

Trouble with Crop Yield Tail Correlations: Searching for Geographic Regularities

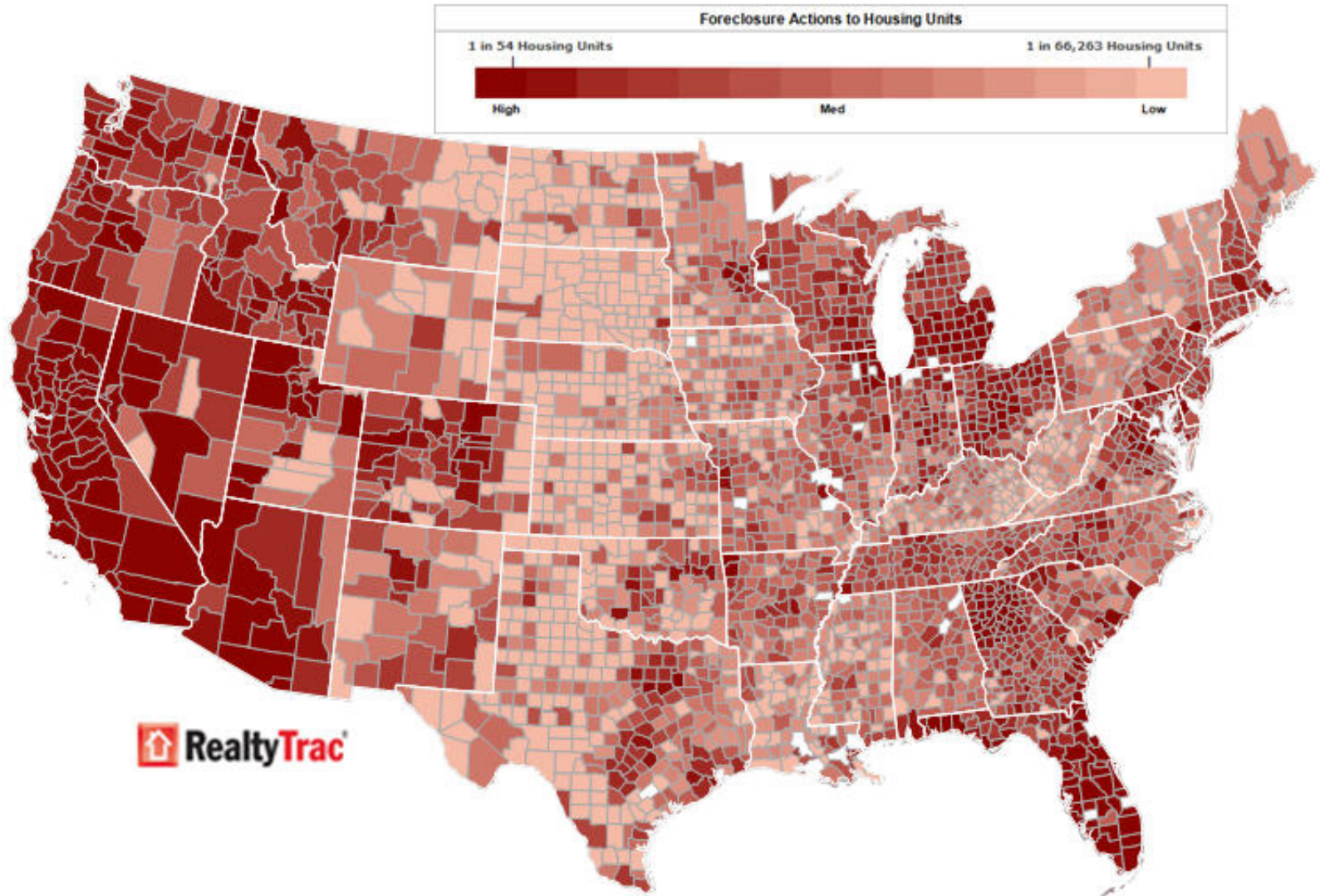
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Joint work with Xiaodong Du, University of Wisconsin
Madison, Hongli Feng, Michigan State University

Trends in U.S. Agricultural Policy

- Gradual, uneven movements toward Environmental and related policies
- Biofuels
- Traditional income support is being replaced by support through crop insurance
 - Limited availability in unsubsidized markets
 - A variety of means of support, including compensation for administration and delivery costs
 - Premium subsidies, falling with level of coverage relative to crop mean yield
 - Two contract forms, yield and revenue
 - *Federal government sets rates*

U.S. Housing Foreclosures, Heat-Map August 2010



How did mortgage portfolio values collapse?



A Fall Guy

- A Copula is a way of modeling correlation structures. It is a function linking marginal distributions into a multivariate distribution

$$C[u_1, u_2, \dots, u_n]$$

$$= \text{Prob}[F_1(x_1) \leq u_1, F_2(x_2) \leq u_2, \dots, F_n(x_n) \leq u_n]$$

$$\text{for } u_i \in [0,1]$$

where x_i are random variables with marginals $F_i(x_i)$

- The best known of these is the Gaussian Copula. It lets the marginal distributions be anything but requires that the way they interact follow the multivariate normal distribution

A Fall Guy, II

- The multivariate normal is a flexible and simple way of modelling many sources of randomness, hence its popularity
- This comes at a cost. For our purposes the Gaussian copula implies distribution tail independence:

$$\frac{C[u_1 = u, u_2 = u]}{u} \rightarrow 0 \quad \text{as} \quad u \rightarrow 0.$$

- What that more-or-less says is that correlations between outcomes can't increase as things get worse in general
- But that is at variance with reality in financial markets
- When most needed for modeling and managing portfolio uncertainty, the model breaks down

Back to Crop Insurance

- The standard approach to modeling price-yield and yield-yield correlations when rate-setting in crop insurance applies a sorting approach in

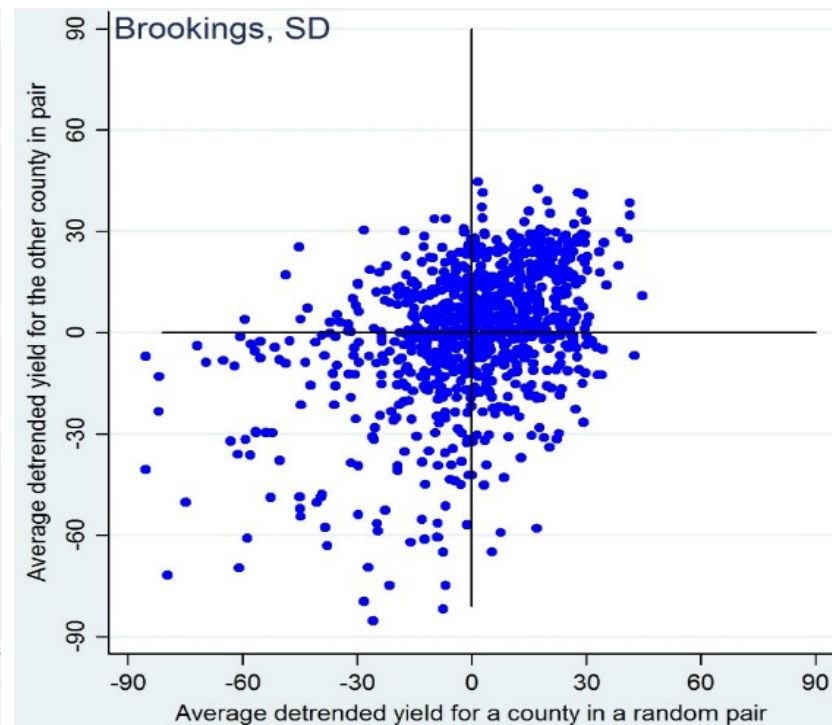
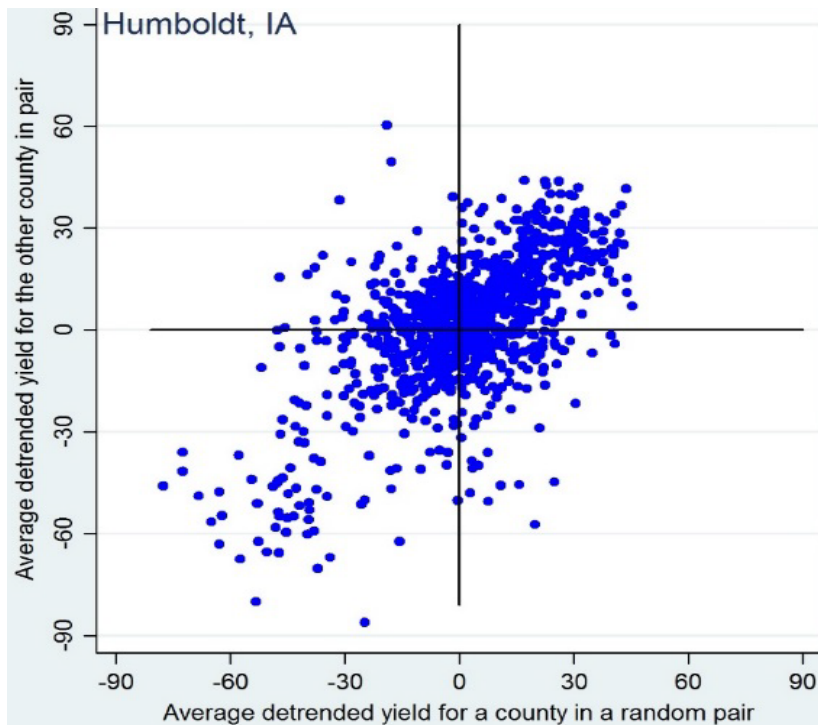
Johnson, M.E., and A. Tenenbein. "A Bivariate Distribution Family With Specified Marginals." *J. Amer. Statist. Assoc.* 76(March 1981):198-201.

- It turns out that this essentially imposes the Gaussian copula, a point Bruce Babcock and I didn't have any sense of when first proposing this approach
- Is it an appropriate assumption, or might crop insurance rates be mis-priced as a result?

A tale of two states, with poetic license



For a County in Iowa and a County in South Dakota, Scatter Plot of Detrended Yields when Units within County are Randomly Matched



Our work

- We developed an hypothesis on how tail dependence between yields in a region should differ by region and land attributes. It has to do with soil quality and what that means for plant resilience
- Using actual farm-level yield data and a variety of statistics, we find evidence in favor of this land yield resilience hypothesis
- In particular, tail dependence is to be expected among crop yield risks

Our work, II

- Iowa yields tend to be more correlated in the upper tail (good crop), less correlated in the lower tail than is imposed by the Gaussian Copula
- South Dakota yields tend to be more correlated in the lower tail (bad crop), less correlated in the upper tail than is imposed by the Gaussian Copula
- Statistics reject the Gaussian copula model, calling into question current rate-setting methods
- Federal government self-insures crop yield exposures but budgeting is problematic for agency budgets

TALE END

*Agric. Econ. is a very broad field linked through
markets studied, with important emerging issues &
endless opportunities for useful research. Think
technology & IPRs, e.g., GMOs
property rights and institutions
water and air quality, invasive species
international, infrastructure and development
food safety & quality
nutrition, obesity & human health externalities
behavioral economics perspectives on food
risk, finance, storage, famine
industrialization & increasing roles for
information in food marketing*

Thank you