Climate Change Impacts on US Agriculture: Accounting for Omitted Variables in the Hedonic Approach

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Over the past twenty years a large literature has focused on developing econometric approaches for assessing the potential impacts of climate change on agriculture. The magnitude of these impacts will largely depend on farmer's ability to adapt to a new climate. Consequently, a central theme in this literature is how to account for the possible range of farmer adaptations based on observational data.

In a seminal paper, Mendelsohn, Nordhaus and Shaw (1994, henceforth MNS) introduced the so-called "Ricardian" approach, a hedonic model estimating the contribution of climatic attributes on US farmland values. The approach relies on the fact that farmland values reflect the expected discounted future stream of rents from the most valuable use of the land. MNS argue that greater agricultural productivity stemming from exogenous climatic inputs should therefore be capitalized on farmland values. The marginal effects of climatic variables on farmland values are subsequently employed for projecting agricultural welfare changes under climate change.

Although MNS find slightly positive impacts for US agriculture under a hypothetical climate change scenario, Schlenker, Hanemann and Fisher (2005) show that these impacts are large and negative if the sample is restricted to the mostly rainfed eastern counties. Furthermore, in an in-depth study based on this approach, Schlenker, Hanemann and Fisher (2006, henceforth SHF) find that extreme temperature (>34ºC) is the major climatic factor driving large and negative projected climate change impacts on eastern US agriculture. The result is robust to alternative specifications and controls including state fixed effects. This finding is important because it suggests that a negative relationship between farmland values and high temperatures exists even within states.

A well-known concern with the hedonic approach is its vulnerability to time-invariant omitted variables. This potential shortcoming prompted Deschênes and Greenstone (2007, henceforth DG) to propose a "profit" panel approach with county fixed effects to control for time-invariant unobserved heterogeneity. DG estimate the effect of weather shocks on net county yearly revenue to infer a lower bound on long run climate change impacts on the sector. Because the approach only accounts for short run adaptation and the projected effects are found to be insignificant or slightly positive, the long run benefits would be at

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least greater. However, in a recent comment, Fisher, Hanemann, Roberts and Schlenker (2012) show that DG has data issues and modeling assumptions that bias impacts toward zero. Although Deschênes and Greenstone (2012) acknowledge these shortcomings, they emphasize the hedonic approach remains vulnerable to time-invariant omitted variables and that associated climate change impact projections are ultimately unreliable.

The concern of omitted variable bias has a clear grounding in the theoretical framework of the hedonic approach. In order to make projections of climate change impacts on *agriculture*, the approach must rely on the effect of climate variation on the discounted future stream of rents from the most valuable *agricultural* use of the land. Agriculture faces competition over land from other sectors, and this pressure is reflected on farmland values when the alternative non-farm use is more profitable. For instance, Nickerson et al. (2012) find that farmland near urban areas reflect higher values because of its potential for residential housing development and other non-farm purposes. Hedonic studies have included measures of population density as well as income per capita to control for this potential concern in case urban pressures are correlated with climate variables. SHF goes as far as excluding "urban" counties with population density exceeding 400/sq.mi.

However, there are other factors affecting farmland values that may be correlated with climate. In this study, I show that omitted variables are responsible for the negative relationship between high temperatures and farmland values. An initial analysis based on statewise sample exclusions indicates that the estimated detrimental effect of extreme temperature on farmland values is driven by a handful of states (primarily Georgia and North Carolina). For most census years, omitting two to three key states yields an insignificant coefficient for extreme temperature, as measured by degree-days over 30ºC.[1]

A visual inspection of regression residuals for a model without heat variables reveals, that observations potentially driving this result in Georgia and North Carolina have a distinct spatial distribution. Counties with unexplained high farmland values (large positive residuals) are located in the relatively cold areas of the Southern Appalachian mountains, where farmland is reportedly under high demand for vacation and retirement home development. A similar but less pronounced pattern is identified for other states (recreational areas of northern Michigan, the arrowhead of Minnesota, the Ozark mountains of Arkansas, islands of Massachusetts, etc.).

On the other hand, unexplained low farmland values (large negative residuals) are located in the warmer and fertile coastal areas of the "Black Belt", where once stood a large portion of the nation's plantations and slaves. This region is characterized today by the highest proportion of African-American farmers and by some of the highest levels of rural poverty in the nation. Chetty et al. (2014) find that upward income mobility is significantly lower in this region. That study suggests the historical legacy of greater racial segregation as a possible mechanism. Similarly, racial segregation could be introducing frictions in local land markets which may depress farmland values.

The differential effect on farmland values from recreational home development in the cooler regions and from historical high levels of poverty in warmer areas, suggest the existence of omitted variables in the hedonic approach. To verify this possibility, I develop an alternative state fixed effects model that includes dummy variables for identified recreational

[1] The 30ºC threshold is based on more recent work from Schlenker and Roberts (2009).

regions as well as variables for the percent of the population under the poverty line and the fraction of African-American farmers. The results indicate that extreme temperature is not capitalized on farmland values when these controls are included. Because the number of states in the sample is small (37), the result could stem from chance. To address this concern, I resample state boundaries and re-estimate the model thousands of times. The detrimental effect of degree days over 30ºC remains insignificant, suggesting that large climate change damages on rainfed US agriculture from increased exposure to high temperatures may be unlikely. This result converges with earlier work based on biophyisical models that suggests mildly positive impacts for temperate agriculture.

Key words: climate change, agriculture, hedonic model, spatial error model, farmland values, recreational values, poverty

JEL codes: Q15, Q51, Q54, R33

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