Title of the Presentation

Estimating Crop Yields Using Temporally and Spatially-Varying Models

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Introduction

- The Federal Crop Insurance program costs US taxpayers billions of dollars each year as it protects farmers against the loss of revenues and yields. The program is heavily subsidized and thus involves a significant transfer of wealth from taxpayer to farmers. Accurately measuring the risks associated with crop yields and estimating actuarially fair insurance contract parameters such as premium rates and insurance guarantees depends on accurate measurement of risks.
- The distributions underlying the measurement of yield and price risks are time-varying and space-dependent. Empirical measures of yield distributions are typically complicated by the fact that technological improvements have resulted in significant positive (typically nonlinear) trends in yields. And empirical measures of yield distributions also suffer from large sampling variations due to rather short time series for each county, especially when we assume a nonlinear technological change and fit more complicated models.
- The majority of studies of crop yield distributions utilizing crop yields that are observed over time undertakes an initial detrending of yield data and then proceeds with analysis of the detrended yields with the maintained assumption that they are observed (modeled) without error, and most of the studies rely on large-N small-T county-year level data and estimate separate densities for each county without making use of possible spatial dependence.

Objectives

- This paper tackles two above-mentioned issues and extends those earlier analyses to consider a broader class of model. We utilize lasso-penalized linear regression model to estimate corn yields in major agricultural producing States over the 1926-2016 period. We utilize data-driven adaptive lasso method to model the trend in mean yields and the changes in the yield density over time using information from other counties and other periods. Using time-varying moments allows us to estimate the trend (first moment) and higher order conditional moments simultaneously and get stronger out-of-sample predictive power, while using adaptive LASSO method allows us to pool information from neighboring counties efficiently and reduce large sampling variations due to small sample size for each county.
- Accurately measurements of spatial and temporal dependence allow pooling risks among counties and periods and improve the estimation for actuarially fair premium for agricultural reinsurance.

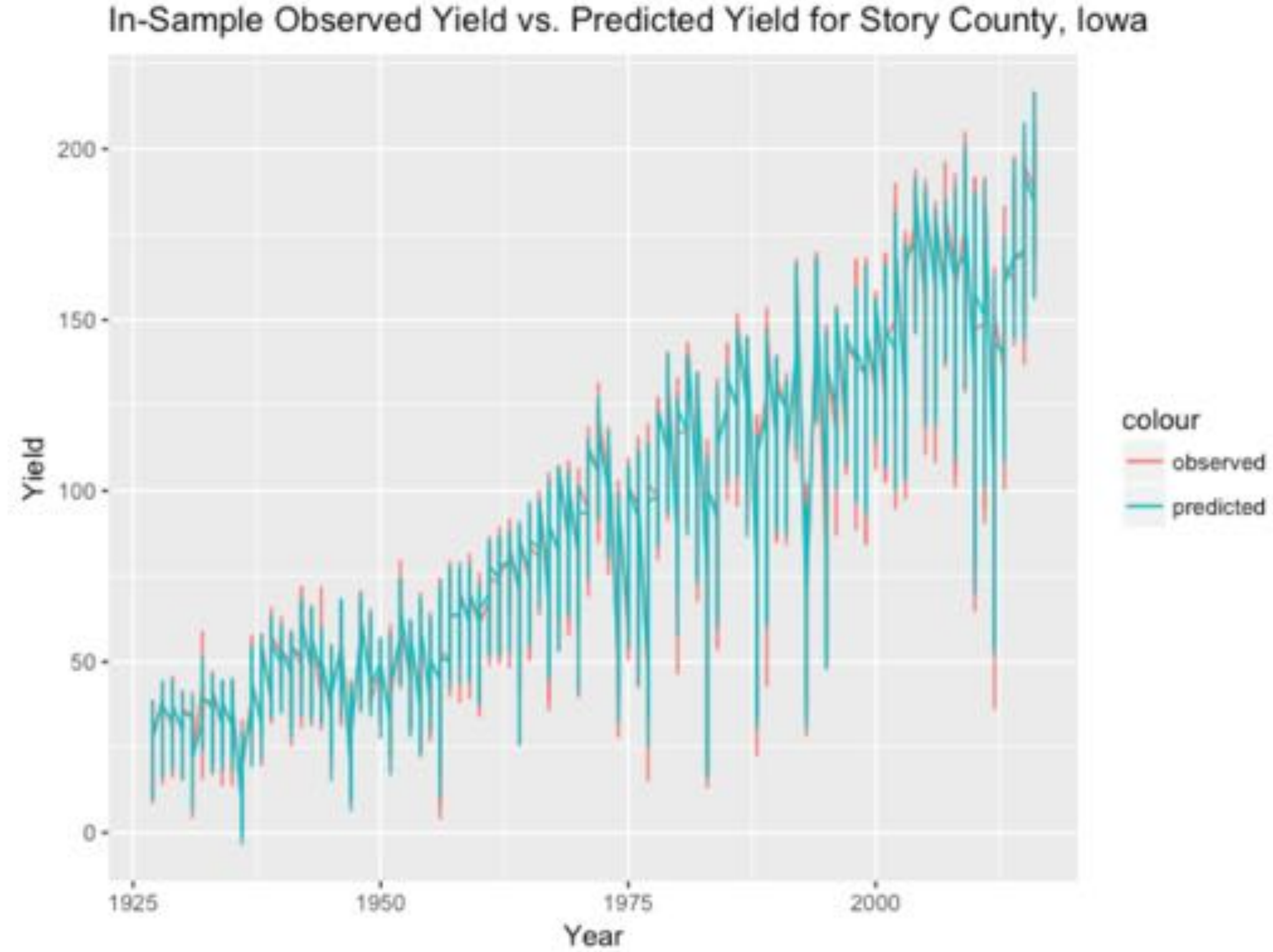
Methods

- We model the crop yield of county i in the following model:

$$Y_{it} = \mu_{it} + \sum_{j \in N_i} \beta_{ij}(Y_{jt} - \mu_{jt}) + \sum_{j \in N_i} \rho_{ij}(Y_{jt-1} - \mu_{jt-1}) + \varepsilon_{it}$$

- Mu is the trend of the crop yield of the county, and j belongs to the set of county i's neighbors. Therefore, beta represents the effects of contemporary shocks from neighboring counties, while rho represents the effects of shocks from neighboring counties.

In-Sample Observed Yield vs. Predicted Yield for Story County, Iowa



Corn Yield for Story, IA	Coefficient
Beta_19015	0.532211863
Beta_19079	0.005575269
Beta_19083	0.071320793
Beta_19099	-0.168799652
Beta_19127	0.324386668
Beta_19153	0.296229919
Rho_19015	0.087528524
Rho_19079	0.101553920
Rho_19083	-
Rho_19099	0.008247178
Rho_19127	-0.152474471
Rho_19153	-

Results

- Here we present the fitted model for a sample county – Story, Iowa. The graph on the left shows the plot for in-sample observed yield versus predicted yield, while the table above shows the coefficients (Betas and Rhos) for the model.

Conclusions

- We show that taking into consideration the spatial and temporal dependence can improve the estimation of crop yields significantly and provide guidance for pooling risks across counties and periods.
- We can extend our study by applying our models to agricultural reinsurance premium calculation and examine the direction of spatial shocks.