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AMS 518 Project Topic: Optimal Crop Production and Insurance Coverage

This case study investigates an optimal crop production and insurance coverage under three types of risk constraints: CVaR, VaR, and Probability Exceeding Penalty constraint.
Farmers face uncertainties of crop yields and market prices affecting their profit. These uncertainties contribute to the profit risk. To hedge the risk, farmers can purchase insurance against the uncertainties of yields and prices. There are several insurance policies on the market providing different protections with different prices. This case study finds the best planting plan and insurance policy creating maximum profit under an acceptable risk exposure.
Crop yields are affected by climate type. Hansen et al. (1998) shows that El Nino Southern Oscillation (ENSO) is a strong driver of seasonal climate variability that impact cotton and peanut crop yields in the southeastern US. Climate can be categorized into three phenomena: El Nino, La Nina and Neutral. The phenomenon can be predicted by the sea surface temperature. When the temperature is normal, the phenomenon is called Neutral. If the temperature is lower or higher than normal, the phenomenon is referred to as La Nina or El Nino, respectively. Each phenomenon has different effects on the crop yields due to the different temperature and rainfall. For instance, El Nino brings more rainfall and cooler temperatures, while La Nina brings less rainfall and warmer temperatures than normal.
The harvest price of crops is an important factor affecting farmers' income. Based on the multivariate time series of historical crop prices, we calculated the variance of prices for each crop and covariance of prices between crops. Scenarios of the prices of crops were generated by multivariate simulation. The procedure followed the methodology of Letson et al. (2005).
There are three main types of crop insurance: the Actual Production History crop insurance (APH), the Crop Revenue Coverage insurance (CRC), and the Catastrophic Insurance Coverage (CAT). APH assures a percentage of the farmers' history yield. If the yield becomes lower than the insured yield, the insurance pays an indemnity covering the difference between the insured yield and the real yield. CRC assures income by indemnifying farmers based on historical average yield and the market price. If the actual yield multiplied by the established price or actual market price is lower than an indemnified income level, a farmer is entitled to an insurance payment. CAT can be defined as an APH policy at 50% yield coverage with 55% price base election.
Several studies have addressed the impacts of the ENSO based climate forecasts on the selection of crop insurance policy. Cabrera et al. (2005) used the utility function to address farmers' risk aversion. Utility function is widely used for theoretical and mathematical purposes. The disadvantage is that farmers can not specify their utility functions. Instead Lui (2005)

employed CVaR as the risk measure and formulated the problem as a quadratic problem. This case study improves the quadratic model proposed by Lui. Similarly, we consider a model for planting and insurance by maximizing the total profit under a risk level measured by CVaR, VaR, and Probability Exceeding Penalty.
Three ENSO climate phases are considered in the optimal crop production and insurance coverage problems:
1. El Nino
2. La Nina
3. Neutral

I will be using the latest datasets to analyze this problem statement once again.

Case study link:
http://uryasev.ams.stonybrook.edu/index.php/research/testproblems/logistics/optimal-crop-production-and-insurance-coverage/