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Estimating Market Implications From Corn and Soybean Yields Under Climate Change in the United States

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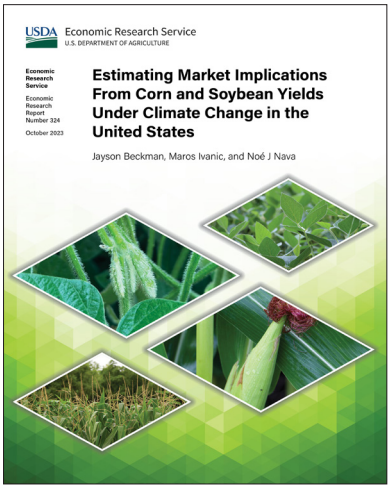

What Is the Issue?

The Intergovernmental Panel on Climate Change (IPCC) climate scenarios indicate U.S. climate pattern changes such as rising temperatures and mild declines in precipitation toward the middle of the 21st century. Some outlooks for the United States predict declines in crop yields due to warming temperatures and the increased likelihood of extreme weather events such as droughts and floods, suggesting that U.S. agricultural production and exports might be affected. However, there have not been many studies that examine how past yields and their relationship with weather could help inform future yields, and how this can affect agricultural production and exports. That is, trade outlooks are often conducted using climate and crop model simulations–such as that from the Agricultural Model Intercomparison and Improvement Project (AgMIP)–rather than work that links historical yields with historical changes in climate, such as those coming from econometric studies. The authors' approach to estimating yields in this report is based on historical outcomes. This approach highlights the need to consider data at a finer resolution for those data associated with climate change, as yield estimates vary by county.

What Did the Study Find?

The authors estimated changes in corn and soybean yields in 2036 relative to 2016 for the counties east of the 100th meridian part of the United States. These estimates incorporated evidence on the interaction between weather variations and past crop yield growth. Here are several findings:

- The direction and magnitude of climate effects vary by U.S. county.
- Results indicate that increasing temperatures will likely reach extreme levels that could hinder crop growth during the growing season.
- Similarly, results indicate that precipitation during the growing season will likely decline further and affect crop growth.
- Crop yield projections highlight opposite effects for corn and soybeans as follows:

  - Corn yields in the United States increase 3.1 percent (bushels per acre).
  - Soybean yields decrease 3.0 percent in yields (bushels per acre).
- The analysis considered the main corn and soybean growing regions, which are east of the 100th meridian part of the United States. Yield projections varied by region, including:
  - North and South Dakota, Kansas, and Nebraska experience sharp declines in crop yields of 14.5 percent for corn and 7.1 percent for soybeans.
  - Midwestern States such as Illinois, Missouri, Iowa, and Wisconsin experience crop yield gains of 1.2 percent for soybeans and 5.7 percent for corn.
  - Indiana, Kentucky, and Tennessee experience yield gains for corn of 5.4 percent and yield declines for soybeans of 5.8 percent.

A global economic model was used to examine how these yield changes could affect U.S. agricultural production and trade patterns. Among the findings:

- Production increases 0.11 percent across all U.S. corn-producing States. The model indicates that producers allocate less land to corn due to the increase in yields. U.S. corn exports increase 0.36 percent, the equivalent of $63 million based on 2016 exports.
- U.S. soybean production decreases 0.93 percent due to the decrease in yields, while exports decline 1.17 percent. Producers allocate more land to soybeans in the model, to compensate for the decrease in yields.

How Was the Study Conducted?

The authors used a multistep approach that connects crop yield projections under climate change with a global economic model. In the first step, a geographically weighted regression (GWR) estimator was used to estimate county-specific marginal effects of climate change on corn and soybean yields for counties east of the 100th meridian part of the United States. The estimation procedure assumed that farmers adapt to climate change through new technologies and adopt different managerial practices over the projected future period that are consistent with differences in yields achieved over 1996 to 2016.

The study projects out into 2036 and shows how yields might change based on changes in climatic data. The analysis is conducted independently for each crop. In the next step, the Global Trade Analysis Project-Agro-Ecological Zone (GTAP-AEZ) economic model, which incorporates agro-ecological zones (AEZs) into the GTAP framework, is introduced. Yield projections are incorporated into the GTAP-AEZ model to study how domestic yield changes could affect U.S. agricultural production and trade while holding trading partner yields constant. That is, the effect of climate change on production is held constant in the rest of the world (ROW) to analyze how trade is affected by projected U.S. production responses to projected climate change.