Identifying the Impact of Weather Variation on Crop Yield in the Northern Plains

Yong Jiang and Won Koo

Center for Agricultural Policy and Trade Studies
Dept. of Agribusiness and Applied Economics
North Dakota State University, Fargo, ND 58103
Phone: *(701)231-7451,* Email: *yong.jiang@ndsu.edu*

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Research Objective

- Examine weather variation and its impact on spring wheat yield in North Dakota
- Understand the role of weather in spring wheat production and growth, agroecosystem vulnerability to weather, and possible spatial heterogeneity
- Simulate the impact of climate change on spring wheat yield

Background and Motivation

- Varying weather patterns have partially contributed to global food market instability.
- Changing climate raises concerns on agroecosystem vulnerability and food security .
- Information on the weather-food production linkage is needed to inform government actions to better help agroecosystem adaptation to climate change

Research Challenges and Issues

- Stochastic weather process and crop growth
  Weather as a stochastic process can be measured by different variables and in many different ways. How to characterize weather variation in relation to the physiology of crop growth is an open empirical question.
- Dynamic and adaptive production process
  Agricultural production may be a dynamic process, with input decision depending on current prices, weather turnout, and crop growth progress.
- Spatial heterogeneity and production adaptation
  Biophysical conditions for crop growth are heterogeneous across space. Agricultural production can vary among regions and may have well adapted to local production conditions, including both infrastructure investment and biophysical conditions.

An Integrated Bioeconomic Model of Weather and Crop Yield

Crop Production Function

- **Assumption**: farmers tend to maximize their production profits once crops have been planted
- **Economic model**:

  Max Profit = $Price_{Output}$ X Acreage X Yield(fixed inputs, variable inputs, biophysical conditions, production technology) – $Input_{variable}$ X Acreage X $Price_{Input}$
- **Empirical specification of production function**:

  Yield = Y($price_{input}$ /$price_{output}$, biophysical conditions, production technology)

Physiology of crop growth

- **Physiological characteristics and assumptions**:
  - The effects of temperature and precipitation may be cumulative
  - The effects of temperature and precipitation may vary depending on the stage of crop growth
  - There may exist optimal temperature and precipitation for crop growth
- **Empirical specification**:

  ln(Yield) =, f($price_{input}$ /$price_{output}$, cumulative heat and precipitation, soil quality, production technology)

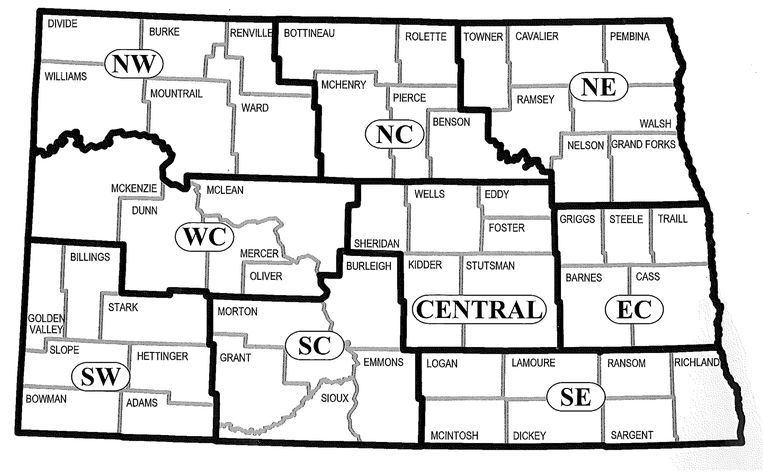
Data

- Yield
  crop reporting district total production output divided by planted acreage, both of which are from USDA NASS
- Weather variables
  cooperative observations of daily weather (temperature and precipitation) from national climatic data center
- Soil quality and prices
  variation in soil quality measured by variation in acreage, prices including output price, and fertilizer price index, all of which are from USDA NASS

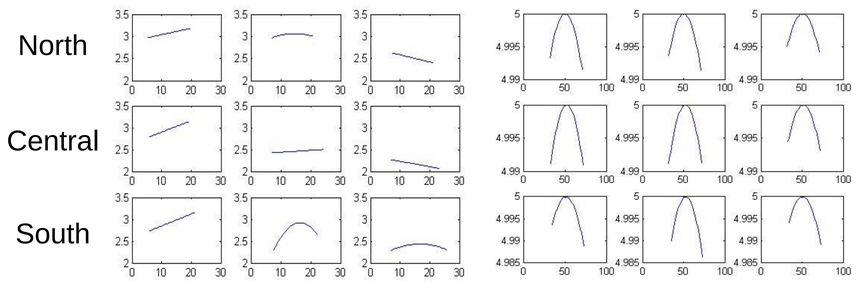
Econometric Estimation

- Approach: seemingly unrelated regression
- Modeling tool: Matlab

Crop Reporting Districts in North Dakota



SW Yield v.s. Precipitation[1] SW Yield v.s. Temperature[2]



1. Yield in natural logarithm with other variables evaluated at sample means

2. Yield is relative growth rate, y axis being indicative

Research Findings

- There is significant spatial heterogeneity in the effect of precipitation on crop yield.
- The effect of temperature on crop growth are similar, despite minor differences, across space.
- The effect of weather variation on crop yield might be local specific, depending on other biophysical conditions and perhaps reflecting farm adaptation to local production conditions.

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