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Delphi-Entropy Weight-TOPSIS Evaluation Model for Urban Safety Development

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Abstract Based on relevant data and evaluation indicators, selection criteria were established to preliminarily design an evaluation indicator system for urban safety development. The Delphi method was used to refine and improve the evaluation indicator system proposed in this paper, ultimately determining the evaluation indicator system for this study. Subsequently, the entropy weight-TOPSIS algorithm was employed to design an evaluation model for urban safety development. Under the influence of the evaluation model, an assessment and analysis of urban safety development levels from 2014 to 2023 was conducted. It was found that the urban safety development level was optimal in 2018 and the worst in 2023, with values of 0.6492 and 0.2489, respectively, comprehensively showcasing the urban safety development levels from 2014 to 2023.

Index Terms Delphi method, Entropy weighting method, TOPSIS method, Urban safety development

I. Introduction

Cities serve as important vehicles for industrialization, modernization, marketization, internationalization, and informatization, acting as hubs for the flow of people, goods, and information [1]. As China's modernization process accelerates, cities increasingly exhibit trends toward resource intensification, population densification, equipment enlargement, process complexity, and operational acceleration, becoming concentrated areas where various safety production contradictions manifest [2]-[5]. Cities have evolved into vast, complex operational systems. Compounded by the frequent occurrence of extreme weather disasters and the accumulation of safety risks, these factors pose a significant threat to the safe operation of cities [6]-[8]. Promoting urban safety development is not only an inevitable path for implementing the scientific concept of development and transforming the pattern of economic growth, but also a fundamental requirement for fundamentally transforming the urban landscape and innovating urban social management [9]-[11]. It is also an objective necessity to implement the principle of prevention first, properly handle the relationship between safety and development, and ensure that socio-economic development is based on the actual protection of the lives and property of the people and the comprehensive safeguarding of the safety rights and interests of workers [12]-[15]. Therefore, studying the goals and manifestations of urban safety development and assessing the state of safety development are important criteria for measuring the effectiveness of urban management and have significant implications for promoting urban safety development.

Scientific planning, construction, and management of cities are of great significance for enhancing urban safety development capabilities and promoting urban safety development. To this end, some scholars have conducted in-depth analyses of the application effects of urban safety development assessment tools from the perspectives of sustainable development, ecology, water resources, networks, and food security. Chen, G., et al. developed an urban safety assurance evaluation method system based on the weighted average method and functional models, which can effectively quantify assessments of development risks and emergency response capabilities, thereby promoting sustainable development in urban regions [16]. Ameen, R. F. M., and Mourshed, M. used the analytic hierarchy process to rank indicators related to urban development, thereby constructing a city sustainability assessment framework that considers local conditions, with urban safety development indicators accounting for a higher weighting [17]. Shach-Pinsly, D explored quantitative assessment methods for the safety of the built environment within urban spaces from a human-centered perspective, providing valuable insights for planners and decision-makers to continuously optimize the characteristics and hotspots of unsafe spaces in cities [18]. Han, B et al. combined the entropy weight method and fuzzy comprehensive evaluation method to construct a pressure-state-response conceptual model for evaluating urban ecological safety, enabling a detailed understanding and analysis of the development process of urban ecological safety [19]. Zhu, D., and Chang, Y. J., based on a thorough analysis of urban water safety conditions, integrated urban water management into urban development policy planning, contributing to the development of a framework for urban water safety research and comparative assessment practices, while also providing valuable recommendations for decision-makers to improve urban water resource needs [20]. Chapagain, K., et al. also demonstrated that rapid urban development has brought about urban issues related to water security. By linking the urban water security assessment framework with urban planning, strategies, and policies, urban water supply, sanitation, and human well-being can be fully considered in the urban development process [21]. Zhou, Q, and Luo, J studied smart city public safety evaluation modeling methods, proposing the integration of the PSR method, fuzzy logic model, and entropy weight method to establish a multi-dimensional evaluation model to ensure urban network public safety [22]. Haysom, G, and Tawodzera, G discussed the food security challenges in urban development, pointing out that extending food system assessments from rural to urban levels can provide valuable insights for urban planning and policy interventions [23]. However, the aforementioned studies only conducted specialized quantitative analysis and evaluation of individual indicators and were unable to effectively conduct a comprehensive analysis and evaluation of urban safety development capabilities. Therefore, there is an urgent need to propose a new urban safety development capability evaluation indicator system and conduct a comprehensive evaluation calculation.

Under the principle of establishing evaluation indicators, this paper preliminarily constructs an urban safety development evaluation indicator system, which consists of three first-level evaluation indicators and 22 second-level indicators. To make the evaluation indicator system more practical, the Delphi method was used to optimize the system. After optimization, the final urban safety development evaluation indicator system was determined, with the number of first-level indicators remaining unchanged, while the number of second-level indicators was reduced from 22 to 18. Based on this, a city safety development assessment model based on the entropy weight-TOPSIS algorithm was designed, and the model was applied to a case study for exploratory analysis.

II. Design of urban safety development assessment program

II. A. Principles for establishing evaluation indicators

As mentioned above, there are commonalities and issues among existing studies on urban safety development evaluation indicator systems, which result in certain limitations and practicality in their findings. The selection and determination of evaluation indicators form the foundation and core of the entire evaluation system, directly influencing the final evaluation results and their precision. Therefore, the selection of evaluation indicators is of utmost importance to the entire research project. In the process of constructing the indicator system, this paper primarily focuses on existing statistical indicators. Existing loss-related statistical indicators reflect the current state of urban safety development, while regulatory and investment-related indicators reflect the future direction of urban safety development. Statistical indicators from other countries can provide valuable references and insights for this study, guiding the direction of urban safety development. However, if too many indicators are selected, it may increase the complexity of the indicator system structure, potentially leading to a lack of distinction between primary and secondary indicators, obscuring key indicator factors, and resulting in insufficient precision in the evaluation outcomes. Conversely, if too few indicators are selected, it may simplify the indicator system structure, making it difficult to comprehensively reflect the objective status of the system, thereby compromising the accuracy of the evaluation outcomes. To address these issues, this paper will implement solutions during the establishment and selection phase of evaluation indicators, employing the following specific measures:

II. A. 1) Principle of practicality and operability

The ultimate purpose of the indicator system is to be applied in real-life scenarios, so the data for the indicators must be based on real-world data. That is, the data must be based on existing real-world data to establish the foundation for the indicators, avoiding the creation of indicators without a data source, thereby ensuring the practicality and feasibility of the entire evaluation indicator system. The data in this paper primarily draws from: Statistical Yearbooks, Urban Statistical Yearbooks, Transportation Yearbooks, Fire Safety Statistical Yearbooks, Environmental Statistical Yearbooks, Health Statistical Yearbooks, and provincial/municipal statistical yearbooks, among others. The selection of indicators can be based on the statistical indicators in these yearbooks or on data derived from further processing of the yearbook's statistical indicators.

II. A. 2) Principle of fairness and reasonableness

The evaluation indicator system is established to provide references and suggestions for the next phase of urban safety work. It is not targeted at any specific city or region, so the evaluation indicator system should be fair and reasonable. Given the characteristics of cities, such as their wide geographical distribution, varying levels of development, and different structures and natures, the project will try to select relative values and per capita values as indicators.

II. A. 3) Principle of dynamism

Urban safety development is both a goal and a process. Therefore, the urban development safety evaluation index system should be a dynamic analysis and monitoring system that can be continuously updated in response to new circumstances, reflecting trends in urban safety development. This will ensure that the system remains advanced and enhances its vitality.

II. A. 4) Principle of Accuracy

The level of urban safety development can be directly reflected by accident indicators, but it is also influenced by factors such as regulation, personnel quality, training, and the environment. Therefore, when selecting indicators to establish, these factors should be considered in a reasonable and comprehensive manner. Of course, more indicators are not necessarily better. When selecting indicators, it is important to consider the difficulty and accuracy of obtaining indicator values, while also highlighting key indicators that are critical to the evaluation objectives.

II. B. Determining the evaluation indicator system

Combining evaluation indicators with selection principles and relevant references, a preliminary urban safety development evaluation indicator system was constructed. In order to ensure the effective application value of this system, the Delphi algorithm was used to revise and improve the evaluation indicator system, and the urban safety development evaluation indicator system was finally determined.

II. B. 1) Preliminary establishment of an evaluation indicator system

The foundation for assessing urban safety and development lies in scientifically and reasonably identifying the unique characteristics of urban development. The purpose of establishing a foundational indicator system for urban safety and development is to distinguish between the scale, complexity, and total potential risk sources of different cities, thereby evaluating the alignment between urban safety and development. The framework of the urban safety development indicator system constructed in this paper is shown in Table 1. The evaluation indicator system selects three aspects of indicators: urban scale, construction status, and potential risk sources. As urban scale, economic volume, and construction levels increase, the complexity of the urban system also increases, potentially leading to more potential risk sources. Therefore, it is necessary to conduct an urban risk census to identify the volume of potential risk sources affecting the safety development of the urban system. The preliminary urban safety development evaluation indicator system consists of three primary indicators and 22 secondary indicators. The primary indicators include urban scale (X1), construction status (X2), and potential risks (X3). The secondary indicators include administrative regional land area (X11), permanent resident population (X12), regional gross domestic product (X13), regional gross domestic product composition (X14), Urban Construction Land Status (X21), Water Supply Pipeline Length (X22), Completed Rail Transit Length (X23), Bridge Data (X24), Number of High-Rise Buildings (X25), Industrial Land Status (X26), Gas Pipeline Length (X27), Road Length (X28), Tunnel Length (X29), Hazardous Chemicals Units (X31), Construction projects (X32), Power companies (X33), Heating and gas companies (X34), Hazardous goods transportation companies (X35), Crowded public places (X36), Industrial companies (X37), Water supply companies (X38), Interprovincial passenger transport companies (X39).

II. B. 2) Evaluation index system based on the Delphi algorithm

The Delphi method is suitable when historical data or information is insufficient, or when the model requires a significant degree of subjective judgment. It involves conducting a questionnaire survey among a selected group of experts, followed by statistical analysis of the returned survey forms. After one or two rounds of consultation, expert opinions converge, resulting in an urban safety development evaluation indicator system that meets research requirements [24]. This study followed the Delphi method application guidelines, conducting two rounds of consultations with participating experts via email. A Likert 5-point rating scale was used to develop the expert consultation questionnaire. In the first round, experts were presented with background materials and the expert consultation questionnaire, and asked to rate the importance of each indicator and provide suggestions for revisions. After the questionnaires were returned, the results were organized and analyzed. The indicator system was then adjusted based on expert opinions, and the second round of expert consultation was conducted. After the second round of questionnaires were returned, the threshold method was used for preliminary indicator screening, ultimately determining the urban safety development evaluation indicator system.

The expert consultation questionnaire included the following sections:

(1) Introduction: This section provided an overview of the study's objectives and instructions for completing the questionnaire.

(2) Expert Profile: This section collected basic information about the experts, including their professional background, years of experience, criteria for judgment, and familiarity with the content.

(3) Questionnaire Content Section: The initial questionnaire included three primary indicators and 21 secondary indicators, all of which were derived from the aforementioned urban safety development evaluation indicator system.

(4) Likert Scoring:

In the expert consultation questionnaire, we use the Likert 5-point scale to evaluate indicators as "very important," "important," "neutral," "not very important," or "unimportant." During data analysis, each response is assigned a score: "very important" is 5 points, "important" is 4 points, 'neutral' is 3 points, "not very important" is 2 points, and "unimportant" is 1 point.

(5) Evaluation Indicator System Screening Criteria

Table 1: Evaluation index system

First-level indicator	Symbol	Secondary indicators	Symbol
Urban scale	X1	Land area of the administrative region	X11
		The number of permanent residents.	X12
		Regional gross domestic product	X13
		Composition of regional GDP	X14
Construction situation	X2	The status of urban construction land	X21
		Length of water supply pipeline	X22
		Length of rail transit (completed)	X23
		Bridge data	X24
		The number of high-rise buildings	X25
		The status of industrial land	X26
		Length of gas pipeline	X27
		Road length	X28
		Tunnel length	X29
Potential risk sources	X3	Hazardous chemicals unit	X31
		Construction project	X32
		Electric power enterprises (including power generation)	X33
		Heating and gas enterprises	X34
		Dangerous goods transportation enterprises	X35
		Crowded places	X36
		Industrial enterprise	X37
		Tap water (drainage) enterprises	X38
		Inter-provincial (tourist) passenger transport enterprises	X39

Based on the quantified values of evaluation indicators obtained from the expert consultation questionnaire, we calculated the mean, standard deviation, and coefficient of variation. We screened evaluation indicators by determining whether the coefficient of variation (calculated as the standard deviation divided by the mean) was less than 0.2. If the condition was met, the evaluation indicator was retained; otherwise, it was excluded.

II. C.Building an evaluation model

II. C. 1) Entropy Weight-TOPSIS Method

The entropy weight method is an information entropy-based weighting method used to determine the importance and dispersion of indicators. By calculating the entropy values of indicators, their weights can be determined, thereby influencing the results of comprehensive evaluations. When combined with the TOPSIS method, the entropy weight method evaluates the relative distance between the indicator evaluation value vectors and the positive and negative ideal solutions to assess the quality of the evaluation objects, thereby ranking and evaluating them [25]. This method comprehensively considers the importance and performance of each indicator, assisting decision-makers in more accurately assessing and selecting options. This paper adopts the entropy weight-TOPSIS method as the evaluation method for urban safety development. First, the entropy weight method is an objective weighting method. Using the entropy weight method to determine indicator weights and the TOPSIS method for comprehensive evaluation reduces the bias caused by subjective factors when evaluating urban safety development. Additionally, the entropy weight-TOPSIS method overcomes some of the shortcomings of traditional evaluation methods, providing a more objective reflection of the level of urban safety development.

II. C. 2) Calculation steps

(1) Constructing a standardized matrix

When constructing a multi-indicator matrix, assume that there are a evaluation objects $(a_1, a_2, a_3 ..., a_m)$, and b evaluation indicators $(b_1, b_2, b_3, ..., b_n)$ are considered. Then, X_{ij} is defined as the value of the i th evaluation object for the j th evaluation indicator $(i = 1, 2, 3, ..., m; j = 1, 2, 3, ...n)$ to establish the evaluation matrix: $X = \{x_{ij}\}_{m \times n} (i = 1, 2, 3, ..., m; j = 1, 2, 3, ..., n)$ The original matrix is:

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{nn2} & \cdots & x_{nn} \end{bmatrix} \tag{1}$$

(2) Data standardization processing

Since indicators of different natures can have a significant impact on the results, the effects of dimensions must be eliminated during the calculation process, and the data must be normalized. The processing steps are as follows:

For positive indicators:

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

The handling of negative indicators is as follows:

$$b_{ij} = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)} \tag{3}$$

The treatment of moderate indicators is as follows:

$$b_{ij} = 1 - \frac{| x_{ij} - d_{bost} |}{\max | x_{ij} - d_{bost} |} (d_{bost} \text{ is the definite standard value}) \tag{4}$$

(3) Define standardized values.

To ensure the validity of the values, add 0.0001 to each value after dimensionless conversion. Calculate the weight of the nth indicator for each evaluation object as shown below:

$$p_{ij} = \frac{b_{ij}}{\sum_{i=1}^{m} b_{ij}} \tag{5}$$

(4) Calculate the entropy value of the indicators.

Further calculate the entropy value of each indicator, as shown below:

$$e_j = -\frac{1}{\ln_n} \sum_{i=1}^{n} p_{ij} \ln p_{ij} \tag{6}$$

(5) Calculate the degree of variation of the indicators.

Calculate the degree of variation of the j th indicator as follows:

$$g_j = 1 - e_j \tag{7}$$

(6) Calculate indicator weights

The weight W_j of the j th indicator is calculated as follows:

$$w_j = \frac{g_j}{\sum_{i=1}^{m} g_j} \tag{8}$$

(7) Calculate the weighted norm matrix.

The main purpose of this step is to reduce the influence of subjective factors. It is calculated by multiplying the weights calculated in the previous step by the standardized data, as shown below:

$$z_{ij} = y_{ij} W_j \tag{9}$$

(8) Determine positive and negative ideal solutions and Euclidean distance

The purpose of this calculation step is to define different indicators. The closer the indicator vector value is to the positive ideal solution, the better the performance, and vice versa, as shown below:

Positive ideal solution:

$$z_j^+ = \max(z_{1j}, z_{2j}, \cdots, z_{nj}) \tag{10}$$

Negative ideal solution:

$$z_j = \min(z_{1j}, z_{2j}, \cdots, z_{nj}) \tag{11}$$

The Euclidean distance formula is derived from the positive and negative ideal solutions obtained as follows:

$$d_i^+ = \sqrt{\sum_{j=1}^{n} (c_j - c_j^+)\hat{}2} \tag{12}$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} (c_{ij} - c_j^-)\hat{}2} \tag{13}$$

(9) Calculate ideal proximity:

$$c_i = \frac{z_j}{z_j^+ + z_j^-} \tag{14}$$

(10) Finally, the cities are ranked according to their proximity. The greater the proximity, the better the city's safety development level, and vice versa.

III. Urban Safety Development Assessment and Analysis

III. A. Analysis of the evaluation indicator system construction process

III. A. 1) Results of the first round of evaluation indicator screening

(1) First-level evaluation indicators

A total of 10 expert consultation forms were issued in the first round, and 10 were collected, with a recovery rate of 100%. The results of the first round of first-level indicator screening are shown in Table 2. The results show that the coefficient of variation of the three first-level indicators is less than 0.2, so the three first-level indicators are retained.

Table 2: The results of the first round of first-level indicator screening

Index	Number of people	Min	Max	Mean	SD	Coefficient of variation
X1	10	1	5	4.653	0.472	0.101
X2	10	1	5	4.333	0.685	0.158
X3	10	1	5	4.189	0.767	0.183

(2) Secondary indicators

Through expert consultation questionnaires, the results of the first round of secondary indicator screening were investigated, as shown in Table 3. Based on the data in the table, it can be seen that the coefficients of variation for X29 and X39 are greater than 0.2, so they were removed. The remaining 20 indicators have coefficients of variation less than 0.2, so they were retained.

III. A. 2) Results of the second round of evaluation indicator screening

(1) First-level indicators

Using the same method as above, the second round of first-level indicators was screened and investigated. The results of the second round of first-level indicator screening are shown in Table 4. The data in the table shows that the coefficients of variation for the three first-level evaluation indicators are 0.118, 0.154, and 0.143, respectively, all of which are less than 0.2. Therefore, all three first-level indicators are retained.

Table 3: The results of the first round of secondary indicator screening

Index	Number of people	Min	Max	Mean	SD	Coefficient of variation
X11	10	1	5	4.108	0.561	0.137
X12	10	1	5	4.121	0.646	0.157
X13	10	1	5	4.028	0.575	0.143
X14	10	1	5	4.032	0.505	0.125
X21	10	1	5	4.117	0.408	0.099
X22	10	1	5	4.14	0.651	0.157
X23	10	1	5	4.053	0.656	0.162
X24	10	1	5	4.077	0.614	0.151
X25	10	1	5	4.122	0.482	0.117
X26	10	1	5	4.032	0.523	0.130
X27	10	1	5	4.038	0.573	0.142
X28	10	1	5	4.124	0.586	0.142
X29	10	1	5	4.041	1.525	0.377
X31	10	1	5	4.055	0.673	0.166
X32	10	1	5	4.111	0.636	0.155
X33	10	1	5	4.038	0.525	0.130
X34	10	1	5	4.186	0.652	0.156
X35	10	1	5	4.076	0.444	0.109
X36	10	1	5	4.002	0.54	0.135
X37	10	1	5	4.127	0.514	0.125
X38	10	1	5	4.145	0.619	0.149
X39	10	1	5	4.189	1.547	0.369

Table 4: The screening results of the second round of first-level indicators

Index	Number of people	Min	Max	Mean	SD	Coefficient of variation
X1	10	1	5	4.108	0.484	0.118
X2	10	1	5	4.148	0.637	0.154
X3	10	1	5	4.032	0.575	0.143

(2) Secondary indicators

After exploring the results of the second round of primary indicator screening, we proceeded to screen and explore the secondary indicators in the second round. The analysis of the results of the second round of secondary indicator screening is shown in Table 5. Based on the data sizes in the table, among the 20 secondary indicators analyzed, only X28 and X38 have coefficient of variation values greater than 0.2, while the remaining 18 secondary indicators have coefficient of variation values less than 0.2. Therefore, X28 and X38 are excluded, and the remaining 18 secondary indicators are retained.

III. A. 3) Determining the evaluation indicator system

After two rounds of evaluation indicator screening and analysis, the urban safety development evaluation indicator system was finally determined. This evaluation indicator system consists of three first-level indicators and 18 second-level indicators. The urban safety development evaluation indicator system is shown in Table 6.

III. B. Weighting and evaluation results analysis

III. B. 1) Weighted Results Analysis

(1) Data Statistics

The data for calculating the evaluation indicator weights is sourced from statistical yearbooks, urban statistical yearbooks, transportation yearbooks, fire safety statistical yearbooks, environmental statistical yearbooks, health statistical yearbooks, and provincial and municipal statistical yearbooks, among others. Data on urban safety development from 2014 to 2023 was obtained and statistically analyzed. The statistical results for urban safety development from 2014 to 2023 are shown in Table 7. The results show that the distribution range of urban safety development data from 2014 to 2023 is 5 to 10.

Table 5: Analysis of the screening results of the second round of secondary indicators

Index	Number of people	Min	Max	Mean	SD	Coefficient of variation
X11	10	1	5	4.115	0.513	0.125
X12	10	1	5	4.183	0.664	0.159
X13	10	1	5	4.039	0.569	0.141
X14	10	1	5	4.038	0.513	0.127
X21	10	1	5	4.127	0.637	0.154
X22	10	1	5	4.059	0.493	0.121
X23	10	1	5	4.037	0.438	0.108
X24	10	1	5	4.019	0.408	0.102
X25	10	1	5	4.042	0.481	0.119
X26	10	1	5	4.016	0.574	0.143
X27	10	1	5	4.104	0.528	0.129
X28	10	1	5	4.135	1.645	0.398
X31	10	1	5	4.134	0.592	0.143
X32	10	1	5	4.118	0.589	0.143
X33	10	1	5	4.018	0.676	0.168
X34	10	1	5	4.036	0.638	0.158
X35	10	1	5	4.182	0.454	0.109
X36	10	1	5	4.051	0.611	0.151
X37	10	1	5	4.102	0.607	0.148
X38	10	1	5	4.044	1.403	0.347

Table 6: Evaluation index system for urban safe development

First-level indicator	Symbol	Secondary indicators	Symbol
Urban scale	X1	Land area of the administrative region	X11
		The number of permanent residents.	X12
		Regional gross domestic product	X13
		Composition of regional GDP	X14
Construction situation	X2	The status of urban construction land	X21
		Length of water supply pipeline	X22
		Length of rail transit (completed)	X23
		Bridge data	X24
		The number of high-rise buildings	X25
		The status of industrial land	X26
		Length of gas pipeline	X27
Potential risk sources	X3	Hazardous chemicals unit	X31
		Construction project	X32
		Electric power enterprises (including power generation)	X33
		Heating and gas enterprises	X34
		Dangerous goods transportation enterprises	X35
		Crowded places	X36
		Industrial enterprise	X37

(2) Data standardization processing

Since the various urban safety development data have different units of measurement, it is necessary to first avoid the impact of different units and directions of data on the research. This paper uses data standardization processing to avoid this impact. The results of data standardization processing are shown in Table 8. The results show that after data standardization processing, all data are within the range of 0 to 1.

Table 7: Urban safety development data from 2014 to 2023

Index	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
X11	6.026	6.012	8.875	8.83	7.411	5.661	7.68	6.342	9.037	5.683
X12	9.102	8.079	7.093	5.613	6.735	9.483	5.825	6.584	7.02	5.932
X13	7.82	8.802	7.507	5.732	6.281	6.715	9.221	6.551	5.647	5.012
X14	5.214	7.734	8.333	6.015	8.678	7.323	6.778	7.746	7.045	5.197
X21	8.02	6.293	6.308	7.804	8.758	7.311	7.657	9.858	6.122	7.479
X22	6.813	6.776	9.238	9.06	8.327	6.96	6.524	7.999	9.291	7.756
X23	9.801	5.641	7.563	5.097	9.823	5.488	7.443	6.466	6.819	5.657
X24	5.397	7.678	8.663	8.242	6.458	7.111	6.737	5.298	7.08	5.385
X25	7.242	6.851	5.189	8.282	9.845	8.509	5.273	6.859	9.256	6.595
X26	7.349	5.781	7.859	5.05	9.982	8.734	8.192	6.154	6.473	7.009
X27	9.742	8.255	8.584	8.459	6.423	9.434	6.088	7.129	5.154	8.439
X31	5.503	7.194	7.737	8.686	8.396	6.33	5.51	6.396	6.641	6.806
X32	9.168	5.898	8.614	8.775	9.387	9.493	5.402	8.041	7.368	8.025
X33	9.436	7.649	9.633	5.154	5.763	9.308	9.665	9.877	5.2	9.49
X34	8.787	7.87	9.215	7.351	9.473	9.455	6.961	9.669	9.792	8.436
X35	5.999	5.282	6.769	6.133	8.125	9.529	6.94	5.118	8.713	5.189
X36	9.529	9.198	7.111	5.712	8.034	5.782	7.165	9.951	7.181	6.945
X37	7.931	6.564	5.892	9.479	8.334	9.759	9.986	5.15	5.199	6.951

Table 8: The result of data standardization processing

Index	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
X11	0.108	0.104	0.952	0.939	0.518	0.000	0.598	0.202	1.000	0.007
X12	0.902	0.637	0.382	0.000	0.290	1.000	0.055	0.251	0.364	0.082
X13	0.667	0.900	0.593	0.171	0.301	0.405	1.000	0.366	0.151	0.000
X14	0.005	0.729	0.901	0.235	1.000	0.611	0.454	0.732	0.531	0.000
X21	0.508	0.046	0.050	0.450	0.706	0.318	0.411	1.000	0.000	0.363
X22	0.104	0.091	0.981	0.917	0.652	0.158	0.000	0.533	1.000	0.445
X23	0.995	0.115	0.522	0.000	1.000	0.083	0.496	0.290	0.364	0.118
X24	0.029	0.707	1.000	0.875	0.345	0.539	0.428	0.000	0.530	0.026
X25	0.441	0.357	0.000	0.664	1.000	0.713	0.018	0.359	0.873	0.302
X26	0.466	0.148	0.570	0.000	1.000	0.747	0.637	0.224	0.289	0.397
X27	1.000	0.676	0.748	0.720	0.277	0.933	0.204	0.430	0.000	0.716
X31	0.000	0.531	0.702	1.000	0.909	0.260	0.002	0.281	0.358	0.409
X32	0.921	0.121	0.785	0.824	0.974	1.000	0.000	0.645	0.481	0.641
X33	0.907	0.528	0.948	0.000	0.129	0.880	0.955	1.000	0.010	0.918
X34	0.645	0.321	0.796	0.138	0.887	0.881	0.000	0.957	1.000	0.521
X35	0.200	0.037	0.374	0.230	0.682	1.000	0.413	0.000	0.815	0.016
X36	0.900	0.822	0.330	0.000	0.548	0.017	0.343	1.000	0.347	0.291
X37	0.575	0.292	0.153	0.895	0.658	0.953	1.000	0.000	0.010	0.372

(3) Calculation of standardized values

Based on the above data standardization process, the entropy weight method mentioned above was used to calculate the standardization of each indicator. The standardized values are shown in Table 9. Based on the data in the table, it can be seen that the maximum standardized value for urban safety development from 2014 to 2023 is 0.265, and the minimum value is 0, which lays the theoretical foundation for the calculation of the weights of each evaluation indicator for urban safety development in the following text.

(4) Calculation of entropy values, variability, and indicator weights

This paper uses the entropy weight method to calculate the entropy values, variability, and indicator weights of each evaluation indicator. The results of the entropy values, variability, and indicator weights are shown in Table 10. The data show that the weight values for X1 to X3 are 0.3225, 0.3486, and 0.3289, respectively, while the weight values for the secondary indicators are 0.0917, 0.0716, 0.0725, 0.0867, 0.0729, 0.0568, 0.0724, 0.0514, 0.0476, 0.0270, 0.0205, 0.0449, 0.0301, 0.0482, 0.0448, 0.0650, 0.0729, and 0.0230, respectively.

Table 9: Standardized value

Index	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
X11	0.024	0.023	0.215	0.212	0.117	0.000	0.135	0.226	0.001	0.001
X12	0.228	0.161	0.097	0.000	0.073	0.252	0.014	0.092	0.021	0.021
X13	0.146	0.198	0.130	0.038	0.066	0.089	0.220	0.033	0.000	0.000
X14	0.001	0.140	0.173	0.045	0.192	0.118	0.087	0.102	0.000	0.000
X21	0.132	0.012	0.013	0.117	0.183	0.083	0.107	0.000	0.094	0.094
X22	0.021	0.019	0.201	0.188	0.134	0.032	0.000	0.205	0.091	0.091
X23	0.250	0.029	0.131	0.000	0.251	0.021	0.125	0.091	0.030	0.030
X24	0.007	0.158	0.223	0.195	0.077	0.120	0.095	0.118	0.006	0.006
X25	0.093	0.076	0.000	0.141	0.212	0.151	0.004	0.185	0.064	0.064
X26	0.104	0.033	0.127	0.000	0.223	0.167	0.142	0.064	0.089	0.089
X27	0.175	0.119	0.131	0.126	0.048	0.164	0.036	0.000	0.126	0.126
X31	0.000	0.119	0.158	0.225	0.204	0.058	0.000	0.080	0.092	0.092
X32	0.144	0.019	0.123	0.129	0.152	0.156	0.000	0.075	0.100	0.100
X33	0.144	0.084	0.151	0.000	0.021	0.140	0.152	0.002	0.146	0.146
X34	0.105	0.052	0.130	0.022	0.144	0.143	0.000	0.163	0.085	0.085
X35	0.053	0.010	0.099	0.061	0.181	0.265	0.110	0.216	0.004	0.004
X36	0.196	0.179	0.072	0.000	0.119	0.004	0.075	0.075	0.063	0.063
X37	0.117	0.060	0.031	0.182	0.134	0.194	0.204	0.002	0.076	0.076

Table 10: Entropy value, degree of variation, and index weight results

First-level indicator	Weight	Secondary indicators	Entropy value	Degree of variation	Weight
X1	0.3225	X11	0.7413	0.2587	0.0917
		X12	0.7980	0.2020	0.0716
		X13	0.7954	0.2046	0.0725
		X14	0.7555	0.2445	0.0867
X2	0.3486	X21	0.7943	0.2057	0.0729
		X22	0.8398	0.1602	0.0568
		X23	0.7957	0.2043	0.0724
		X24	0.8550	0.1450	0.0514
		X25	0.8657	0.1343	0.0476
		X26	0.9239	0.0761	0.0270
		X27	0.9422	0.0578	0.0205
X3	0.3289	X31	0.8734	0.1266	0.0449
		X32	0.9152	0.0848	0.0301
		X33	0.8641	0.1359	0.0482
		X34	0.8736	0.1264	0.0448
		X35	0.8167	0.1833	0.0650
		X36	0.7944	0.2056	0.0729
		X37	0.9353	0.0647	0.0230

III. B. 2) Analysis of assessment results

(1) Weighted processing

Based on the weights of the above indicators, the urban safety development assessment data for 2014–2023 was weighted, and the weighted results are shown in Table 11. After weighting, the distribution range of the urban safety development assessment data for 2014–2023 was 0.106–0.829.

(2) Euclidean distance and proximity of positive and negative ideal solutions

Based on Table 11, the Euclidean distance and proximity of positive and negative ideal solutions were calculated, and the results are shown in Table 12. According to the table, the larger the value of c_i, the better the city's safety development capability. Conversely, the smaller the value of c_i, the poorer the city's safety development capability. As shown in the data in the table, in the safety development assessment analysis of cities from 2014 to 2023, the city's safety development capability was optimal in 2018 and poorest in 2023. The assessment results reflect the trend of city safety development from 2014 to 2023.

Table 11: Weighted processing result

Index	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
X11	0.553	0.551	0.814	0.810	0.680	0.519	0.704	0.582	0.829	0.521
X12	0.652	0.578	0.508	0.402	0.482	0.679	0.417	0.471	0.503	0.425
X13	0.567	0.638	0.544	0.416	0.455	0.487	0.669	0.475	0.409	0.363
X14	0.452	0.671	0.722	0.522	0.752	0.635	0.588	0.672	0.611	0.451
X21	0.585	0.459	0.460	0.569	0.638	0.533	0.558	0.719	0.446	0.545
X22	0.387	0.385	0.525	0.515	0.473	0.395	0.371	0.454	0.528	0.441
X23	0.710	0.408	0.548	0.369	0.711	0.397	0.539	0.468	0.494	0.410
X24	0.277	0.395	0.445	0.424	0.332	0.366	0.346	0.272	0.364	0.277
X25	0.345	0.326	0.247	0.394	0.469	0.405	0.251	0.326	0.441	0.314
X26	0.198	0.156	0.212	0.136	0.270	0.236	0.221	0.166	0.175	0.189
X27	0.200	0.169	0.176	0.173	0.132	0.193	0.125	0.146	0.106	0.173
X31	0.247	0.323	0.347	0.390	0.377	0.284	0.247	0.287	0.298	0.306
X32	0.276	0.178	0.259	0.264	0.283	0.286	0.163	0.242	0.222	0.242
X33	0.455	0.369	0.464	0.248	0.278	0.449	0.466	0.476	0.251	0.457
X34	0.394	0.353	0.413	0.329	0.424	0.424	0.312	0.433	0.439	0.378
X35	0.390	0.343	0.440	0.399	0.528	0.619	0.451	0.333	0.566	0.337
X36	0.695	0.671	0.518	0.416	0.586	0.422	0.522	0.725	0.523	0.506
X37	0.182	0.151	0.136	0.218	0.192	0.224	0.230	0.118	0.120	0.160

Table 12: European-style distance and closeness degree results

Year	d_i^+	d_i^-	c_i
2014	1.871	2.044	0.5221
2015	2.311	1.604	0.4097
2016	1.656	2.259	0.5770
2017	2.440	1.474	0.3766
2018	1.373	2.541	0.6492
2019	1.881	2.033	0.5194
2020	2.255	1.660	0.4240
2021	2.068	1.847	0.4718
2022	2.111	1.803	0.4607
2023	2.940	0.974	0.2489

IV. Conclusion

This paper establishes selection criteria and a preliminary urban safety development evaluation indicator system based on evaluation criteria and relevant literature. To make the evaluation indicator system more aligned with research requirements, the Delphi method is used to revise and improve the evaluation indicator system. Subsequently, the entropy weight-TOPSIS algorithm is employed to construct an urban safety development assessment model, which is then used to conduct an in-depth analysis of urban safety development levels from 2014 to 2023. The proximity value for the level of urban safety development in 2018 was calculated to be 0.6492. A higher value indicates a more outstanding level of urban safety development in 2018, thereby fully revealing the trends in urban safety development from 2014 to 2023.

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