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Research and analysis of the insurance industry based on extreme weather

Xinyi Chen, Boning Zou

School of International Economics, China Foreign Affairs University, Beijing, 102206, China

Abstract: *Nowadays, the insurance industry is facing increasing challenges while the number of extreme weather phenomena is increasing. This paper provides support for the insurance industry by establishing models after quantifying the risks faced by property insurance companies and so on. This paper build a risk assessment model that focuses on extreme weather factors. Through SARIMA forecasts, the frequency of extreme weather is translated into economic quantifiers. Then visual data is used to determine the decision of whether or not an insurance company should underwrite one policy. Lastly, this paper provides recommendations for property owners to reduce their risk and upgrade their insurance. Then focus on property developers, further breaking out the limitations of extreme weather factors and expanding to socio-economic and GIS factors. First, this study uses the entropy weight method and PCA to assign weights to the insurance underwriting index system of different regions, and applies the data to SVM. Then the model is validated by taking the U.S. continents as an example. This question aims to better measure the factors in the companies' decision-making process to establish property insurance, and to ensure the self-interest of property insurance companies while providing a reference for the construction of real estate.*

Keywords: *SARIMA Prediction, PCA Evaluation, K-means Clustering*

1. Introduction

There are still relatively few papers focusing on extreme weather insurance, and agricultural insurance is a priority. China begins exploring new models for catastrophe insurance and empowered by technology[1][2].Risk level of the insured is also defined[3].Tang proposed agricultural insurance strategies[4].Liu found overall level of vulnerability to natural hazards in China was high and regular by using DEA[5].Zhao uses binary logistic model and other methods to study the influencing factors of farmers' willingness to purchase agricultural insurance under natural disaster risk shocks, and provides suggestions for the insurance industry and the government's work[6].Dai studies the current situation of catastrophe insurance in China while analysing foreign systems and making recommendations[7].Xu measures agricultural catastrophe risk using the Pareto distribution model and VaR[8]. Xue explored the critical importance of chain thinking in disaster prevention, mitigation, response and emergency management[9].Sun summarises the cutting-edge results and features of foreign research on disaster economics[10].Through the study, the paper used SARIMA,PCA,K-means, etc. methods to measure the risks and hazards associated with extreme weather. Thus, the paper gives property owners some practical suggestions surrounding pre-emptive prevention, loss mitigation and after-the-fact rectification to reduce their risk and upgrade their insurance, as well as some practical suggestions for property developers' project development location surrounding environment, market, accessibility, infrastructure to ensure the self-interest of property insurance companies while providing a reference for the construction of real estate which are focusing on more practical parts in this field.

2. Risk assessment focuses on extreme weather

2.1 Risk assessment models

To assess the risk of extreme weather in different regions and predict future risk trends. Analyze historical meteorological data using the SARIMA model to predict the frequency and intensity of future extreme weather events. Risk assessment process: Prediction of extreme weather events: using the established SARIMA model, we predict extreme weather events, such as precipitation anomalies or temperature anomalies, within a certain period of time in the future.

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2.1.1 SARIMA Model

SARIMA is used to forecast time series data with seasonal fluctuations. It can be shown as $SARIMA(p,d,q)(P,D,Q,m)$, first three are non-seasonal parameters and the last four are seasonal parameters.

2.1.2 Demonstration of modeling using examples

The paper selected two representative world powers, China and the United States, and the recurrent natural disasters in these two countries, and put them into the model for simulation.

We first process the total economic losses caused by all natural disasters in mydata.xlsx for both the U.S. and China, because we need to discretize the variables using the Poisson distribution. Here we assume that the economic loss caused by a natural disaster in the two countries is about 10e+8, and we can get the number of natural disasters in each year by dividing the total economic loss by the economic loss in each year.

Based on the extreme weather event predictions and socio-economic data from the SARIMA model, we will conduct a risk assessment to estimate the potential economic impacts and losses in different regions.

2.1.3 Economic Impact Assessment

$$Expeted\ Losses = \sum(Intensity\ of\ event \times Value\ of\ affected\ assets \times Vulnerable\ coefficient) \quad (1)$$

In this case, the intensity of the event can be predicted from the SARIMA model, and the value of the affected assets and the vulnerability coefficients can be based on socio-economic data as shown in Figures 1 and 2.

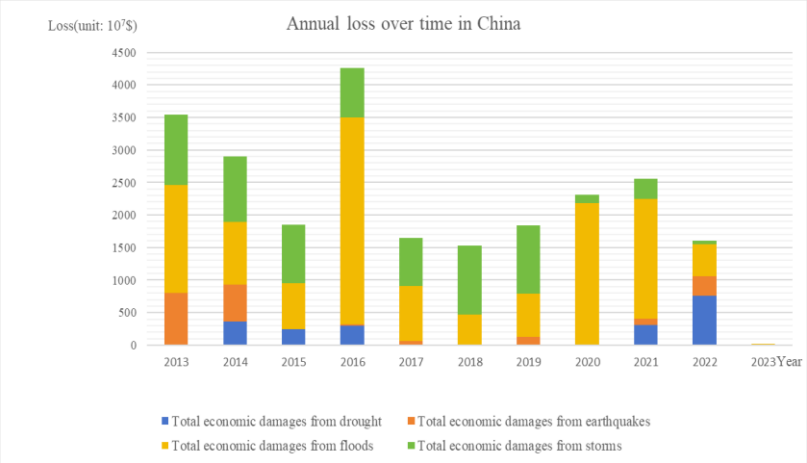

Figure 1: Annual loss in China over-time

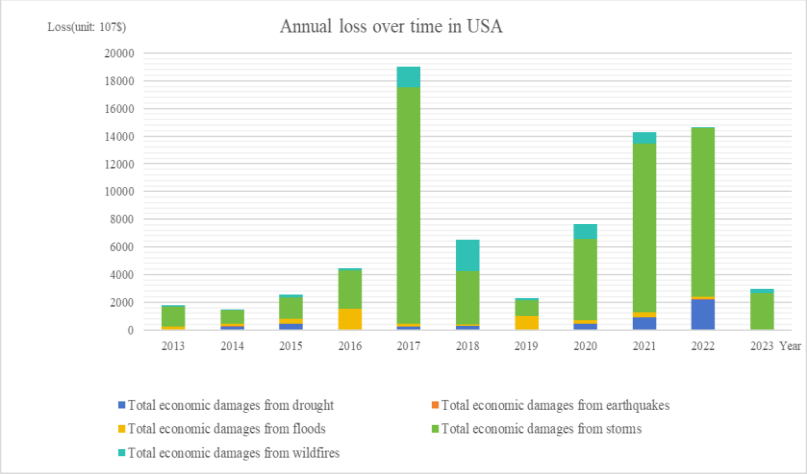

Figure 2: Annual loss in USA over-time

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The graph above shows the total economic losses from all natural disasters in China and the United States from 2003 to 2020 as shown in Figures 3.

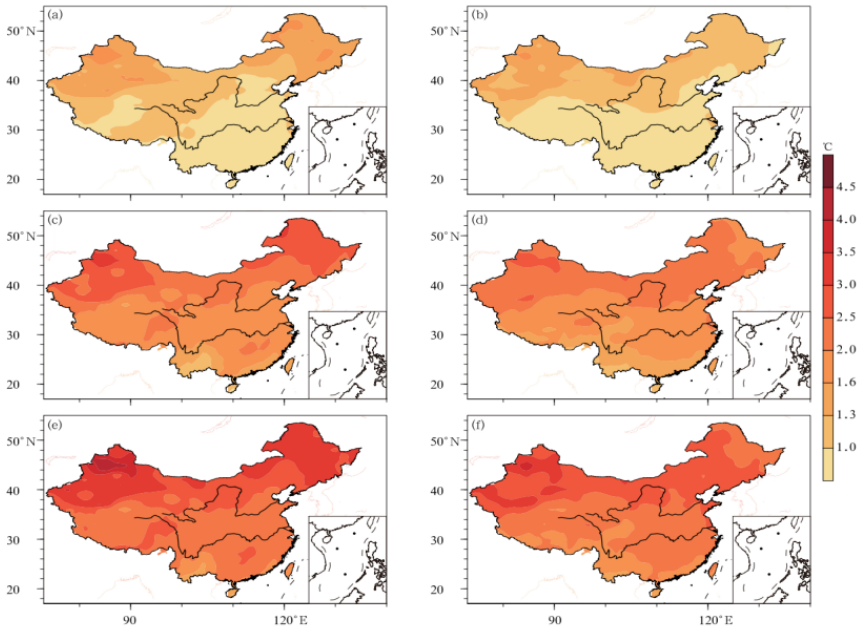

Figure 3: Spatial distribution of winter and summerseasonal temperature changes in China averaged over Bayesian model predictions[11]

2.1.4 TOPSIS and Risk Level Map

Risk level map shows the distribution of risk levels in different regions through color coding. The TOPSIS model is a distance-integrated evaluation method that ranks evaluation objects according to their proximity to an idealized target as shown in Figures 4.

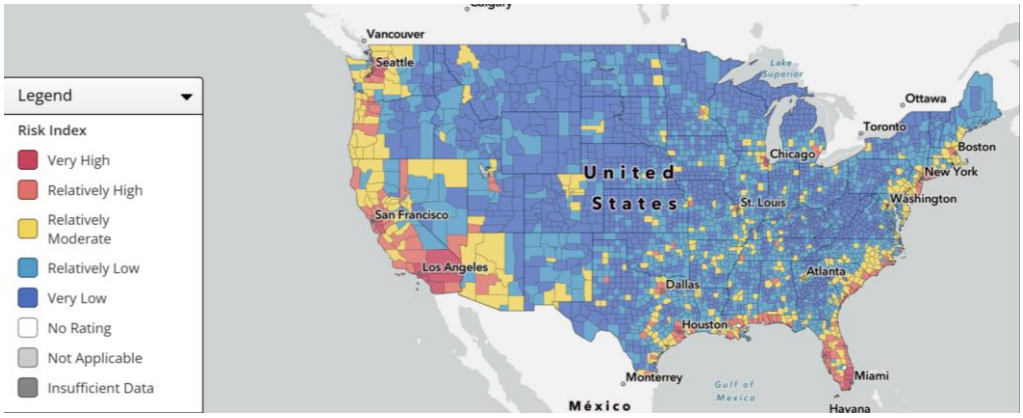

Figure 4: Risk level map[12]

2.2 Underwriting Decision

In order to calculate the cost of insurance, based on the results of the previous data analysis and risk assessment, the following steps will be followed:

$$Insurance\,Premiums = Expected\,Losses + Operation\,Cost + Risk\,Premiums \quad (2)$$

Expected losses can be derived from the aforementioned expected economic loss function, operating costs can be derived from the insurer's own financial statements, and risk premiums can be derived from a combination of risk rating maps and SARIMA projections. These components will combine to form a complete model for calculating insurance costs.

Next, the paper provide insurers with an intuitive understanding of their fee structure by visualizing

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the proportion of these components in the total insurance fee as shown in Figures 5.

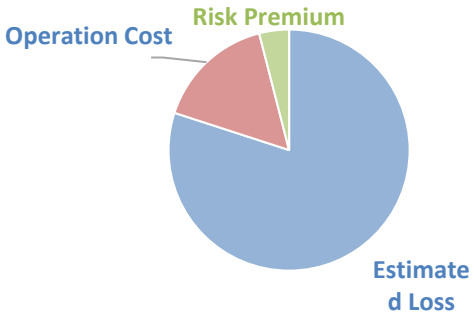

Figure 5: Premium components

2.3 Results: Property Owner Strategy

In order to protect their interests and to be able to obtain insurance coverage for their properties from insurance companies at the lowest possible premiums, property owners need to improve their insurance ratings and take precautionary measures that will make insurance companies willing to underwrite them.

Pre-emptive prevention means preventing disasters from occurring before they happen by means of regular disaster prevention inspections and the development of risk response plans.

Loss mitigation in the event that the risk has occurred, owners need to actively rescue the subject matter of the insurance.

After-the-fact rectification means optimizing the mechanism of disaster prevention and loss reduction through summarizing experience, investigating and analyzing the cause of the disaster. For example, homeowners can conduct a comprehensive survey of housing hazards, replace old household facilities.

3. Focuses on property developers

3.1 Entropy weight method

Information entropy method of different indicators weight indicator value is based on the evaluation of the actual measurement data of the indicators, the moment amount of comprehensive evaluation of the method of influencing factors, through the calculation of the information entropy of the indicators for the evaluation of the effective amount of information reflecting the indicators as shown in Table 1.

Table 1: Indicator Weights for Socio-economic Factors

Criteria	Information Entropy	Information Utility Value	Weight (%)
The Number of Extreme Weather Events in Past Decade	0.947	0.053	11.164
The Number of Extreme Weather Events in Next 10 Years	0.96	0.04	8.36
Per capita Insurance Expenditure(%)	0.898	0.102	21.412
Age Composition (median rate)(%)	0.969	0.031	6.494
Employment Status (employment rate)(%)	0.988	0.012	2.583
Regional crime rate(%)	0.819	0.181	37.864
GDP per capita (US $10.000)	0.957	0.043	9.052
Home Ownership Rate(%)	0.985	0.015	3.071

Communities and real estate developers can assign weights to the more important indicators, combine them with the weights assigned by the entropy weighting method above, and carry out sum averaging, so as to obtain characteristics that can satisfy the different focuses of different communities and real

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estate developers, and at the same time correct the undesirable classification results that may be caused by the subjective assignments through the objective assignments by the entropy weighting method.

For example, a real estate developer attaches great importance to the crime rate of the area, the weight of the indicator is set too high, which leads to high crime rate but the rest of the indicators perform well, so that the real estate developer can only be in a small range of housing, thus increasing the probability of bankruptcy, so the combination of the entropy weighting method mentioned above, better reflect the different needs of different communities and real estate developers, but also to ensure that the subjective assignment may lead to undesirable classification results.

3.2 PCA

The paper then use the PCA evaluation method to set the weights for the GIS data. Our use of PCA also allows us to visualize the importance of the hidden variables in each principal component so that we can better make the right decision in decision making and get the desired results as shown in Table 2.

Table 2: Indicator Weights for GIS Factors

Criteria	Weight	
Long-term Extreme Weather Events Risk	0.348	
Environment Fragile Level	0.469	
Architecture Elasticity	-0.018	
Infrastructure Development	Environmental Facilities	0.25
	Transportation Facilities	0.23
	Postal and Telecommunications Facilities	0.18
	Water Supply and Drainage Facilities	0.22
	Energy Facilities	0.12
	For Total	-0.202
Disaster Risk Level	0.403	

3.3 SVM Establishment

Simply put, SVM is a two-class classification model, his basic model is defined in the feature space of the interval of the maximum of the linear classifier, SVM learning strategy is interval maximization.

By comparing the results with the categorization results in part 1, we can find that after increasing the weights of certain indicators, more areas were assessed as having too high a property risk, leading to the conclusion that it is not recommended to build in these areas. Therefore, appropriate subjective empowerment based on the characteristics of different communities and real estate developers can be more effective in finding suitable areas for them to develop their properties.

3.4 Results: Recommendations for real estate developers

A good location affects the decision of insurance companies to underwrite property insurance, the following suggestions are made.

Environment: Choose a location with good environmental quality, away from noise and pollution sources, to provide a pleasant living environment.

Market Research: Before deciding on the location, it is crucial to conduct comprehensive market research. Understanding the needs of the target customer base, ensures that the project meets the expectations of potential customers.

Accessibility: Choosing a location with good access to public transportation will make it easier for residents to commute to work and increase the attractiveness of the lot.

Infrastructure: Ensure that there is good infrastructure close to the lot, including schools, medical facilities, shopping centers, etc.

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4. Model Advantages

·Fast program runtime and small footprint.

·Some degree of accuracy and skill in describing the problem, and it is quite simplified and easy to understand the operations.

·The model is built on the premise assumption that accurate results can be obtained in a small angle range, and the assumption conditions have some limitations.

5. Conclusions

Through the study, the paper first focuses on property owners and used SARIMA, expected losses, TOPSIS, risk level map and insurance premiums to measure the risks and hazards associated with extreme weather. Through SARIMA forecasts, the frequency of extreme weather is translated into economic quantifiers. Then visual data is used to determine the decision of whether or not an insurance company should underwrite one policy. Lastly, the paper gives property owners some practical suggestions surrounding pre-emptive prevention, loss mitigation and after-the-fact rectification to reduce their risk and upgrade their insurance. What's more, the paper also focuses on property developers. First, this study uses the entropy weight method and PCA to assign weights to the insurance underwriting index system of different regions, and applies the data to SVM. We help to give some practical suggestions for property developers' project development location surrounding environment, market, accessibility, infrastructure to ensure the self-interest of property insurance companies while providing a reference for the construction of real estate.

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