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Comment James B. Bushnell

This intriguing chapter explores two important central questions regarding climate change and the agricultural sector. First, how will changing climate conditions effect the productivity of the sector? Second, how will the sec-

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tor be able to adapt to mitigate the impacts of climate change? Climate change threatens the continuation of the remarkable gains in agricultural productivity that have been experienced over the last fifty years at a time when continued productivity increases are projected to be needed to satisfy the demand for calories from a growing global population. The diversion of cropland to bioenergy production or land-use related forms of carbon sequestration will put further stress on the need for continued gains. This further emphasizes the need to understand the relationship between future climate conditions and the production capabilities of the sector.

Among the many changes predicted by climate models is the increase in the variability in weather conditions, resulting, for example, in an increase in extreme weather events that might be experienced during the growing season in agricultural areas. The important contribution of the work of Roberts and Schlenker (R&S) has been to estimate the relationship between weather and yields more flexibly. This flexibility is necessary to tease out the potential impacts of these extreme weather incidences, which can be dramatically different than the potential impacts predicted by average weather changes. For example, an increase of a tenth of a degree in temperature spread evenly over a four-month growing season may have negligible effects. If that same average, 122 degree-day increase were instead experienced as ten days with a 12.2 degree increase, it can have dramatically more severe implications for yields. In other work, R&S have explored this relationship using very flexible specifications. Here they apply previous insights to classify seasons according to the number of "moderate" or "extreme" (above 29° or 30°C) days.

Focusing on corn and soybeans, they find that yields are very sensitive to extreme heat events. This general finding is concerning as climate change is widely believed to increase the number of extreme heat days in key US growing regions. Most provocative is the evidence that, for corn, this sensitivity to extreme temperatures appears to have been increasing over the last fifty years. In other words, while yields have grown substantially, the sensitivity to extreme heat may have grown with them.

One possible implication is these two trends are not coincidental, that the remarkable gains in yields has come at the cost of increased sensitivity to heat. If this interpretation is correct, and past evidence can be extrapolated into a future of more extreme weather conditions, then the authors' findings imply that the agricultural sector may have to give up some of its productivity gains in order to address increasing volatile weather conditions.

It is worth noting that a sense of increased weather vulnerability is not consistent with much of the conventional wisdom in the corn belt. Part of this seeming contradiction could be attributable to the fact that the midwest has experienced relatively mild growing seasons in past decades. Another source of difference could be the industry and academic focus on *drought* as opposed to heat. While closely related, R&S contend that the effects of

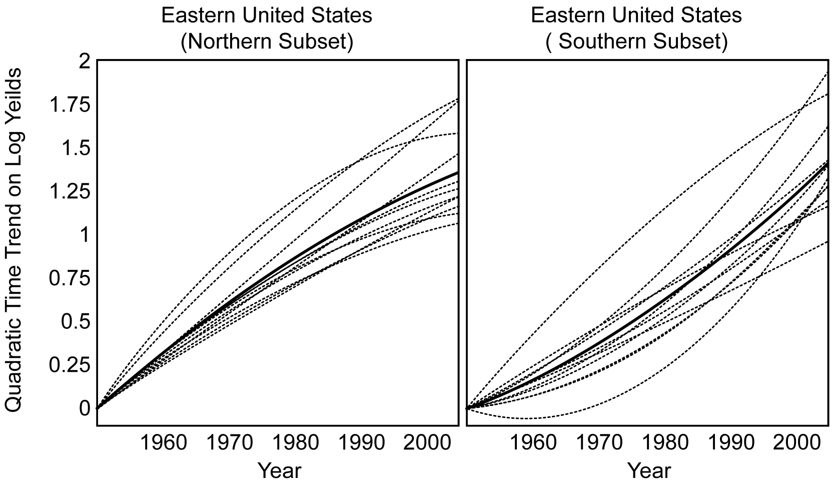

Fig. 17C.1 Time trends in corn yields

high heat can be separated from those of low moisture. By contrast, Yu and Babcock study the joint interaction of high heat and low rainfall and find that US corn and soybeans have become more tolerant of drought.[1]

There remains the curious and distinct difference in corn yield response between the northern and southern states in the sample of R&S. While heat tolerance appears to decline in the northern states for corn, there is no discernable trend in the south. One possibility might be that this is further evidence of a yield-versus-tolerance trade-off. Corn yields are (and always have been) quite a bit higher in the north. However, improvements in yields appear to be relatively consistent for both regions. Figure 17C.1 plots the quadratic time trends in yields produced from equation (4) in R&S. While there is some state to state variation, trends northern yields do not appear to be much different from those in southern states.

Implications for Adaption and Mitigation

Roberts and Schlenker also document another trend in the industry relating to research on seeds and productivity. Much of the research relating to agricultural productivity has migrated from publicly supported institutions to private firms. In the context of the results of this chapter, such a trend would be of concern if there were a mismatch between crop attributes that yield societal benefits and those that produce private economic gains. At first glance, these incentives seem reasonably aligned. Both society and individual producers would like to see an increase in expected yields although there

1. See Tian Yu and Bruce Babock, "Are U.S. Corn and Soybeans Becoming More Drought Tolerant?" *American Journal of Agricultural Economics* (forthcoming).

Table 17C.1 **Changes in planted corn acreage by region (millions)**

	Corn			Soybeans		
Region	1996	2004	Change	1996	2004	Change
North	42.71	43.81	1.10	31.88	39.64	0.78
South	4.47	3.78	–0.70	9.74	9.39	–0.35

Source: USDA Economic Research Service.

may be differences in the relative tolerance of risk associated with those expected gains.

Such a misalignment in risk preferences, which really would lie at the heart of private incentives to focus on the mean, as opposed to the variance, of yields, could be a side effect of U.S. crop insurance and disaster relief policies. Farmers have access to insurance on yields and revenues through government subsidized crop insurance programs and also receive periodic disaster relief payments in the face of extreme drought and other natural disasters.[2] It is worth noting that enrollment in crop insurance programs is much higher in the "northern" states that R&S identify as experiencing increased vulnerability to heat. Their findings may be evidence of moral hazard effects of these programs.

From 1996 to 2004, planted corn acreage increased by over 1 million acres in the northern states, while *decreasing* by over half a million acres in the south (table 17C.1). It could be that planting was retreating from areas that would be more sensitive to heat in the south, while expanding into such areas in the north. For this to be a factor in the results of R&S, however, this expansion into "heat sensitive" soil would have to be within-county. Further, similar trends in planted acreage played out in soybeans over this period (table 17C.1), with no apparent impact on heat sensitivity in either the south or the north.

2. Crop insurance was intended to replace disaster relief, but in general this has not happened, creating a potential "double indemnity" for effected producers. See J. Glauber, "Double Indemnity: Crop Insurance and the Failure of U.S. Agricultural Disaster Relief Policy," in *Agricultural Policy for the U.S. Farm Bill and Beyond.* Washington, DC: American Enterprise Institute, 2007.