Research Statement

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Overview and Research Vision

My research focuses on improving agricultural decision-making under uncertainty by combining agricultural economics, applied econometrics, and machine learning. I study how on-farm field experiments and harmonized multi-farm datasets can be used to estimate economically optimal input levels, quantify yield risk, and guide policy on sustainable intensification.

Agriculture is a high-stakes sector facing growing demands for productivity and environmental stewardship. Farmers often operate under substantial uncertainty about input responses and climate conditions. My overarching goal is to develop data-driven, risk-aware, and scalable frameworks that help farmers make better input decisions while improving profitability and reducing environmental impacts.

Research Accomplishments and Current Work

Job Market Paper — From Mean EONR to Risk-Adjusted EONR

My job market paper develops a framework to move beyond conventional mean-based economic optimal nitrogen rate (EONR) decisions toward **risk-adjusted EONR** that accounts for weather-driven uncertainty. Standard EONR methods rely solely on the expected yield response to nitrogen, implicitly assuming risk neutrality and stable weather. However, farmers face **stochastic profits** due to precipitation variability, and both **variance and downside yield risk** shape their optimal nitrogen choices.

I use data from 56 large-scale on-farm corn nitrogen trials across Illinois over six years (30–100 acres per field, with up to three replications) and develop a **hierarchical mixed-model approach** to separate (i) **between-field productivity heterogeneity** and (ii) **within-field responsiveness to nitrogen**, using shrinkage (empirical Bayes) to obtain stable field-level productivity ranks. I then fit **generalized additive models (GAMs)** for the population mean yield response and **location–scale GAMs** to estimate how **conditional variance changes with nitrogen and precipitation**. Combining the estimated mean and variance, I compute **certainty-equivalent (CE) profits** for each nitrogen level under five precipitation regimes.

I contrast two perspectives: a **regional policy maker** optimizing a representative field versus an **individual farmer** optimizing using their field-specific productivity premium, responsiveness, and risk profile. This comparison quantifies how **heterogeneity shifts EONR** across precipitation regimes. The framework produces farmer-specific decision sheets showing mean-based and risk-adjusted EONR, decomposed into contributions from responsiveness, productivity, and risk.

This paper contributes to the literature on production under uncertainty (e.g., Just and Pope 1979; Antle 1983) by providing a **distributional framework for nitrogen decisions** that is both **econometrically rigorous and operationally usable** for precision agriculture and policy targeting.

Seeding Rate Optimization Using On-Farm Experiments

In a second project, I analyze the profitability of seeding rate decisions using farmer-run precision experiments. I estimate profit-maximizing seeding rates with panel fixed-effects and random-coefficient models, complemented by counterfactual simulations of alternative rates.

This project advances the literature on input demand under uncertainty (e.g., Just and Pope 1979) by demonstrating how integrating experimental variation with structural modeling can improve both profits and input efficiency. The resulting framework can be embedded in farmer advisory systems.

Multi-Field Experiment Externalities

Another ongoing project investigates how pooling on-farm experiments across farms can generate positive information externalities. I harmonized data from over 100 farm-years of precision agriculture experiments and developed a design-based estimator to quantify how neighboring fields' data reduce bias and variance in estimated input–yield response functions.

This work contributes to the literature on agricultural technology adoption and learning (e.g., Feder and Umali 1993; Foster and Rosenzweig 1995) by showing that collective experimentation accelerates knowledge diffusion and improves the external validity of recommendations. It has direct implications for designing data-sharing platforms and public–private research collaborations.

International Application: South Africa

I also lead data infrastructure and statistical analysis for a collaborative project on site-specific input management in South Africa. I developed reproducible pipelines integrating on-farm experiments across diverse agro-ecological zones, enabling the creation of scalable recommendations for smallholder farmers. This work demonstrates that my framework is generalizable to low- and middle-income settings and suitable for global development partnerships.

Future Research Agenda (3–5 Years)

Building on this foundation, I will pursue three interrelated lines of research:

1. **Risk-based optimization frameworks**
   I will extend my distributional yield response modeling to incorporate farmer heterogeneity in risk preferences using CARA and CRRA utility functions. This will generate certainty-equivalent recommendations that align with farmers' risk attitudes and credit constraints, supporting the design of risk-contingent input subsidies or insurance schemes.

2. **Integrating real-time and remote sensing data**
   I will fuse on-farm experimental data with weather nowcasts, soil sensor data, and remote sensing imagery to build adaptive decision support tools that update recommendations within-season. Such tools can respond dynamically to climate shocks and are aligned with the mission of agencies like USDA and NSF to support climate-resilient agriculture.

3. **Linking productivity to environmental externalities**
   I plan to couple input response models to environmental indicators such as greenhouse gas emissions and nitrogen leaching, allowing policymakers to evaluate profitability–sustainability tradeoffs. This will inform incentive designs for climate-smart agriculture and contribute to the emerging literature on agri-environmental policy evaluation.

These projects are ambitious yet feasible: they extend my existing datasets, pipelines, and modeling frameworks, and align with the research priorities of USDA-NIFA, NSF, and international development agencies.

Conclusion

My research program develops rigorous, data-intensive methods to optimize agricultural input decisions under uncertainty. By combining experimental data, econometric modeling, and machine learning, I aim to generate tools that improve farm profitability while reducing risk and environmental harm.

In the long term, I envision building a research group that bridges field experimentation and regional policy evaluation, contributing both to the academic literature in agricultural and applied economics and to real-world decision support systems for sustainable agriculture.