Balancing Acts: Tradeoff among Insurance, Architecture and Community Resilience

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Abstract. Extreme weather events worldwide have led to substantial economic losses, prompting a crisis for property owners and insurers. This paper introduces the Available Profit of Insurance Model and the Architecture Conservation Model, aiming to reconcile insurer profitability with property owner affordability. First, the model is constructed, comprising the insurance rate and risk components, with specific formulas derived using methodologies such as the Black-Scholes model and gray prediction model. Then nine construction location types are identified and analyzed across various countries, revealing geographical location as a significant factor in insurer decision- making. Furthermore, fifteen secondary indicators are selected to establish the Architecture Conservation Model, aiding in recognizing and preserving architectural value. The model's accuracy is validated through application to a specific region, offering recommendations for protective measures. A sensitivity analysis is conducted on influencing factors, and the model's strengths, weaknesses, and suggestions for optimization are discussed. Finally, with the combination of above two models, Buenos Aires Metropolitan Cathedral goes down as a typical case with analytical value, and recommendations are provided to the community.

Keywords: Black-Scholes Model; EWM-TOPSIS model; Insurance Sustainability; Historical Architecture; Architecture Conservation Model

1. Introduction

As extreme weather has become more common in recent years, the frequency of various natural disaster events has increased dramatically. More and more property owners and insurers are facing potentially large financial losses. Today, property insurance premiums are rising and becoming more expensive; and fewer and fewer companies are willing to offer property insurance because the risks are too high. So there is a crisis of profitability for insurance companies and affordability for policyholders.

In order to effectively address the practical problems arising from the above and ensure the security of individuals and businesses' property, it is important to develop a widely applicable measurement model and discuss and analyze it.

Looking through the data, we can see that a lot of relevant research has been done around the world based on the above questions. 2018 He, YJ's team used a voting TOPSIS approach to

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investigate the priority determination problem for areas that have been damaged during disasters.

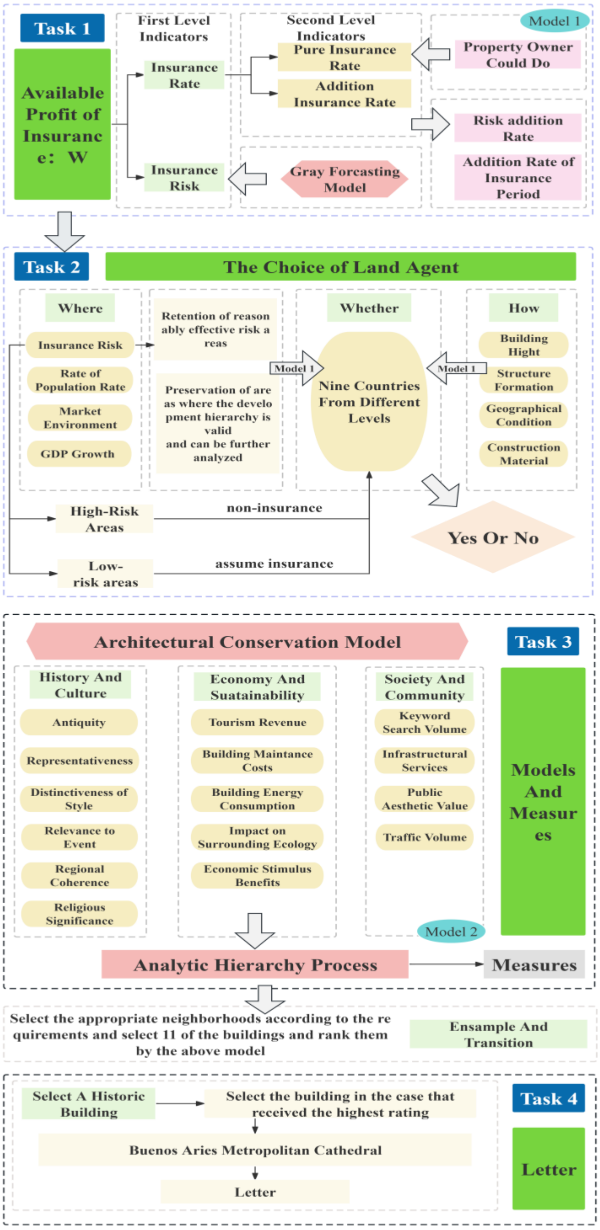

Fig. 1. Flow Chart of Our Work

The method is proved to be feasible by real cases. 2017 Lin, J proposed a risk-based approach to estimate the earthquake insurance rates of buildings. Examples of application of the approach to buildings located in Taipei city of Taiwan were examined. 2016 Sturm, M's team demonstrate a modified version of the Black-Scholes option pricing formula to evaluate strategic decisions in a rapidly changing climate. They demonstrate the method by examining the viability of building ice roads in the Northwest Territories of Canada, where a strong negative warming trend is underway, and applying it to the problem of the ongoing California drought, estimating expected water costs with and without storage.

In addition, there are other relevant research examples. Combined with the previous research results and through our efforts, we hope to fill the gap in this area.

The main focus and research proposes of this paper are as follows: Developing a model for insurance companies to determine if they should underwrite policies in an area that has a rising number of extreme weather events, making the insurance model be adapted to assess where, how, and whether to build on certain sites, developing a preservation model for community leaders to use to determine the extent of measures they should take to preserve buildings in their community, selecting a historical landmark and evaluating it by using insurance profit assessment models and architecture conservation models.

The specific steps of the study are shown in Figure 1.

2. Assumptions and Explanations

Considering those practical problems always contain many complex factors, accordingly, we need to make some reason- able assumptions to simplify the model, enables to make the model more accurate and clearer.

Assumption 1:

1) The data which we use are accurate and valid.

Explanation: The authenticity and reliability of the data is conducive to the output of the model being closer to real life and the conclusions obtained being more inline with real life.

2) Assumed that the mathematical indicators for each of the influencing factors are independent of each other. Explanation: The mathematical indices of the influencing factors are independent of each other facilitating the simplification and construction of the model, making the model structure clearer and easier to obtain reasonable output results.

3) A community under study is a whole unit, regardless of its intra-regional influence factors.

Explanation: The exclusion of influences within each community helps to guarantee the uniqueness of the relevant data used in the model, making the results comparable across communities and more reasonable.

3. Notations

Some important mathematical notations used in this paper are listed in Table 1.

Table 1notations Used in this Paper

Symbol	Description
W	Profit from insurance premiums
K1	The insurance premium rate
IA	The Insurance amount
K2	Insurance Risk
M	The amount of the subject matter
Q	Insurance pricing
Rate 1	Pure premium rate
Rate 2	Additional rate
NF	Non-catastrophic impact factor
NF1	The type of subject matter
NF2	The environment in which the subject matter is located
NF3	Local economic conditions
DF	Disaster impact factor
RR	Risk rider
AOSM	Current value of the subject matter
r	The annual risk-free rate of return
t	The option maturity in years
x	Extreme weather event indicator size
max(x)	Maximum value in the extreme weather event metrics
min(x)	Minimum value of the extreme weather event metrics
m	Number of extreme weather events
i	Serial number of the city
j	number of extreme weather events
β	Weight of each level 1 indicator
S	Historic Building Preservation Needs Score
ScoreHC	Secondary weighting index for History and Culture
ScoreES	Secondary weighting index for Economy and Sustainability
ScoreSC	Secondary weighting index for Society and Community

*There are some variables that are not listed here and will be discussed in detail in each section.

4. Model 1: Insurance Premium Profitability Model

The occurrence of extreme weather events can result in significant financial losses for property owners and insurance companies. The continued increase in extreme weather events in recent years has further created a significant challenge for property owners as well as insurance companies. As the world's climate continues to change, insurance companies need to balance profitability with risk in order to remain profitable while reducing the risk of huge premium expenses. Therefore, it needs to strike a balance between risk taking and underwriting volume to maximize profitability. Therefore, in order to solve the above problems this paper will construct a model of insurance premiums to obtain profit. By calculating the profit to determine whether underwriting a policy in a certain area can be profitable or not, so as to assist the insurance company to make decisions. In this paper, the factors affecting profit are divided into two parts: insurance premium rate and insurance risk, respectively. These two from two major aspects together cause the change of profit, so can be constructed insurance premiums to obtain the profit model formula is:

$$W = K_1 \times IA - K_2 \times M \quad (1)$$

4.1. Constructing a pricing model (Q)

First of all, the insurance pricing model is constructed to divide the insurance pricing into two parts: the insurance rate and the insurance amount, while the insurance amount is determined by the influence of the price of the subject matter, so it is not taken into account, then only the insurance rate as an influencing factor needs to be taken into account, while the insurance rate (K_1) is mainly determined by the pure insurance rate (Rate1) and the additional rate (Rate2). And there are many factors affecting the rider rate, including other factors such as the risk rider rate and the rate of influence of insurance years. For the sake of research, this paper will focus on analyzing the pure insurance premium rate, risk rider rate, and insurance life impact rate. [1]

The formula for the pricing model is:

$$Q = K_1 \times IA \quad (2)$$

Where:

IA represents the insurance amount

1) Pure Premium Rate (Rate1): The pure premium rate is the rate at which only the portion of the premium that covers the expected claimed loss is taken into account, to the exclusion of other costs and expenses. This rate expresses the percentage of costs to be paid to cover expected claim losses per unit of total sum assured. In pricing models, the pure premium rate provides insurers with a basis for reasonable premiums.

By looking through the literature we can derive a macro formula: the pure insurance premium rate (Rate1) is equal to the base rate (δ) multiplied by the non-catastrophe impact factor (Nf) multiplied by the respective catastrophe impact factor (Df).

Base rate (δ): this is a base rate that typically reflects the core cost of risk of the insurance product, i.e., the cost of covering expected claim losses. From a literature review we can get $\delta = 0.2$.[2]

Non-catastrophic impact factor (Nf): this is an adjustment factor introduced to take into account the impact of non- catastrophic factors on risk. This can include a range of factors such as the type of subject matter (Nf_1), the environment in which the subject matter is located (Nf_2), local economic conditions (Nf_3).

The specific values of the adjustment factors obtained from the literature and official data are shown in Table 2, Table 3 and Table 4.

Disaster impact factor (Df): Disaster impact factor (D-f): This is an adjustment factor introduced to take into account the impact of catastrophic factors on risk. Disaster impact factor (D-f) = disaster risk * disaster loss * disaster vulnerability * amplification factor. Where: per-hazard hazard * per-hazard loss * per-hazard vulnerability are available from the literature and are collectively referred to as per-hazard base rates. The values are shown in Table 4. [3]

By looking at the chart, we can see the disaster base rates corresponding to the eight types of disasters, such as

Table 2 Classification and Corresponding Factors

		Typology	Factor
Environment	**Geographical Conditions**	Mountain area	1.45
		Hill	1.15
		Plain	1.10
		City	0.80
	Moisture Degree	Soaking wet	1.25
		Humidity	1.00
		Relatively humid	0.90
		Not humid	0.85
	Geological Condition	Passing a landslide	1.25
		Karst	1.125
		Loess	1.125
		Coal measure	1.10
		Non-above mentioned geology	1.00

* Classification and Corresponding Factors 1

Table 3 Classification and Corresponding Factors

		Typology	Symbol
Building Style	**Structure Formation**	Brick hybrid structure	I
		Frame structure	II
		Frame-scissor wall construction	III
		Scissor wall construction	IV
		Frame-core structure	V
	Building Height	**Typology**	**Symbol**
		Ground floor	1
		Multi-storey	2
		Medium and high	3
		High-rise	4
		Extremely high	5

* Classification and Corresponding Factors 2

Table 4 Factors Corresponding to Different Factors

	I	II	III	IV	V
1	0.96	0.96	0.95	0.9	0.85
2	None	0.98	0.98	0.93	0.87
3	None	None	1.01	0.98	0.9
4	None	None	1.02	1.01	0.95
5	None	None	1.03	1.02	0.97

Table 5 Basic Rate By Disaster

Name	Basic Rate	Name	Basic Rate
Earthquake	1	Extreme Temperature	1
Flood	1.5	Volcanoes	1.2
Storm	1	Drought	1.3
Landslide	1.5	Wildfire	1.3

earthquakes, floods, storms, landslides, and so on, as shown in the Table 5.

In this paper, the amplification factor is set equal to the data predicted for 2025 divided by the average value of the previous 20 years' data. In the actual data processing process, we need to correct for the situation where the forecast data is zero and the average value of the previous 20 years of data is also zero. We can take the continent of the list where the data is located and add the average of the valid data in the extreme

weather types and then average them to obtain, i.e:

$$F = \frac{\bar{x}_{continent} + \bar{x}_{type}}{2} \tag{3}$$

For the prediction of 2025 data first the Gray Prediction Model is introduced. Gray forecasting is a method for predicting systems that contain uncertainty. [4] The initial non-negative data sequence $X^{(0)}$ is set out, and the first- order cumulative sequence of $x^{(0)}$ obtained by the cumulant operation can weaken the perturbation of $x^{(0)}$:

$$x_k^{(1)} = \sum_{i=1}^{k} x_i^{(0)}, k = 1,2,\cdots,n \tag{4}$$

$$Z^{(1)} = \left\{z^{(1)}(2), z^{(1)}(3), \cdots, z^{(1)}(n)\right\}$$

$$z^{(1)}(k) = \frac{1}{2}\left(x^{(1)}(k) + x^{(1)}(k-1)\right) \tag{5}$$

Next, the data matrix B and the data vector Y are constructed

$$B = \begin{bmatrix} -z(2) & 1 \\ -z(3) & 1 \\ \vdots & \vdots \\ -z(n) & 1 \end{bmatrix} \quad Y = \begin{pmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{pmatrix} \tag{6}$$

Then the column of least squares estimated parameters of the gray differential equation satisfies the following equation:

$$u = [\,a \quad b\,]^T = (B^T B)^{-1} B^T Y \tag{7}$$

Where:

• A mainly controls the development trend of the system, which is called the development coefficient; the size of B reflects the relationship between data changes, which is called the gray effect quantity.

Finally, the model is built and solved for the generated and reduced values. The predictive model is obtained by solving the equation.

$$x^{(1)}(k) = \left[x^{(0)}(1) - \frac{a}{b}\right] e^{-a(k-1)} + \frac{a}{b}, k = 1,2,\cdots,n \tag{8}$$

Reduced projections, which are cumulative, are the projections for 2025.

In summary:

$$Rate1 = \delta \times Nf_1 \times Nf_2 \times Nf_3 \times Df_1 \times Df_2 \times \ldots \times Df_j \tag{9}$$

Where:

• Dfj represents the j th extreme weather type impact factor

In the end, we can then get the pure insurance rate.

2) Risk Attachment Rates under Black-Scholes Option Based Modeling: A risk rider (RR) is a rate in the insurance industry that adjusts the standard premium to take into account the specific risk factors of the insured. Therefore, in order to achieve more personalized and accurate pricing, this paper decides to introduce and solve the risk rider in the pricing model. The Black-Scholes option pricing model [5] is a mathematical model used to estimate the price of European options. By applying the Black-Scholes option model, taking into account the market volatility, the change in the price of the asset, and other influencing factors, it enables us to calculate the insurance risk rider, so as to evaluate the pricing of insurance products more accurately, and further protect the maximization of insurance premium profits, the specific model is as follows:

$$\mathrm{C} = \mathrm{AOSM} \times \mathrm{N}(\mathrm{d}_1) - \mathrm{IA} \times \mathrm{e}^{-\mathrm{rt}} \times \mathrm{N}(\mathrm{d}_2) \tag{10}$$

Where:

• C stands for call option

• N(d1) represents the value of a function of the d1 normal distribution.

• N(d2) represents a function of the d2normal distribution.

$$\mathrm{P} = \mathrm{IA} \times \mathrm{e}^{-\mathrm{rt}} - \mathrm{AOSM} + \mathrm{C} \tag{11}$$

Where:

• P stands for put period

In property insurance, for the insurer believes that the subject matter of the insurance will incur a loss in the future, so in this paper put options are used. The d1 and d2 in Equation 17 and Equation 18 have the following relationship:

$$\mathrm{d}_1 = \frac{\ln\left(\frac{\mathrm{AOSM}}{\mathrm{IA}}\right) + \mathrm{t}\left(\mathrm{r} + \frac{\sigma^2}{2}\right)}{\sigma\sqrt{\mathrm{t}}} \tag{12}$$

$$\mathrm{d}_2 = \frac{\ln\left(\frac{\mathrm{AOSM}}{\mathrm{IA}}\right) + \mathrm{t}\left(\mathrm{r} - \frac{\sigma^2}{2}\right)}{\sigma\sqrt{\mathrm{t}}} = \mathrm{d}_1 - \sigma\sqrt{\mathrm{t}} \tag{13}$$

Where:

• σ represents the standard deviation of the annual com- pound rate of return of the corresponding asset of the contract

The ratio of the difference between the put option and the pure premium rate to the total premium rate is the risk rider.

$$RR = \frac{P - Rate1}{Rate1} \tag{14}$$

3) Years of Insurance Impact Rate: The age impact ratio is often used to examine the level of risk over different years of insurance. The risk to the insured may vary over the years of insurance, e.g. there may be a low risk in the short term, but then the risk increases over the years. Calculating the LIR helps to achieve more customized risk pricing, ensuring that future risks are taken into account and that premiums match the actual level of risk that may be incurred, thus further rationalizing the setting of premiums. In order to facilitate the calculation of the ALIR, we have broadly categorized the factors affecting the ALIR into three major components: operating costs, marketing costs and profits. [6]

Table 6 Years Of Insurance Impact Rate

Year	Year of Insurance Impact Rate
Year ≤ 1	0.80 %
1<Year≤ 3	1.00 %
3<Year≤ 5	1.15 %
Year>5	1.30 %

From the Table 6: Year of Insurance Impact Rate is 0.08 when the insurance period is less than or equal to one year; Year of Insurance Impact Rate is 1.0 when the insurance period is less than three years to one year; Year of Insurance Impact Rate is 1.15 when the insurance period is less than or equal to five years and greater than three years; Year of Insurance Impact Rate is 1.3 when the insurance period is greater than five years. Impact Rate is 1.15; when the insurance period is greater than five years, the Year of Insurance Impact Rate is 1.3.

4.2. Insurance Risk Composite Index Based on EWM and TOPSIS

1) Insurance Risk Assessment and Classification: In the insurance industry, the level of risk directly determines the profitability of insurance. Therefore, it is important to calculate and manage risk to ensure its profitability and long-term stability of operations. Insurance policies with higher risks may face more frequent or higher amounts of liability. This has a critical impact on the profitability of insurance companies. Therefore, in order to achieve sustainable profit income, insurance companies need to provide appropriate insurance services through risk management and premium pricing.

In order to find the insurance risk, we categorized the extreme weather. The number of occurrences of 8 different types of extreme weather and the number of deaths caused by each type of extreme weather was calculated for each of the 215 countries, as shown in the figure 2 and figure 3.

From the right panel of the map-heat map, we can see that the regions with higher frequency of extreme weather are mainly the eastern part of South America, the eastern part of Europe, the southern part of Asia, the northern part of Asia, and Oceania. Specifically, we can see that extreme weather occurs more frequently in China, India, Australia, Russia, the United States, and Brazil.

Similarly, on the left we can see that the regions with the highest number of deaths due to extreme weather are Eastern South America, Eastern Asia, Southern Asia, Northern Asia, Oceania, and Eastern Europe. Specifically, we can see that extreme weather kills more people in countries such as China, India, Russia, Australia, and Brazil.

By synthesizing all the extreme weather data from 1991 to 2022 for each continent, we can draw a line graph as shown

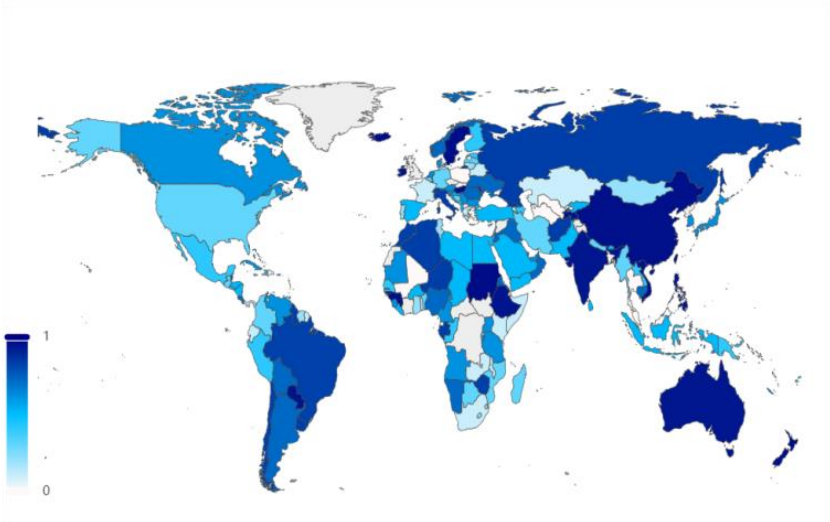

Fig. 2. Heatmap of Deaths Caused by Extreme Weather

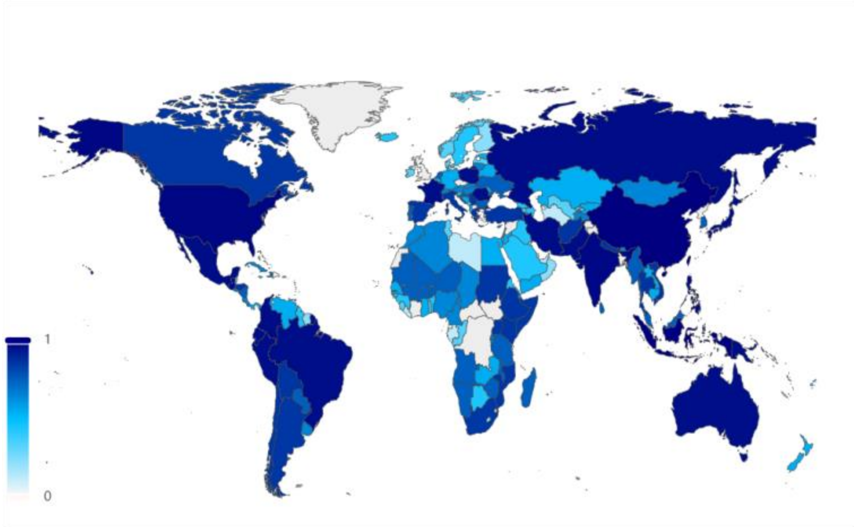

Fig. 3. Heat Map of Extreme Weather Frequency

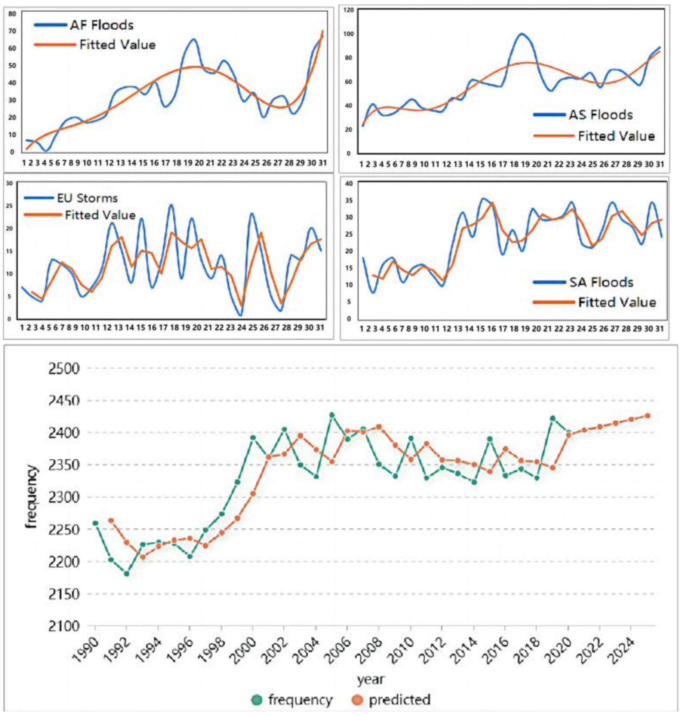

Fig. 4. Global Extreme Weather Data Harmonization Chart

in the Figure 4 to clearly reflect the trend of the frequency of extreme weather in the past 20 years. The purple line in the middle line graph represents the actual number of extreme weather occurrences in the world, and the orange line is the line graph after fitting the data with the LSTM-RNN model [7]. It can be clearly seen from the graph that the frequency of extreme weather has been increasing in the past 20 years. The upper left graph represents the curve of flood disaster data [8] in Africa over the past three decades, the blue line represents the actual data curve, and the red line represents the curve fitted to the actual data. Ditto for the rest of the charts. A visualization of the four graphs shows that the frequency of extreme weather events has been increasing on all continents over the past 30 years.

2) EWM-Based Weighting of Indicators: In order to accurately calculate the insurance risk and ensure that insurance companies are able to maintain profitability while providing insurance services, we need to keep statistics on the frequency of the eight extreme weather hazards occurring in various regions. The weights of the indicators are obtained through the EWM model.

The weight of each indicator in the EWM calculation is determined by its information entropy, which reflects the degree of variability of the indicator. The higher the information entropy, the more significant the index is in the evaluation. Therefore, in the calculation of the risk composite index, using EWM to determine the weight of each indicator is an objective method. After pre-processing the data, we obtained data for 215 countries for the last twenty-four years. Immediately after that, we standardized the data:

As a first step, we need to positively and negatively normalize the indicators.

$$x' = \frac{x - min(x)}{max(x) - min(x)} x'' = \frac{max(x) - x}{max(x) - min(x)} \quad (15)$$

In the second step, after the data has been processed, we proceed to solve the information entropy of each indicator by the following formula.

$$p_{ij} = \frac{x'ij}{\sum_{j=1}^{m} x'_{ij}} \quad (16)$$

$$e_j = -\frac{1}{ln\ m} \sum_{i=1}^{m} p_{ij}\ ln\ p_{ij} \quad (17)$$

Where: x'_{ij} represents size of the indicator for the j th

extreme weather event for the ith city; p'_{ij} represents ratio of

the indicator size of the j th extreme weather event for the i th city under each scenario; e_j represents information entropy of the indicator for the j th extreme weather event

In the third step, based on the information quotient of each indicator solved in the second step, we can find the weight of each indicator.

$$w_j = \frac{1 - e_j}{m - \sum_{j=1}^{m} e_j} \quad (18)$$

From this we can then obtain the weights of the indicators.

3) Calculation of Probability Composite Score Based on TOPSIS Model: The TOPSIS model is a multi-criteria decision analysis method for evaluating and ranking alternatives. [9] Its strength lies in its ability to handle multi-criteria decision problems and provide clear ranking results. Thus, using the TOPSIS model we can convert the frequency of different extreme weather hazards occurring in various regions into the form of a composite score and ultimately an insurance risk index.

Using the weights W_{ij} of each indicator solved by the EWM above, the composite score of each indicator can be finally calculated. A higher composite score represents a higher probability of occurrence of each extreme weather in the region.

In the first step, the normative decision matrix is obtained by normalizing the vectors.

$$B = (b_{ij})_{m \times n} \quad (19)$$

Then the weighted normative matrix is constructed.

$$z = (z_{ij})_{m \times n} = z_{ij} = w_{ij} \times b_{ij} \quad (20)$$

Where: m represents the ordinal number of the city, n represents the ordinal number of the extreme weather event, b_{ij} stands for the decision matrix representing the normalized decision matrix, $(z_{ij})_{m \times n}$ with z_{ij} stands for the weighted normalized matrix, and W_{ij} stands for the weight of the jth extreme weather indicator for the ith city.

In the second step, after normalization and orthogonalization, we can solve for the positive ideal solution (optimal solution) using the weighted norm matrix.

$$z^{+} = (\max\{z_{11}, z_{21}, \cdots, z_{i1}\}, \max\{z_{12}, z_{22}, \cdots, z_{i2}\}, \cdots \max\{z_{1j}, z_{2j}, \cdots, z_{ij}\}) = (z_1^{+}, z_2^{+}, \cdots, z_j^{+}) \quad (21)$$

Similarly, the negative ideal solution (worst solution) is:

$$z^{-} = (\min\{z_{11}, z_{21}, \cdots, z_{i1}\}, \min\{z_{12}, z_{22}, \cdots, z_{i2}\}, \cdots \min\{z_{1j}, z_{2j}, \cdots, z_{ij}\}) = (z_1^{-}, z_2^{-}, \cdots, z_j^{-}) \quad (22)$$

Where: $max(z_{1j}, z_{2j}, \cdots, z_{ij}$) represents the maximum value in $z_{1j}, z_{2j}, \cdots, z_{ij}$, $min(z_{1j}, z_{2j}, \cdots, z_{ij})$ represents the minimum value in $z_{1j}, z_{2j}, \cdots, z_{ij}$,$z_j^{+}$ represents a positive ideal solution, and z_j^{-} represent a negative ideal solution.

In the fourth step, using the results of the previous step we can then calculate the distance from each city to the positive ideal solution.

$$D_i^{+} = \sqrt{\sum_{j=1}^{n} \left(z_{ij} - z_j^{+}\right)^2} \quad (23)$$

Similarly, the distance between each city to the negative ideal solution is:

$$D_i^{-} = \sqrt{\sum_{j=1}^{n} \left(z_{ij} - z_j^{-}\right)^2} \quad (24)$$

Where: D_i^{+} represents the distance between the city and

the positive ideal solution, and D_i^{-} represents the distance between the city and the negative ideal solution.

In the fifth step, using the positive and negative ideal solutions, we can then calculate the relative proximity of each city to the ideal solution - i.e. the composite score

$$C_i = \frac{D_i^{-}}{D_i^{-} + D_i^{+}} \quad (25)$$

Where: D_i^{-} the larger C_1 the closer to 1, the higher the composite score, the higher the risk and the lower the safety.

In the sixth step, similarly, we can find the relative proximity (composite score) of the casualty scenarios caused by the eight weather types in 215 countries.

Combining the two composite scores and sorting them from largest to smallest yields the following Table 7. (top five) (bottom five)

Table 7 Top 5 Countries in Terms of Overall Rating

Country	Comprehensive score of death toll	Comprehensive score of frequency	Overall score	Rank
China	8.82×10^{-2}	5.21×10^{-1}	6.09×10^{-1}	2

Indonesia	2.37×10^{-4}	5.07×10^{-1}	5.07×10^{-1}	3
USA	5.93×10^{-5}	4.56×10^{-1}	4.56×10^{-1}	4
India	2.84×10^{-2}	3.82×10^{-1}	4.11×10^{-1}	5

From the chart above, columns 2, 3, and 4 represent the composite score for deaths, the composite score for extreme weather outbreaks, and the overall composite score weighted by both. According to the ranking, the top 5 countries with the highest overall composite scores are Solomon Islands, China, Indonesia, United States of America, and India, which means that these are risky areas and insurers need to consider their business carefully.

Table 8 Countries In The Bottom 5 Of The Composite Rating

Country	Comprehensive score of death toll	Comprehensive score of frequency	Overall score	Rank
Saint Martin (French part)	4.38×10^{-6}	6.3×10^{-4}	6.34×10^{-6}	215
Sint Maarten (Dutch part)	1.47×10^{-4}	6.29×10^{-4}	7.77×10^{-4}	214
Bermuda	2.96×10^{-4}	6.3×10^{-4}	9.26×10^{-4}	213
Sao Tome and Principe	7.02×10^{-5}	9.77×10^{-4}	1.05×10^{-3}	212
Niue	1.75×10^{-5}	1.26×10^{-3}	1.27×10^{-3}	211

Similarly, as in table 8 the five countries with the lowest risk of extreme weather in the world are Saint Martin (French part), Sint Maarten (Dutch part), Bermuda, Sao Tome and Principe,

Niue. Therefore, these areas are less risky for insurance and insurance companies can properly consider insurance business.

Based on the total composite score obtained above and the ratio of the number of extreme weather disasters to the number of days in a year for the countries with the highest number of extreme weather disasters in 2022, the total composite score obtained and the insurance riskiness are converted into the probability of extreme weather disasters, i.e., the insurance risk.

4.3. Conclusion

Based on the construction of **the above model** and the analysis of **the problem**, we can get the following conclusions.

◊ Arranging subject matter insurance based on profit modeling. By arranging subject matter insurance in areas where profits are predicted to be greater than zero through profit modeling, risk is effectively reduced. Flexibility to cover the cost of future claims also ensures the long-term health of the insurer.

◊ According to the profit model, the future profit of a region is predicted, if the profit is greater than zero, then the policy can be written in the region, if the profit is less than zero, then the policy can not be written. The balance between the number of customers and the risk is maintained by the selection of regions.

◊ Based on the above we can see that there are many factors that affect the profit model. In order to make the insurance company willing to underwrite the policy, the factors that the customer can change are mainly non-catastrophic influences. Specifically, customers can change the type of subject matter and the environment in which the subject matter is located, which in turn reduces the risk and improves the safety, thus successfully insuring the policy.

◊ Based on the above we can see that there are many factors that affect the profit model. In order to make the insurance company willing to underwrite the policy, the factors that the customer can change are mainly non-catastrophic influences. Specifically, customers can change the type of subject matter and the environment in which the subject matter is located, which in turn reduces the risk and improves the safety, thus successfully insuring the policy.

◊ Based on the above model, this paper selects two regions on two different continents where the frequency of extreme weather is increasing, Papua New Guinea and Malta. Collect their data and bring them into the model to get the following figure 5 and figure 6 and Table 9:

By visualizing the data, we can get the two graphs above. The chart on the left shows the data for Papua New Guinea and the chart on the right shows the data for Malta. The horizontal coordinate of the chart represents the year of the data for the last 30 years and the vertical coordinate of the chart represents the number of occurrences. From this we can clearly see that Papua New Guinea has had some volatility in the occurrence of extreme weather hazards over time but the overall trend is slowly increasing. Malta, which has never experienced extreme weather events in the last two decades, has seen a significant

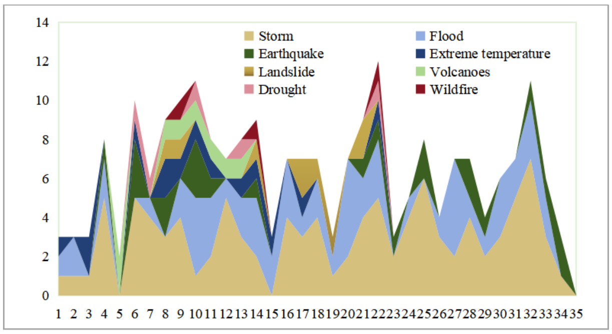

Fig. 5. Frequency of extreme weather in Papua New Guinea

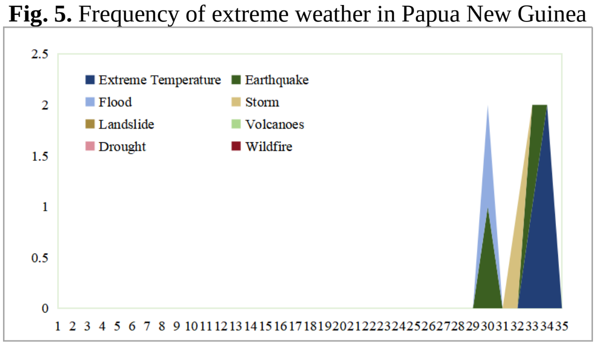

Fig. 6. Frequency of extreme weather in Malta

increase in the frequency of extreme weather events in recent years.

Table 9 Global Extreme Weather Data Harmonization Chart

country	Moisture degree	Geographic Condition	Drought Amplification Factor	Earthquake Amplification Factor
PNG	1.45	1.25	1.28	1.16
Malta	1.15	1.25	1.07	0.95
country	Volcanoes Amplification Factor	Flood Amplification Factor	Storm Amplification Factor	Landslides Amplification Factor
PNG	1.23	1.52	1.29	1.79
Malta	0.95	1.31	1.08	1.58
country	Wildfire Amplification Factor	Extreme Temperature	Addition Insurance Rate	Pure Insurance Rate
PNG	1.18	1.48	2.50 %	1.70 %
Malta	0.97	1.27	2.17 %	0.34 %
country	Insurance Rate	Insurance Risk	Profit	Yes Or No
PNG	4.20 %	12.99 %	<0	No
Malta	2.51 %	0.60 %	>0	Yes

[1] PNG refers to Papua New Guinea.

Insurers should choose to write their policies in Malta, specific data are shown in the Table 9 above.

5. The Choice of Community Agent

5.1. Adding New Indicators

As the frequency of extreme weather events continues to rise globally, the insurance industry is facing increasingly challenging times as fewer and fewer property insurance policies are being written to the community. For real estate developers, decisions about whether, where and how to proceed with real estate development are becoming particularly important. They need to ensure that real estate assets are sufficiently resilient to risk, while at the same time providing essential services to the community and population. By analyzing and solving the first question, we have developed a comprehensive model of insurance profitability. We can now use this model, in conjunction with variables such as the geography of the real estate location and the method of construction, to predict whether or not insurance profits will be positive, and thus whether or not it is appropriate to build real estate in a specific area.

This paper first addresses the question of where to build the house. The following four factors are considered in the selection of the geographic location of housing construction: insurance risk, population growth rate, insurance market environment, and GDP growth rate. For insurance risk, this paper will be categorized into five tiers, which are: low risk, lower risk, medium risk, higher risk, and high risk, for countries in the low-risk region, we will consider no other factors and consider that we can directly assume the policy; for countries in the high-risk region, we will consider that we can not assume the policy; and for the other three tiers, we will further consider the population growth rate of the country, insurance market environment, GDP growth rate of these three indicators, through the collection of data from literature and official websites [10], we can summa- rize the above three indicators into one general indicator of sustainable development prospects, and tiering sustainable development prospects into five categories, which are: low development prospects, lower development prospects, medium development prospects, higher development prospects, and high development prospects. And for these five categories of tiers, we believe that insurers do not choose to underwrite policies in regions with low development prospects and lower development prospects.

5.2. Selection of Countries for Judgement

After assuming a 5 year insurance period, the data is taken into the profit model to obtain specific calculated values for the catastrophic impact factor, the non-catastrophic impact factor, the pure premium rate, the risk rider, the premium rate, and the insurance risk vs. profit for the two regions. When comparing these specific values, it is obvious to conclude that between Papua New Guinea and Malta, the two continents with the increasing frequency of extreme weather events,

Through the above division of regions, the countries in the remaining tiers can be divided into nine categories, and in order to make the final results referable, this paper will randomly select a country in each category as an example to judge, as shown in the following Table 10:

After determining nine specific countries, combined with the specific location of each country, the geographic environment, the possible form of housing structure, the possible height of the house, the possible construction materials and the local

Table 10 Nine Types Of Countries

	Medium Risk (Prospect)	Relatively High Risk (Prospect)	High Risk (Prospect)
Relatively High Risk (Insurance)	Greece	Ecuador	Guatalama
Medium Risk (Insurance)	Croatia	Nigeria	Algeria
Relatively Low Risk (Insurance)	Egypt	Qatar	Iraq

economic situation and other data, will be brought into the first question of the model, that is, Model 1, can be obtained in each country’s insurance rates and insurance risk, and finally through the formula judgment can be known whether to establish the insurance in the area of its specific results are shown in the figure 7.

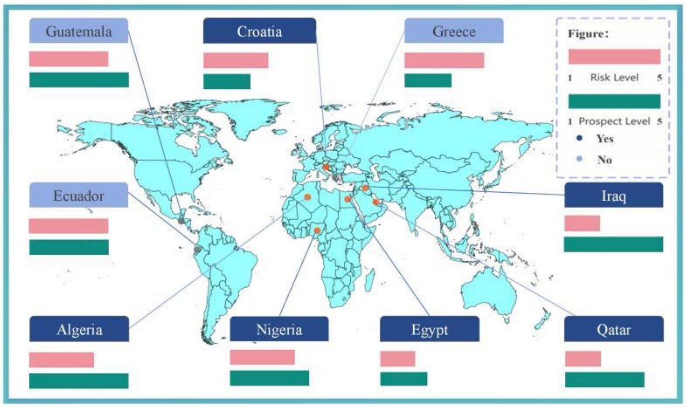

Fig. 7. Possibility of Building Insurance Outcome Maps in Nine Countries

As can be seen from the above figure 7, the house style cannot have a significant impact on the model compared to the frequency of extreme weather in the area, and therefore cannot influence the outcome of whether or not to establish insurance in the area by adjusting the house style. In addition, the above figure 7 shows that three countries are located in areas that are not suitable for insurance: Greece, Ecuador, and Guatemala, and six countries are located in areas that are suitable for insurance: Croatia, Nigeria, Algeria, Egypt, Iraq, and Qatar.

6. Model 2: Historic Architecture Preservation Model

Certain properties of cultural or community significance may be in a regional property insurance policy that the insur- ance model suggests not to cover, so this could potentially lead to community leaders being faced with the difficult question of what level of preservation measures should be taken for such properties to be effectively decided. Therefore, this paper begins by constructing a building preservation model to help community leaders identify whether a building is a building that should be preserved and, based on the model, determine the preservation measures that need to be taken. [11]

6.1. Building Preservation Model

First of all, according to the data we have collected, official related indicators and the literature we have reviewed, we can categorize the main influencing indicators affecting the architectural conservation model into three dimensions, and take these three dimensions as the first level indicator system, while each of these dimensions contains a number of second level indicators, and the specific set of influencing factors is shown in the figure 8.

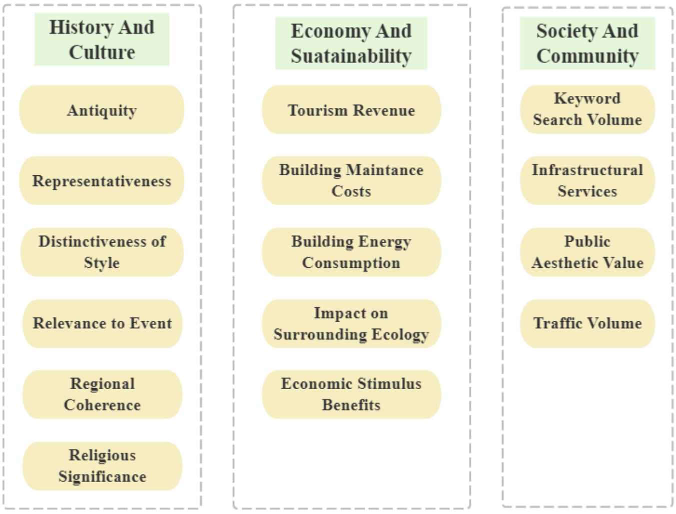

Fig. 8. Setting-Specific Impact Factor Charts

In this paper, we will combine Models 1 and 2 to select the region that meets the requirements of the topic, which is: Buenos Aires, Argentina.

1) Historical and Cultural Indicators:

◊ 1. Historical Significance

The year of existence of a building and the historical heritage category it belongs to are extremely important to whether it has significant conservation value, the older it is and the more precious the heritage category it belongs to, the more the building needs to be protected. In the text, according to the different types of different buildings and the category of cultural relics represented by the classification of determination, based on professional literature can be obtained from Representativeness (REP), Antiquity (ANT) of the weight indicators.

◊ 2. Cultural Significance

The particularity of the architectural style can have a certain impact on the formation of the local culture, and whether or not there is an event in history related to the establishment of the building can also promote to a certain extent the dissemination of the culture embodied in the building in the local area. Whether or not the building is in harmony with its environment and whether or not it is related to the local religious culture also affects the degree of the building's popularity in the local community and the degree of people's willingness to protect it. Therefore, the cultural significance

of the building can be split into four secondary indicators for evaluation.

2) Economic and Development Indicators:

◊ 1. Economic consumption Historic buildings, due to the special nature of their construction years, will cause their maintenance costs to increase exponentially with the age and style of the building, so it is very important to measure the economic consumption of the building for the community, which is divided into the following two aspects: building maintenance costs, building energy consumption.

◊ 2. Economic Development Things have two sides

Although historical buildings will bring certain economic consumption, but at the same time will also bring corresponding economic development, that is, due to its important ornamental value and historical and cultural value, thus generating an economic driving effect, and people's field appreciation will bring considerable economic income for the community.

◊ 3. Impact on the surrounding ecology

The impact on the surrounding ecology needs to be considered in a dual way, i.e. historic buildings may be beneficial to the development of the surrounding ecology because of their good integration and high degree of compatibility with the surrounding environment, or they may be detrimental to the development of the surrounding ecology because of their low degree of integration and high degree of dilapidation.

3) Social and Livelihood Indicate:

◊ 1. Functions of Historic Buildings to Safeguard the Society

The economic consumption of historic buildings is mainly in two parts, namely, the cost of future maintenance and the cost of energy consumption to maintain the operation of the building, which can be reduced to a certain extent according to the degree of construction of local basic services, so if the community's ability to provide basic services is good, the economic consumption can be effectively reduced, so that the community's willingness to conserve the historic buildings will be greatly enhanced.

◊ 2. Public aesthetic value

If a historic building has a high public aesthetic value, it will generate a greater willingness of the community to protect it, which has an indispensable influence on whether the historic building should be protected.

◊ 3. Popularity Depending on the [12], the degree of people's favoritism can be evaluated by the following two indicators:

the number of keyword searches, the number of people visits.

6.2. Quantitative Outcome of Historic Architecture Preservation

As our first-level indicator system is divided into three dimensions: historical and cultural indicators, economic and development indicators, social and livelihood indicate. We ap- ply the judgment matrix constructed by experts in the literature into the AHP model to each of these three dimensions and objectively obtain the weights of each secondary indicator, which are shown in the table 11 below.

Table 11 Table of Specific Weights for Secondary Indicators

Object	Indicators	Description	Weight
History and	ANT	Antiquity	0.22
	REP	Representativeness	0.17

Culture(HC)	DIS	Distinctiveness of Style	0.19
	RTE	Relevance to Events	0.18
	RC	Regional Coherence	0.09
	RS	Religious Significance	0.15
Economy and Sustainability(ES)	TR	Tourism Revenue	0.32
	BMC	Building Maintenance Costs	0.21
	BEC	Building Energy Consumption	0.11
	IOSE	Impact on Surrounding Ecology	0.09
	ESB	Economic Stimulus Benefits	0.27
Society and Community(SC)	KSV	Keyword Search Volume	0.18
	IS	Infrastructural Services	0.26
	PAV	Public Aesthetic Value	0.31
	TV	Traffic Volume	0.25

In order to assign values to the weights of these three first-level indicators and obtain the final value of the need for historic building preservation, we continue to use the hierarchical analysis method (AHP) to construct a judgment matrix to determine the weights of each first-level indicator.

$$\beta = (0.4396, 0.3470, 0.2134) \tag{26}$$

Where the consistency ratio of the judgement matrix=0.009, passed the consistency test of the model.

The final Historic Building Preservation Needs Score was calculated as follows.

$$S = \beta_{HC} \cdot \text{ Score }_{HC} + \beta_{ES} \cdot \text{ Score }_{ES} + \beta_{SC} \cdot \text{ Score }_{SC} \tag{27}$$

In this paper, Buenos Aires, Argentina is chosen as an example of a region where eleven buildings are selected and their specific data are brought into the model to determine whether they need to be preserved or not, as well as to prioritize their preservation, with the following results:

6.3. Protective Measures

According to the table above, the conservation priority of the eleven selected buildings is known, and the three buildings, Buenos Aires Metropolitan Cathedral, The Alberto José Armando Stadium and El Ateneo Grand Splendid, should be actively protected by restoration measures, and the need for restoration should be judged at regular intervals. For the Buenos Aires Metropolitan Cathedral, The Alberto José Armando Stadium and El Ateneo Grand Splendid, active conservation and restoration measures should be taken to strengthen the structure and to determine at regular intervals the need for restoration, as well as to establish appropriate green buffer zones in the context of the environment and to regulate the relationship between the building and nature.

In the case of the Floralis Genérica and The Mafalda Monument, consideration should be given to relocating the building away from hazardous areas so that it can be effectively protected.

7. Sensitivity Analysis

We perform sensitivity analysis on the profit model. In order to determine the impact of the four factors in the profit model, namely the number of years of insurance, the basic rate, the annual risk-free rate of return and the standard deviation of the annual compound rate of return. we will take the nine countries identified in Problem 2 as an example, and apply the control variable method to change the value of individual factors and observe the sensitivity of the model, so as to determine whether the model is stable or not, as shown in the figure 9,10,11,12 below:

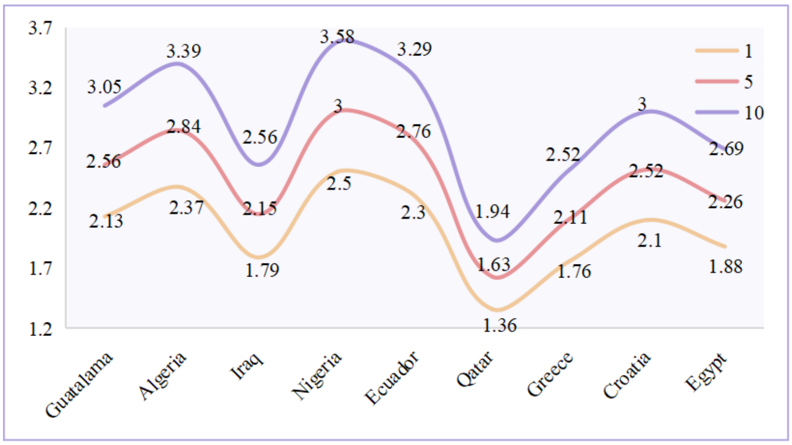

Fig. 9. Insurance Period

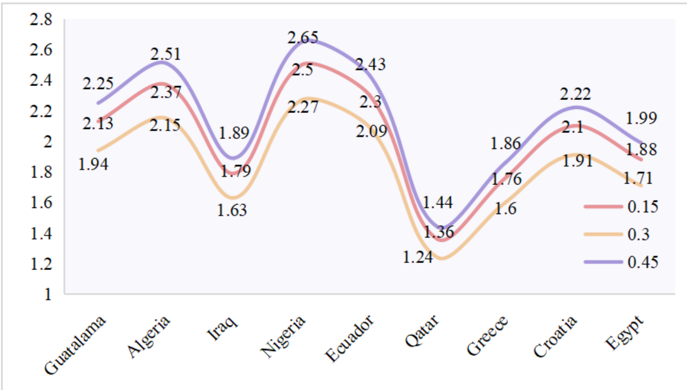

Fig. 10. Statistics Standard

From the above four graphs, it is easy to see that the four main influencing factors have a certain degree of influence on the final value of the model, so the model is stable and sensitivity.

8. Empirical Application

The protection model derived from the Q3 reveals the estimated rankings of these buildings in the city of Buenos Aires. For the eleventh-ranked the Puente de la Mujer, its value can be approximately estimated using the Net Present Value method based on construction costs. Costing about US 6 million, the bridge was manufactured by the Urssa steel fabrication conglomerate in the city of Vitoria-Gasteiz in the Basque Country of northern Spain, without considering currency fluctuations, its current value, calculated at a 5% annual

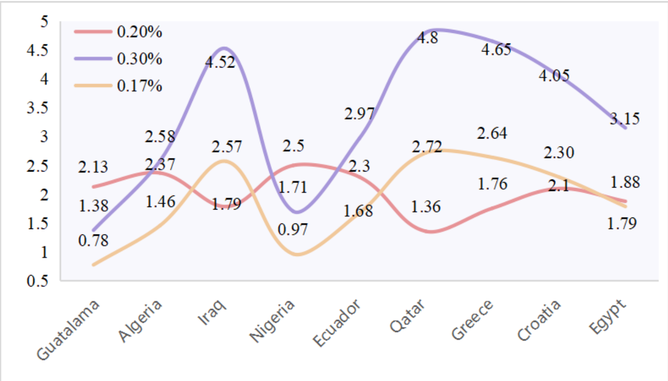

Fig. 11. Base Rate

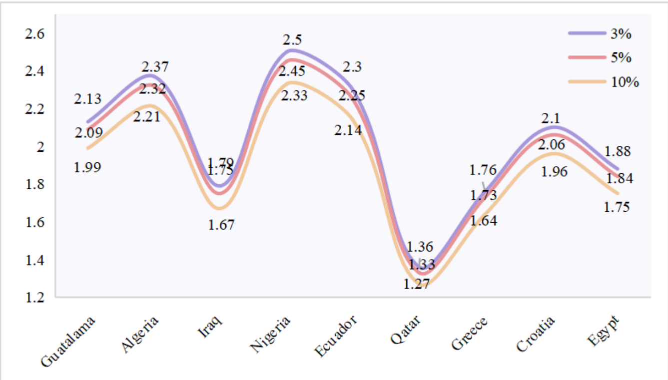

Fig. 12. Annual Risk-Free Rate of Return

interest rate, is approximately 21.33 million. However, for higher-ranked buildings, their additional significant historical and cultural value makes them priceless.

Nevertheless, according to the globally predicted model of disaster frequency constructed earlier, it is evident that the number of extreme weather events in Argentina will increase annually. The frequent occurrence of El Niño weather patterns in recent years substantiates this conclusion. Moreover, due to the rise in disaster frequency, insurance risks also escalate, far exceeding insurance premium rates. This poses a challenge for insurance companies to provide satisfactory coverage for these buildings, despite the strong willingness of building authorities in Buenos Aires to participate in insurance programs.

Taking Buenos Aires Metropolitan Cathedral as an example, a comprehensive protection plan is essential to ensure the preservation of this century-old structure in the face of increasingly frequent extreme weather conditions. The following outlines a protection plan which could be provided to the local authority, along with specific measures, timelines and Cost Proposal:

Protection proposal: 1. Structural Assessment: - Conduct a thorough structural assessment of the cathedral to identify vulnerabilities 2. Retrofitting and Reinforcement: - Implement retrofitting measures to strengthen the cathedral's structural integrity and enhance its resilience to potential hazards. 3. Disaster Preparedness and Emergency Response: - Conduct

regular training sessions for cathedral staff on emergency response protocols. 4. Collaboration with Stakeholders: - Foster collaboration with local authorities, heritage preservation organizations, and relevant stakeholders to ensure coordinated efforts in protecting the cathedral.

Timeline:

03/2024 - 09/2024 Step 1: Initiate the assessment to ensure timely identification of risks.

09/2024 - 09/2026 Step 2: Begin retrofitting work completing the structural assessment.

09/2025 - 09/2025 Step 3: Conduct training sessions periodically.

09/2026 -09/2027 Step 4: Formulate collaborative partnerships immediately.

Cost Proposal: Step1: Allocate funds for hiring qualified structural engineers and conducting necessary tests. Step2: Budget for materials, labor, and equipment required for retrofitting. Step3: Allocate funds for training programs and emergency supplies. Step4: Budget for administrative expenses and coordination efforts.

9. Strengths and Weaknesses

9.1. Strengths

⋆ To ensure the reliability of the results, the data used in this paper are the most accurate and up-to-date data available on the official website. In addition, various factors have been considered in an attempt to synthesize the problem. Therefore, the results of this paper are of a high reference value.

⋆ Our combination of many different influences makes our modeling of profits and protections more comprehensive and accurate.

⋆ The results calculated by our model are in line with reality and experience.

9.2. Weaknesses

▽ Due to the specificity and complexity of the data, some of the data collected in this paper are not sufficiently complete to obtain all the data for the required indicators, and may therefore affect the results to a certain extent.

▽ In order to simplify the model, we rounded off some of the influencing factors, which may lead to a certain error between the model calculation results and the actual situation.

9.3. Further Discussion

We can continue to collect data in the follow-up and gradually improve the dataset, so that the data of the model is more accurate and the output results are more credible.

10. Conclusion

In this paper, we consider the economic loss of the insurance industry due to the yearly increase in the number of extreme weather events from the perspective of insurance companies. First of all, in order to strike a balance between the profitability of insurance companies and the affordability of property owners, so that insurance companies can maximize their profitability, this paper designs a more emerging model architecture.

based on the collected data and related literature, and combines the EWM-TOPSIS model, the Black-Scholes option pricing model, the LSTM prediction model and other related models, which can help insurance companies to determine the areas in which they should take on property insurance, enabling the protection of the property insurance industry to continue to grow well and be more resilient in paying future claim costs. In order to verify the practicality of the model, Papua New Guinea and Malta, which experience extreme weather events on different continents, are selected to demonstrate our model, and from the final results, we can see that we choose not to insure in Papua New Guinea, while we choose to insure in Malta.

To validate the practicality of the model, this study selects countries experiencing frequent extreme weather events across different continents as empirical research subjects. The results indicate that both Papua New Guinea and Malta have relatively high disaster risk indicators. However, due to the differences of building vulnerability, specific environmental conditions etc., we ultimately decide not to insure in Papua New Guinea, while opting for insurance coverage in Malta.

However, there are exceptions to the rule, and a region's economic stability or growth should not be at the expense of protecting its cultural, historical, social, and other tangible assets. In some regions, buildings that are not suitable for property insurance may need to be preserved due to their economic and cultural significance, so this paper will develop a preservation model to help the local government determine whether and to what extent the building needs to be pre- served. In conjunction with the previous global catastrophe prediction, Argentina's performance results in the model are striking, which means that Argentina has a greater likelihood of experiencing extreme weather in the future. Therefore, this paper utilizes conservation modeling to quantitatively analyze important buildings in its capital city, selecting the Catedral Metropolitana de Buenos Aires as the focus of the study, and while concluding that it should be fully protected, it proposes a plan, timeline, and cost proposal for the local authority to help readers better understand it.

In conclusion, it is hoped that by quantifying information about the insurance industry and the real estate industry, this paper will help the industry to grow and the global economy to become more prosperous and stable.

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