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Diversifying Systemic Risk in Agriculture: A Copulabased Approach

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Diversifying Systemic Risk in Agriculture: A Copula-based Approach

Background

- One of the biggest obstacles for the development of private crop insurance markets is the systemic risk inherent in crop yields.
- Driven by spatially correlated weather events, crop losses are highly correlated within a certain area.
- As a result, the portfolio insurance risk has been raised prohibitively high for viable private crop insurance markets unless subsidized by the government.
- For example, the portfolio risk faced by U.S. crop insurers is about ten times larger than that of conventional insurance lines (Miranda and Glauber, 1997).

Objectives

- Propose a risk-pooling approach to address the systemic risk problem in agriculture.
- Investigate the effectiveness of diversifying systemic risk by creating a risk pool across multiple crops and countries.
- If evidence could be found that risks in the pool were no longer exhibiting systemic nature, then creating such a risk pool would facilitate the development of private crop insurance and reinsurance markets, as well as the withdrawal of government involvement in crop insurance.

Crop Types and Study Area

• A synthetic state/province-level area-yield insurance portfolio across five major crops in two large agricultural producing countries is considered.

	Corn	Cotton	Rice	Soybeans	Wheat
United States	10 major producing states	10 major producing states	6 major producing states	10 major producing states	10 major producing states
China	10 major producing provinces				

Methods

- As shown by Goodwin (2001), the correlation of crop yields tends to be much stronger during extreme weather than in normal years, which makes the assumption of linear correlation not appropriate.
- Therefore, the joint behavior of the area-yield variables x_1, \ldots, x_k is modeled using a copula-based approach:

 $F(x_1, ..., x_k) = C[F_1(x_1), ..., F_k(x_k)],$

- where F is the joint distribution, $F_1, ..., F_k$ are the respective marginal beta distributions, and C is the associated copula.
- Specifically, the hierarchical Kendall copula (HKC) is applied since the HKC achieves both flexibility and parsimony in modeling the joint distribution of extremely high dimensional variables.
- The HKC parameters are estimated sequentially by a Bayesian approach to take into account estimation risk. Non-informative priors are assigned and inference is conducted by Markov Chain Monte Carlo (MCMC) methods.

Correlations

• While there are significant positive correlations among the area-yield variables within each country, the between-country correlation is very close to zero (Figure 1), indicating the potential of diversifying the risks across the two countries.

Figure 1. The Posterior Distribution of the Kendall's Correlation **Coefficient of the Between-country Correlation**



References

Goodwin, B. K. (2001) "Problems with market insurance in agriculture," American Journal of Agricultural Economics, 83, 643-49.

Miranda, M. and Glauber, J. (1997) "Systemic risks, reinsurance, and the failure of crop insurance markets," American Journal of Agricultural Economics, 79, 206215.

Diversification Effect

- of net insurance income at 70% strike level.
- of the risks has been removed.



Diversification Effect of Combining Insurance Policies across the Crops in China



Diversification Effect of Combining Insurance Policies across the U.S. and China



Conclusions

- across the crops and countries.
- eliminated.

• Diversification effect is defined as the percentage of risk diversified off by combining crop insurance policies into a joint insurance portfolio.

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• Diversification effect is reported with regard to the risks in terms of the standard deviation (Std), the minimum value (Min), the value at risk at 1% (VaR1%), and the value at risk at 5% (VaR5%) of the distribution

• The diversification effect under the estimated correlation structure is compared to that under a situation in which the risks are assumed to be independent across insurance policies. If the diversification effect is comparable to the independent case, it implies that the systemic nature

> Diversification Effect of Combining Insurance Policies across the Crops in the U.S.





• The empirical results obtained in this study indicate that the yield risks have been significantly reduced by combining crop insurance policies

• In addition, the risks are losing systemic nature when crop insurance policies across the two countries are combined under one pool.

• This suggests that by including more countries, systemic risk can be