

Comprehensive Risk Assessment and Underwriting Investment Decision-Making Based on the EWM-TOPSIS Method

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Abstract. The escalating frequency of extreme weather events poses a critical challenge for both property owners and insurers. Not only is property insurance becoming more costly, but it is also increasingly difficult to obtain. This article discusses how the best construction of the property insurance system to solve the profit crisis of the insurance company, The first task is to evaluate the serious weather in the area. Through search for related documents, the article determines the five remarkable features that describe serious weather events (temperature, precipitation, carbon dioxide concentration, humidity, air pressure), and then establish a risk evaluation system. In response to these indicators, use the EWM-TOPSIS method to evaluate 20 regions. The results of the K-MEANS cluster analysis are used to divide these areas into three categories: high risk, medium risk and low risk. By calculating the mathematical expectation of the insurance profit, it is expected to determine whether the area is worth investing, and put forward insurance pricing strategies in different risk areas, and develop insurance pricing models in different risk areas. Finally, two regions that have undergone two major weather events on different continents (Toronto in Canada and Queensland in Australia) use models to prove the feasibility of investment. The article also proposes that insurance owners can take some measures to affect the decision -making of insurance. Overall, through this model, it can help determine the areas that are most suitable for investment.

Keywords: EWM-TOPSIS; Risk Assessment; Insurance Underwriting.

1. Introduction

Extreme weather events are a growing concern for many prosper owner and insures around the world. As a result of extreme weather events, people suffer huge economic losses^[1]. Premiums for insurance are rising rapidly, which is indicative of the current difficulties in the profitability of insurance companies and the affordability of insurance owners. In order to solve the profit crisis of the insurance company, it is important for us to evaluate the risk of underwriting in the region to determine the underwriting area. Scholars such as Gunasekera Don proposed the method of evaluating the risk of climate change and formulating policies, emphasizing the importance of the global comprehensive evaluation model. This model helps to formulate policies to respond to climate change more effectively^[2]. Scholars such as Hagen I used Peru, India, and Austria as cases in actual situations, and conducted empirical inspection of comprehensive climate risk assessment and management methods, and verified the feasibility of applying comprehensive risk assessment methods to the climate field^[3]. However, in the comprehensive risk assessment of the climate, no scholars have used Entropy Weight-Topsis methods. Based on previous studies, this article uses Entropy Weight-Topsis method to evaluate the regional climate. In terms of insurance contract decision-making, Kraehnert Kati and other summarized the advantages and limitations of three major types of insurance types in the three main insurance types^[4]. Tiga Neya and others took Mali as an example to explore the importance of disaster risk financing decisions in responding to climate change, and introduced a variety of insurance types and decision methods applicable to Mali^[5].

Although the insurance system in the climate is becoming more and more complete, decision -making is increasingly abundant. However, this article is different from traditional insurance decisions. Different insurance decisions are formulated according to different risk levels, so as to reduce the losses caused by risks more effectively and promote the sustainable development of the insurance industry. The article first assesses the risk levels of extreme weather in different regions^[6], then uses a regional investment decision model to determine investment feasibility, and finally selects different regions to validate the model^[7].

2. The establishment of a comprehensive risk assessment model

2.1. The system of risk assessment

Firstly, in order to address the profit crisis faced by insurance companies, an assessment of the severe weather conditions in the region is necessary. Through the examination of relevant literature, five prominent characteristics have been identified to describe severe weather events. (temperature, precipitation, CO2 concentration, humidity, air pressure).The Insurance risk assessment system is shown in the Figure 1.

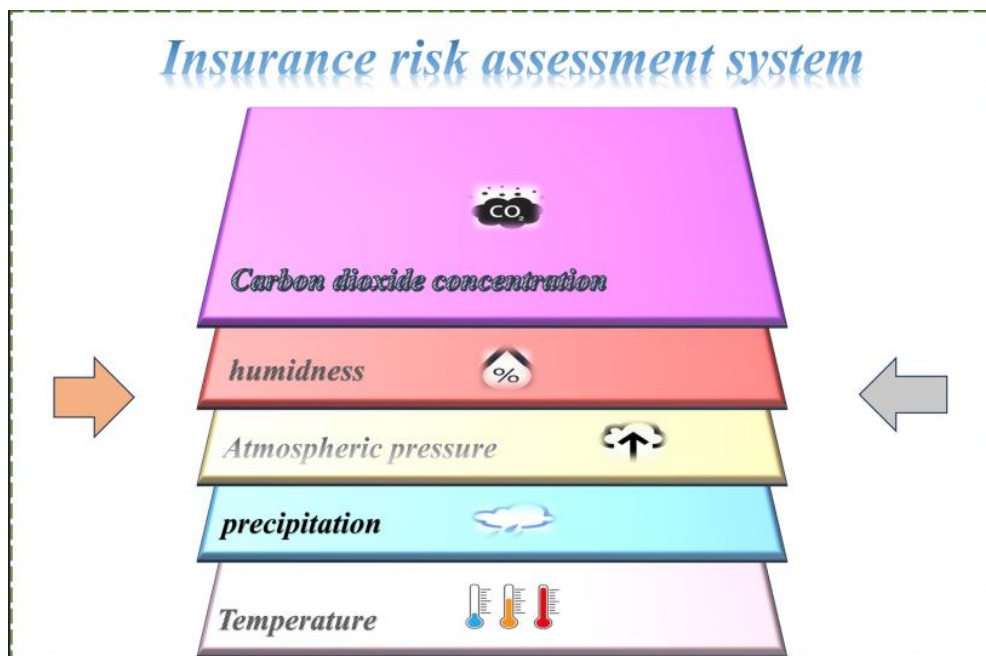


Figure 1. Insurance Risk Assessment System

2.2. The application of the Entropy Weight-Topsis method

A risk assessment system is established in this manner, as illustrated in Figure 1. Furthermore, utilizing the aforementioned five indicators, a total of 20 districts were randomly selected and evaluated by means of the Entropy Weight-Topsis method.

Using the Entropy Weight-Topsis method, rankings for twenty cities were obtained in the aforementioned section. To determine the risk level classification of the twenty cities, a cluster analysis was conducted on the dataset. Finally, the optimal clustering results, consisting of three distinct classes, were obtained using the elbow method. Consequently, with regards to district risk level classification, the designations of A, B, and C were utilized to indicate high risk, medium risk, and low risk, respectively^[8].

Upon analyzing the clustering results, it was determined that regions with high scores were classified as low-risk areas, while those with low scores were designated as high-risk areas. The final results are shown in the Figure 2. The scoring clusters converged around 0.46 for low-risk areas, 0.62 for medium-risk areas, and 0.87 for high-risk areas.

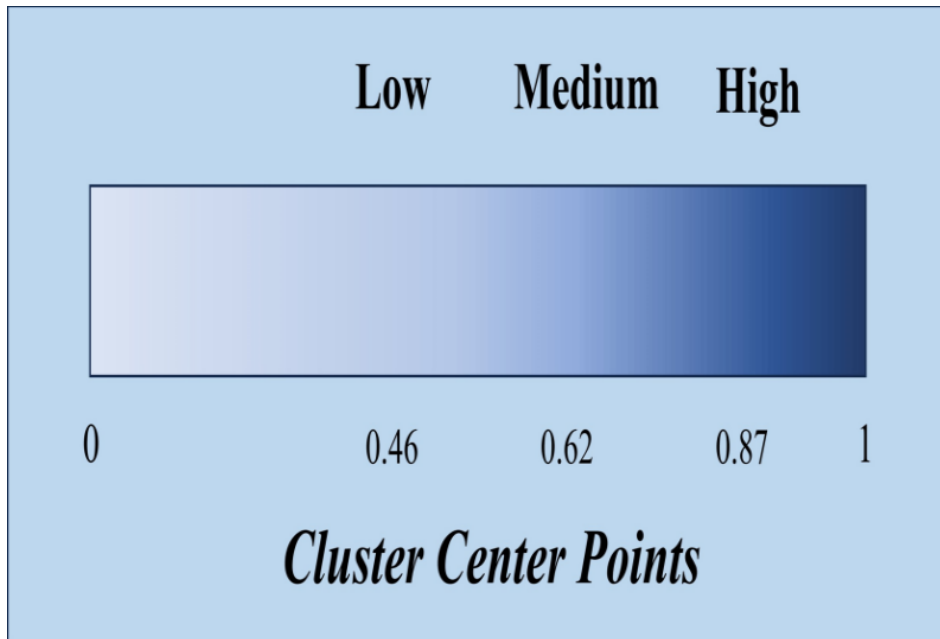


Figure 2. Cluster Center Point

Subsequently, with the clustering centroids in hand, a combined evaluation of the 20 districts was conducted using the Entropy Weight-Topsis method to assess their respective rankings. The results are shown in Table 1.

Table 1. Scoring After clustering

RRI	Ratio	RRI	Ratio
High level	0.8391	Mediate level	0.5485
Low level	0.4242	Mediate level	0.7129
High level	0.8232	Low level	0.4147
Low level	0.4651	Low level	0.4455
Low level	0.5161	Low level	0.473
Mediate level	0.5562	Low level	0.4735
Mediate level	0.6836	High level	0.8465
Mediate level	0.6459	High level	0.9579
Low level	0.5239	Mediate level	0.5778
Mediate level	0.5864	Low level	0.4037

2.3. Calculation of underwriting investment profits

In order to assess whether an area is worthy of investment in accordance with our policies, it is necessary to calculate the mathematical expectation in order to make a determination. List the probabilities and gain or loss values to find the mathematical expectation.

Table 2. Probability Distribution

<i>Probability</i>	<i>p</i>	<i>1-p</i>
<i>Consequences</i>	<i>q * t</i>	<i>M</i>

Based on the Table2, the profit expectation insurance model can be developed:

$$MIP = (1 - p) * M_i - p_i * q_i * t \quad (1)$$

- MIP represents profit expectations of insurance companies.
- M_i represents insurance pricing by insurers in different risk areas.
- p_i represents frequency of extreme weather in different risk areas.
- q_i represents average amount of money people lose in the event of an extreme weather event.
- t represents insurance premium rate. By reviewing the information, we know that the international insurance industry's insurance rates for high, medium and low risks are generally 15%, 10% and 5%.

It is deemed appropriate for an insurer to provide insurance coverage to a particular region when the profit expectation (W) exceeds 0. If the profit expectation (W) for a particular region is less than 0, the insurer is deemed to be uninsurable.

2.4. Insurance Pricing Strategies for Different Risk Areas

As previously explained, the international insurance industry typically applies premium rates of 15%, 10%, and 5% for high, medium, and low risk regions respectively, based on the varying levels of risk present. These differing premium rates are offered due to the recognition that risk levels vary between regions. Furthermore, upon investigating the pricing of extreme weather insurance in the global insurance industry, a sliding factor of 8% has been identified for adjusting pricing in accordance with varying risk levels in different areas. Consequently, insurance pricing has been formulated for distinct risk regions, resulting in figures of \$4,938.26, \$3,248.75, and \$3,540.76 respectively^[9].

2.5. Calculation of Probabilities for Different Risk Areas

Upon acquiring the clustering result diagram, targeted analysis can be conducted accordingly. The number of extreme weather events in various risk areas over the past decade was investigated, and the findings were depicted in Figure 3 for visualization purposes.

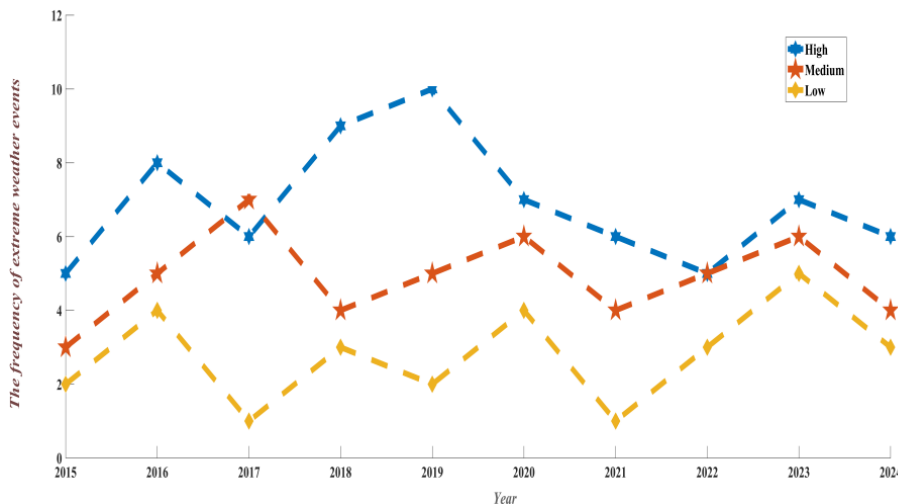


Figure 3. the Frequency of Extreme Weather Events

Subsequently, the probability of extreme weather occurring in diverse risk regions was computed using the following formula:

$$p_i = \frac{s_i}{d} \quad (2)$$

- s_i represents number of extreme weather events over the last decades.

- d represents days of the decades.
- p_i represents the probability of occurrence in different areas.

In this study, areas with a probability (p) greater than 0.01891 were classified as high-risk regions. Furthermore, regions with a probability falling between 0.01891 and 0.01342 were categorized as medium-risk areas, while those with a probability lower than 0.00767 were identified as low-risk regions.

2.6. Example of underwriting investment decision

Upon completing the establishment of the model, the initial demonstration was conducted by selecting two distinct areas on separate continents that have encountered extreme weather events. For the purpose of showcasing our model, Toronto in Canada and Queensland in Australia were chosen as the selected areas^[10].

- The risk resistance coefficient was determined via the Entropy Weight-Topsis method, revealing that Queensland possesses a coefficient of 0.3900, indicating it is a high-risk region. Conversely, Toronto exhibited a coefficient of 0.9518, categorizing it as a low-risk area.

- Through data analysis, it was observed that the insurance pricing for Queensland is determined as $M_Q = 4938.26$ RMB. Additionally, the probability of an extreme weather event transpiring in the Queensland region is denoted as $p_q = 0.1891$.

- It is noted that the pricing for insurance in Toronto is determined as $M_T = 3540.26$ RMB. Furthermore, the probability of an extreme weather event occurring in the Toronto region is denoted as $p_T = 0.00767$. Additionally, the evaluated losses for a single extreme weather event in the Toronto region were estimated to be $q = 164276.62$ RMB.

- Utilize the profit formula for calculating the insurance formula post-insurance profit:

$$MIP_Q = (1 - p_q) * M_Q - p_q * q * t \quad (3)$$

$$MIP_T = (1 - p_T) * M_T - p_T * q * t \quad (4)$$

Based on the presented insurance profit model, it can be concluded that both areas are viable options for investment. Therefore, this model can assist in determining the most suitable regions for investment purposes.

2.7. Behaviors that affect underwriting investment decisions

- Strengthen the disaster resistance of buildings.
- Participate in climate education and early warning systems.
- Comply with local building codes.

3. Conclusions

Extreme weather incidents are becoming a crisis of property owners and insurance companies. In recent years, losses caused by more than 1,000 extreme weather events around the world have reached more than \$ 1 trillion. In the insurance industry, the claims of natural disasters in 2022 increased by 115% over the 30 -year average. The primary focus of this article is to establish a comprehensive risk assessment model for evaluating regional risks, with the aim of informing underwriting investment decisions within the region. The article employs five evaluation indicators to construct a comprehensive risk assessment system, comprehensively applying the Entropy Weight-Topsis methods. Subsequently, clustering analysis is utilized to categorize the obtained results into three distinct risk levels. Through the calculation of mathematical expectations for underwriting investment

profits, investment decisions can be made based on a positive profitability criterion. Ultimately, we conducted a comparative analysis of two cities located on different continents worldwide, aiming to assess the viability of underwriting in each respective city. In some high-risk areas that are prone to extreme weather, through the research of this article, it is found that the insurance company can also obtain returns through reasonable formulation of insurance strategies, thereby promoting the sustainable development of the insurance industry.

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