ISSN 2616-5872 Vol.8, Issue 1: 32-39, DOI: 10.25236/AJEE.2026.080105

The Coupling and Coordination of Insurance Development and Urban Resilience in the Beijing-Tianjin-Hebei Urban Agglomeration

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Abstract: *As the core carrier of urban risk buffer, the insurance industry can effectively improve the resilience of society after disasters and the efficiency of economic restart, enhance social resilience, and inject continuous impetus into the construction of resilient cities. By using panel data from 2014 to 2023, we employ the entropy method and the coupling coordination model to measure the coordination degree between insurance development and urban resilience. The results demonstrate that: (1) The coordination degree between urban resilience and insurance development in this region fluctuates and declines, and there are noticeable gradient differences among cities. (2) The level of urban resilience and insurance development in the region is in the stage of dynamic optimization, and the overall pattern of mild imbalance, reluctant coordination, and primary coordination coexists. This paper puts forward corresponding policy suggestions on how to improve urban resilience for sustainable development.*

Keywords: U*rban resilience; Insurance development; Coupling coordination; Urban agglomeration; Sustainable development*

1. Introduction

As a world-class urban agglomeration centered around the capital Beijing, the Beijing-Tianjin-Hebei region is one of the most economically promising urban agglomerations in China, as well as an area sensitive to climate change and with fragile ecosystems [1]. The accelerated development of urbanization also brings various risk factors that interweave, affect, and amplify each other, further enhancing the complexity, systematicity, and networking of risks, forming more complex risk networks within the city [2], and thus displaying complex correlations, overall emergence, diffusion amplification, multiple superposition, and uncertainty of urban risks. Promoting the construction of resilient cities has become a necessity for current development, and to a certain extent, it is a way and method to improve the ability, strength, and resilience of cities to cope with various disaster risks. In 2015, the United Nations Global Summit on Sustainable Development stated that building resilient cities and human settlements by 2030 is one of the key paths to achieving Sustainable Development Goals.

The insurance industry, as an essential tool for urban risk management, can enhance the resilience of society by strengthening its ability to recover from major disasters and restart economic growth, thereby playing a role in the construction of resilient cities. This study selected seven core cities in the Beijing-Tianjin-Hebei urban agglomeration, including two municipalities directly under the central government, Beijing and Tianjin, and five prefecture-level cities in Hebei Province. By collecting panel data from 2014 to 2023, we construct an evaluation system, and use the entropy method and coupling coordination model to measure the level of insurance development and urban resilience, as well as the degree of coordination between the two. Relevant suggestions for improving urban resilience were proposed to help achieve sustainable urban development.

2. Literature review

2.1. The definition and assessment of urban resilience

According to UN-Habitat, urban disaster resilience in response to crises refers not only to reduced risk and damage caused by disasters (e.g., loss of life and property) but also to the ability to return quickly

ISSN 2616-5872 Vol.8, Issue 1: 32-39, DOI: 10.25236/AJEE.2026.080105

to a stable state [3]. The Resilience Alliance defines resilience as follows: “Resilience is the capacity of a social-ecological system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions. It describes the degree to which the system is capable of self-organization, learning and adaptation” [4,5]. In recent years, some scholars argue that disaster resilience should be viewed not as the ability of a society to “bounce back,” but as the ability of a society to adapt to or transform toward a desirable future; they also suggest three conditions that justify transformation under the name of resilience: sustainability, welfare, and dignity [6].

The urban system is an open and complex system, not a single dimension. It has multiple main elements such as society, economy, ecology, environment, and culture, and closely linked to multiple public service facilities such as transportation, public health, and education. The corresponding urban resilience is also reflected in various dimensions. For example, Cutter et al. (2008) developed the Disaster Resilience of Place Model based on community conditions before a disaster, characteristics of the disaster itself, and absorptive capacity, which applies to rapid-onset disaster events or slow cumulative impact events [7]. The urban governance perspective combines emergency management systems with urban planning to evaluate the existing state of resilience. Cutter et al. (2010) also proposed the Baseline Resilience Indicators for Communities (BRIC) [8]. The BRIC is constructed from the six aspects of ecology, institutions, society, economy, infrastructure, and community capital to measure community resilience quantitatively. Multiple studies have classified urban resilience into four major elements: economy, infrastructure, and society [9,10]. Economic resilience underscores the importance of cities with robust economic strength, enabling those with higher economic levels to activate protective mechanisms swiftly when facing disaster risks. Adequate financial support further ensures the adaptability and recovery capacity of urban systems. Social resilience emphasizes maintaining individuals’ fundamental living standards, thereby fostering an equitable, harmonious, and prosperous living environment and ensuring material and spiritual growth. Environmental resilience strives for harmonious coexistence between humanity and nature, aiming to establish a sustainable society through environmental protection and resource conservation. Infrastructure resilience, which pertains to a city’s physical facilities, plays a crucial role both before and after risks emerge.

2.2. Insurance development and urban resilience

Finance has gained prominence as key factors influencing environmental sustainability. Several studies find that financial technology (FinTech) promotes ecological performance in emerging nations and developed countries [11-13]. And there is a connection between insurance development and urban resilience. The development of urban resilience provides market opportunities for the development of insurance, and insurance also plays a promoting role in the development of urban resilience. Insurance can also provide stable expected benefits to society, especially the insured, thereby enhancing the psychological resilience of society to disasters and achieving post-disaster stability.

Firstly, insurance enables urban residents and businesses to pay attention to risks, enhance the risk awareness of urban stakeholders, and strengthen their independent risk management awareness. When people realize that they have to bear specific economic responsibilities for risks, they will be more motivated to implement preventive measures, such as building seismic upgrades and emergency supplies reserves, in order to strengthen the resistance of the entire city to risks. Secondly, insurance funds have both long-term and stable characteristics, and can be invested in multiple fields such as urban infrastructure construction and emerging industries. When a city encounters natural disasters or economic crises, insurance can provide quick claims for affected units and individuals, assisting them in achieving a rapid restart of production and life. Adopting insurance compensation payment can reduce the impact of disasters on the urban economy, alleviate the growth terminals and intensified conflicts caused by high economic losses, and achieve stable urban development, thereby improving the comprehensive stress resistance level of cities. Finally, insurance improves urban resilience by strengthening the carrying capacity effect. Insurance adopts a combination of occupational security and economic assistance strategies to enhance the level of urban population capacity indirectly. Developing energy-saving and emission reduction insurance projects can support the virtuous cycle of urban ecology and enhance the environmental support of cities. Adopting risk management and service upgrade plans help achieve efficient operation and reliable guarantee of urban resources, and enhance the level of urban resource capacity. Therefore, involving a multi-level insurance service portfolio could enhance the public service carrying capacity of the city.

ISSN 2616-5872 Vol.8, Issue 1: 32-39, DOI: 10.25236/AJEE.2026.080105

3. Evaluation systems and calculation

3.1. Evaluation systems of insurance development and urban resilience

To effectively evaluate the coordination level between urban resilience and insurance development in the Beijing-Tianjin-Hebei region, this study comprehensively refers to existing literature research [9,10,14], the study systematically decomposes urban resilience from four aspects: economic resilience, social resilience, environmental resilience, and infrastructure resilience, and revolves around this. 18 evaluation indicators are selected from four dimensions to construct an evaluation system for the resilience level of the Beijing-Tianjin-Hebei urban agglomeration. Drawing on Li et al. (2024) [15], Gao and Xing(2021) [16], seven secondary indicators were selected based on the three major elements of insurance development scale, climate, and potential to form a primary indicator. A measurement system for the level of urban insurance development was developed to measure the level of insurance development in each city. As shown in Table 1.

Table 1: Indicator system and weighting for urban resilience and insurance development

	Dimensions	Weight	Indicators	Weight
Urban resilience	Economic resilience	0.277	Per Capita GDP	0.062
			Disposable income of urban residents	0.063
			Total industrial assets of industrial companies with annual revenue of more than 20 million yuan	0.054
			Local fiscal revenue	0.055
			The proportion of the added value of the tertiary industry to GDP	0.043
	Social resilience	0.202	population density	0.029
			Insurance Density	0.037
			The registered urban unemployment rate	0.028
			Number of students enrolled in regular universities	0.026
			Hospital beds	0.082
	Environmental resilience	0.267	Greening coverage rate of urban built-up areas	0.064
			Green areas in urban parks	0.065
			Industrial sulfur dioxide emissions	0.045
			Industrial wastewater discharge volume	0.046
			Comprehensive utilization rate of industrial solid waste	0.046
	Infrastructure resilience	0.254	Number of buses per 10,000 people	0.097
			Length of drainage pipeline	0.088
			Per capita road area	0.069
Insurance development	Development scale	0.791	Original premium income	0.307
			Insurance compensation expenses	0.227
			Insurance Density	0.257
	Development climate	0.029	Per Capita Disposable Income	0.002
			Proportion of science and education expenditure to fiscal expenditure	0.027
	Growth potential	0.180	Number of insurance institutions	0.081
			Insurance premium growth rate	0.099

The weights for indicators were determined using the entropy weight method. As an objective weighting technique, the entropy method minimizes deviations resulting from subjective factors. The detailed calculation procedure is outlined below.

(1) The Min–Max normalization method was used to standardize the data.

The processing formula for positive indicators is as follows:

$$Y_{ij} = \frac{X_{ij}-Min(X_{ij})}{Max(X_{ij})-Min(X_{ij})} \tag{1}$$

The treatment for negative indicators is as follows:

$$Y_{ij} = \frac{max(x_j)-x_{ij}}{max(x_{ij})-min(x_{ij})} \tag{2}$$

In equations (1) and (2), Y_{ij} denotes the 12 indicators X_{ij} after dimensionless indexing (i.e., standardized data); X_{ij} is the original statistical value of the indicator; Max and Min are the maximum and minimum values of the same indicator, respectively.

(2) Calculate the information entropy of each indicator:

$$E_j = -\frac{1}{\ln m}\sum_{i=1}^{m} p_{ij} \ln p_{ij} \tag{3}$$

$$p_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \tag{4}$$

In Equations (3) and (4), E_j is the information entropy of indicator j, and m and n are the numbers of prefecture-level cities and indicators, respectively.

(3) The weight of each indicator was calculated.

$$\omega_j = \frac{1-E_j}{\sum_{j=1}^{m} E_j} \tag{5}$$

ω_j is the weight of indicator j.

3.2. Assessment of Urban Resilience and Insurance Development Level

The data for each indicator in the table mainly comes from the “China Urban Statistical Yearbook”, “China Regional Economic Statistical Yearbook”, “China Insurance Yearbook” from 2014 to 2023, public data of the China Banking and Insurance Regulatory Commission, statistical yearbooks of various cities, national economic and social development statistical bulletins, as well as official websites of various city statistical bureaus, finance bureaus, and human resources and social security bureaus.

The indicators of urban disaster resilience were processed in a dimensionlessly manner, with the raw data for each evaluation indicator standardized for further analysis. The processing formulas for the positive and negative indicators are shown in equations (1) and (2). Comprehensive evaluation is the method most commonly used for calculating the evaluation index, which is adopted in this study. The comprehensive evaluation index is equal to the sum of the product of the standard value of the indicator data and the weight value of each evaluation index. The formula for calculating the comprehensive evaluation index of urban resilience and insurance is as follows:

$$R = \sum_{j}^{m} \omega_{ij} \cdot p_{ij} \tag{6}$$

In equation (6), ω denotes the combined weight of the tertiary indicators to the primary indicators, p denotes the evaluation index of the tertiary indicators, and R denotes the composite index.

Then we derived the urban resilience indices and insurance development for the Beijing-Tianjin-Hebei urban agglomeration, as presented in Table 2 and Table 3.

Table 2: Urban Resilience of the Beijing-Tianjin-Hebei Urban Agglomeration

City	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Beijing	0.596	0.596	0.559	0.557	0.565	0.575	0.586	0.596	0.543	0.557
Tianjin	0.392	0.403	0.348	0.403	0.407	0.405	0.424	0.486	0.359	0.367
Shijiazhuang	0.288	0.307	0.305	0.333	0.324	0.326	0.319	0.205	0.201	0.207
Tangshan	0.209	0.236	0.179	0.277	0.277	0.282	0.277	0.268	0.203	0.208
Hengshui	0.351	0.352	0.283	0.302	0.280	0.262	0.243	0.229	0.203	0.207
Handan	0.379	0.411	0.242	0.322	0.300	0.291	0.281	0.262	0.208	0.202
Qinhuangdao	0.443	0.313	0.282	0.295	0.286	0.275	0.267	0.256	0.206	0.201

Table 3: Insurance development in the Beijing-Tianjin-Hebei urban agglomeration

City	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Beijing	0.394	0.269	0.285	0.459	0.274	0.407	0.479	0.495	0.496	0.597
Tianjin	0.298	0.316	0.339	0.273	0.272	0.283	0.358	0.265	0.318	0.402
Shijiazhuang	0.048	0.048	0.074	0.262	0.075	0.085	0.166	0.131	0.160	0.259
Tangshan	0.266	0.266	0.301	0.267	0.269	0.271	0.318	0.361	0.230	0.228
Hengshui	0.260	0.261	0.284	0.267	0.266	0.253	0.292	0.264	0.229	0.227
Handan	0.279	0.275	0.285	0.262	0.261	0.268	0.303	0.255	0.229	0.225
Qinhuangdao	0.255	0.256	0.272	0.265	0.262	0.264	0.305	0.241	0.228	0.228

ISSN 2616-5872 Vol.8, Issue 1: 32-39, DOI: 10.25236/AJEE.2026.080105

4. Calculation of coupling coordination degree

4.1. Coupling coordination model

The coupling coordination describes the dynamic interaction and mutual influence between two or more systems under the linkage of internal elements and external environmental effects. In terms of urban resilience and insurance development, the two are interdependent and interrelated. Therefore, a coordination analysis should be conducted to explore the interaction between the two. Use the following model for calculation:

$$C = \frac{\sqrt{(U1 \cdot V1)}}{(U1+V1)} \tag{7}$$

In equation (7), C is the coupling degree value, U is the level of urban insurance development, and V is the urban resilience. Furthermore, the following model can be established to calculate in detail the coordination degree between the resilience of cities in the Beijing-Tianjin-Hebei cluster and insurance development.

$$T = \alpha U1 + \beta V1 \tag{8}$$

$$D = \sqrt{(C \cdot T)} \tag{9}$$

T represents the comprehensive coordination index, D is the coordination degree value, and α and β represent the importance of insurance development level and urban resilience, respectively. This article believes that urban resilience and insurance development level have equal importance, so α and β are set to 0.5, respectively. The calculation result of coordination degree D represents the synergistic relationship between the two: the larger the value, the higher the degree of coordinated development between urban resilience and insurance development level; Conversely, the lower the level of coordination.

To more intuitively reflect the coordination relationship between the insurance development level and urban resilience, based on existing research [9], the coordination degree values of the two systems were classified and graded, as shown in Table 4. The value range of coupling coordination degree D is 0 to 1, and this parameter is positively correlated with the level of system coordination. The higher the coupling coordination degree, the higher the degree of coordination between systems.

Table 4: Classification Criteria for Coupling Coordination Degree

Range of coupling coordination degree D value	Coupling coordination level
(0.0,0.2]	Serious imbalance
(0.2,0.3]	Mild imbalance
(0.3,0.4]	Barely coordinating
(0.4,0.6]	Primary Coordination
(0.6,0.8]	Mild Coordination
(0.8,0.1]	Advanced Coordination

4.2. Results

Using the aggregated scores of urban resilience and insurance development, and employing a coordination analysis model, a coordination degree model was established to calculate the coordination level of urban resilience and insurance in seven cities in the Beijing-Tianjin-Hebei region during the observation period. The results are as follows in Table 5.

Table 5: Coordination Degree of Urban Resilience and Insurance Development Level in the Beijing-Tianjin-Hebei Urban Agglomeration

City	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Beijing	0.492	0.448	0.447	0.503	0.444	0.492	0.515	0.521	0.509	0.537
Tianjin	0.413	0.422	0.415	0.407	0.408	0.411	0.441	0.424	0.411	0.438
Shijiazhuang	0.243	0.247	0.274	0.384	0.280	0.288	0.339	0.286	0.299	0.340
Tangshan	0.343	0.354	0.340	0.369	0.370	0.372	0.385	0.394	0.329	0.330
Hengshui	0.389	0.389	0.376	0.377	0.370	0.359	0.365	0.351	0.329	0.329
Handan	0.403	0.409	0.362	0.381	0.374	0.374	0.382	0.360	0.330	0.326
Qinhuangdao	0.410	0.376	0.372	0.374	0.370	0.367	0.378	0.352	0.329	0.327

ISSN 2616-5872 Vol.8, Issue 1: 32-39, DOI: 10.25236/AJEE.2026.080105

From Table 5, it can be seen that there is a clear spatial distribution pattern in the coordination between urban resilience and insurance development level in the Beijing-Tianjin-Hebei urban agglomeration in the past ten years. The coordination between Beijing and Tianjin has shown an upward trend, while Shijiazhuang has shown a fluctuating upward trend, and the other four cities have experienced volatility, showing a mild decline. And each city has shown a certain range of reverse fluctuations over a period of time. In terms of coordination values, cities in urban agglomerations are distributed across primary coordination, barely coordination, and mild imbalance, with most of the time being barely coordinated. From a spatial perspective, there are significant intercity differences in the coordination between urban resilience and insurance development level in the Beijing-Tianjin-Hebei urban agglomeration. The coordination value between Beijing and Tianjin is significantly higher than that of cities in Hebei Province, and Beijing is in a leading position in the urban agglomeration.

From the overall research data, the comprehensive evaluation results of the two systems reflect a significant gap between the level of insurance development and urban resilience. In the coordinated pattern, the level of insurance development shows a slight lag. Modern cities like Beijing, relying on their superior geographical location and strong economic strength, have a good level of urban resilience. The progress of the insurance industry effectively promotes the improvement of urban resilience; Tangshan, a city with low insurance density, is a representative of the city. Even though the maturity of the insurance market is not high and cannot keep up with the pace of urban development, after time sedimentation, the matching degree between insurance level and urban risk resistance ability has steadily improved, coordination has gradually improved, and the phenomenon of imbalance has significantly weakened, showing a trend from imbalance to coordinated development.

4.3. Spatial differences of coordination

Based on the coordination model, it focuses on exploring the coordination between urban resilience and insurance development level. From Figure 1, it can be seen that the empirical results show a significant differentiation in the coordination between the development of the insurance industry and urban resilience in various cities in the Beijing Tianjin Hebei region. Except for Beijing and Tianjin, which have achieved primary coordination, the remaining five cities belong to the category of barely coordinated and mildly imbalanced. It can be seen that the overall synergy between urban resilience and insurance development level is not high, and needs to be significantly improved. In the planning, it is necessary to strengthen the coordinated development between urban resilience and insurance level, enhance the spatial and temporal distribution control ability of each city in the Beijing Tianjin Hebei urban agglomeration, and further consolidate the underlying effects of resilience space.

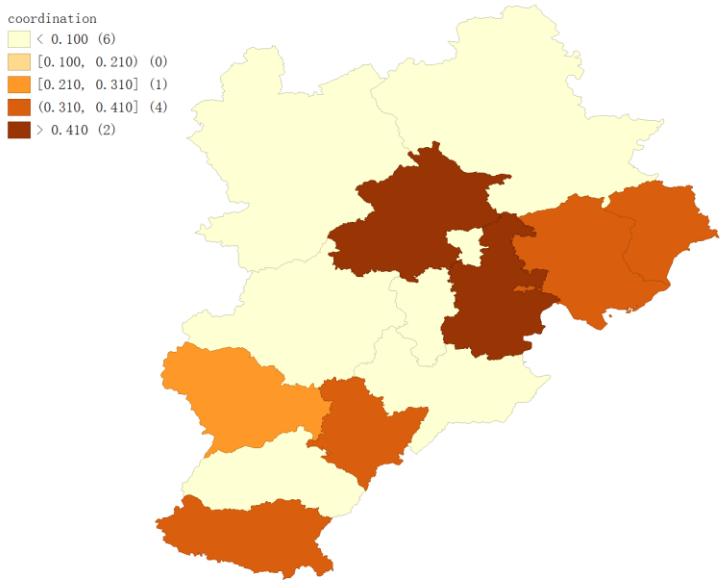

Figure 1: Spatial pattern of coordination between urban resilience and insurance development level in the Beijing-Tianjin-Hebei urban agglomeration (Source: Created by the authors).

ISSN 2616-5872 Vol.8, Issue 1: 32-39, DOI: 10.25236/AJEE.2026.080105

5. Discussion and Conclusion

With the help of a coordination model, the study focused on the coordination between urban resilience and insurance development level. Results have shown that the resilience level of cities in the Beijing-Tianjin-Hebei region has fluctuated and decreased, and the gap in resilience level between cities has gradually widened since 2014. Beijing has taken the lead in resilience assessment in this region. The overall level of urban insurance development in the Beijing-Tianjin-Hebei urban agglomeration has shown a wave-like upward trend, with significant regional differences within the region, with Beijing having the highest level of insurance development. The degree of alignment between urban resilience and insurance development in the region has fluctuated and declined, and the absolute level is limited, with significant gradient differences among cities. The resilience and insurance development level of cities in the region are currently in a dynamic optimization stage, presenting a pattern of mild imbalance, barely coordinated, and primarily coordinated coexistence. 70% of cities have not yet broken through the state of mild imbalance or barely coordinated, with only Beijing reaching the level of primary coordination.

To comprehensively enhance the coordination between urban resilience and insurance development level in the Beijing-Tianjin-Hebei urban agglomeration, efforts should be made to enhance urban resilience and improve the regional imbalanced spatial patterns. It is necessary to strengthen the balanced development of the overall resilience level within urban agglomerations, ensure the steady growth of resilience in cities such as Beijing and Tianjin, and continuously increase support and assistance for some underdeveloped areas in Hebei Province, give full play to regional advantages according to local conditions, strengthen the completeness of urban social systems and the construction of monitoring and emergency mechanisms for urban public safety, to enhance the effectiveness of urban disaster prevention and relief systems and continuously improve their post disaster repair capabilities.

Acknowledgements

This research was supported by the Science Research Project of Hebei Education Department (Grant No. SQ2024110) and Langfang Science and Technology Research and Development Project (Grant No. 2025029125).

References

[1] Qin D, Ding Y, Zhai P. eds. Climate and ecological environment evolution in China. Science Press, Beijing, 2021.
[2] Yi C, Zheng X. Construction of emergency plans for urban composite risks in a resilience perspective [J]. Probe, 2025, 01: 101–113.
[3] UN-Habitat: https://unhabitat.org/cn/node/3774
[4] Gunderson L, Holling C. eds. Panarchy: Understanding Transformations in Systems of Humans and Nature. Island Press, Washington DC, 2002.
[5] Walker B, Holling C, Carpenter S, Kinzig A. Adaptability and transformability in social-ecological systems[J]. Ecology and Society, 2004, 9: 5.
[6] Nagamatsu S. The evolution of the "disaster resilience" concept and its implications for disaster risk reduction [J]. J. Disaster Res, 2025, 20(5): 737–745.
[7] Cutter S, Barnes L, Berry, M, Burton C, Evans E, Tate E, Webb J. A place-based model for understanding community resilience to natural disasters[J]. Global Environmental Change, 2008, 18(4): 598–606.
[8] Cutter S, Burton C, Emrich C. Disaster resilience indicators for benchmarking baseline conditions[J]. Journal of Homeland Security and Emergency Management, 2010, 7(1): 598–606.
[9] Zhang M, Feng X. A comparative study of urban resilience and economic development level of cities in Yangtze river delta urban agglomeration[J]. Urban Development Studies, 2019, 26(1): 82–91.
[10] Wang C, Gao L, Sun Y. Urban disaster resilience in Hebei province under urbanization in China[J]. J. Disaster Res, 2025, 20(2): 242–250.
[11] Uddin M, Siddik AB, Yuhuan Z, Naeem MA. Fintech and environmental efficiency: the dual role of foreign direct investment in G20 nations[J]. J Environ Manage, 2024, 360:121211.
[12] Andlib Z, Scicchitano S, Padda IUH. The role of natural resources, fintech, political stability, and social globalization in environmental sustainability: evidence from the United Kingdom[J]. Resour Policy, 2024, 91:104922.

[13] Okere K, Dimnwobi S, Fasanya I. Pathways to environmental sustainability: exploring the role of FinTech, natural resources and globalization in North Africa[J]. International Journal of Sustainable Development & World Ecology, 2025, 32(4): 446-464.

[14] Zhang H, Liu Y, Feng J. Impact of urbanization quality and urban resilience on flood disaster risk: based on panel data of 11 prefecture-level cities in Shanxi[J]. On Economic Problems, 2020, 4: 114–120.

[15] Li J, Yin D, Tian H, Zhao X. Prediction, regional differences and dynamic evolution of high-quality development level of agricultural insurance in Beijing-Tianjin-Hebei city cluster[J]. Review of Investment Studies, 2024, 43(09): 147–159.

[16] Gao J, Xing H. Analysis of Urban Insurance High-Quality Development Evaluation System: Based on 19 Vice-provincial and Municipalities Cities[C]. In: China International Conference on Insurance and Risk Management, Harbin, China, 2021: 387-397.