Diversifying Systemic Risk in Agriculture: A Copula-based Approach

Xiaoguang Feng
Graduate Assistant
Department of Economics
Iowa State University
xgfeng@iastate.edu

Dermot J. Hayes
Pioneer Chair of Agribusiness
Professor of Economics
Professor of Finance
Iowa State University
dhayes@iastate.edu

Selected Poster prepared for presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 27-29, 2014.

IOWA STATE UNIVERSITY
Department of Economics

2014 AAEA Annual Meeting
Minneapolis MN
July 27-29, 2014

Xiaoguang Feng, Dermot J. Hayes

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	10 major producing provinces	10 major producing provinces	10 major producing provinces	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:

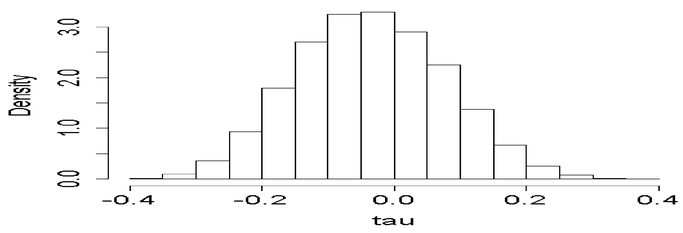
$$F(x_1,\ldots,x_k)=C[F_1(x_1),\ldots,F_k(x_k)],$$

- where F is the joint distribution, $F_1, \ldots, F_k$ 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

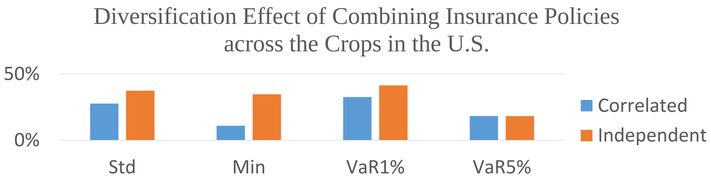
Goodwin, B. K. (2001) "Problems with market insurance in agriculture," American Journal of Agricultural Economics, 83, 643-49.

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

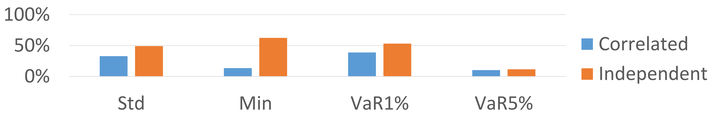
Diversification Effect

- Diversification effect is defined as the percentage of risk diversified off by combining crop insurance policies into a joint insurance portfolio.
- 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 of net insurance income at 70% strike level.
- 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 of the risks has been removed.

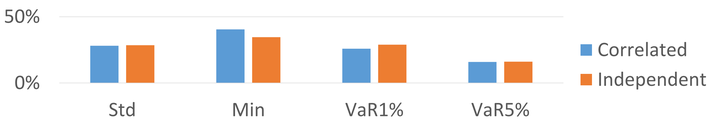
Diversification Effect of Combining Insurance Policies across the Crops in the U.S.



Diversification Effect of Combining Insurance Policies across the Crops in China



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



Conclusions

- The empirical results obtained in this study indicate that the yield risks have been significantly reduced by combining crop insurance policies across the crops and countries.
- 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 eliminated.

Acknowledgements