

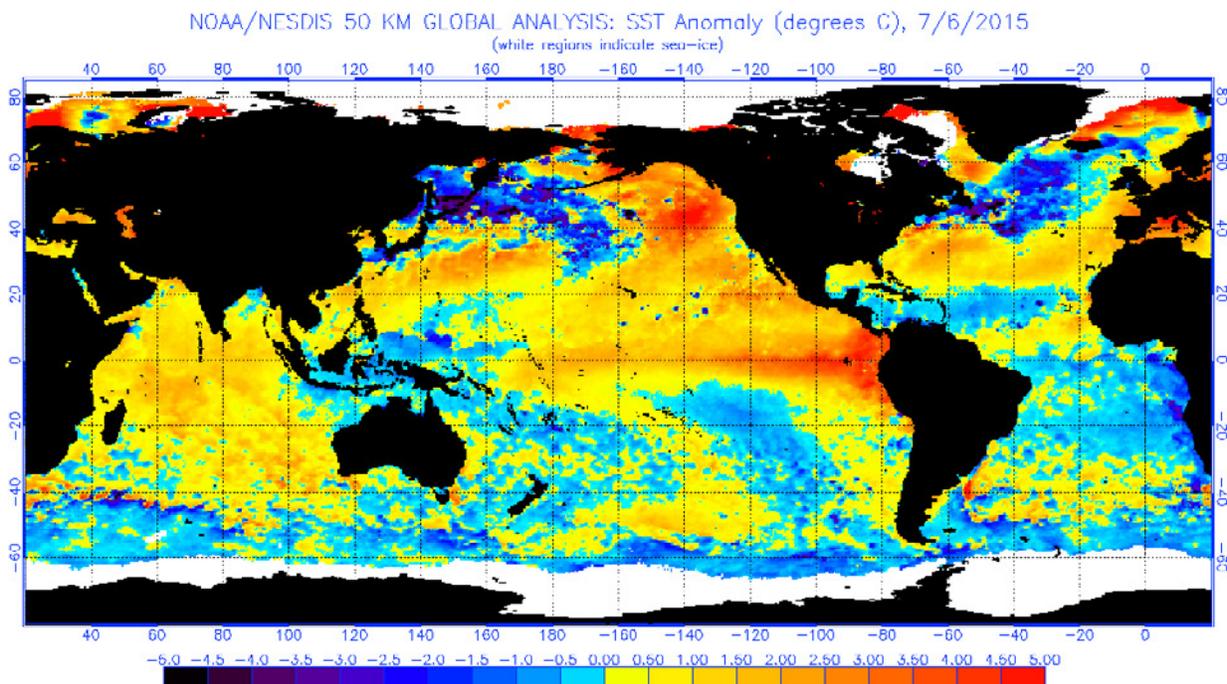
# El Niño: Corn Cares; Cows & Pigs Care; You Should Care, Too.

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El Niño is a macro-scale weather phenomenon that occurs when sea surface temperatures become unusually warmer-than-normal across the central and east-central Equatorial Pacific Ocean. Warmer waters tend to have more evaporation. Where the extra precipitation comes down depends on the direction the winds are blowing. And El Niño shifts wind patterns, too. The warmer-than-usual air over the equator in the Pacific Ocean leads to rising air current, which can exert a southerly pull on storm tracks

in North America. Indeed, the National Oceanographic and Atmospheric Administration (NOAA) refers to ENSO, or El Niño Southern Oscillation, for the way wind patterns and storm tracks shift. Just to complete the picture, with equatorial Pacific Ocean surface water temperatures unusually warm, wind patterns shifting, and ocean currents impacted, one should not be surprised that an El Niño can bring some disruptive changes to typical weather patterns.

**Figure 1: Global Sea Surface Temperature Anomalies**  
(Source: NOAA, July 6, 2015)



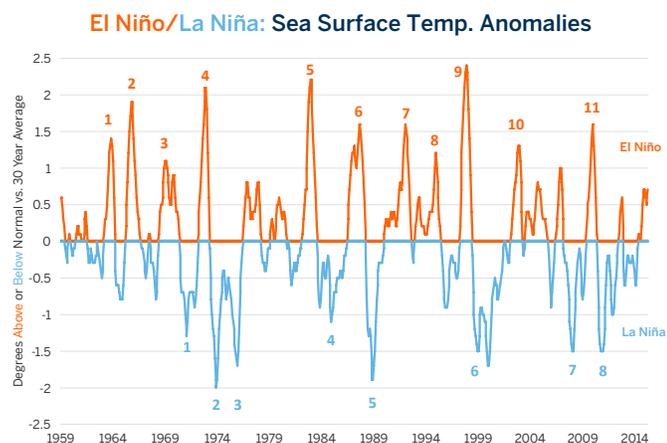
So, why do we care about an El Niño? When weather patterns shift, particularly impacting areas where precipitation occurs (and where it does not is equally important), one can expect an impact on agricultural production – and when this happens, there is likely to be increased uncertainty about agricultural prices around the globe.

While there are variations to the outcome because every El Niño occurrence is unique, the weather anomaly typically increases temperatures over western and central Canada and the western and northern United States, reducing wintertime snow fall in those regions while creating cool and wet conditions in Florida and the U.S. Gulf Coast. There will be rain in Brazil and Argentina. And, since an El Niño is associated with cooler waters near Australia and Indonesia, there is a drought potential there.

We should also note that a few years after an El Niño abates, there is the possibility for a La Niña - a cooling of waters below average levels along the equatorial Pacific Ocean. Not surprisingly, La Niña has quite different effects than El Niño.

NOAA has been collecting data on the variations (in degrees Celsius) from a 30-year, seasonally adjusted, moving average of temperatures for this region of the Pacific since the 1950s. In this paper we relate the variations in NOAA's El Niño/La Niña index to both the spot returns and the reinvested futures returns for a variety of agricultural goods including corn, wheat, soybeans, soybean oil, soybean meal, live cattle, feeder cattle, lean hogs, rough rice, and dairy. Since 1959, there have been eleven episodes of El Niño and eight of La Niña (Figure 2) in which sea surface temperatures varied by more than one degree Celsius from their average.

**Figure 2:**



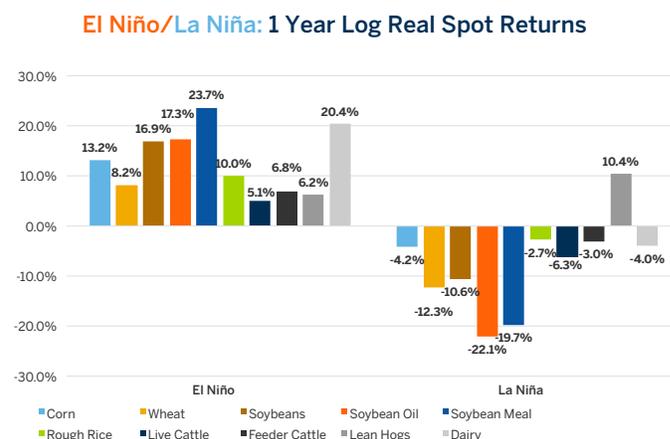
Source: NOAA, National Weather Service, Climate Prediction Center

Some of the futures contracts have weathered all 19 episodes. Corn, wheat, and soybean futures have existed since before 1959 and have therefore been present for each of the episodes. The other contracts are of more recent origin: Live Cattle (1964), Soybean Oil (1974), Soybean Meal (1980), Lean Hogs (1986), Rough Rice (1988), and Dairy (1998).

Without exception, and with significant variation from one El Niño episode to another, the real (inflation adjusted) value of these goods tends to rise under El Niño. With the exception of rough rice (and again with significant variation from one La Niña to another), inflation-adjusted (real) spot prices tend to fall under La Niña (Figure 3). In the chart below, we look at the one-year change in the inflation-adjusted spot price from the time that the temperature index crosses an arbitrary threshold of +1 degree Celsius in the event of El Niño or -1 degree Celsius in the event of La Niña. To smooth out the data, we took a 20-business-day moving average of the spot price, which is approximately one month's worth of data. For instance, if the temperature index crossed +1 degree Celsius above the moving average in September 1963, we looked at the return from the average price in September 1963 to the average price in September 1964.

We use a proxy for spot prices based on the 1st nearby future (also called the lead contract). We adjust the spot price for inflation using the Consumer Price Index produced by the U.S. Bureau of Labor Statistics.

**Figure 3:**



Source: NOAA, National Weather Service, Bloomberg Professional (C 1, W 1, S 1, BO1, SM1, RRI, LC1, LH1 and DA1, CPI INDX), Calculations Done by CME Group Economic Research

It should be noted, however, that there are considerable variations from one El Niño (or La Niña) event to another, both in terms of severity and in terms of the response

from spot prices. El Niño events during the 1960s produced relatively modest impacts on spot prices (Figure 4). The mild reaction to El Niño events of the 1960s might be attributed, in part, to food markets being less significantly globalized at the time than during subsequent El Niños from the 1970s.

**Figure 4: One Year Change in 20 Day Moving Average Inflation Adjusted Spot Prices**

One Year Change in 20 Day Moving Average Inflation Adjusted Spot Prices

Month El Niño Begins	Corn	Wheat	Soybeans	Soybean Oil	Soybean Meal	Rough Rice	Live Cattle	Feeder Cattle	Lean Hogs	Dairy
1: Aug '63	-3.2%	-24.0%	-3.5%							
2: Jul '65	5.8%	22.9%	18.7%				-5.7%			
3: Jan '69	-3.0%	1.7%	-9.8%				-0.9%			
4: Jul '72	60.0%	62.2%	90.3%				25.3%	33.2%		
5: Sep '82	44.7%	10.6%	47.5%	65.3%			-4.8%	-14.1%		
6: Nov '86	3.3%	-1.6%	8.6%	11.7%			1.7%	16.9%	-18.1%	
7: Nov '91	-17.2%	-0.7%	-3.4%	2.8%	9.7%	-32.0%	-2.6%	0.4%	1.5%	
8: Dec '94	41.4%	23.8%	22.0%	-16.1%	-2.7%	32.3%	-6.3%	-16.1%	28.6%	
9: Jun '97	-10.8%	-22.0%	-29.2%	9.1%	105.2%	-11.0%	0.4%	-5.8%	-29.3%	9.7%
10: Oct '02	-13.9%	-14.8%	27.1%	23.3%	5.5%	61.3%	30.7%	24.9%	26.4%	26.7%
11: Oct '09	37.5%	31.9%	17.7%	25.3%	0.5%	-0.6%	14.0%	15.2%	28.0%	24.7%
Average	13.2%	8.2%	16.9%	17.3%	23.7%	10.0%	5.1%	6.8%	6.2%	20.4%

Source: National Weather Service, Bloomberg with CME Economic Research Calculations

**1972: The biggest response to El Niño thus far:** The El Niño that crossed the threshold of +1 degree above normal in July 1972 coincided with a massive run up in spot prices. July 1973 corn prices averaged 60% higher than their July 1972 average after inflation. Inflation-adjusted wheat prices rose 62% while soybeans almost doubled, rising 90% when adjusted for CPI. The rising cost of animal feed may have pushed the live cattle spot prices up by an inflation-adjusted 25% over the same period.

The exceptionally large increase in agricultural goods prices between July 1972 and July 1973 can be attributed to several factors. First, the 1972 El Niño was quite intense with central/east central Pacific Ocean temperatures peaking at 2.1 degrees Celsius above their normal levels (Figure 1). Second, the El Niño temperatures abruptly collapsed into a significant La Niña by July 1973 bringing further weather disturbance. Additionally, the Soviet Union suffered a major crop failure, which led them buy a great deal of grain on the US market, pushing prices higher. Lastly, commodity prices in general soared with gold rising from \$66 an ounce in July 1972 to \$120 per ounce in July 1973. From this vantage point, the rise in agricultural goods prices may have simply reflected an inflationary process that sent the cost of many raw materials higher in the lead up to and in the aftermath of the first oil crisis.

**1982:** When the next significant El Niño struck a decade later in September 1982, the spot price response wasn't quite as dramatic as in 1972 but was still generally positive. Inflation-adjusted prices rose 44.7% for corn, 10.6% for wheat, 47.5% for soybeans, and 65.1% for soybean oil over the period from September 1982 to September 1983. Inflation-adjusted live cattle prices fell by 5.2% over the same period. In 1982-83, unlike in 1972-73, rising agricultural goods prices cannot be attributed to rising commodity prices, or to inflation. Gold prices, for example, fell from \$440 on average in September 1982 to an average of \$412 in September 1983 and inflation remained contained at around 4% per year after the 1981-82 recession.

**1986 and 1991:** The next two El Niños, which began in November 1986 and November 1991, respectively, produced mixed responses from inflation-adjusted spot prices during the first twelve months after the NOAA El Niño index crossed +1°C versus its 30-year seasonally-adjusted moving average. In both cases, however, inflation-adjusted spot prices rose substantially in the second year after the El Niño began (Figure 5). In 1988, a severe drought in the mid-western United States sent the inflation-adjusted spot prices of corn, wheat, soybeans, and soybean oil soaring. Inflation-adjusted spot prices for live cattle advanced as well between November 1986 and November 1988, but the prices of lean hogs declined.

Similarly, inflation-adjusted spot prices for agricultural goods didn't move much between November 1991 and November 1992, but increased significantly during the subsequent 12 months.

**Figure 5: Two Year Change in 20 Day Moving Average Inflation Adjusted Spot Prices**

Two Year Change in 20 Day Moving Average Inflation Adjusted Spot Prices

Month El Niño Begins	Corn	Wheat	Soybeans	Soybean Oil	Soybean Meal	Rough Rice	Live Cattle	Feeder Cattle	Lean Hogs	Dairy
1: Aug '63	-4.0%	-19.4%	-1.8%							
2: Jul '65	-5.6%	-0.1%	-6.3%					-3.0%		
3: Jan '69	17.1%	11.4%	3.7%					-3.8%		
4: Jul '72	81.0%	91.1%	54.4%					5.0%	-13.8%	
5: Sep '82	21.4%	-2.2%	4.5%	36.8%				-2.9%	-3.0%	
6: Nov '86	45.7%	22.9%	46.1%	50.1%				7.1%	25.4%	-23.1%
7: Nov '91	6.1%	-9.5%	11.7%	23.2%	41.7%	24.5%	-7.4%	0.0%	4.3%	
8: Dec '94	11.2%	-4.9%	16.1%	-28.1%	-5.9%	43.9%	-12.5%	-11.7%	60.0%	
9: Jun '97	-23.7%	-34.2%	-62.1%	-34.5%	97.5%	50.2%	-2.0%	-1.2%	-50.3%	-2.7%
10: Oct '02	-25.8%	-28.2%	-8.2%	-1.9%	7.6%	55.4%	18.1%	33.0%	45.0%	24.5%
11: Oct '09	48.3%	18.4%	17.9%	29.8%	-15.2%	13.6%	31.4%	39.6%	48.2%	27.4%
Average	15.6%	4.1%	6.9%	10.8%	25.1%	17.4%	3.0%	8.5%	14.0%	16.4%

Source: National Weather Service, Bloomberg with CME Economic Research Calculations

The lesson of the 1986 and 1991 El Niños is that the impact of crossing above +1°C higher-than-normal temperatures for the central/east central Pacific Ocean isn't always felt immediately. Sometimes the consequences aren't felt in the first year but rather in the second year.

### 1997: Distorted by the Asian and Russian Crisis/LTCM

**Meltdown:** The June 1997 El Niño was the most severe episode on record, yet prices for agricultural products did not rally in the next 12 or even 24 months. Rather, with the exception of soybean meal, the inflation-adjusted spot prices of agricultural goods plunged. Some of this decline may be attributable to the general weakness of commodity prices around the time of the Asian financial crisis, which began in June 1997 (the same month as the El Niño), as well as the Russian default, and collapse of Long Term Capital Management, which occurred in August 1998. In June 1997, for example, West Texas Intermediate Crude Oil which averaged \$19.30/barrel fell to \$13.36/barrel on average by June 1998. Gold prices fell from \$339 to \$295 over the same period. Moreover, many emerging market currencies collapsed versus the US Dollar during this period. Overall, it might be fair to say that the 1997 El Niño didn't boost agricultural goods prices in terms of US Dollars but did boost them from the perspective of many other currencies.

**2002:** The El Niño that began (by our measurement) in October 2002 boosted the prices of most agricultural goods in US Dollar terms, with the exception of corn and wheat. The effects were pretty short-lived though as the impact didn't seem to carry over much into the October 2003-October 2004 period. The exceptions here were rough rice, whose prices soared, along with those for livestock and animal feed products.

**2009:** The October 2009 El Niño coincided with soaring prices for most agricultural goods in the next 12-24 months. It should be noted, however, that the period from October 2009 to October 2010 (and October 2011) was a period of generally rising commodity prices as the US Federal Reserve continued its quantitative easing programs (begun in March 2009), and there was a general reflation and economic recovery from the depths of the financial crisis. Most of the world's economies, with the notable exception of those of Southern Europe, recovered during this period.

Overall, El Niño more often than not boosts the inflation-adjusted spot prices of agricultural goods. If the run-up in price doesn't happen in the twelve months after NOAA's

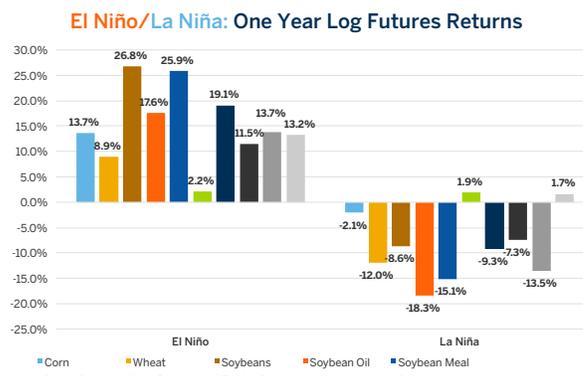
index of central and east central Pacific Ocean Sea Surface Temperatures crosses one degree higher than the seasonal norm, then the price increase can still happen in the subsequent twelve months. This seems to be the case, especially after the 1960s when agricultural markets became increasingly globalized as barriers to trade diminished.

### Futures Returns: So Much for the Strong Form of Efficient Markets Hypothesis

If agricultural goods markets were perfectly efficient, and had incorporated the likely impact of El Niño and La Niña into futures prices, the average returns to long positions in futures contracts should be no different between El Niño and La Niña. For example, in the case of El Niño, the market should have anticipated higher spot prices by moving the forward curve more steeply into contango as central and east-central Pacific Ocean temperatures rose. Likewise, in the case of La Niña, the futures market should have anticipated better growing conditions for most crops (except rice) and should have moved the forward curve into backwardation with lower expected prices in the future.

As the futures returns (lead contract rolled five days prior to expiry) indicate, however, the futures market has generally not priced in the consequences of El Niño and La Niña ahead of time (Figures 5, 6, 7 and 8). In fact, comparing Figures 2 and 5, one has the sense that futures markets have done little better than spot markets at anticipating the consequences of El Niño and La Niña over the past half century.

### Figure 6: What Became of Lady Jane and Efficient Market Hypothesis?



Source: NOAA, National Weather Service, Bloomberg Professional (C 1, W 1, S 1, BO1, SMI, RRI, LCI, LHI, DAI) and Calculations from CME Group Economic Research

**Figure 7. One Year Rolled Futures Returns in Log Percent Changes**

One Year Rolled Futures Returns in Log Percent Changes

Month El Niño Begins	Corn	Wheat	Soybeans	Soybean Oil	Soybean Meal	Rough Rice	Live Cattle	Feeder Cattle	Lean Hogs	Dairy
1: Aug '63	7.6%	6.9%	-2.0%							
2: Jul '65	12.3%	20.7%	31.6%				5.8%			
3: Jan '69	3.7%	5.6%	3.4%				25.5%			
4: Jul '72	77.0%	70.0%	118.0%				36.2%	38.0%		
5: Sep '82	44.8%	-4.6%	40.7%	61.3%			13.8%	-6.1%		
6: Nov '86	-9.7%	1.6%	15.5%	8.9%			33.0%	26.7%	41.8%	
7: Nov '91	-18.5%	11.9%	-2.0%	1.7%	8.5%	-21.9%	14.8%	20.3%	14.7%	
8: Dec '94	31.8%	23.7%	17.5%	-0.4%	-0.2%	19.6%	5.3%	-7.7%	33.4%	
9: Jun '97	11.2%	-35.6%	11.0%	5.6%	107.3%	-5.0%	6.3%	-13.7%	-19.5%	23.4%
10: Oct '02	-11.5%	-19.6%	40.9%	25.3%	9.6%	28.2%	45.3%	28.7%	-14.9%	3.1%
11: Oct '09	24.3%	17.8%	19.7%	21.1%	4.0%	-10.0%	17.9%	5.7%	26.9%	13.2%
Average	13.7%	8.9%	26.8%	17.6%	25.9%	2.2%	19.1%	11.5%	13.7%	13.2%

Source: National Weather Service, Bloomberg with CME Economic Research Calculations

**Figure 8: Two Year Rolled Futures Return in Log Percent Changes**

Two Year Rolled Futures Return in Log Percent Changes

Month El Niño Begins	Corn	Wheat	Soybeans	Soybean Oil	Soybean Meal	Rough Rice	Live Cattle	Feeder Cattle	Lean Hogs	Dairy
1: Aug '63	9.8%	13.9%	6.3%							
2: Jul '65	-3.8%	-11.2%	25.1%				-6.0%			
3: Jan '69	29.9%	27.2%	15.1%				34.4%			
4: Jul '72	111.0%	114.2%	100.8%				-15.7%	2.4%		
5: Sep '82	40.2%	-15.6%	-0.6%	45.6%			37.6%	-3.5%		
6: Nov '86	21.9%	17.4%	51.7%	46.8%			58.7%	48.7%	50.7%	
7: Nov '91	-5.5%	36.2%	16.4%	20.3%	33.4%	20.1%	28.2%	29.5%	26.5%	
8: Dec '94	45.4%	21.3%	20.6%	-15.4%	-0.2%	35.8%	4.0%	-11.3%	74.1%	
9: Jun '97	-34.6%	-64.6%	-16.0%	-39.7%	101.9%	-39.2%	10.9%	-25.0%	-90.0%	18.8%
10: Oct '02	-31.0%	-43.0%	30.5%	15.5%	15.4%	42.4%	60.0%	67.9%	19.6%	31.6%
11: Oct '09	38.1%	-9.6%	21.8%	25.2%	-5.1%	-6.0%	34.5%	21.6%	42.7%	34.5%
Average	20.1%	7.8%	24.7%	14.0%	29.1%	10.6%	22.5%	16.3%	20.6%	28.3%

Source: National Weather Service, Bloomberg with CME Economic Research Calculations

## Outlook

NOAA's El Niño index rose to +0.9°C above the seasonal norm of the past 30 years in May and probably crossed the +1.0°C threshold in June. Perhaps coincidentally, corn, soy, and wheat prices jumped sharply at the end of June in response to wetter-than-normal conditions and delayed planting.

If temperatures continue to rise in the central and east-central Pacific Ocean, one might reasonably expect an increased likelihood of crop failures and reduced harvests for significant portions of the world, impacting a wide variety of agricultural markets. El Niño's impact, if any, could be spread out over a long time, however, unfolding over the next 12 to 24 months.

To the extent that past is prologue, if the El Niño continues to intensify in the coming months, it is more likely to put upward rather than downward pressure on the prices of agricultural goods. That said, past episodes of El Niño demonstrate that there is no guarantee that prices will rise. One major downside risk for agricultural goods would be a stronger US Dollar combined with a crisis in emerging markets akin to what occurred in the June 1997 El Niño episode.

For the moment, futures curves are not especially steeply in contango for agricultural goods markets. This implies that traders don't currently anticipate a major impact from El Niño. Furthermore, it indicates that, if El Niño does have a substantial impact on harvests, long positions in futures markets could achieve returns that are close to the changes in spot prices.