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2017 Outlook of the U.S. and World Corn and Soybean Industries, 2017-2026

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ABSTRACT

This report evaluates the United States and world corn and soybean markets for the 2017-2026 period using the Global Corn and Soybean Policy Simulation Model. This analysis is based on a series of assumptions about general economic conditions, agricultural policies, weather conditions, and technological change.

Corn-based ethanol production has influenced the United States corn industry. However, since 2010 U.S. ethanol production has remained near the 14 billion gallon level. Changes in Federal fuel mandates could significantly impact the world corn market. Under the current assumptions in the model, corn price is expected to slowly increase to $4.02 per bushel from $3.35 per bushel in 2016.

Chinese soybean imports are the leading factor influencing the world soybean market. China currently imports 64% of the soybeans traded in the world market, and that is expected to increase by another 21% by 2026. Major exporters will continue to be the U.S., Brazil and Argentina. However, Brazil and Argentina are expected to increase exports while U.S. exports will remain at the current level. Soybean prices are expected to slowly increase to $9.07/bushel over the time period.

Keywords: corn, soybeans, production, exports, consumption, ethanol, ending stocks

HIGHLIGHTS

World corn trade is projected to increase by 34% between 2016 and 2026. U.S. exports are expected to increase by 17% by 2026, however much of that increase is due to low exports in 2015. Both Argentina and Brazil will increase exports through 2026.

World soybean trade will increase by 24% between 2016 and 2026. China is expected to increase imports by 21% in 2026 from the 2015-2016 average. Argentina has been increasing soybean production rapidly due to restrictions on the exportation of beef and a reduction in soybean export taxes. Brazil will also continue to increase soybean exports to satisfy Chinese soybean demand.

World corn production is expected to increase by 11%, from 31 billion bushels in 2015-2016 to 35 billion bushels in 2026. The United States will increase corn production by 6% while Argentina will increase production by 3.2%. Brazil is expected to increase corn production by 23.7% because of higher corn yields.

The U.S. is projected to increase soybean production by about 6.5% by 2026. U.S. production growth is limited because of land constraints. Argentina and Brazil are expected to increase soybean production by 23.5% and 10.8%, respectively.

U.S. corn yields are expected to increase in all states/regions except Minnesota because of record 2015 yields in that state. Harvested acres in the U.S. are expected to decrease slightly from 86.7 million acres in 2016 to 85.6 million acres in 2026. U.S. soybeans yields are expected to increase in most states/regions in the country. The multi-state West region has the largest corn harvested acres in the United States, followed by Iowa and Illinois.

Total U.S. corn production in 2016 was 15.2 billion bushels and is expected to increase by 6.2% to 15.3 billion bushels by 2026. The fastest growth is expected to be in Indiana (9%), followed by Iowa (7%), and the Nebraska (4%).

U.S. exports of corn are expected to increase from 1.9 billion bushels in 2016 to 2.0 billion bushels in 2026. The feed use of corn is projected to increase by 7.9% from 5.1 billion bushels in 2016 to about 5.5 billion bushels in 2026. Ethanol use of corn is expected to decrease by 3% from 5.3 billion bushels in 2016 to 5.1 billion bushels in 2026. Other industrial uses are projected to increase by 2% between 2016 and 2026. Total U.S. utilization of corn is expected to increase less than 1% during the forecast period.

U.S. exports of soybeans are expected to increase during the forecast period from 1.8 billion bushels in 2016 to 2.1 billion bushels in 2026. U.S. domestic processing is projected to increase by 15% from 1.9 billion bushels in 2016 to about 2.2 billion bushels in 2026. Feed and other uses are expected to increase by about 15%. Total domestic consumption is expected to increase by about 15% during the forecast period.

Corn price is expected to increase to $3.44 per bushel in 2017 and then increase to $4.02 by 2026. Soybean price is expected to be $9.02 per bushel in 2017 and then increase to $9.07 by 2026.

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INTRODUCTION

World corn and soybean production is concentrated in a few countries unlike other agricultural crops. The U.S. produces 37% of the world's corn and 34% of the world's soybeans. In contrast, the U.S. produces only 9% of the world's wheat. China is the next largest corn producer followed by Brazil and the European Union. Over the past five years, these four areas produce over 60% of the world's corn. Brazil produces 32% and Argentina produces 16% of the world soybeans compared to 34% for the United States.

Increased ethanol production under the Energy Independence and Security Act of 2007 (EISA) resulted in a significant increase in the price of corn which also impacted soybeans along with most other commodities. The increased price of corn led to major structural changes in the corn industry in the U.S. as well as other corn producing and consuming countries. Corn production in the U.S. and other countries increased in response to higher prices in 2007. In 2010 US corn production fell 4% while consumption increased 6% which resulted in a reduction of carry-over stocks by 60% from 1.7 billion bushels to 675 million bushels between 2009 and 2010. Changes in corn prices affect prices of other commodities, especially soybeans, mainly because they are close substitutes in production. Production of both corn and soybeans was much smaller in 2012 because of the drought which increased prices for both corn and soybeans to $7.31 and $14.40, respectively. However, a 14 billion bushel corn crop and a 3.3 billion bushel soybean crop in 2013 reduced prices to $5.30 for corn and $12.50 for soybean. In 2012 carry-over stocks for corn was 821 million bushels. By 2014 carry-over stocks had grown to 1.73 billion bushels, an increase of 116% since 2012. That increase lowered the price of corn from $7.31/ bushel in 2012 to $3.65/bushel in 2014. In 2015 carryover increased to 1.84 billion bushels which led to an average yearly corn price of $3.71 per bushel. In 2016 the average corn price was $3.35.

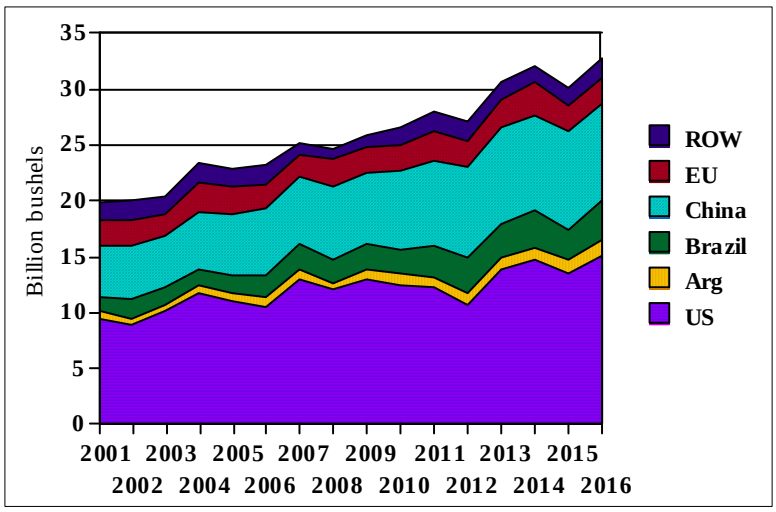
Argentina had a small soybean crop in 2008. Argentine soybean production fell by 31% in 2008 compared to 2007, but soybean production returned to normal levels in 2009. Both Brazil and Argentina had smaller soybean crops in 2010 compared to 2009, but the United States soybean crop was slightly larger. Both Argentina and Brazil along with the United States had large soybean crops in 2015 and 2016 which increased world soybean carry-over stocks.

Industrial use of corn has increased dramatically during the past two decades. The most recent increases are due mainly to increasing ethanol production, which is expected to remain level since the United States have reached the Renewable Fuel Standard (RFS) mandate. 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 to approximately 5.3 billion bushels in 2011 before falling to 4.5 billion bushels in 2012. In 2014 and 2016 5.3 billion bushels of corn were used for ethanol. These two non-traditional uses of corn account for almost 47% of the current U.S. corn crop.

World soybean production has increased due mainly to the introduction of soybeans into Argentina and Brazil in the mid-1980s. Soybean production in those two countries reached 4.2 billion bushels in 2009, compared to 3.1 billion bushels in the United States. Soybean consumption in China is the main reason for increased world soybean production. In 1995, China consumed 517 million bushels of soybeans and produced 640 million bushels. In 2016, China consumed 3.7 billion bushels and produced 459 million bushels and imported 3.2 billion bushels which was over 64% of the soybeans traded in the world market.

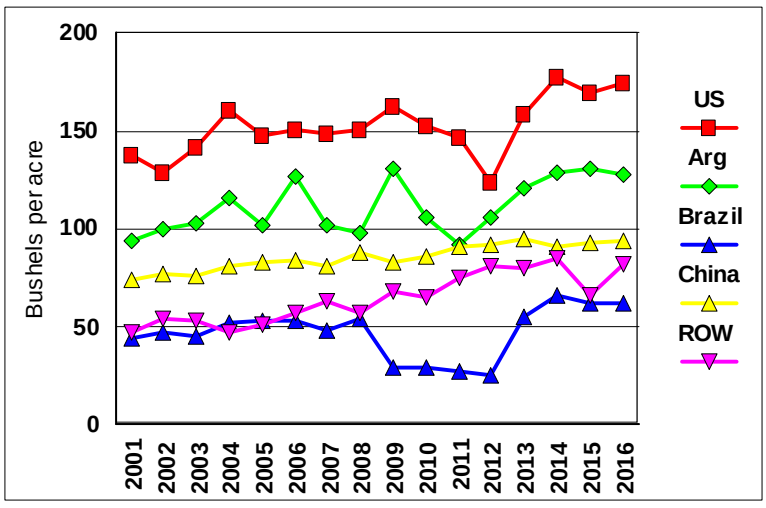
WORLD CORN INDUSTRY

Figure 1 shows the world corn production in the major corn producing countries. U.S. corn production has increased by 60% between 2001 and 2016, although harvested acres increased by only 7.8%. China's corn production increased by 92% while Brazil and the Argentina increased production by 144% and 148%, respectively, during the same time period.



Source: FAS-PS&D

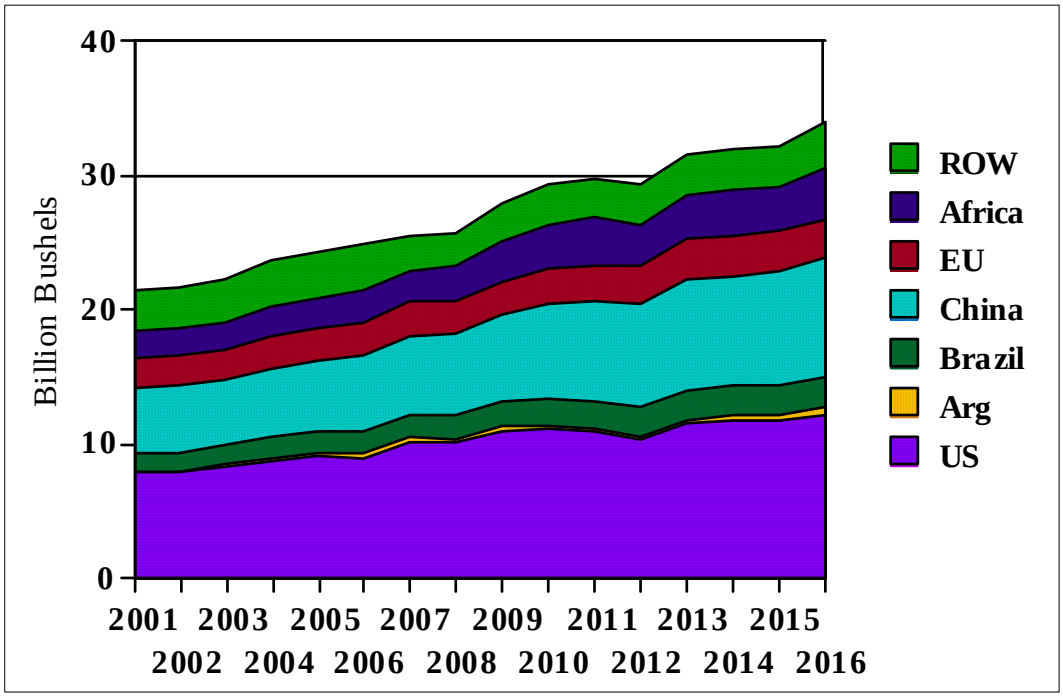
Figure 1. World Corn Production, 2001-2016



Source:FAS-PS&D

Figure 2. World Corn Yields, 2001-2016

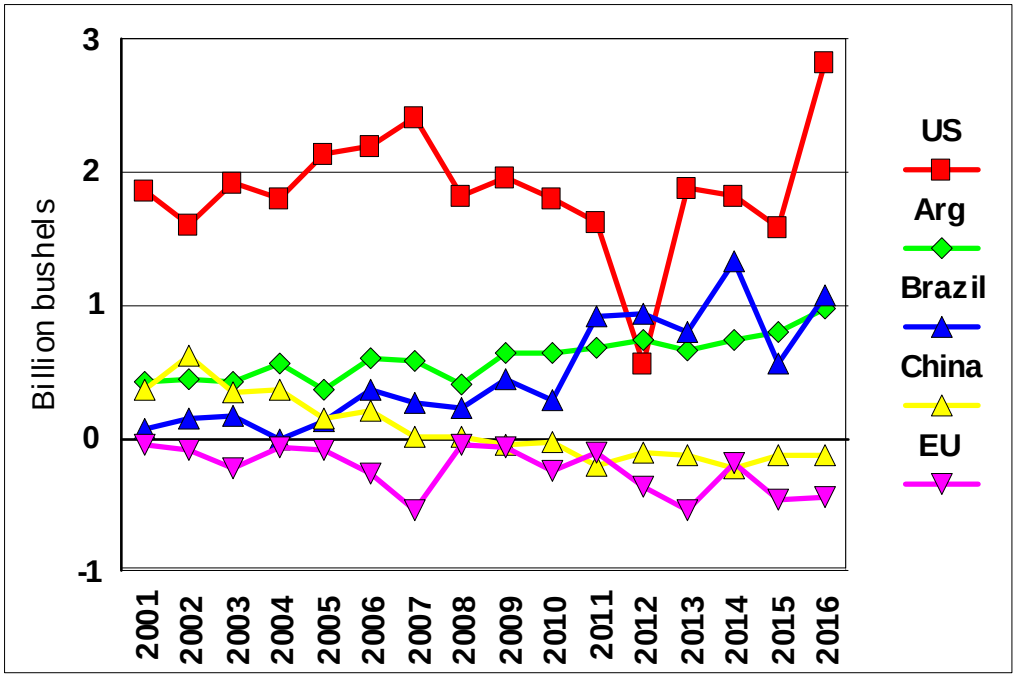
In addition to larger world corn acres, world average corn yields have increased by 30% between 2001 and 2016. Corn yields in the U.S. increased from 138 bushels per acre in 2001 to 175 bushels per acre in 2016 and corn yields also increased in other countries. Chinese corn yields increased by 27%, while corn yields in Brazil increased by 40%. Brazil's corn yield is low because corn is a secondary, low input crop rotated with soybeans.



Source:FAS-PS&D

Figure 3. World Corn Consumption, 2001-2016

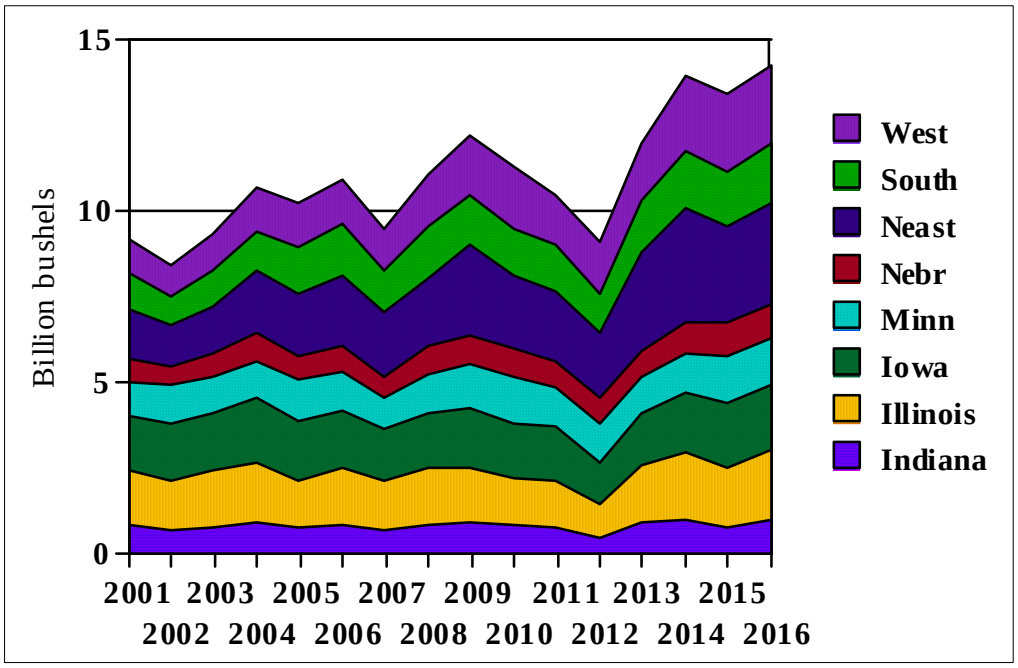
World corn consumption increased by 64% between 2001 and 2016 (Figure 3). The countries with the largest growth in corn consumption have been the EU, the United States and China. China's consumption growth is due mainly to growth in the livestock sector and in the United States growth is a result of corn based ethanol production. Corn consumption in China increased by 87% between 2001 and 2016, while that in the U.S. increased by 57% during the same time period. Corn consumption in the European Union increased by 21% while the Rest of World (ROW) region increased by 14% during the same time period.



Source:FAS-PS&D

Figure 4. World Corn Exports, 2001-2016

The United States was the main exporter of corn for the 2001-2016 period, although China, Brazil, and Argentina exported corn for the period. During the past 15 years, corn exports in the U.S. have averaged about 1.9 billion bushels except for 2012. 2012 was a drought year which limited U.S. exports to 570 million bushels.



Source:ERS-Wheat Yearbook

Figure 5. U.S. Corn Production by Region/State, 2001-2016

Corn Production in the United States

In 2016, The five largest corn producing states in the United States are Illinois (2.0 billion bushels), Iowa (1.9 billion bushels), Minnesota (1.4 billion bushels), Indiana (1.0 billion bushels), and Nebraska (0.9 billion bushels). Those five states produced 68% of the total quantity of corn production in the U.S. Iowa increased corn production by 19% between 2001 and 2016, while Illinois and Indiana increased corn production by 26% and 15%, respectively, during the same time period. Minnesota and Nebraska increased corn production by 53% and 32%, respectively. The other regions of the country also increased corn production. The North East, South and West increased corn production by 66%, 111%, and 127%, respectively.

Table 1 shows the states that are included in the three corn growing regions of the United States. Several states have no corn production and are not listed in the table. Area harvested for corn increased in most regions/states between 2001 and 2016. Corn acres increased by 46% in the West region because of profit incentive and the 1996 Farm Bill which did not require planting wheat and barley program acres. Illinois and Iowa increased corn acres by 6% and 18%, respectively, while Nebraska increased corn acres by 23%. The North East region reduced corn acres by 9% and the South region increased acres by 23%.

Table 1. Corn Producing States Divisions by Regions

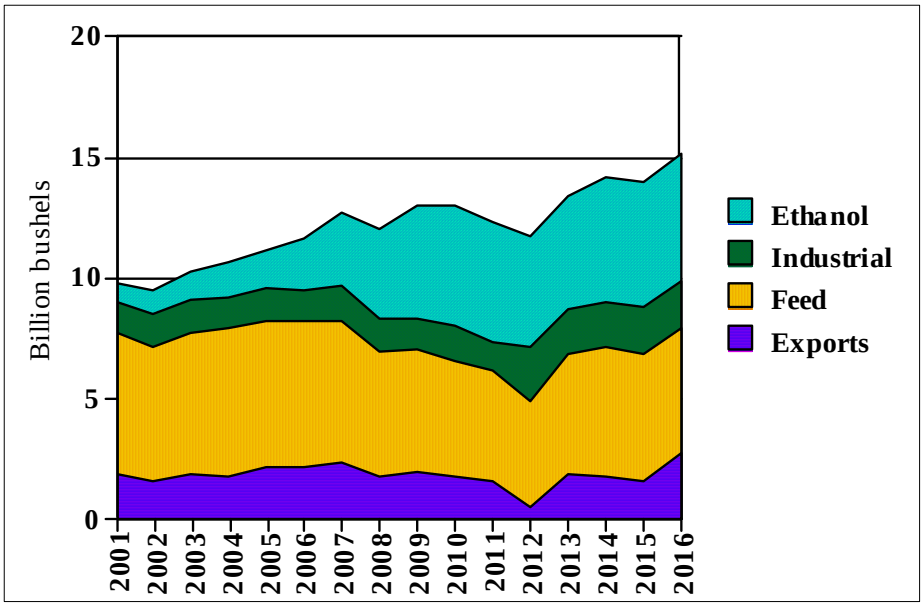
Major	North East	South	West
Iowa	Delaware	Alabama	Arizona
Illinois	Maryland	Arkansas	California
Indiana	Michigan	Florida	Colorado
Minnesota	New Jersey	Georgia	Idaho
Nebraska	New York	Kentucky	Kansas
	Ohio	Louisiana	Montana
	Pennsylvania	Missouri	North Dakota
	Virginia	Mississippi	New Mexico
	Wisconsin	North Carolina	Oklahoma
	West Virginia	South Carolina	Oregon
		Tennessee	South Dakota
			Texas
			Utah
			Washington
			Wyoming

Table 2 shows corn yields by states/regions in the United States for the years 1999 through 2002 and 2014 through 2016. Iowa the highest average corn yield for the years 1999-2002 at 151 bushels per acre, followed by Minnesota at 146 bushels per acre. For the 2014-2016 time period, Illinois had the highest average corn yield at 192 bushels per acre followed by Iowa at 190 bushels per acre. The fastest growth region for yields was in the South region, 79%, followed by the North East, 59%, and the West region, 41%.

Table 2. U.S. Corn Yields by Region/State

	1999-2002	2014-16	% Change
	----------bushels per acre----------		
Indiana	138.8	171.7	23.7
Illinois	144.5	192.3	33.1
Iowa	150.5	189.7	26.0
Minnesota	145.5	178.0	22.3
Nebraska	135.0	182.7	35.3
South	89.5	160.2	79.0
North East	101.5	161.3	58.9
West	102.9	145.0	40.9

Figure 6 shows the U.S. utilization of corn for the years 2001 through 2016. The largest increase was corn for ethanol production, an increase of 645%, from 627 million bushels in 2001 to 5.3 billion bushels for 2016. Feed use decreased by 13%, other industrial uses increased by 41% and exports increased by 52%. Total utilization increased by 56% during the time period.

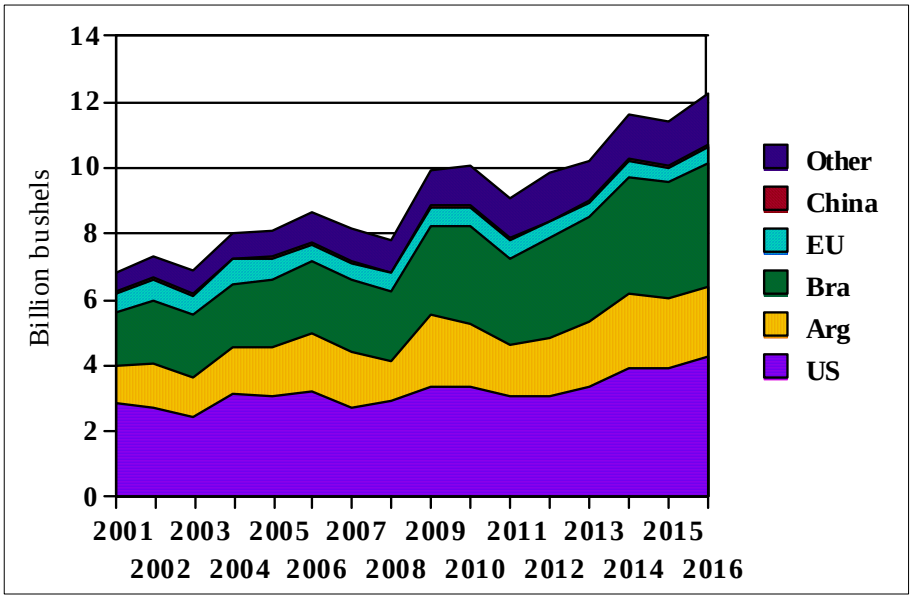


Source:FAS-PS&D

Figure 6. U.S. Corn Utilization, 2001-2016

WORLD SOYBEAN INDUSTRY

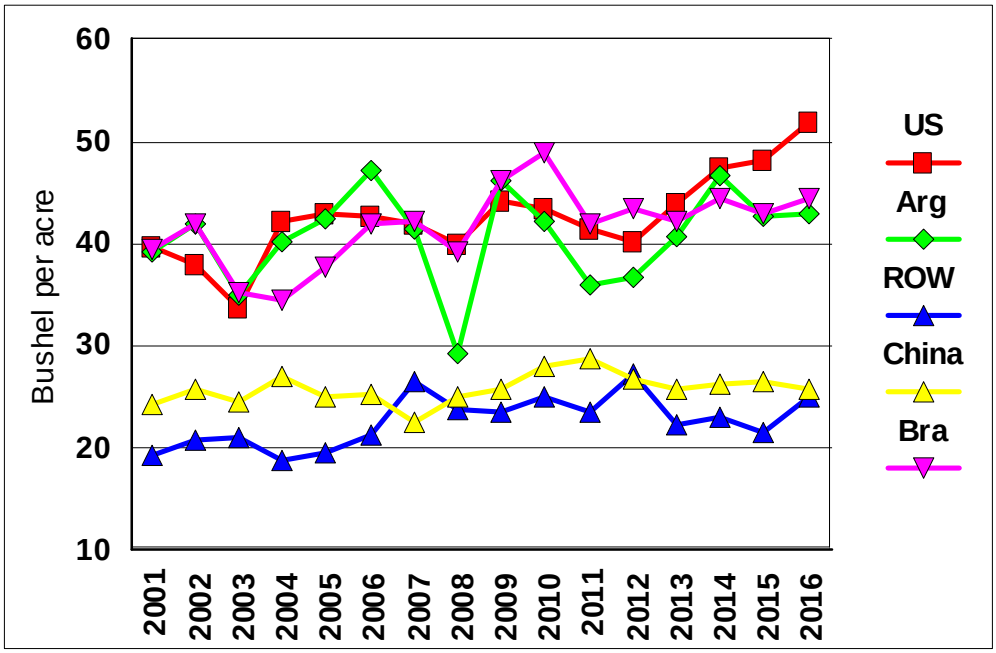
Figure 7 shows world soybean production by country/region. World soybean production has increased by 84% from 6.8 billion bushels in 2001 to 12.5 billion bushels in 2016. Brazil and Argentina increased soybean production by 148% and 85%, respectively, during the same time period. The United States increased soybean production by 49% between 2001 and 2016 while soybean production increased by 129% in the ROW region. Most of that increase took place in other South American countries.



Source:FAS-PS&D

Figure 7. World Soybean Production, 2001-2016

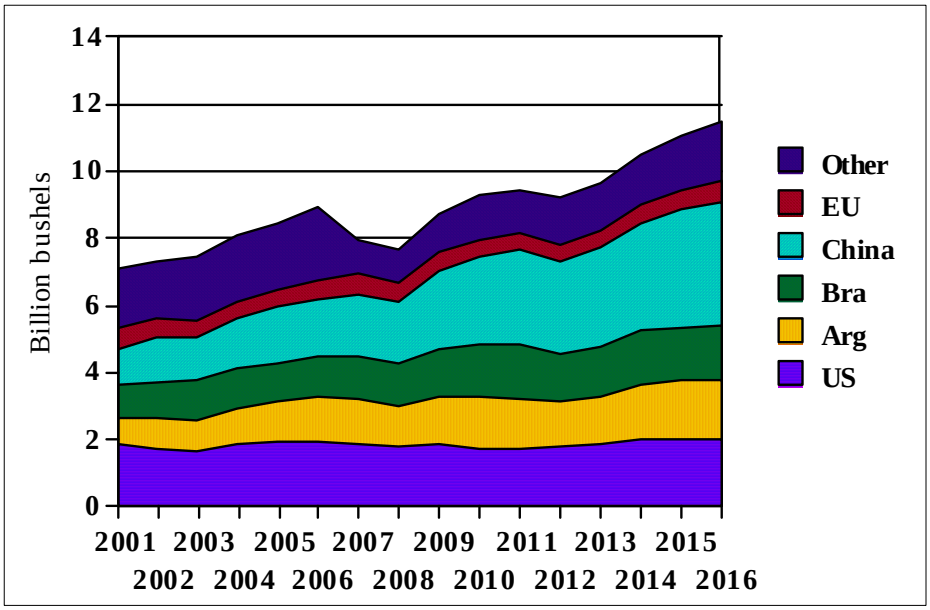
World soybean yields have increased by 23% for the last 16 years. Soybean yields in the U.S., Brazil and Argentina are very similar throughout the time period as shown in Figure 8. In 2001 they ranged between 39 bushels per acre and 40 bushels, increasing to between 43 bushels and 50 bushels per acre in 2016. Soybean yields in China have remained at about 26 bushels per acre and ROW soybean yield increased from 19 bushels per acre to 25 bushels per acre for the same period.



Source:FAS-PS&D

Figure 8. World Soybean Yields, 2001-2016

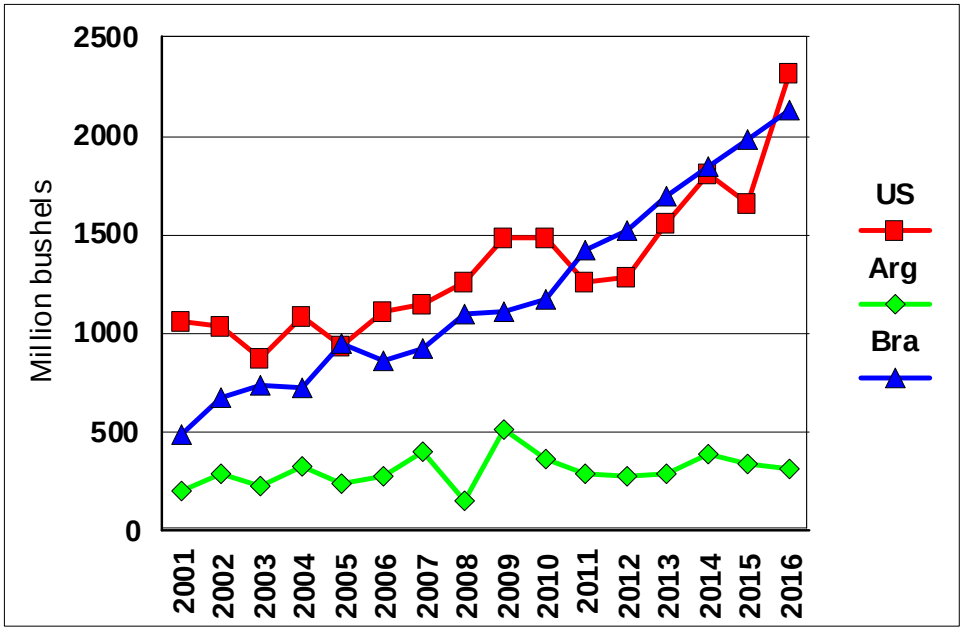
World soybean consumption increased by 80% between 2001 and 2016 (Figure 9). Soybean consumption in China increased from 1.0 billion bushels in 2001 to 3.7 billion bushels in 2016. In 2008, China became the largest soybean consumer in the world, passing the United States. Soybean consumption increased by 65% in Brazil and 126% in Argentina for the 2001-2016 period. U.S. consumption increased by 11% from 1.9 million bushels in 2001 to 2.1 million bushels in 2016.



Source:FAS-PS&D

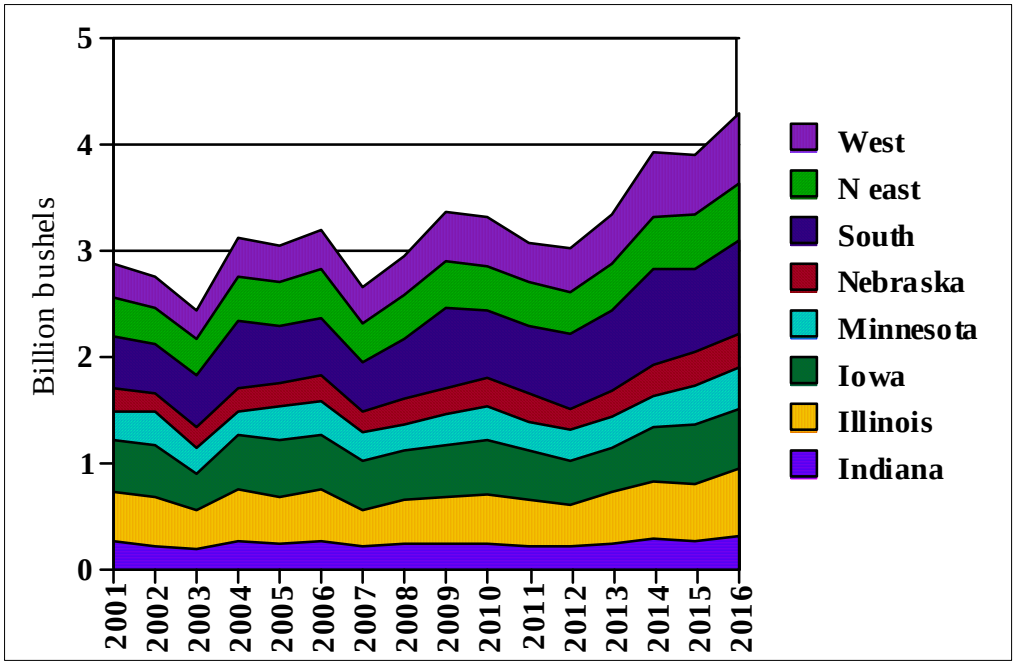
Figure 9. World Soybean Consumption, 2001-2016

The United States, Brazil and Argentina export over 90% of the soybeans traded in the world market (Figure 10). China imports about 64% of the world's exportable supplies of soybeans. The U.S. was the largest exporter of soybeans until 2011. However, Brazil exported 1.4 billion bushels compared to 1.3 billion bushels from the United States and 290 million bushels from Argentina in 2011. In 1995, the U.S. exported 84% of the soybeans traded in the world market. In 2016 the United States exported 2.3 billion bushels compared to 2.1 billion bushels from Brazil and 320 million bushels from Argentina.



Source:FAS-PS&D

Figure 10. World Soybean Exports, 2001-2016



Source:ERS-Oilseed Outlook

Figure 11. U.S. Soybean Production, by Region/State, 2001-2016

Soybean Production in the United States

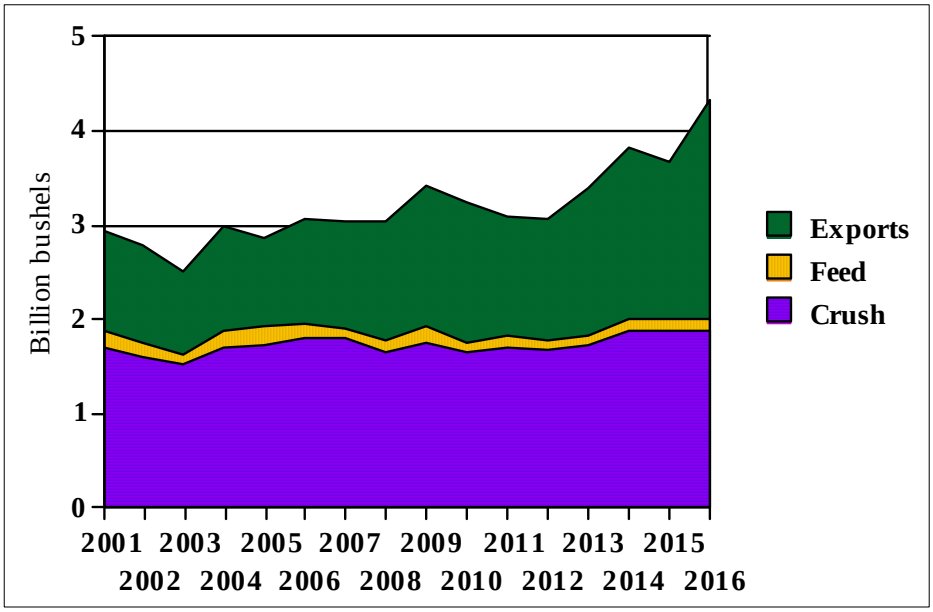
Figure 11 shows U.S. soybean production by state/region. Illinois is the largest producer of soybeans (623 million bushels), followed by Iowa (561 million bushels), and Minnesota (393 million bushels). Between 2001 and 2016 the fastest growth has been in the West region (110%), followed by the South region (81%) and North East (47%).

Much of the production growth has been caused by increased harvested area rather than yield growth (Table 3). Soybean yields are the highest in Nebraska, followed by Illinois and Indiana. The yield growth from 2001 to 2016 has been the fastest in the South region (45%), followed by the Nebraska (41%), and North East region (34%).

Table 3. U.S. Soybean Yields by Region/States

	1999-2002	2014-16	% Change
	----------bushels per acre----------		
Indiana	43.9	54.8	24.9
Illinois	43.5	58.0	33.3
Iowa	45.0	55.5	23.3
Minnesota	40.9	47.8	16.9
Nebraska	41.1	58.0	41.1
South	30.3	45.5	50.1
North East	37.1	49.7	33.9
West	30.8	39.3	27.6

In spite of the increased production of soybeans in Argentina and Brazil, US exports of soybeans have increased by 119% between 2001 and 2016. The production of bio-fuels from soybeans has not been a major factor influencing the U.S. soybean industry. Biodiesel makes up a very small percentage of diesel use in the United States. Domestic crush of soybeans has increased by 10% and feed, seed, and waste have decreased by 26% between 2001 and 2016.



Source:FAS-PS&D

Figure 12. US Soybean Utilization, 2001-2016

AN ECONOMETRIC SIMULATION MODEL FOR CORN AND SOYBEANS

The empirical model for this study is a global corn and soybean econometric policy simulation model. The basic structure of the model is similar to the global wheat model by Benirschka and Koo. The model is divided into a corn sector which is has the following regions, the United States, Argentina, Brazil, China, the European Union (EU), Canada, India, Indonesia, Japan, South Korea, Mexico, Pakistan, Philippines, Russia, Thailand, Ukraine, Vietnam, Africa and the rest of the world (ROW) ; and a soybean sector which is divided into the United States, Argentina, Brazil, China, the European Union (EU) and the rest of the world (ROW). The model has both corn and soybeans since they compete for the same cropland. Wheat also competes with corn for crop-land. However, it is not included in the model since the competition is limited to only Plains states in the U.S. Supply, demand, and carry-over stock equations are estimated for the crops in all the countries/regions. An equilibrium condition is reached when the aggregated demand for each crop in each county/region equals the aggregated supply of each crop in each county/region based on changes in the prices of the crops. The model is used to make conditional projections for production, consumption, exports, and price of each crop over the next 10 years. It is assumed that U.S. and world agricultural policy remains unchanged, there are normal weather patterns, and there are no dramatic macroeconomic or political changes in the future simulation period.

The behavioral equations of corn and soybeans are estimated for the countries/regions and included in the model. The behavioral equation is supply, demand and carryover stocks of each crop.

Supply of Corn and Soybeans

Supply of corn and soybeans consists of production, beginning stocks, and imports. Harvested area of corn or soybeans is affected by the lag of the real prices of the crop and competing crops. The real prices of corn or soybeans are expected to have a positive impact on the harvested area of the crop. The prices of the competing crops are expected to have a negative impact on harvested area. In addition, lagged harvest area (HA_{t-1}) is included as an independent variable to capture dynamics in a producer's response. The harvested area equation is specified as:

$$HA^n_t = f(HA_{t-1}, P^n_{t-1}, P^w_{t-1}) \quad n= 1, 2. \tag{1}$$

Where n is index for crop; n = 1 for corn and n = 2 for soybeans. HA^n_t = harvested area of crop n in time t, P^n_{t-1} = real prices of crop n in time t-1 and P^w_{t-1} = wheat price in time t-1. The lagged dependent variable is used as an independent variable to capture dynamics in corn production based on the partial adjustment hypothesis (Nerlove).

The yield equation of each crop includes the real price and a trend variable to account for advances in farming technology. The yield equation is specified as:

$$Y^n_t = f(P^n_t, T_t) \tag{2}$$

where Y^n_t = yield of crop n in time t, P^n_t = price of crop n in time t, and T_t = trend.

Total U.S. production of each crop is harvested area times yield as follows:

$$Pd^n_t = HA^n_t * Y^n_t \quad (3)$$

where Pd^n_t = U.S. production of crop n in time t.

Demand for Corn and Soybeans

Domestic demand for corn and soybeans is comprised of domestic consumption and ending-stocks. These two crops are used for different purposes in the United States. Corn is mainly used for animal feed and industrial uses including ethanol production, while soybeans are used for producing edible oil, soybean meal and bio-energy.

Demand for Corn for Feed

Corn is used to feed beef, pork, poultry, turkey and dairy.
Feed used for livestock is specified as a function of the price of corn, the price of livestock, and a trend variable, as follows:

$$FD^l_t = f(P^c_t , P^l_t , T_t), \; l= 1,2,\ldots.5. \quad (4)$$

where FD^l_t = the quantity of corn used to feed livestock l in time t, P^c_t = real price of corn in time t, P^l_t = real price of livestock l in time t and T_t = trend variable. L= 1 for beef, 2 for pork, 3 for poultry, 4 for turkey and 5 for dairy.

It is expected that all feed use will have a negative relationship with corn price and a positive relationship with livestock price. The total feed use is:

$$FD_t = \sum_{l=1}^{n} FD^l_t \quad (5)$$

When ethanol is produced from corn, by-products can be used for animal feeding, thus, the quantity of by-product (*BP*) from ethanol should be subtracted from FD_t as:

$$NFD_t = FD_t - BP_t . \quad (6)$$

where NFD_t is net consumption of corn for feed use in time t. $BP_t = a(b*E_t)$ where E_t = corn used for ethanol, a = conversion rate from by-product to animal feed, and b = conversion rate from corn to by-product.

We assumed that a=70%, b=30%, and the by-products (BP) are being fed to cattle. One pound of corn used in ethanol production will produce about 0.3 pounds of BP that can be fed to livestock (FAPRI 2005, Lardy 2003, Iowa Beef Center 2002). One pound of BP can substitute for about 0.7 pounds of corn (FAPRI 2005, Oleson 2005).

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. Government subsidies are expected to have a positive impact on ethanol production. A dummy variable is used to represent 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:

$$E_t = f(P^c_t, P^g_t, E_{t-1}, G^c_t, D^{mtbe}) \quad (7)$$

where E_t = corn used for ethanol production in time t, P^c_t = real price of corn in time t, E_{t-1} = corn used for ethanol production in time t-1, P^g_t = gasoline price, G^c_t = government subsidy, and D^{mtbe} is a dummy variable for removal of MTBE in California. The government subsidy was removed at the end of 2011. The lagged dependent variable is used as an independent variable to capture dynamics in the use of corn for ethanol production based on the partial adjustment hypothesis (Nerlove).

Corn Used for Other Industrial Purposes

It is expected that a high corn price will have a negative impact on other industrial use of corn such as HFCS, starch, glucose, and dextrose, and higher price of these industrial goods will have a positive impact on the industrial use of corn. The demand model for other industrial use is specified as:

$$I^c_t = f(P^c_t, P^o_t) \quad (8)$$

where I_t = the quantity of corn used for other industrial uses in time t, P^c_t = real price of corn in time t, P^o_t = real average price of other industrial goods.

Demand for Soybeans for Industrial and Other Uses

Domestic soybean crush is specified as a function of the price of soybeans and a trend variable, as follows:

$$CD^s_t = f(P^s_t, T_t) \quad (9)$$

where CD^s_t = the quantity of soybeans used for domestic crush in time t, P_t = real price of soybean in time t, and T_t = trend variable.

Other uses of soybeans include food, seed, and bio-energy. It is specified as a function of the price of soybeans and a trend variable, as follows:

$$OD^s_t = f(P^s_t, T_t) \quad (10)$$

where OD^s_t = the quantity of soybeans used for other purposes in time t, P^s_t = real price of soybean in time t, and T_t = trend variable.

The total demand for industrial and other uses are:

$$I^{s}_{t},=CD^{s}_{t} + OD^{s}_{t} \quad (11)$$

Carry-over Stocks for Corn and Soybeans

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

$$CS^{n}_{t} = f(P^{n}_{t}, CS^{n}_{t-1}) \quad (12)$$

where CS^{n}_{t} = carry-over stocks of crop n.

ROW Import Demand and Export Supply

ROW import demand is the summation of the import demand from other countries (Canada, Taiwan, Algeria, Egypt, and other Latin American countries). The price of a crop is expected to have a negative impact on import demand. In addition, consumer income has a positive relation with demand for crop n. The import demand model for the ROW is specified as:

$$ED^{Wn}_{t} = f(P^{n}_{t},Y_{t}) \quad (13)$$

where ED^{Wn}_{t} = ROW import demand for crop n in time t, P^{n}_{t} = real world price of crop n in time t, and Y_{t} = weighted average real per capita income in t.

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:

$$ES^{Wn}_{t} = f(P^{n}_{t}, T_{t}) \quad (14)$$

where ES^{Wn}_{t} = ROW excess supply in time t, P^{n}_{t} = real price of crop n in time t, and T_{t}= trend variable. It is expected that the export price of each crop and trend variable will have a positive impact on excess supply of individual crop.

Corn to Soybean Price Ratio

Harvested acres of corn and soybeans, traditionally, have followed the corn to soybean price ratio. Since the land area is limited, producers make planting decisions based on the prices of both crops. If the corn price is high compared to soybeans, more corn is planted and vice-versa. Historically the ratio has varied between 2.2 and 2.7 (USDA 1998). The corn to soybean price ratio and the area of corn and soybeans are determined for each region and country in the model. The forecasted area for corn and soybeans is required to be less than the maximum available land area planted to the two crops during the past 10 years. If the estimated areas for the two crops were greater than the maximum area,

both crops are reduced based on the estimated corn soybean ratio for that year.

Equilibrium Conditions

The equilibrium conditions for crop n are established in such a way that the aggregated excess supply of crop n equals the aggregated demand for the crop. Excess supply of crop n (XS^n_t) equals beginning stocks (CS^n_{t-1}) plus production (Pd^n_t) minus domestic use for feed (NFd^n_t), domestic use for bio-energy production (EN^n_t), other industrial use (I^n_t), and carry-over stocks CS^n of the corresponding crop in country/region as follows:

$$XS^n_t = CS^n_{t-1} + Pd^n_t - NFd^n_t - EN^n_t - I^n_t - CS^n_t \quad (15)$$

where XS^n_t = export supply of crop n in time t.

The aggregated excess supply of each crop for all countries/regions (m) and ROW should be equal to zero under the equilibrium condition, as follows:

$$\sum_{m=1} XS^{nm}{}_t + (ES^{Wn}{}_t - ED^{Wn}{}_t) = 0.0, \text{ n=1,2.} \quad (16)$$

Equation 16 represents two equilibrium conditions; one for corn and the other for soybeans. These equations are a function of prices of corn and soybeans. The equations, therefore, are solved for the prices of corn and soybeans. Equilibrium demands, supply and carry-over stocks of corn and soybeans are determined simultaneously. Since the base year for the simulation is 2016, the simulation is continued for 10 years until 2026. The simulation results in 2026 represent the full effects of the Energy Act of 2007 which requires the production of 15 billion gallons of corn-based ethanol and the removal of the ethanol production tax credit.

Data

Historical harvest area, yield, production, feed use, import demand, domestic consumption, and carry-over stocks data were obtained from the PS&D database from the Economic Research Service (ERS) for the years 1980 to 2016. Corn and soybean prices and corn use for ethanol were obtained from ERS. Actual gasoline prices, as well as forecasted prices were obtained from the U.S. Department of Energy, and cattle on feed numbers were obtained from the National Agricultural Statistics Service (NASS). All price data were converted to real terms using the GDP deflator (International Monetary Fund). Ethanol production data were obtained from ERS and the Renewable Fuels Association website.

OUTLOOK FOR THE CORN AND SOYBEAN INDUSTRIES

World Trade of Corn and Soybeans

World corn trade is projected to increase by 34% between 2016 and 2026 (Table 4). U.S. corn exports are expected to increase to 2.6 billion bushels in 2026. Both Argentina and Brazil will increase exports. The EU is expected to reduce imports to 266 million bushels of corn.

World soybean trade will increase by 24% between 2016 and 2026. China is expected to increase imports by 21% in 2026 from the 2015-2016 average (Table 4). U.S. soybean exports are expected to increase 5% as some acres will return to soybean production. Since 2007, Argentina has been increasing soybean production rapidly due to restrictions on the exportation of beef. Pasture land is being converted to soybean production. The Argentine government has changed export tariffs on soybeans and soybean meal which now favors the export of meal over soybeans. Brazil will continue to increase soybean exports to satisfy Chinese soybean demand.

Table 4. World Corn and Soybean Trade

	2015-2016	2016	2026	Change
	----------million bu----------			%
Corn				
US	2,215	2,829	2,585	16.7
Arg	896	984	1,009	12.7
Brazil	819	1,079	1,079	31.7
China	-121	-117	86	NA
EU	-455	-445	-266	-41.5
ROW	-1,745	-1,822	-3,593	106.0
Soybeans				
US	1,992	2,324	2,089	4.9
Arg	330	320	520	57.6
Brazil	2,058	2,133	2,366	15.0
China	-3,104	-3,154	-3,739	20.5
EU	-519	-502	-503	-3.0
ROW	-273	-275	-186	-23.3

Figure 13 shows the projected corn exports for the United States, Brazil, Argentina and Ukraine. U.S. exports are expected to increase throughout the forecast period. The exports for Brazil are expected to remain relatively constant throughout the forecast period. Exports are expected to increase 13% and 75% for Argentina and Ukraine, respectively, for the 2016-2026 period.

Figure 14 shows the projected soybean exports for the major exporting countries. Brazil is currently the largest exporter of soybeans. The U.S. soybean production is expected to remain near current levels until later in the forecast period which allows Brazil to increase soybean exports to satisfy world demand. Argentina is also expected to increase soybean exports throughout the forecast period.

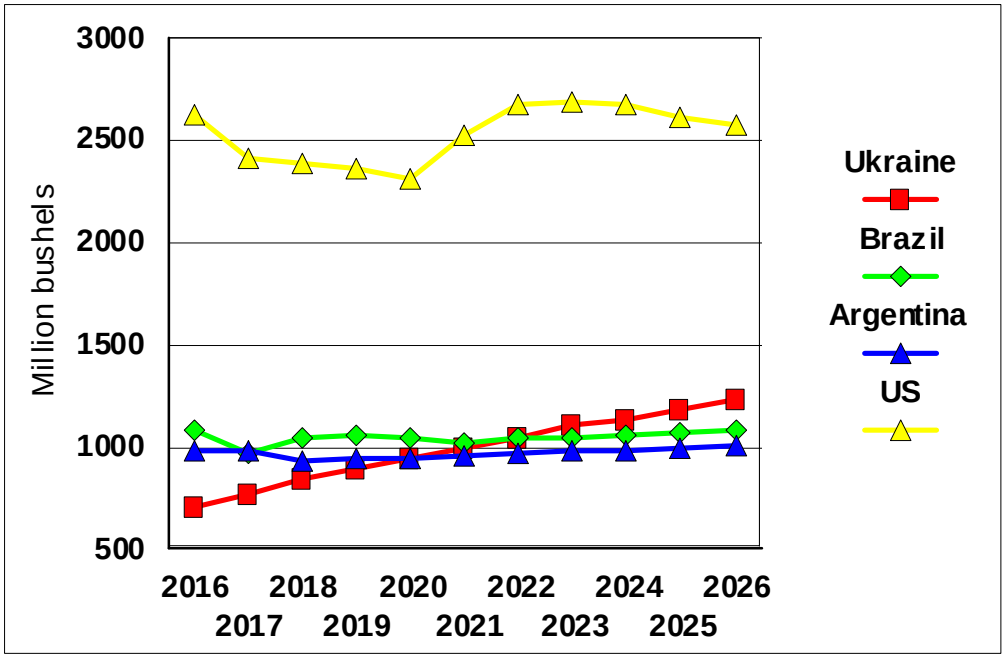


Figure 13. Projected Corn Exports by Major Producers

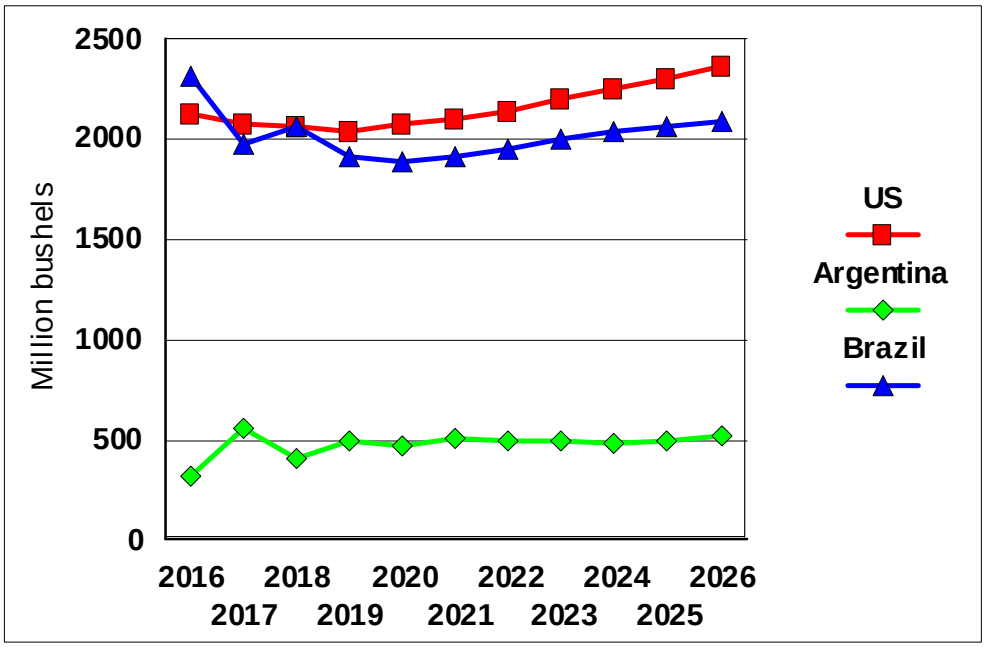


Figure 14. Projected Soybean Exports by Major Producers

World Production of Corn and Soybeans

World corn production is expected to increase by 11%, from 31 billion bushels in 2015-2016 average to 35 billion bushels in 2026. The U.S. will increase corn production by 6% (Table 5). Brazil's production in 2026 is expected to be larger than the 2015-2016 average. Historically, Brazil has produced between 2.3 and 2.8 billion bushels of corn per year. Chinese corn production is expected to

increase by about 18% to 10.3 billion bushels by 2026. Corn production in the European Union is expected to increase from 2.4 billion bushels in 2016 to about 3.1 billion bushels in 2026 which will not satisfy domestic needs. Corn production by the major producing countries is shown in Figure 15. U.S. corn production is expected to increase slightly during the forecast period. Argentine corn production has ranged between 1.3 million and 1.4 million bushels per year and it is expected to remain near that level.

Table 5. World Corn and Soybean Production

	2015-2016	2016	2026	Change
	----------million bu----------			%
Corn				
US	14,389	15,177	15,283	6.2
Arg	1,290	1,437	1,331	3.2
Brazil	3,022	3,405	3,737	23.7
China	8,743	8,643	10,291	17.7
EU	2,346	2,390	3,128	33.3
ROW	1,555	1,471	1,227	-21.1
Soybeans				
US	4,124	4,308	4,392	6.5
Arg	2,091	2,094	2,582	23.5
Brazil	3,647	3,748	4,040	10.8
China	446	459	524	17.5
EU	86	89	94	9.9
ROW	1,425	1,535	1,841	29.2

The U.S. is projected to increase soybean production by about 7% by 2026. U.S. production growth is limited because of land constraints, however some land will switch from corn. U.S. production is expected to increase from about 4.3 billion bushels in 2016 to about 4.4 billion bushels in 2026. Argentina and Brazil are expected to increase soybean production by 24% and 11%, respectively. Brazil has range and pasture land available for conversion and Argentina is converting pasture land into cultivated land due to government regulations concerning beef exports. Argentine soybean production should increase from 2.1 billion bushels to 2.6 billion bushels between 2016 and 2026. Figure 16 shows the projected soybean production for the major producing countries. China's soybean production will increase during the forecast period but remain below 600 million bushels.

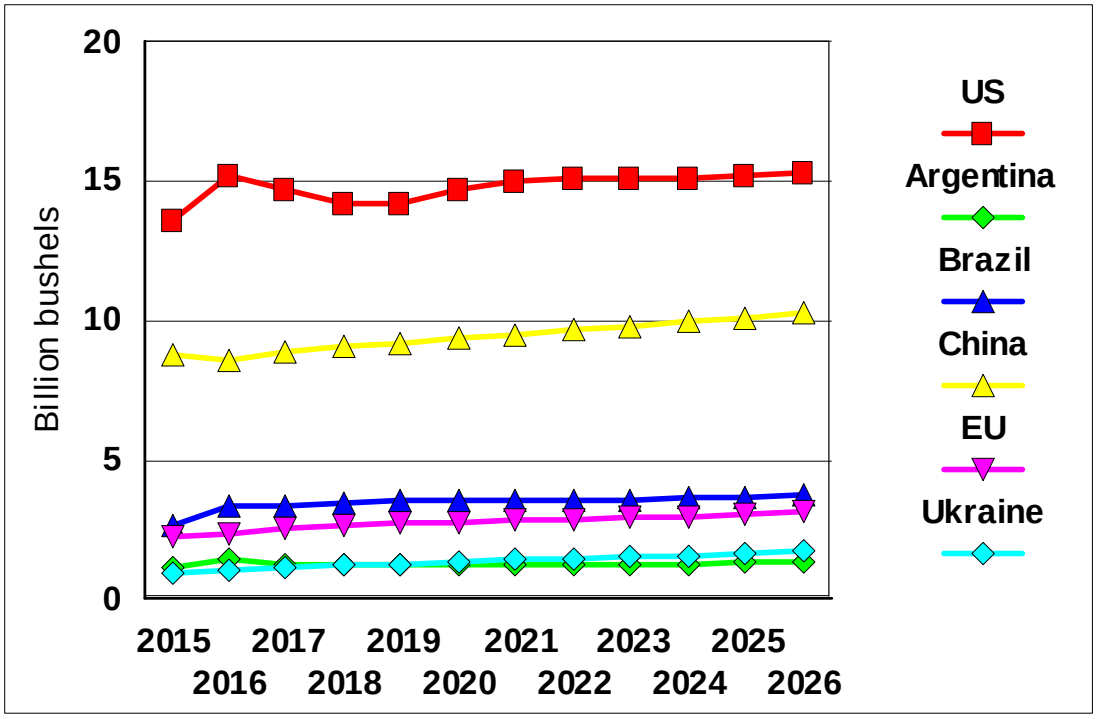


Figure 15. Projected Corn Production by Major Producers

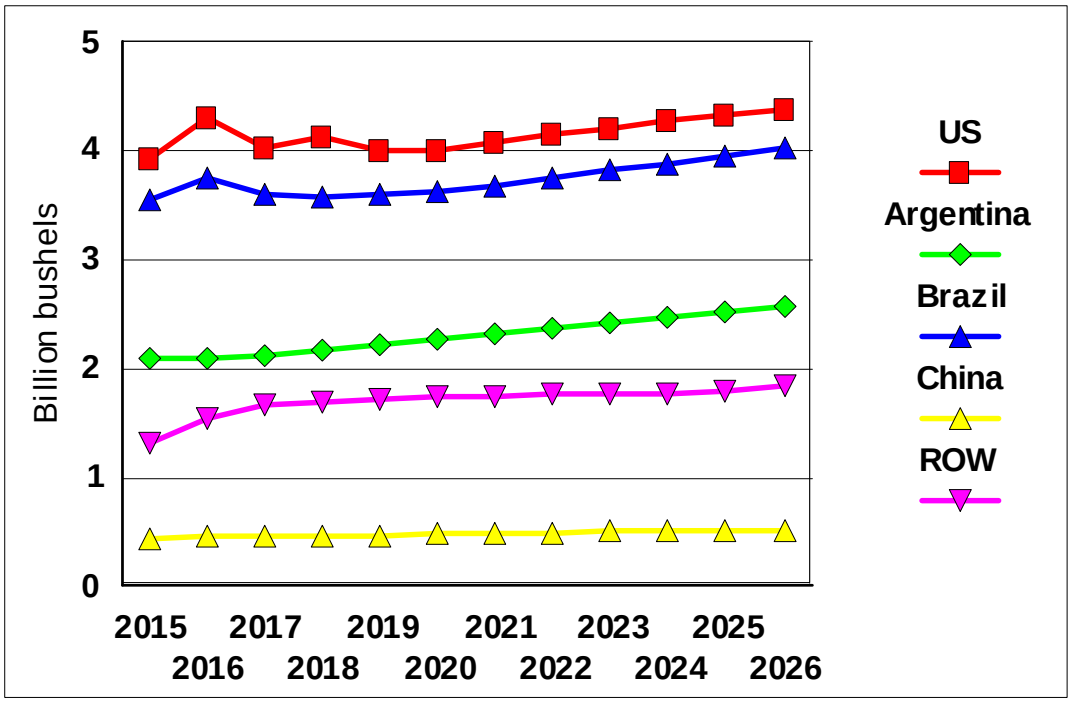


Figure 16. Projected Soybean Production by Major Producers

Corn and Soybean Production in the U.S.

Table 6 shows the yield and harvested acres for the states/regions in the United States. In 2016, Illinois had the highest average yield of 202 bushels per acre followed by Iowa, Minnesota, Nebraska

and Indiana. Outside of the major corn producing states, the North East region has the highest yield at 160 bushels per acre. Yields are expected to increase in all states/regions except in Minnesota. Harvested acres in the U.S. are expected to increase from 83.5 million acres to 85.6 million acres in 2026. Historically, U.S. corn producers planted around 80 million acres of corn. They responded to high corn prices in 2011, 2012 and 2013 to increase corn acres between 84 million and 87 million acres but corn acres fell to 83.5 million acres in 2016.

Table 7 shows yields and harvested acres for U.S. soybeans. Soybean yields are expected to increase in all states/regions in the United States. Yields for the West are projected to be 4.5% higher in 2026 than in 2015-2016. The largest harvested acres are in the south region followed by the West and the North East region. The U.S. harvested 83.0 million acres of soybeans in 2016 and harvested acres are expected to increase to 85.3 million acres by 2026.

Figure 17 shows the production of corn by state/region for the United States. Iowa is expected to be the largest corn producing state in 2026 (2.0 billion bushels), followed by Illinois and Minnesota. Total U.S. corn production in 2016 was 14.3 billion bushels and is expected to increase by 5.3% to 15.0 billion bushels by 2026. The fastest growth is expected to be in Indiana (19%), followed by Iowa (7%), and the Nebraska (4%).

In Figure 18 shows the production of soybeans by state/region. The South region is expected to be the largest soybean producing region in 2026 with 879 million bushels, followed by the West region, Iowa and Illinois. The fastest increase in soybean production is projected to be in Iowa (14%), followed by the Minnesota and Indiana.

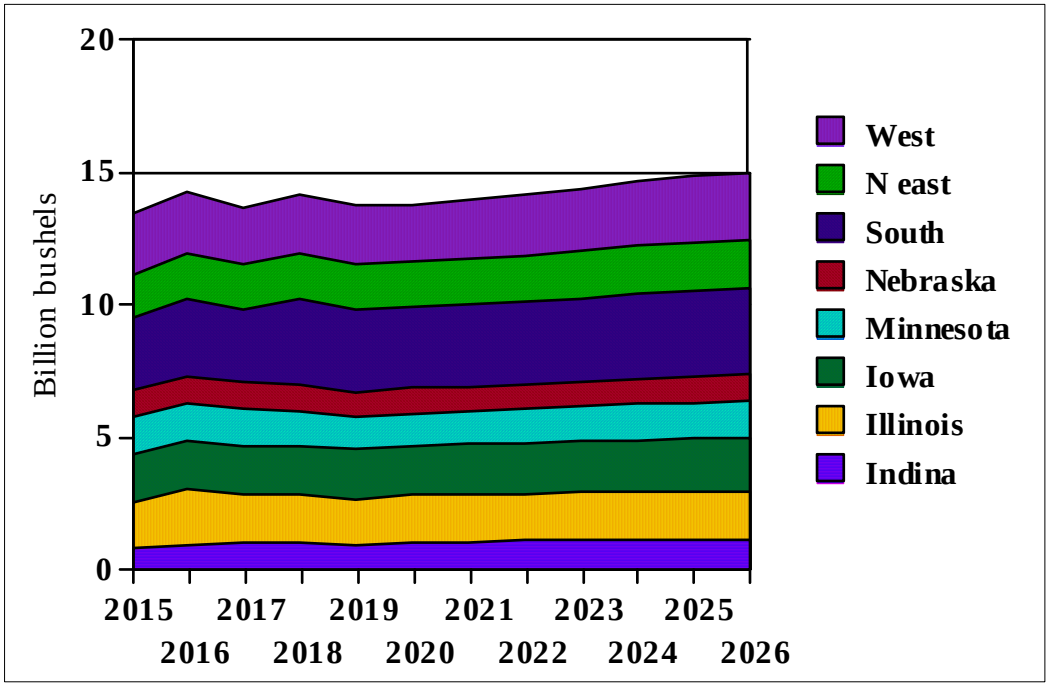


Figure 17. Projected US Corn Production by State/Region

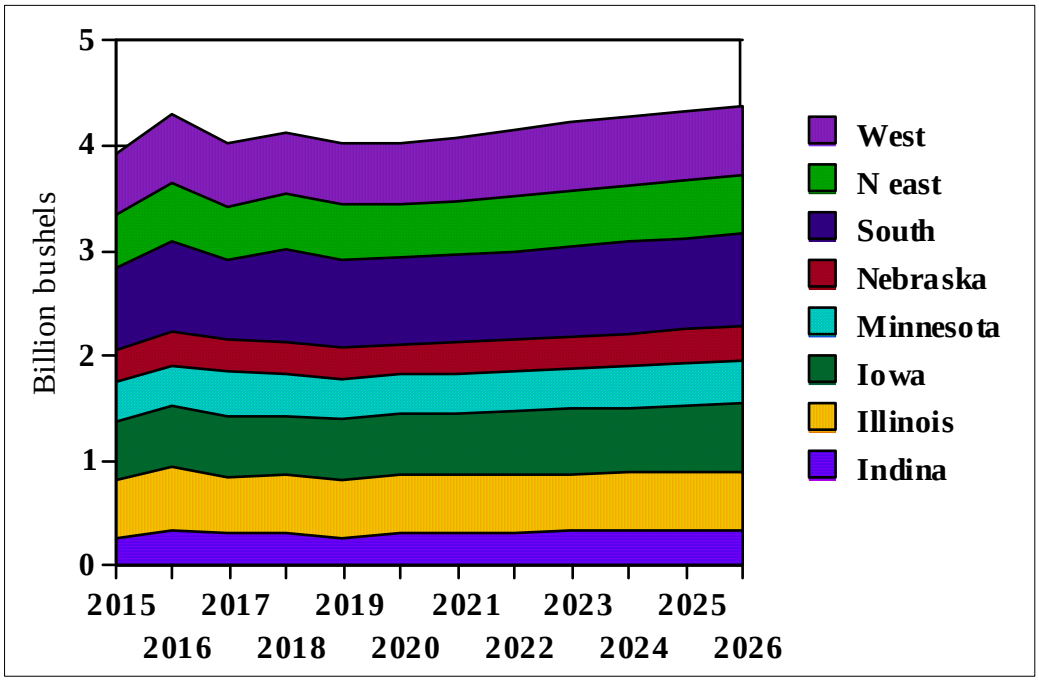


Figure 18. Projected US Soybean Production by State/Region

Table 6. U.S. Corn Yields and Harvested Acres

Yields	2015-2016	2016	2026	change
	---------bushels per acre--------			%
Indiana	164	177	193	15.2
Illinois	189	202	195	3.2
Iowa	196	199	194	-0.8
Minnesota	189	190	174	-8.4
Nebraska	185	184	188	1.9
South	155	159	172	9.7
Northeast	160	162	170	5.7
West	145	143	155	6.2
Harvested acres				
	----------thousand acres----------			
Indiana	5,445	5,410	5,933	8.2
Illinois	11,500	11,500	12,196	5.7
Iowa	13,275	13,500	12,819	-3.6
Minnesota	7,800	8,000	7,802	0.0
Nebraska	9,325	9,500	10,020	6.9
South	9,263	10,175	9,956	7.0
Northeast	10,448	10,815	10,691	2.3
West	16,536	17,925	16,206	-2.0

Table 7. U.S. Soybean Yields and Harvested Acres

Yields	2015-2016	2016	2026	change
	--------bushels per acre---------			%
Indiana	55	59	56	3.0
Illinois	59	62	60	1.5
Iowa	58	59	61	5.7
Minnesota	51	52	52	2.5
Nebraska	60	62	60	0.4
South	45	46	47	4.0
Northeast	50	53	51	0.6
West	40	41	42	4.5
Harvested acres				
	----------million acres----------			
Indiana	5,590	5,680	6,210	10.0
Illinois	9,885	10,050	9,304	-6.2
Iowa	9,650	9,500	10,436	7.5
Minnesota	7,550	7,550	7,969	5.3
Nebraska	5,210	5,150	5,259	0.9
South	18,542	18,717	18,920	2.0
Northeast	10,442	10,581	10,945	4.6
West	15,492	15,798	16,232	4.6

Prices of Corn and Soybeans in the U.S.

Figure 19 shows the projected corn and soybean prices for 2016 through 2026. Corn price is expected to increase slightly to $3.44 per bushel in 2017 from $3.35 in 2016 and then increase to $4.16 by 2019 before falling slowly to $4.02 in 2026. Soybean price is expected to be about $9.02 per bushel in 2017 and slowly rise to $9.12 by 2024 before falling slowly to $9.07 in 2026.

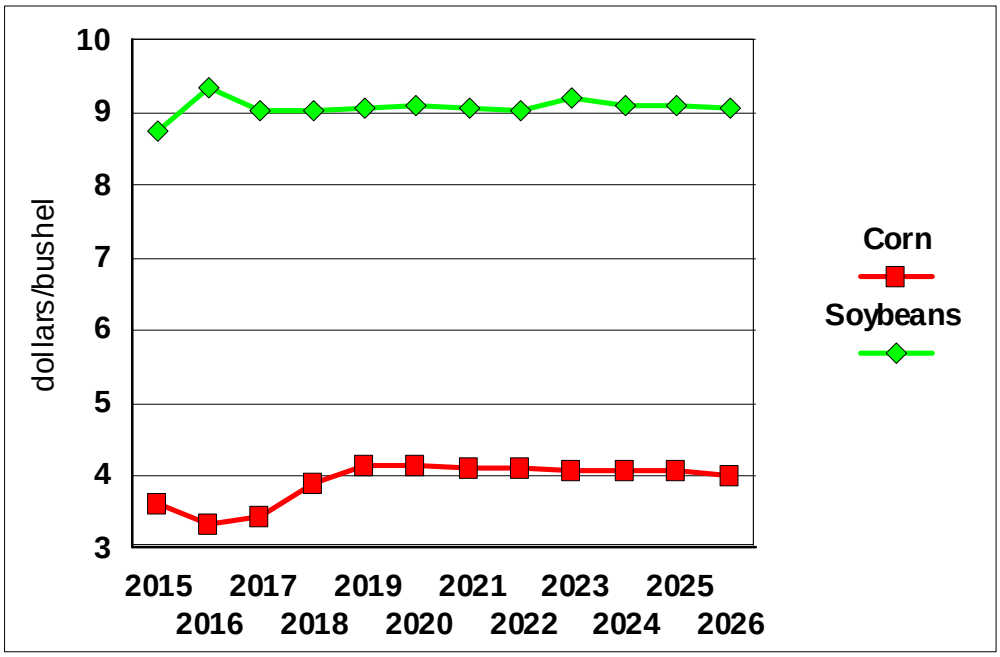


Figure 19. Projected U.S. Corn and Soybean Prices

U.S. Export and Utilization of Corn and Soybeans

Figure 20 shows the projected utilization for U.S. corn. Exports are expected to increase from 1.9 billion bushels in 2016 to 2.0 billion bushels in 2026. The feed use of corn is projected to increase by 7.9% from 5.1 billion bushels in 2016 to about 5.5 billion bushels in 2026. Ethanol use of corn is expected to decrease by 3% from 5.3 billion bushels in 2016 to 5.1 billion bushels in 2026. Other industrial uses are projected to increase by 2% between 2016 and 2026. Total U.S. utilization of corn is expected to increase by less than 1% during the forecast period.

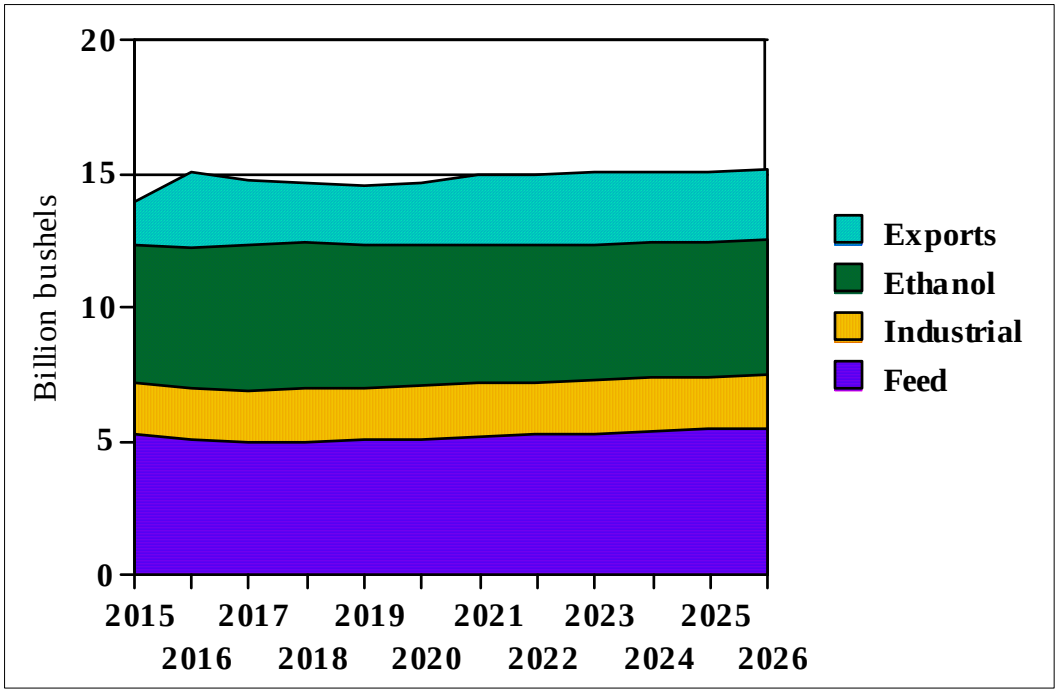


Figure 20. Projected U.S. Corn Utilization

U.S. exports of soybeans are expected to increase during the forecast period from 1.8 billion bushels in 2016 to 2.1 billion bushels in 2026 (Figure 21). U.S. domestic processing is projected to increase by 15% from 1.9 billion bushels in 2016 to about 2.2 billion bushels in 2026. Feed and other uses are expected to increase by about 15%. Total domestic consumption is expected to increase by about 15% during the forecast period.

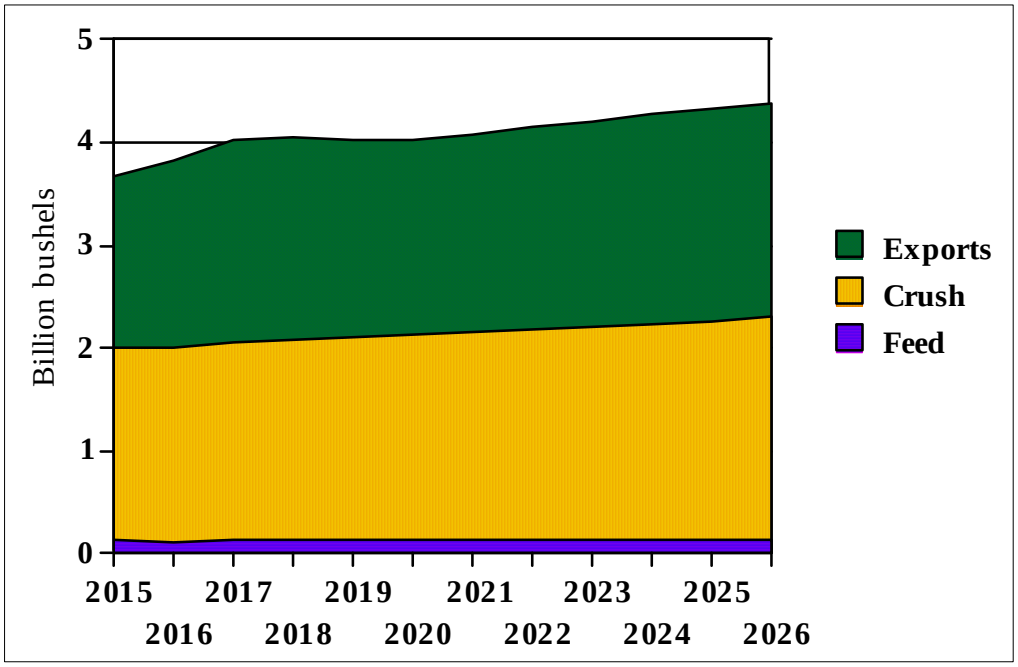


Figure 21. Projected U.S. Soybean Utilization

CONCLUSIONS

Recently, commodity markets experienced price increases which were caused, in the most part, by forces outside of agriculture. In late 2005 and early 2006 the price of crude oil doubled which drove up the price of energy. Increased energy prices increased the demand for and price of ethanol. The high price of corn caused by increases in ethanol production impacted all other commodities. During 2008, commodity prices reached historical levels. Prices again increased for most commodities in late 2010 and early 2011. The United States experienced a near record drought in 2012. The dry weather conditions reduced the corn crop by 19% and soybeans by 10%. The decreases in production increased commodity prices substantially. In 2013 the United States had a record corn crop and a near record soybean crop which depressed prices to levels which had not been seen in several years. In 2014 the United States raised a record production of corn and soybeans followed by a near record crop in 2015 and record crop in 2016. That record production decreased commodity prices for corn and soybeans to $3.35 and $9.36, respectively.

Until 2012, the United States was the largest exporter of corn, however, because of the drought the United States, Argentina and Brazil exported a similar amount of corn. In 2013 the United States exported 1.9 billion bushels of corn which was greater than the past six years. In 2014 the United States exported 1.8 billion bushels of corn followed by exports of 1.6 billion bushels in 2015 and 2.8 million bushels in 2016. Feed use for corn increased in 2014 and 2015 but fell in 2016.

The ethanol industry in the United States will continue to grow but at a slower rate than in the past. The processing capacity of corn-based ethanol will not continue to increase because the industry has reached the blend wall. The Energy Independence and Security Act of 2007 requires 36 billion gallons of ethanol to be blended with the U.S. gasoline supply with about 15 billion gallons from corn-based ethanol and 25 billion gallons coming from bio-mass based ethanol by 2022. The corn based ethanol industry currently produces about 15 billion gallons. Biomass ethanol production has not moved beyond the testing and research stage due to high production costs. The U.S. ethanol industry is expected to decrease slightly throughout the forecast period. In 2015, 5.2 billion bushels of corn was used for ethanol production and 5.3 billion bushels were used in 2016. By 2026 it is projected that 5.1 billion bushels of corn will be used for the production of ethanol.

China’s demand for soybeans continues to increase into the future as increases in consumer income continue to change dietary patterns in the country. In 2016, China imported 3.2 billion bushels of soybeans. By 2026, it is projected to import about 3.7 billion bushels of soybeans. Most of the additional soybeans demand in China will come from the South American nations since the U.S. does not have additional land to increase soybean production.

The price of corn is expected to increase from the current price of $3.35 to $4.16 in 2019 before decreasing to $4.02 in 2026. Soybean price is expected to fall to $9.02 in 2017 before increasing to $9.07 in 2026.

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