The Impact of Global Warming on Agriculture: A Ricardian Analysis: Comment

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To assess the desirability of policies to reduce greenhouse gas emissions, it is necessary to estimate the costs that climate change is likely to impose. A number of studies have estimated the costs of climate change to agriculture by modeling changes in yield on the assumption that the existing pattern of land use will remain unchanged. Robert Mendelsohn et al. (1994), hereafter MNS, call this the "dumb-farmer scenario" and observe that costs derived in this way represent an upper-bound estimate for the costs of climate change. As an alternative, MNS propose a "Ricardian" approach, based on comparative static estimates of the change in equilibrium rents to land associated with a one-time change in climatic conditions. MNS estimate that a 5°F increase in mean temperatures will yield changes in farmland rents ranging from a 4.9-percent loss to a 1.2-percent gain.

The main purpose of this note is to observe that, just as the "dumb-farmer scenario" implicitly assumes infinite adjustment costs and therefore yields an upper-bound estimate, the "Ricardian" approach implicitly assumes zero adjustment costs and therefore yields a lower-bound estimate of the costs of climate change. Before developing this point, it is necessary to observe that the model estimated by MNS is not well-behaved. This leads to some difficulties in explaining the logic of the distinction between the MNS comparative static and a more appropriate dynamic model.

The comparative static approach allows us, in principle, to calculate the optimal temperature for U.S. agriculture, when there are zero adjustment costs. For this calculation to be made, however, it is necessary that the implied technology have the concavity properties required for the existence of a global optimum. For the model estimated by MNS, where land values are a quadratic function of temperatures, the relevant condition is that the quadratic term should be negative. In the equations estimated by MNS, this condition is not satisfied, since the quadratic term for October is typically positive.

Using equation (iv) of MNS Table 3, we can calculate that the deviations from the means of January, April, and July temperatures that maximize farm values are −30°, 1°, and −146°F. Mean January, April, and July temperatures in the United States are roughly 37°, 56°, and 78°. Therefore, the optimal temperatures for January, April, and July are in the neighborhood of 7°, 57°, and −68°, while no finite optimum exists for October temperatures. These unusual results presumably reflect estimation problems, probably arising from multicollinearity. Whatever the cause, it is evident that, although the MNS equations fit the data reasonably well, they will not, in general, be well-behaved for data points lying outside the range of the data set used in estimation. This casts doubt on the accuracy of comparative static estimates of the costs of global warming derived from the MNS model.

Even if the MNS model produced accurate comparative static estimates, however, these estimates would not provide an appropriate basis for estimating the costs of global warming or for assessing policies designed to mitigate warming. The question addressed by MNS may be stated as, "If temperatures were and always had been 5°F higher, what difference would it make to the net social surplus arising from US agriculture?" But the effect of a 5°F change would be very different if the climate were 5°F warmer *next year,* than if mean temperatures rose by 0.01°F per year over 500 years. The difference between these cases is in the costs that would be incurred in adjusting to the new climate, not in the overall temperature increase. The MNS

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analysis cannot distinguish between these two cases.

There are strong reasons to expect that a comparative static approach will yield small estimates of global warming's impact on agriculture. Agriculture is possible under a wide range of climate conditions, and the United States contains both regions where low temperatures are the main limiting factor and regions where high temperatures are the main limiting factor. In a well-behaved version of the MNS model, this fact would be reflected by an observation that actual climatic conditions in the United States are above the estimated temperature optimum in some counties and below it in others. Temperature change would be expected to be disadvantageous in the former areas but beneficial in the latter, and if land area is approximately uniformly distributed across regions then global warming will have a small effect on aggregate output, when adjustment costs are ignored.

Therefore, economists should focus attention on the costs of adjustment, which are necessarily positive. If, in the example of MNS, land currently used for wheat and corn is to be turned over, first to grazing and then to retirement homes, it will be necessary for farmers with crop-specific skills to move (presumably northward) or acquire new skills, and for items of capital stock such as grain elevators and flour mills to be relocated or scrapped. How large these adjustment costs will be is as yet unanswered, but the comparative static analysis can give no indication of their magnitude.

There are also practical difficulties with the comparative static approach. The MNS approach is based on differences between the current climate and that predicted to prevail with higher greenhouse gas concentrations. By contrast, a fully dynamic assessment will focus attention on the rate of change of temperature and other climate variables rather than their level. Users of the static approach must not only select an (implicit) estimate of the rate of change of temperature but also a cutoff date at which to make the calculation. This will produce either noncomparable estimates across different studies, if different stopping dates are chosen, or an unjustified focus on a particular date.

Adjustment costs might be estimated in two ways. First, a micro-level examination of capital stocks and depreciation rates could be used to estimate the rate at which climate-specific capital would need to be scrapped in order to achieve the necessary rate of adjustment. For agriculture, it seems likely that the largest costs would arise with respect to irrigation. As MNS note, irrigation is an endogenous response to climate, but it is a response characterized by large stocks of long-lived capital. A significant change in temperature or rainfall patterns could render many existing investments useless.

An alternative approach to the estimation of adjustment costs could focus on observed responses to changes in relative prices. Changes in relative yields arising from climate change are, from the point of view of profit-maximizing farmers, similar to changes in relative prices. However, estimation difficulties would arise from the fact that changes in climate are more persistent than changes in prices.

In summary, the main costs of global warming are almost sure to be adjustment costs. Economic analysis of global warming should focus on the rate of temperature change, not temperature level. Such an analysis is more difficult than the comparative static analysis offered by MNS. However, it is likely to give us a very different, and more accurate, picture of the impact of global warming.

REFERENCES

Mendelsohn, Robert; Nordhaus, William D. and Shaw, Daigee. "The Impact of Global Warming on Agriculture: A Ricardian Analysis." *American Economic Review*, September 1994, *84* (4), pp. 753–71.

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