ethanol production case) and concluded a 1.7 percent increase in retail food prices. Leibtag found food prices would increase less

than 1 percent per year. USDOE and USDA found that food prices could increase up to 0.85 percentage points as a result of farm-level price increases due to biofuels during April 2007 to April 2008. Fourth, others conclude that current analyses are likely to be significantly underestimating future food price increases (Lapp). Taking into account expected higher meat and dairy product prices, price increases for other inputs used in food production and distribution, and low grain stocks that will lead to much higher commodity prices should weather be adverse, Lapp now forecasts the CPI for food will average 9.0 percent per year during 2008-12, up from his earlier forecasts.

In addition, experts from international organizations have addressed the role of biofuels in higher food prices. The New York Times reported that the UN Food and Agriculture Organization (FAO) predicted biofuels would increase food costs by 10 to 15 percent (Martin). However, the UN FAO attributed to the World Bank the conclusion that 65 percent of the increase in world food prices is due to world biofuels (UN FAO). The World Bank itself points to biofuels as the primary reason for higher food prices over 2004-2007, indicating adverse weather and higher energy costs account for small shares (World Bank). The International Food Policy Research Institute indicates actual biofuel production compared with the 1990-2000 trend accounts for 30 percent of the increase in real grain prices and 39 percent of the increase in real corn prices (Rosegrant). Simon Johnson, Chief Economist at the IMF, stated that biofuels have "played quite a significant role," estimating that 20-30 percent of the price increases in the past two years are accounted for by biofuels (Open Europe, April 14, 2008). The IMF also indicated that 70 percent of the increase in corn prices and 40 percent of the increase in soybean prices has been due to increased biofuel production (Lipsky). In contrast, the Administration estimated that U.S. biofuels accounted for about a 30 percent increase in corn prices and a 10 percent of the increase in the IMF food commodity price index from April 2007 to April 2008 (calculated from data in the source, 40.6/45 times 100 percent)(U.S. Department of Energy and U.S. Department of Agriculture).

### **Potential Contribution of Biofuels to Food Price Increases**

The wide range of conclusions about the main factors behind higher food prices reflects the different prices being measured (farm, wholesale, or retail), different models being used and different time periods for the data being analyzed, perspective of different analysts, and different forecast periods. For example, since corn is mainly used as a feed grain, higher corn prices in one year may not affect livestock prices for up to several years. That is the case today as U.S. meat production is expected to be record high in 2008 partly because high feed prices are causing increased slaughter of beef and dairy cows and sows. The consequence of this is more meat production today, but the reduction in breeding animals and herd sizes will mean lower meat production and higher meat prices over next several years.

**Measuring the effect of biofuels through its effect on increased feed and ingredient costs to farmers, ranchers and food processors.** Tokgoz et al., Leibtag, and US DOE and USDA all accounted for higher corn prices in food prices by estimating effects in different ways on livestock that have not yet been realized in retail meat prices. A similar approach is used here to approximate the effect of recent increases in biofuel production on food prices. The approach involves three steps: first, estimate the increase in expenditures by buyers of feed grains, oilseed meals, vegetable and animal fats and oils from 2006 to 2008; second, assume these costs will be passed on to retail consumers over a several year period; and third, attribute an appropriate portion of the increase in these costs to biofuels.

From 2006/07 to 2008/09, the increase in corn going to ethanol plants is expected to be greater than the entire increase in total U.S. corn use. However, that does not mean ethanol accounts for 100 percent of the increase in corn prices from 2006/07 to 2008/09. Other factors, such as foreign economic

growth and exchange rates are also increasing corn demand and yield is expected to be below trend. Earlier in this paper, a mathematical simulation was used to estimate that about 60 percent of the increase in corn prices from 2006 to 2008 may be due to the increase in corn used in ethanol from 2006 to the expected use in 2008. Oilseed prices and returns bear a consistent long-term relationship to corn prices and returns. This relationship is a powerful force causing oilseed markets to adjust prices and returns to maintain the relationships with corn. Since biodiesel and soybean acreage that is being bid away to corn production are major factors behind higher soybean price increases, it is reasonable to assume that 60 percent of the increase in soybean and soybean product prices between 2006 and the expected levels for 2008 are also due to biofuels. Then, these conclusions follow:

- Domestic livestock producers and food processors would pay an estimated \$74 billion for feed grains, protein meals, vegetable oils, and animal fats and oils during 2008/09 (calculated using USDA projected 2008/09 domestic consumption levels if available, or 2007/08 levels, and USDA forecast prices for 2008/09). This level is \$34 billion above costs using 2006/07 prices. No effects of biofuels are assumed on the prices for other crops such as hay, wheat, peas, dry beans, lentils, etc.
- If biofuels account for 60 percent of the increase in these prices, biofuels would account for \$20.5 billion in increased feed and ingredient costs from 2006/07 levels to expected 2008/09 levels.
- Total U.S. personal consumption expenditures on food in 2007 were \$1.109 trillion. Thus, a \$20.5 billion increase in ingredient costs when passed on as higher meat and food prices would increase food spending by 1.8 percent, which could account for a substantial portion of food price inflation over the next several years.
- The annual average increase in food prices during 2000-2006 was 2.5 percent, thus a 1.8-percent increase in food costs may look small, but it is a substantial portion of the normal increase in food prices. It may take 2-3 years for this increase to be reflected in food prices. If the normal increase in annual food prices is 2.5 percent, food prices would normally rise 5.1 to 7.7 percent over a 2-3 year period. The 1.8-percent increase in food prices due to biofuels would be a 23-35 percent increase over the normal rate of food price inflation over a 2-3 year period.
- This approach does not take into account the effect of biofuels on the price increases in other commodities that may result from competition for land, and it does not take into account any markups in margins that processors, wholesalers, and retailers may take due to farm price increases. While it is clear biofuels have already had a major effect on increased feed costs, they are also likely to be a more important contributor to higher food prices over time as higher feed and other costs move through the food system.

## Conclusions

### U.S. farm prices have risen sharply since 2006.

- U.S. farm prices, particularly for crops and some animal products, have increased sharply over the past two years. The index of prices received by farmers for all farm products increased by 34 percent over the period January 2006 through May 2008. The index of prices received for feed grains and hay, led by surging corn prices, increased 144 percent over that period. Table 7 shows price increases for key major crops.

<b>Crop year</b>	<b>Corn</b>	<b>Soybeans</b>	<b>Wheat</b>
<b>2005/06</b>	2.00	5.66	3.42
<b>2006/07</b>	3.04	6.43	4.26
<b>May 2008</b>	5.12	12.30	8.80
<b>Change from 2005/06</b>	156% increase	117% increase	157% increase
Source: USDA, National Agricultural Statistics Service			

**A number of factors are combining to drive up U.S. farm and food prices. They include:**

- Expanding demand for U.S. commodity exports. This demand is the result of higher foreign incomes, changing diets, the declining value of the dollar, and production shortfalls in key countries the past two years. Foreign policies that are insulating some countries' agricultural markets from the world market are also transmitting higher and more volatile prices to countries not insulating their markets, such as the United States.
- Increasing animal numbers in the United States, which have increased the demand for feed the past two years.
- Increasing energy prices, which have increased production costs of agricultural commodities and added to the costs of processing and distributing food.
- Increasing investment and speculation in commodities, which mainly increases volatility.
- Expectations that markets will get increasingly tight over the next few years, increasing the prospect that adverse weather could lead to even higher prices and shortages.
- Expanding demand for crops from increased biofuel production, stimulated by higher oil prices, tax credits, tariff protection and mandates.

**Nearly all of the increase in total use of corn over the past two years has been due to use of corn by ethanol plants, thus most of the corn price increase has likely been due to ethanol.**

- A comparison of corn use during the 2005/06 corn marketing year, just prior to the acceleration of ethanol production, with corn use during the current 2007/08 marketing year reveals that ethanol, by far, dominated the increase in corn use. Based on current USDA estimates, 95 percent of the increase in total corn use over that period has been for corn ethanol plants.
- Corn use in ethanol is estimated to equal 23 percent of the record-large 2007 U.S. corn crop. Producers harvested more corn acres than in any year since 1933. With competition for land expected to intensify, and using the mandates in the RFS, the share of corn production used for ethanol is likely to exceed 35 percent by 2015.
- Between 2006/07 and 2008/09, USDA forecasts indicate the increase in corn going to ethanol plants is expected to exceed the increase in total U.S. corn use. Because corn stocks are expected to fall to such low levels relative to total corn use and expected corn prices are so high, any surge in corn demand has an amplified effect on corn prices. In this environment, if substantially less corn were to be used in ethanol production than now expected, corn prices would be much lower. A simplified analytical approach suggests that expected corn prices may be 40 percent higher than they would be had corn used in ethanol production remained at the 2006/07 level. Expressed in an alternative way, the increase in corn expected to be used in ethanol between 2006/07 and 2008/09 may account for up to 60 percent of the increase in corn prices between 2006/07 and 2008/09.

**Corn prices are likely to remain high for several years and exceed current government long-term projections.**

- The effect of ethanol on corn prices is demonstrated by the changes observed in cash and futures prices. The price of No. 2 yellow corn at country elevators in Central Illinois (a common benchmark market) averaged about \$2.00 per bushel in 2005/06. By mid-November 2007, just prior to the increase in the RFS under EISA, corn prices had increased to about \$3.60 per bushel. By the end of the second week in June 2008, corn prices had exceeded \$6.60 per bushel, more than triple the 2005/06 level. Futures prices at the end of that week ranged from \$7.65 to \$6.93 per bushel for corn delivered in December 2008, 2009 and 2010. Such price levels are not reflected in either USDA's short-term forecasts for 2008/09 or their long-run commodity price projections released in 2008, or by other groups, such as the Food and Agricultural Policy Research Institute or the Congressional Budget Office.

**Global grain economies are at risk due to extraordinarily low grain reserves.**

- While global wheat production is expected to increase this year and raise wheat stock levels, the steadily increasing share of corn production going to ethanol is likely to reduce corn stocks to minimum levels and keep them low over the next several years. With very low corn stock levels, global consumers of corn, particularly producers of livestock and poultry and their products, will be put at a high economic risk from U.S. or foreign weather disruptions to feed grain production and will be vulnerable to much higher than normal price volatility. With this year's weather disruptions and prospective declining corn supplies, all users are facing rapidly escalating costs and the need to reduce corn use, and it is increasingly likely that RFS levels of ethanol use would not be realized without the mandate.

**Increased corn production needed to meet demand increases the prices of other crops and foods made from those crops.**

- The increase in corn prices due to ethanol has spread to other crop prices due to the competition for land to produce biofuels versus food. Moreover, biodiesel production has accounted for 52 percent of the increase in soybean oil use between 2005/06 and 2007/08. While wheat price increases are generally thought not to have been affected by higher corn prices, the higher corn prices, largely due to ethanol expansion, will keep wheat prices higher, longer because corn and soybeans will compete with wheat for land.

**The increase in corn and other biofuels is raising retail food prices.**

- Because of their dominant position in expanding demand and prices for feed grains and oilseeds over a sustained period, biofuels are expected to account for a significant portion of food price increases over the next several years. While some analyses conclude corn price increases have little effect on food prices, those analysis do not account for the time lags between increases in feed grain, oilseed meal, and other crop prices and their incorporation into retail animal product and other food prices. If the current increases in feed grain and other prices due to biofuels are fully reflected in meat, vegetable oil, and animal fats and oil prices and prices of other processed products over 2-3 years, the increases in retail food prices over that period are estimated to be 23-35 percent higher than the normal increase in food prices (which is 2.5 percent per year). Although energy price increases and other factors, such higher labor costs, will likely continue to

be major contributors to food price inflation, biofuels are now becoming a significant factor in increasing food prices.

#### **Forecasters have been under estimating food price inflation.**

- The December 2006 to December 2007 increase in the food CPI was the largest in 17 years. The risks to food price inflation are on the rise and many forecasters have been underestimating the increase in food prices. In fact, for the past 4 years, the annual USDA baseline forecasts have underestimated the increase in food prices, and it will do so again this year.

#### **Policy actions that will affect farm and food prices.**

- Food prices are going to be affected by several factors, including (1) high energy costs, (2) general inflation, (3) foreign income growth and the declining value of the dollar, (4) foreign governments closing their markets to exports, and (5) with very low stocks, even modest reductions in production due to bad weather.
- These factors are largely outside of the control of the U.S. government. However, the Federal Government has the ability to control certain factors.

U.S. biofuels policy could be reconsidered. Although high crude oil prices have been an important factor in the expansion of ethanol production to this point, they do not guarantee profitable ethanol production at high corn price levels for now or the future. With ethanol plant margins declining over the past two years, tax credits and the RFS mandate will increasingly keep ethanol production capacity expanding, capacity utilization high, corn prices high, livestock and poultry producers under stress, and pressure on food price inflation. Government support for corn-based ethanol ensures a permanent, significant, and increasing demand for corn. These policies interfere with the normal price rationing function of markets when supplies are short such as in 2008, with production being reduced by flooding and excess moisture. In this short-crop environment, biofuels policy, including mandated use of ethanol, causes even higher corn prices, shifts the demand adjustment burden to non-ethanol users of corn--particularly the livestock sector--and puts continuing pressure on food prices.

The Federal government should give serious consideration to whether (1) biofuels programs should be permitted to intervene significantly in corn and soybean markets or (2) whether consumers, acting through market forces, should be the primary mechanism for allocating crops between food and fuel use, with biofuels programs functioning as a safety net for biofuel producers.

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## Appendix

The mathematical simulation model of the corn market used in this paper to approximate the effects of demand and supply factors on the price of corn consists of demand equations that specify the quantity of corn used in animal feed,  $QF$ , the quantity of corn used in ethanol production,  $QE$ , and the quantity of corn exported,  $QX$ . Each demand equation is specified as a function of the price of corn,  $PC$ . Because other uses of corn, principally industrial, food, and seed uses, changed very little over the past few years, that demand is taken as a constant,  $QO$ . The supply of corn,  $Q$ , is taken to be production plus the change in stocks and is also specified as a function of the price of corn. Each equation (except supply) has a variable that shifts the equation and could be used to account for underlying economic changes, such as increased animal inventories, new ethanol plant construction, or foreign economic growth and exchange rates. The shift variables are denoted  $KF$ ,  $KE$ , and  $KX$  and equal 1 during the reference period.

The model is:

$$QF = KF * F(PC); QE = KE * E(PC); QX = KX * X(PC); QS = S(PC); Q = Q(PC)$$

$$QF + QE + QX + QO = Q \text{ (market clearing condition: total use = supply)}$$

Substituting the demand and supply equations into the market clearing equation and taking total differentials yields the following equation:

$$dPC/PC = [QF_o * (dKF/KF) + QE_o * (dKE/KE) + QX_o * (dKX/KX)] / [Q_o * \epsilon - QF_o * \eta_f - QE_o * \eta_E - QX_o * \eta_X]$$

This equation expresses the percentage change in the price of corn ( $dPC/PC$ ) from the reference period (the 2008 crop year, denoted by the subscript zero) as a function of the percentage change in the shift in each demand component, weighted by the values of each demand component in the reference period, divided by the sum of the elasticities with respect to the price of corn for: supply,  $\epsilon$ ; corn demand for feed,  $\eta_f$ ; corn demand for ethanol,  $\eta_E$ ; and corn demand for exports, with each elasticity weighted by the values of each demand component in the reference period. Corn in ethanol is reduced by 30 percent of the official USDA estimate of corn used in ethanol for the 2008 and 2006 crop years to account for coproducts fed to animals. Feed use is increased by that amount. The data for the reference period, the elasticities used and the exogenous reduction in ethanol used to estimate the price effect are described in the text.

## Appendix Table

**Appendix Table 1. Energy Independence and Security Act of 2007, Renewable Fuel Standard Requirements, billion gallons**

Year	Total renewable fuels 1/	Total renewable fuels less advanced biofuels	Advanced biofuels 2/		
			Cellulosic biofuel 3/	Biodiesel 2/	Other advanced biofuels 2/ 4/
2006	4.00	4.00			
2007	4.70	4.70			
2008	9.00	9.00			
2009	11.10	10.50		0.50	0.10
2010	12.95	12.00	0.10	0.65	0.20
2011	13.95	12.60	0.25	0.80	0.30
2012	15.20	13.20	0.50	1.00	0.50
2013	16.55	13.80	1.00	5/ 1.00	0.75
2014	18.15	14.40	1.75	1.00	1.00
2015	20.50	15.00	3.00	1.00	1.50
2016	22.25	15.00	4.25	1.00	2.00
2017	24.00	15.00	5.50	1.00	2.50
2018	26.00	15.00	7.00	1.00	3.00
2019	28.00	15.00	8.50	1.00	3.50
2020	30.00	15.00	10.50	1.00	3.50
2021	33.00	15.00	13.50	1.00	3.50
2022	36.00	15.00	16.00	1.00	4.00

1/ Requires a 20% LCA reduction in GHG compared with petroleum 1 year after enactment

2/ Requires a 50% LCA reduction in GHG compared with petroleum

3/ Requires a 60% LCA reduction in GHG compared with petroleum

4/ Other advanced biofuels could be cellulosic or biodiesel biofuels

5/ For 2013 and beyond, the level is determined by EPA, DOE and USDA