The Use of Probabilistic Crop Models to Assess Agriculture Insurance Risks in China

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ABSTRACT

Chinese government policies related to food production and food security have traditionally focused on increasing production efficiency, improving irrigation and flood mitigation and access to loans to secure stable domestic food supplies in order to improve the livelihoods of farming households. As part of the programs to secure financing and to provide a safety net for farmers in case of natural disasters, government-subsidized agriculture insurance started on a large scale in 2007. It grew from a premium volume of USD 100 million in 2006 to USD 5 billion in 2013 with the anticipation to reach over USD 8 billion in 2017. Such large financial exposure requires robust risk quantification and significant risk transfer towards reinsurance and ultimately capital markets.

China has an indemnity-based crop insurance system where perils are selectively insured. A sophisticated risk quantification model therefore needs to be peril-specific and address all insured crop types in a variety of climate zones. The use of actuarial science in assessing crop risks is not adequate because crop insurance in China only has a seven year history and while a few provinces showed high crop insurance losses, the insurance industry has not yet experienced systemic losses which affect a large number of provinces at the same time. The rapid growth of the insured exposure is pointing to the potential risk to be assessed more quantitatively. Crop modeling is needed at high resolution (e.g. county level) in order to understand how exposure and simulated losses varies within a province under extreme weather events. A multi-disciplinary approach is needed in using the latest techniques of climate modeling, the experience in modeling natural catastrophes from the property insurance domain and outputs of complex yield forecast models to reproduce past time series. This approach forms the basis to financially quantify agriculture insurance risk and to provide a scalable framework of analytical tools. Outputs of a crop catastrophe model needs to be based on the hazards that are relevant for the risk transfer products in (i) multi peril-based if the insurance product is based on yield reduction like in the US and (ii) named peril-based if the insurance claims are settled on mean damage ratios like in China or Europe.

This paper presents results of research initially undertaken by Asia Risk Centre in collaboration with Beijing Normal University and Risk Management Solutions and which has been further developed into a risk modeling framework by Asia Risk Centre to assess financial losses to crop insurance exposure in China in a probabilistic way. First, daily weather data are simulated over China based on historical weather data using a Principal Component Analysis so that extreme weather events can be accurately modeled. The resulting simulated weather events are aggregated over periods that reflect key growth phases for summer and winter crops. Different indices are developed and this paper discusses how they relate to specific perils and resulting crop yield reductions. Stochastic approaches are developed to model affected crop areas at different levels of damage ratios using 62 years of historical peril-specific area affected data at different damage intensity levels. These results are compared with historical insurance losses for validation purposes. The obtained results are processed to calculate financial losses to insurance portfolios after consideration of original policy terms such as crop- and peril-specific franchises, deductibles, riders and government protection programs. Typical risk metrics such as Average Annual Losses as well as Ground-Up and Gross Losses at different return periods are generated in the form of excedance probability curves.

This paper discusses how outputs of robust crop risk models benefit the insurance sector and government stakeholders in assessing weather risks in a probabilistic way in order to define sustainable risk transfer products.

Based on metrics of the modeled risk, peak exposure can ultimately be transferred to capital markets through insurance linked securities in the same way as natural catastrophe risks are securitized for property risks. Farmers are currently the key beneficiaries of crop insurance which forms a safety net and as it acts as collateral against bank loans, access to loans is facilitated. This in return should lead to increased crop production and help to achieve food security targets. Equally, the agriculture supply chain including traders, processors, input suppliers, logistics companies, agriculture funds and lending institutions can benefit from outputs of crop risk models to assess the downside risk and business interruption potential from natural disasters to develop effective hedging strategies.