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The relationship between crude oil prices and export prices of major agricultural commodities

By Kevin M. Camp

Corn, soybeans, and wheat are important export crops in the United States. Combined, these commodities make up a large portion of staple foods and animal feed consumed worldwide. On an annual basis, the United States typically ranks as the world's largest corn exporter. U.S. exports accounted for about 36 percent of global corn trade in 2016–17. For soybeans, the United States is among the world's largest exporters, with a global trade share close to 40 percent in 2016–17. The U.S. share of world wheat exports has declined in recent decades. Nonetheless, the United States remains one of the largest wheat exporters worldwide, accounting for nearly 16 percent of world wheat production in 2016–17.[1]

Prices for corn, soybeans, and wheat generally trend together because the crops share common price-determining factors. Common price determinants for these commodities are substitutability, demand, biofuels, the value of the U.S. dollar, weather, and crude oil.[2]

The export prices of corn, soybeans, and wheat have trended similarly to each other for years because the grains are interchangeable both in terms of animal feed usage as well as for other foodstuffs.[3] The export price for each of these agricultural commodities closely aligns with the domestic price, because the world market for these bulk products is so competitive that prices converge. In addition, crude oil prices influence the price for each of these commodities because crude oil has become a more important input to producing corn, soybeans, and wheat.[4] Domestic and imported crude oil are both sources of supply. Like agricultural commodities, crude oil prices are set through daily commodity trading—meaning, on a particular day, crude oil in New Orleans costs roughly as much as crude oil arriving at the port in Houston.

This article investigates how price trends for corn, soybeans, and wheat exports are linked together, and details the interaction of crude oil prices with the export prices for these three commodities. The article also examines two periodic peaks in world price changes for these commodities and the causes that led up to those changes.

Factors contributing to commodity price linkages

Export prices for corn, soybeans, and wheat trend similarly over time, as illustrated in chart 1. Contributing to the shared price changes is a variety of factors, which can be split into categories. One category is demand-related factors: substitutability, worldwide demand, biofuels production, and the value of the U.S. dollar. Another category is supply-related factors, namely weather and crude oil prices. Market speculation, which falls outside the categories of demand and supply, is an additional factor affecting crop prices in the short run.[5]

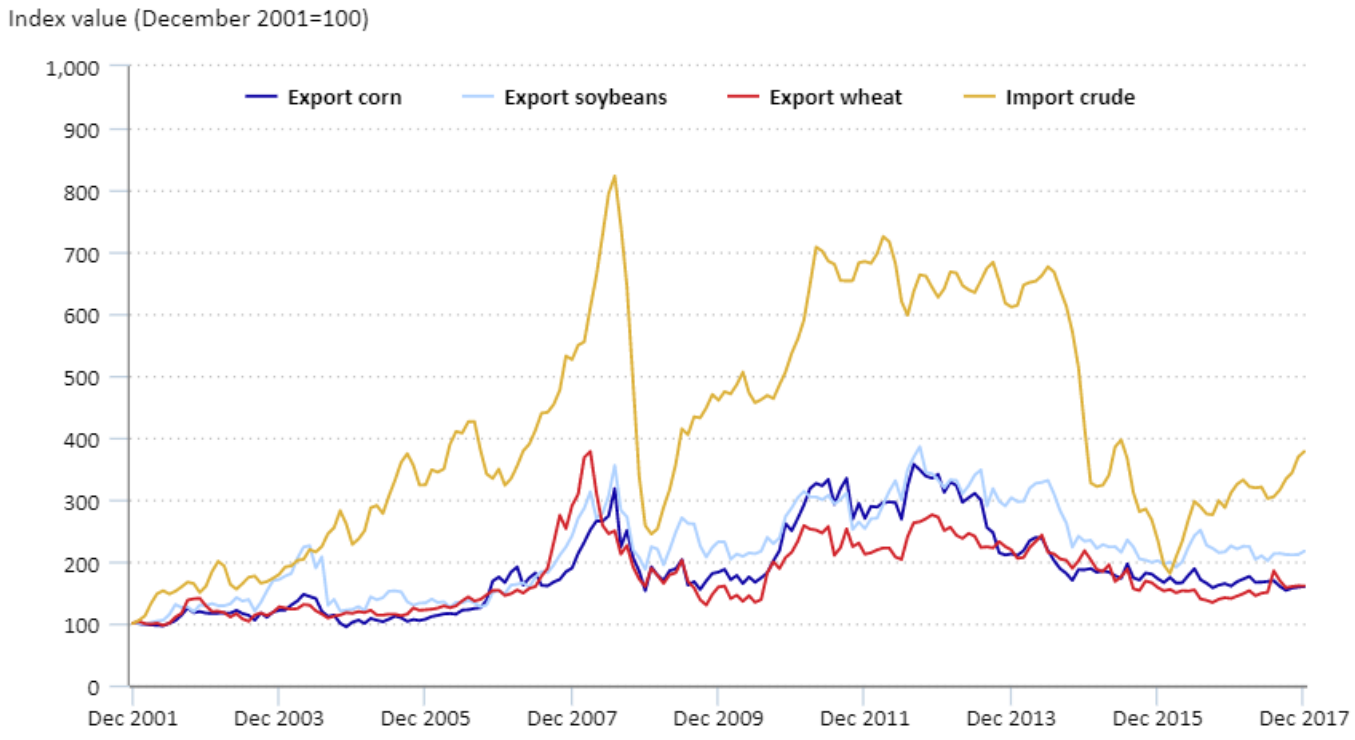
Substitution effect

The ability of buyers to substitute among corn, soybeans, and wheat creates a strong price linkage.[6] If corn prices suddenly increase, a livestock farmer can switch to a cheaper commodity at that time, for example, soybeans. Economy-wide, this effect results in an eventual increase in soybeans prices, thereby linking the original corn price rise to the newly increased price for soybeans.

Worldwide demand

World demand for each of the crops is influenced by global population, overall economic growth, and meat consumption worldwide.[7] An increase in meat demand results in a proportionally larger rise in prices for grain (e.g., corn and wheat) and protein (e.g., soybeans) feeds, which are used in meat production.[8]

Chart 1. Agricultural export and crude oil import price indexes, December 2001–17



Click legend items to change data display. Hover over chart to view data.
Source: U.S. Bureau of Labor Statistics.

Biofuels

Biofuels production increases create a more direct link between commodity and energy prices.[9] The production of biofuels, such as ethanol and biodiesel, is an important determinant of corn and soybeans prices, but less so for wheat prices. Ethanol is an alcohol fuel produced almost entirely from corn. U.S. ethanol production has increased substantially from 183 thousand barrels per day in 2003 to 977 thousand barrels per day in 2016. In 2016, 5.3 billion bushels of U.S. corn were used for ethanol production, more than 36 percent of the total 14.5 billion bushels produced in the United States during the year.[10]

Biodiesel, a fuel made from vegetable oils, fats, or greases, is produced primarily in Argentina, Brazil, the European Union, and the United States. Soybeans are the largest biodiesel feedstock in all but the European Union.[11] U.S. biodiesel production has increased substantially, dating back to the early 2000s, rising from 14 million gallons in 2003 to 1,556 million gallons in 2016.[12]

An increase in ethanol production creates an increase in demand for corn, just as biodiesel production increases the demand for soybeans. In addition, both ethanol and biodiesel are substitutes for crude oil. For example, blending biofuels with conventional gasoline and diesel decreases the use of the crude oil derivatives in powering cars.[13] From 2001 to 2010, the majority of gasoline in the United States shifted to a 10-percent ethanol blend.[14] Meanwhile, the Renewable Fuel Standard prompted an increase in U.S. biodiesel production

from 0.2 billion gallons in 2010 to 2.1 billion gallons in 2017, resulting in an especially strong relationship among prices for corn, soybeans, and crude oil.[15]

Value of the U.S. dollar

The value of the U.S. dollar also has an impact on world prices for corn, soybeans, and wheat; generally, the dollar and agricultural commodity prices are negatively correlated. For example, declines in the value of the U.S. dollar, up to and during 2008, contributed to rising prices for U.S. agricultural exports.[16] Given that U.S. corn, soybeans, and wheat account for large shares of global production, a depreciated U.S. dollar gives foreign buyers more purchasing power for the crops. The added purchasing power of foreign buyers will drive up prices for corn, soybeans, and wheat.

Weather

On the supply side, weather events can have an impact on crop growth and thereby influence prices for corn, soybeans, and wheat. For example, droughts and unseasonably cold temperatures can affect production by reducing yields. The resulting decrease in supply would tend to increase prices for all affected crops. The reverse is true for better-than-expected growing conditions. Higher yields due to improved growing conditions will translate to increased supply resulting in decreased prices for the affected crops.

Crude oil as an input

Input prices play an important role in determining supply as well. Crude oil is a critical input, both directly and indirectly, to agricultural production, meaning crude oil prices are another substantial factor linking prices for corn, soybeans, and wheat.[17] Over time, growers have used increasing amounts of energy to produce these agricultural commodities. Farm production uses energy directly (e.g., fuel to power equipment and transport products) and indirectly through “energy-intensive inputs,” including pesticides and fertilizer.[18] A majority of the direct energy used by U.S. growers comes from diesel and gasoline which power farm machinery. By extension (given crude oil’s role as the primary feedstock for diesel and gasoline production), most direct energy use on farms is attributable to crude oil. The link between energy intensive-inputs and crude oil is mixed—pesticides are made of ethylene and propylene derived from either crude oil or natural gas, while fertilizer production primarily uses ammonia derived in large part from natural gas. Crude oil products account for a large part of total cost among agricultural producers. From 2010 to 2016, combined chemicals, fuel, oil and lubricants, and electricity costs were 8.8 percent of total costs for corn farmers, 9.8 percent of total costs for soybeans farmers, and 10.4 percent of total costs for wheat farmers in the United States.[19] As crude oil prices increase, the production of commodities such as soybeans and wheat becomes more expensive, and growers may pass higher prices through to buyers as a result.

Correlation in prices

Calculations reveal the extent to which price changes for the major agricultural commodities correlate positively with each other. The correlation coefficient, ranging from -1 to 1, is an indication of how movements in two variables are related. Values close to -1 indicate a strong negative relationship (the variables move in opposite directions), and values close to 1 indicate a strong positive relationship (the variables move in the same direction). A correlation coefficient of 0 indicates movements in the two variables are not linearly related. Corn and soybeans, the two most important crops in biofuels production, share a strong link—from December 2002 to

December 2017, 12-month percent changes in the two price indexes have a correlation coefficient of 0.72. Corn and soybeans price changes are each positively related to price changes for wheat as well, with correlation coefficients of 0.71 and 0.74, respectively.[20]

Agricultural exports and crude oil imports: price trends, 2006–13

This section discusses which factors influenced prices at various times from 2006 to 2013. Prices for U.S. agricultural exports are more volatile than overall U.S. export prices.[21] This volatility occurs because agricultural goods prices are susceptible to weather events, crude oil price changes, and the value of the U.S. dollar. In turn, prices for corn, soybeans, and wheat are generally more volatile than those for overall U.S. agricultural exports.[22] This volatility is demonstrated in chart 1, which tracks price changes over time for corn, soybeans, and wheat exports, and crude oil imports. During the period shown in the chart, the graphs for export corn, soybeans, and wheat reveal prices subject to volatility—in other words, recording large price changes on 1- or 12-month bases.

A record high in 2008

From 2006 to 2008, prices for most food commodities rose rapidly.[23] The price index for export corn reached a record high in July 2008, after rising 185.8 percent from January 2006. Soybeans export prices rose to record levels in July 2008, advancing 154.7 percent from January 2006. The price index for export wheat peaked in March 2008 from January 2006, a 207.1-percent increase.

As agricultural commodity prices soared, crude oil prices rose to historical highs as well. From January 2006 to July 2008, when the price index for import crude oil reached a record level, crude oil prices increased 136.2 percent. The surge in crude oil prices was due to stronger demand and more speculative activity in oil markets.[24]

Prices reversed soon after mid-2008, when the recession led to a decrease in world oil demand.[25] The price index for import crude oil dropped 70.3 percent from July 2008 to January 2009. Agricultural commodity prices followed suit, as corn, soybeans, and wheat export prices returned to mid-2007 levels in early 2009. Corn prices fell 39.8 percent, soybeans prices dropped 36.9 percent, and wheat prices declined 24.2 percent from July 2008 to January 2009.

Another rise, then a drought, 2010–13

Prices for agricultural commodities again increased rapidly from mid-2010 to mid-2011 while crude oil prices also rose substantially during the same period. Prices for export corn, soybeans, and wheat advanced 99.7 percent, 44.3 percent, and 91.3 percent, respectively, from June 2010 to June 2011. Crude oil prices rose 50.1 percent over the same period. However, adverse weather was a larger contributing factor to the agricultural price advances. Worldwide droughts, as well as an unseasonable freeze in Mexico, decreased production unexpectedly, forcing prices upward.[26]

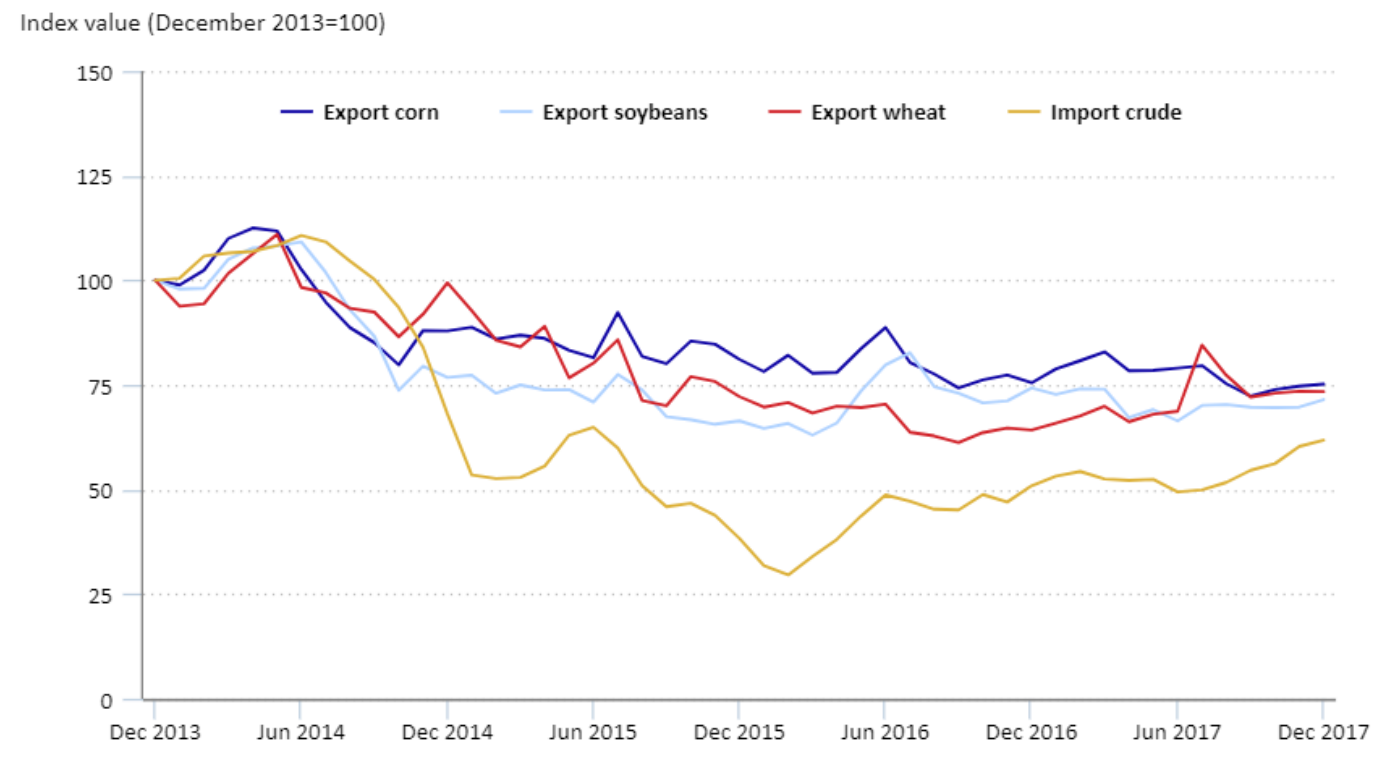
In the summer of 2012, a drought affected much of the United States, damaging crops and pushing up prices further for corn, soybeans, and wheat.[27] Export prices for corn rose 29.6 percent from June to September 2012. Soybeans export prices increased 28.8 percent and wheat export prices advanced 29.9 percent during the

same period. Meanwhile, crude oil import prices rose more modestly—6.9 percent—further evidence that the sizeable agricultural commodity price swing was drought-related. In 2013, soybeans and wheat export prices fluctuated, with both ultimately recording modest decreases compared to the previous year. By contrast, prices for export corn fell sharply, decreasing 37.7 percent from December 2012 to December 2013. Record U.S. corn production was the primary contributor to the year-over-year decline.[28]

Price trends, 2014 to 2018

In the period from 2014 to 2018, the weaker dollar and a drought each heavily influenced prices. An oil production increase, starting around May 2014, resulted in a sharp drop in crude oil prices later that year. As depicted in chart 2, from June 2014 to February 2015, crude oil prices decreased 52.5 percent. Export prices for the major agricultural commodities dropped over the same period; corn, soybeans, and wheat prices fell 16.2 percent, 33.1 percent, and 12.8 percent, respectively. Despite sagging crude oil prices, as well as a stronger U.S. dollar pushing prices down, the price drops for corn, soybeans, and wheat were relatively modest from mid-2014 to the beginning of 2015.[29] While crude oil prices decreased, prices for energy-intensive inputs decreased by less, preventing farm production costs from falling commensurately to crude oil prices.[30]

Chart 2. Agricultural export and crude oil import price indexes, December 2013–17



Click legend items to change data display. Hover over chart to view data.
Source: U.S. Bureau of Labor Statistics.

Weaker dollar and OPEC impacts, 2016–17

Crude oil prices reached a recent low in early 2016. Subsequent oil production shortfalls led to a price increase, with the price index for import crude oil rising 64.5 percent from February to June 2016.[31] The U.S. dollar lost value relative to other currencies during the same time period. Crude oil price increases and the weaker dollar led to advances in corn and soybeans prices, which rose 8.1 percent and 21.3 percent, respectively. Wheat prices, however, fell 0.6 percent from February to June 2016. The wheat price drop was likely due to strong output both domestically and globally. In October 2016, world wheat production was 9.4 million tons greater than the previous year and U.S. production was 6.7 million tons greater than the prior year.[32]

Crude oil prices increased 21.4 percent from December 2016 to 2017 amid an output cut imposed by Organization of the Petroleum Exporting Countries (OPEC).[33] The value of the U.S. dollar trended downward overall in 2017. The resulting crude oil price and U.S. dollar effects combined to put upward pressure on crop prices, and accordingly the export wheat price index rose 14.4 percent over the 12 months ended December 2017. But in contrast, price indexes for export corn and soybeans fell in 2017. Corn export prices edged down 0.5 percent, and prices for soybeans exports dropped 3.8 percent. Downward pressure on corn prices in 2017 came from record supply.[34] In late 2017, low export demand and strong overall production for U.S. soybeans decreased prices for exports of that crop.[35]

The drought of 2018

In 2018, the weather in the United States had an impact on the winter growing season during the early part of the year. A pronounced drought lasting through mid-February gave way to substantial precipitation in much of the country.[36] Notwithstanding the precipitation, drought conditions remained in U.S. growing regions. Areas experiencing drought contained 15 percent of corn production and 15 percent of soybeans production for the week ended February 20, 2018. Wheat, more commonly grown during winter, faced larger impacts from the drought; production of 42 percent of winter wheat and 48 percent of spring wheat occurred in areas experiencing drought in late February 2018.

Corn, soybeans, and wheat prices were mostly up in the first three quarters of 2018. From December 2017 to May 2018, export corn prices rose consistently on a month-to-month basis. Overall, prices for export corn increased 8.1 percent from December 2017 to August 2018. Soybeans prices fell sharply in the summer of 2018, resulting in an overall decrease of 8.6 percent during the December to August period. Prices for export wheat rose 15.0 percent from the end of 2017 through August. Notwithstanding decreases in February, March, and August, crude oil prices advanced 14.0 percent from December 2017 to August 2018. These 2018 data indicate positive price correlations among corn, wheat, and crude oil. By contrast, 2018 export price data suggest that soybeans market factors more than offset the cross-commodity factors that typically create a link with soybeans prices.

Conclusion

Major agricultural commodity prices generally trend together due to common price determinants. Food commodity prices are also linked with those for crude oil. However, more conventional supply (e.g., weather events) and demand (e.g., the value of the U.S. dollar) factors are important determinants of the recent price movements for corn, soybeans, and wheat. In particular, favorable weather conditions resulted in strong corn

and soybeans supply in 2017, driving prices downward. The positive weather conditions persisted for soybeans in 2018, further decreasing prices for soybeans in spite of crude oil price advances. These price data suggest supply and demand factors dominate when food commodity prices and crude oil prices diverge.

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NOTES

[1] For more information on corn, soybeans, and wheat trade data see, “World agricultural supply and demand estimates,” USDA Economic Research Service, report WASDE-586.

[2] Biofuels are defined as, “transportation fuels such as ethanol and biodiesel that are made from biomass materials.” For more information see, https://www.eia.gov/energyexplained/index.php?page=biofuel_home.

[3] Ronald Trostle, “Global agricultural supply and demand: factors contributing to the recent increase in food commodity prices,” USDA Economic Research Service, report WRS-0801.

[4] Ardian Harri, Lanier Nalley, and Darren Hudson, "The relationship between oil, exchange rates, and commodity prices," *Journal of Agricultural and Applied Economics*, no 41.2 (August 2009), pp. 501-510.

[5] Lihong McPhail, Xiaodong Du Lu, and Andrew Muhammad, "Disentangling corn price volatility: The role of global demand, speculation, and energy." *Journal of agricultural and applied economics*, no 44.3 (August 2012), pp. 401-410.

Also see, Philip C. Abbott, Christopher Hurt, and Wallace E. Tyner, “What's driving food prices? March 2009 update,” *Farm Foundation*, no. 48495, (March 2009).

[6] Ronald Trostle, “Global agricultural supply and demand: factors contributing to the recent increase in food commodity prices,” USDA Economic Research Service, report WRS-0801.

[7] Increases in each of these demand-side factors contributed to the agricultural commodity price peaks in 2008.

[8] Ronald Trostle, “Global agricultural supply and demand: factors contributing to the recent increase in food commodity prices,” USDA Economic Research Service, report WRS-0801.

[9] Philip C. Abbott, Christopher Hurt, and Wallace E. Tyner, "What's driving food prices? March 2009 update," *Farm Foundation*, no. 48495, (March 2009).

This may help explain why wheat, which is affected relatively less by biofuels demand and relatively more by weather events, reached a record high price earlier in 2008 than corn, soybeans, and rice. Wheat export prices peaked in March, while export prices for the remaining crops peaked in July.

For more information see, Joseph P. Janzen, Colin A. Carter, Aaron D. Smith, and Michael K. Adjemian, "Deconstructing wheat price spikes: A model of supply and demand, financial speculation, and commodity price comovement," USDA Economic Research Service, report ERR-165, April 2014.

[10] "U.S. total corn production and corn used for fuel ethanol production," U.S. Department of Energy, Alternative Fuels Data Center, https://www.afdc.energy.gov/data/10339.

[11] Ronald Trostle, "Global agricultural supply and demand: factors contributing to the recent increase in food commodity prices," USDA Economic Research Service, report WRS-0801.

[12] "U.S. biodiesel production, exports, and consumption," U.S. Department of Energy, Alternative Fuels Data Center, https://www.afdc.energy.gov/data/10325.

[13] "Biofuels: ethanol and biodiesel explained," U.S. Energy Information Administration, https://www.eia.gov/energyexplained/index.cfm?page=biofuel_home.

[14] "U.S. total corn production and corn used for fuel ethanol production," U.S. Department of Energy, Alternative Fuels Data Center, https://www.afdc.energy.gov/data/10339.

[15] For more information on renewable fuel standards visit, https://www.epa.gov/renewable-fuel-standard-program/final-renewable-fuel-standards-2017-and-biomass-based-diesel-volume.

[16] Ronald Trostle, "Global agricultural supply and demand: factors contributing to the recent increase in food commodity prices," USDA Economic Research Service, report WRS-0801.

[17] BLS export price index data do not include the cost of transporting the crops to the final export destination, but are inclusive of costs related to domestic transport to the locality of exportation.

[18] Claudia Hitaj, and Shellye Suttles, "Trends in U.S. agriculture's consumption and production of energy: Renewable power, shale energy, and cellulosic biomass," USDA Economic Research Service, report EIB-159, August 2016.

[19] "Commodity costs and returns," USDA Economic Research Service, https://www.ers.usda.gov/data-products/commodity-costs-and-returns/.

In the data product, farm costs for "chemicals" derive from answers to an Agricultural Resource Management Survey question reading, "What was the total cost of all chemical, biocontrol, or pesticide products applied to this field? (Include operator, landlord, and contractor costs, defoliants, herbicides, insecticides, fungicides, surfactants, wetting agents, growth regulators, and materials applied before planting and during 2015 fallow period. Exclude seed treatments.)," see, https://www.ers.usda.gov/webdocs/DataFiles/83637/W%5E2016%5ECorn%5EPhase2%20Questionnaire%20Production%20Practices_Costs%5EQ%5ECOP_CPP.pdf?v=42877.

[20] The calculation between the commodities came from the correlation coefficient of X and Y formula, Correl (X,Y) = sigma(x - x-bar)(y - y-bar)/square root of sigma(x - x-bar)^2 (y - y-bar)^2 , where x and y are monthly price index percent change values of the

commodities being compared; *x*-bar and *y*-bar and are the average monthly price index percent change values of the commodities being compared over the entire period from January 2002 to December 2017. (Monthly percent change data for export soybeans prices were first published in January 2002.)

[21] Tamar Rosenstein, "Impact of the 2015 U.S. dollar rise on export prices and on the agricultural industry," *Beyond the Numbers*: *Global Economy*, vol. 5, no. 18 (U.S. Bureau of Labor Statistics, December 2016), https://www.bls.gov/opub/btn/volume-5/impact-of-the-2015-us-dollar-rise-on-export-prices-and-on-the-agricultural-industry.htm.

[22] The coefficient of variation measures volatility in a series, and is calculated by dividing the sample standard deviation by the sample mean. A higher coefficient of variation evinces greater volatility. Based on U.S. Bureau Labor Statistics export price index data from December 2001 to December 2017, the coefficient of variation for all exports was 0.10 and the coefficient of variation for agricultural exports was 0.24. The coefficient variation for corn, soybeans, and wheat prices over the same time period were 0.32, 0.37, and 0.31, respectively.

[23] Kuhanathan Ano Sujithan, Sanvi Avouyi-Dovi, and Lyes Koliai, "On the determinants of food price volatility," *International Conference on Food Price Volatility: Causes and Challenges*, 2014.

[24] James Einloth, "Speculation and recent volatility in the price of oil," Federal Deposit Insurance Corporation, August 2009, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1488792.

[25] Jad Mouawad, "Oil prices drop to 20-month low," *The New York Times*, November 11, 2008, www.nytimes.com/2008/11/12/business/worldbusiness/12oil.html.

[26] Ronald Trostle, "Why another food commodity price spike?" USDA Economic Research Service, Amber Waves, 2011, https://www.ers.usda.gov/amber-waves/2011/september/commodity-price-spike/.

[27] Will Adonizio, Nancy Kook and Sharon Royales, "Impact of the drought on corn exports: paying the price," *Beyond the Numbers: Global Economy*, vol. 1, no. 17 (U.S. Bureau of Labor Statistics, November 2012), https://www.bls.gov/opub/btn/volume-1/impact-of-the-drought-on-corn-exports-paying-the-price.htm.

[28] "Grain: World markets and trade," USDA Economic Research Service, Foreign Agriculture Service, report FG 12-13, December 2013, https://downloads.usda.library.cornell.edu/usda-esmis/files/zs25x844t/z029p515h/bk128b388/grain-market-12-10-2013.pdf.

[29] "Real trade weighted U.S. dollar index: major currencies," Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/TWEXMMTH.

[30] Kandice K. Marshall, et al., "Effects of recent energy price reductions on U.S. agriculture," USDA Economic Research Service, 2015.

[31] For more information on international energy statistics, see https://www.eia.gov/cfapps/ipdbproject/IEDindex3.cfm?tid=5&pid=53&aid=1.

[32] Jennifer Bond and Olga Liefert, "Wheat outlook," USDA Economic Research Service, report WHS-16j, October 2016, https://www.ers.usda.gov/webdocs/publications/80243/whs-16j.pdf?v=42658.

[33] Stanley Reed, "Oil producers comply with OPEC deal to cut output, but for how long?" *The New York Times*, February 13, 2017, www.nytimes.com/2017/02/13/business/energy-environment/opec-oil-energy-cuts.html.

[34] Going forward, higher projected usage of corn could tighten the market, pushing prices up. See Tom Capehart and Olga Liefert, "Feed outlook." USDA Economic Research Service, report FDS-18a, January 2018, https://www.ers.usda.gov/webdocs/publications/86752/fds-18a.pdf?v=0.

[35] Mark Ash, and Mariana Matias, "Oil crops outlook." USDA Economic Research Service, report OCS-18a, January 2018, https://www.ers.usda.gov/webdocs/publications/86741/ocs-18a.pdf?v=0.

[36] "This Week's Drought Summary," *U.S. Drought Monitor*, http://droughtmonitor.unl.edu/data/narrativepdf/20180220_nar_usdm.pdf.

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