Dissertation Chapter: N rate justification, higher moment of yield, cliamate uncertainty

immediate

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Abstract

Start with literature review and idea about how to estimate moment function with DIFM data

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1 Dissertation Outline

1.1 1. Introduction

In recent years, the economic and environmental concerns associated with nitrogen (N) fertilizer application in agriculture have gained increasing attention. Despite considerable progress in estimating economically optimal nitrogen rates (EONR), empirical evidence suggests that farmers often apply nitrogen rates exceeding EONR. This research aims to evaluate the appropriateness of farmers' nitrogen application decisions by examining the yield distribution's higher moments (variance, skewness, and kurtosis) under different climate and nitrogen interactions.

Research Objectives

- To determine if observed nitrogen application rates by farmers exceed the estimated EONR.
- To evaluate the impact of nitrogen rates and climate factors on the higher-order moments (variance, skewness, kurtosis) of yield distribution.
- To explore whether the observed over-application of nitrogen by farmers is justified in terms of profitability, taking into account climate uncertainty and price volatility.

The methods used are built upon Antle (1983) and Tack, Harri, and Coble (2012), focusing on how higher-order moments of yield distribution can be influenced by climate and input interactions.

1.2 2. Literature Review

The literature review focuses on the relationship between nitrogen use, yield response, and climate interactions.

2.1. Optimal Nitrogen Application

- Economically Optimal Nitrogen Rates (EONR): Discuss studies that have estimated the EONR and provide insights into how observed farmer behavior deviates from optimal levels. Emphasize how over-application leads to diminishing returns and environmental harm.

2.2. Yield Distributions and Moments

- Antle (1983): Introduced the concept of modeling yield distributions based on higher-order moments, using production moments to represent stochastic production functions. Farmers' preferences over different moments (mean, variance, skewness) can determine their risk management strategies.
- Tack, Harri, and Coble (2012): Extended Antle's work by examining the impact of climate on higher-order yield moments, employing a maximum entropy approach to derive yield distributions under uncertainty.

2.3. Nitrogen Use and Climate Uncertainty

- Explore literature on how climate variability (e.g., temperature, precipitation) interacts with nitrogen application to impact yield. Include studies that consider ex-ante versus ex-post perspectives of uncertainty.

1.3 3. Methodology

3.1. Data

- Field Experiment Data: Utilize on-farm experimental data from 100 fields with randomized nitrogen and seeding rate applications.
- Weather and Soil Data: Include weather data (e.g., rainfall, temperature) and soil characteristics for each field.

3.2. Econometric Model for EONR Estimation

- Regression Analysis: Estimate yield response as a function of nitrogen rate (N), seeding rate (S), and control variables (soil characteristics, weather).

$$Y_i = eta_0 + eta_1 N_i + eta_2 S_i + \sum_{j=1}^{K} \gamma_j X_{ij} + \epsilon_i$$

  where Y_i is the yield, N_i is nitrogen rate, S_i is seeding rate, and X_{ij} represents other field-specific variables (e.g., climate, soil).

- Test for Over-application: Compare observed farmer nitrogen application rates ($N_{extfarmer}$) to the estimated EONR ($N_{extEONR}$).

$$H_0 : N_{extfarmer} = N_{extEONR} \quad \text{vs.} \quad H_1 : N_{extfarmer} > N_{extEONR}$$

3.3. Modeling Higher Moments of Yield Distribution

- Moment-based Yield Response: Adapt Antle (1983)'s approach to model the second (μ_2), third (μ_3), and fourth (μ_4) moments of yield.

$$\mu_1(N, Z) = E[Y|N, Z]$$
$$\mu_2(N, Z) = E[(Y - \mu_1)^2|N, Z]$$
$$\mu_3(N, Z) = E[(Y - \mu_1)^3|N, Z]$$
$$\mu_4(N, Z) = E[(Y - \mu_1)^4|N, Z]$$

  where Z represents climate variables.

- Maximum Entropy Approach: Following Tack et al. (2012), estimate the yield distribution under nitrogen-climate interaction by maximizing entropy, subject to moment constraints.

$$f^*(Y) = \frac{1}{\psi(\gamma^*)} \exp\left(-\sum_{j=1}^{J} \gamma_j^* Y^j \right)$$

  where γ_j^* are the Lagrange multipliers obtained from moment conditions, and $\psi(\gamma^*)$ is a normalization factor.

1.4 4. Results and Discussion

4.1. Estimation of EONR

- Present the results of the yield response regression model.
- Discuss the extent to which observed nitrogen rates exceed the estimated EONR and potential reasons for this behavior (e.g., risk aversion, yield variability).

4.2. Impact of Nitrogen and Climate on Yield Moments

- Variance (μ_2): Analyze how nitrogen and climate jointly impact yield variability. High variance may indicate that nitrogen over-application leads to unpredictable outcomes under climate variability.
- Skewness (μ_3): Evaluate whether the distribution of yield outcomes is negatively skewed, implying higher risk of low yields under excess nitrogen application.
- Kurtosis (μ_4): Assess if higher kurtosis suggests greater probability of extreme yield outcomes (both high and low).

4.3. Implications for Farmer Behavior

- Discuss the implications of yield variability and risk, relating back to farmers' over-application behavior.
- Argue that, given the observed patterns in higher moments, over-application of nitrogen is not economically justified due to increased risk and lack of consistent yield gains under varying climate conditions.

1.5 5. Conclusion

- Summarize the key findings regarding nitrogen application, yield response, and the effect of climate interactions on yield distribution moments.
- Highlight policy recommendations for encouraging farmers to optimize nitrogen use, considering yield variability and environmental sustainability.

1.6 6. References

- Antle, J.M. (1983). Sequential Moments and the Analysis of Risk Preferences.
- Tack, J., Harri, A., & Coble, K. (2012). More than mean effects: Modeling the effect of climate on the higher order moments of crop yields. American Journal of Agricultural Economics, 94(5), 1037-1054.