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The Growing Corn Economies of Mexico and the United States

Steven Zahniser, Nicolás Fernando López López, Mesbah Motamed, Zully Yazmin Silva Vargas, and Tom Capehart

Abstract

Mexico is the largest foreign market for U.S. corn in terms of export volume and value. The North American Free Trade Agreement (NAFTA), implemented in 1994, facilitated closer integration of the U.S. and Mexican corn markets, as evidenced by rising exports to Mexico and the co-movement of U.S. and Mexican prices. Since the start of 2008, U.S. corn exports to Mexico have been free of tariff and quota restrictions due to one of NAFTA's provisions. The recently signed United States-Mexico-Canada Agreement (USMCA) would continue tariff- and quota-free trade in corn. In the United States and Mexico, corn production has risen, due partly to higher yields. USDA's long-term agricultural projections suggest that in the coming decade, consumption of Mexican and U.S. grown corn will continue to increase due to expanding livestock production in both countries, even though U.S. production of corn-based ethanol is projected to decline. In terms of policy, Mexico has new support programs for small- and medium-scale producers, while the 2018 U.S. Farm Act largely maintains the income support and risk management programs that appeared in previous legislation.

Keywords: Corn, United States, Mexico, trade, domestic supports, NAFTA, USMCA.

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Contents

Introduction

In both Mexico and the United States, corn is the largest crop in terms of production and consumption volume. In Mexico, corn accounts for a large share of the population's caloric intake and is used to make tortillas and other corn-based foods—a practice that dates back thousands of years (see box, "Corn: More than a Commodity"). Corn farms in Mexico are diverse, ranging from large-scale, irrigated, commercial operations to households growing local varieties on small, rainfed plots for subsistence. In the United States, about 38 percent of corn use goes to ethanol production, and about 33 percent serves as feed for livestock.[1] U.S. growers are among the world's most productive, with the result that about 15 percent of U.S.-grown corn enters the world market, accounting for 40 percent of total world corn trade [USDA, Foreign Agricultural Service (FAS), 2019b]. Major destinations for U.S. corn exports include Japan, South Korea, Colombia, and, most significantly, Mexico. Since the start of 2008, U.S. corn exports to Mexico have been free of tariff and quota restrictions due to a provision in the North American Free Trade Agreement (NAFTA) that allows Mexican buyers to purchase substantial quantities of U.S. corn, primarily for use as livestock and poultry feed.

This report provides an overview of the corn economies of Mexico and the United States, including corn production and its geography; the sectoral composition of corn use; price relationships across the two countries; and the domestic supports available to corn producers in each country. The focus is on how the U.S. and Mexican corn sectors have changed since NAFTA's transition to free intraregional trade in corn and corn-based products and the extent to which the sectors may change further in the coming decade, according to the scenario explored in USDA's long-term agricultural projections. While many of the broad features of the U.S. and Mexican corn sectors have changed relatively little over the past decade, others have seen noteworthy developments, such as rising corn production in both countries, the consolidation of the U.S. ethanol sector, increasing feed use of corn in Mexico, and the Mexican Government's creation of new, publicly available data resources [Mexico's Secretariat of Agriculture and Rural Development (SADER—Secretaría de Agricultura y Desarrollo Rural), Agrifood and Fisheries Information Service (SIAP—Servicio de Información Agroalimentaria y Pesquera), 2019b], similar to USDA's World Agricultural Supply and Demand Estimates (WASDE) [USDA, Office of the Chief Economist (OCE), 2019b].

This report does not address the delay in planting the 2019/20 U.S. corn crop due to excessive rains in major corn-producing areas. The new crop is likely to be substantially reduced due to below-trend acreage and yields, which will result in significant shifts in corn supply, demand, and price. For details, see ERS's *Feed Outlook Report* (USDA, ERS, 2019c).

[1]The shares in this sentence are calculated using disappearance data from ERS's Feed Grain Database for the past three marketing years, 2015/16 to 2017/18 (Capehart, 2019b). The U.S. marketing year (MY) for corn as grain begins on September 1 and ends on August 31. For instance, MY 2018/19 began on September 1, 2018, and will end on August 31, 2019.

Corn: More than a Commodity

Human beings have cultivated corn (maize) in the Americas for millennia, and the origins of the plant, its cultivation, and its use as a staple crop have prompted extensive study [e.g., Katz, et al. 1974; Coe, 1994; Doebley, 2004; Long, 2008; Cheetham, 2010; Tuxill, et al., 2010; Mexico's National Coordination of Anthropology (CNAN-INAH—Coordinación Nacional de Antropología y Instituto Nacional de Antropología e Historia), 2016]. Maize, whose wild ancestor is the grass teosinte, has been in cultivation for roughly 12,000 years and is one of the world's longest known food grains [Mexico's Secretariat of Agriculture, Livestock, Rural Development, Fisheries, and Food (SAGARPA—Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca, y Alimentación), Agency for Marketing Services and Development of Agricultural Markets (ASERCA—Agencia de Servicios a la Comercialización y Desarrollo de Mercados Agropecuarios), 2018]. Among the earliest evidence of maize production in Mexico are maize fragments from approximately 6,250 years ago that were found in a cave in the southern State of Oaxaca (Benz, 2001; Piperno and Flannery, 2001). Earlier evidence in the form of stone tools with starch grain and other plant residues, excavated from beneath a rock overhang in the southern State of Guerrero, suggests that maize production took place there at least 8,700 years ago (Ranere, et al. 2009).

Researchers have identified several centers of maize domestication in central and southern Mexico and Guatemala where farmers selected for traits that ultimately produced hundreds of varieties of the familiar crop with large ears and soft, densely-packed kernels (Serratos-Hernández, et al. 2016). After boiling and steeping dried maize kernels in an alkaline solution (usually of lime), Mesoamerican cooks would grind the resulting mixture into a dough for making tortillas, the staple that fed emerging civilizations throughout the region. This process—known as nixtamalization—was revolutionary from a nutritional standpoint, as it greatly increases the corn's content of protein, calcium, niacin, and iron and is still in use today [International Maize and Wheat Improvement Center (CIMMYT—Centro Internacional de Mejoramiento de Maíz y Trigo), 2015; Cravioto, et al., 1945; Bressani and Scrimshaw, 1958; Bressani et al., 1958; Katz et al., 1974].

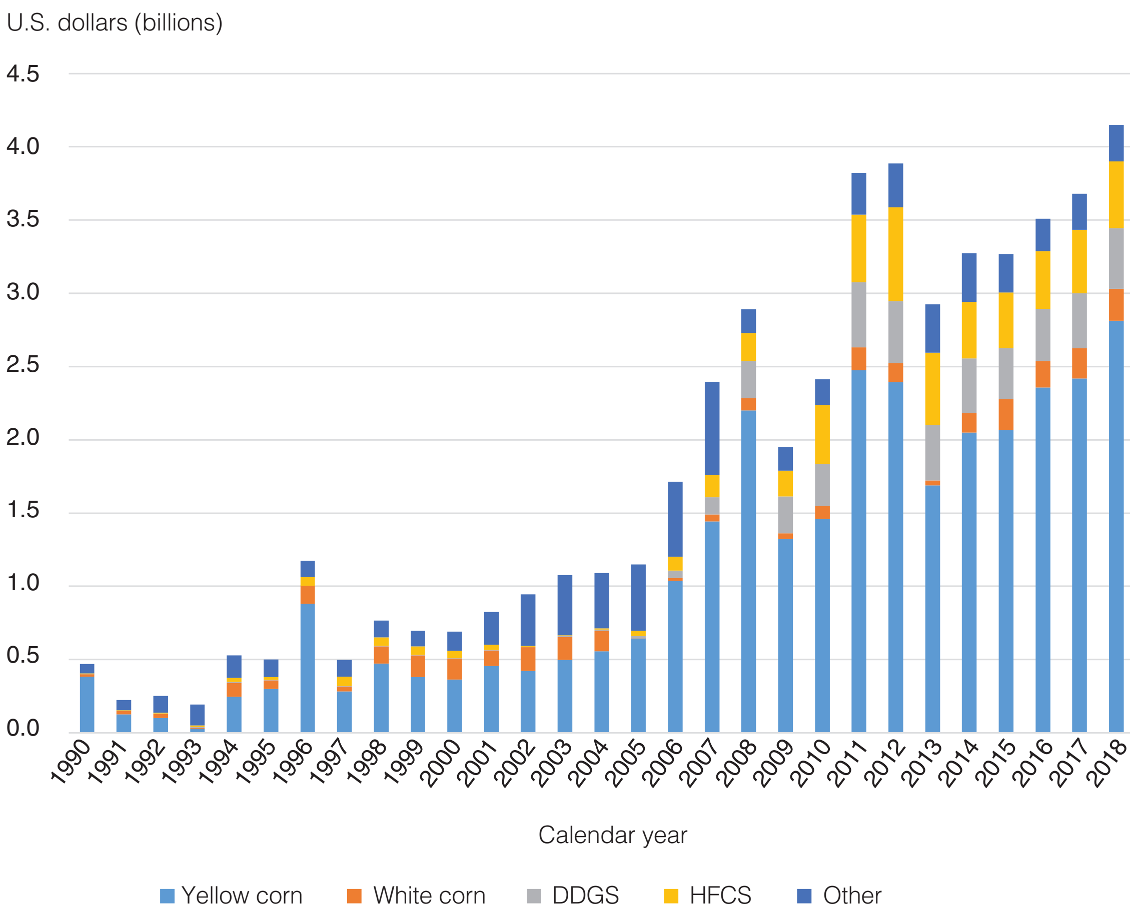
Knowledge and cultivation of the crop gradually spread throughout the Americas in complex patterns that are still the subject of scholarship and debate (e.g., Serratos-Hernández, et al. 2016, Kistler, et al., 2018), including to native inhabitants of the southwest region and later the eastern seaboard of what is today the United States (Ranum et al., 2014). Centuries later, settlers spreading into the U.S. Midwest encountered a favorable geography and climate for corn production to feed their livestock (Hudson, 1994). Over time, new technologies in transportation and refrigeration gradually delinked corn and livestock production, allowing corn growers to specialize increasingly in their crop (Hamilton, 2008). With the aid of enhanced seed varieties, mechanization, and fertilizers, farms grew in size, and corn production soared.

From NAFTA to USMCA

NAFTA, implemented in 1994, opened a new chapter in U.S.-Mexico corn trade. From 1994 to 2007, the agreement permitted Mexico to regulate U.S. access to its corn market via a tariff-rate quota (TRQ). While these TRQs aimed to assist Mexico's domestic producers as they adjusted to international markets, they also constrained the country's ability to satisfy its growing demand for corn through the importation of yellow corn. Consequently, the Mexican Government opted to pursue a more liberal trade policy toward corn than that which NAFTA outlined, particularly during the later years of the transition to free trade. As a result, U.S. corn entered Mexico relatively freely during this period.[2]

Figure 1

U.S. exports to Mexico of corn and corn-based products have increased since the end of NAFTA's transition to free trade



DDGS = distillers' dried grains with solubles. HFCS = high fructose corn syrup.

Source: USDA, Economic Research Service, and SADER, ASERCA calculations, using data from U.S. Department of Commerce, Census Bureau, *Foreign Trade Statistics*, as cited by USDA, FAS (2019a).

[2]For example, NAFTA specified a duty-free quota for U.S. corn of about 3.7 million metric tons for 2007, with an over-quota tariff equal to the greater of 18.2 percent or 1.7 U.S. cents per kilogram. However, Mexico opted to apply a tariff of about 1–3 percent to yellow corn and created an additional duty-free quota of 1.3 million metric tons for corn imported from any country. With these policies in place, U.S. corn exports to Mexico equaled about 8.2 million metric tons in 2007 (Zahniser and Crago, 2009).

Beginning in 2008, NAFTA lifted all formal restrictions, allowing U.S. corn to enter Mexico free of all tariffs and quotas. In this policy context, the annual value of U.S. exports to Mexico of corn and corn-based products has increased by about $1.8 billion in nominal terms since 2007 (fig. 1). During the period 2016-18, the United States sold an annual average of 15.1 million metric tons of corn to Mexico, valued at about $2.8 billion, with additional corn-related products adding around another $1 billion (USDA, FAS, 2019a). As the number one foreign buyer of U.S. corn, Mexico received about one-fourth of all U.S. corn exports (USDA, FAS, 2019a), representing about 4 percent of total U.S. corn production [USDA, National Agricultural Statistics Service (NASS), 2019]. Imports accounted for roughly one-third of Mexico's total corn supply (USDA, FAS, 2018b), and 98 percent of those imports came from the United States during 2016–18, with most of the remainder coming from Brazil [Mexico's Secretariat of Economy (SE—Secretaría de Economía), 2019]. At the same time, Mexico has emerged as a more consistent exporter of white corn, selling an annual average of about 1.4 million metric tons of this product to foreign buyers during 2016–18 (SE, 2019). U.S. corn imports from Mexico, however, are small in total volume, with an annual average of about 37,000 metric tons during 2016–18 (USDA, FAS, 2019a).

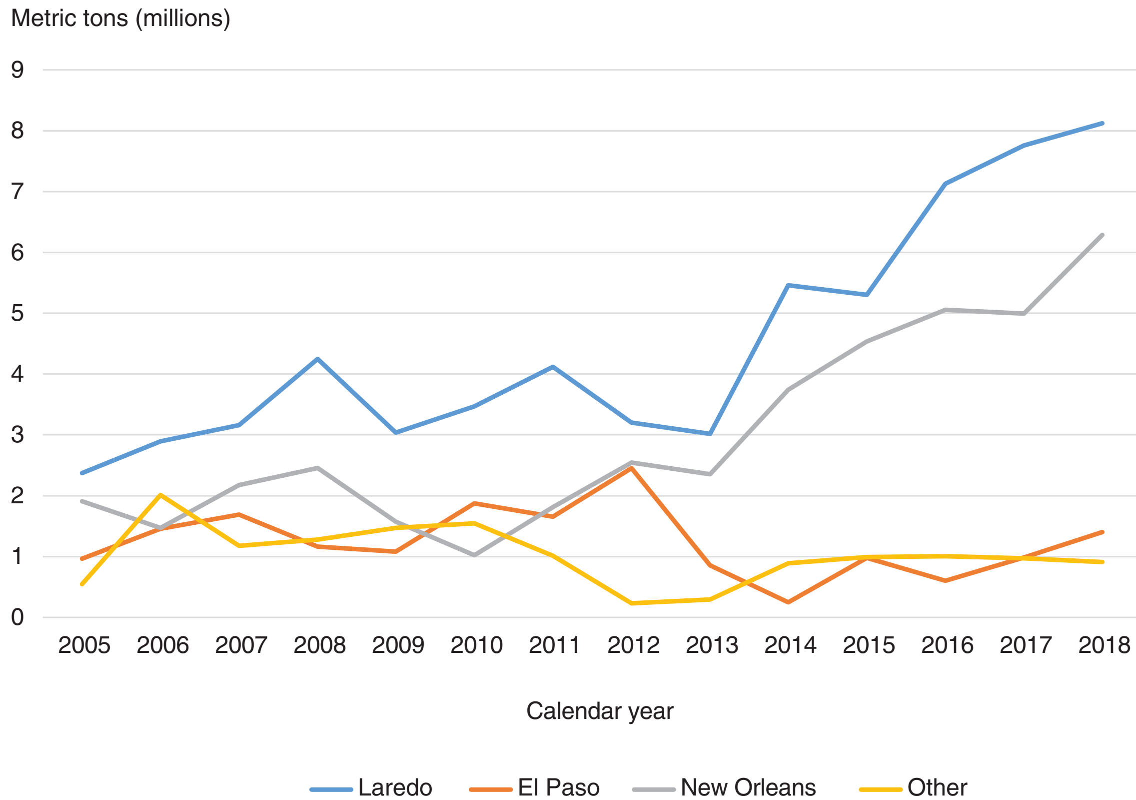
The bulk of U.S. corn exports to Mexico are shipped from the United States via two Customs Districts: Laredo, Texas—a major crossing for U.S.-Mexico trade—and New Orleans, Louisiana—a major seaport for U.S. agricultural trade in general (fig. 2).[3] With U.S. corn exports to Mexico growing since the end of NAFTA's transition to free trade and particularly since 2013, a larger share of this trade utilizes these two Customs Districts. Between 2005–07 and 2016–18, the Laredo District's share increased from 39 percent to 51 percent, while New Orleans's share increased from 25 percent to 36 percent.

In November 2018, the Canadian, Mexican and U.S. Governments signed the United States-Mexico-Canada Agreement (USMCA), a new trade accord that would replace NAFTA while continuing tariff- and quota-free trade among the member countries in the overwhelming majority of products, agricultural and nonagricultural, including corn. (Office of the U.S. Trade Representative, 2018; Secretaría de Economía [SE], 2018a). The USMCA also includes new provisions regarding the notification of export restrictions and commitments to share information regarding domestic support measures that potentially harm trade. In June 2019, the Mexican Senate ratified the USMCA by a vote of 114 to 4; at the time of writing, the new agreement had not yet been ratified by the national legislatures of the United States and Canada.

[3]One should take care not to confuse customs districts with the ports for which they are named. For instance, the Laredo Customs District encompasses the Ports of Laredo and Eagle Pass, among others. During 2016–18, the Port of Laredo accounted for 53 percent of the total value of U.S. corn exports to Mexico departing from the Laredo Customs District, and Eagle Pass accounted for 42 percent, with other ports such as Progreso accounting for the remaining 5 percent. Similarly, the New Orleans Customs District encompasses the Ports of New Orleans, Gramercy, and Baton Rouge, among others. During 2016–18, these ports accounted for 57 percent, 26 percent, and 15 percent, respectively, of the total value of U.S. corn exports to Mexico departing from the New Orleans Customs District (U.S. Department of Commerce, Census Bureau, 2019).

Figure 2

The Customs Districts of Laredo and New Orleans have become more prominent departure points for U.S. corn exports to Mexico



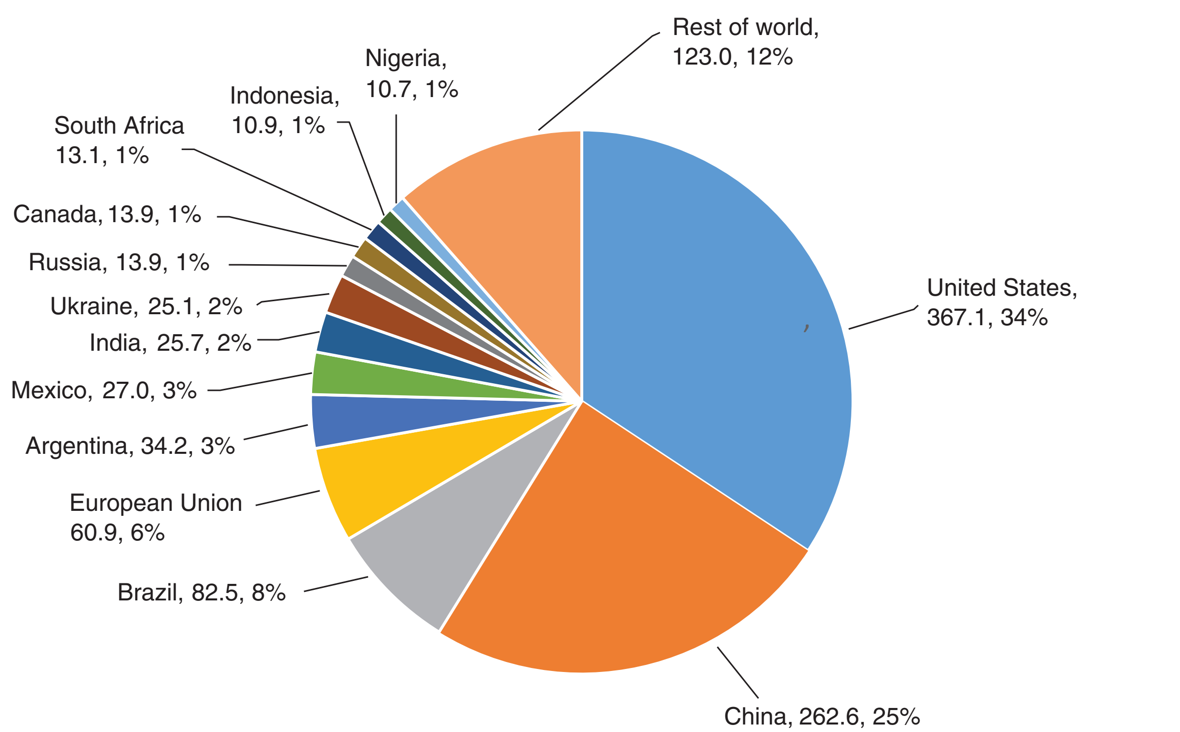
Source: USDA, Economic Research Service, and SADER, ASERCA calculations using data from USDA, FAS (2019a).

Both countries look to increase corn production

The United States and Mexico are both large corn producers, and their production is expected to rise in the coming decade. As the world's largest corn producer, the United States accounts for 34 percent of global production, and Mexico, the world's sixth largest, accounts for 3 percent (fig. 3). During marketing years (MYs) 2015/16 to 2017/18, U.S. farmers produced an annual average of 367.1 million metric tons (about 14.5 billion bushels), while Mexican farmers produced 27.0 million metric tons (1.1 billion bushels).[4]

Figure 3

The United States and Mexico are among the world's largest corn producers



Note: Figure depicts average annual corn production by country during U.S. marketing years 2015/16 to 2017/18. Data labels indicate country, average annual production (millions of metric tons), and share of world production (percent).

Source: USDA, Economic Research Service and SADER, ASERCA calculations using production data from USDA, FAS (2019b).

[4]The U.S. marketing year (MY) for corn as grain begins on September 1 and ends on August 31. For instance, MY 2018/19 began on September 1, 2018, and will end on August 31, 2019.

Mexican corn production in the form of grain reached 27.7 million metric tons in Mexico's 2017 agricultural year (AY).[5] Of this quantity, about 87 percent was white corn, and the remainder was yellow. The year before, AY 2016, saw a record crop for Mexico, owing to favorable weather and expanding area planted, as many sorghum-growing areas switched to corn in response to a sugarcane aphid infestation.

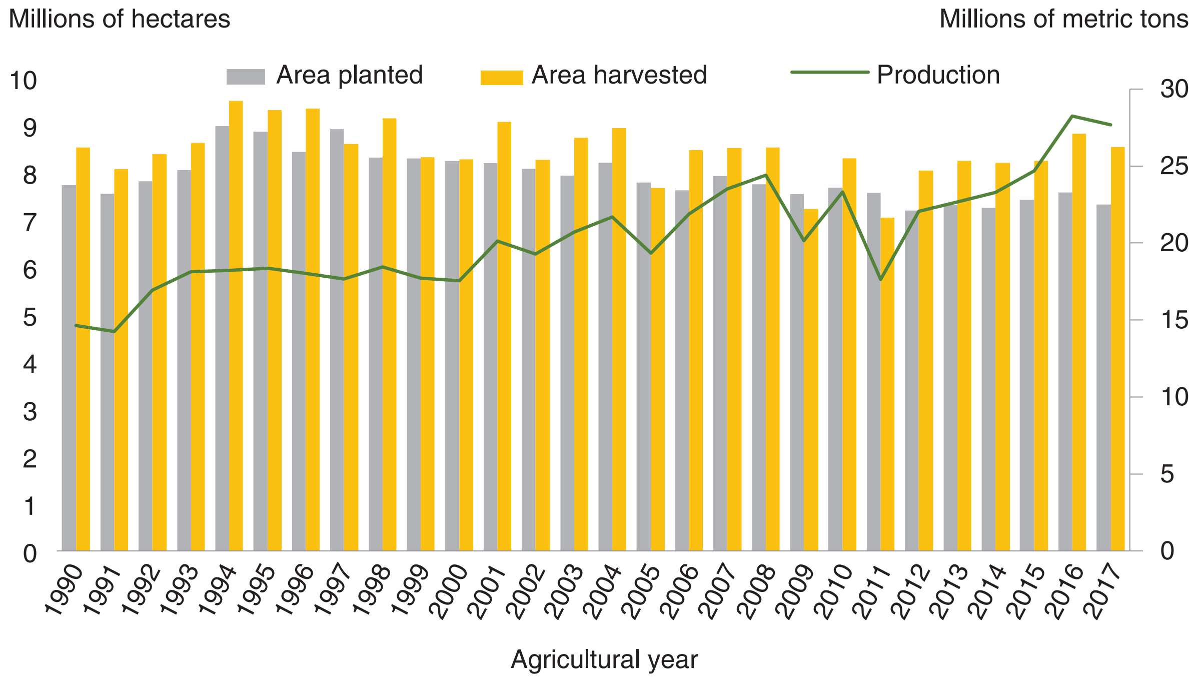
Mexico's corn production has grown since the end of NAFTA's transition (fig. 4). Between 2007 and 2017, production increased at a compound annual rate of 1.6 percent, with white corn growing at 1.2 percent and yellow corn at 7.0 percent. Behind these growth rates are rising yields, thanks to increased mechanization and improved seed varieties. Over the period 2012–17, mechanized corn area (for grain) grew at an annual average rate of 3.5 percent—7.8 percent for irrigated production and 2.1 percent for rainfed production. Over that same period, the area cultivated with improved corn seed increased at an annual average rate of 4.4 percent—8.2 percent for irrigated land and 2.7 percent for rainfed production. As a result of these advances in technological adoption, Sinaloa and Jalisco, Mexico's largest and second largest producing States for white corn, saw yields rise by 1.8 percent and 0.6 percent, respectively, between 2007 and 2017 (see box, "Where is Corn Grown in Mexico and the United States?").

In AY 2017, Mexico planted about 7.5 million hectares of corn (fig. 4). Due to rising yields, Mexico has raised production while devoting less land to corn. Between 2007 and 2017, area planted fell at a compound annual rate of 0.7 percent, or about 576,000 hectares over the period. Total area planted to corn has fallen by about 706,000 hectares since AY 1993, the year before NAFTA's implementation. Apart from the gains achieved through higher yields, rising prices over this time period helped lift the value of corn production in Mexico by over 100 percent in the period starting after 2005 (Dyer et al., 2018).

[5]Mexico's agricultural year (AY) is divided into two production cycles: fall-winter and spring-summer. For corn, planting in fall-winter begins in October and ends in March, while the harvest begins in December and ends as late as September. Planting in spring-summer begins in April and ends in September, while the harvest begins in June and ends as late as March. Thus, AY 2018 for corn covers the crops planted from October 2017 to March 2018 (fall-winter 2017/18) or from April to September 2018 (spring-summer 2018). Because Mexico's AY differs from the U.S. marketing year (MY), making comparisons between Mexican production statistics and USDA's estimates of Mexican production requires extra effort; for example, Mexico's spring-summer 2016 and fall-winter 2016/17 seasons roughly correspond to U.S. MY 2016/17. Rounding to the nearest 100,000 metric tons, both the sum of Mexico's corn production for spring-summer 2016 and fall-winter 2016/17 and the USDA estimate for Mexico's corn production in U.S. MY 2016/17 (as reported by USDA, FAS, 2019b) equal 27.6 million metric tons.

Figure 4

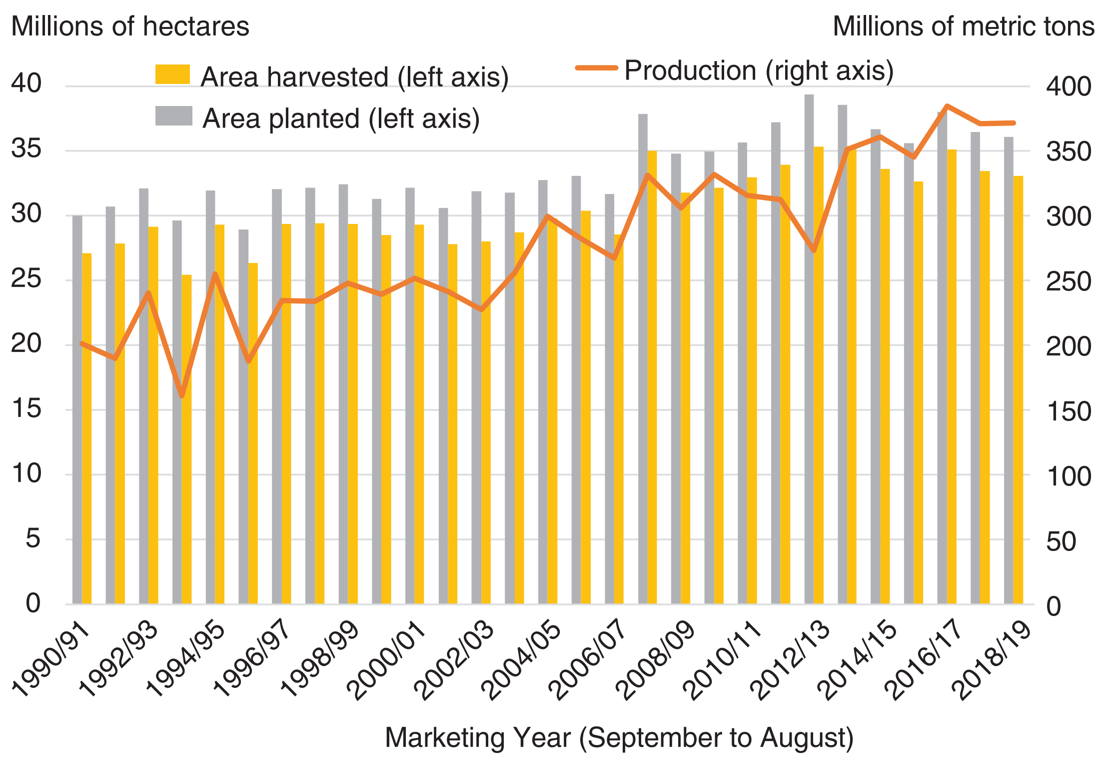
Mexican corn area and production, agricultural years 1990–2017



Source: USDA, Economic Research Service and SADER, ASERCA calculations using data from SADER, SIAP (2019a).

Figure 5

U.S. corn area and production, marketing years 1990/91–2018/19



Source: USDA, Economic Research Service and SADER, ASERCA calculations using data from USDA, ERS (2019b).

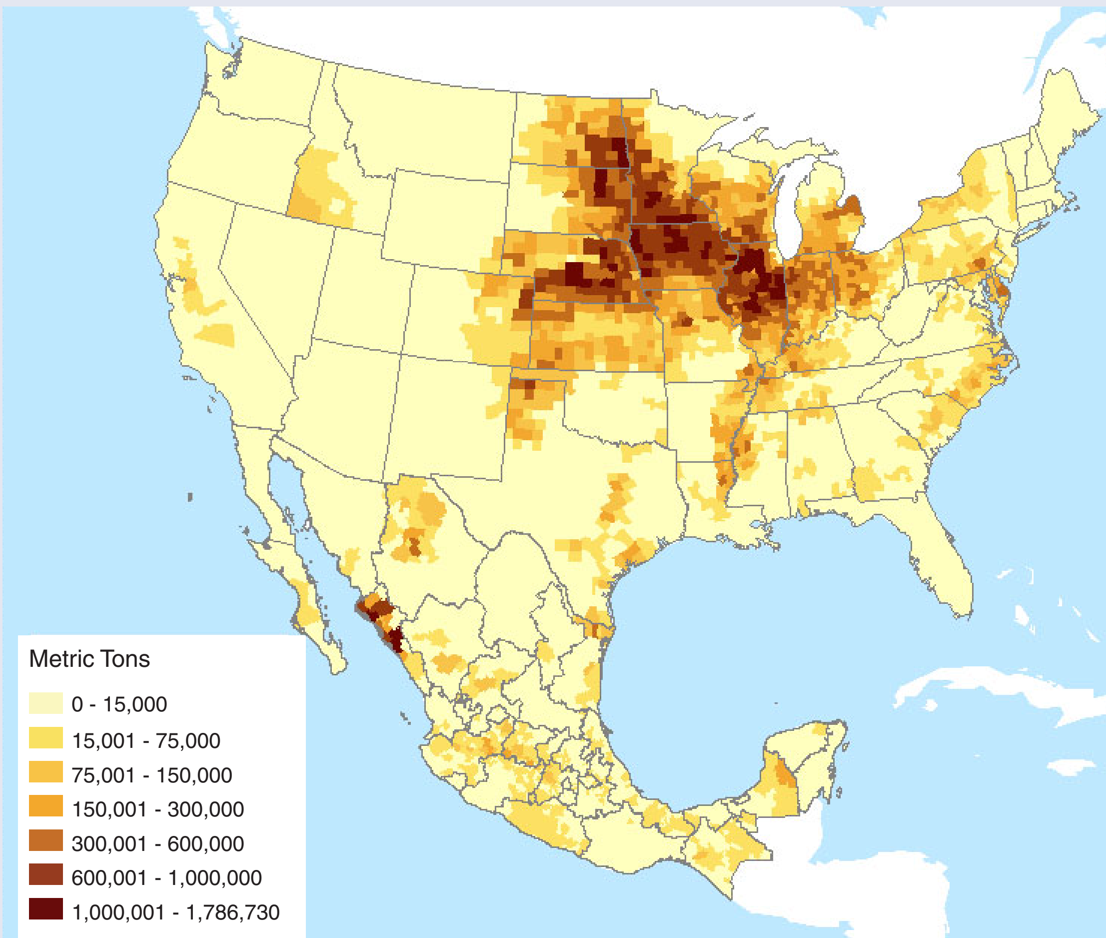
U.S. corn production since NAFTA's transition to intraregional free trade has also steadily increased, due to both rising yields and increased area, enabling the sector to respond to growing domestic and foreign demand (fig. 5). Corn area harvested in the United States averaged 33.8 million hectares during 2015–17, a 7.7-percent rise compared with 2005–07 and a 22.8 percent rise compared with 1991–93. While some of this area is new to cultivation, a significant portion reflects more frequent rotations of corn and the displacement of other crops (Wallender et al, 2011). Across the same two periods, yields rose by around 35 percent and currently average close to 10 metric tons per hectare. In certain areas, irrigated production achieves average yields above 12 metric tons per hectare (USDA, NASS, 2019a). Yield improvements are rooted in productivity-increasing inputs such as enhanced seed varieties, fertilizers, and pesticides, as well as cultivation techniques such as reduced tillage, more optimal crop rotations, and irrigation. Irrigated corn not only produces higher yields but also is less vulnerable to fluctuations in rainfall. An annual average of 7.1 million hectares (17 million acres) of area harvested with corn for grain during 2015–17 was irrigated, accounting for 21 percent of the total (USDA, NASS, 2019a).

Where is corn grown in Mexico and the United States?

As the leading crop of both Mexico and the United States, corn appears across many parts of each country, but cultivation is concentrated in areas better suited for corn (box fig. 1). For example, although white corn is grown in each of Mexico's 32 States (box fig. 2, box table 1), 10 States account for 84 percent of production, and two States—Sinaloa and Jalisco—account for over one-third. The production attributes of these two States differ substantially from each other. Sinaloa primarily grows white corn during the fall-winter season and relies almost entirely on irrigation, while Jalisco plants white corn in the spring-summer season, with over 90 percent of its production rainfed. During AYs 2014–16, an average of 82 percent of Mexico's white corn area was rainfed, compared with 54 percent for yellow corn (SADER, SIAP, 2019a). About three-fourths of Mexico's white corn production comes from spring-summer plantings.

Figure 1

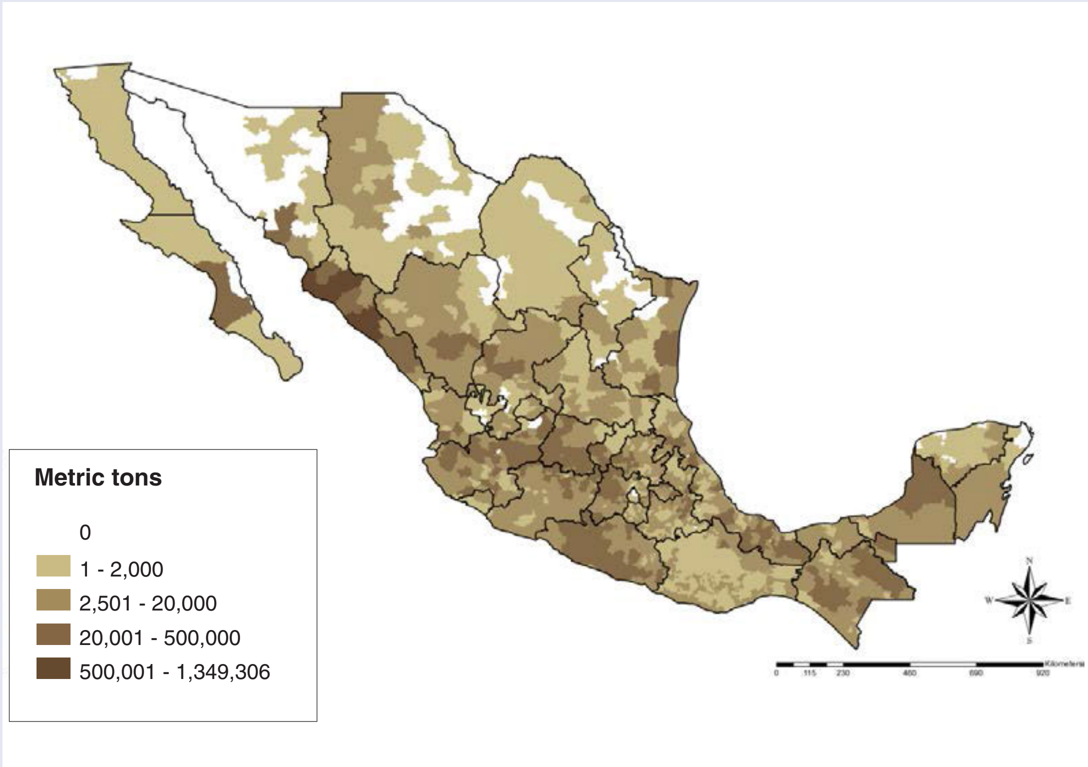
Geographic location of U.S. and Mexican corn production (all seasons, rainfed and irrigated, white and yellow)



Source: Prepared by USDA, Economic Research Service and SADER, ASERCA, using municipal-level data from SADER, SIAP (2019a) and county-level data from USDA, NASS (2018).

Figure 2

Geographic location of Mexico's white corn production, 2017



Source: Prepared by SADER, ASERCA using municipal-level data from SADER, SIAP (2019a).

Table 1

Top 10 Mexican white corn producing States, based on 2014–17 average

State	Production	Area harvested	Yield	Share of production that is: Spring-Summer Plantings	Share of production that is: Irrigated
	Metric tons (millions)	Hectares (millions)	Metric tons per hectare	Percent	
Sinaloa	5.3	0.512	10.3	11.7	93.9
Jalisco	2.9	0.448	6.5	99.2	6.2
México	2.0	0.501	4.0	99.9	15.9
Michoacan	1.8	0.439	4.1	98.2	23.3
Guanajuato	1.5	0.383	4.0	99.9	32.4
Veracruz	1.3	0.565	2.2	66.4	0.9
Guerrero	1.2	0.452	2.8	94.1	8.2
Chiapas	1.1	0.586	1.8	83.1	1.8
Puebla	1.0	0.519	1.9	95.3	8.9
Hidalgo	0.7	0.242	2.9	89.2	23.8
Other States	3.9	2.033	1.9	90.1	28.3
Total	22.8	6.7	3.4	84.7	18.3

Source: USDA, Economic Research Service and SADER, ASERCA calculations using data from SADER, SIAP (2019a).

Mexico's yellow corn sector is about one-seventh the size of the country's white corn sector in terms of output (box fig. 3, box table 2). About three-fourths of Mexico's yellow corn production comes from spring-summer plantings, and roughly 70 percent is irrigated. Chihuahua, bordering the U.S. States of New Mexico and Texas, accounts for about 40 percent of Mexico's yellow corn production and is the largest producing State for this commodity. All of Chihuahua's yellow corn production comes from spring-summer plantings and is irrigated.

Table 2

Top 10 Mexican yellow corn producing States, based on 2014–17 averages

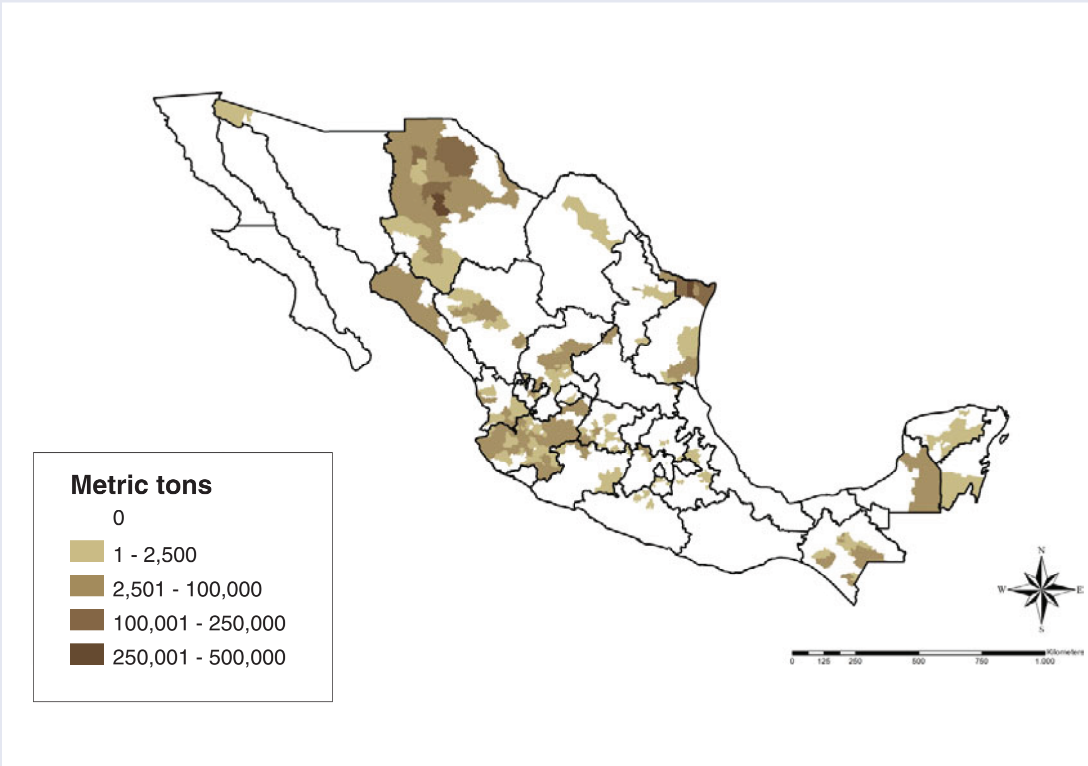
State	Production	Area harvested	Yield	Share of production that is:	
				Spring-Summer Plantings	Irrigated
	Metric tons (millions)	Hectares (millions)	Metric tons per hectare	Percent	
Chihuahua	5.3	0.140	8.6	100.0	80.5
Jalisco	2.9	0.110	6.4	99.6	8.7
Tamaulipas	2.0	0.091	6.4	2.2	94.5
Sinaloa	1.8	0.015	9.9	0.4	100.0
Chiapas	1.5	0.080	1.5	90.3	0.5
Michoacán	1.3	0.014	5.5	100.0	34.3
Zacatecas	1.2	0.010	6.3	100.0	69.3
Campeche	1.1	0.018	2.4	97.9	0.1
Durango	1.0	0.011	3.1	100.0	23.7
Guanajuato	0.7	0.004	9.6	100.0	97.5
Other States	3.9	0.048	2.1	93.1	4.9
Total	22.8	0.540	5.8	79.0	48.9

Source: USDA, Economic Research Service and SADER, ASERCA calculations using data from SADER, SIAP (2019a).

In the United States, corn cultivation occurs primarily in the country's Midwestern states, stretching from Nebraska to Ohio, a region dubbed the Corn Belt (box fig. 1). Nearly 80 percent of U.S. corn area is rainfed, with irrigated production occupying much of corn-growing areas in Nebraska, Colorado, Kansas and Texas (USDA, NASS, 2019a). The largest quantities of production occur in Iowa, Illinois, Nebraska, and Minnesota, States which also lead in yields (box table 3). Among the leading producing States, yields range from 8.8 metric tons per hectare (Kansas) to 12.5 metric tons per hectare (Iowa). The climate and geography in the leading corn-producing states combine to create ideal conditions for growing corn, with warm spring and summer temperatures averaging around 20–22 degrees Celsius, and average annual total precipitation ranging from 193–257 centimeters. Planting begins within two weeks of the last winter frost, which corresponds to early April for much of the region. Plants typically reach maturity within 100–115 days, with more northern regions with shorter growing seasons planting hybrids that mature in less than 80 days.

Figure 3

Geographic location of Mexico's yellow corn production, 2016



Source: Prepared by SADER, ASERCA using municipal-level data from SADER, SIAP (2019a).

Table 3

Top 10 U.S. corn producing states, based on 2015–17 averages

State	Production	Area harvested	Yield
	Metric tons (millions)	Hectares (millions)	Metric tons per hectare
Iowa	66.5	5.3	12.5
Illinois	54.8	4.6	12.0
Nebraska	43.0	3.8	11.4
Minnesota	37.7	3.1	12.0
Indiana	22.9	2.2	10.5
South Dakota	20.0	2.1	9.7
Kansas	16.6	1.9	8.8
Ohio	13.4	1.3	10.2
Wisconsin	13.3	1.2	10.8
Missouri	13.2	1.3	10.0
Other States	65.7	7.0	9.5
Total	367.1	33.8	10.9

Note: USDA data on corn production (area, yield, volume, and farm price) do not distinguish among different types of corn since most corn produced in the United States is Yellow No. 2. However cash market prices, trade data and export grain inspection data are available for both yellow and white corn.

Source: USDA, Economic Research Service and SADER, ASERCA calculations using data from USDA, NASS (2019a).

The U.S. Federal Government does not collect production data for white corn because of the crop's small size, but both U.S. trade figures and grain inspection data include details about white corn trade. Private-sector estimates place annual U.S. white corn production during the 2011–16 crop years in the range of 2.3–4.0 million metric tons (Global Risk Management, 2016), suggesting that white corn accounts for about 1 percent of U.S. corn production. The available evidence points to concentrations of white corn production in Nebraska, Kentucky, Tennessee, Illinois, Indiana, and Texas (Dahl and Wilson, 2002; U.S. Grains Council, 2006; Global Risk Management, 2015). Most U.S. production is contract-based and sold to food processors, including U.S. tortilla and chip makers. White corn yields are close to or on par with yellow corn (U.S. Grains Council, 2006). Production methods broadly resemble those used to grow yellow corn, with the stipulation that white corn fields remain removed from nearby yellow corn fields to prevent cross-pollination. Quality consistency issues are more salient given that the grain is destined for human consumption. As is the case for yellow corn, exports are key to U.S. growers of white corn. During MYs 2015/16 to 2017/18, the United States exported an annual average of 1.6 million metric tons of white corn, of which 59 percent went to Mexico (USDA, FAS, 2019a).

Cross-country differences motivate U.S.-Mexico corn trade

The pattern of U.S.-Mexico corn trade is due to several differences between the corn sectors of the two countries. First, relative to population, the U.S. corn sector is much larger than Mexico's, reflecting differences in the two countries' land endowments. During MY 2017/18, U.S. corn production per capita was about 1.1 metric tons, compared with 0.2 metric tons in Mexico (calculated using production data from USDA, FAS, 2019b, and population data from U.S. Department of Commerce, Census Bureau, 2018), and in 2016, arable land per capita was 0.47 hectares in the United States, compared with 0.18 hectares in Mexico (World Bank, 2019). As a result, the United States enters the global corn market primarily as an exporter, while Mexico participates mainly as an importer.[6]

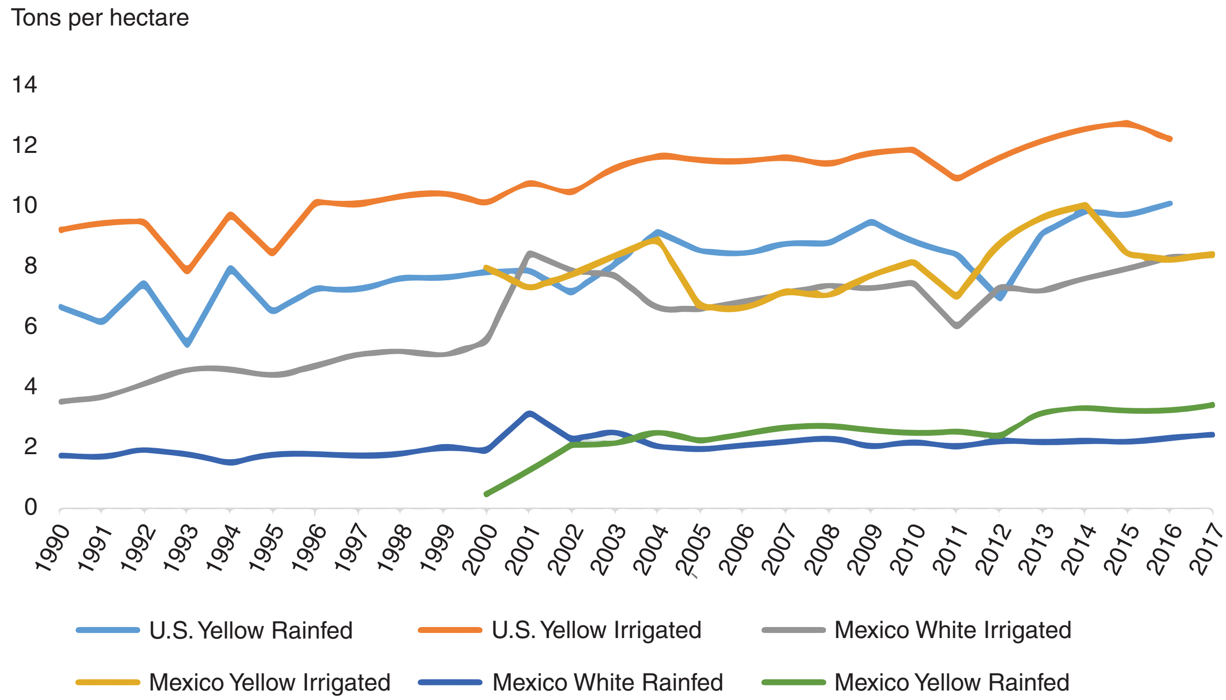
Second, the two countries specialize in different types of corn. Mexico primarily produces white corn, used mostly to make tortillas and other corn-based foods for direct human consumption, while the United States mainly produces yellow corn—used primarily as livestock feed, as a feedstock for ethanol production, and for export, with a small share consumed directly in the United States in the form of cereals, tortillas, snacks, and other foods. White corn accounts for roughly 90 percent of Mexican corn production, compared with just 1 percent in the United States. As a result, U.S. corn exports to Mexico primarily consist of yellow corn—about 93 percent during MYs 2015/16 to 2017/18, according to U.S. trade statistics (USDA, FAS, 2019a).

Third, average corn yields are much higher in the United States than in Mexico, although some Mexican producers achieve yields comparable to those in the United States. For U.S. corn crops during 2015–17, annual yields averaged 10.9 metric tons per hectare (USDA, NASS, 2019a). For Mexican crops during agricultural years (AYs) 2014–17, annual yields averaged 3.6 metric tons per hectare (SADER, SIAP, 2019a). Mexico's corn yields have registered an upward trend over the last three decades (fig. 6). For irrigated white corn, this trend is particularly impressive, with yields rising from 3.7 metric tons per hectare in 1991 to 8.4 metric tons per hectare in AY 2017, an increase of 126 percent. For rainfed white corn, yield growth has been more modest, rising from 1.8 metric tons per hectare in AY 1990 to 2.5 metric tons per hectare in AY 2017. Since the end of NAFTA's transition to free trade over a decade ago, U.S. yields have increased at a compound annual rate of 1.6 percent for rainfed corn and 1.0 percent for irrigated corn (using 2007–17 data), while Mexican yields have increased at a compound annual rate of 1.9 percent for irrigated white corn, 1.3 percent for rainfed white corn, and 2.3 percent for irrigated yellow corn (using 2006–16 data).

[6]The statistics presented in this paragraph were calculated using production and consumption estimates from USDA, FAS (2018b) and population estimates from U.S. Department of Commerce, Census Bureau (2017).

Figure 6

U.S. and Mexican corn yield, by type and irrigation, 1990–2017



Notes: For Mexican data, the years correspond with Mexico's agricultural years (AYs). Mexico's AY is divided into two production cycles: fall-winter and spring-summer. For corn, planting in fall-winter begins in October and ends in March, while the harvest begins in December and ends as late as September. Planting in spring-summer begins in April and ends in September, while the harvest begins in June and ends as late as March. Thus, AY 2017 for corn covers the crops planted from October 2016 to March 2017 (fall-winter 2016/17) or from April to September 2017 (spring-summer 2017). Prior to AY 2003, Mexican production data for corn did not differentiate between white and yellow corn. For U.S. data, the years correspond with U.S. marketing years. The U.S. marketing year (MY) for corn as grain begins on September 1 and ends on August 31. For instance, MY 2017/18 began on September 1, 2017, and ended on August 31, 2018.

Sources: USDA, Economic Research Service and SADER, ASERCA calculations using data from SADER, SIAP (2019a) and USDA, NASS (2019a).

Water availability matters to yields because two-thirds of Mexico's white corn area is rainfed, and many producers must contend with a semi-arid climate and frequent drought, particularly in the country's northern states. Management practices and technology vary widely across the country. Whereas high-yielding producers in the State of Sinaloa plant improved seed varieties on large, highly mechanized operations, small-scale and often subsistence farmers, particularly in the southern States of Chiapas and Guerrero, rely on indigenous varieties and manual labor to cultivate their crops—features which limit yield growth.

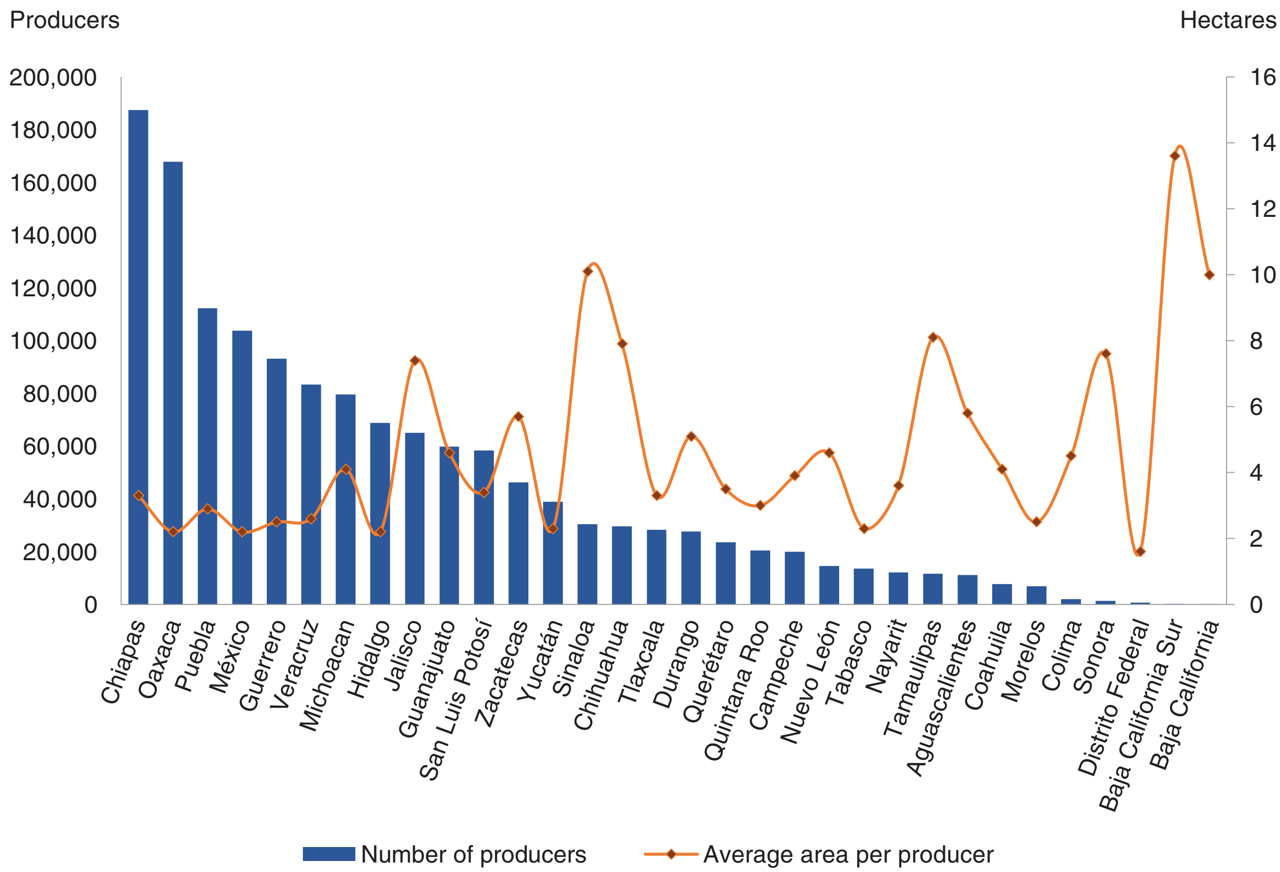
Also driving the two countries' yield differences is the varying use of higher-yielding genetically engineered (GE) varieties. In 2018, GE varieties accounted for about 92 percent of U.S. corn production (Wechsler, 2018). The Mexican Government readily allows for science-based approvals of GE corn for imports (consumption) but not for cultivation. In September 2013, a provisional injunction issued by a Mexican federal court effectively prohibited both experimental and commercial planting of GE corn in Mexico (Otero, 2017; Juárez and Harrison, 2018). The Mexican Government does allow other GE crops, namely cotton, to be cultivated in Mexico.

Perhaps the largest explanation of yield differences, however, is farm size and its attendant scale economies. In the United States, the average size of a corn operation is 101 hectares, based on data from the 2012 Census of Agriculture, compared with just 3.6 hectares in Mexico, based on agricultural support program data for 2014 (tables 1 and 2). Large U.S. farms achieve greater land and labor efficiencies through mechanized tillage, planting, and chemical applications—technologies that are more profitable when applied at a large scale.[7] In contrast, such technologies remain out of reach on Mexico's smaller plots, and farmers must use traditional practices of production, resulting in lower yields. Moreover, some researchers have suggested that small-scale corn farmers in Mexico respond differently to prices than large-scale ones. For example, subsistence farmers facing a decrease in the price of corn may actually plant more corn for consumption to offset market-based losses as well as the accompanying decrease in land rents and farm wages (Taylor, et al., 2005; Dyer, et al., 2006).

In Mexico, farm size in the corn sector varies widely from one State to the next (fig. 7). In the two largest corn-producing States, Sinaloa and Jalisco, farm size in 2014 averaged 10.1 hectares and 7.4 hectares, respectively, reflecting the commercial orientation and use of technology by corn farmers in those States. States with larger numbers of corn producers tend to host much smaller operations. For instance, the States of Chiapas, Oaxaca, and Puebla together accounted for about 33 percent of Mexico's corn producers in 2014; their average area per producer that year was 3.3 hectares, 2.2 hectares, and 2.9 hectares, respectively.

Figure 7

Mexican corn sector: number of producers and average size of operation in 2014, by State



Source: SADER, ASERCA calculations using PROAGRO program data for 2014. PROAGRO is described in the policy section of this report.

[7]About one-half hour of labor time is required to produce one metric ton of corn in the United States (Foreman, 2014).

In spite of these differences, historical data show that the size of a corn farm has increased in both countries, but the timing of these changes and the extent to which they occurred differ across the two countries. In the United States, Census of Agriculture data indicate that the average size of a corn operation experienced sizable growth between 1987 and 2007 and again between 2012 and 2017 (table 1). According to the 2017 Census of Agriculture, 82 percent of U.S. corn production took place on farms larger than 250 acres (about 101 hectares) (USDA, NASS, 2019b).

Table 1

U.S. corn sector: number of farms and area harvested, 1987–2017

Census year	Number of farms	Area harvested	Average corn area per farm
		Millions of hectares	Hectares per farm
2017	304,801	34.3	113
2012	348,530	35.4	101
2007	347,760	34.9	100
2002	348,590	27.6	79
1997	450,520	28.8	64
1992	430,711	28.2	66
1987	503,935	28.1	56

Note: Statistics cover only corn grown for grain and do not include corn grown for silage.

Source: USDA, Economic Research Service and SADER, ASERCA calculations using data from USDA, NASS (2019b, 2014, 2009, 2004, 1999, 1994).

Combining data from Mexico's 1991 and 2007 agricultural censuses with the program data presented in figure 6 reveals that the Mexican corn sector has also experienced consolidation—especially in the decade following NAFTA's transition to intraregional free trade (table 2).[8] Over the period 1991 to 2007, the average size of a Mexican corn operation increased slightly from 2.7 hectares to 2.8 hectares (spring-summer average). By 2014, however, the average size had grown to 3.6 hectares.

[8]Mexican census and production data distinguish between production obtained from the fall-winter and spring-summer planting seasons. Since some farmers might take part in both agricultural cycles, one must be careful in comparing the number of producers for a particular agricultural cycle with the number for an entire agricultural year. Moreover, Mexican program data do not include producers who opt not to receive government supports. The program data in figure 6, for example, cover 5.1 million hectares of corn, compared with the roughly 7 million harvested in AY 2014. If one adjusts the Mexican program data upwards to account for corn area not covered by the program, Mexico had roughly 2 million corn producers in 2014.

Table 2

Mexican corn sector: number of farms and area harvested

Agricultural Cycle	Number of farms	Area harvested	Average corn area per farm
		Millions of hectares	Hectares per farm
Fall winter 1991			
Total	471,586	1.2	2.6
Spring summer 1991			
Total	2,679,813	7.4	2.7
Fall-winter 2007			
Total	166,577	0.6	3.6
White	140,530	0.6	3.9
Yellow	26,047	0.1	2.0
Spring summer 2007			
Total	2,627,363	7.3	2.8
White	2,143,099	6.0	2.8
Yellow	484,264	1.3	2.8
Agricultural year 2014 (PROAGRO participants only)			
Total	1,427,068	5.1	3.6

Note: Mexican program data do not include producers who opt not to receive government support, as such programs are voluntary.

Source: USDA, Economic Research Service, and SADER, ASERCA calculations, using data from Mexican agricultural census and Mexico's Agricultural Support Program (PROAGRO—Programa de Oferta Agropecuaria) program data.

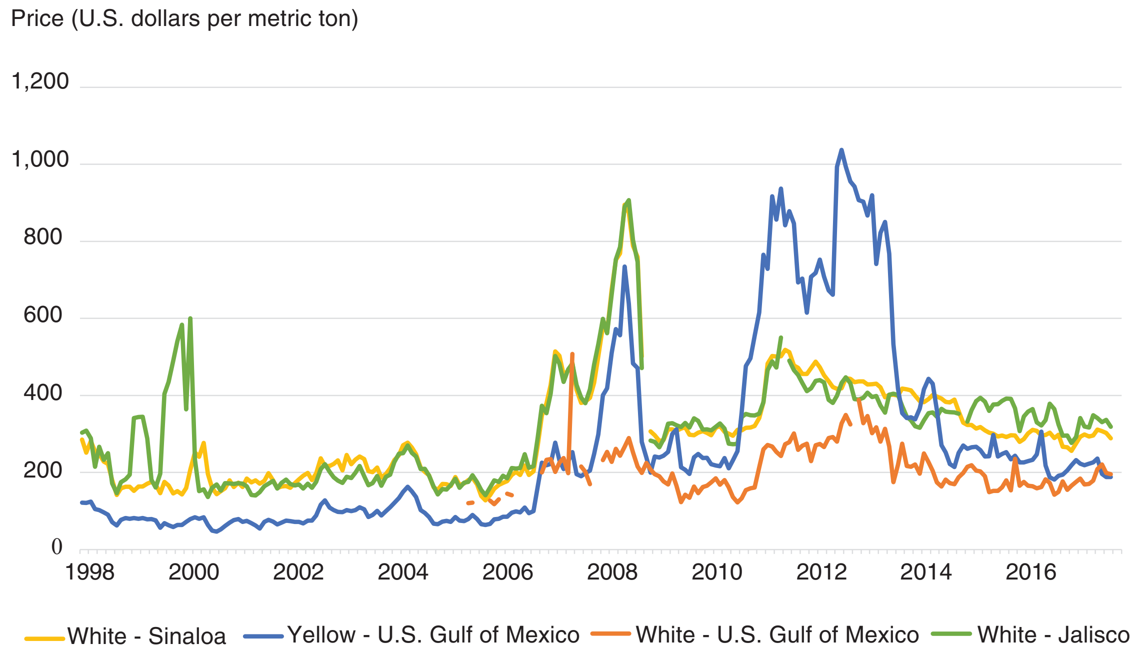
U.S. and Mexican corn prices became more integrated with NAFTA

The U.S. and Mexican corn markets have become more integrated since NAFTA's implementation, with corn and corn-based products flowing in both directions across the border, but primarily from the United States to Mexico. Given the large volume of U.S. corn production and Mexico's reliance on corn imports from the United States, market forces in the United States can influence prices in Mexico. An observable outcome of this relationship is the convergence of corn prices in different locations (Fiess and Lederman, 2004; Jaramillo et al., 2015). But different parts of Mexico are not all equally integrated with the U.S. market, and as such, prices across Mexico move with the U.S. price to different degrees (Motamed et al., 2008).

Figure 8 illustrates the relationship between U.S. and Mexico prices by presenting four monthly price series over the period January 1998 to October 2017. The first two series are the U.S. Gulf of Mexico prices for yellow corn No. 2 and for white corn. The other two series are white corn prices observed in Sinaloa and Jalisco, Mexico's number one and two corn-growing States. All of the prices are expressed in real terms (base year = 1982). U.S. corn prices have experienced a decline from their high values of the period 2011–13, partially due to rising world corn production. By the end of 2017, the prices of U.S. yellow and white corn fell below $200 per metric ton.

Figure 8

Corn prices in the Mexican States of Sinaloa and Jalisco broadly track the movements of U.S. corn prices at Gulf of Mexico ports



Note: All prices are in real terms, and the base year is 1982. Weekly State-level price data from Mexico were averaged to obtain monthly data and then converted into U.S. dollars per metric ton equivalent using contemporaneous exchange rates and then converted into real terms using the producer price index for corn from the U.S. Department of Labor's Bureau of Labor Statistics. The vast majority of U.S. corn exported to Mexico is yellow corn No. 2.

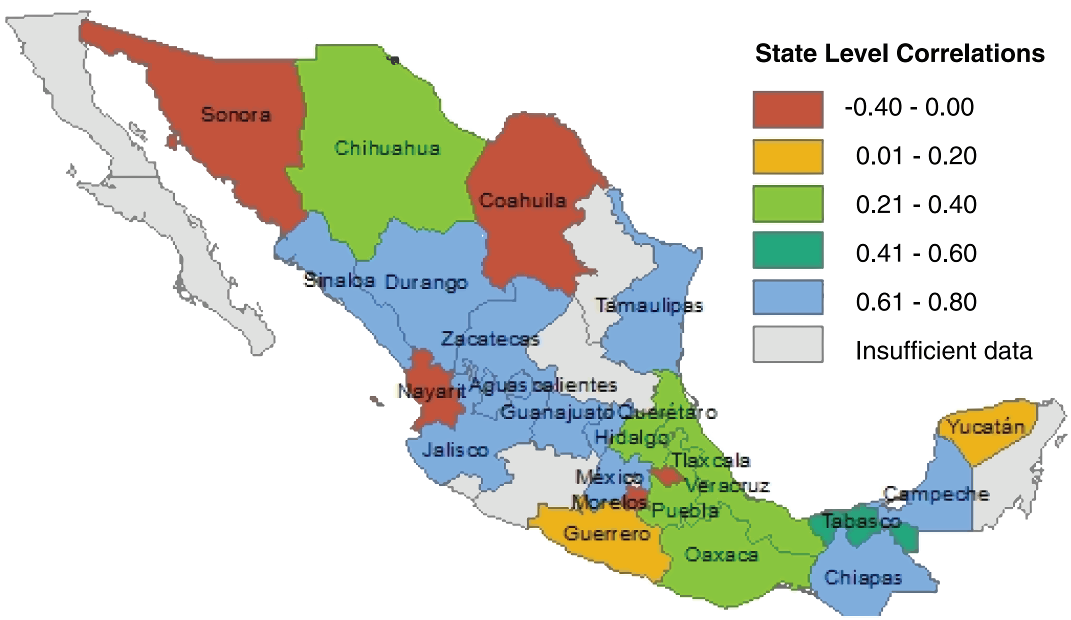
Source: USDA, Economic Research Service and SADER, ASERCA calculations using data for Mexican prices from SE (2018b) and monthly data for U.S. prices from USDA, ERS (2018).

Prices in both Sinaloa and Jalisco appear to track the movement of U.S. prices broadly, implying some commonly felt market forces. In Sinaloa, virtually all production is commercial, and most producers participate in the Agricultura por Contrato program, a price guarantee program (described later in the report) which customarily refers to the Chicago futures price in its contracts. In Jalisco, while about 15–25 percent of production occurs on traditional small-scale operations, a sizeable portion of modern, commercial production ensures that its connection with worldwide markets also remains strong.

A simple way to observe the integration of markets is to measure how much prices in different locations move together. The map in figure 9 presents price correlations between each Mexican State and the U.S. Gulf Port price, revealing the variation in market integration among Mexico's different corn producing states. To prepare the map, monthly state-specific Mexico prices, deflated using Mexico's corn-specific producer price index (PPI) from Mexico's National Institute of Statistics and Geography (INEGI–Instituto Nacional de Estadística y Geografía), were correlated with the monthly U.S. Gulf port price, which was deflated using the corn-specific PPI from U.S. Bureau of Labor Statistics. From the map, price correlations appear relatively high in States with large volumes of corn production, including Sinaloa, Jalisco, Mexico, and Guanajuato. Meanwhile, smaller producing states such as Oaxaca, Guerrero, and Veracruz exhibit much smaller correlations, suggesting weaker connections with the U.S. market.

Figure 9

Mexico State level price correlations with U.S. gulf price (1998–2017)



Note: Weekly State-level price data from Mexico were averaged to a monthly basis and then converted into U.S. dollars per bushel equivalent using contemporaneous exchange rates. States that lacked monthly price information during more than 75 percent of the period examined were omitted and labeled as "Insufficient data."

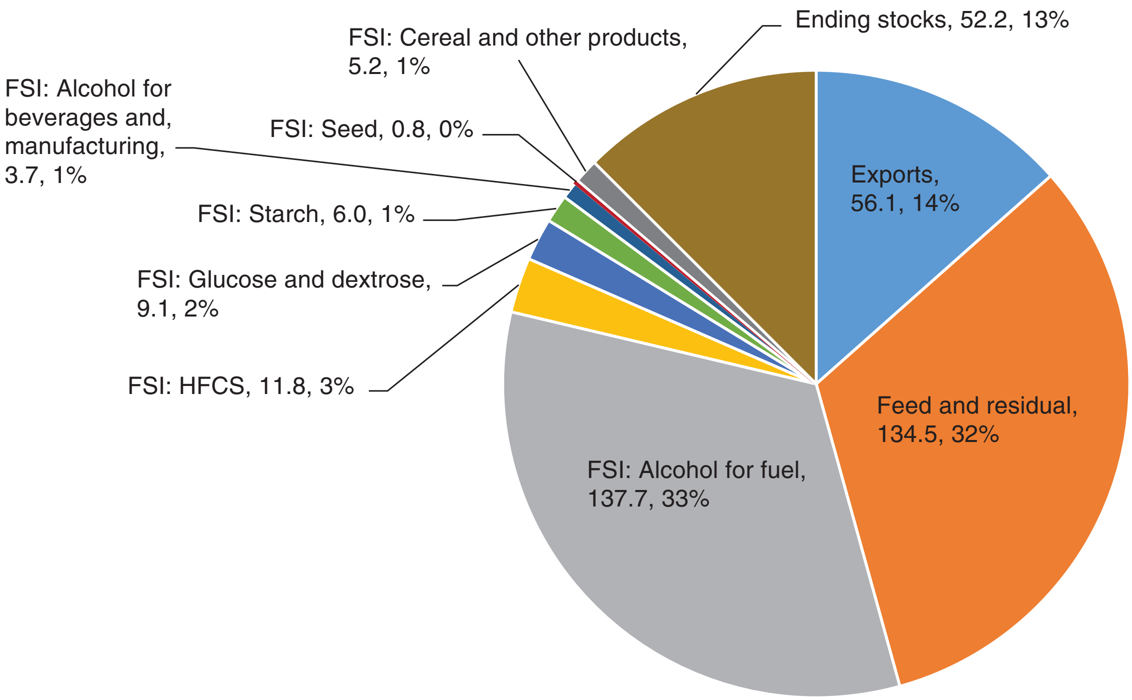
Source: USDA, Economic Research Service and SADER, ASERCA calculations using weekly data for Mexican prices from SE (2018b) and monthly data for U.S. prices from USDA, ERS (2018).

Many uses of corn are expected to increase

Corn is a versatile commodity that is present in many intermediate and consumer products in both the United States and Mexico. USDA classifies corn use into three main categories: (1) feed and residual; (2) exports; and (3) food, seed, and industrial use (FSI) (fig. 10), (Capehart, 2019a). FSI in turn is divided into several subcategories, of which fuel ethanol is by far the most significant. During MYs 2015/16 to 2017/18, total U.S. corn distribution averaged 417.3 million metric tons per year. Alcohol for fuel was the largest category of corn use—33 percent—followed closely by feed and residual, at 32 percent.[9]

Figure 10

Composition of U.S. corn distribution: marketing years 2015/16 to 2017/18



Note: Figure depicts average annual corn distribution during marketing years 2015/16 to 2017/18. The U.S. marketing year for corn begins in September and ends in August. Data labels indicate distribution category, average annual volume (millions of metric tons), and share of total distribution. FSI = Food, seed, and industrial. HFCS = High fructose corn syrup.

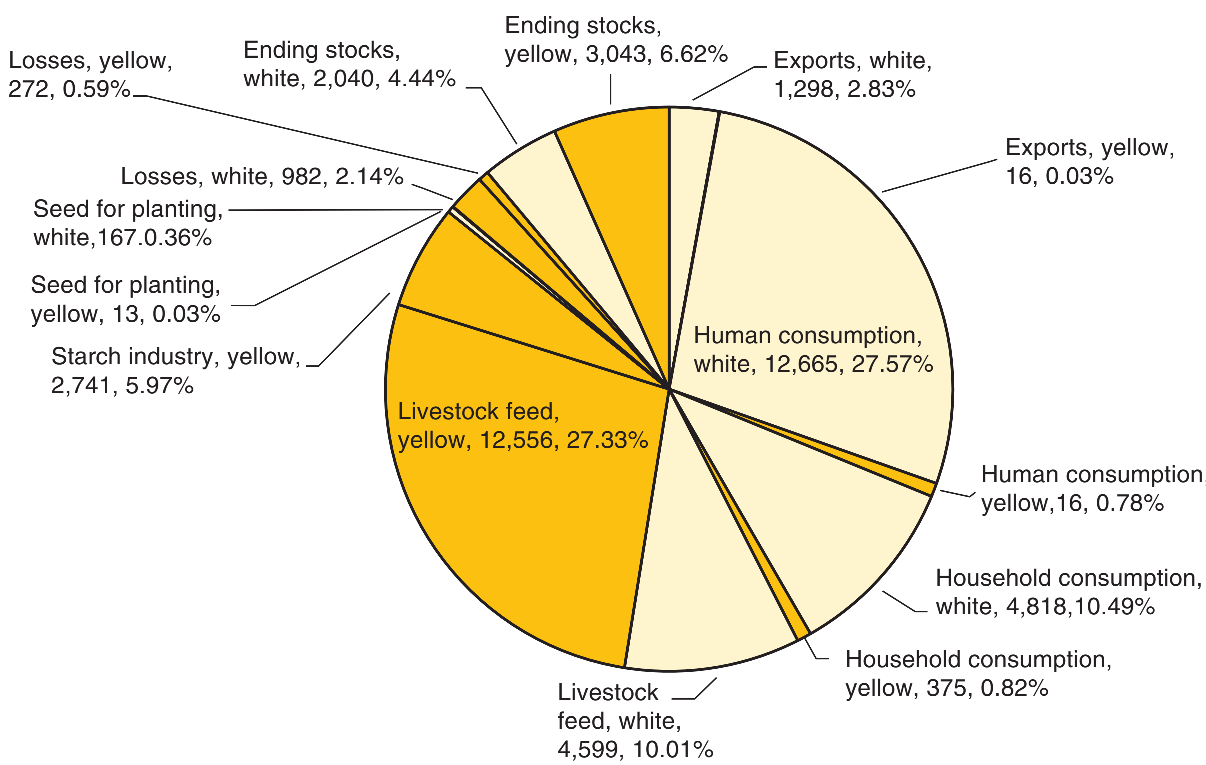
Source: USDA, Economic Research Service and SADER, ASERCA calculations using data from USDA, ERS (2019b).

[9]As defined by USDA, corn for grain does not include corn for silage or corn that is consumed directly by people, such as in the form of corn on the cob or canned or frozen corn.

SADER uses a similar classification scheme for Mexico's corn demand, but unlike USDA, SADER distinguishes between white corn and yellow corn (fig. 11). For white corn, the five main categories are: (1) human consumption; (2) household consumption; (3) livestock feed; (4) seed for planting; and (5) losses. For yellow corn, there is also a sixth category: the starch industry. SADER's categories approximate those of USDA, with the exception of household consumption (see Box, "How do SADER's Números del Campo compare to USDA's WASDE?"). During MYs 2015/16 to 2017/18, Mexico's total corn distribution averaged 45.9 million metric tons per year. For the purposes of Números del Campo, the marketing year begins in October and ends in September. Livestock feed and human consumption were the two largest categories of total corn use according to Números del Campo, with shares of 37 percent and 28 percent, respectively.

Figure 11

Composition of Mexican corn demand: Mexican marketing years 2015/16 to 2017/18



Note: Figure depicts the composition of Mexican corn demand during marketing years 2015/16 to 2017/18. The Mexican marketing year for corn, as reflected in Números del Campo, begins in October and ends in September. Data labels indicate distribution category, average annual volume (millions of metric tons), and share of total distribution.

Source: USDA, Economic Research Service and SADER, ASERCA calculations using data from SADER, SIAP (2019a).

How do SADER's Números del Campo compare to USDA's WASDE?

Since October 2012, Mexico's agricultural secretariat has published monthly forecasts of the availability, consumption, production, international trade, and prices of key agricultural commodities (SADER, SIAP, 2019b). These forecasts—called Números del Campo (Numbers from the Field)— are similar in construction and purpose to USDA's monthly World Supply and Demand Estimates (WASDE) for U.S. wheat, rice, coarse grains (corn, barley, sorghum, and oats), oilseeds (soybeans, rapeseed, and palm), cotton, and meat (USDA, OCE, 2019b). Both Números del Campo and WASDE are produced through interagency processes that engage a large number of specialists on domestic and international agriculture, and both are intended to inform decisionmaking in the public and private sectors.[10]

Recent estimates from Números del Campo and WASDE for Mexico's corn sector are fairly similar, as evidenced by the 3-year averages for each variable (box 3, table). For instance, Números del Campo's three-year average for production is equal to WASDE's (both at 27.0 million metric tons), when rounded to the nearest 100,000 metric tons. But several noteworthy differences stand out. First, Números del Campo distinguishes between white and yellow corn, while WASDE does not—a sign of the differing relative importance of white corn in the two countries. Second, Números del Campo includes a category for household consumption, since many of Mexico's smaller farms grow corn for their own household's corn-based foods and livestock. For this reason, Números del Campo's estimates of livestock feed use tend to be smaller than WASDE's, and the sum of the estimates for human consumption, starch industry, seed for planting, and losses in Números del Campo tends to be smaller than the estimate of food, seed, and industrial use (FSI) in WASDE.

Table

Números del Campo and WASDE: two similar views of Mexico's corn sector

Attributes	Marketing Years			Average
	2015/16	2016/17	2017/18	
Mexico white corn (SADER)				
Begining stocks	1,834	1,528	2,106	1,826
Production	22,335	24,468	24,384	23,729
Imports	1,028	983	1,029	1,013
Total supply	25,206	24,873	25,034	25,038
Exports	1,499	1,486	909	1,298
Human consumption	12,399	12,659	12,937	12,665
Households consumption	4,266	5,002	5,186	4,818
Livestock feed	4,440	4,542	4,815	4,599
Seed for planting	170	165	167	167

— continued

[10]The Números del Campo are part of an effort by SADER to provide a "dashboard" of economic indicators for key agricultural commodities so that decisionmakers can anticipate unusual conditions in supply or demand and make opportune decisions to avoid or reduce imbalances in supply or prices. Fourteen commodities are monitored: corn (white and yellow), beans, wheat (breadmaking and crystalline), sorghum, sugar, rice, tomatoes, lemons, onions, poultry meat, beef, pork, eggs, and milk. An interagency working group is responsible for the Dashboard's production and operation. ASERCA serves as the group's technical secretary.

Table

Números del Campo and WASDE: two similar views of Mexico's corn sector—continued

Attributes	Marketing Years			Average
	2015/16	2016/17	2017/18	
Mexico white corn (SADER)				
Losses	904	1,023	1,020	982
Ending stocks	1,528	2,106	2,485	2,040
Total distribution	25,206	26,983	27,519	26,569
Mexico yellow corn (SADER)				
Begining stocks	1,086	2,670	3,082	2,279
Production	3,545	3,135	3,186	3,289
Imports	12,883	13,637	14,905	13,808
Total supply	17,514	19,442	21,172	19,376
Exports	35	6	6	16
Human consumption	348	352	378	359
Household consumption	324	324	478	375
Livestock feed	11,206	12,655	13,807	12,556
Starch industry	2,650	2,743	2,831	2,741
Seed for planting	12	13	14	13
Losses	268	266	281	272
Ending stocks	2,670	3,082	3,378	3,043
Total distribution	17,513	19,441	21,173	19,376
Mexico total corn (SADER)				
Beginning stocks	2,929	4,198	5,188	4,105
Production	25,880	27,603	27,570	27,018
Imports	13,911	14,620	15,934	14,822
Total supply	42,720	44,315	46,206	44,414
Exports	1,534	1,492	915	1,314
Human consumption	12,747	13,011	13,315	13,024
Household consumption	4,590	5,326	5,664	5,193
Livestock feed	15,646	17,197	18,622	17,155
Starch industry	2,650	2,743	2,831	2,741
Seed for planting	182	178	181	180
Losses	1,172	1,289	1,301	1,254
Ending stocks	4,198	5,188	5,863	5,083
Total distribution	42,719	46,424	48,692	45,945

— continued

Table
Números del Campo and WASDE: two similar views of Mexico's corn sector—continued

Attributes	Marketing Years			Average
	2015/16	2016/17	2017/18	
Mexico total corn (WASDE)				
Beginning stocks	4,090	5,159	5,409	4,886
Production	25,971	27,575	27,450	26,999
Imports	13,957	14,614	16,129	14,900
Total supply	44,018	47,348	48,988	46,785
Exports	1,559	1,539	958	1,352
Feed domestic consumption	20,300	22,500	24,300	22,367
FSI consumption	17,000	17,900	18,000	17,633
Domestic consumption	37,300	40,400	42,300	40,000
Ending stocks	5,159	5,409	5,730	5,433
Total distribution	39,424	47,348	48,988	45,253

Note: FSI = Food, seed, and industrial. Marketing year begins in October and ends in September for Números del Campo and begins in September and ends in August for WASDE.

Sources: USDA, Economic Research Service and SADER, ASERCA calculations using Números del Campo data from SADER, SIAP (2019b) and WASDE data from USDA, FAS (2019b).

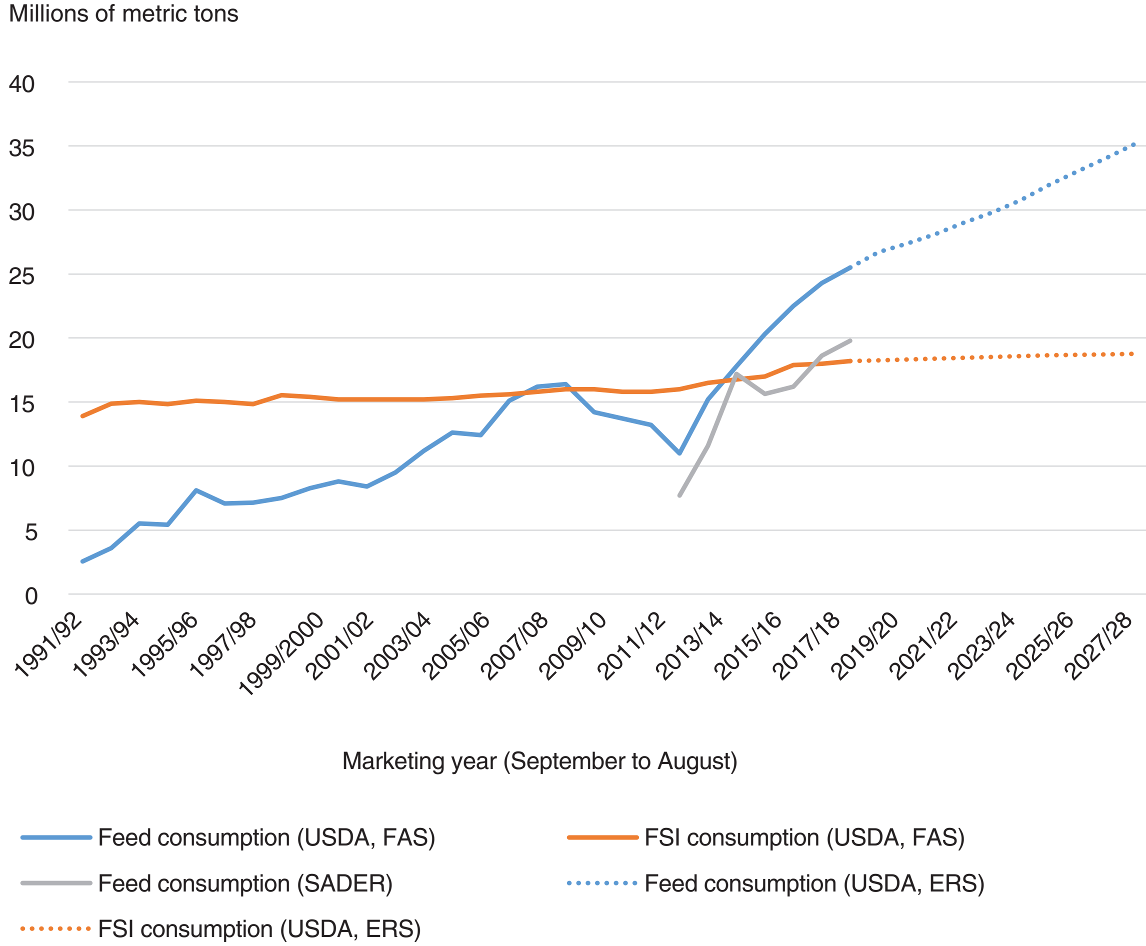
Livestock and poultry feed

A major category of corn use is livestock and poultry feed. Corn grain is fed to livestock and poultry either by itself or in combination with supplements in compound feeds. Feed accounts for about 32 percent of U.S. corn use and 37 percent of Mexico's corn use (17 percent of Mexico's white corn use and 65 percent of its yellow corn use). USDA does not survey end users of corn for feed. It constructs estimates by accounting for all other uses which are observable, and subtracting these uses from total use, producing a result known as feed and residual. The feed and residual category includes any reporting or estimating errors in the surveys for production, stocks, industrial use, and trade.

In Mexico, feed use accounts for a much larger share of total corn use than in the United States because of continuing growth in Mexico's animal product sector—especially poultry meat and eggs. Mexico uses little if any corn to produce fuel ethanol. Feed use of corn in Mexico initially declined after NAFTA's transition to free trade due to higher commodity prices and the U.S. drought of 2012. Feed use rebounded in 2013/14, however, and has grown rapidly from then until the present, according to USDA estimates (fig. 12).

Figure 12

Feed and food use of corn in Mexico, marketing years 1991/92–2028/29 (estimated and projected)



Note: FSI = Food, seed and industrial.

Source: USDA, Economic Research Service and SADER, ASERCA calculations using international long-term agricultural projections from USDA, ERS (2019d), historical consumption estimates from USDA, FAS (2019b), and feed consumption estimates from SADER, SIAP (2019b).

In contrast, direct human consumption (i.e., food use) of corn in Mexico has grown slowly and steadily since the end of NAFTA's transition period, reflecting the continued use of corn to make tortillas and other food products, albeit at roughly the same per capita level. Estimates of annual per capita tortilla consumption in Mexico cover a wide range—from 50 to 75 kilograms.[11] USDA's long-term agricultural projections through 2029 suggest that these trends will continue during the coming decade (USDA, OCE, 2019b). On a per capita basis, annual feed use of corn is projected to rise from 200 kilograms in 2018/19 to 253 kilograms in 2028/29, while FSI use is projected to decline from 143 kilograms to 135 kilograms.

[11]Calculations by the authors using price and household expenditure data for the years 2010, 2012, 2014, and 2016 suggest that per capita tortilla consumption in Mexico has remained in the neighborhood of 50 kilograms over the past decade; Solono Pérez (2018) places per capita consumption at 75 kilograms.

By using grain consuming animal units (GCAUs) as a proxy for the distribution of feed use, one can estimate the total quantities of corn used to feed different types of livestock and poultry (table 3).[12] In the United States, hogs consume the most corn grain for feed at 29 percent of the total, In Mexico, poultry consume more than half (52 percent) of the corn used as animal feed, with 28 percent going to the production of poultry meat and 24 percent going to egg production.

Table 3

Distribution of U.S. corn feed and residual and Mexican corn feed use by animal type

Animal type (U.S. categories)	U.S. corn feed use and residual	Mexican corn feed users	Animal type (Mexican categories)
	Percent		
Broilers	19	28	Poultry meat
Chicken, hens, and pullets	10	24	Egg layers
Turkeys	4		
Hogs	29	16	Hogs
Dairy cattle	11	16	Dairy cattle
Beef cattle	26	11	Beef cattle
Other	1	5	Other

Source: USDA, Economic Research Service and SADER, ASERCA calculations using U.S. distribution data from table 30 of the *Feed Grains Yearbook Tables* (USDA, ERS, 2018) and Mexican distribution data for 2017 for the balanced feed industry from Asociación Mexicana de Productores de Alimentos A.C. (AMEPA) (2017).

Food, seed, and industrial use

Food, seed, and industrial (FSI) use is the next largest category of domestic corn use in the United States, accounting for nearly half of total U.S. corn use. In Mexico's classification scheme of corn demand, the categories that correspond most closely to FSI are human consumption, household consumption, starch industry, and seed for planting, although the household consumption category includes some feed use of corn. Together, these four categories account for about 46 percent of Mexico's total corn distribution, according to SADER's estimates (box 3, table 1 in box entitled "How do SADER's Números para el Campo compare to USDA's WASDE?"). USDA's estimates place Mexico's FSI consumption of corn around 39 percent of the country's total corn distribution.

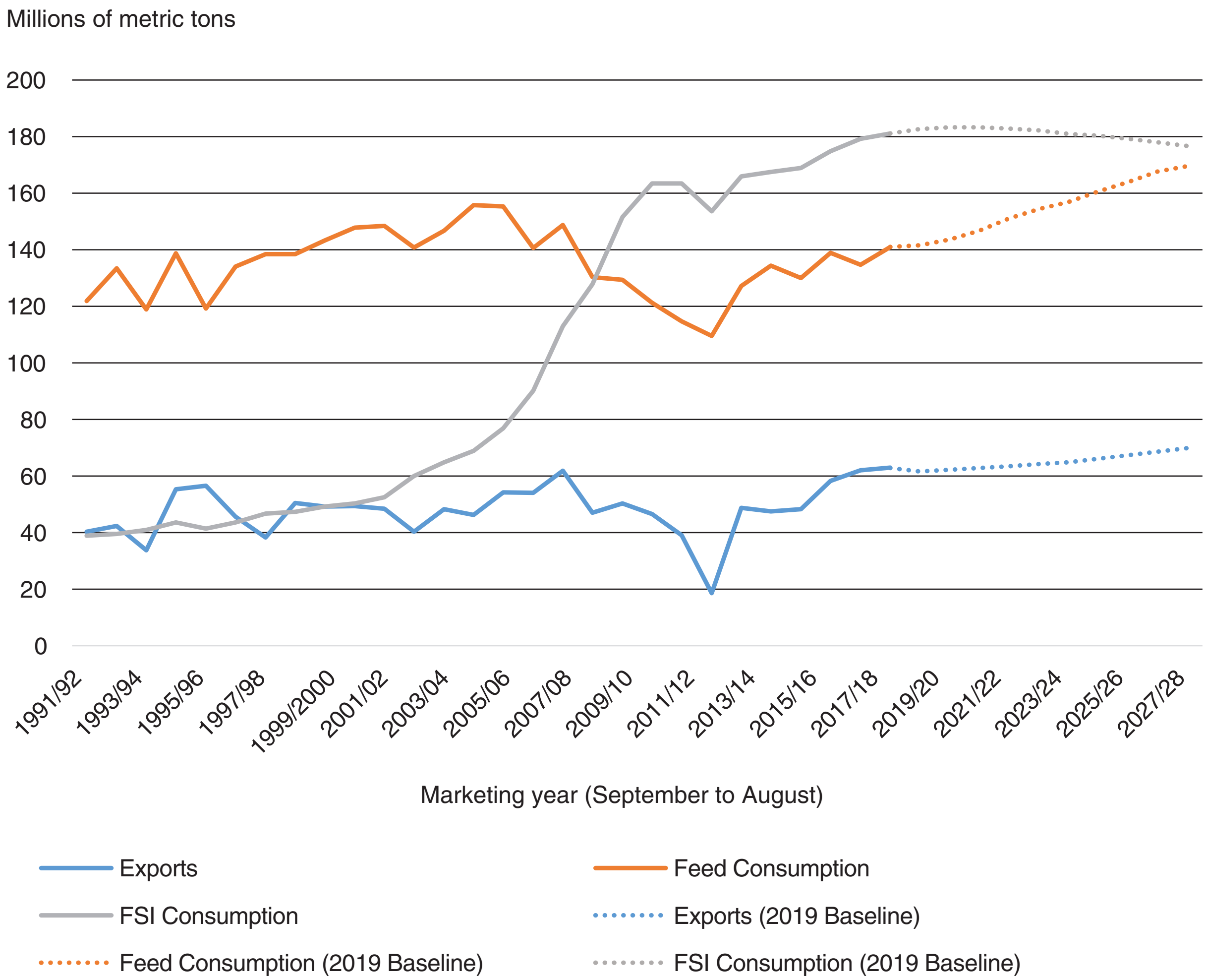
Since the 1990s, the major FSI category in U.S. corn use has been fuel ethanol (ethyl alcohol denatured with gasoline). Corn used for fuel ethanol production increased from less than 1 percent of total U.S. corn use in 1980/81 to about 38 percent of total U.S. corn use during marketing years 2015/16 to 2017/18. This large and rapid expansion of U.S. ethanol production, which coincided with NAFTA's liberalization of U.S.-Mexico corn trade, is illustrated by the line in figure 13 depicting U.S. FSI consumption of corn, which rose sharply between MY 2005/06 and MY 2011/12. This development affected virtually every aspect of the field crops sector, ranging from domestic demand

[12]ERS calculates standardized estimates of the size of the U.S. livestock herd and poultry stock. The estimates are an effort to account for differences in the volume of feed consumed across species (i.e., hogs, cattle, broilers, etc.) to arrive at a single metric for the number of GCAUs, "high protein animal units," "roughage consuming animal units," and "grain and roughage consuming animal units." Each of these measures incorporates weights reflecting the estimated high protein feed use by each species relative to the standard consumption of a dairy cow. The results are standardized indices of livestock populations that can be used as indicators of feed use. Similar estimates can be calculated for the distribution of feed use of corn in Mexico using corn demand estimates for the balanced feed industry and program data from ASERCA's Agriculture by Contract (AxC—Agricultura por Contrato) program, which is described in the policy section of this report.

and exports to market prices and the allocation of acreage among crops. Because the growth of fuel ethanol production increased corn demand, many other users of corn were affected by this development, including livestock producers in both the United States and Mexico. Over the coming decade, however, corn-based ethanol production is projected to decline to the quantity produced in 2016 due to decreasing U.S. gasoline consumption and constraints limiting the use of gasoline containing even larger proportions of ethanol (USDA, OCE, 2019a).

Figure 13

U.S. corn disappearance: feed, food, seed, and industrial use, and exports, marketing years 1991/92 to 2028/29 (estimated and projected)



Note: Exports represent total U.S. corn exports (to all countries in the world).

Source: USDA, Economic Research Service and SADER, ASERCA calculations using data from USDA, OCE (2019a), USDA, ERS (2019d), and USDA, FAS (2019b).

Fuel ethanol is used as a gasoline additive to reduce the carbon monoxide content of engine exhaust and to increase gasoline's octane rating, which reduces engine knock. Ethanol is made by fermenting and distilling simple sugars. In the United States, corn is the primary feedstock used to produce ethanol. There are about 200 fuel ethanol mills in the country, producing roughly 15 billion gallons of ethanol each year. Most ethanol is used in a 10-percent blend with gasoline called E-10. Ethanol is also used in higher blends by flex-fuel vehicles which can run on blends up to 85 percent, known as E-85.

In Mexico, methyl tertiary butyl ether (MTBE) continues to be the primary oxygenate blended with gasoline. Currently, the volume of U.S. fuel ethanol exports to Mexico is small—averaging 742,000 barrels (about 118 million liters) per year during 2015–17 [U.S. Department of Energy (USDOE), Energy Information Administration (EIA), 2019]. These exports account for less than one percent of U.S. ethanol production. Interest within the U.S. grain and bioenergy sectors in exporting more ethanol to Mexico led USDA to organize and implement a U.S. ethanol trade mission to Mexico in 2016 (Voegele, 2016).

High fructose corn syrup (HFCS), a sweetener, is another product milled from corn. Used as a sugar substitute in beverage and food manufacturing, HFCS accounts for 3 percent of total corn use in the United States. HFCS exports to Mexico are an important component of this use, accounting for 77 percent of total U.S. HFCS exports and 12 percent of U.S. HFCS production during calendar years 2015–17. Under NAFTA, U.S. HFCS exports to Mexico have burgeoned, rising from negligible levels in the early 1990s to an annual average of 906,000 metric tons during calendar years 2015–17 (USDA, ERS, 2018).

Starch is another important co-product of the corn milling process. Dry wall materials for construction, paper products and packaging materials, and many processed foods all contain starch. Other key uses include flocculating agents, anticaking agents, mold-release agents, dusting powder, and thickening agents. Dextrins derived from starch are used in adhesives, and modified starches are used for coatings of pills and in time-release capsules. Glucose and dextrose resulting from the ethanol milling process appear in hundreds of food and industrial products as well. In Mexico, the starch industry accounts for about 6 percent of total corn use and 14 percent of yellow corn use.

Food uses

Corn can be used to make numerous types of food, food ingredients, and beverages. Examples include tortillas, tamales, atole (a corn-based beverage), tortilla chips, breakfast cereals, corn flour and meals, beer, and certain distilled spirits. White corn is generally used to manufacture such products, although some yellow corn varieties are also used for this purpose. Also included in the food use category is popcorn. Special hybrids are used to grow popcorn, and nearly all popcorn is grown under contract.

In the United States, the food and other products category accounts for just 1 percent of total corn use. In Mexico, where corn is a major staple food, direct human consumption accounts for 28 percent of total corn use, 48 percent of white corn use, and 2 percent of yellow corn use, according to SADER's estimates. Additional food use in Mexico appears under the household consumption (subsistence) category, which accounts for 11 percent of Mexico's total corn use, 18 percent of white corn use, and 2 percent of yellow corn use.

Industrial uses other than fuel alcohol

Corn is also used for alcoholic beverages and nondurable consumer products. Beer and distilled spirits both use corn as an input to the fermentation process. Industrial products such as hand sanitizer, medical alcohol, cosmetics, and health products are other end uses for corn. The beverage and manufacturing category accounts for about 1 percent of U.S. corn use.

Seed corn, like popcorn, is produced using hybrids, generally under contract. Seed corn produced during a given crop year is used to plant the following year's crop, so the volume produced one year is closely related to prospective plantings for the next. Trends toward higher per acre plant populations have increased the number of seeds planted per acre and had a positive impact on seed corn consumption in both countries. Seed for planting accounts for less than 1 percent of total corn use in Mexico and in the United States.

Feed co-products

Corn processing generates various products that can be used as livestock feed. Corn-based ethanol production yields distillers' dried grains with solubles (DDGS), while starch and sweetener production results in corn gluten meal and corn gluten feed. These high-protein feed products are close substitutes for corn grain and other feedstuffs. For every bushel of corn used for ethanol, 16.4 pounds of DDGS are produced (Renewable Fuels Association, 2019), which can substitute for corn in some livestock rations on a 1-to-1 basis. DDGS yields have declined in recent years since corn oil, which can be used in animal feed rations, is more frequently being extracted from DDGS. Corn gluten meal has even higher protein levels and can substitute for soybean meal, a major component of mixed ration feeds. Mexico is a major market for DDGS, with U.S. exports to Mexico of this product averaging 2.0 million metric tons ($382 million) per year during 2016–18. U.S. exports to Mexico of corn gluten meal and corn gluten feed are much smaller, with annual averages of 25,000 metric tons ($15 million) and 26,000 metric tons ($4 million), respectively (USDA, FAS, 2019a).

Continuity and change in farm programs

Changes are underway to Mexican and U.S. domestic agricultural programs—not just for corn but for agriculture as a whole. In Mexico, a new presidential administration began on December 1, 2018, and has indicated that it will give a high priority to the promotion of small- and medium-scale farmers and the pursuit of food sovereignty (SADER, 2019f). In the United States, the new Agricultural Improvement Act of 2018 (2018 Farm Act) largely maintains the suite of risk management programs and major conservation programs that appeared in earlier legislation.

The programs now being implemented in the two countries provide some insight into the likely composition of Mexican and U.S. domestic agricultural programs over the next 5–6 years. In Mexico, presidential administrations are six years in length, without the possibility of reelection. However, the Mexican agricultural secretariat lacks the type of budgetary authority necessary to implement a multiyear agricultural and food policy agenda along the lines of that implemented by the United States, and some programs may be provided subject to budget availability, even if they are intended to be national in scope. Thus, the Mexican Government customarily makes some adjustments to its farm programs each year. In the United States, the 2018 Farm Act will remain in force through 2023, with some provisions extending beyond 2023.

Mexico emphasizes small- and medium-scale farmers

SADER is implementing several new programs that focus on small- and medium-scale producers. Direct payments for producers of corn, dry beans, wheat for bread, rice, and other grains are being channeled through a new program called Production for Wellbeing (Producción para el Bienestar). Farmers registered for two previous support programs—a direct payment program called Productive PROAGRO (PROAGRO Productivo) and the Program of Incentives for Producers of Corn and Beans (PIMAF—Programa de Incentivos para Productores de Maíz y Frijol)—are eligible to participate. For 2019, the payment rates are either 1,000 or 1,600 pesos (about $52 or $83) per hectare, depending on farm size and access to irrigation (table 4). In nominal terms, these payment rates are similar to what existed under Productive PROAGRO. Payments are generally limited to 20 hectares, compared with 80 hectares under Productive PROAGRO.[13]

[13]SADER (2019e) specifies guidelines for Production for Wellbeing; Juárez (2019) offers an informal summary.

Table 4

Production for Wellbeing payment rates for 2019

Type of farm	Farm size	Payment rate (pesos per hectare)
Productive PROAGRO registrants:		
Small-scale, rainfed	Less than or equal to 5 hectares	1,600
Small-scale, irrigated	Less than or equal to 0.2 hectares	1,600
Medium-scale, rainfed	Greater than 5 hectares and less than 20 hectares	1,000
Medium-scale, irrigated	Greater than 0.2 hectares and less than or equal to 5 hectares	1,000
PIMAF registrants and indigenous producers	Less than or equal to 3.0 hectares	1,600

Source: USDA, Economic Research Service and SADER, ASERCA calculations using data from SADER (2019a).

As part of another new program called Mexican Food Security (SEGALMEX—Seguridad Alimentaria Mexicana), the Mexican Government is reestablishing guaranteed prices for white corn, dry beans, rice, wheat for bread, and milk, but limiting their availability to small- and medium-scale producers or, in the case of rice and wheat, to specified quantities of production. Prior to NAFTA, when Mexican imports of basic agricultural commodities were tightly regulated, guaranteed prices were one of the main instruments used to support the country's farmers. While the guaranteed prices of the past were available to all producers, the guaranteed prices under SEGALMEX are intended only for small- and medium-scale producers. For example, SEGALMEX's guaranteed price for white corn—5,610 pesos per metric ton (about $290) for the crop planted in Spring-Summer 2019—is only available to producers with up to 5 hectares of rainfed land. This guaranteed price is much higher than the price available in the market. For example, the unit price of U.S. white corn exports to Mexico in 2018 was $203 per metric ton (USDA, FAS, 2019b). SEGALMEX does not provide a guaranteed price for yellow corn.[14]

On the input side, the Mexican Government has instituted a new program simply called the Fertilizer Program. It provides up to 450 kilograms of fertilizer per hectare for as many as 3 hectares per producer to qualifying growers of corn, dry beans, rice, coffee, and sugarcane in municipalities with a high or very high level of marginalization.[15] To qualify, the farmer must be a small producer of at least one of the priority crops mentioned above, submit the required documentation indicated in the program rules, and be registered in either Productive PROAGRO or PIMAF for the years 2017 and 2018. Priority is given to farmers in marginalized communities in Mexico's South or Southeast regions (SADER, 2019c).[16]

[14]SADER (2019d) specifies the program guidelines for SEGALMEX.

[15]Mexico's National Population Council (Consejo Nacional de Población) calculates indices to describe the level of marginalization in each municipality resulting from lack of access to education, adequate housing, and income. For details, see Consejo Nacional de Población (2016).

[16]For the purposes of the Fertilizer Program, small producers are generally defined as subsistence family farms with limited links to the market and whose annual sales of primary products to the market do not exceed 55,200 pesos (about $2,800). The program's rules (SADER, 2019c) provide a full identification of the target population and the program's requirements.

Modification of Agricultural Promotion Program

The Mexican Government has modified an existing farm program for small- and medium-scale producers called the Agricultural Promotion Program (Programa de Fomento a la Agricultura). This program has 10 components:

- Productive agricultural capitalization;
- Integral strategies for public agricultural policy;
- Agricultural research, innovation, and technological development;
- Productive improvements to soil and water;
- Renewable energy;
- Access to financing;
- Productive and logistical assets;
- Agroalimentary certification and standardization;
- Productive development in the South Southeast and Special Economic Zones; and
- Strengthening the productive chain and sharing risks.

None of these components focus exclusively on corn, although many are potentially related.

As part of the "access to financing" component, direct payments are provided in the case of natural disasters to low-income producers without access to insurance. For example, producers of corn and certain other crops with 20 hectares or less are eligible to receive direct payments of up to 1,500 pesos (about $77) per hectare as compensation for damages resulting from natural disasters to their entire operations. For these payments, the Federal Government covers 60 percent of the cost, and the State Government covers the remaining 40 percent. Separate provisions offer subsidies for the purchase of insurance against natural disasters to producers with 20 hectares or less in low-income municipalities (table 5). Corn is one of many eligible crops in this program.

Table 5

The discounts offered by the Agricultural Promotion Program on the cost of insurance premiums vary by location and by level of marginalization

Municipality's level of marginalization	Campeche, Chiapas, Guerrero, Oaxaca, Puebla, Quintana Roo, Tabasco, Veracruz, and Yucatán	All other States
High or very high	32 percent discount	27 percent discount
Medium, low, or very low	30 percent discount	25 percent discount

Note: In certain municipalities (Ahome and El Fuerte in the State of Sinaloa and Álamos and Huatabampo in the State of Sonora), applications for corn, dry beans, soybeans, and fruit trees are limited to the Fall-Winter cycle, if planting occurred between January 1 or 31, or the Spring-Summer cycle.

Source: USDA, Economic Research Service and SADER, ASERCA presentation of policy information from SADER (2019a).

Sustainable and Social Agricultural Markets Program provides new framework for marketing and countercyclical incentives

The Sustainable and Social Agricultural Markets Program (AMSYS—Agromercados Sociales y Sustentables) incorporates several incentives formerly implemented by the previous administration. For corn, the available incentives include:

- Marketing Incentives (Incentivos a la Comercialización);
- The Complementary Incentive to Target Income (Incentivo Complmentario al Ingreso Objetivo);
- The Incentive for Attending to Specific Marketing Problems (Incentivo para Atender Problemas Específicos de Comercialización); and
- The Incentive for Grain Storage Infrastructure and Information Services for Agricultural Competitiveness (Incentivo a la Infraestructura de Almacenamiento de Granos y Servicios de Información para la Competitividad Agrícola).

The Marketing Incentives and Complementary Incentive to Target Income are combined using an approach called Agriculture by Contract (AxC—Agricultura por Contrato), in which the price agreed upon by the producer and buyer must be greater than or equal to the futures price plus the minimum basis.[17] This price is used to determine the level of support provided by the two incentives.

The Marketing Incentives also include financial support for various hedges carried out via the purchase and sale of options on futures contracts. Incentives for hedges incorporated within AxC equal 50 percent of the cost of the coverage; marketing incentives not incorporated within AxC can equal as much as 100 percent.[18]

The Complementary Incentive to Target Income provides countercyclical assistance by guaranteeing participating producers that their income from the market will not fall below a certain level. AMSYS's guidelines set the target income for corn at 3,960 pesos per metric ton (about $5.25 per bushel), compared with 3,330 pesos per metric ton (about $4.41 per bushel) in 2018. Wheat (for bread and crystalline), soybeans, sorghum, rapeseed, safflower, cotton, rice, and sunflower are the other crops eligible for the Complementary Incentive to Target Income (SADER, 2019b).

The Incentive for Attending to Specific Marketing Problems, provided only "under extraordinary circumstances," has the objective of supporting small- and medium-scale producers and addresses marketing problems arising from unfavorable conditions affecting the purchase price and/or the costs of storage, conservation, movement, and distribution of the product. For the Complementary Incentive to Target Income and the Incentive for Attending to Specific Marketing Problems, priority is given to producers with up to 50 irrigated hectares or 100 rainfed hectares. For larger farms, the incentives are limited to the first 50 irrigated hectares or first 100 rainfed hectares of production, subject to budget availability (SADER, 2019b).

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[17]In Mexico, the minimum basis is defined by mutual agreement by producers and direct buyers of commodities during meetings convened by ASERCA. Producers and buyers are free to establish bases above the minimum.

[18]Wheat, soybeans, sorghum, cotton, and coffee are also among the crops eligible for the incentives for hedges (SADER, 2019b).

The Incentive to the Infrastructure of Grain Storage and Information Services for Agricultural Competitiveness provides qualifying organizations of corn growers with financial support for the construction and/or rehabilitation of grain collection centers, including equipment. This incentive covers up to half of the cost of the approved project, not counting the value added tax. The maximum incentive is 10 million pesos (about $524,000) for new collection centers and 7 million pesos ($367,000) for rehabilitated ones (SADER, 2019b).

Mexican injunction blocks alignment of U.S. and Mexican gasoline specifications

A Mexican regulation that would align U.S. and Mexican gasoline specifications by increasing the maximum allowable ethanol blend rate to 10 percent, thereby opening the door to larger volumes of U.S. fuel ethanol exports to Mexico, has been blocked by an injunction since 2017 (Barrera, Esposito, and Orlofsky, 2017; Hirtzer, 2017; Pedrick and Struthers, 2017). Under the regulation, fuel ethanol would still be banned for use as a gasoline oxygenate in Mexico's three largest cities: Mexico City, Monterrey, and Guadalajara. The States in which these cities are located—Mexico City, Nuevo León, and Jalisco, respectively—account for a sizable portion of Mexico's registered motor vehicles, including 28 percent of automobiles, 13 percent of passenger trucks, 15 percent of cargo trucks, and 23 percent of motorcycles, according to data for 2017 [INEGI, Deputy General Directorate of Economic Surveys and Administrative Records (Dirección General Adjunta de Encuestas Económicas y Registros Administrativos) and Directorate of Economic Statistics of Administrative Records (Dirección de Estadísticas Económicas de Registros Administrativos), 2019]. There is also interest in Mexico in the development of a domestic bioenergy sector that would rely on feedstocks other than corn. The renewable energy component of the Agricultural Promotion Program contains provisions to support the production of nopal, sugarcane, sweet sorghum, Jatropha curcas, castor bean, and beets as feedstocks, but corn is not specified as one of the feedstocks eligible for such support (SADER, 2019a).

Mexican government institutions augment commercial lending

While U.S. corn farmers have broad access to commercial lending, access to private-sector financing has been a long-term challenge for Mexican agriculture. As a result, Mexico counts on several government institutions separate from SADER to augment the activities of commercial banks. One major example is FIRA (Funds Instituted in Relation with Agriculture—Fideicomisos Instituidos en Relación con la Agricultura), a set of second-tier, government-owned funds managed by the Banco de México, Mexico's central bank. FIRA offers credits, guarantees, training, technical assistance, and support of technology transfer to Mexico's agricultural, forestry, fishery, and rural sectors. In recent years, FIRA has developed new products such as structured financial instruments and inventory financing and fostered a wider distribution network for its funds that includes nonbank lending institutions. In 2017, FIRA lent 222.6 billion pesos ($11.8 billion) for agricultural and rural financing, benefiting about 1.5 million producers. Of this amount, 175.0 billion pesos ($9.2 billion) was devoted to discounts, while 47.6 billion pesos ($2.5 billion) corresponded to guarantees without discounts. Roughly 80 percent of these funds were channeled through commercial banks. About 24.6 billion pesos ($1.3 billion) of financing went specifically to corn producers (FIRA, 2018).

Another important governmental institution in agricultural finance is Financiera Nacional de Desarrollo Agropecuario, Rural, Forestal, y Pesquerio (FND), Mexico's National Agricultural, Rural, Forestry, and Fishing Development Fund. Its mission is to increase financing at both the first and second tiers for any economic activity carried out in rural communities under 50,000 inhabitants that improves their quality of life. This is done at the first tier via the delivery of resources to direct beneficiaries and at the second tier via the delivery of resources through rural financial intermediaries. Rather than disperse funds through its own network of offices, FND does so through branches of affiliated banks. In 2018, FND provided a projected 75 billion pesos ($3.3 billion) in financing to stimulate Mexico's agri-food sector and for projects to strengthen commercial activities in communities with less than 50,000 inhabitants (FND, 2018).

U.S. provides farm programs continuity through 2018 Farm Act[19]

The United States provides a variety of risk management programs under Federal law to help stabilize producers' incomes in the presence of uncertain prices and yields. Programs recently reauthorized under the 2018 Farm Act—including Price Loss Coverage (PLC), Agriculture Risk Coverage (ARC), and the Marketing Assistance Loan program (MAL)—offer support to producers when prices or revenues fall below specific thresholds. Complementing these programs are Federally subsidized insurance programs provided under the Federal Crop Insurance Act, in which producers pay premiums in exchange for varying levels of protection from losses to revenues or yields.

Commodity programs

Producers with base acres—area that was historically planted in "covered commodities," including corn—are eligible to participate in either PLC or ARC on a commodity-by-commodity basis.[20] These programs are not tied to the farmer's current production. PLC pays producers when the covered commodity's market price falls below the effective reference price specified for the program. The effective reference price can change in response to changing market conditions.[21] When a commodity's price dips below the effective reference price, producers receive a per-base acre payment that equals 85 percent of the price difference times the crop's historic yield. Over the period 2014–17, a little over 6 percent of corn base acres, amounting to just under 6.4 million acres (about 2.6 million hectares), were enrolled in PLC and received on average $118 million annually, yielding producers with corn base acres about $18 per acre each year.

In contrast to PLC's price trigger mechanism, ARC payments trigger on the basis of changes in revenues, whether due to prices or yields. ARC pays producers when a covered commodity's revenue falls below a benchmark determined by the effective reference price and historical yields. Specifically, payments equal the difference between 86 percent of the benchmark revenue and the realized revenue but cannot exceed 10 percent of the total benchmark amount. In the ARC-County program, the most popular version of ARC, producers receive payments based on their county's average yields. Over 90 percent of corn base acres were enrolled in ARC over the duration of the 2014 Farm Act, with annual total payments during 2014–17 averaging around $2.8 billion. This

[19]Some information for this section is drawn from USDA, ERS (2019a), Motamed et al. (2018), and Cooper and Motamed (2019).

[20]Covered commodities" for PLC and ARC include wheat, corn, sorghum, barley, oats, seed cotton, long- and medium-grain rice, certain pulses, soybeans and other oilseeds, and peanuts.

[21]USDA, ERS (2019a) offers an overview of the calculations underlying the 2018 Farm Act's effective reference price.

translates to about $31 per acre paid to producers with corn base acres. This payment is made irrespective of the farmer's revenue from corn.

As mentioned earlier, the 2018 Farm Act also provides for the continuation of the Marketing Assistance Loan Program (MAL). MAL offers producers low-interest loans on harvested but unsold commodities, allowing them to store the harvested amount until market conditions improve.[22] Producers can repay the loan at the lower market price, or producers may choose to forfeit the commodity in lieu of repaying the loan, or if market prices fall below the loan rate, producers can repay the loan at the lower market price. Producers who do not wish to take a loan can also participate by applying for a direct payment (called a loan deficiency payment) equivalent to the difference between the loan rate and the lower market price. Because market prices have remained well above the loan rates, fewer producers have used this program in recent years.

Crop insurance

The Federal Crop Insurance Act authorizes a variety of crop insurance programs for which corn producers are eligible. To participate, producers pay premiums based on the level of losses they wish to insure, with coverage ranging from 50 to 85 percent of expected revenues. The Federal Government subsidizes anywhere from 38 to 80 percent of the premium, depending on the type of policy and coverage level purchased. Subsidy rates decline with higher coverage levels. Among these programs, the most popular by far for corn is Revenue Protection, which pays producers when revenues fall below the producer's expected revenues, determined by the expected yields and harvest price at planting time. Revenue Protection insurance not only reduces corn producers' revenue variability but also raises the lower bound of possible revenues they might experience. In 2017, over 71 million acres of corn were covered by Revenue Protection (corresponding to about 86 percent of total corn acres insured under all types of crop insurance policies), for which $3.5 billion in premiums were collected ($1.4 billion paid by producers) and $1.3 billion in indemnities were paid.

Environment and conservation programs

To remain eligible for most program benefits, farmers cropping highly erodible land are required to implement an approved conservation plan and farmers with wetlands are required to be in compliance with wetland preservation provisions. The Food, Conservation, and Energy Act of 2008 (2008 Farm Act) expanded support for conservation practices on all cultivated land (including fallow). Working land programs, such as the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program, provide assistance on lands in production. Land retirement programs—including the Conservation Reserve Program (CRP), the Conservation Reserve Enhancement Program, and the Agricultural Conservation Easement Program—remove environmentally sensitive land from production and establish long-term, resource-conserving cover. Under the 2014 Farm Act, the CRP's area cap was 24 million acres (9.7 million hectares) in FY 2017; that cap is gradually being raised to 27 million acres (10.9 million hectares) under the 2018 Farm Act.

[22]Commodities eligible for MAL include wheat, corn, sorghum, barley, oats, upland and extra-long-staple cotton, long- and medium-grain rice, soybeans and other oilseeds, certain pulses, peanuts, sugar, honey, wool, and mohair.

Policy incentives help to motivate U.S. fuel ethanol production

Corn is the leading feedstock used to produce ethanol in the United States. U.S. ethanol production has expanded rapidly, in part due to policy incentives. The Energy Policy Act of 2005 established the Renewable Fuels Standard (RFS), which mandates that specific minimum quantities of biofuels be blended into gasoline in order to reduce greenhouse gas emissions, bolster energy independence, and foster rural economic development. Enacted in its current form via the Energy Independence and Security Act of 2007 (EISA), the RFS required increasing volumes of ethanol from conventional feedstocks (mostly corn) in gasoline over time to a maximum of 15 billion gallons (about 56.8 billion liters) in 2017. The result has been a substantial increase in U.S. ethanol production from 2.8 billion liters in 1990 to 60.8 billion liters in 2018 (USDOE, EIA, 2019). Other factors affecting fuel ethanol production (and the amount of corn used as an ethanol feedstock) include various State production subsidies, some States' required use of fuel alcohol, and the cost and availability of substitute fuel additives and alternative biofuels.

Overall, the EISA required the use of 9.0 billion gallons (34.1 billion liters) of renewable fuels in 2008, with the total mandate increasing each year until it reaches a statutory level of 36 billion gallons (136.3 billion liters) in 2022. The annual mandates can be subject to waivers, which result in a lower actual level in a given year. In addition, the EISA requires that an increasing share of the mandate be met with advanced biofuels, which are biofuels produced from feedstocks other than corn starch (and with 50 percent lower-lifecycle greenhouse gas emissions than petroleum fuels). Potential advanced biofuels include ethanol from cellulosic material (such as perennial grasses and municipal solid waste), ethanol from sugarcane, and diesel fuel substitutes produced from a variety of feedstocks.

Market development and food aid programs

Market development and food aid programs administered by USDA's Foreign Agricultural Service (FAS) and the U.S. Agency for International Development (USAID) help to promote and facilitate purchase of U.S. feed grains in foreign markets. Among these programs, the one used most commonly in recent years to promote U.S. corn exports to Mexico is the Market Access Program (MAP). MAP forms partnerships between USDA's Commodity Credit Corporation and nonprofit trade associations, cooperatives, trade groups, or small businesses to share the cost of overseas marketing and promotional activities, such as consumer promotions, market research, trade shows, and trade servicing. For FY 2018, MAP allocated about $8.9 million to the U.S. Grains Council (USDA, FAS, 2017), a private, non-profit corporation that "develops export markets for U.S. barley, corn, grain sorghum, and related products, including ethanol and distiller's dried grains with solubles" (U.S. Grains Council, 2017). The Council has 10 international offices, including one in Mexico City. USDA and USAID also provide food aid overseas, but food aid sales account for a very small portion of U.S. feed grain exports. As an upper-middle-income country, Mexico is not a recipient of such assistance.

Conclusion

Both the United States and Mexico are home to large corn sectors. With production spanning different varieties, technologies, and practices, and with uses ranging from food for human consumption to feed for livestock and poultry to ethanol production, corn plays critical roles in both economies. As the destination for over $3 billion annually in exports of U.S.-grown corn and corn-based products, Mexico is the largest foreign market for U.S. corn farmers in terms of export value and volume. Completion of NAFTA's transition to free trade has facilitated even closer integration of both countries' corn markets, as evidenced by the rising volume of U.S. corn exports to Mexico and the co-movement of U.S. and Mexican corn prices.

In broad terms, the U.S. and Mexican corn sectors have shown a high degree of stability since the transition to free trade. On the supply side, Mexico's corn farmers continue to focus on growing white corn, the main ingredient in the country's corn-based tortillas, while U.S. corn farmers continue to grow predominantly yellow corn, used primarily as livestock and poultry feed and as a feedstock in ethanol production. As was the case before NAFTA, Mexican corn farms tend to be small (average corn area per farm of roughly 4 hectares), and U.S. corn farms tend to be large (113 hectares). Both countries' corn sectors have exhibited a capacity for growth over the past decade through the achievement of higher yields, with the fastest yield growth in Mexico observed in irrigated production. There are a number of noteworthy changes on the supply side, however, particularly in Mexico: a small but expanding yellow corn sector has emerged, and the country has become a more consistent and larger exporter of white corn.

On the demand side, Mexico's growing livestock and poultry sector increasingly relies on imports of U.S.-grown corn, a supply made possible by regional trade liberalization and the high production levels achieved by U.S. producers combining modern technologies and management with favorable climate and soils. USDA's long-term projections offer insights into the possible future of U.S. and Mexican corn demand over the coming decade. With Mexican incomes rising, Mexican diets shifting to include more poultry meat and pork, and U.S. corn yields increasing, exports of U.S.-grown corn are expected to continue meeting the growing input needs of Mexico's livestock and poultry producers. With the further expansion of U.S. corn production, U.S. feed use of corn will continue to grow, but use of corn as an ethanol feedstock will decline to levels seen in 2016.

The new presidential administration in Mexico is implementing new agricultural programs that focus on small- and medium-scale producers of corn and other commodities, while the 2018 Farm Act continues current U.S. risk management and income support programs with relatively few changes. U.S. Federal support programs in agriculture offer domestic producers a variety of risk management tools, including price- and revenue-triggered income support programs tied to a farm's crop-specific acreage of crops eligible to participate in commodity programs (i.e., historical base acres), as well as commodity loans and crop insurance programs. The extent to which any changes made to U.S. and Mexican agricultural programs affect the corn sector will ultimately depend on the content of the policy changes and how those changes interplay with market forces. For its part, the new United States-Mexico-Canada Agreement (USMCA) retains NAFTA's provisions for tariff- and quota-free intraregional trade in corn and corn-based products—provisions that facilitated the integration of the U.S. and Mexican corn markets.

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