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Implications of Climate Variation and Climate Prediction for Agricultural Markets

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Agriculture is remarkably adaptable, yet periodic crop failure due to drought or flooding imposes significant costs on farmers and taxpayers. Fortunately, advances in the climate sciences raise the hope that we can mitigate some of the negative effects of adverse climate shocks in the future.

Climate scientists now know that relatively slow-changing conditions on the earth's surface can cause shifts in storm tracks that last anywhere from a year to a decade. Such phenomena are called climate variation and are distinct from the long-term trends associated with global warming. The most studied and well-understood example is El Niño. However, there are several other ocean-atmosphere-land linkages actively being researched. This issue of the *NC State Economist* explores recent research on the size and distribution of benefits from improved climate prediction.

Climate Variation and Weather

Climate variation has at least two unique features that distinguish it from what we ordinarily think of as "weather fluctuations." Both features have important economic consequences. First, climate variation can sometimes be forecasted up to a year in advance. With the development of long-lead climate forecasts, the information publicly available will include scientifically-based forward predictions.

Second, we typically think of weather at different geographic locations as being unrelated. For example, the fact its raining in San Francisco has no implications for today's weather in Raleigh. In contrast, climate variation can link weather patterns over vast areas of the globe. For example, the 1998 floods in Peru and drought in Indonesia were not independent events. They were both manifestations of climate changes caused by El Niño.

Recently, there have been a number of simulation studies measuring the potential value of climate prediction to farmers in the United States. These studies generally show that climate prediction is sufficiently well developed to produce large net benefits to society. Adams, et al. estimate the potential value of climate prediction to agriculture in the southeastern United States to be $100 million per year in 1990 dollars. Solow, et al. estimate the value of an El Niño forecast to be in the range of $240 to $323 million per year for the entire United States.

However, the reality is somewhat different from the potential benefits measured in these studies. Despite a good deal of optimism on the social benefits of understanding and predicting climate variation, there has been limited actual use of long-lead climate forecasts.

Part of the reason why scientific climate prediction has not become an integral part in the day-to-day functioning of agricultural markets is its novelty. Little is known about just what kind of information is most useful to decision makers, and the climate models used to generate the predictions are themselves not fully developed. Just as critical, however, are supporting infrastructure, economic policies, and institutions. In practice, climate forecasts are issued into market environments wherein a wide range of responses, insurance products, and market-based buffering mechanisms already exist.

Trade and storage are especially important instruments for responding to agricultural production shocks caused by climate variation. Trade can mitigate the negative impacts of a climatic disturbance in a given location by allowing demands there to be met by production that took place elsewhere. Similarly, storage allows demands at one point in time to be met by production that occurred at an earlier point in time.

However, the effect of trade and storage on the use and value of climate prediction is an open question. If trade and storage do away with the need for climate prediction, further expenditure on this information technology will have to be justified on its value to basic science, or its use in other industries. Conversely, if trade and storage complement climate prediction, there may be an argument for further removal of agricultural trade restrictions and increased investment in transportation and storage infrastructure.

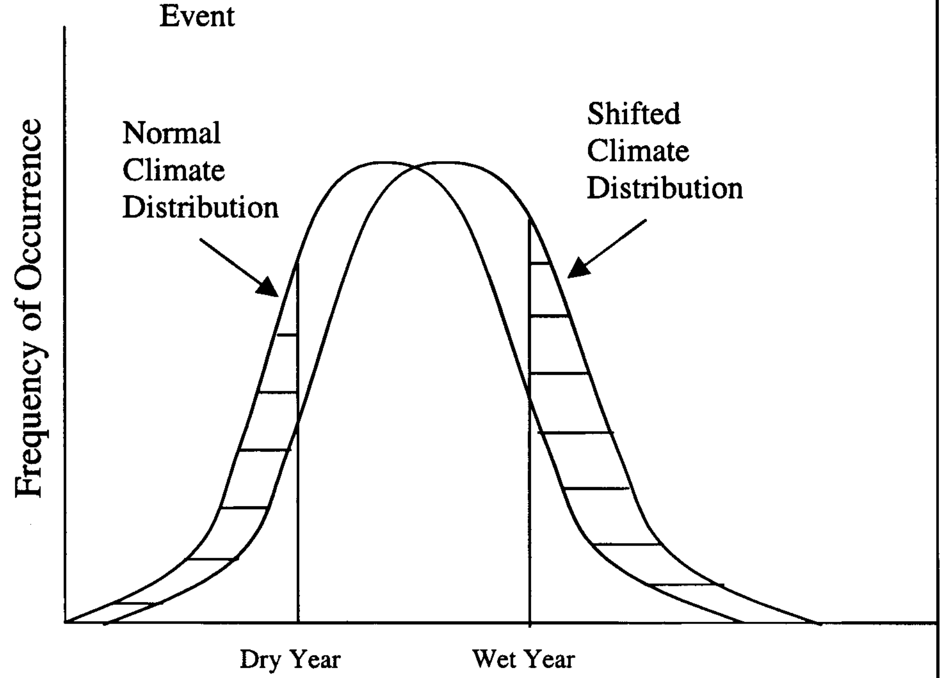
Economic Responses to Climate Prediction

To begin to understand the role of climate prediction in today's sophisticated agricultural markets, we have developed a stylized economic equilibrium model (Hallstrom and Sumner). The model allows for three economic responses to climate variation and forecasts: (1) Farmers allocate land across crops according to expected profitability. (2) Consumption and storage respond to both actual and expected prices. (3) Trade occurs between regions that experience different climate shocks and weather realizations. Farmers, stockholders and trading companies all adjust their expectations of future prices and crop yields in response to a climate forecast.

Using this model, three broad economic questions were considered: (1) How does climate variation affect prices, costs and economic welfare of crop producers and consumers? (2) How does climate prediction affect these relationships, and what is the value of climate forecasts in this system? (3) How do economic policies influence the effects of climate variation and the economic value of climate prediction?

Figure 1 contains a stylized representation of the type of information that a climate forecast provides. In this figure are two probability distributions for an atmospheric variable such as rainfall. A climate forecast tells which of these distributions will apply in the upcoming crop year. For example, a forecast of higher than normal rainfall is represented by a shift to the right in the distribution. In this case, the probability of observing higher than average rainfall has increased, but there is still a chance rainfall will be

Figure 1: Climate Forecast Predicting Increased Likelihood of Wet Event



normal or even below normal. Finally, the cross-hatched areas show the change in the probability of an extreme event such as drought or flood. Even relatively small shifts in the distribution for rainfall can have large implications on the likelihood of crop failure.

Major Findings

A large number of simulation results may be derived under alternative economic policies. None of the simulations represent the outcome of a detailed economic model constructed for a quantitative cost-benefit analysis. However, the pattern of results illustrate principles of interest that go some way toward understanding why and when climate information is useful in agricultural markets.

Figure 2 shows how the economic value of climate prediction depends on trade and storage opportunities. The horizontal axis in this figure measures the information contained in a forecast. Going from the left to right, climate forecasts predict ever larger shifts in the probability distributions shown in Figure 1.

In the first scenario we only allow for trade; storage costs are assumed to be sufficiently large to eliminate any opportunity for profitable speculation. In the second scenario we allow storage, but restrict trade through an import quota. Finally, in the last scenario we allow both storage and trade.

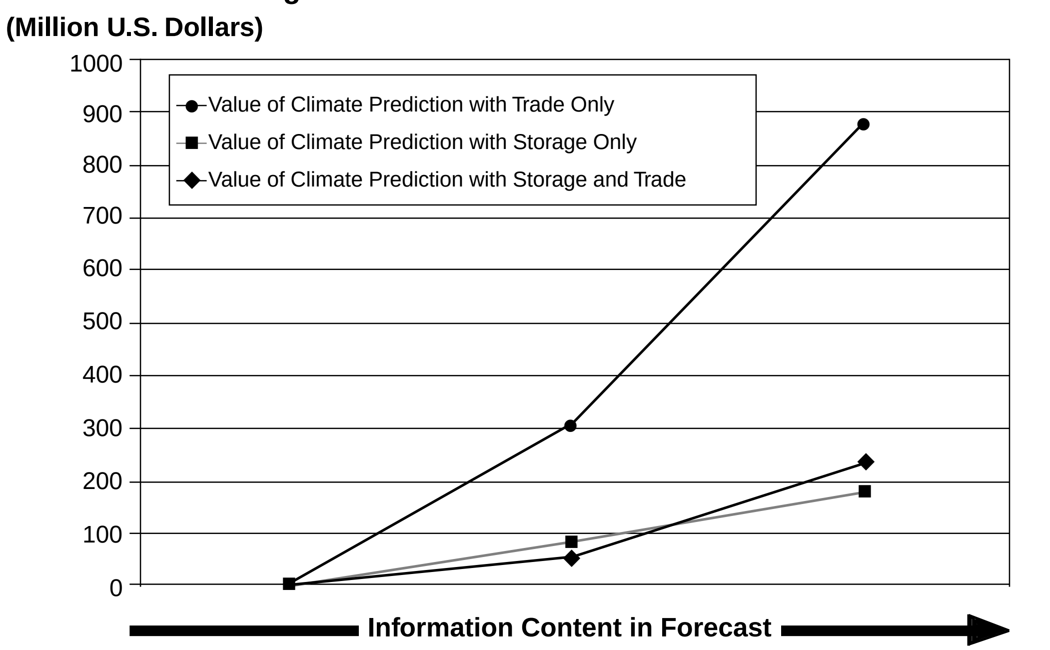
Immediately apparent from Figure 2 is that the value of climate prediction depends crucially on trade and storage opportunities. Markets unfettered by trade restrictions, with well developed mechanisms for communicating price information, and with transportation and storage infrastructure make much better use of climate prediction than markets where any of these complementary requirements are absent.

This is both good news and bad news. On one hand, it illustrates the potential benefits of further liberalizing agricultural trade. On the other hand, the poorest farmers in the world generally operate in markets characterized by high transaction costs. Our results suggest that the value of climate prediction to this group appears to be quite minimal.

Three other important results of our analysis may be summarized as follows:

- Climate prediction increases specialization and trade.
- Climate prediction decreases expected prices, but (due to specialization) increases price variability.

Figure 2: The Value of Climate Prediction



- Related to the above, climate prediction increases agricultural output, but also increases output variability.

Conclusions

Climate prediction has the potential to yield large social benefits. Agriculture in particular stands to gain, as droughts and floods repeatedly show how vulnerable the sector is to sudden changes in growing conditions. Understanding why and when climate prediction is valuable to agriculture is a necessary step toward informed policy choices. Unlike climate itself, trade policies, transportation costs, and storage costs are all within our power to change.

A general conclusion is that climate prediction typically does not have the highest value in areas we would expect to be the most vulnerable to climate shocks. A country that is relatively isolated from world markets is more vulnerable to an unexpected shock to agricultural production than a country that is integrated into world markets. However, the value of climate prediction to an isolated country is significantly less than in countries more integrated into world markets, especially when significant storage occurs.

A unifying principle underlying these results is that the value of information depends on agents responding to that information. Both storage and trade are margins along which agricultural markets can incorporate information and realize the resulting gains in economic efficiency.

References

Adams, R.M., Bryant, K.J., McCarl, B.A., Legler, D.M., O'Brien, J.J., Solow, A., and Weiher, R. 1995. "Value of Improved Long Range Weather Information." *Contemporary Economic Policy* 13: 10-19.

Hallstrom, D.G. and D.A. Sumner. 2000. "Agricultural Economic Responses to Forecasted Climate Variation: Crop Diversification, Storage and Trade." *Proceedings of the International Forum on Climate Prediction, Agriculture and Development*. Palisades, NY: International Research Institute, 2000.

Solow, A.R., R.F. Adams, K.J. Bryant, D.M. Legler, and J.J. O'Brien. 1998. "The Value of Improved ENSO Prediction to U.S. Agriculture." *Climatic Change* 39: 47- 60.

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