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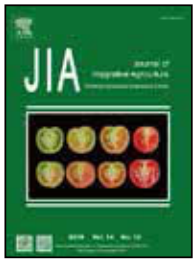

RESEARCH ARTICLE

Empirical study on optimal reinsurance for crop insurance in China from an insurer's perspective

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Abstract

This study investigates the optimal reinsurance for crop insurance in China in an insurer's perspective using the data from Inner Mongolia, Jilin, and Liaoning, China. On the basis of the loss ratio distributions modeled by AnHua Crop Risk Evaluation System, we use the empirical model developed by Tan and Weng (2014) to study the optimal reinsurance design for crop insurance in China. We find that, when the primary insurer's loss function, the principle of the reinsurance premium calculation, and the risk measure are given, the level of risk tolerance of the primary insurer, the safety loading coefficient of the reinsurer, and the constraint on reinsurance premium budget affect the optimal reinsurance design. When a strict constraint on reinsurance premium budget is implemented, which often occurs in reality, the limited stop loss reinsurance is optimal, consistent with the common practice in reality. This study provides suggestions for decision making regarding the crop reinsurance in China. It also provides empirical evidence for the literature on optimal reinsurance from the insurance market of China. This evidence undoubtedly has an important practical significance for the development of China's crop insurance.

Keywords: optimal reinsurance, crop insurance, limited stop loss reinsurance

1. Introduction

In its 18th Third Plenary Session of the Central Committee, the Chinese Communist Party adopted the "Decision on the major issues about economic and social comprehensive reform" (hereinafter referred to as Decision). The Decision requests "to improve the agricultural insurance system". Since 2007, when national fiscal subsidies became available to agricultural insurance, crop insurance has developed dramatically. The premium of crop insurance reached 19.86 billion CNY in 2012, the highest in Asia and the second in the world after the United States. However, some problems underlie the premium "halo" (Zhou *et al.* 2012). One important issue is the high cost of reinsurance. During 2008–2012, the cumulated ceded premium of crop insurance in China reached 9.50 billion CNY, but claims and expenses were only 4.57 and 2.33 billion CNY from reinsurers, respectively. In other words, the cumulated ceded net profit was 2.13 billion CNY, accounting for 3.4% of the total primary premium or 22.42% of the ceded premium during this period. The high cost of reinsurance is unfavorable for

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the development of the growing crop insurance in China. Is it necessary to buy reinsurance? If yes, what is the appropriate cost for it? We are greatly interested in determining the answers to these questions.

Why do primary insurers buy reinsurance? The existing literature has reached a consensus that insurers can smooth fluctuations in underwriting results, reduce the effect of catastrophes, obtain professional advice from reinsurers, and improve underwriting capacity by purchasing reinsurance. When primary insurers transfer risks to reinsurers, they need to bear additional costs, such as reinsurance premium. Such premium is usually higher than the expected ceding losses. Therefore, primary insurers need to make a trade-off between the risks transferred and the premium paid. If the purchase of reinsurance is unnecessary or excessive, then the underwriting profit decreases because of the high reinsurance cost. Conversely, if the purchase of reinsurance is inadequate, then a catastrophe may cause insolvency or even bankruptcy for primary insurers (Fu and Khury 2010). Venter *et al*. (2001) point out that the reinsurance decision-making process consists of weighing the risk and profit. If the two match well, then the optimal reinsurance decision is reached.

Studies on optimal reinsurance designs date back to the 1960s (Borch 1960; Kahn 1961; Ohlin 1969). For half a century, optimal reinsurance has been a popular issue for both scholars and practitioners, and considerable achievements have been made. Early studies mainly focused on the form of optimal reinsurance, but they failed to reach a consensus.

Among the studies on optimal reinsurance, most scholars have indicated the theoretical stop loss reinsurance as optimal (Borch 1969; Gajek and Zagrodny 2004; Guerra and Centeno 2008), especially if the reinsurance premium has no budget constraint. Borch (1969) concludes that stop loss reinsurance is the optimal form, but this conclusion is based on the assumption that the safety loading coefficient of the reinsurer is the same as that of a quota share reinsurance. Quota share reinsurance may be the optimal reinsurance in the sense that it is the least expensive way to limit the variance of the retained risk (Beard *et al*. 1977). If the safety loading coefficient is independent of the form of reinsurance and the expected value principle is used to calculate the reinsurance premium, then the Excess of Loss Reinsurance is optimal when the ceded risk is a function of individual claims (Gerber 1979). However the fact is, the safety loading coefficient usually increases with the variance of the ceded risk.

We do not deny stop loss reinsurance as a general form of theoretical optimal reinsurance, but in reality, the providers of agricultural insurance cannot afford stop loss reinsurance without a limit. This condition can be attributed to either the unwillingness of reinsurers to expose themselves to fat tail risk or the ability of reinsurers to provide it but at a fairly high price, which is exorbitant for agricultural insurers. Is there an optimal reinsurance design in the practice of crop insurance? If yes, what are the optimal upper and lower limits? This study answers these questions using Chinese empirical data.

Recent studies have almost reached a consensus that stop loss reinsurance or its variants are optimal. Assuming the standard deviation reinsurance premium principle and the target of minimizing the variance, Gajek and Zagrodny (2000) find that the optimal reinsurance form is stop loss reinsurance when the safety loading coefficient is zero. When the safety loading coefficient is greater than zero, the optimal reinsurance form is a combination of stop loss reinsurance and quota share reinsurance. Cai *et al*. (2008) find different optimal reinsurance forms under the risk measures VaR and CTE. Under the principle of minimizing CTE, stop loss reinsurance is always the optimal; the result is complicated under the target of minimizing VaR. If the ceded loss function is an increasing convex function, then stop loss reinsurance is optimal. However, if we relax the assumption slightly, such as assuming that the ceded loss function and retained loss function are increasing functions, then stop loss reinsurance with an upper limit becomes the optimal form. If the assumption is further relaxed to assume that the retained loss function is an increasing and left continuous function, then truncated stop loss reinsurance is optimal. Gajek and Zagrodny (2004) provide a straightforward summary: if the insurer has sufficient money to buy reinsurance to minimize the probability of bankruptcy, then only stop loss reinsurance is optimal. Aside from the substantially same conclusions, all of these studies consider optimal from the perspective of minimizing risk and disregard the other side of the trade-off, that is, profit. Assuming the expected value reinsurance premium principle, Guerra and Centeno (2008) find that stop loss reinsurance is the optimal form of maximizing the expected utility. In addition, Kaluszka (2004) uses a mean-variance analysis of the optimal reinsurance and shows that Change Loss Reinsurance, a variant of stop loss reinsurance, is optimal.

Almost all of these results show that stop loss reinsurance is optimal. However, in reality, is it actually helpful in the decision-making process for buying reinsurance? Bu (2005) suggests that, if the insurer wants to balance the variance of retained risk and expected profit, the best practice is to purchase middle-layer reinsurance because the purchase of reinsurance for high-loss layer is uneconomical. It is actually the second question when designing optimal reinsurance, that is, the optimal retention problem, which is of great concern to practitioners. Given that stop loss reinsurance is the optimal form of reinsurance, Cai and Tan (2007) deduce optimal retention by minimizing the value at