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Study on the assessment approach for crop loss risk

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Abstract

This paper proposes a new approach to assess crop loss risk more accurately by using cause of loss data. We believe the new approach can overcome the 'risk underestimate problem' of the traditional approach and can capture the underlying risk distribution. Corn loss risk assessments of eight provinces in the Chinese Corn Belt based on the two kinds of approaches are used to test the feasibility and effect of our proposed approach. Empirical results prove that 1) yield aggregation of the traditional approach not only underestimates the true risk, but also twists the underlying risk distribution; and 2) cause of loss data, rather than yield data, are preferred in the assessment of crop risk for a higher-level region.

Key words: crop loss; risk assessment; evaluation approach; cause of loss data

1. INTRODUCTION

Crop loss risk refers to the possibility of crop loss due to natural hazards such as drought, flood, and windstorms. Accurate assessment of crop loss risk is not only the foundation for setting an actuarial premium for crop insurance contacts, but is also linked to government policies, such as the collection and distribution of agricultural disaster relief funds. Since accurate assessment of crop loss risk is important, agricultural economists have conducted several studies on this issue. The main approach for crop loss risk assessment is based on yield history data and by following the pattern of 'Yield data-Detrend data-Distribution Fitting-Evaluation' [1-8]. However, the risk assessment approach based on yield data has a problem with data aggregation bias [9]. At higher levels of aggregation, poor yields in some areas are offset by good yields in others, thereby reducing the overall variability. Coble, Dismukes, and Thomas [10] estimated acreage-weighted yield coefficients of variation (CVs) for U.S. maize, soybeans, and cotton at different levels of aggregation. The study found that the average yield CVs measured at farm-level are more than double those measured at the state-level, and more than three times those measured at the national-level. Thus, farm-level data are the appropriate level of yield aggregation used in traditional approach for assessing

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producer risk; otherwise, the assessment will severely underestimate the underlying risks that producers face [11]. However, available farm-level data in most countries in the world, including China, are not enough to meet the requirements of risk assessment. Although some disaggregation methods were developed to extend farm-level data (by multiplying county-level data with a 'multiplier' that can reflect the relationship between farm- and county-level data) [9, 12], the methods are based on the assumption that both farm-level and county-level crop risk follow the same distribution. However, due to yield aggregation, crop loss series in the county-level may present different distribution features from those in the farm-level.

Outside the mainstream research of crop loss risk approach, Li, He, and Yang [13] and Zhang et al. [14] evaluated grain loss in the provinces of Yunnan and Fujian using cause of loss data from the Ministry of Civil Affairs of China. Their studies needs to be improved, and they did not provide an explanation why the approach based on cause of loss data instead of traditional yield data are adopted. However, they presented a new idea for evaluating crop loss risk. The higher level of cause of loss data comes from the sum and not from the spatial aggregation of lower-level data. Therefore, crop loss risk assessment based on cause of loss data can overcome the 'risk underestimate problem' caused by data aggregation of the traditional approach and can capture the underlying risk that producers face. This paper proposes to assess crop loss risk in a higher-level region using cause of loss data. Corn yield loss risk assessment based on yield data and cause of loss data for eight provinces in the Chinese Corn Belt are used to test the feasibility and the effect of the proposed approach.

The structure of this paper is arranged as follows: Section 2 introduces the methods adopted in this paper; the empirical results of corn yield loss risk assessment based on yield data and cause of loss data were presented and analyzed in Section 3; and the summary and conclusion are provided in Section 4.

2. Approach

Many literature have demonstrated the approach to evaluate crop loss risk based on yield data, thus we are not going to repeat it here. Only the risk assessment approach based on cause of loss data is introduced in this paper.

In China, the Ministry of Civil Affairs is in charge of recording the data related to natural disasters. Data sets from the Ministry of Civil Affairs provide three indicators (areas covered by natural disasters, areas affected by natural disasters, and areas with no harvest) that are useful for crop loss risk assessment. Areas covered by natural disasters, areas affected by natural disasters, and areas with no harvest are defined as the number of hectares with 10%–30%, 30%–80%, and over 80% damage. Therefore, we can estimate total loss using the above cause of loss data. The formula is shown as follows:

$$L_i = a_1 * Y_i * (AS_i - AC_i) + a_2 * Y_i * (AC_i - AJ_i) + a_3 * Y_i * AJ_i \quad (1)$$

Where Li is the crop total loss in year i; ASi , ACi , and AJi are the crop area covered, affected, and with no harvest by natural hazard in year i, respectively; Yi denotes the crop yield per hectare in year i; a1, a2, and a3 are the crop mean loss in each bins, equal to 0.2, 0.3, and 0.9 in this paper. Let TAi denote the total sown hectares of crop in year i. Then, the percentage of crop loss due to natural hazard can be calculated as

$$LR_i = \frac{L_i}{TA_i} \quad (2)$$

Although the cause of loss data from the Ministry of Civil Affairs did not include data for a specific crop, the percentage of specific crop loss can be estimated through mathematical derivation. For simplicity, it is assumed that natural hazard can result in the same damage to all crops in a region. Therefore, specific crop loss can be estimated by total loss multiplied by the sown ratio of the specific crop against total sown hectares. Suppose the plant area of a specific crop (such as corn) accounts for 1/K of the total sown area, thus the percentage of corn loss can be calculated as Equation (3):

$$LRC_i = \frac{\frac{1}{k} * [a_1 * Y_i * (AC_i - AS_i) + a_2 * Y_i * (AS_i - AJ_i) + a_3 * Y_i * AJ_i]}{TA_i * \frac{1}{k}} = LR_i \quad (3)$$

After the percentages of crop loss are calculated, kernel smoothing approach was used to model the crop loss data and derive a continuous nonparametric density function from the discrete estimates. The average annual loss is the 50th percentile of the kernel cumulative distribution.

3. Results

3.1 Data

Cause of loss data and corn history data were used to assess corn yield loss risk for the provinces of Heilongjiang, Jilin, Liaoning, Shandong, Henan, Guangxi, Guizhou, and Sichuan. All eight provinces are located at the Chinese Corn Belt, where Heilongjiang, Jilin, and Liaoning are the three major production provinces of the Chinese North Spring Corn Region; Henan and Shandong are the major production provinces of the Chinese Huang-Huai-Hai Plain Corn Region; and Sichuan, Guizhou, and Guangxi are the top corn provinces of the Chinese Southwest Mountain Corn Region.

Data on crop sown hectares, areas covered by natural hazard, areas affected by natural hazard, and areas with no harvest were available from 1978 to 2007, and were obtained from the Chinese Statistics Yearbook and the Chinese Agricultural Statistics Yearbook. Corn yield history data of eight provinces from 1949 to 2005 came from the Chinese Statistics Yearbook.

3.2 Comparison of corn risk based on two kinds of data sets

Figure 1[†] provides the percentage of corn yield loss of the eight provinces from yield history data and cause of loss data. It can be visible seen that the crop loss risk from cause of loss data is obviously higher than that from yield data. The result is consistent with our theoretical analysis that yield aggregation will underestimate the risk. However, the amount of risk underestimated by the aggregation data still needs to be determined. Figure 2 provides risk assessment based on yield aggregate data and shows that crop risk is greatly underestimated. The underlying corn yield risk of Guangxi, Guizhou, Heilongjiang, Henan, Jilin, Liaoning, Shandong, and Sichuan are 10.3%, 10.6%, 15.1%, 10.6%, 17.2%, 16.8%, 12.8%, and 9.6%, respectively. However, the estimated corn yield risk based on yield data for these provinces are only 4.5%, 3.9%, 7.7%, 6.8%, 11.3%, 9.1%, 5.3%, and 3.8%, which are less than half of the underlying risk, except for the provinces of Henan, Jilin, Liaoning, and Heilongjiang. Underestimated risks in the four provinces are also above 30%.

3.3 Comparison of risk distribution based on two kinds of data sets

As mentioned above, we assumed that the aggregation of yield data will not only determine the true risk, but may also distort the underlying crop risk distribution in farm-level. Kernel smooth approach was used to model the distribution of corn loss risk for the eight provinces. Probability density functions (PDF) were used to compare the risk distribution based on yield data and cause of loss data. The kernel PDF estimators for the eight provinces are listed in Figure 3. It can be seen that the PDF of corn loss risk using yield data do changed the underlying distribution features, there are obvious difference in the PDF of eight provinces from two kinds of data sets. Figure 3 provide us evidence to support the theoretical analysis mentioned above.

[†] To compare the feature of the two lines more clearly, the lower bound of the x axis (year) in Figure 1 was limited to 1978.

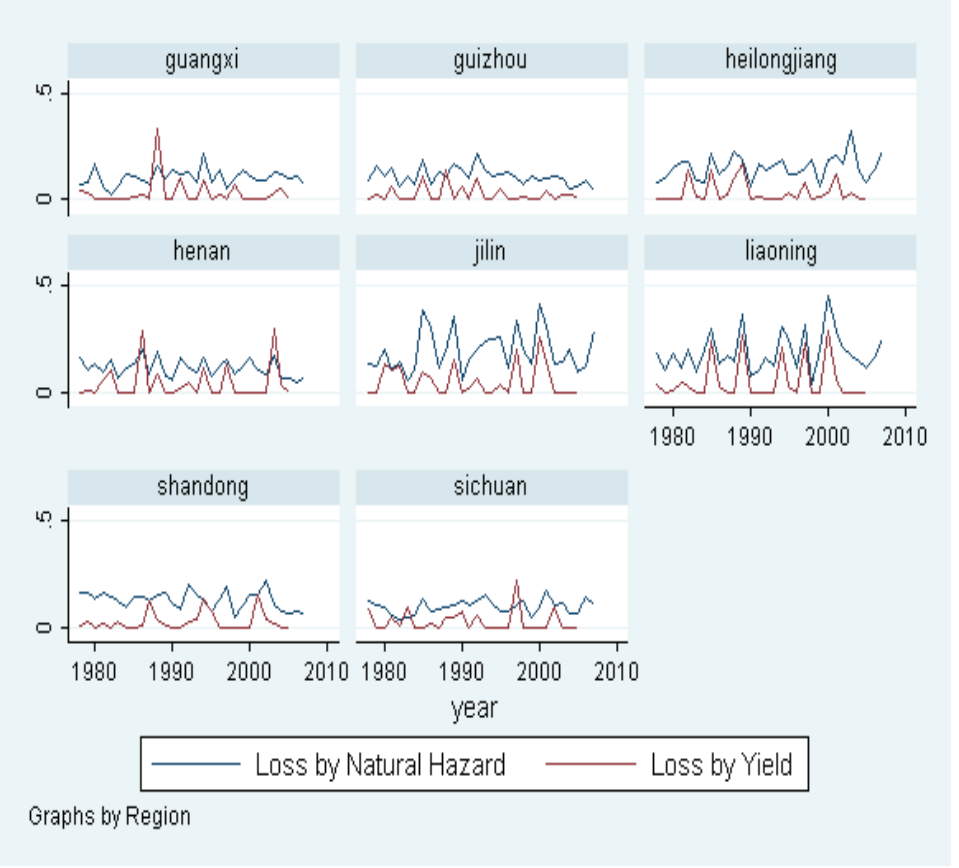

Figure 1 Corn loss series of eight provinces based on yield data and cause of loss data

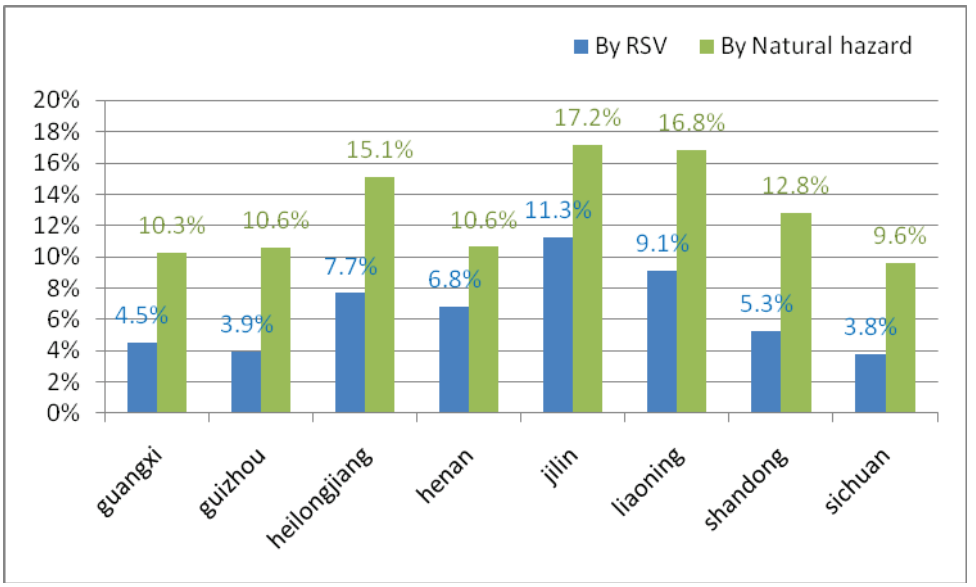

Figure 2 Average annual corn loss of eight provinces based on two kinds of data sets

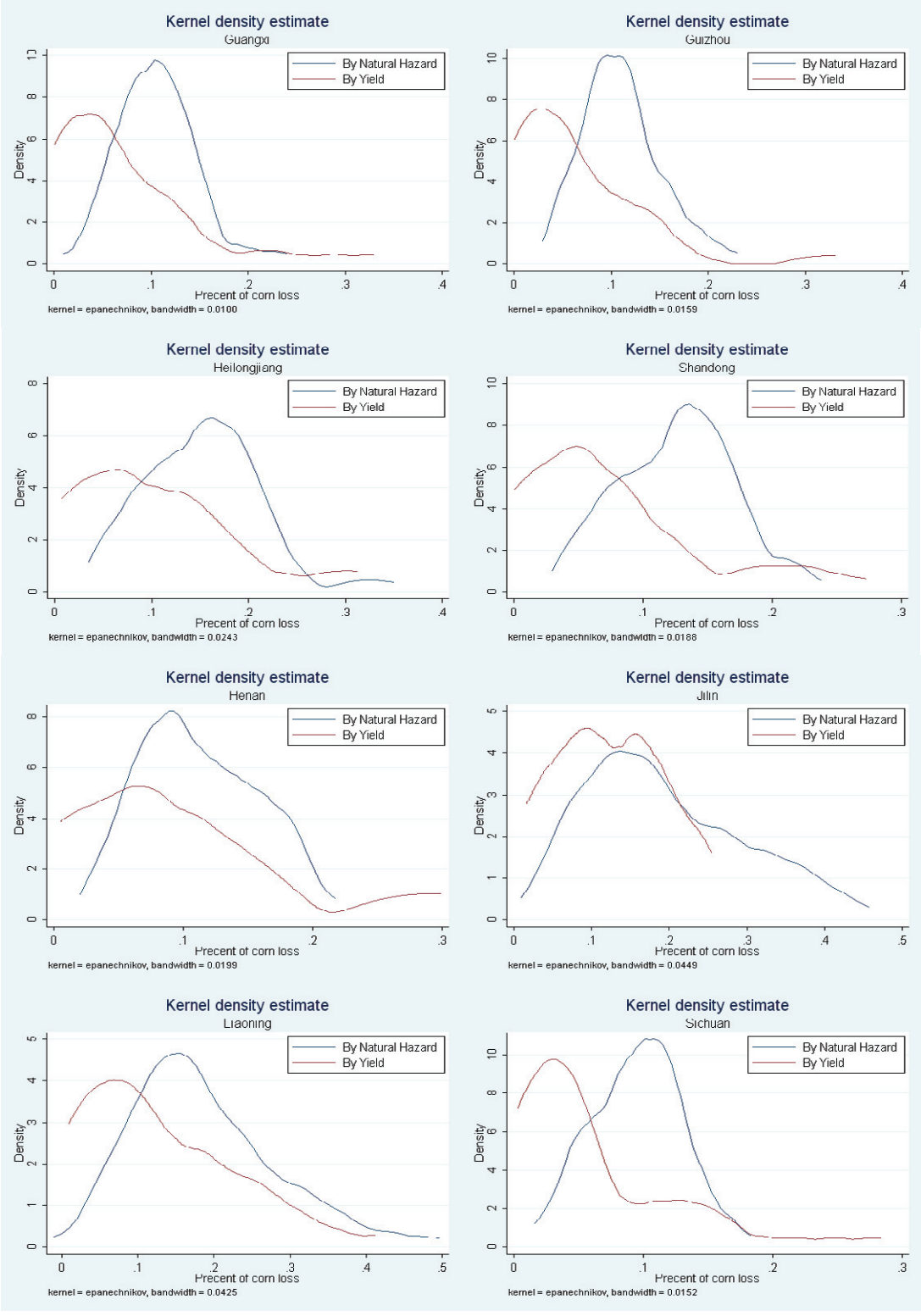

Figure 3 Average annual corn loss of eight provinces based on two kinds of data sets

4. Summary and Conclusion

Accurate assessment of crop loss risk is not only the foundation for setting an actuarial premium for crop insurance contacts, but is also related to the rationale of government policies. To overcome the 'risk underestimate problem' due to data aggregation of the traditional approach, this paper proposed a new approach to assess crop loss risk. This new approach employs cause of loss data and an empirical analysis of corn yield risk assessment of eight provinces in the Chinese Corn Belt were used to test the feasibility and the effect of the proposed approach. Based on the empirical results, the following conclusions are provided.

1) Crop loss risk assessment based on yield aggregation data will underestimate the underlying risk that producers face, as expected. Based on the empirical results of this paper, the underestimated risk of corn yield risk from yield data ranks from 34% to 62%, which is a serious bias. Moreover, yield aggregation data not only result in the underestimation of the crop risk that producers face, but also change the risk distribution features.

2) Cause of loss data rather than yield data is proposed to be used to assessing the crop loss risk of a higher-level region. The empirical results of this paper had proved the advantage of our proposed approach using cause of loss data. However, the proposed approach also need to be improved because the cause of loss data for specific crops are lacking and cause of loss data for corn are estimated under a straightforward assumption in this paper. More robust approaches may used to capture the cause of loss data for specific crops in future.

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