



United States  
Department  
of Agriculture

FDS-07D-01  
May 2007



A Report from the Economic Research Service

[www.ers.usda.gov](http://www.ers.usda.gov)

# Ethanol Expansion in the United States

## How Will the Agricultural Sector Adjust?

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### Abstract

A large expansion in ethanol production is underway in the United States. Cellulosic sources of feedstocks for ethanol production hold some promise for the future, but the primary feedstock in the United States currently is corn. Market adjustments to this increased demand extend well beyond the corn sector to supply and demand for other crops, such as soybeans and cotton, as well as to the livestock industries. USDA's long-term projections, augmented by farmers' planting intentions for 2007, are used to illustrate anticipated changes in the agricultural sector.

**Keywords:** Ethanol, corn, soybeans, distillers grains, livestock, cattle, hogs, poultry.

### Acknowledgments

This report draws from the February 2007 publication *USDA Agricultural Projections to 2016* and benefited from the contributions of many analysts in different agencies of USDA to that report. In particular, the author thanks the members of USDA's Feed Grains Interagency Commodity Estimates Committee, including Jerry Norton of the World Agricultural Outlook Board, USDA; Peter Riley and Philip Sronce of the Farm Service Agency, USDA; and Allen Baker of ERS, USDA. The author also thanks Jerry Norton of the World Agricultural Outlook Board, USDA and Steven Zahniser of ERS, USDA for their many helpful review comments. The overall ethanol analysis in USDA's long-term projections also benefited from the contributions of D. Demcey Johnson and Nicholas Bradley of ERS, USDA. The author also thanks Dale Simms for editorial assistance, David Nulph for preparation of the map, and Wynnic Pointer-Napper for the other graphics and layout.

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## Introduction

Ethanol production in the United States totaled almost 5 billion gallons in 2006, about 1 billion gallons more than in 2005. While this was a significant increase, further expansion in the industry is continuing, with production expected to exceed 10 billion gallons by 2009. This large and rapid expansion of U.S. ethanol production affects virtually every aspect of the field crops sector, ranging from domestic demand and exports to prices and the allocation of acreage among crops. Many aspects of the livestock sector are affected too. As a consequence of these commodity market impacts, farm income, government payments, and food prices also change. Adjustments in the agricultural sector are already underway and will continue for many years as interest grows in renewable sources of energy to lessen dependence on foreign oil.

## What's Behind the Expansion?

Both market conditions and policy incentives underlie the interest in ethanol. A rapid runup in oil prices over the past several years has combined with the Energy Policy Act of 2005 and Federal and State biofuel programs to provide impetus for the large expansion of U.S. ethanol production.

Crude oil prices, which averaged less than \$20 a barrel (refiners' acquisition cost for imports) in the 1990s, reached almost \$68 in the summer of 2006 and averaged \$59 for the year. This increase reflects strong global demand for crude oil resulting from world economic growth, including rapid manufacturing gains in China and India. World demand for oil is expected to continue to rise due to further growth in global economic activity, particularly in energy-intensive economies in Asia. Although discovery of new oil reserves, new technologies for finding and extracting oil, and continued expansion and improvement in renewable energy are likely to be partly offsetting, oil prices are expected to remain high by historical standards.

Further contributing to the interest in ethanol, the Energy Policy Act of 2005 mandated that renewable fuel use in gasoline (with credits for biodiesel) reach 7.5 billion gallons by 2012, with gains in later years in line with growth in the volume of gasoline sold or introduced into commerce. Additionally, the legislation did not provide liability protection for methyl tertiary butyl ether (MTBE), an additive in gasoline blending that has been found to contaminate drinking water, leading to sharp reductions in its use and a switch to ethanol as a fuel additive.

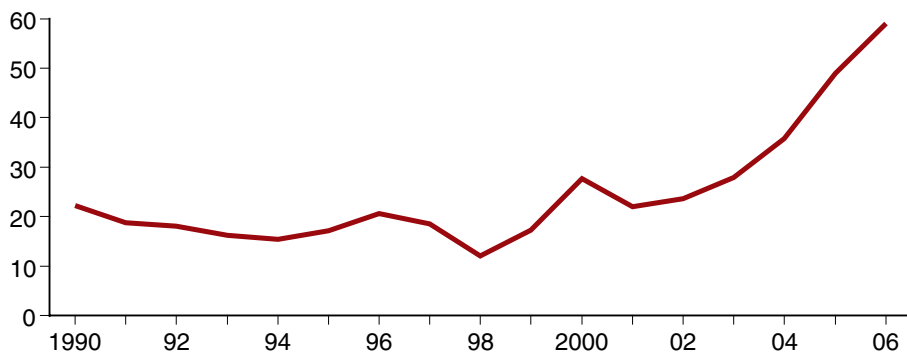
Federal tax laws also provide incentives for biofuels. Under current law, tax credits are available to blenders equal to 51 cents for each gallon of ethanol blended with gasoline. Additionally, an import tariff of 54 cents per gallon is assessed on imported ethanol, with duty-free status on up to 7 percent of the U.S. ethanol market for imports from designated Central American and Caribbean countries.

In combination, these factors have made ethanol more economical to produce. High oil prices have boosted gasoline prices and raised the value of ethanol. Elimination of using MTBE has increased demand for ethanol as a fuel additive, also raising ethanol prices. And the blender tax credit further

Figure 1

### Crude oil prices have risen dramatically in recent years

\$ per barrel<sup>1</sup>



<sup>1</sup>Refiners' acquisition cost for imports.

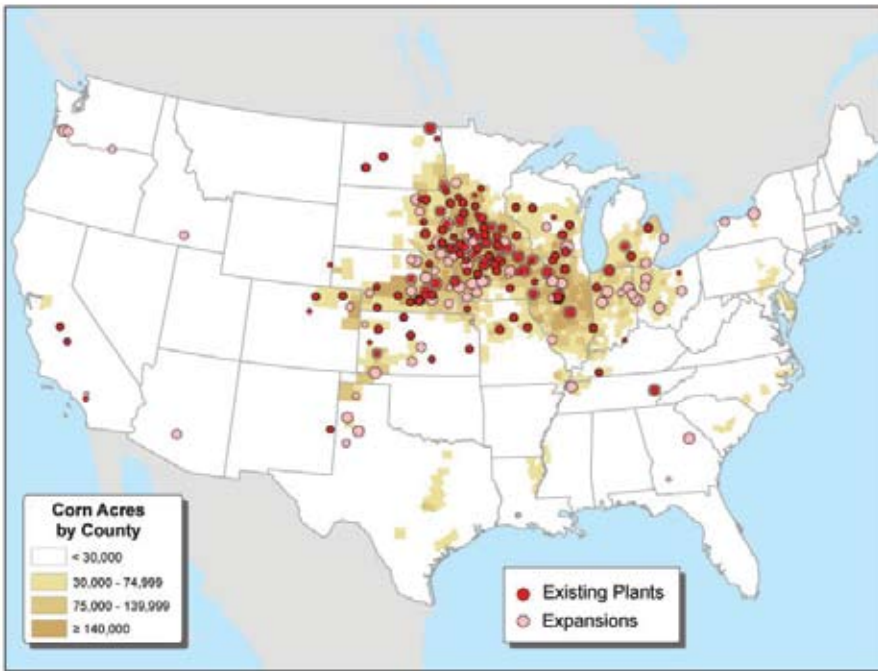
Source: U.S. Department of Energy, Energy Information Administration.

improves the bottom line for ethanol producers, as market forces result in part of this benefit being effectively passed back from blenders.

In response to these strong profit incentives, the production capacity of the U.S. ethanol industry is rising sharply as new plants have been built or are under construction. Production capacity in the industry will exceed 12 billion gallons within a few years. Further expansion in ethanol output during the next decade is expected to be more moderate. Still, even with less than full capacity utilization in the industry, ethanol production grows to more than 12 billion gallons by 2015 in USDA's 2007 long-term projections, well above the renewable fuel standard mandated by the Energy Policy Act.

Figure 2

**U.S. ethanol capacity growing rapidly**

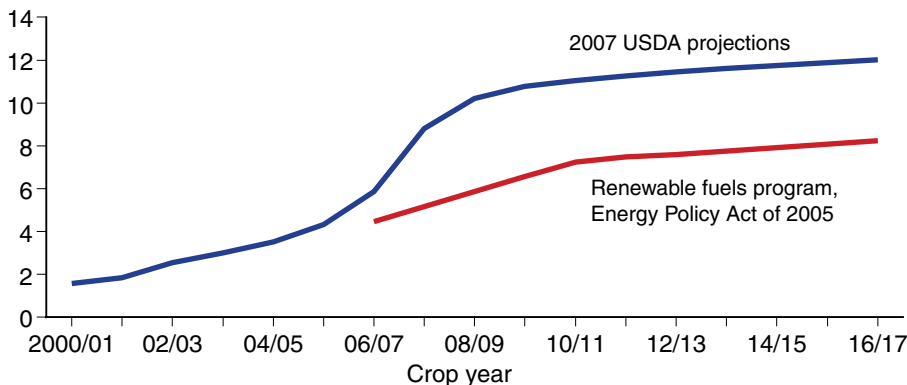


Source: Ethanol plant information, updated April 2007, based on Renewable Fuels Association data.

Figure 3

**Corn-based ethanol production projected to exceed renewable fuels mandate**

Billion gallons



Source: USDA Agricultural Projections to 2016, February 2007.

## Ethanol's Effect on Agriculture Larger Than Its Role in the Gasoline Market

Most ethanol production in the United States uses corn as the feedstock. Although cellulosic-based production of renewable fuels holds some promise in the long term, much research is needed to make it commercially viable and expand beyond the 250-million-gallon minimum mandated for 2013 in the Energy Policy Act.

Ethanol's share in the overall gasoline market is relatively small, but its importance to the corn market is comparatively large. In 2006, ethanol (by volume) represented about 3.5 percent of motor vehicle gasoline supplies in the United States. However, about 14 percent of corn use went to ethanol production in the 2005/06 crop year. While carryover stocks of corn represented about 17.5 percent of use at the end of 2005/06, expanded use of corn to produce ethanol in the 2006/07 crop year will leave the ending stocks-to-use ratio at 7.5 percent (USDA, April 2007).

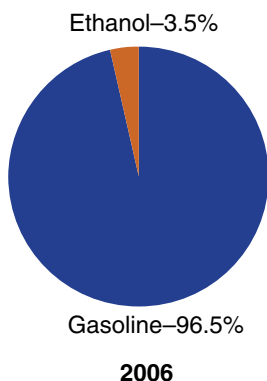
With continued strong ethanol expansion, USDA's 2007 long-term projections indicate that more than 30 percent of the corn crop will be used to produce ethanol by 2009/10, remaining near that share in subsequent years. Corn carryover stocks remain tight over the next 10 years, representing 4-6 percent of annual use. Still, even by 2017, ethanol production (by volume) represents less than 8 percent of annual gasoline use in the United States.

Figure 4

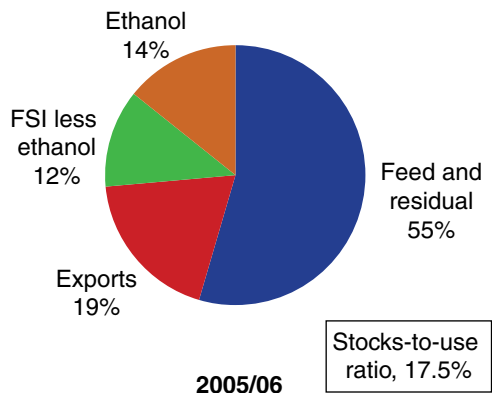
**Ethanol's role in gasoline and corn markets**

**Current relationships**

Ethanol is small relative to overall gasoline use

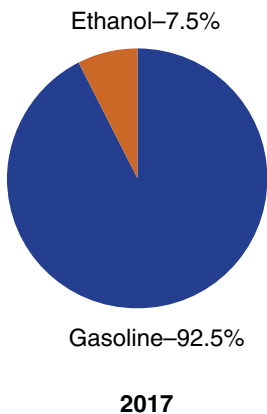


But ethanol accounts for a large and growing share of corn use

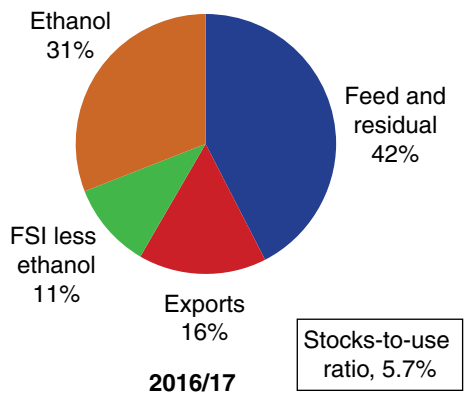


**Projected relationships in 10 years**

Ethanol still small relative to overall gasoline use



Ethanol accounts for over 30 percent of corn use



Note: FSI = food, seed, and industrial.

Source: *USDA Agricultural Projections to 2016*, February 2007.

## How Will Agricultural Markets Adjust?

Expansion of the U.S. ethanol sector has large and far-reaching effects throughout the agricultural sector. The corn market is affected directly by the increase in ethanol production. Corn used to produce ethanol rises rapidly over the next several years and is expected to reach 4 billion bushels annually by 2010/11.

Other crops are affected as movements in relative prices trigger supply and demand adjustments. Effects are also seen in the livestock sector due to higher costs of feeding animals. And all of these changes have implications for farm income and retail food prices. Most of the adjustments in agriculture occur over the next several years, during the largest expected increase in ethanol production.

### Direct Effects for Corn

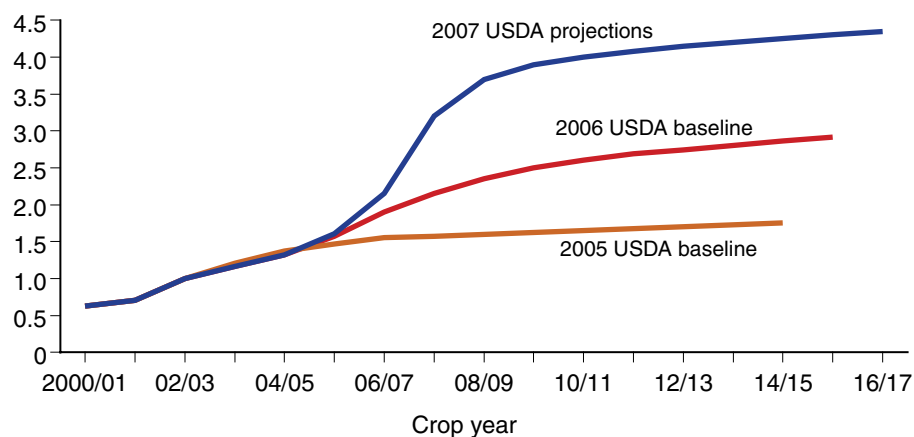
As the ethanol industry absorbs a larger share of the corn crop, higher prices for corn will intensify demand competition among domestic industries and foreign buyers of feed grains. USDA's 2007 long-term projections show average corn prices reaching \$3.75 a bushel in the 2009/10 marketing year and then declining to \$3.30 by 2016/17 as the ethanol expansion slows. Corn prices at these levels are record high and are unprecedented on a sustained basis, exceeding the previous high average over any 5-year period by more than 50 cents a bushel.

Higher corn prices affect corn's role as an animal feed. Livestock feeding is the largest use of U.S. corn, typically accounting for 50-60 percent of the total. With higher prices, corn used for animal feeding declines to 40-50 percent of total use over the next decade. A coproduct of dry-mill ethanol production, distillers grains can be used as a livestock feed, particularly for ruminant animals such as beef cattle and dairy cows. Monogastric animals,

Figure 5

#### Corn use for ethanol production shows a larger expansion in 2007 projections

Billion bushels

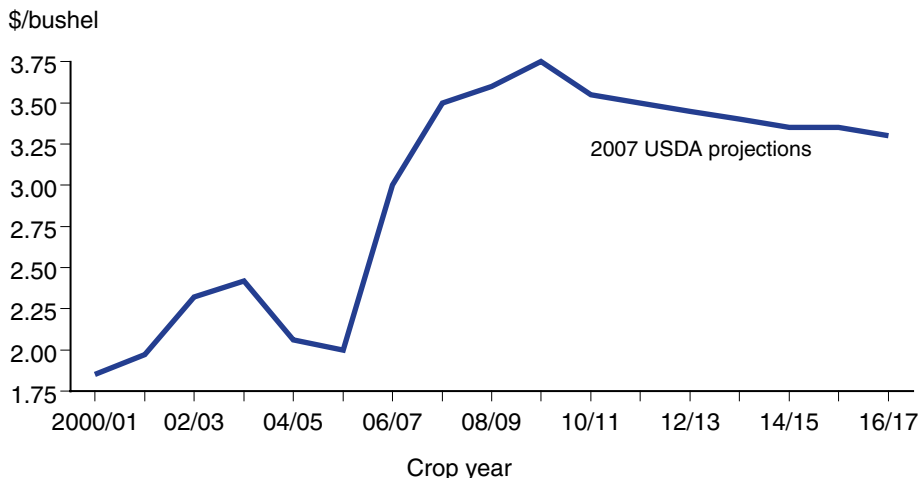


Sources: *USDA Agricultural Projections to 2016*, February 2007; *USDA Agricultural Baseline Projections to 2015*, February 2006; *USDA Agricultural Baseline Projections to 2014*, February 2005.



Figure 6

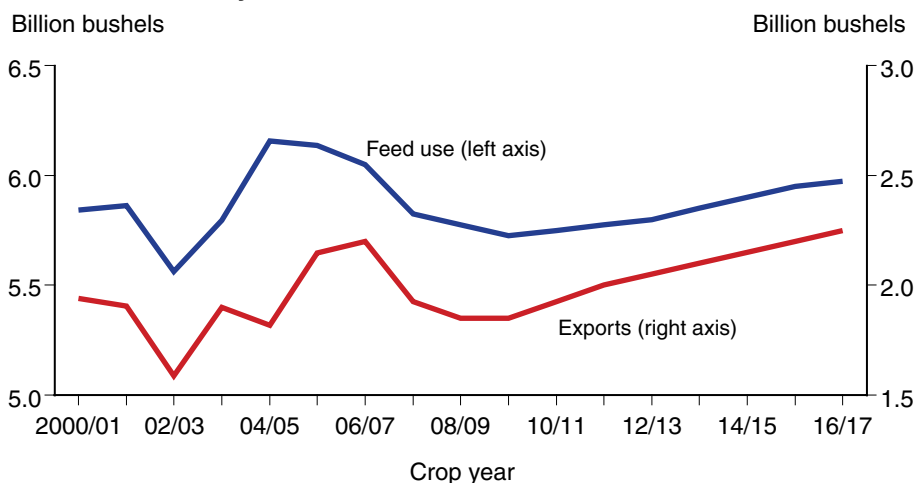
**Corn prices projected to peak in 2009/10**



Source: *USDA Agricultural Projections to 2016*, February 2007.

Figure 7

**Feed use and exports of U.S. corn decline over the next few years**



Note: Feed use includes statistical residual.

Source: *USDA Agricultural Projections to 2016*, February 2007.

such as hogs and poultry, are more limited in their ability to use distillers grains in rations (see box, “Livestock Feed Use of Distillers Grains”).

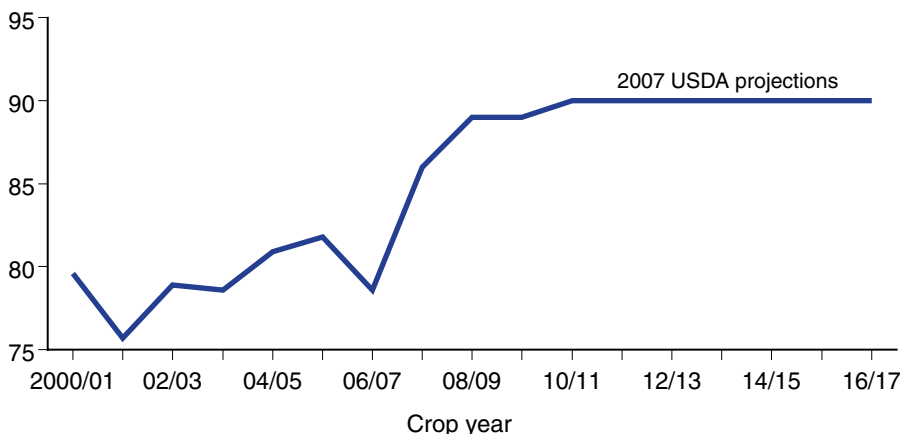
The increased use of corn for ethanol production and higher corn prices have important implications for global trade and international markets. The United States has typically accounted for 60-70 percent of world corn exports. With the ethanol expansion and higher prices, however, the U.S. share of global corn trade drops to 55-60 percent. Global adjustments to higher corn prices include reduced foreign demand and increased foreign production.

Higher corn prices and producer returns also encourage farmers to increase corn acreage. Much of this increase occurs by adjusting crop rotations between corn and soybeans. Other sources of land for increased corn plantings include cropland used as pasture, reduced fallow, acreage returning to

Figure 8

### Corn plantings increase in response to higher corn prices

Million acres



Source: *USDA Agricultural Projections to 2016*, February 2007.

production from expiring CRP contracts, and shifts from other crops such as cotton. USDA's *Prospective Plantings* report, released on March 30, 2007, showed farmers' planting intentions for corn exceeding 90 million acres this year, up over 12 million acres from 2006.

On balance, increased use of corn to produce ethanol results in higher prices, which trigger reductions in other demands and increases in supplies to bring the corn market into equilibrium. In this new equilibrium, carryover stocks of corn are reduced, as the sector attempts to balance, through price signals, current use with future market needs. Lower stocks make the sector potentially more volatile and susceptible to market shocks such as a reduction in production due to drought (see box, "Potential Market Volatility Likely To Increase").

### Indirect Effects on Other Crops

With higher corn prices, relative prices among crops initially favor corn production over production of other crops. Soybeans compete most directly with corn and on the largest amount of land. Thus, much of the expansion in corn plantings comes from soybeans, and soybean plantings and production decline. In the Corn Belt, where corn and soybeans are frequently used in rotations, planting corn one year and soybeans the next, some of the acreage shift can occur by changing rotational practices. For example, the rotation might be changed to planting corn 2 years successively, with soybeans planted every third year. NASS's *Prospective Plantings* report indicated that much of the 2007 increase in corn acreage will come from reduced soybean plantings, which are down more than 8 million acres from 2006, a larger decline than shown in USDA's long-term projections.

With reduced production, soybean prices rise. As with corn, this reduces exports and carryover stocks for soybeans.

Reduced production and higher prices for soybeans also bring higher prices for both soybean meal and soybean oil. Further contributing to higher

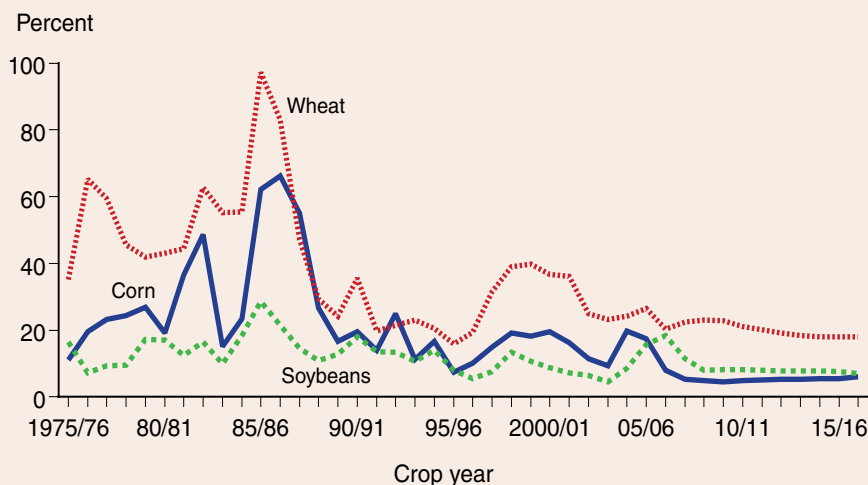
## Potential Market Volatility Likely To Increase

### Low Stocks and Inelastic Demand Make Markets More Vulnerable to Shocks

Ethanol demand is very inelastic (unresponsive to price changes) over the range of prices projected for the next decade, and is more inelastic than other major demands for corn, such as feed use and exports. Thus, overall demand in the corn sector is expected to become more inelastic as ethanol production expands. At the same time, carryover stocks of corn are expected to be maintained at relatively low levels (see figure). In combination, these factors make the corn market more vulnerable to shocks, such as production shortfalls due to weather, pests, or other factors. Stocks are also lower for crops such as soybeans and wheat, making those markets vulnerable to shocks too.

An important issue is how these commodity markets and the agricultural sector in general might respond should such a shock occur. Relatively low stocks can provide only a limited buffer to shocks. And with demand for corn becoming more inelastic, a greater change in market prices would be needed in response to a shock to adjust uses and bring the market to equilibrium. Thus, overall price variability and market volatility in the agricultural sector are likely to increase.

#### Stocks-to-use ratios: Corn, wheat, and soybeans



Sources: Historical data, USDA, Economic Research Service; projections, *USDA Agricultural Projections to 2016*, February 2007.

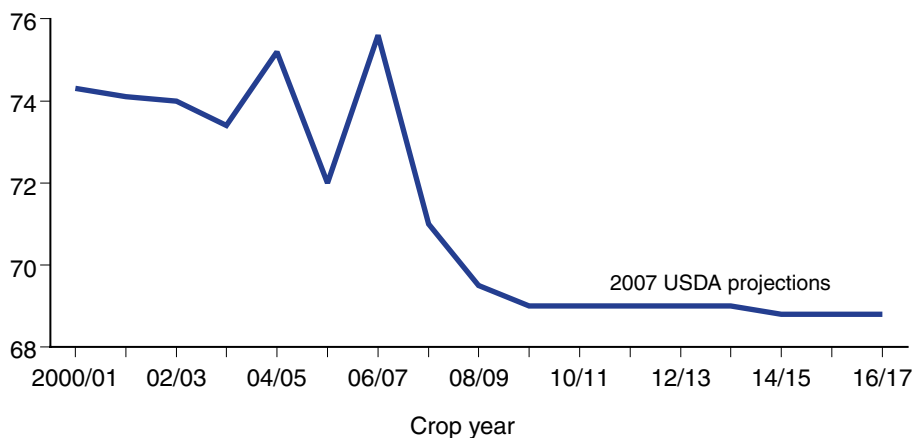
soybean oil prices is its expanded use in the production of biodiesel, which results in a larger share of the value of soybeans deriving from soybean oil.

Plantings for crops that compete with corn or soybeans for acreage in some regions of the country are also likely to decline. Planting intentions for 2007 indicated a 3-million-acre decline in upland cotton acreage, for example. Shifts for other crops, such as wheat and rice, would be smaller, so price impacts and demand adjustments would be smaller as well.

Figure 9

### Much of the expansion in corn area comes from soybeans

Million acres, soybeans

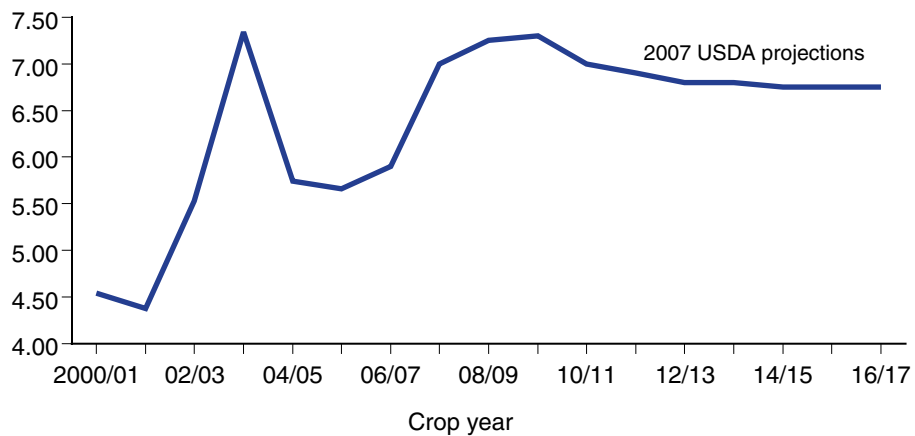


Source: *USDA Agricultural Projections to 2016*, February 2007.

Figure 10

### Soybean prices move higher, reflecting lower acreage and reduced supplies

\$/bushel

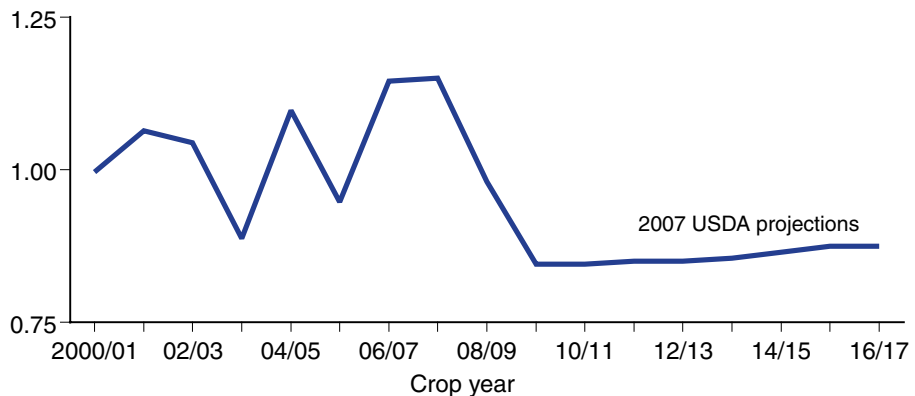


Source: *USDA Agricultural Projections to 2016*, February 2007.

Figure 11

### Soybean exports projected to decline

Billion bushels

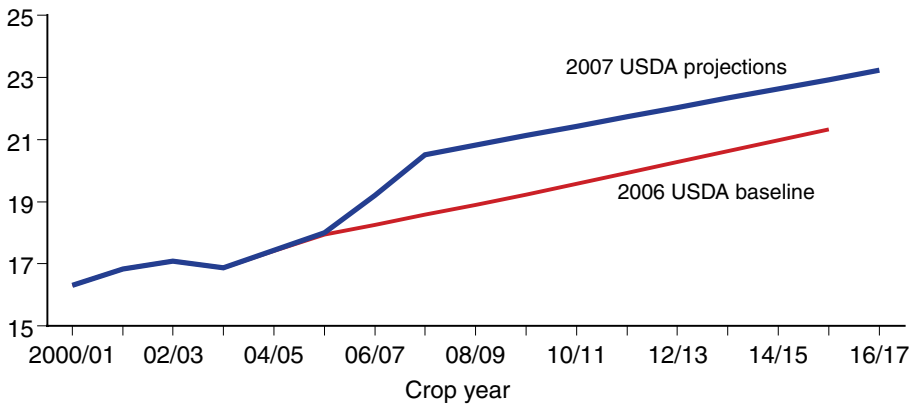


Source: *USDA Agricultural Projections to 2016*, February 2007.

Figure 12

### Biodiesel expansion raises domestic use of soybean oil

Billion pounds, soybean oil

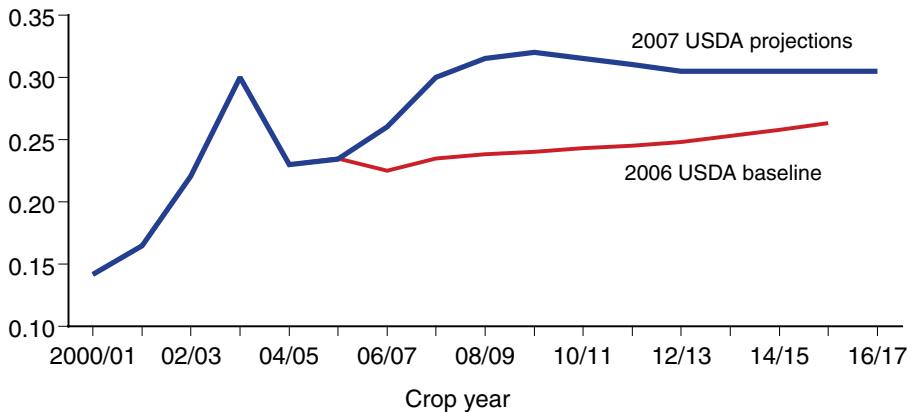


Sources: *USDA Agricultural Projections to 2016*, February 2007; *USDA Agricultural Baseline Projections to 2015*, February 2006.

Figure 13

### Higher soybean oil prices are partly due to biodiesel expansion

\$/pound



Sources: *USDA Agricultural Projections to 2016*, February 2007; *USDA Agricultural Baseline Projections to 2015*, February 2006.

## Livestock Production Reduced

Higher corn prices affect the livestock sector because of corn's importance as an animal feed. In response to higher corn prices, red meat production declines and growth in poultry output slows in the United States, particularly during the next several years as ethanol production ramps up. Higher corn prices reduce the profitability of meat production, although the greater availability of distillers grains from dry-mill ethanol production partly offsets this effect.

Effects are different across the livestock types due to differences in feed conversion efficiencies and the ability to use distillers grains in rations. Ruminants can use distillers grains more readily than monogastric animals, which favors use by beef cattle over hogs and broilers (see box, "Livestock Feed Use of Distillers Grains"). However, broilers and hogs are more

## Livestock Feed Use of Distillers Grains

With expansion of the U.S. ethanol industry and higher prices for corn, a reduced share of the corn crop is used directly for domestic livestock feeding. However, distillers grains, a coproduct of dry-mill ethanol production, can be used in livestock rations.

Ruminant animals, such as beef and dairy cattle, can use distillers grains more readily. Meanwhile, distillers grains are less suitable in rations for monogastric animals, such as hogs and poultry. Thus, the growth of ethanol production and increased supply of distillers grains result in different adjustments across U.S. livestock industries.

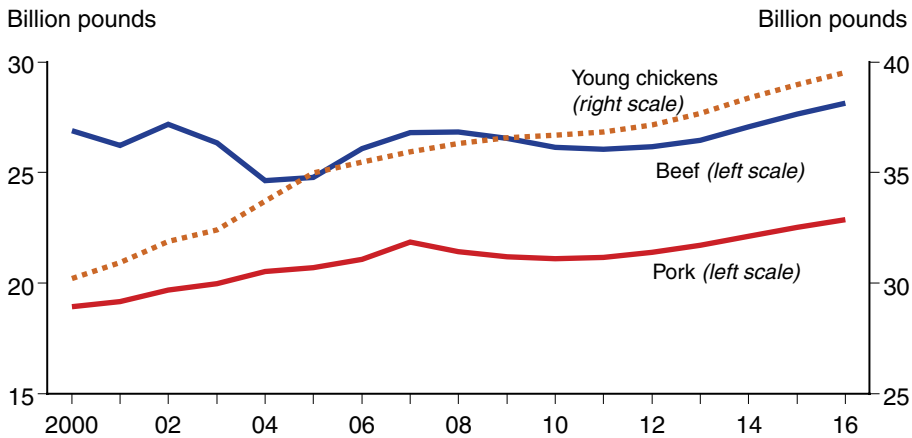
Distillers grains produced in a dry-mill ethanol plant are relatively wet, with as much as 65-70 percent moisture content. This coproduct can be used in livestock feed wet or can be dried and used in a form with lower moisture content. Using wet distillers grains avoids drying costs, but increases handling costs. Also, wet distillers grains must be used relatively quickly to avoid spoilage, limiting how far they can be transported. Dried distillers grains incur costs of drying, but can be shipped over greater distances, including for export. For each 56-pound bushel of corn used in the production of ethanol, about 17.5 pounds of dried distillers grains (or wet-product equivalent) are produced.

Whether used in a wet or dried form, distillers grains used in livestock feed replace some direct corn use, as well as soybean meal in some animal rations. Animal nutrition studies suggest optimal inclusion rates of 30-40 percent for beef cattle rations, although higher rates can be used (Vander Pol et al.). Recommended maximum inclusion rates are 20-25 percent for dairy, 20 percent for growing and finishing hogs, and 15 percent for the grower and finisher stages of poultry feeding (Anderson et al., Shurson et al., and Lumpkins, Batal, and Dale). These studies also indicate that distillers grains (on a dry matter basis) can replace corn in beef cattle rations pound for pound; dairy rations, 1 pound distillers grains for 0.45 pound corn; hog rations, 1 pound distillers grains for 0.85 pound corn; and poultry rations, 1 pound distillers grains for 0.55 pound corn. For each animal type, other feed components are adjusted to rebalance the ration. Protein adjustments affect soybean meal feeding for hogs, poultry, and dairy cattle. Most distillers grains used for cattle feeding displace urea rather than soybean meal as the protein source.

Based on these results and other assumptions, distillers grains from each bushel of corn used to produce ethanol substitutes for about a fifth of a bushel of direct corn feeding in livestock rations. Since beef cattle are large users of distillers grains, only a small reduction is expected in soybean meal use due to the substitution of distillers grains in rations.

Figure 14

### Red meat and poultry production slowed by higher corn prices



Source: *USDA Agricultural Projections to 2016*, February 2007.

efficient feed converters than cattle. Although cattle feeding practices can adjust to higher corn prices by keeping animals on grass to heavier weights before entering feedlots, feed requirements for finishing weight gain for beef cattle are the highest among these meat animals.

With reduced production, prices for meats at both the producer and retail level rise, and per capita consumption declines. Since beef cattle can use distillers grains most readily, an important development will be how feeding performance and beef quality are affected if distillers grains are included at greater than 40 percent of beef cattle rations.

A related issue in the livestock sector has been the variability of distillers grains from different sources and from the same source at different times. This lack of consistency in nutrient content makes determining the best inclusion rate for distillers grains and the overall feed formulation for livestock rations more difficult. Over time, adjustments in the market for distillers grains are likely to address these concerns (see box, “Potential Market Adjustments to Variability of Distillers Grains”).

## Potential Market Adjustments to Variability of Distillers Grains

Variability of distillers grains makes their use in animal rations more challenging. Consistency in the nutrient makeup of feed is important to ensure the overall balance in rations. Both supply and demand adjustments can address this problem.

On the supply side, this variability has resulted in part from ethanol producers focusing more on the production of ethanol than distillers grains. Since ethanol production has been so profitable, distillers grains have been considered an economic “byproduct” by ethanol producers. Once ethanol margins narrow, however, ethanol producers will have a greater incentive to pay more attention to the value of distillers grains and thus treat it as an economic “coproduct.” These economic incentives suggest that adjustments in the ethanol production process will improve the consistency of distillers grains for use in the livestock sector.

Adjustments can also occur on the demand side. The increased quantity of distillers grains now available for feed use is a new market development. As the market develops further and variability of distillers grains is reduced, the livestock sector will become more familiar with the product and learn how to better manage it in ration formulation.



## Aggregate Sector Measures Also Affected

Commodity market changes in response to the ethanol expansion are also reflected in effects on aggregate measures for the U.S. agricultural sector, including farm income, farmland values, and retail food prices.

### Farm Income Projected To Be Higher

Overall net farm income is higher due to the expansion in ethanol. Higher commodity prices over the next several years, particularly for corn and soybeans, result in large increases in cash receipts to farmers. Rising production expenses (such as for seed and livestock feed) and lower government payments offset some of the gains in cash receipts and other sources of farm income. Nonetheless, net farm income remains strong over the next decade.

Higher prices for corn and other crops result in smaller government payments under current farm commodity programs, particularly for price-sensitive market loan benefits and counter-cyclical payments. In contrast, with higher crop prices, use of land for production is more valuable, so new rental rates for land in the Conservation Reserve Program (CRP) rise. As a result, conservation payments and fixed direct payments under the 2002 Farm Act (which do not change with market prices) account for a larger share of total direct government payments.

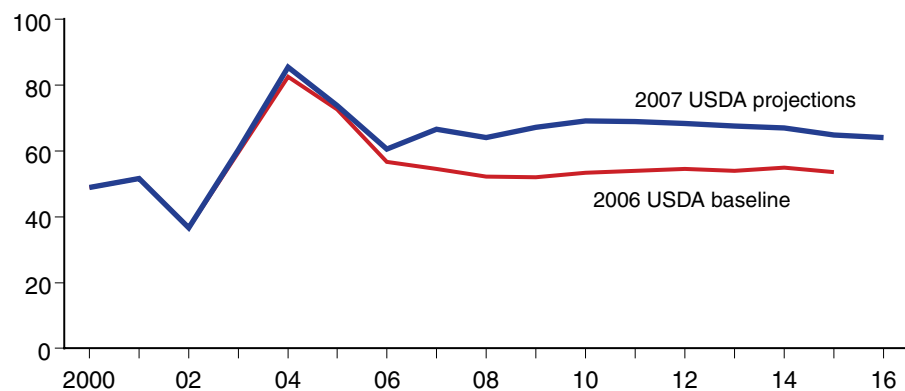
Additionally, although not part of the farm income accounts, greater production of ethanol and increased blending into the Nation's fuel supply result in reduced tax revenues to the government because of increased biofuel blender tax credits.

With lower government payments, the agriculture sector relies on the market for more of its income and the share of income provided by government payments falls. Government payments, which represented more than

Figure 15

#### Net farm income projected to be higher

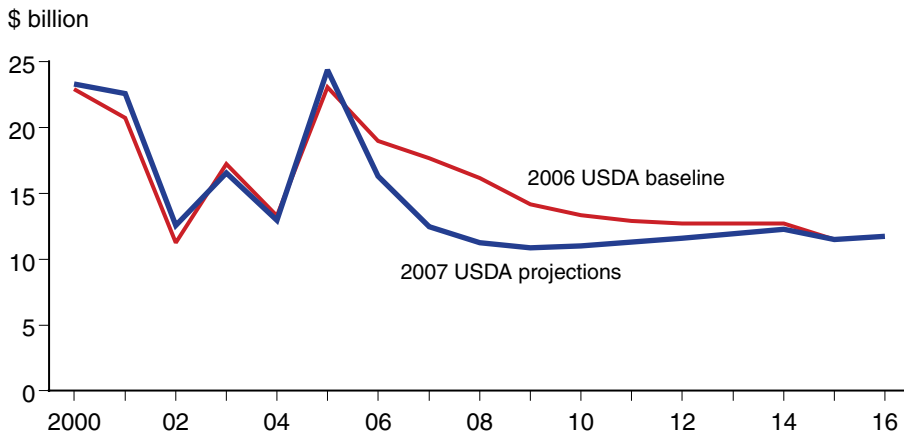
\$ billion



Sources: *USDA Agricultural Projections to 2016*, February 2007; *USDA Agricultural Baseline Projections to 2015*, February 2006.

Figure 16

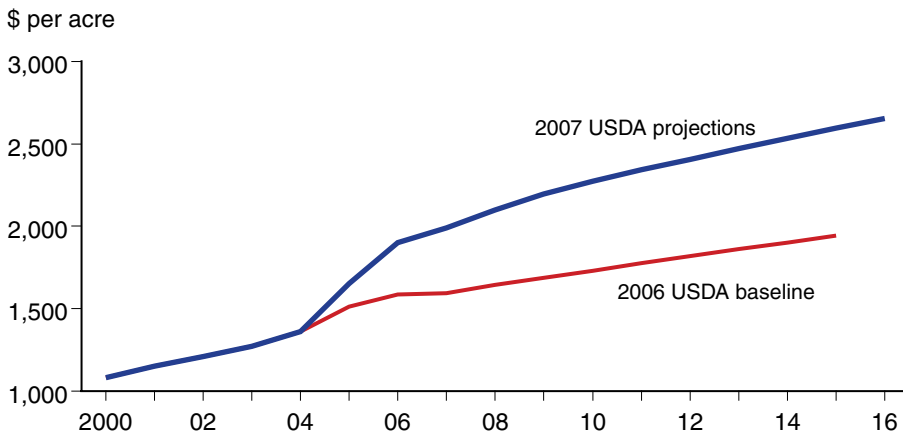
### Direct government payments decline with ethanol's expansion



Sources: *USDA Agricultural Projections to 2016*, February 2007; *USDA Agricultural Baseline Projections to 2015*, February 2006.

Figure 17

### Farmland values higher



Sources: *USDA Agricultural Projections to 2016*, February 2007; *USDA Agricultural Baseline Projections to 2015*, February 2006.

8 percent of gross cash income in 2005, account for less than 4 percent during most of the next decade.

### Farmland Values Increase

With higher crop prices, farmland prices rise to reflect the increased value of crop production. This accelerates gains in farmland prices, which also reflect demand for land for nonagricultural uses, such as housing and recreation.

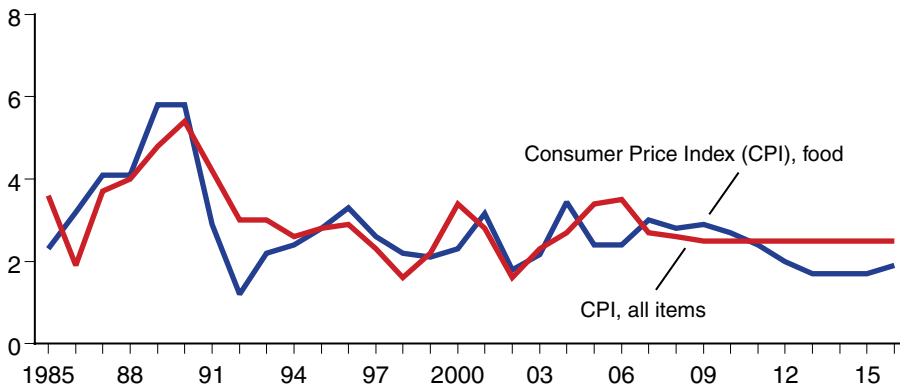
## Retail Food Prices Higher

As the livestock sector adjusts to higher feed costs resulting from the expansion in corn-based ethanol production, overall production of meats is reduced over the next few years. As a result, consumer prices for red meats, poultry, and eggs are expected to exceed the general inflation rate in 2008-10. Consequently, overall retail food prices in USDA's 2007 long-term projections rise faster than the general inflation rate for several years.

Figure 19

### Retail food prices rise faster than the general inflation rate over the next few years

Percent change



Sources: *USDA Agricultural Projections to 2016*, February 2007; 2007 reflects USDA-ERS short-term food price forecast, April 2007.

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