The Potential Role of Weather Markets for U.S. Agriculture [1]

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Weather markets have grown at a rapid pace since their introduction in 1997. A Pricewaterhouse Coopers study commissioned by the Weather Risk Management Association reports that weather trades have exceeded $7.5 billion since their introduction. Weather market makers are looking for new end users to join the dominant energy generation industry. Agriculture is the unexploited industry offering the most significant growth potential for weather markets. Both crops and livestock are vulnerable to the vagaries of weather.

This article provides an overview of the potential use of weather-based derivatives for U.S. agriculture. To be sure, the market is in the early stages. Few documented weather trades have been completed for agricultural end users. As will be explained below, success for weather markets in agriculture may involve a number of uniquely designed products that do not involve farmers directly. Three classes of weather based products that link weather and agricultural risk are described below: 1) crop yield risk; 2) livestock risk; and 3) environment and natural resource risk. While much of this discussion is designed to motivate thinking, the true test of product acceptance will come in the market when the right products are designed for end user who understand the value of using weather based products to manage their risk.

Crop Yield Risk

Given heavy subsidies for crop insurance in the U.S., it is clear that the potential for enticing farmers to purchase weather derivatives to protect against crop losses will be relatively limited. Farmers pay an average of about 20 to 25 cents for every dollar of real cost in the U.S. crop insurance program (Skees, 2001). Furthermore, crop insurance is offered for actual farm yields for multiple perils, making it even less likely that farmers would use weather derivatives to hedge against select weather events that damage crop yields.

Despite heavy crop yield insurance subsidies in North America, only farmers have direct access to these subsidies. Others in the sector also suffer when crop yields are devastated by a major weather event such as a drought, excess rain, or a wide spread freeze. The key will be to develop tailored products to meet the needs of non-farmers. It may be possible to develop products for agribusinesses that do not have direct access to crop insurance subsidies and are vulnerable to supply risk in specific locales.

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Processors and grain elevator operators earn profits based on through put. It is not uncommon to learn that these firms charge a flat fee for the volume that moves through their plants. Thus, weather products that provide compensation when through put is reduced by adverse weather should be of interest to these margin-based industries. Further, some processors depend heavily on obtaining a produce of a specific quality. Adverse weather can also influence the quality of the inputs needed by a local processor.

A specific weather trade that met both the quality and quantity aspects for crop yield occurred with Barley growers this past summer. Barley differs from most bulk cereal markets because barley is used for special purposes that are very sensitive to quality. The most common example is beer manufacturers who contract specific acreage or have their own elevators to buy the quality of barley they need. If the quality is insufficient, the barley can be used for animal feed or alcohol, both commanding a significantly lower price than high quality barley used for beer. The key risk to the quality of the crop occurs once the plant is mature. Once the crop is nearing harvest, excessive rain and humidity create both test weight problems and damage to the color.

Cargill developed a weather-based product to hedge this exposure and marketed the product in the Carrington, ND area. The following excerpt is taken from a Cargill press release dated August 23, 2001.

> "The Barley Hedge is tied to the occurrence of rain "events" defined as three consecutive days with total precipitation equal to or greater than 0.35 inches. Under the terms of this year's hedge agreement, nine "events" during the period will trigger a $.65 per bushel payment to producers using the hedge. Minimum hedging volume is typically 5,000 bushels, and the hedge can be purchased for $.12 per bushel, yielding a net $.53 per bushel gain in payout situations."

This structure was traded in the weather markets and did payoff due to excess rain at the specific weather station that was used. Numerous other agricultural commodities also suffer from quality problems when there is excess rain at harvest: 1) cotton; 2) tobacco; 3) vegetables; 4) etc.

Livestock Risk

Highly concentrated firms that are vertically integrated dominate the poultry and pork sectors in the U.S. Finishing beef is also dominated by large feedlots. Concentrating animals in one location creates significant economic exposure when there are extreme weather events. Animals generally perform poorly when temperatures are either too hot or too cold. Feed conversion rates drop, health problems emerge, or costs of production are increased as growers attempt to cool or heat the confinement barns. For example, when beef animals in large feedlots use significant energy simply staying warm during sustained cold and wet conditions reducing average daily gains. Dairy cows also give less milk during prolonged hot weather.

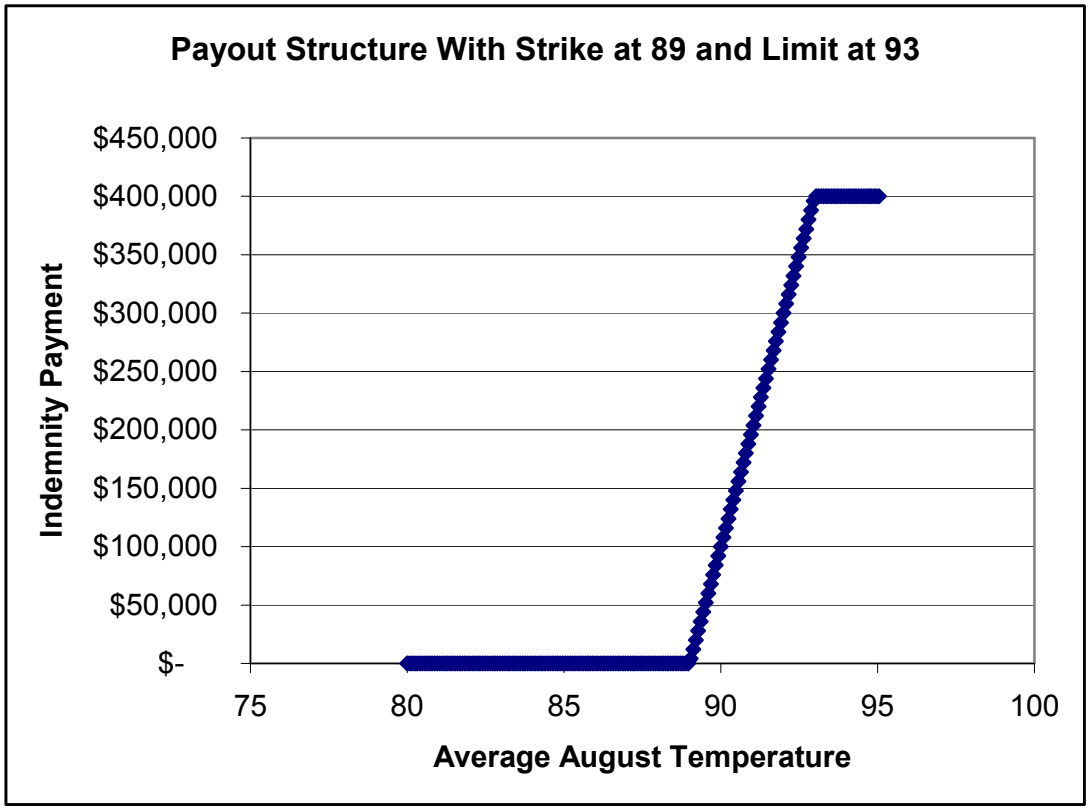
Interestingly, animal producers are exposed to serious losses at the same time that generators of electricity are making significant revenues due to peek demands to heat or cool homes and businesses. Thus, it should be of significant value to the industry to learn the relationship between extreme weather events and the economics of animal production. It might be possible to facilitate cooling degree or heating degree day swaps between electricity providers and animal producers.

As an example of such a trade that might emerge, a hypothetical poultry egg operation in the Atlanta area is developed. The egg producer is concerned about extreme temperatures during the month of August. Feed conversion ratios drop significantly during hot weather. In addition, both the quality and quantity of eggs declines. As a matter of convenience, we assume that the producer has significant problems when average temperatures exceed 89 degrees during August. Further, we assume that these losses are a linear function of higher temperatures. Thus, a simple weather contract would pay anytime

the average temperature for the Atlanta airport station for the month of August exceeds 89 degrees. This is a call option on temperature.

If the poultry operator can lose up to about $500,000 during August under the worst conditions, the weather provider should design a contract that will pay nearly $500,000 when conditions are extreme. When examining the Atlanta maximum temperature data from 1927-2001, the extreme average temperature is about a 93 degree average during the month of August. The average of the maximum daily temperatures is about 87 degrees.

A very simple contract that might meet the needs of our hypothetical poultry producer can now be designed. The contract should begin payments when the average of the daily maximum temperatures during the month of August exceeds 89 degrees and stop payments when the average reaches 93 degrees. Since the grower stands to lose up to $500,000, a reasonable upper limit on payments might be $400,000. Payments will be made in the range of 89 to 93. Thus, we can set tick size at $10,000 for each one tenth of degree. To be clear, if the average temperature is 90 degrees that is 10 ticks and the payment would be $100,000. If the average temperature is 89.1, then $10,000 is paid. The payout structure is presented in Figure 1. Given the probability distribution that can be constructed from the historic data, such a call option is likely to cost between $60,000 and $80,000 in today's market.



Environment and Natural Resource Risk

Weather markets could also play a significant role in new products that may help U.S. agriculture meet the challenges from society to reduce pollution and improve resource use, in particular for water. Three cases are presented which illustrate society's current demands: 1) fertilizer use, 2) concentrated animal feeding operations, and 3) irrigation use. Agricultural productivity will be affected by attempts to reduce fertilizer leaching into ground water, prevent manure lagoon overflows, and reclaim surface water

rights for non-agricultural use. Rainfall contracts could play a role in each of these cases. Rather than use command and control regulations from government, incentive based risk sharing markets that use weather trades could facilitate changed behavior (Skees, Barnett, and Zeuli).

Rainfall Contracts and Nitrogen Fertilizer Use

Nitrogen fertilizer is an extremely important input in corn production: however, runoff and leaching of nitrogen adversely affects surface and groundwater. Both the timing and application rates of nitrogen fertilizer are key to more environmentally sensitive use. Many corn farmers in the Midwest apply all of their nitrogen fertilizer prior to planting because they are concerned that excess rain will prevent access to the field when a second fertilizer application would be needed. This practice also means that they must apply excess amounts of fertilizer to compensate for what may be lost due to excess rains. If growers used a split application process whereby the second application was made after the corn was several inches high, application rates could be lower. Furthermore, when nitrogen is applied to a growing crop, the uptake is much quicker and this reduces the chances that the nitrogen will end up in either the surface or groundwater.

The Agricultural Conservation Innovation Center worked with several insurance companies to offer excess rainfall insurance during the period when farmers need access to the field to put on a second application. The motivation is to entice farmers to adopt a split application process that will result in less fertilizer use. The policy has recently been introduced on a limited basis but its impacts have not been studied. It is not clear whether the insurance policy has actually caused farmers to modify their fertilizer application techniques. However, even a modest reduction in nitrogen application through the Midwest could potentially generate significant environmental benefits.

Rainfall Contracts and CAFO Manure Lagoon Management

Confined Animal Feed Operations (CAFOs) illustrate a unique set of interrelated risks and environmental concerns. The concentration of animals in one location creates problems in managing large amounts of manure. In 1998, Carol Browner, of the U.S. Environmental Protection Agency (EPA), announced that livestock operations would come under increased scrutiny. Since that time, both national and state policies have focused more intently on CAFOs and nutrient management plans. CAFO hog facilities have been a particular source of concern. Extreme weather events, such as the 1996 and 1999 hurricane-induced flooding in North Carolina, cause significant financial losses for producers, serious environmental damage, and threats to public health (Easterling, et al.; Kilborn).

While the traditional approach has been to regulate such operations through command and control, animal producers may be more responsive if they have a risk-sharing partner who requires that they adopt best management practices to reduce the risk. Offering insurance against serious manure spills would likely mean that the insurance underwriter would become the regulator. Given the serious exposure due to extreme rainfall events, such insurance would likely require some form or reinsurance. Weather markets could shift the risk (Martin, Barnett, and Coble). The American Clean Water Foundation is investigating offering insurance against manure spills.

Rainfall Contracts and Water Markets

In many areas of the U.S., as well as in other countries around the world, irrigated agriculture has traditionally enjoyed unrestricted rights to available water. Today that is changing due to water demands from rapidly growing urban and industrial users. In addition, environmentalists are increasingly demanding that stream flows be maintained at minimum levels necessary to sustain aquatic ecosystems.

Rainfall contracts could be used to shift water availability risk to broader financial markets, thereby enhancing the operation of markets for water rights (Skees and Zeuli). For example, the water management authority could allocate water rights among competing users for a specified time period (e.g., five years or more). The quantity of water allocations would be based on some percentage (e.g., 80 or 90 percent) of expected water availability. Following this initial allocation, participation in water markets may be limited due to buyer concerns about the risk of insufficient water availability in a given year. The water management authority could purchase rainfall options to provide capital contingent upon insufficient rainfall in the watershed. In turn, the authority could provide a water rights contract stipulating that the authority will provide either the specified water or compensation to make up for water that is not delivered.

By shifting the risk of insufficient water availability, such a system would add significant value to water rights. Furthermore, the water management authority would have incentives to be diligent in making certain that the infrastructure was in place to deliver water. Otherwise, the water management authority would have to pay farmers who do not receive their allocations. More importantly, water market participants could do long-run planning, making the system more efficient. If water shortages developed, those who do not receive their full allocation of water would receive compensation. This compensation could be used to offset financial losses or to purchase available water in the spot market. By addressing risk concerns, the efficiency of the water market would be improved, ensuring that scarce water resources are allocated to their most valued use.

Hydroelectric users who depend heavily on the level of water in reservoirs for power generation are implementing these concepts. In the fall of 2000, the Sacramento Municipal Utility District completed a five-year contract with Aquila that would trigger based on rainfall that feeds the reservoir (Saunderson). The intent is to hedge against the adverse effects of low water levels in generating electricity. Saunderson goes on to report on how farmers in the Northwest are becoming interested in using stream flow indexes to protect against the likelihood that irrigation water will not be available when stream flows are down.

Conclusions

Weather markets are receiving an increased interest from agricultural users. Importantly, some of these contracts will offer explicit offsets to existing weather trades for the energy industry. Understanding and modeling the relationship between economic losses and weather events will be critical in designing tailored weather products that meet the needs for various agricultural users. There are numerous opportunities for those traders who care to take the time to understand the end user and offer products that meet their needs.

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