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Ethanol's Impact on the U.S. Corn Industry

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Abstract

This report evaluates the U.S. corn sector, especially changes in ethanol production. This analysis is based on a series of assumptions about general economic conditions, agricultural polices, weather conditions, and technological change.

Changes in ethanol production will impact the production, feed use, and exports of corn, as well as the general price level. Federally mandated ethanol usage dictates the growth of ethanol production in the United States. Other factors have limited impact on corn price.

Keywords: ethanol, government subsidies, feed use, corn, exports

Highlights

Corn production has increased 37% since the early 1990s and 64% since 1980. Increased yield has been the main reason for rising levels of corn production, as harvest acres have not increased significantly over time.

Exports of corn have been stagnant over the past 25 years, but they are expected to increase by approximately 30% by 2014. The increases are due to rising income worldwide and increases in meat consumption.

The feed use of corn has increased about 25% during the past 15 years to 6.2 billion bushels.

The industrial use of corn has been the fastest growing sector, consisting mainly of corn used for ethanol production. Ethanol use has increased from nothing in 1980 to 1.4 billion bushels today.

The federal government currently provides a $0.51 per gallon subsidy on ethanol production, and the Energy Security Act of 2005 has mandated ethanol consumption to increase to 7 billion gallons by 2012. This provides a rapidly increasing demand for corn used in the production of ethanol.

The mandated ethanol use will increase the forecasted corn price for 2014 from $2.32 per bushel to $2.46 per bushel, under the 7 billion gallon scenario. If 14 billion gallons of ethanol are produced, the price of corn should increase to $3.00 per bushel.

Other scenarios, which account for high and low energy prices and the loss of the ethanol subsidy, do not affect the price of corn substantially.

Exports decrease 3% under the 7 billion gallon scenario and 13% under the 14 billion gallon scenario. Also, feed use decreases 8% and 39%, respectively. Substantial quantities of corn by-products are available to replace corn in livestock rations.

When corn used for ethanol production increases, government payments to corn producers decrease, because they are based on current prices. Under the base scenario, government payments to corn producers are estimated to be $339 million; under scenarios 1 (7) and 2 (14), corn price is above the target price so the government does not make counter-cyclical payments, reducing government spending.

Increased corn production for ethanol use reduces the supply of competing crops. These include soybeans in the corn belt and wheat in the central and northern plains. When 7 billion gallons of ethanol are produced, wheat growers receive $26.1 million more in gross returns than they do in the base scenario, and soybean growers receive $179.7 million more. If 14 billion gallons of ethanol are produced, wheat producers receive $183.2 million more and soybean producers receive $1.79 billion more.

Ethanol's Impact on the U.S. Corn Industry

Richard Taylor, Jeremy Mattson, Jose Andino, Won Koo*

INTRODUCTION

The industrial uses of corn have changed dramatically during the past two decades. High fructose corn syrup (HFCS) production, used as a substitute for sugar in the soft drink industry, caused a major increase in demand for corn during the 1980s, utilizing 500 million bushels of corn per year. During the late 1990s and early in the 2000s, the corn required for ethanol production increased from nothing to its current level of 1.4 billion bushels. These two non-traditional uses of corn consume almost 20% of the current U.S. corn crop. Significant growth in ethanol production is likely to continue given recent federal legislation mandating increased ethanol use. The by-products of corn used for these industrial purposes are utilized as animal feed, replacing a substantial amount of corn.

The objective of this study is to model the U.S. corn industry with emphasis on the industrial uses of corn, especially ethanol. Several scenarios will be evaluated dealing with various ethanol production levels, federal subsidies, and different energy prices in order to estimate the impact on corn prices. The effects of the new renewable fuels standard are analyzed, as well as the effects from an even greater increase in ethanol production. Trends in corn supply and use over the last several years are identified in the next section, followed by a description of the government support which has encouraged the rapid expansion in this industry. After a discussion of previous studies that have analyzed the impact of ethanol production on the corn industry, a partial equilibrium econometric model for the U.S. corn industry is developed. Alternative scenarios are then developed, and the results are presented.

CORN SUPPLY AND USE

U.S. corn production has followed a long-term upward trend, due mostly to yield increases (Figure 1). Annual U.S. corn production averaged 4.1 billion bushels in the 1960s, 6.0 billion bushels in the 1970s, 7.2 billion bushels in the 1980s, 8.6 billion bushels in the 1990s, and 10.1 billion bushels from 2000-2004. Production reached a high of 11.8 billion bushels in 2004. The area harvested has not increased significantly over time, but yields have consistently risen, doubling since the 1960s. Also, there has been a shift in the corn production regions to the west and north. The United States imports a minimal amount of corn, usually about 10-15 million bushels per year, which is well below 1% of domestic production.

The majority of U.S. corn production has been used domestically as livestock feed. Domestic feed use has increased over time, reaching 6.2 billion bushels in 2004 (Figure 2). The other uses of corn include food, seed, other industrial uses, and exports. U.S. corn exports have been

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stagnant over the last 25 years, averaging approximately 1.8 billion bushels per year. Food and industrial uses, on the other hand, have risen steadily, reaching 2.7 billion bushels in 2004. Feed use has averaged about 60% of production, though it declined to 52% in 2004. The percentage of production exported had averaged 27% in the 1980s, but has since declined to approximately 15-20%. Food, seed, and industrial use has increased to about 25% of production.

The food and industrial uses of corn include ethanol, HFCS, glucose and dextrose, starch, cereals and other food products, and alcohol for beverage and industrial use. Seed use is a very small component of total use, averaging 21 million bushels per year. Ethanol accounted for the largest percentage of food and industrial use, followed by HFCS and then starch, glucose, and dextrose (Figure 3).

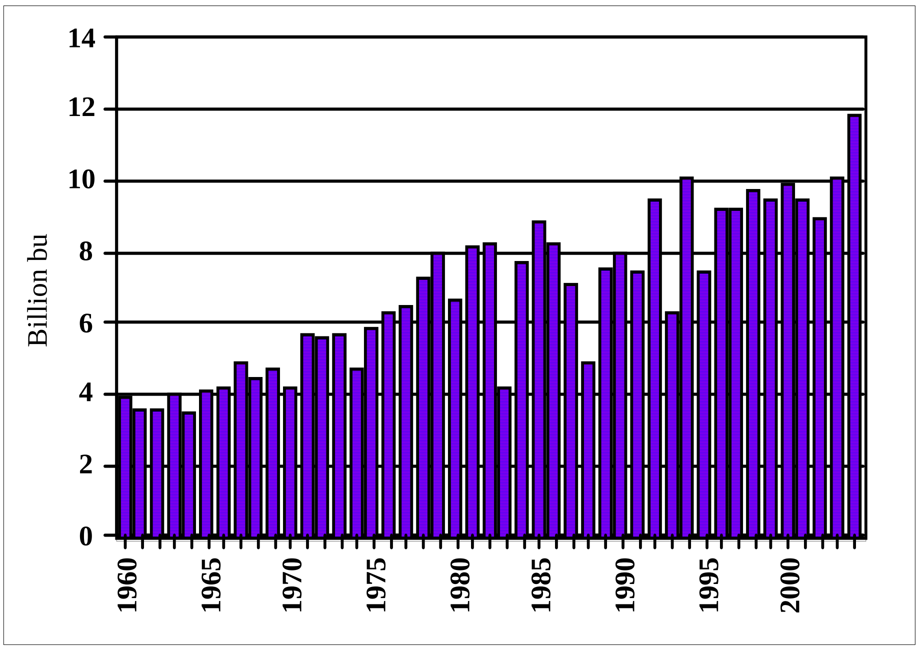

Figure 1. U.S. Corn Production

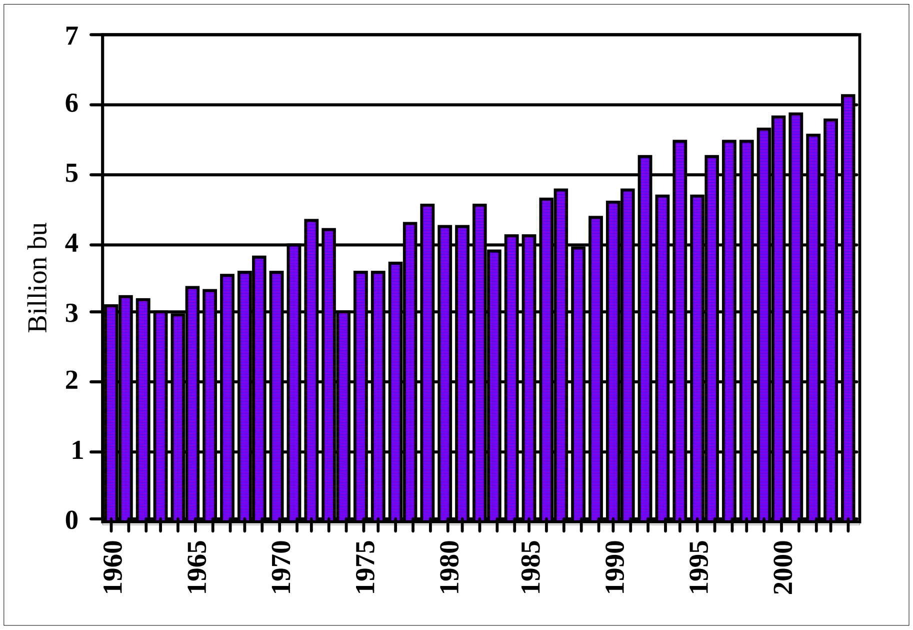

Figure 2. U.S. Consumption of Corn for Livestock Feed

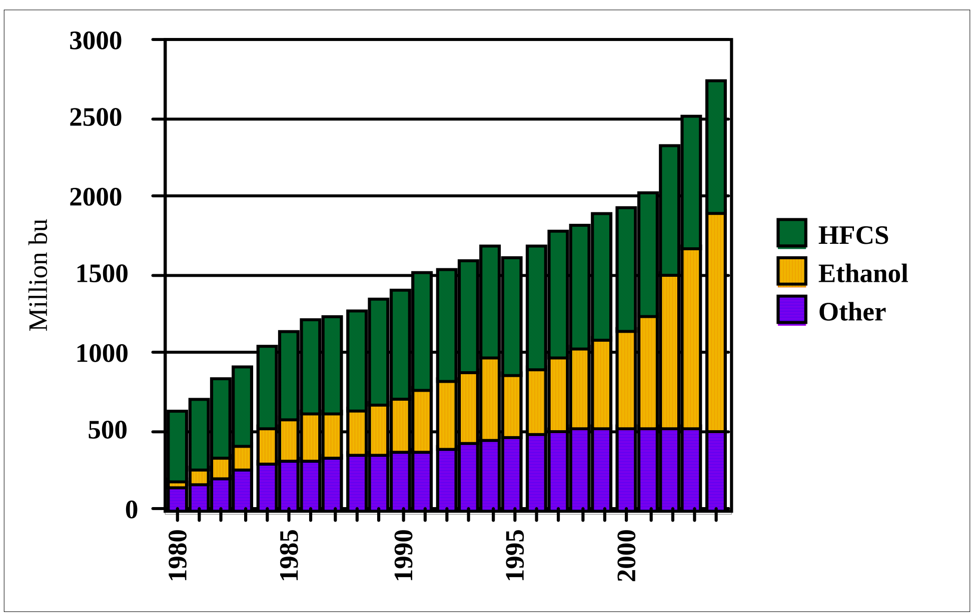

Figure 3. U.S. Industrial Uses for Corn

The recent increase in food and industrial use of corn is due largely to ethanol production. The amount of corn devoted to ethanol steadily increased from almost nothing prior to the 1980s to about 400 to 500 million bushels per year in the mid 1990s. Since then, ethanol production has increased sharply, consuming 1.4 billion bushels of corn in 2004, which was 12% of the corn crop. Figure 4 shows ethanol production in gallons since 1980. Ethanol production increased in every year but 1996. Production has doubled over the last five years, increasing from 1.6 billion gallons in 2000 to 3.4 billion gallons in 2004, and is expected to continue to rise.

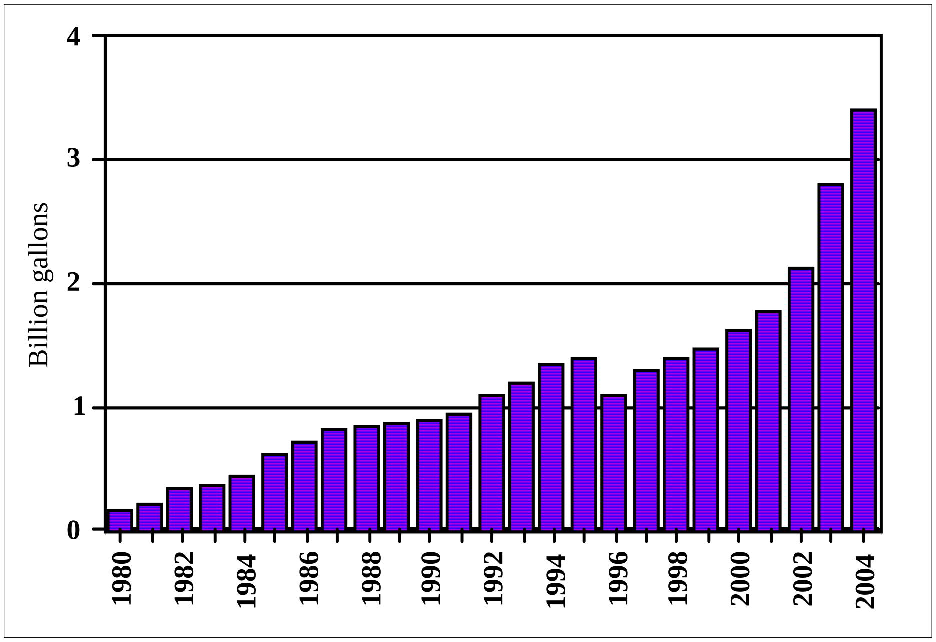

Figure 4. U.S. Ethanol Production

HFCS production increased rather significantly in the 1980s and the early-to-mid 1990s, but it peaked in the late 1990s. The amount of corn consumed by HFCS production increased steadily from 165 million bushels in 1980 to 540 million bushels in 1999. Since then, HFCS production has stabilized, and it even declined slightly in 2004. As Figure 5 shows, HFCS price dropped sharply in the mid 1990s as production increased, and then rebounded slightly when production leveled off. Other food and industrial uses of corn, such as starch, have been gradually increasing.

GOVERNMENT SUPPORT FOR ETHANOL

The rapid increase in ethanol production has been driven to a large extent by government policy. Ethanol has historically cost more per gallon than gasoline. Federal subsidies help the ethanol industry to overcome its price disadvantage, encouraging production. The ethanol industry benefits from a production tax credit of $0.51 per gallon of pure (100%) ethanol. There is a small producer income tax credit of $0.10 per gallon for the first 15 million gallons of production for ethanol producers whose total plant output does not exceed 60 million gallons of ethanol per year.

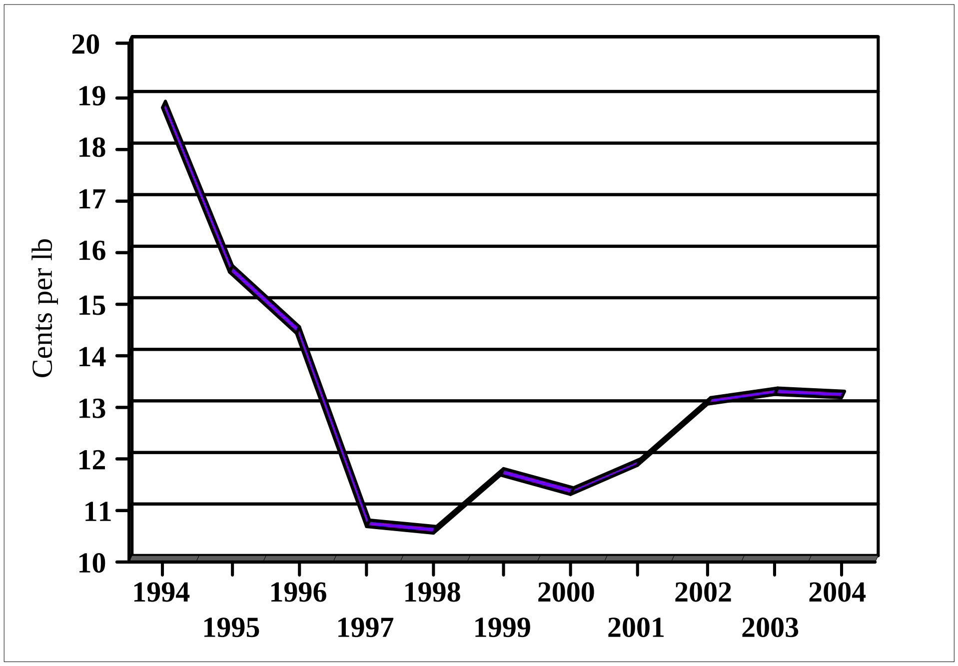

Figure 5. HFCS Price

The ethanol industry also benefits from other government policies. Certain areas of the country are required by federal policy to blend an oxygenate into gasoline to help the fuel burn cleaner and reduce air pollution. Methyl tertiary butyl ether (MTBE) has been the primary oxygenate added to gasoline. Ethanol, which is also an oxygenate, has been the second-most used. A growing list of states has banned the use of MTBE after it was found to pollute ground water. This has increased demand for ethanol.

A renewable fuels standard in the Energy Security Act of 2005 assures increased ethanol demand for several years in the future. This legislation requires that the combined use of ethanol and biodiesel must equal at least 4 billion gallons in 2006, and this requirement will increase each year to 7.5 billion gallons in 2012.

Several states also have policies promoting ethanol use, besides their MTBE bans. Minnesota, for example, requires all gasoline in the state to consist of 10% ethanol. Recent legislation requires this to increase to 20% by 2013. In 2005, North Dakota temporarily reduced the state tax on ethanol-blended gasoline fuel containing 85% ethanol (E85), from $0.21 to $0.01 per gallon.

Federal and state governments have supported ethanol production for economic, environmental, and national security reasons. One reason for the support is that it is believed that ethanol production helps farmers by increasing demand for corn and, therefore, raising its price. Ethanol production adds value to corn and could be beneficial to rural economies by creating jobs. Ethanol production is also supported for environmental reasons because it is cleaner than gasoline and for national security reasons because it could help lessen U.S. dependence on foreign oil, although corn-based ethanol could replace only a small percentage of U.S. gasoline consumption. The objective of this study is to analyze the economic impact from increased ethanol production, specifically the effects on corn price, feed use, and exports.

PREVIOUS RESEARCH ON THE PRICE EFFECTS OF ETHANOL PRODUCTION

A few studies have shown that increased ethanol production has a positive impact on corn prices. U.S. Department of Agriculture (USDA) Chief Economist Keith Collins testified in 2000 that a phase-out of MTBE would result in an increase of 500 million bushels of corn used for ethanol per year, and USDA analysis found that this increase in corn demand would raise the average price of corn $0.14 per bushel.

Otto and Gallagher (2001) analyzed the impact in Iowa from a West Coast MTBE ban and a nation-wide MTBE ban. With the West Coast ban, they found annual ethanol production increases in Iowa by 193 million gallons, using 77.2 million bushels of corn. The statewide corn price increases $0.043 per bushel, resulting in a $74.8 million income gain to corn farmers. They found that this price benefit is expected to be concentrated in the 50-mile radius surrounding a new ethanol facility. Their analysis indicated that producers near the facility could expect a $0.20 per bushel premium that diminishes as distance and transportation costs to the facility increase. With an extended MTBE ban, Otto and Gallagher estimated that ethanol production in Iowa increases 505.9 million gallons, using 202.4 million bushels of corn. As a result, they found the statewide corn price increases $0.109 per bushel, resulting in a $189.7 million income gain to corn farmers.

In a 2004 study, Ferris and Joshi estimated the impact that a MTBE ban, a proposed renewable fuels standard, potential rising petroleum prices, and the proposed revision of the eight-hour ozone air quality standards could have on ethanol production and key agricultural variables. They estimated that by 2010, ethanol production would increase from 2.5 billion gallons in 2003 to a range from 3.3 to 4.7 billion gallons. The percentage of corn production used for ethanol would increase from 9% in 2003 to 14.8% in 2010 in their high demand scenario. In their scenario in which ethanol production increases to 4.7 billion gallons in 2010, they found that corn prices received by farmers would increase by 18% (in comparison to the base case) in 2007 and by 7% in 2010. They estimated that corn acreage would increase by 4%, and that higher corn prices would encourage more feeding of wheat, causing a 4% increase in wheat acreage. They also found that soybean meal usage for feed would decrease 3.6%, soybean acreage would decrease 3%, livestock production would decrease because of higher feed costs, livestock prices would increase, and soybean oil price would decrease 5% because of increased corn oil production.

Given recent expansion in the ethanol industry and the new renewable fuels standard in the 2005 energy bill, the estimate by Ferris and Joshi of 4.7 billion gallons of ethanol produced in 2010 is likely to be on the conservative side. Bothast (2005) expects ethanol demand to more than double in the next decade from the 3.4 billion gallons produced in 2004.

The Food and Agricultural Policy Research Institute (FAPRI) (2005) conducted a study following the passage of the 2005 energy bill to estimate the impact of the new renewable fuels standard. Under FAPRI's baseline scenario, they estimate that, before the new energy bill, corn use for ethanol was projected to increase from the 2004 level of 1.4 billion bushels to an average of 1.93 billion bushels for the 2010/11 to 2014/15 time period. With the addition of the renewable fuels standard in the new energy bill, the FAPRI estimate of corn use for ethanol increases an additional 632 million bushels per year, to 2.57 billion bushels. FAPRI estimates that the additional 632 million bushels of corn used for ethanol would increase the price received by farmers by 12.5 cents per bushel, or 5.41%. They found that as a result of the energy bill, corn production would increase 0.92%, and total use would increase 0.94%. Corn use for ethanol would increase 32.6%, but feed use and exports would decrease 3.3% and 11.4%, respectively, due to higher prices.

McNew and Griffith (2005) examined the impact of ethanol plants on local grain prices, using data for a number of local cash markets near newly opened ethanol plants. They found that, on average across plants, corn prices increased 12.5 cents per bushel at the plant site, and some positive impact on price was felt up to 68 miles from the plant.

MODEL

This study expands upon previous research by examining the impact of changes in ethanol production, federal subsidies, and gasoline prices on the U.S. corn industry and farm revenue. The empirical model for this study is a partial equilibrium econometric simulation model for the U.S. corn industry. The model contains behavioral equations for production, domestic consumption, import demand, and U.S. carry-over stocks. The world is divided into two sectors, the United States and a rest of the world (ROW) region. U.S. and ROW export supply is equated to ROW import demand by varying the corn price. It is assumed that U.S. and world agricultural policy remains unchanged, normal weather patterns continue, and there are no dramatic macroeconomic or political changes in the future.

The United States produces 41% of the world's corn and provides 61% of exports. A simulation model is developed for the United States and the ROW region which forecasts production, consumption, exports, and corn price over the next 10 years. Corn supply and demand equations are estimated econometrically for the United States and the ROW region. Elasticities are calculated from the supply and demand equations. The behavioral equations are equated, based on changes in the price of corn, so that U.S. and ROW excess supply equals ROW import demand.

Corn Supply

Corn supply consists of production, beginning stocks, and imports. Corn imports in the United States are very minor and beginning stocks are equal to last year carry-over stocks. Harvested area in the United States has remained relatively constant over time, while yield has increased from about 60 bushels per acre in the 1960s to over 120 bushels per acre today. Harvested area was estimated using the lag of harvested area, lag of the real corn price, the real soybean price, and the real wheat price. The lag of harvested area represents resource endowment, and the lag of corn price is used because producers develop planting intentions based on last year's prices. Real corn price is expected to have a positive impact on harvested area, and soybean and wheat prices are expected to have a negative impact on harvested area since soybeans and wheat are competing crops. The harvested area equation is specified as:

$$HA_t = f(HA_{t-1}, P^c_{t-1}, P^{sb}_t, P^w_t) \tag{1}$$

where HA_t = harvested area,
HA_{t-1} = lag harvested area,
P^c_{t-1} = lag corn price,
P^{sb}_t = soybean price,
P^w_t = wheat price.

The yield equation includes the lag of real corn price and a trend variable to account for changes in technology. The lagged price of corn is used because producers make production decisions, such as the amount of fertilizer and chemicals used, in late winter or early spring before fall prices are shown in the futures markets. The yield equation is specified as:

$$Y_t = f(P^c_{t-1}, T_t) \tag{2}$$

where Y_t = yield,
P^c_{t-1}= lag corn price,
T_t = trend.

Total U.S. corn production is harvested area times yield, as follows:

$$Pd_t = HA_t, *Y_t \tag{3}$$

where Pd_t = U.S. production.

Corn Demand

Domestic demand for corn is comprised of domestic consumption and carry-over. Domestic consumption consists of feed demand, demand for ethanol production, and other industrial uses.

Feed Use: Feed use is specified as a function of the price of corn, number of cattle on feed, and ethanol production in a double-log functional form as:

$$\ln Fd_t = f(\ln P^c_t, \ln N^c_t, \ln EP_t) \tag{4}$$

where $\ln Fd_t$ = natural log gross feed demand,
$\ln P^c_t$ = natural log real corn price,
$\ln N^c_t$ = natural log cattle numbers on feed,
$\ln EP_t$ = natural log ethanol production.

It is expected that feed use has a negative relationship with corn price. The number of cattle on feed will have a positive impact on feed use. One ton of corn will produce 96 gallons of ethanol and 607 pounds of by-product (FAPRI). The feed value of by-product (BP) from ethanol is

$$BP_t = a(b*E_t) \tag{5}$$

where E_t = corn used for ethanol,
a = conversion rate from by-product to animal feed,
b = conversion rate from corn to by-product.

Thus, the net demand for corn for animal feed is

$$NFD_t = Fd_t - BP_t. \tag{6}$$

We assumed that a=70%, b=30%, and the by-products are being fed to cattle.

Corn Used for Ethanol Production: It is expected that high corn prices will have a negative impact on ethanol production, while high gasoline prices are expected to have a positive impact on ethanol production. A dummy variable is used to indicate the year in which California mandated the removal of MTBE from gasoline within the state, which created an immediate increase in demand for ethanol. Demand for corn for ethanol use is specified as:

$$E_t = f(P^c_t, P^g_t, D_t, E_{t-1}) \tag{7}$$

where E_t = corn used for ethanol production,
P^c_t = real corn price,
E_{t-1} = lag corn used for ethanol production,
P^g_t = gasoline price,
D_t = dummy variable, if year > 1999 D=1, otherwise D=0.

The lagged dependent variable is used as an independent variable to capture dynamics in the use of corn for ethanol production.

Corn Used for Other Industrial Purposes: It is expected that a high corn price will have a negative impact on the industrial use of corn for other purposes such as HFCS, starch, glucose, and dextrose, and that a high soybean price will have a positive impact on the industrial use of corn. The demand model for other industrial use is specified in a double-log functional form as:

$$\ln I_t = f(\ln P^c_t, \ln P^{sb}_t) \tag{8}$$

where $\ln I_t$ = natural log other industrial uses,
$\ln P^c_t$ = natural log real corn price,
$\ln P^{sb}_t$ = natural log real soybean price.

Carry-over Stocks: Corn price should have a positive impact on carry-over. As the price of corn increases, total production of corn increases while demand for corn decreases, resulting in increases in carry-over. The opposite will occur as the price of corn decreases. Thus, the carry-over stocks equation is specified as a function of the price of corn, as follows:

$$ES_t = f(P^c_t) \tag{9}$$

where ES_t = carry-over stocks.

ROW Import Demand and Export Supply: ROW import demand is the summation of the import demand from Canada, Taiwan, Mexico, Japan, South Korea, Algeria, Egypt, and Latin America countries. Corn price is expected to have a negative impact on import demand, while soybean price is expected to have a positive impact. The import demand model for the ROW is specified in a double-log functional form as:

$$\ln ED^w_t = f(\ln P^c_t, \ln P^{sb}_t) \tag{10}$$

where $\ln ED^w_t$ = natural log ROW import demand,
$\ln P^c_t$ = natural log corn price,
$\ln P^{sb}_t$ = natural log soybean price.

ROW export supply has increased from about 700 million bushels in 1998 to 1 billion bushels in 2004. ROW export supply is a function of export price and a trend variable to capture changes in technology. The ROW excess supply equation is specified as:

$$XS^w_t = f(XP_t, T_t) \tag{11}$$

where XS^w_t = ROW excess supply,
XP_t = real export corn price,
T_t= trend variable.

It is expected that both the export corn price and trend variable will have a positive impact on excess supply.

Equilibrium Condition

The equilibrium condition exists when total export supply equals total import demand. Total U.S. export supply equals beginning stocks plus production minus domestic feed use, ethanol use, other industrial use, and carry-over stocks, as follows:

$$XS^{us}_{t} = ES_{t-1} + Pd_{t} - NFd_{t} - E_{t} - I_{t} \quad (12)$$

where XS^{us}_{t} = U.S. export supply.

The U.S. export supply of corn and ROW excess supply should be equal to total excess demand for corn from ROW under the equilibrium condition, as follows:

$$XS^{us}_{t} + XS^{w}_{t} = \sum_{1}^{n} ED^{w}_{t}. \quad (13)$$

An equilibrium price of corn is obtained under the market clearing equilibrium condition.

BASE AND ALTERNATIVE SCENARIOS

The federal renewable fuels standard requires 7.5 billion gallons of ethanol or biodiesel to be consumed per year by 2012. Domestically-produced corn-based ethanol will likely account for most of this mandate, but not all of it. FAPRI analysis assumed U.S. production of corn-based ethanol will increase to almost 7.0 billion gallons in 2012 as a result of this requirement, with the remainder of the mandate filled by biodiesel, imported ethanol, and other renewable fuels. Our study makes the same assumption. The base scenario in our analysis does not force ethanol production to the mandated 7 billion gallon level, but allows ethanol production to increase based on current conditions. Scenario 1 (7) analyzes the effects of the renewable fuels standard by forcing ethanol production to the 7 billion gallon level by 2012. Proponents of ethanol and some Midwest politicians have been pushing for an even more aggressive expansion of the ethanol industry than was mandated under the energy bill. To analyze the impact of a much greater increase in ethanol production, scenario 2 (14) increases ethanol production to 14 billion gallons by 2012. Scenarios 3 and 4 examine the effects of gasoline prices on ethanol production and the corn industry. Scenario 3 (high gasoline price) continues current levels of gasoline prices, while under scenario 4 (low gasoline price), gasoline prices return to the levels in 2003 and 2004. Scenario 5 (subsidy loss) estimates the impact on ethanol production and corn price if the federal subsidy for ethanol would end.

DATA

Historical harvest area, yield, production, feed use, import demand, domestic consumption, and carry-over data were obtained from the PS&D database from the Economic Research Service (ERS) for the years 1980 to 2004. Corn and soybean prices and ethanol corn use were obtained from ERS. Gasoline prices, historical and forecasted, were obtained from the U.S. Department of Energy, and cattle on feed numbers were obtained from NASS. All price data were converted to real terms using the GDP deflator.

RESULTS

The base scenario is estimated to develop baseline values for comparison with the other scenarios. Table 1 shows the actual (2004) and forecasted values (2005-2014) for selected variables of the model. Corn price is forecasted to increase 8% from $2.15 in 2004 to $2.32 by 2014. Production is expected to increase 2% from the 2004 level by 2014. However, production in 2004 was about 10% higher than the long-term average; therefore, the production increase from the long-term average to 2014 would be about 14%. Feed use and other industrial usage are expected to increase 2% and 3%, respectively. Ethanol usage is expected to increase 43% from the 2004 level by 2014. Nearly 1.4 billion bushels were converted into ethanol in 2004, and that should grow to about 2 billion bushels by 2014 under the base model. Exports are expected to increase 36% due to strong overseas demand for livestock feed. Carry-over stocks are expected to decrease by 224 million bushels by 2014.

Table 1. Selected Output Values for Various Variables, Base Scenario

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Corn Price	$/bu	2.15	2.12	2.21	2.21	2.24	2.26	2.3	2.33	2.31	2.32	2.32
Production	million bu	11,807	10,755	10,883	11,083	11,223	11,380	11,528	11,689	11,840	11,959	12,099
Feed use	million bu	6,150	6,158	5,872	5,925	6,084	6,305	6,343	6,314	6,293	6,328	6,303
Ethanol	million bu	1,400	1,479	1,465	1,510	1,565	1,628	1,687	1,762	1,844	1,923	2,002
Industrial	million bu	1,290	1,296	1,300	1,299	1,296	1,290	1,287	1,295	1,308	1,321	1,334
Exports	million bu	1,811	1,960	2,249	2,354	2,284	2,358	2,304	2,314	2,391	2,394	2,470
E Stocks	million bu	2,110	1,846	1,677	1,672	1,639	1,552	1,570	1,743	1,869	1,867	1,868

Table 2 displays the estimated elasticities used in the model. All of the elasticities are inelastic except for cattle numbers. It is unclear why the elasticity for cattle numbers is greater than 1.0, although cattle could be fed to higher slaughter weights when cattle numbers are expanding.

Table 2. Estimated Price Elasticities for the Corn Model

	Corn Price	Others
Harvest Area	0.05	-0.001(soybean price)
Yield	0.11	
Feed Use	-0.11	1.3 (cattle numbers)
Ethanol Use	-0.33	0.34 (gasoline price)
Other Industrial Use	-0.22	-0.07 (soybean price)
Carry-over	0.09	-0.18(domestic consumption)

Table 3 shows U.S. corn production under the various scenarios from 2004 to 2014. Production levels do not change substantially between the scenarios. The largest increase in corn production (3%) occurs when 14 billion gallons of ethanol (scenario 2) are produced, and the smallest increase (1%) occurs if ethanol would lose the federal subsidy (scenario 5). The corn production level is not sensitive to changes in gasoline price because the use of ethanol is currently mandated in many states.

Table 3. Corn Production under Various Scenarios (million bu)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Base	11,807	10,755	10,883	11,083	11,223	11,380	11,528	11,689	11,840	11,959	12,099
Scenario 1 (7)	11,807	10,755	10,883	11,111	11,238	11,435	11,571	11,783	11,915	12,025	12,194
Scenario 2 (14)	11,807	10,755	10,883	11,181	11,282	11,601	11,698	12,014	12,151	12,327	12,524
Scenario 3 (High)	11,807	10,755	10,883	11,111	11,224	11,414	11,530	11,729	11,855	11,966	12,112
Scenario 4 (Low)	11,807	10,755	10,869	11,083	11,209	11,379	11,508	11,682	11,840	11,940	12,086
Scenario 5 (Loss)	11,807	10,755	10,869	11,076	11,195	11,379	11,482	11,681	11,833	11,915	12,085

Table 4 shows the feed utilization forecasts under the various scenarios. The largest decrease in feed use (39% by 2014) is under scenario 2, which forces ethanol production to 14 billion gallons. However, the impact on the U.S. livestock industry may not be significant. The increased use of corn for ethanol will provide substantial by-products for livestock feed, replacing over 1 billion bushels of corn. Also, different feeds may be substituted because of higher corn prices. The largest increase in feed use (2%) would be if ethanol production loses the federal subsidy (Scenario 5).

Table 4. Utilization of Corn for Feed under Various Scenarios (million bu)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Base	6,150	6,158	5,872	5,925	6,084	6,305	6,343	6,314	6,293	6,328	6,303
Scenario 1 (7)	6,150	6,177	5,837	5,837	5,930	6,097	6,066	5,986	5,909	5,879	5,809
Scenario 2 (14)	6,150	6,195	5,651	5,445	5,304	5,264	5,003	4,709	4,404	4,156	3,858
Scenario 3 (High)	6,150	6,158	5,867	5,911	6,051	6,275	6,296	6,272	6,251	6,283	6,258
Scenario 4 (Low)	6,150	6,161	5,927	5,992	6,152	6,380	6,406	6,375	6,358	6,392	6,374
Scenario 5 (Loss)	6,150	6,291	6,013	6,069	6,219	6,449	6,473	6,442	6,428	6,451	6,439

Table 5 shows the corn used for ethanol production under the various scenarios. Except for changes in legislation, as in scenarios 2 and 5, projected ethanol corn usage does not change substantially. Under the base scenario, corn used for ethanol is expected to increase 34% from the 2004 level by 2014. If 14 billion gallons of ethanol are produced, corn usage for ethanol would be 3.6 million bu larger (163%). The smallest increase in corn usage would be if ethanol lost the federal subsidy (8%).

Table 5. Utilization of Corn for Ethanol Production under Various Scenarios (million bu)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Base	1,400	1,479	1,465	1,510	1,565	1,628	1,687	1,762	1,844	1,923	2,002
Scenario 1 (7)	1,400	1,452	1,501	1,629	1,755	1,901	2,029	2,188	2,354	2,506	2,677
Scenario 2 (14)	1,400	1,427	1,731	2,165	2,566	3,024	3,432	3,893	4,348	4,797	5,260
Scenario 3 (High)	1,400	1,479	1,458	1,530	1,593	1,671	1,731	1,814	1,901	1,980	2,062
Scenario 4 (Low)	1,400	1,482	1,387	1,422	1,468	1,533	1,601	1,673	1,763	1,839	1,921
Scenario 5 (Loss)	1,400	1,297	1,267	1,319	1,372	1,450	1,505	1,582	1,679	1,755	1,849

Table 6 shows the other industrial uses for corn under the various scenarios. Under scenario 2, the usage of corn for other industrial purposes falls by 81 million bushels because of price increases. The other industrial uses include HFCS, starch, glucose, and dextrose.

Table 6. Other Industrial Utilization of Corn under Various Scenarios (million bu)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Base	1,290	1,296	1,300	1,299	1,296	1,290	1,287	1,295	1,308	1,321	1,334
Scenario 1 (7)	1,290	1,296	1,288	1,295	1,288	1,291	1,283	1,290	1,301	1,300	1,315
Scenario 2 (14)	1,290	1,296	1,276	1,288	1,260	1,270	1,247	1,253	1,252	1,248	1,253
Scenario 3 (High)	1,290	1,296	1,288	1,298	1,291	1,298	1,292	1,300	1,312	1,316	1,324
Scenario 4 (Low)	1,290	1,299	1,293	1,300	1,297	1,302	1,301	1,303	1,317	1,321	1,331
Scenario 5 (Loss)	1,290	1,299	1,294	1,303	1,297	1,307	1,301	1,304	1,322	1,321	1,338

Exports are relatively stable under all scenarios except for ethanol production totalling 14 billion gallons per year (scenario 2) (Table 7). This scenario results in a large increase in price, which reduces import demand for corn. Exports fall 13% under scenario 2.

Table 7. Exports of Corn under Various Scenarios (million bu)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Base	1,811	1,960	2,249	2,354	2,284	2,358	2,304	2,314	2,391	2,394	2,470
Scenario 1 (7)	1,811	1,968	2,256	2,354	2,276	2,355	2,302	2,322	2,352	2,346	2,393
Scenario 2 (14)	1,811	1,975	2,230	2,286	2,174	2,251	2,136	2,165	2,156	2,137	2,160
Scenario 3 (High)	1,811	1,960	2,268	2,374	2,299	2,377	2,319	2,344	2,392	2,392	2,469
Scenario 4 (Low)	1,811	1,950	2,258	2,371	2,300	2,373	2,307	2,334	2,402	2,393	2,460
Scenario 5 (Loss)	1,811	2,004	2,290	2,386	2,316	2,379	2,311	2,356	2,403	2,394	2,477

Prices increase 8% from 2004 to 2014 under the base scenario, 14% under scenario 1, and 40% under scenario 2 (Table 8). The loss of the ethanol subsidy reduces corn price by 4%, while changes in gasoline prices have little impact on corn prices. Compared to the base scenario for 2014, prices are 6% higher under scenario 1 (7), 29% higher under scenario 2 (14), and unchanged under scenario 3. The impact on price is very small for the other scenarios.

Table 8. U.S. Corn Price under Various Scenarios ($/bu)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Base	2.15	2.12	2.21	2.21	2.24	2.26	2.30	2.33	2.31	2.32	2.32
Scenario 1 (7)	2.15	2.12	2.25	2.23	2.32	2.32	2.44	2.44	2.41	2.47	2.46
Scenario 2 (14)	2.15	2.12	2.35	2.29	2.56	2.50	2.78	2.79	2.87	2.98	3.00
Scenario 3 (High)	2.15	2.12	2.25	2.21	2.29	2.26	2.36	2.35	2.32	2.34	2.33
Scenario 4 (Low)	2.15	2.10	2.21	2.19	2.24	2.23	2.29	2.33	2.28	2.30	2.27
Scenario 5 (Loss)	2.15	2.10	2.20	2.17	2.24	2.19	2.29	2.32	2.24	2.30	2.22

The mandated ethanol production level of 7 billion gallons will increase corn prices by $0.08 in 2008, $0.10 in 2012, and $0.14 in 2014. If ethanol production increased to 14 billion gallons, corn prices would increase $0.32 in 2008, $0.56 in 2012, and $0.68 in 2014. If ethanol production were to grow to that level, the federal subsidy would amount to $7.1 billion and would probably be politically unfeasible.

Table 9 shows the estimated gross revenue, percentage change from the base scenario, and the estimated government payments to U.S. corn producers under the provisions of the 2002 farm bill. Under the base scenario, the United States will produce 12.01 billion bushels of corn in 2014 with a producer price of $2.32 per bushel. Gross producer revenue from corn will be $28.07 billion. The estimated government payment to producers through the counter-cyclical program will be $339 million, for a total gross revenue of $28.41 billion. Scenario 1 will increase corn price $0.14 (6.9%) by 2014, which will increase gross producer revenue to $30 billion. Under scenario 1, no counter-cyclical government payments will be made, so the total gross revenue will be $30 billion, or $1.93 billion higher than the base. Scenario 1 will reduce the government subsidy by $339 million. Scenario 2 will increase corn production by 425 million bushels and increase price by $0.68 per bushel (33.9%). Gross revenue will increase $9.16 billion, from $28.41 billion in the base scenario to $37.57 billion. Changes in gasoline prices will have only a small impact on gross revenue, as the government subsidies will remove most of the corn price variations. Total gross revenue under scenario 3 is $40 million higher, and under scenario 4 it is $70 million lower. There is a 0.5% price increase under scenario 3 and a 2.3% price decrease under scenario 4. The loss of the federal ethanol subsidy will lower price by 4.4% and total gross revenue by $700 million but increase government spending by $1.13 billion.

Table 9. Estimated Gross Revenue, Percentage Change from Base, and Estimated Government Payments to Corn Producers

	Production	Price	Gross Revenue	Change From Base	Estimated Government Payments	Gross Revenue Plus Govt
	billion bu	$/bu	billion $	%	million $	billion $
Base	12.099	2.32	28.07		339	28.41
Scenario 1 (7)	12.194	2.46	30.00	6.9	0	30.00
Scenario 2 (14)	12.524	3.00	37.57	33.9	0	37.57
Scenario 3 (High)	12.112	2.33	28.22	0.5	226	28.45
Scenario 4 (Low)	12.086	2.27	27.44	-2.3	904	28.34
Scenario 5 (Loss)	12.085	2.22	26.83	-4.4	1,469	28.30

IMPACT ON OTHER COMMODITIES

Increased use of corn for ethanol production increases the price of corn, as discussed in the previous section, and increased corn production displaces production of other commodities, especially soybeans in the traditional corn belt and wheat in the western and northern regions. The expansion of corn production will increase the price of both soybeans and wheat. To estimate the impact on wheat and soybean prices, the price response to changes in supply was specified for wheat and soybean as follows:

$$P_t^w = a_0 + a_1 S_t^w + a_2 P_{t-1}^w \quad (14)$$

$$P_t^s = a_0 + a_1 S_t^s + a_2 P_{t-1}^s \quad (15)$$

where P_t^w = price of wheat,
S_t^w = supply of wheat,
P_t^s = price of soybeans,
S_t^s = supply of soybeans.

Lagged dependent variables are included to capture the dynamics in interaction of price with supply.

The equations are estimated with 15 years of time series data (1990-2004). The estimated coefficients are presented in Table 10.

Table 10. Estimated Coefficients of Supply Response Equations

	Wheat Price	Soybean Price
Constant	6.371	14.043
	(20.56)	(10.36)
Supply	-0.00006	-0.0006
	(-4.14)	(-2.49)
Lagged Price	0.493	0.409
	(3.30)	(1.89)
R^2	0.769	0.483

t-values are shown in parathesis

Both price coefficients have the correct sign and are significant, and both lagged price coefficients have the correct sign and the lagged wheat price is significant. The R^2 is 0.77 for the wheat equation and 0.48 for the soybean equation.

Since wheat and soybeans compete with corn in the plains and corn belt regions, respectively, the wheat and soybean harvested areas are positively related to their own prices and negatively related to the price of corn. Reductions in wheat and soybean areas resulting from an increase in corn price are calculated on the basis of estimated cross elasticities of wheat and soybean areas with respect to corn price. The cross price elasticities are 0.06 for wheat and 0.2 for soybeans. The elasticities are used to calculate reductions in wheat and soybeans with increased prices of corn. Equations 1 and 2 are used to calculate the effects of reductions in the supply of wheat and soybeans on their prices. The price effects are shown in Table 11.

Table 11. Price Impact and Change in Gross Returns for Wheat and Soybeans under Various Scenarios

	Wheat Price	Change in Gross Returns	Soybean Price	Change in Gross Returns
	$/bu	Million $	$/bu	Million $
Base	3.99		5.74	
Scenario 1 (7)	4.00	26.1	5.80	179.7
Scenario 2 (14)	4.06	183.2	6.08	1,023.0
Scenario 3 (High)	3.99	0	5.74	0
Scenario 4 (Low)	3.98	26.1	5.71	89.0
Scenario 5 (Loss)	3.97	52.2	5.69	149.8

Table 11 shows the price response and changes in gross returns for wheat and soybeans under the various scenarios. Changes in the supply and demand for corn will change the supply and demand for wheat and soybeans. Those changes in supply and demand will impact the prices of wheat and soybeans. Scenario 1 (7) will increase the price of wheat $0.01 per bushel and soybeans $0.06 per bushel. Scenario 2 (14) will increase wheat price $0.07 per bushel and soybean price $0.34 per bushel. While the main impact will be in the corn sector, other sectors in agriculture will also be affected. Gross returns for wheat producers will increase by $26.1 million under scenario 1 (7) and $183.2 million under scenario 2 (14). Gross returns for soybeans will increase $179.7 million and $1,023.0 million under scenarios 1 (7) and 2 (14). Scenarios 4 (Low) and 5 (Loss) will reduce gross returns for wheat and soybeans because of a slight price decrease due to increased supply of wheat and soybeans.

SUMMARY

The two largest growth sectors for corn usage have been HFCS and ethanol production. Currently, these sectors use about 16% of the U.S. corn production, and livestock feeding consumes about 52% of the crop. Exports have remained at about 1.8 billion bushels (15%). Corn production has increased rapidly due to increased yields, but not increased acres.

A simulation model was developed to estimate the impact of changes in ethanol production on corn production, consumption, exports, and price. A model was estimated to establish a base line for comparison. Ethanol production under the base scenario in 2014 is 5 billion gallons. With the mandated increase in ethanol production to 7 billion gallons by 2012, production will increase 95 million bushels, feed use will decrease 494 million bushels, exports will decrease 77 million bushels, and price will increase by $0.14 per bushel compared to the base scenario in 2014. If ethanol production increases to 14 billion gallons per year by 2012, the impact on the corn industry would be significant, with a price increase of $0.68/bu in 2014. The scenario in which ethanol loses its federal subsidy reduces production by 15 million bushels, increases feed usage by 136 million bushels, increases exports by 7 million bushels, and reduces price by $0.10. Ethanol production under this scenario is 4.8 billion gallons in 2014.

The different scenarios have a significant impact on prices and the revenue received by producers. However, the 2002 farm bill dampens the price impact on gross revenue somewhat because of the counter-cyclical nature of the program. A substantial portion of the price change is offset by opposite changes in the level of government subsidy. However, while nation-wide changes in the corn price level are offset by the 2002 farm bill, the local impact of ethanol production on the price of corn would not be dampened. This study does not estimate local price effects but other studies estimate that the local impact could be $0.10 to $0.14 per bushel, which would not be offset by government payments.

Ethanol production has played a major role in the corn industry in the United States, and it will continue to do so. Future ethanol production will increase corn prices worldwide. This model does not estimate changes in world corn production due to increases in U.S. corn prices. If a large supply response occurs, the price impact of increased ethanol production would be dampened. A number of areas have increased corn production recently, notably Argentina, Sub-Sahara Africa, and China, and these regions may have the ability to increase production substantially. This year, corn producers have experienced the impact of another 11 billion bushel corn crop combined with strong demand. In spite of the strong demand, prices for corn are lower than they have been for a number of years, falling 36% since 2002/03.

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