Agribusiness & Applied Economics Report No. 727 **May 2014**

2014 Outlook of the U.S. and World Corn and Soybean Industries, 2013-2023

Richard D. Taylor and Won W. Koo

Center for Agricultural Policy and Trade Studies
Department of Agribusiness and Applied Economics
North Dakota State University
Fargo, North Dakota 58108-6050

ACKNOWLEDGMENTS

The authors extend appreciation to David Ripplinger and Bruce Dahl for their constructive comments and suggestions. Special thanks go to Edie Nelson, who helped to prepare the manuscript**.** The authors assume responsibility for any errors.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Outlook of the U.S. and World Corn Industries, 2013-2023
Richard D. Taylor and Won W. Koo

ABSTRACT

This report evaluates the United States and world corn and soybean markets for the 2013-2023 period using the Global Corn and Soybean Policy Simulation Model. This analysis is based on a series of assumptions that general economic conditions, agricultural policies, weather conditions, and technological change remain at the current levels.

Corn-based ethanol production has influenced the United States corn industry. As long as the production of corn-based ethanol remains strong, corn prices will likely remain at a level higher than the long term average. However, changes in Federal fuel mandates could significantly impact the world corn market. Under the current assumptions in the model, corn price is expected to remain in a range between $4.60 and $5.90 per bushel.

Chinese soybean imports are the leading factor influencing the world soybean market. China currently imports 67% of the soybeans traded in the world market, and that is expected to increase by another 42% by 2023. Major exporters will continue to be the U.S., Brazil and Argentina. However both Brazil and Argentina could increase exports while U.S. exports will remain at the current level. Soybean prices are expected to remain over $12.30/bushel over the time period.

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

HIGHLIGHTS

World corn trade is projected to increase by 15% between 2013 and 2023. U.S. exports are expected to decrease 17.2% by 2023, however much of that decrease is due to a very large corn crop in 2013. Argentina will increase exports, while Brazil is expected to reduce exports by 2023.

World soybean trade will increase by 56% between 2013 and 2023. China is expected to increase imports by 42% in 2023 from the 2012-2013 average. Argentina has been increasing soybean production rapidly due to restrictions on the exportation of beef and Brazil will continue to increase soybean exports to satisfy Chinese soybean demand.

World corn production is expected to increase 11%, from 29 billion bushels in 2012-2013 to 32 billion bushels in 2023. The United States will increase corn production by 4% while Argentina will increase production by 15%. Brazil is expected to increase corn production by 9% because of higher corn yields.

The U.S. is projected to increase soybean production about 24% by 2023. U.S. production growth is limited because of land constraints. Argentina and Brazil are expected to increase soybean production by 18% and 25%, respectively.

U.S. corn yields are expected to increase in all states/regions. Harvested acres in the U.S. are expected to decrease slightly from 87 million acres in 2013 to 86 million acres in 2023. The West region has the largest corn harvested acres in the United States, followed by Iowa and Illinois. The U.S. planted 75.7 million acres of soybeans in 2013 and harvested acres are expected to increase to 83.0 million acres by 2023. U.S. soybeans yields are expected to increase in most states/regions in the country.

Total U.S. corn production in 2013 was 14.0 billion bushels and is expected to increase by 4% to 14.6 billion bushels by 2023. The fastest growth is expected to be in Iowa (12%), followed by Minnesota (11%), and the west region (10%).

U.S. exports of corn are expected to decrease from 2.1 billion bushels in 2013 to 1.7 billion bushels in 2023. The feed use of corn is projected to increase by 14% from 4.9 billion bushels in 2013 to about 5.5 billion bushels in 2023. Ethanol use of corn is expected to increase by 9% from 5.0 billion bushels in 2013 to 5.4 billion bushels in 2023. Other industrial uses are projected to increase by 5% between 2013 and 2023. Total U.S. consumption of corn is expected to increase by 6% during the forecast period.

U.S. exports of soybeans are expected to increase during the forecast period from 1.5 billion bushels in 2013 to 1.8 billion bushels in 2023. U.S. domestic processing is projected to increase by 17% from 1.7 billion bushels in 2013 to about 2.0 billion bushels in 2023. Feed and other uses are expected to increase by about 14%. Total domestic consumption is expected to increase by about 19% during the forecast period.

Corn price is expected to decrease to $4.58 per bushel in 2014 and then increase to $5.91 by 2023. Soybean price is expected to be $12.35 per bushel in 2014 and then increase to $12.82 by 2023.

2014 Outlook of the U.S. and World Corn and Soybean Industries, 2013-2023

Richard D. Taylor
Won W. Koo

INTRODUCTION

World corn and soybean production is concentrated in a few countries unlike other agricultural crops. The U.S. produces 39% of the world's corn and 27% 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 three years, these four areas produce over 60% of the world's corn. Brazil produces 32% and Argentina produces 20% of the world soybeans compared to 31% 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. Prices and production returned to normal levels in 2008 and 2009, however prices increased again in late 2010 and early 2011. The main reason for the increase in corn price is due mainly to the small carry-over stocks in the United States. 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 were 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.

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 corps in 2010 compared to 2009, but the United States soybean crop was slightly larger.

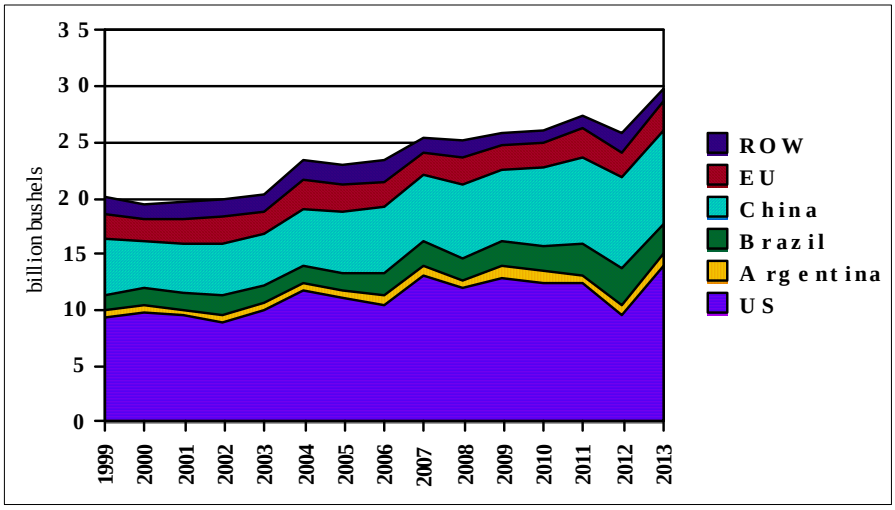
Industrial use of corn has increased dramatically during the past two decades. The most recent increases are due mainly to increasing ethanol production, which is expected to grow slower than in the past since the United States have reached the Renewable Fuel Standard (RFS) mandate. High fructose corn 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 and 5.0 billion bushels in 2013. These two non-traditional uses of corn account for almost 43% of the current U.S. corn crop.

World soybean production has increased in recent years 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 2013, China consumed 3.1 billion bushels and produced 493 million bushels and imported 2.7 billion bushels which was over 67% of the soybeans traded in the world market.

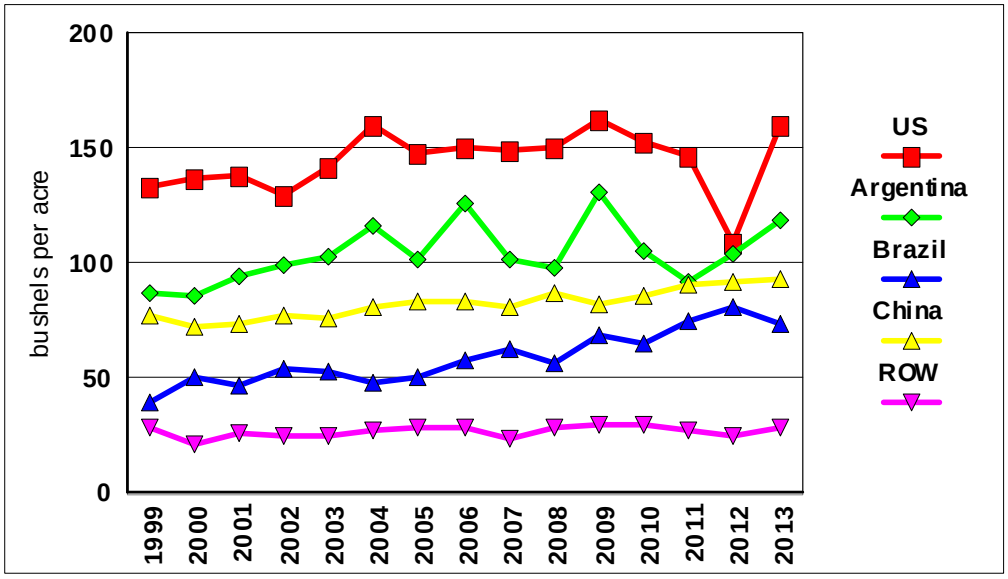
WORLD CORN INDUSTRY

Figure 1 shows the world corn production in the major corn producing countries. U.S. corn production has increased by 49% between 1999 and 2013, although harvested acres increased by only 4.5%. China's corn production increased by 65% while Brazil and the EU increased production by 121% and 13%, respectively, during the same time period.



Source: FAS-PS&D

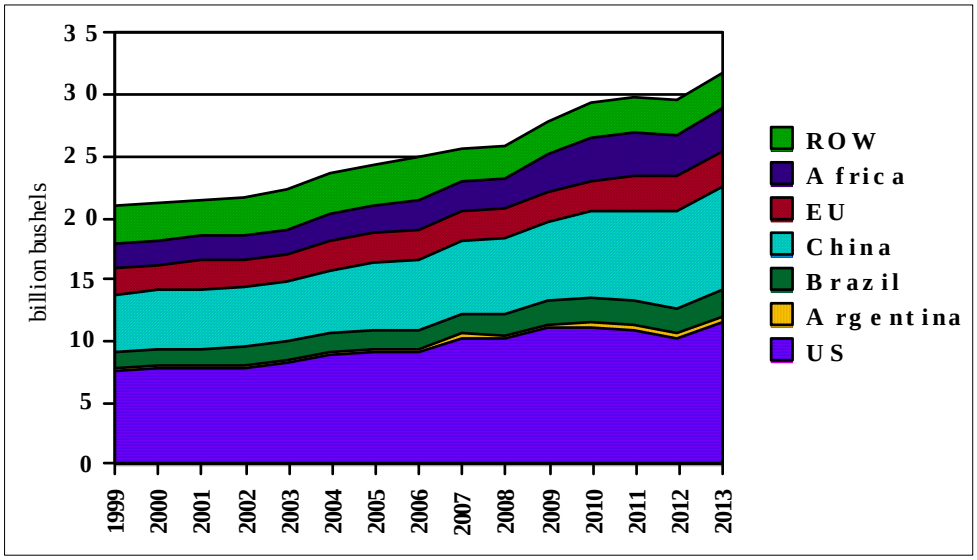
Figure 1. World Corn Production,1999-2013



Source:FAS-PS&D

Figure 2. World Corn Yields, 1999-2013

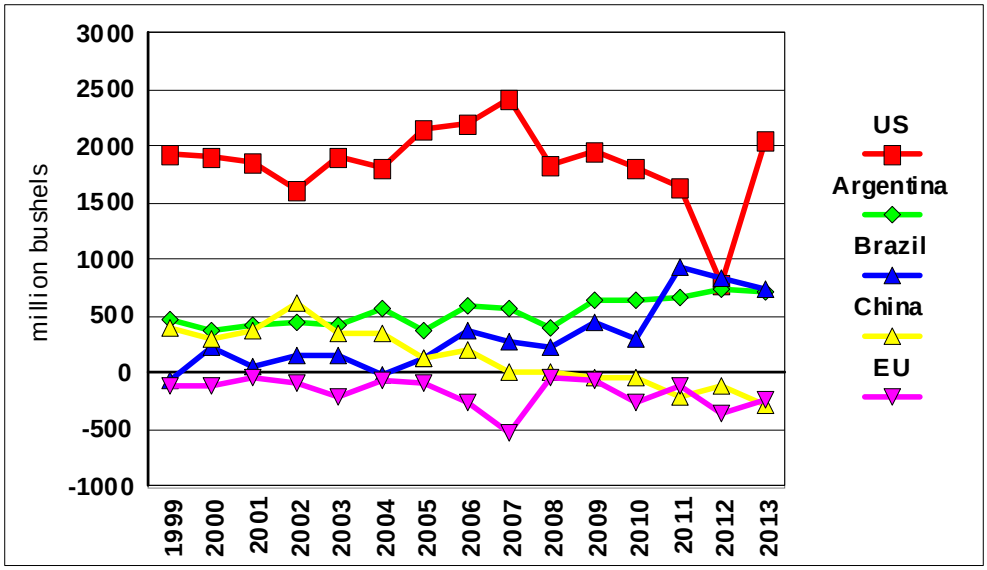
In addition to larger world corn acres, world average corn yields have increased by 47% between 1999 and 2013. Corn yields in the U.S. increased from 139 bushels per acre in 1999 to 169 bushels per acre in 2013 and corn yields also increased in other countries. Chinese corn yields increased by 19%, while corn yields in Brazil and the European Union increased by 85% and 17%, respectively. 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, 1999-2013

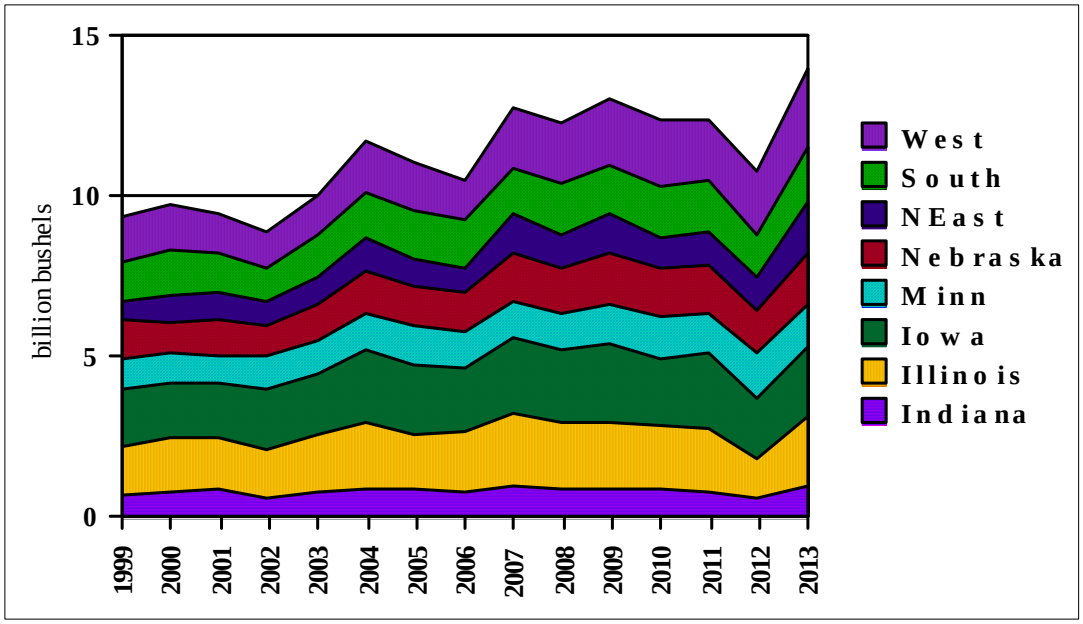
World corn consumption increased by 62% between 1999 and 2013 (Figure 3). The countries with the largest growth in corn consumption have been the EU, the United States and China. China's consumption growth is due mainly to growth in the livestock sector and in the United States growth is a result of corn based ethanol production. Corn consumption in China increased by 85% between 1999 and 2013, while that in the U.S. increased by 53% during the same time period. Corn consumption in the European Union increased by 22% while the Rest of world (ROW) region increased by 3% during the same time period.



Source:FAS-PS&D

Figure 4. World Corn Exports, 1999-2013

The United States was the main exporter of corn for the 1999-2013 period, although China, Brazil, and Argentina exported corn most years. During the past 15 years, corn exports in the U.S. have remained relatively flat until 2011 and 2012. Exports were 1.6 billion bushels and 800 million bushels, respectively in the two years. U.S. corn exports rebounded to 2.1 billion bushels in 2013 after the 2012 drought. The ROW region increased imports of corn from 1 billion bushels in 1999 to 1.9 billion bushels in 2013.



Source:ERS-Wheat Yearbook

Figure 5. US Corn Production by Region/State, 1999-2013

Corn Production in the U.S.

In 2013, The five largest corn producing states in the United States are Iowa (2.2 billion bushels), Illinois (2.1 billion bushels), Nebraska (1.6 billion bushels), Minnesota (1.3 billion bushels), and Indiana (1.0 billion bushels). Those five states produced 69% of the total quantity of corn production in the U.S. Iowa increased corn production by 26% between 1999 and 2013, while Illinois and Indiana increased corn production by 41% and 35%, respectively, during the same time period. Minnesota and Nebraska increased corn production by 33% and 40%, respectively. The other regions of the country also increased corn production. The North East, South and West increased corn production by 40%, 153%, and 74%, respectively.

Table 1 shows the states that are included in the three corn growing regions of the United Sttates. Several states have no corn production and are not listed in the table. Area harvested for corn increased in most regions/states between 1999 and 2013. Corn acres increased by 25% 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 10% and 11%, respectively, while Nebraska and Indiana increased corn acres by 15% and 2%. The North East region reduced corn acres by 10% and the South and West regions increased acres by 23% and 42%, respectively.

Table 1. Corn Producing States Divisions by Regions

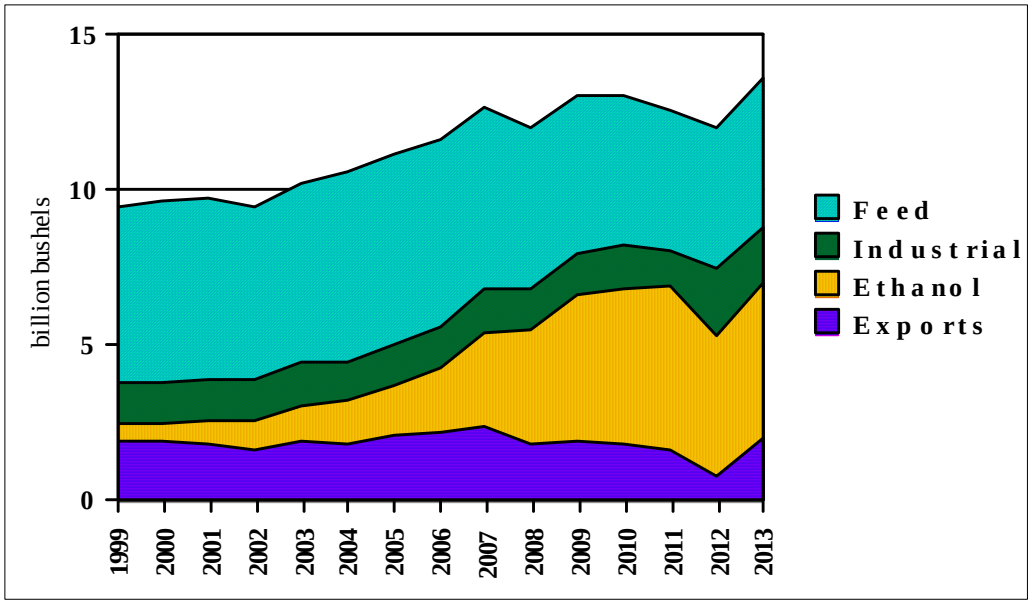
Major	North East	South	West
Iowa	Delaware	Alabama	Arizona
Illinois	Maryland	Arkansas	California
Indiana	Michigan	Florida	Colorado
Minnesota	New Jersey	Georgia	Idaho
Nebraska	New York	Kentucky	Kansas
	Ohio	Louisiana	Montana
	Pennsylvania	Missouri	North Dakota
	Virginia	Mississippi	New Mexico
	Wisconsin	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 1998 through 2001 and 2011 through 2013. Iowa and Illinois have the highest average corn yield for the years 1998-2001 at 146 bushels per acre, compared to Indiana at 143 bushels per acre. For the 2011-2013 time period, Minnesota had the highest average corn yield at 162 bushels per acre followed by Iowa at 159 bushels per acre. The fastest growth region for yields was in the South region, 43%, followed by the North East, 36%, and the West region, 15%. Yields decreased in Indiana due to the 2012 drought.

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

	1998-2001	2011-13	% Change
	----------bushels per acre----------		
Indiana	142.8	139.7	-2.2
Illinois	146.0	147.3	0.9
Iowa	146.0	159.3	9.1
Minnesota	144.5	161.7	11.9
Nebraska	139.3	157.0	12.7
South	88.5	126.6	43.2
North East	106.2	144.5	36.0
West	106.4	122.5	15.2

Figure 6 shows the U.S. utilization of corn for the years 1999 through 2013. The largest increase was corn for ethanol production, an increase of 775%, from 566 million bushels in 1999 to 5.0 billion bushels for 2013. Feed use decreased by 14%, other industrial uses increased by 34% and exports increased by 6%. Total utilization increased by 44% during the time period.

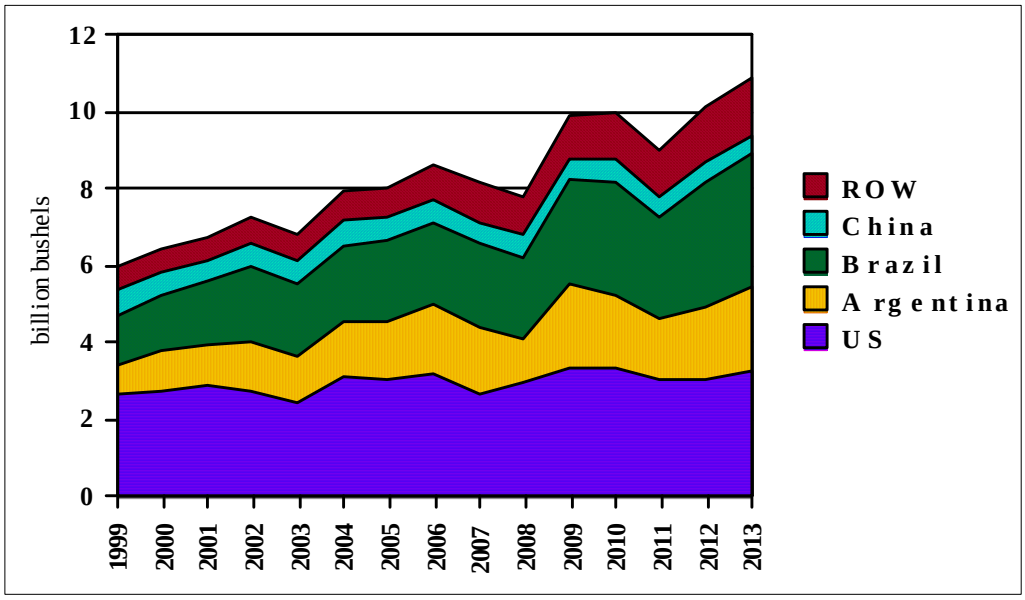


Source:FAS-PS&D

Figure 6. Corn Utilization, 1999-2013

WORLD SOYBEAN INDUSTRY

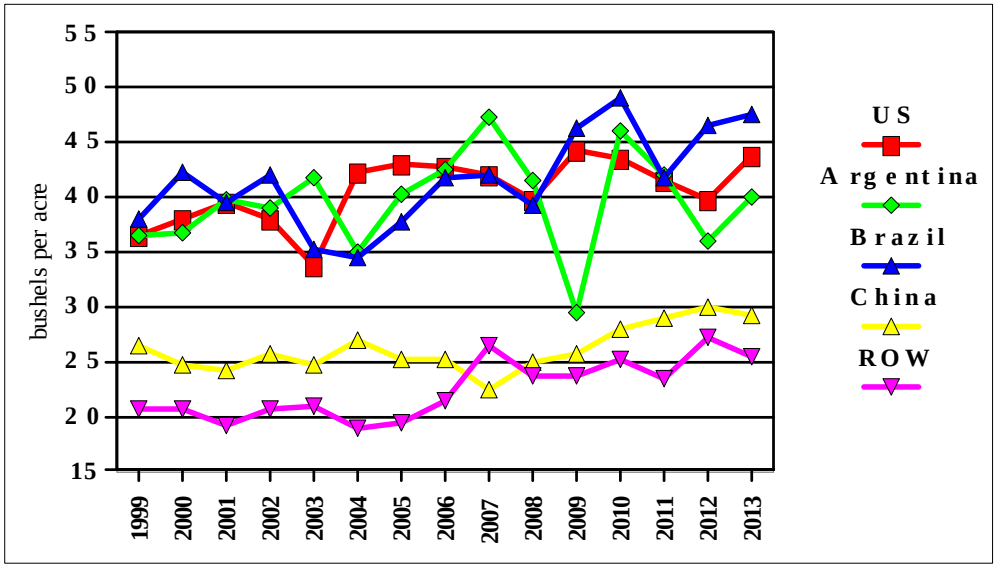
Figure 7 shows the world soybean production by country/region. World soybean production has increased by 80% from 6.0 billion bushels in 1999 to 10.9 billion bushels in 2013. Argentina and Brazil increased soybean production by 175% and 172%, respectively, during the same time period. The United States increased soybean production by 25% between 1999 and 2013 while soybean production increased by 140% in the ROW region. Most of that increase took place in other South American countries.



Source:FAS-PS&D

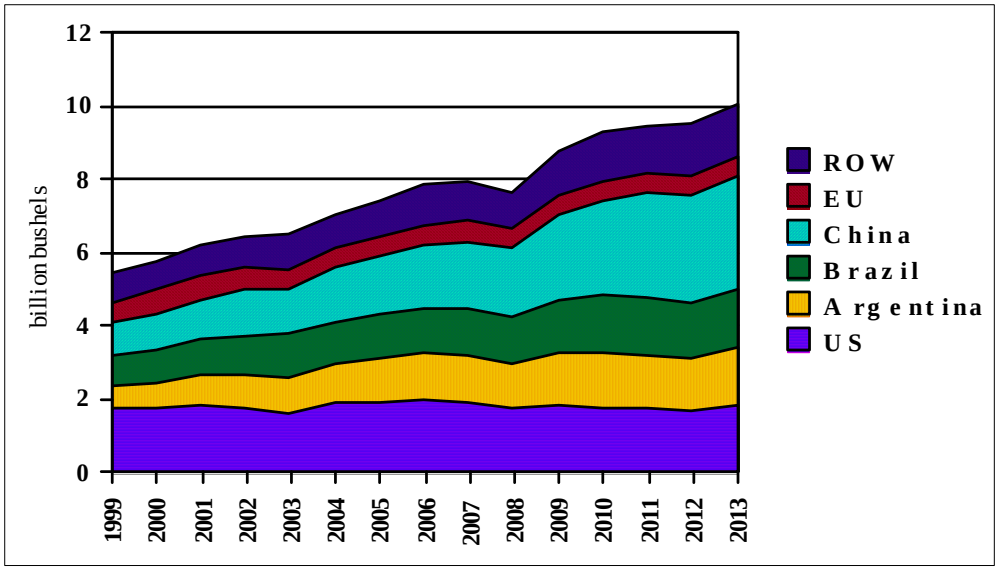
Figure 7. World Soybean Production, 1999-2013

World soybean yields have increased by 21% in the last 15 years. Soybean yields in the U.S., Brazil and Argentina are very similar throughout the time period as shown in Figure 8. In 1999 they ranged between 36 bushels per acre and 38 bushels, increasing to between 40 bushels and 48 bushels per acre in 2013. Soybean yields in China have remained at about 28 bushels per acre and ROW soybean yield increased from 21 bushels per acre to 26 bushels per acre for the same period.



Source:FAS-PS&D
Figure 8. World Soybean Yields, 1999-2013

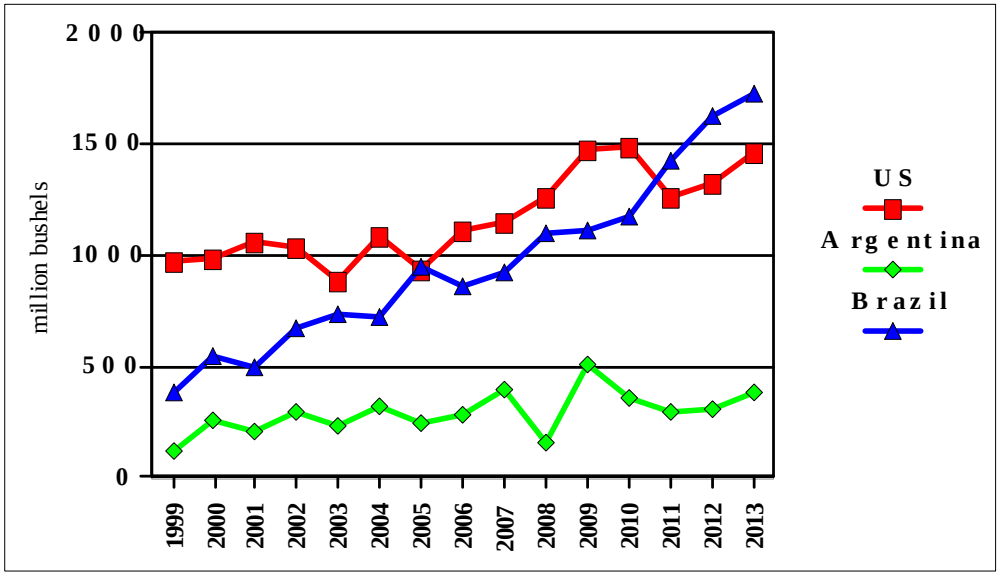
World soybean consumption increased by 120% between 1999 and 2013 (Figure 9). Soybean consumption in China increased from 841 million bushels in 1999 to 3.1 billion bushels in 2013. In 2008 China became the largest soybean consumer in the world, passing the United States. Soybean consumption increased by 87% in Brazil and 143% in Argentina for the 1999-2013 period. U.S. consumption increased by 5% from 1.7 million bushels in 1999 to 1.8 million bushels in 2013.



Source:FAS-PS&D

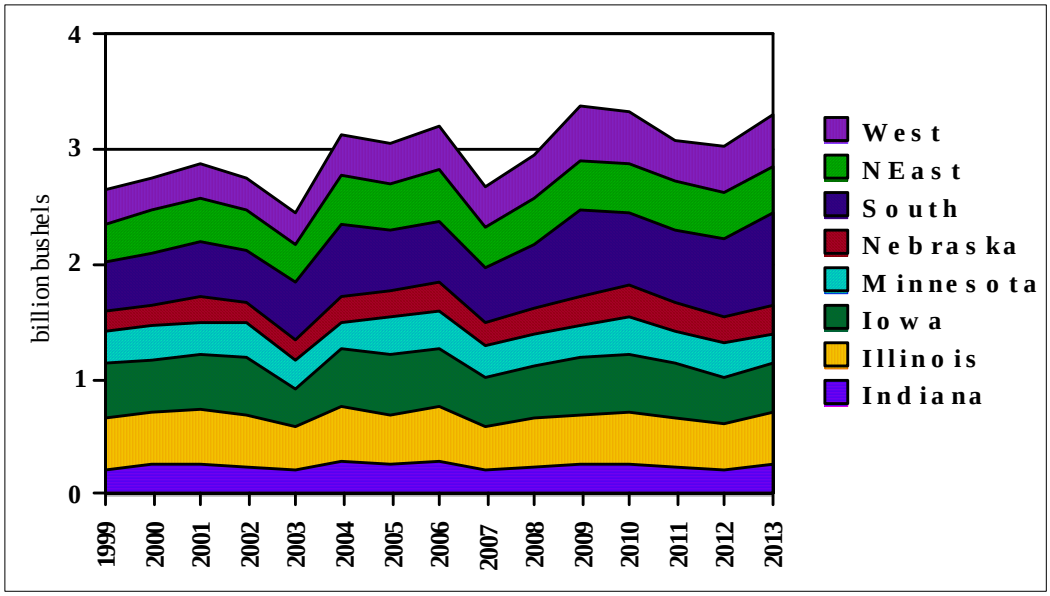
Figure 9. World Soybean Consumption, 1999-2013

The United States, Brazil and Argentina export over 90% of the soybeans traded in the world market (Figure 10). China imports about 67% of the world's exportable supplies of soybeans. The U.S. was the largest exporter of soybeans until 2011. In 2011 Brazil exported 1.4 billion bushels compared to 1.3 billion bushels from the United States and 290 million bushels from Argentina. In 1995, the U.S. exported 84% of the soybeans traded in the world market. In 2013 the United States exported 1.5 billion bushels compared to 1.7 billion bushels from Brazil.



Source:FAS-PS&D

Figure 10. World Soybean Exports, 1999-2013



Source:ERS-Oilseed Outlook

Figure 11. US Soybean Production, by Region/State, 1999-2013

U.S. Soybeans

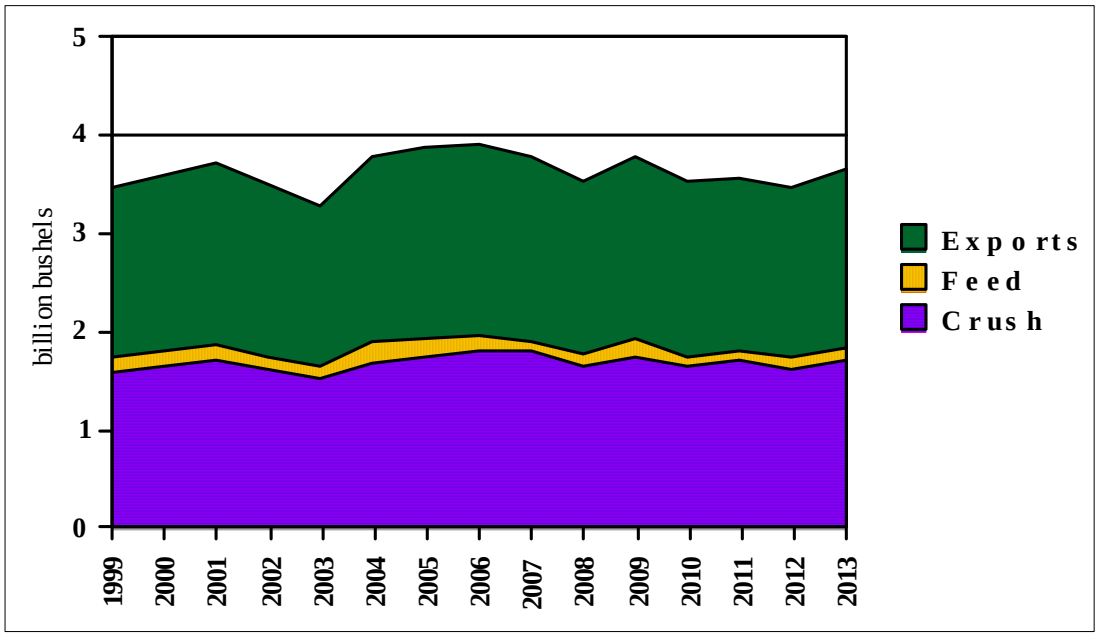
Figure 11 shows the U.S. soybean production by state/region. Illinois is the largest producer of soybeans (461 million bushels), followed by Iowa (415 million bushels), and Indiana (259 million bushels). Between 1999 and 2013 the fastest growth has been in the South region (103%), followed by the West (56%) and the Northeast (37%) regions.

Much of the production growth has been caused by increased harvested area rather than yield growth (Table 3). Highest soybean yields are in Nebraska, followed by Indiana and Illinois. The yield growth is fastest in the South region (35.5%), followed by the Nebraska (15.7%), and the North East region (14.9%).

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

	1998-2001	2011-13	% Change
	----------bushels per acre----------		
Indiana	44.0	46.5	5.7
Illinois	43.8	46.5	6.3
Iowa	45.0	47.0	4.4
Minnesota	40.5	40.5	0.0
Nebraska	42.5	49.2	15.7
South	29.4	39.8	35.5
North East	38.9	44.6	14.9
West	31.8	31.5	-0.9

In spite of the increased production of soybeans in Argentina and Brazil, US exports of soybeans have increased by 5% between 1999 and 2013. 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 8% and feed, seed, and waste have decreased by 21% between 1999 and 2013.



Source:FAS-PS&D

Figure 12. US Soybean Utilization, 1999-2013

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 in 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, Viet Nam, 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, normal weather patterns continue, 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:

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

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:

$$Y^n_t = f(P^n_t, T_t) \quad (2)$$

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 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. $BP_t = a(b*E_t)$ 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-overstock 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 Condition

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 2013, the simulation is continued for 10 years until 2023. The simulation results in 2023 represent the full effects of the Energy Act of 2007 which requires the production of 15 billion gallons of corn-based ethanol.

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 2013. 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 15% between 2013 and 2023 (Table 4). U.S. exports are expected to increase from the low levels of 2012. Both Argentina and Brazil will increase exports and China and the EU are expected to continue to import small amounts of corn.

World soybean trade will increase by 56% between 2013 and 2023. China is expected to increase imports by 42% in 2023 from the 2012-2013 average (Table 4). U.S. soybean exports are expected to increase 28% 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. That trend is expected to continue into the near future. Brazil will continue to increase soybean exports to satisfy Chinese soybean demand.

Table 4. World Exports and Imports of Corn and Soybean Trade

	2012-2013	2013	2023	Change
	----------million bu----------			%
Corn				
US	1,429	2,058	1,703	19.2
Arg	728	708	962	32.1
Brazil	796	756	774	-2.7
China	-188	-272	-105	-44.0
EU	-299	-236	-223	-25.3
ROW	-1,786	-1,842	-4,211	135.8
Soybeans				
US	1,397	1,468	1,783	27.7
Arg	344	382	576	67.7
Brazil	1,681	1,728	2,418	43.8
China	-2,527	-2,707	-3,583	41.8
EU	-483	-481	-429	-11.2
ROW	-50	-43	66	NA

Figure 13 shows the projected corn exports for the United States, Brazil, Argentina and Ukraine. U.S. exports are expected to remain soft until 2017 before increasing towards the end of the forecast period. The exports for Brazil are expected to remain relatively constant until 2017 before increasing later in the forecast period. Exports are expected to increase 32% and 48% for Argentina and Ukraine, respectively, for the 2013-2023 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.

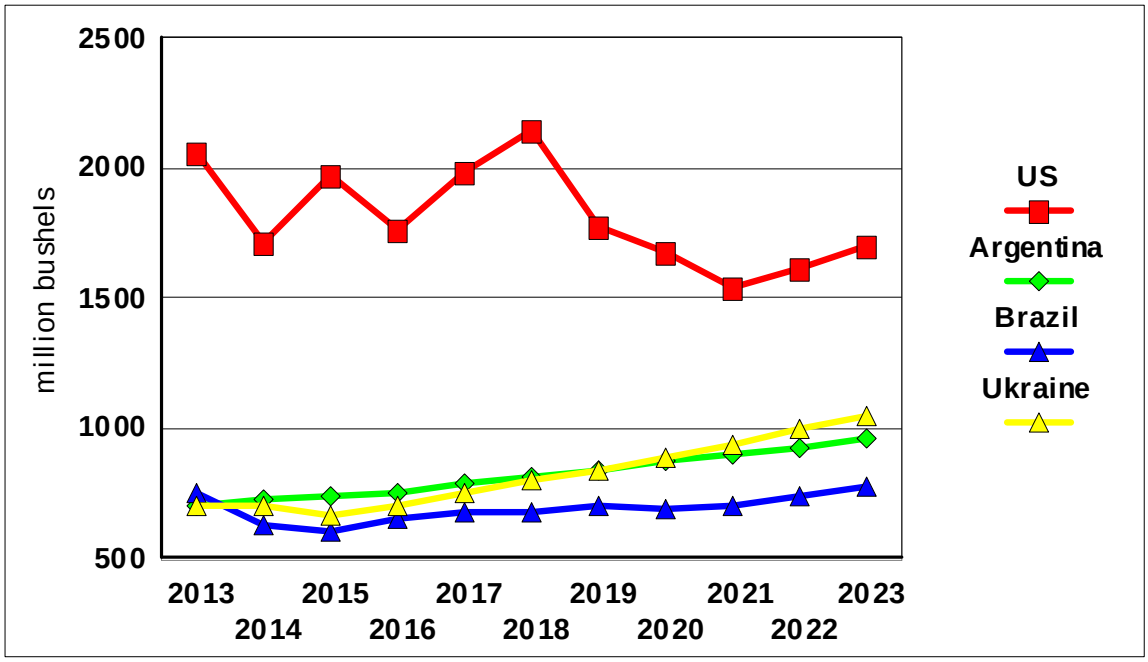


Figure 13. Projected Corn Exports by Major Exporters

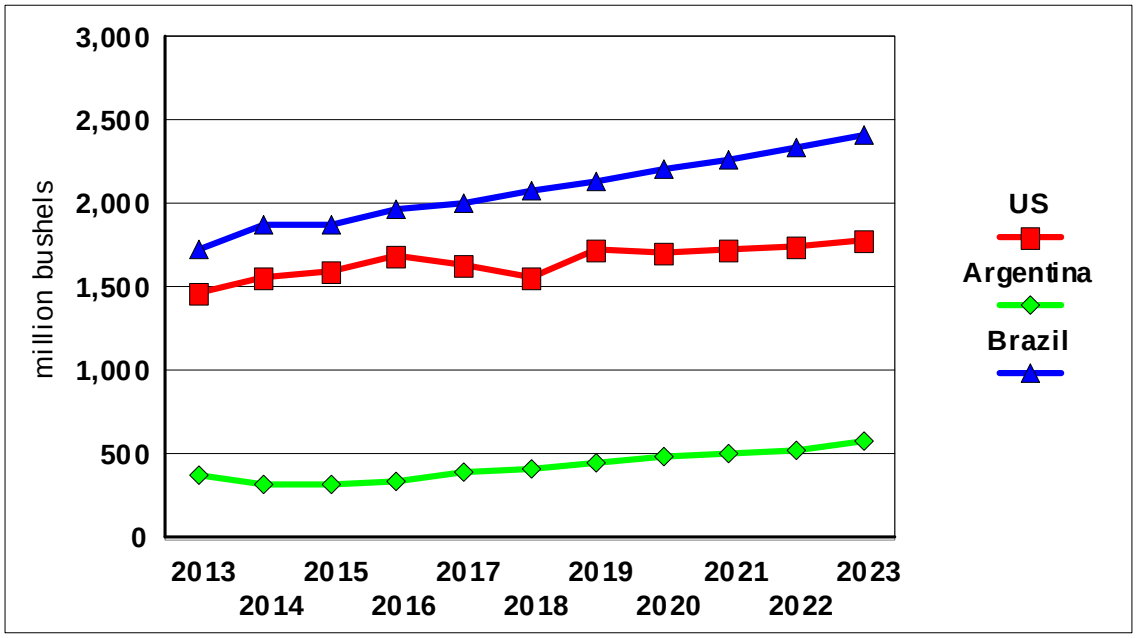


Figure 14. Projected Soybean Exports by Major Exporters

World Production of Corn and Soybeans

World corn production is expected to increase by 11%, from 29 billion bushels in 2012-2013 average to 32 billion bushels in 2023. The U.S. will increase corn production by 25% (Table 5). Brazil's production in 2023 is expected to be larger than the 2012-2013 average. Historically, Brazil

has produced about 2.5 billion bushels of corn per year. Chinese corn production is expected to increase by about 21% to 9.9 billion bushels by 2023 but not enough to prevent the importation of corn for domestic use. Corn production in the European Union is expected to increase from 2.4 billion bushels in 2013 to about 2.9 billion bushels in 2023 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 during the forecast period. Argentine corn production has ranged between 1 million and 1.2 million bushels per year and it is expected to remain near that level.

Table 5. World Corn and Soybeans Production

	2012-2013	2013	2023	Change
	----------million bu----------			%
Corn				
US	11,738	13,989	14,641	24.7
Arg	1,034	1,024	1,193	15.4
Brazil	2,973	2,756	3,251	9.4
China	8,201	8,307	9,899	20.7
EU	2,437	2,557	2,865	17.6
ROW	1,456	1,191	1,454	-0.1
Soybeans				
US	3,173	3,319	3,921	23.6
Arg	2,044	2,146	2,406	17.7
Brazil	3,346	3,464	4,194	25.3
China	492	480	555	12.8
EU	42	44	51	21.9
ROW	1,467	1,462	1,810	23.4

The U.S. is projected to increase soybean production by about 24% in 2023. 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 3.3 billion bushels in 2013 to about 3.9 billion bushels in 2023. Argentina and Brazil are expected to increase soybean production by 18% and 25%, 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 2.0 billion bushels to 2.4 billion bushels between 2013 and 2023. 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 1 billion bushels.

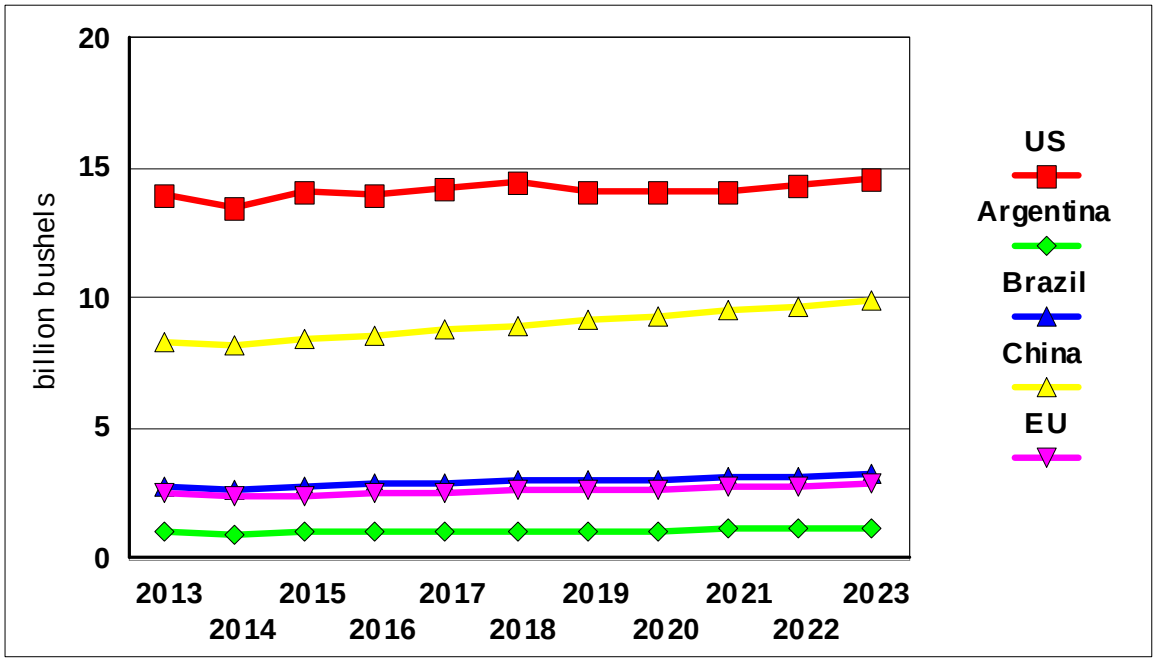


Figure 15. Projected Corn Production by Major Producer

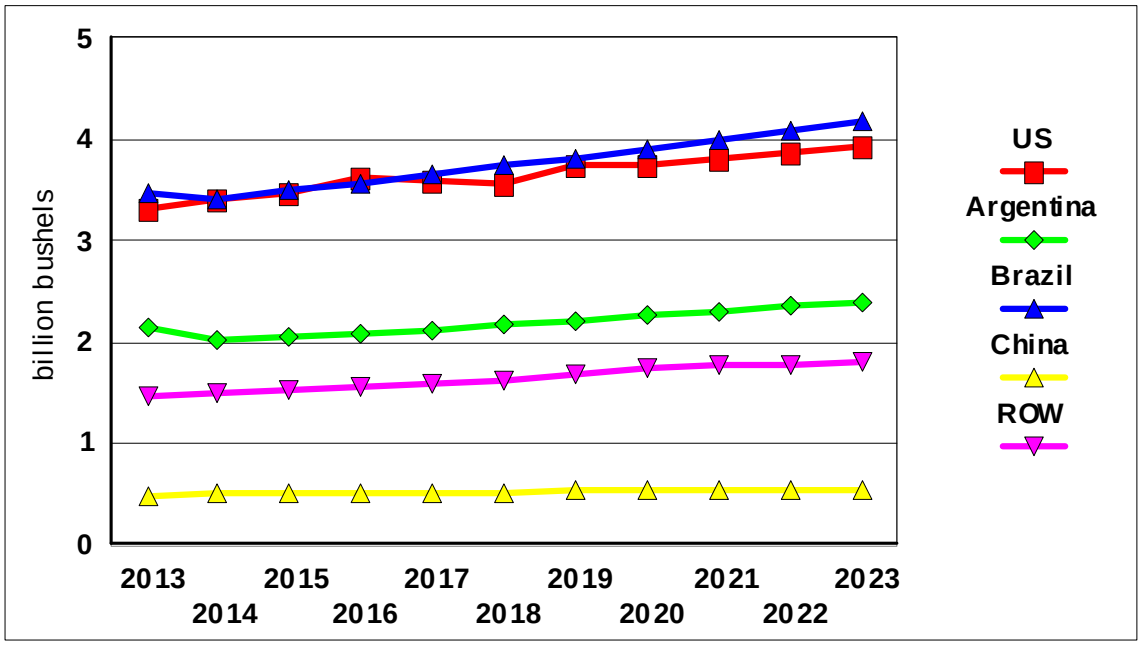


Figure 16. Projected Corn Production by Major Producers

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 2013, Illinois had the highest average yield of 180 bushels per acre followed by Indiana, Iowa and Nebraska. The average yields for 2012 and 2013 are low because of the drought in 2012. Outside of the major corn producing states, the northeast has the highest yield at 159 bushels per acre. Yields are expected to increase in all states/regions. Harvested acres in the U.S. are expected to decrease from 87.2 million acres to 85.7 million acres in 2023. 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. With the lower forecasted corn prices, harvested acres should return to a normal range.

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 West are projected to be 18.4% higher in 2023 than in 2012-2013. The largest harvested acres are in the south region followed by the Nebraska and the northeast region. Illinois had the largest harvested acres of any state followed by Iowa and Minnesota. The U.S. planted 75.7 million acres of soybeans in 2013 and harvested acres are expected to increase to 83.0 million acres by 2023.

Figure 17 shows the production of corn by state/region for the United States. Iowa is the largest corn producing state in 2013 (2.2 billion bushels), followed by Illinois and Nebraska. Total U.S. corn production in 2013 was 14.0 billion bushels and is expected to increase by 5% to 14.6 billion bushels by 2023. The fastest growth is expected to be in Iowa (12%), followed by Minnesota (11%), and the west region (10%).

In Figure 18 shows the production of soybeans by state/region. The south region was the largest soybean producing region in 2013 with 821 million bushels, followed by Illinois, the west region and Iowa. The fastest increase in soybean production is projected to be in the Minnesota (35%), followed by Iowa and Nebraska.

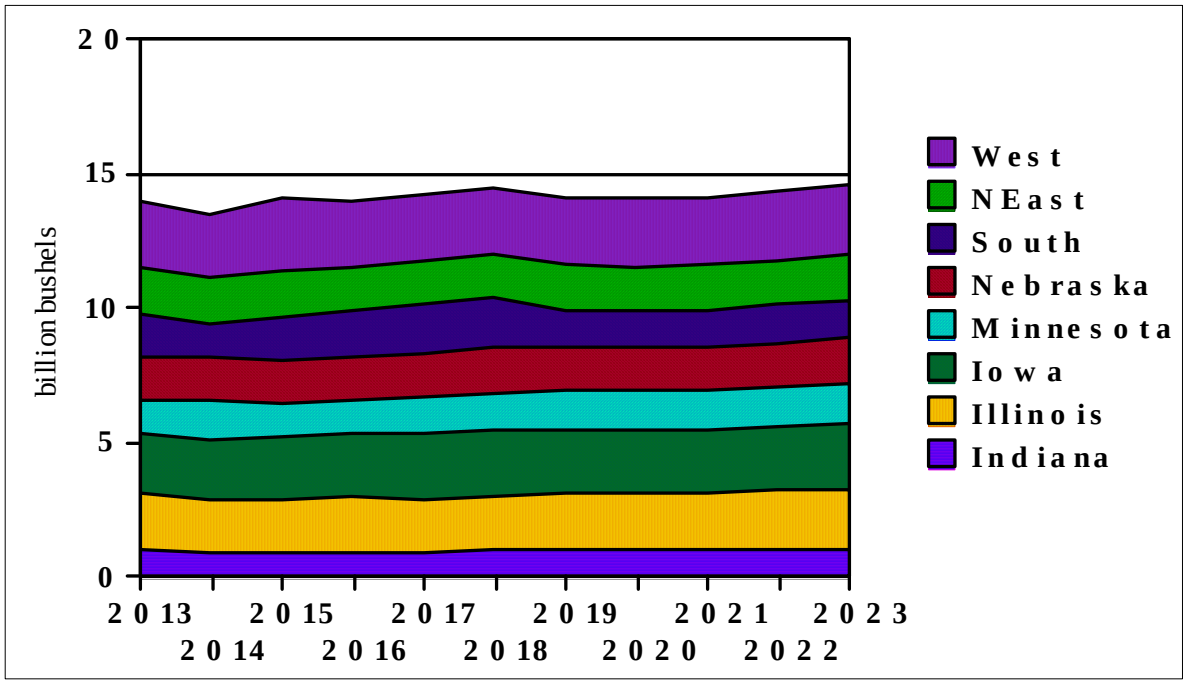


Figure 17. Projected US Corn Production by State/Region

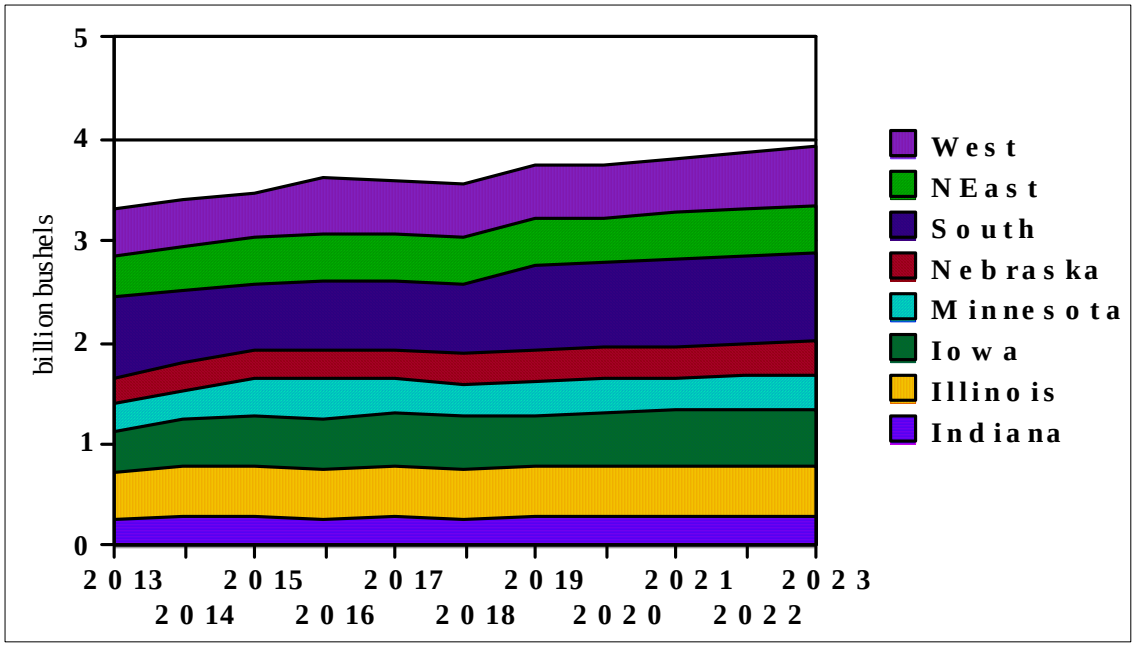


Figure 18. Projected US Soybean Production by State/Region

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

Yields	2012-2013	2013	2023	change
	---------bushels per acre--------			%
Indiana	137	174	188	37.9
Illinois	143	180	183	28.3
Iowa	153	169	190	24.4
Minnesota	165	164	186	12.9
Nebraska	156	169	178	14.3
South	130	155	150	15.0
Northeast	142	159	161	12.9
West	124	134	150	21.0
Harvested acres				
	----------million acres----------			
Indiana	5,915	5,800	5,586	-5.6
Illinois	11,975	11,700	12,138	1.4
Iowa	13,400	13,100	12,991	-3.1
Minnesota	8,215	8,100	7,964	-3.1
Nebraska	9,325	9,550	9,422	1.0
South	10,067	10,160	9,499	-5.6
Northeast	10,972	10,905	10,451	-4.7
West	17,441	17,921	17,656	1.2

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

Yields	2012-2013	2013	2023	change
	--------bushels per acre---------			%
Indiana	47	50	55	16.4
Illinois	46	49	54	16.5
Iowa	45	45	53	18.7
Minnesota	41	39	48	15.2
Nebraska	47	52	58	24.9
South	42	44	43	4.1
Northeast	44	45	47	6.6
West	32	35	38	18.4
Harvested acres				
	----------million acres----------			
Indiana	5,160	5,180	5,490	6.4
Illinois	9,165	9,400	9,362	2.1
Iowa	9,270	9,230	10,189	9.9
Minnesota	6,815	6,630	7,326	7.5
Nebraska	4,870	4,750	5,440	11.7
South	18,171	18,505	20,332	11.9
Northeast	9,108	8,886	10,098	10.9
West	13,365	13,100	14,754	10.4

Prices of Corn and Soybeans in the U.S.

Figure 19 shows the projected corn and soybean prices for 2013 through 2023. Corn price is expected to decrease to $4.58 per bushel in 2014 and then increase to $5.91 by 2023. Soybean price is expected to be about $12.36 per bushel in 2014 and slowly rise to $12.82 by 2023.

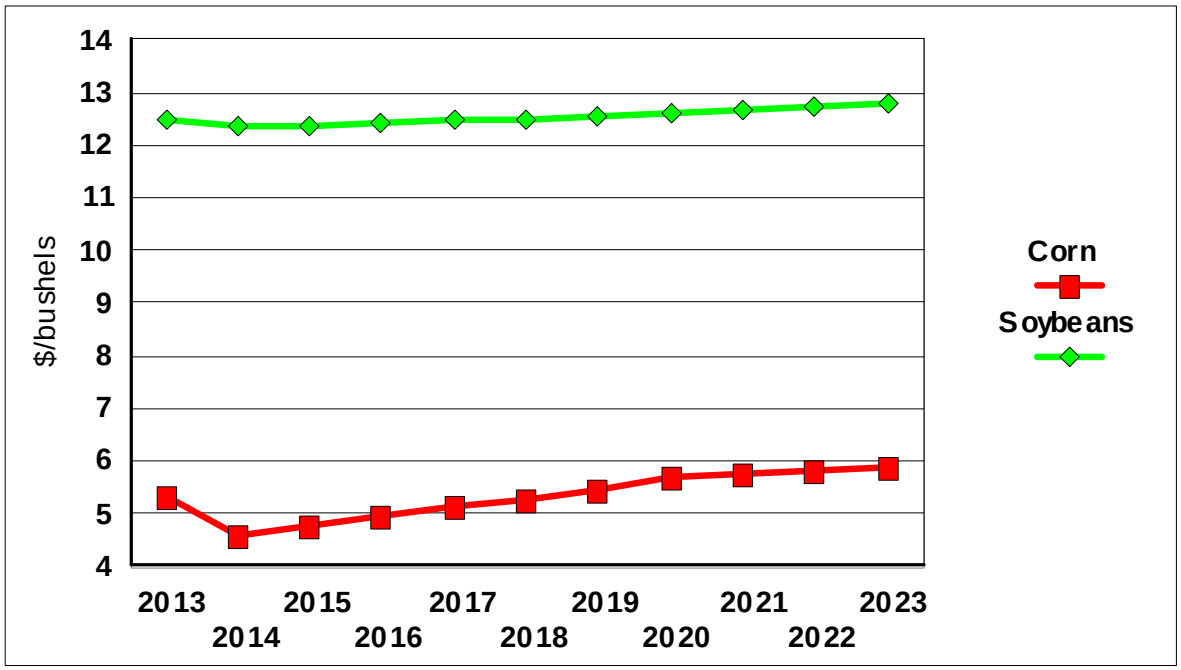


Figure 19. Projected Corn and Soybean Prices

U.S. Export and Utilization of Corn and Soybeans

Figure 20 shows the projected utilization for U.S. corn. Exports are expected to decrease from 2.1 billion bushels in 2013 to 1.7 billion bushels in 2023. The feed use of corn is projected to increase by 14% from 4.9 billion bushels in 2013 to about 5.5 billion bushels in 2023. Ethanol use of corn is expected to increase by 9% from 5.0 billion bushels in 2013 to 5.4 billion bushels in 2023. Other industrial uses are projected to increase by 14% between 2013 and 2023. Total U.S. consumption of corn is expected to increase by 6% during the forecast period.

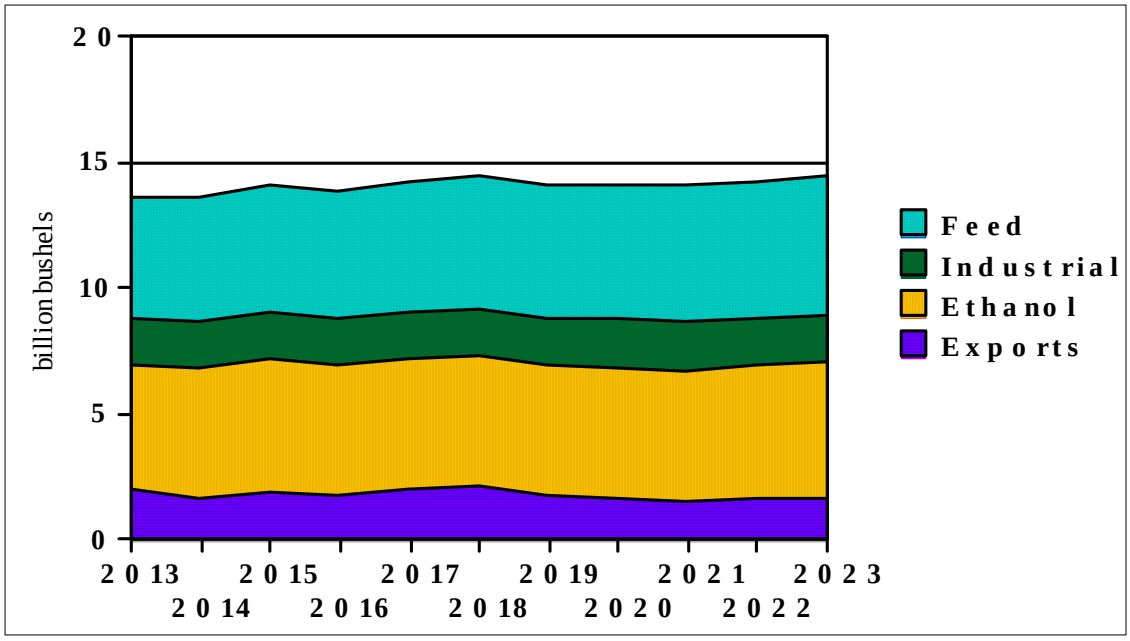


Figure 20. Projected US Corn Utilization

U.S. exports of soybeans are expected to increase during the forecast period from 1.5 billion bushels in 2013 and 1.8 billion bushels in 2023 (Figure 21). U.S. domestic processing is projected to increase by 17% from 1.7 billion bushels in 2013 to about 2.0 billion bushels in 2023. Feed and other uses are expected to increase by about 14%. Total domestic consumption is expected to increase by about 19% during the forecast period.

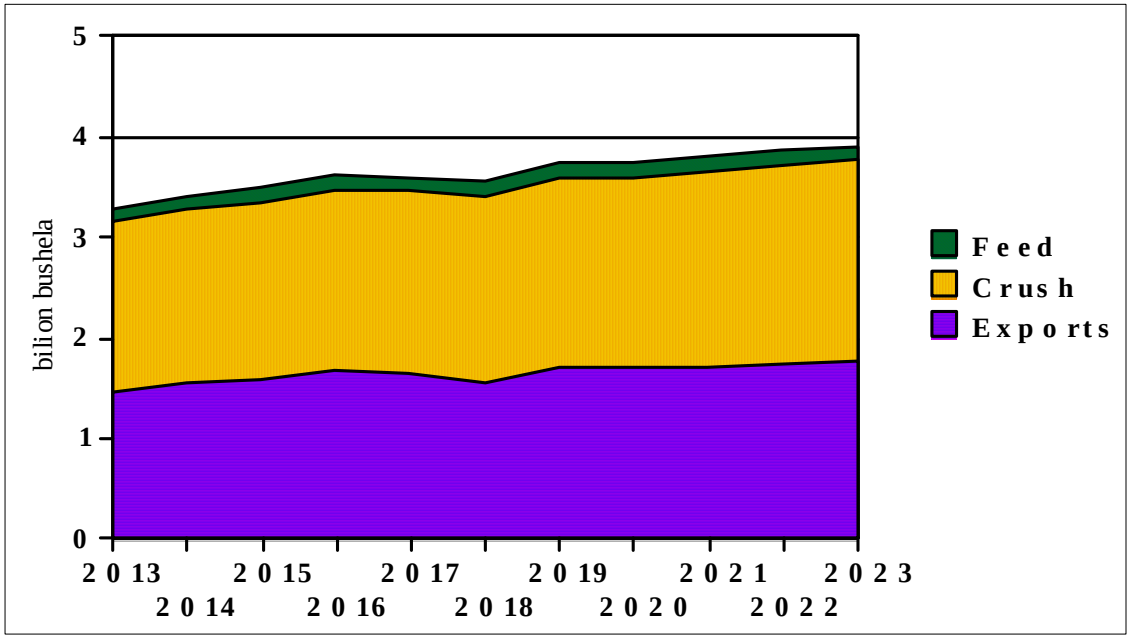


Figure 21. Projected US Soybean Utilization

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 spite of high commodity prices, world trade of corn and soybeans remained strong, due mainly to the weakening of the U.S. dollar against major currencies. China, the largest importer of soybeans, continued to import soybeans for its domestic use.

Until 2012, the United States was the largest exporter of corn, however, because of the drought in the United States, Argentina and Brazil exported a similar amount of corn. In 2013 the United States exported 2.1 billion bushels which was greater than the past six years. Feed use for corn will also increase, but only moderately. Some of the increased demand for feed use will be absorbed by DDGs.

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; about 11 billion gallons from corn-based ethanol and 25 billion gallons coming from bio-mass based ethanol by 2025. The corn based ethanol industry currently produce about 14 billion gallons. Bio-mass ethanol production has not moved beyond the testing and research stage due to high production costs. The U.S. ethanol industry is expected to continue to grow but at a slower rate than in the past. In 2013, 5.0 billion bushels of corn was used for ethanol production. It is projected that 5.4 billion bushels of corn will be used for the production of ethanol in 2023.

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 2013, China imported 2.7 billion bushels of soybeans. By 2023, it is projected to import about 3.6 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 fall from the current price of $5.30 to $4.58 in 2014 before increasing to $5.91 in 2023. Soybean price is expected to fall to $12.35 in 2014 before increasing to $12.85 in 2023.

REFERENCES

Benirschka, Martin, and Won W. Koo. *World Wheat Policy Simulation Model: Description and Computer Program Documentation.* Department of Agricultural Economics, North Dakota State University, Fargo, December 1995.

Food and Agricultural Policy Research Institute. "Implications of Increased Ethanol Production for U.S. Agriculture." FAPRI-UMC Report #10-05. August 22, 2005.

International Monetary Fund. *International Financial Statistics.* Washington, DC, January 2014.

Iowa Beef Center. "Ethanol Coproducts for Cattle," Iowa State University Extension, IBC-18, February 2002.

Lardy, Greg. "Feeding Coproducts of the Ethanol Industry to Beef Cattle," North Dakota State University Extension Service. AS-1242, April 2003.

Nerlove, M. *Lags in Economic Behavior*, Econometrica, vol 40 pp. 221-251. 1972

Oleson, Fred. Ag Canada. Personal conversation, 2005.

Renewable Fuels Association. www.ethanolrfa.org

United Nations. *FAO Production Yearbook*, various years, Rome, Italy.

U.S. Department of Agriculture, NASS. Cattle on Feed. Washington, DC, various issues.

U.S. Department of Agriculture, Economic Research Service. PS&D View (Website).

U.S. Department of Agriculture, Economic Research Service. Feed Grain Situation and Outlook Report. Washington, DC, various issues.

U.S. Department of Agriculture, Economic Research Service. Feed Yearbook/FDS-1998. Rethinking the Soybean-to-Corn Price Ratio: Is it Still a Good Indicator for Planting Decisions? Washington, DC. April 1998.

U. S. Department of Energy. Energy Information Administration. Annual Energy Outlook 2014 With Projections to 2034. (Website).

U.S. Department of Agriculture, Economic Research Service. Website. www:ers.gov/data/macroeconmics.