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Retraction

Retracted: Risk Evaluation Study of Urban Rail Transit Network Based on Entropy-TOPSIS-Coupling Coordination Model

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] F. Gao, Z. Zhang, and M. Shang, "Risk Evaluation Study of Urban Rail Transit Network Based on Entropy-TOPSIS-Coupling Coordination Model," *Discrete Dynamics in Nature and Society*, vol. 2021, Article ID 5124951, 8 pages, 2021.

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Research Article

Risk Evaluation Study of Urban Rail Transit Network Based on Entropy-TOPSIS-Coupling Coordination Model

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As one of the core systems of a city, urban rail transit plays a pivotal role in ensuring the safe, rational, and efficient operation of the city. Therefore, it is of great significance to ensure the safe operation of urban rail transit network to improve the operation efficiency and economic level of the city. The prerequisite to ensure the safety of urban rail transit network is whether the risk situation of urban rail transit network can be reasonably and accurately evaluated. In order to evaluate the risk level of urban rail transit network reasonably and accurately, firstly, with full consideration of the characteristics of urban rail transit, the risk evaluation system of urban rail transit network was established in this paper based on the three levels of regional economy, social resources, and rail transit. Secondly, based on the entropy-TOPSIS-coupling coordination model, the single-factor influence and multifactor coupling influence in the index system are calculated and analyzed, respectively; thus the coupling coordination degree of urban rail transit system is obtained, so as to quantitatively evaluate and analyze the risk situation in urban rail transit network. Finally, based on the actual data of Shanghai from 2000 to 2016, the case simulation and analysis are carried out. The results show that the two indicators of regional economy and social resources are more likely to affect the safety state of urban rail transit. At the same time, the safety factor of urban rail transit coupling system is increasing year by year and gradually develops from disorder to order. This is more in line with current urban rail transit condition, demonstrating the rationality and accuracy of the entropy-TOPSIS-coupling coordination model proposed in this study.

1. Introduction

Urban rail transit is a kind of public transportation that transports a large number of passenger flows in the form of corresponding vehicles through a dedicated track structure, and it occupies a very important position in the urban system. A reasonable and safe urban rail transit network can greatly improve the efficiency and economic level of urban development. The construction of a reasonable and safe urban rail transit network cannot be achieved without an accurate evaluation of the risk of the existing urban rail transit network. Therefore, in order to establish a reasonable risk evaluation system of urban rail transit network, a risk evaluation method of urban rail transit based on the entropy-TOPSIS-coupling coordination model is proposed in this paper, aiming to accurately evaluate the risk situation of urban rail transit network, so as to lay a solid theoretical foundation for optimizing and perfecting urban rail transit network.

Relevant scholars have conducted a series of research on the evaluation of urban rail transit planning and have achieved certain research results. The research content mainly focuses on the exploration, improvement, and optimization of the evaluation model; for example, Yixiu Song [1] used the Analytic Hierarchy Process (AHP) to evaluate the rail transit planning and compared each evaluation index of the transportation planning to obtain its relative importance. Jing Li [2] established a comprehensive evaluation model of traffic network by combining the relative theory of topology and entropy for the shortcomings of the existing urban rail transit network evaluation index system. Chaoxia Su [3] proposed a comprehensive evaluation method of urban traffic network planning and constructed the comprehensive evaluation model of urban rail transit network by fuzzy evaluation method. Yong Jiang [4] believed that the material element analysis model can provide an operable method for VFM evaluation of urban rail transit PPP projects, reduce the subjectivity in the evaluation process, and improve the scientific and reasonable evaluation results. Xin Liu [5] proposed an evaluation model based on the extension cloud theory for the characteristics of urban rail transit safety evaluation, taking advantage of the uncertain reasoning of the cloud model and the quantitative analysis of the extension theory. Xu XD [6] evaluated the potential benefits and limitations of deploying eco-driving strategies on different transit services, service areas, fleet composition, and road terrain. Bin S [7] proposed a quantitative method to evaluate the performance of urban subway network under different damage scenarios. Hy et al. [8] proposed a vague fuzzy matter-element model for the risk assessment of urban rail transit projects by combining vague set and matter-element theory. Hu et al. [9] provided an improved DS/AHP method in this study for the evaluation of hazard source for urban rail transit risk evaluation with incomplete information. Aydin [10] proposed a fuzzy-based multidimensional and multiperiod service quality evaluation outline for rail transit systems. Wang et al. [11] used the grey incidence method for evaluating the hazards of urban rail transit dynamic operating systems and conducting quantitative analysis of risks in the operation process.

At the same time, scholars prefer to use various types of evaluation models in combination, so that the evaluation method is more efficient and reasonable. For example, Ying Wang et al. [12] used AHP method and entropy method to determine index weight and applied TOPSIS method to determine the ideal scheme of line network and selected the optimal scheme by comparing the gap between each scheme and the ideal scheme. Bingyi Qian et al. [13] combined entropy method and expert method to determine the evaluation indexes, combined with TOPSIS method to calculate the pros and cons of each scheme and the optimal solution to determine the optimal scheme, and verified by practical case. Zhifeng Zhou [14] proposed the correlation function as the qualitative index for screening in order to evaluate the service level of transfer stations more reasonably. Ruisong Zhao [15] analyzed the basic form of rail network layout and the suitable form of rail network layout, improved the calculating method of existing rail network scale, and also improved the Analytic Hierarchy Process (AHP) network layout method, established the evaluation index system of line network layout, and constructed the evaluation model. Xie [16] constructed an evaluation model based on ISM-ANP-Fuzzy to evaluate the interface risk in urban rail transit PPP projects. Huang et al. [17] proposed a technique for order preference entropy by similarity to ideal solution (TOPSIS) method to evaluate the operational performance of urban rail transit systems from the perspective of operators, passengers, and government. Wu et al. [18] evaluated the urban rail transit operation safety based on an improved CRITIC method and cloud model. Bouraima MB [19] used a combined SWOT matrix and Analytic Hierarchy Process (AHP) to evaluate the priority factors and to employ them in developing strategies for the railway transportation system.

Most of the above literature only makes quantitative analysis on the single index factor in the evaluation of urban rail transit; the influence situation and coupling condition between index factors were not calculated and analyzed. Therefore, based on the discussion of the above literature, the entropy-TOPSIS-coupling coordination model evaluation method of urban rail transit is proposed by combining entropy weight method, TOPSIS method, and coupling coordination model. Combined with the relevant traffic system data of Shanghai from 2000 to 2016, the system risk and coordination degree are quantitatively analyzed and comprehensively analyzed, and the development of Shanghai's rail transit system in these ten years is obtained.

2. Identification of Evaluation Index

The evaluation index system of the urban rail transit planning network is the key to measuring the results of the traffic system scheme, as well as an important precondition for picking the most reasonable traffic system scheme. This index system needs to comprehensively reflect the traffic system's economic efficiency, social development, network structure, operation effect, and other rail transit characteristics. Based on an analysis of the related literature's index system, combined with the characteristics of the city and the needs of social development, and in accordance with the principles of strong purpose, hierarchy, science, rationality, ease of operation, and the quantitative and qualitative combination, the evaluation index system of urban rail transit network is constructed in this paper from three aspects of regional economy, social resources, and urban rail transit, as shown in Table 1.

3. Evaluation Modeling

Step 1. Statistical panel data of three potential variables in Shanghai from 2000 to 2016 are defined as kth, where kth denotes the three subsystems of regional economy (E), social resources (S), and urban rail transit (T), respectively; kth is the$k$th second index under the subsystem, $k = 1, 2, 3, \ldots, l, l \in N^{+}$; jth is the$j$th year to be evaluated, $j = 1, 2, 3, \ldots, n, n \in N^{+}$. The initial matrix of the subsystem $\mathrm{X}_i = [x_{i,k,j}]_{l\times n}$ is expressed as

$$\mathrm{X}_i = \left[x_{i,k,j}\right]_{l\times n} = \begin{bmatrix} x_{i,1,1} & x_{i,2,1} & x_{i,3,1} & \cdots & x_{i,l,1} \\ x_{i,1,2} & x_{i,2,2} & x_{i,3,2} & \cdots & x_{i,l,2} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{i,1,n} & x_{i,2,n} & x_{i,3,n} & \cdots & x_{i,l,n} \end{bmatrix}. \quad (1)$$

Step 2. For each subsystem separately, the entropy weight method is used to calculate the weight of the kth second index in the$j$th time period. The smaller the entropy

Table 1: System of evaluation indicators for urban rail transit systems.

Target layer	Criterion layer	Index layer	Description
Evaluation of urban rail transit systems	Regional economy	Total GDP (E1)	Annual gross regional product
		Investment in urban infrastructure (E2)	Annual city investment in the engineering and social infrastructure necessary for survival and development
		Investment in traffic service (E3)	Annual investment in necessary tools for transportation, such as machinery and equipment and communication equipment
		Population density along the rail (E4)	Average number of people per unit area of land along urban rail lines per year
	Social resources	Number of hospital beds (S1)	Total number of people using beds in all hospitals within the urban rail system per year
		Number of park visitors (S2)	Total number of people visiting all parks within the urban rail system per year
		Number of mall patrons (S3)	Total number of people patronaging all shopping malls within the urban rail system per year
		Total number of jobs along the rail (S4)	Total number of jobs along urban rail lines that provide money-making opportunities for citizens per year
		Total number of students enrolled along the rail (S5)	Total number of students enrolled in all schools along the urban rail line per year
		Building area of houses along the rail (S6)	Total above-ground floor space along urban rail lines per year
	Rail transit	Urban rail mileage (T1)	Total length of lines in normal operation in the urban rail system
		Daily average flow of rail transit (T2)	Daily passenger volume of urban rail system
		Peak hourly cross-sectional flow (T3)	The peak number of passengers passing through each section of the rail line in the same direction per unit time
		Rail transit share (T4)	The ratio of trips made by urban residents choosing rail transit to total trips

value, the larger the entropy weight, indicating that the more informative the indicator is, the more important the indicator weight will be. Firstly, the initial matrix is normalized to eliminate the dimension problem, and the normalized matrix $Y_i = [y_{i,k,j}]_{l\times n}$ of subsystem i is formed as follows:

$$y_{i,k,j} = \frac{\left[\left(x_{i,k,j}\right)_{\max} - x_{i,k,j}\right]}{\left[\left(x_{i,k,j}\right)_{\max} - \left(x_{i,k,j}\right)_{\min}\right]}, \quad \forall i, k, j, \tag{2}$$

where k^{th} is the value after normalization and k^{th} and k^{th} are the maximum and minimum values of k^{th}, respectively. Calculate the entropy value $e_{i,k}$ of the k^{th} second index under subsystem i as follows:

$$\begin{aligned} e_{i,k} &= -\frac{1}{\ln n}\sum_{j=1}^{n} f_{i,k,j} \cdot \ln\left(f_{i,k,j}\right), \\ f_{i,k,j} &= \frac{y_{i,k,j}}{\sum_{j=1}^{n} y_{i,k,j}}, \quad \forall i, k, j, \end{aligned} \tag{3}$$

when $f_{i,j,k} = 0$; let $f_{i,j,k} \times \text{In } f_{i,j,k} = 0$. Calculate the entropy weight $\varpi_{i,k}$ by using the entropy value of the kth second index under subsystem i as follows:

$$\varpi_{i,k} = \frac{\left[1 - e_{i,k}\right]}{\left[l - \sum_{i=1}^{l} e_{i,k}\right]}, \quad \forall i, k, \tag{4}$$

Step 3. Using the normalization matrix $Y_i = [y_{i,k,j}]_{l\times n}$ of subsystem i and the entropy weights $\varpi_{i,k}$ of the kth second index under subsystem i, the normalization matrix of the subsystem is weighted as $U = [u_{i,j}]_{m\times n}$:

$$\begin{aligned} u_{i,j} &= y_{i,k,j} \times \varpi_{i,k}, \\ \mathrm{U} = \left[u_{i,j}\right]_{m\times n} &= \begin{bmatrix} u_{1,1} & u_{2,1} & u_{3,1} \\ u_{1,2} & u_{2,2} & u_{3,2} \\ \vdots & \vdots & \vdots \\ u_{1,n} & u_{2,n} & u_{3,n} \end{bmatrix}. \end{aligned} \tag{5}$$

Then the probability of subsystem i in the jth year is

$$t_{i,j} = \frac{u_{i,j}}{\sum_j u_{i,j}}, \quad \forall i, j. \tag{6}$$

Step 4. Repeat Step 2 and calculate the weight of subsystem i for the jth time period using the entropy weight method. Form the normalization matrix $R = [r_{i,j}]_{m\times n}$,

$$r_{i,j} = \frac{\left[\left(u_{i,j}\right)_{\max} - u_{i,j}\right]}{\left[\left(u_{i,j}\right)_{\max} - \left(u_{i,j}\right)_{\min}\right]}, \quad \forall i, j. \tag{7}$$

Calculate the entropy weight ϖ_i by the entropy value of subsystem i:

$$\varpi_i = \frac{\left[1 - e_i\right]}{\left[m - \sum_{i=1}^{m} e_i\right]}, \quad \forall i. \tag{8}$$

Step 5. Use the TOPSIS method to solve the comprehensive evaluation index C_j of the urban rail transit system in the jth year, first calculating the weighting matrix$O = [o_{i,j}]_{m\times n}$:

$$o_{i,j} = \varpi_i \times r_{i,j}, \quad \forall i, j. \tag{9}$$

Determine optimal S_i^+ and inferior solutions S_i^- for the weighted value of subsystem i:

$$\begin{aligned} S_i^+ &= \max\left(o_{i,1}, o_{i,2}, o_{i,3}, \ldots, o_{i,n}\right), \quad \forall i, \\ S_i^- &= \min\left(o_{i,1}, o_{i,2}, o_{i,3}, \ldots, o_{i,n}\right), \quad \forall i. \end{aligned} \tag{10}$$

Calculate the Euclidean distance between the weighted value for the jth year and the optimal and inferior solutions:

$$\begin{aligned} \text{sep}_j^+ &= \sqrt{\sum_{i=1}^{m}\left(S_i^+ - o_{i,j}\right)^2}, \quad \forall j, \\ \text{sep}_j^- &= \sqrt{\sum_{i=1}^{m}\left(S_i^- - o_{i,j}\right)^2}, \quad \forall j. \end{aligned} \tag{11}$$

Calculate the overall evaluation index $C_j = \text{sep}_j^- / \text{sep}_j^+ + \text{sep}_j^-, \forall j, C_j \in [0,1]$ of urban rail transit systems for the jth year:

$$C_j = \frac{\text{sep}_j^-}{\text{sep}_j^+ + \text{sep}_j^-}, \quad \forall j, C_j \in [0,1]. \tag{12}$$

Step 6. Calculate coupling B_j of multiple factors in the$j$th year. The smaller the deviation between the single factors, the greater the coupling among the factors. Calculate deviation B_v by selecting the formula corresponding to the number of subsystems to be coupled:

$$B_v = S_i \cdot M \sum t_{i,j} \times \sqrt{2\left[1 - \frac{\sum\left(t_{i',j} \times t_{i,j}\right)}{M\left(\sum t_{i,j}/M\right)^2}\right]}, \tag{13}$$

where S_i is the standard deviation of accidents caused by a single factor; M is the number of coupled subsystems to be calculated, $2 \le M \le 5, M \in N^+$, let $B' = M\sum (t_{i_I,j} \times t_{i,j}) / \sum (t_{i,j})^2$, $t_{i_I,j} \times t_{i,j}$ is the product of the probability of two coupled subsystems, and the larger B', the smaller the deviation. The index is mainly used to evaluate the annual risk coupling strength between the subsystems of urban rail transit coupling model, and at the same time the evaluation results are given to propose decoupling measures. The coupling degree of multifactor risk coupling is calculated by the following formula:

$$B_j = \sqrt[M]{\frac{M\sum\left(t_{i_I,j} \times t_{i,j}\right)}{\left(\sum t_{i,j}\right)^2}}, \quad \forall j. \tag{14}$$

Step 7. Calculate the comprehensive coordination index V_j of probability in the jth year; this index is mainly used to evaluate the orderly and disorderly development of urban rail transit system every year. The more orderly the system develops, the more likely it will lead to safety accidents.

$$V_j = \frac{\sum_{i=1}^{m}\left(t_{i,j} \times \varpi_i\right)}{\sum_{j=1}^{n}\sum_{i=1}^{m}\left(t_{i,j} \times \varpi_i\right)}, \quad \forall j. \tag{15}$$

Step 8. Calculate the coupling coordination degree K_j of the urban rail transit system in the jth year. This indicator comprehensively considers the characteristics of coupling degree and coordination degree and is mainly used to evaluate the annual coupling strength and orderly and disorderly development between subsystems of urban rail transit coupling model. At the same time, the decoupling method is proposed based on the evaluation results.

$$K_j = \left|\sqrt{B_j \times V_j}\right|, \quad \forall j. \tag{16}$$

The flow chart of the model is shown in Figure 1.

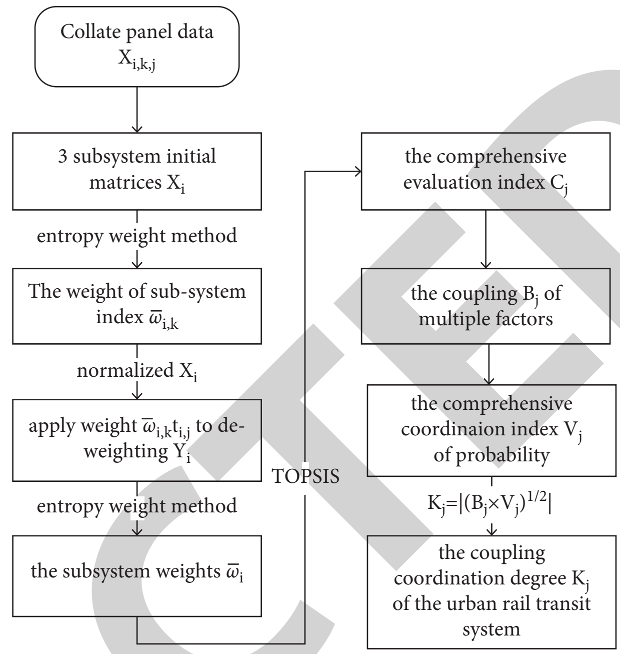

Figure 1: Entropy-TOPSIS-coupling coordination model flow chart.

4. Case Study

Using year as the statistical time period, the panel data of three variables of regional economy (E), social resources (S), and urban rail transit (T) in Shanghai from 2000 to 2016 are counted; the results are shown in Table 2 (see Appendix).

The statistical results of Table 2 show that the economic development of the region is rapid and the investment in infrastructure and transport facilities is increasing, and the growth is increasing over time; in addition, the population density is increasing year by year; the number of times or the number of people using social resources is increasing rapidly; the flow of rail

Table 2: Initial data on regional economy, social resources, and urban rail transportation in Shanghai, 2000–2016.

	Regional economy				Social resources						Rail transit			
Year	Total GDP (E1)	Investment in urban infrastructure (E2)	Investment in traffic service (E3)	Population density along the rail (E4)	Number of hospital beds (S1)	Number of park visitors (S2)	Number of mall patrons (S3)	Total number of jobs along the rail (S4)	Total number of students enrolled along the rail (S5)	Building area of houses along the rail (S6)	Urban rail mileage (T1)	Daily average flow of rail transit (T2)	Peak hourly cross-sectional flow (T3)	Rail Transit Share (T4)
Year	Hundred million	Hundred million	Hundred million	Persons/km	Person	Ten thousand	Person	Ten thousand	Ten thousand	hm2	km	Million passengers/ day	Passengers/ h	%
2000	4771.17	449.9	48.83	1575.13	1100.933	3.037425	303690	195.64	26.01	8917	62.92	42	6232	9.6
2001	5210.12	510.78	60.72	1594.793	1141.098	3.378192	410220	202.38	26.41	11470	62.92	80	6912	7
2002	5741.03	583.49	63.01	1627.999	1162.36	3.481151	470640	224.1	27.0125	12790	62.92	98	7580	8.8
2003	6694.23	604.62	273.77	1945.152	1183.371	4.681288	693240	240.13	27.615	14123	108.65	111	8080	10
2004	8072.83	672.58	316.96	2262.305	1292.254	6.586164	759972.3	244.83	28.2175	16729	121.23	131	8392	11
2005	9164.1	885.74	385.58	2579.396	1492.024	6.119151	841110	290.53	28.82	18333	147.8	163	8861	22.5
2006	10366.37	1125.54	589.52	2699.295	1515.009	6.392849	935715	308.57	29.4225	19588	169.4	180	8948	15
2007	12188.85	1466.33	840.46	2793.656	1557.748	8.024164	1068480	355.07	30.025	21217	234	223	9026	18
2008	14275.8	1733.18	838.91	2786.73	1451.267	10.25247	1210483	374.57	30.6275	21920	264.3	308.21	9745	22.5
2009	15285.58	2113.45	978.24	2880.225	1775.846	10.40956	1775855	374	31.23	24819	355.05	361	10268	32
2010	17433.21	1497.46	754.66	3606.419	2015.141	12.08282	2071563	377.81	32	29188	452.57	516	11056	31.8
2011	19533.84	1157.34	595.75	3702.511	2128.829	10.62455	2121537	384.38	32.82	29634	454.1	576	11274	34.5
2012	20553.52	1038.61	473.43	3759.09	2350	11.22973	2364330	390.042	33.96	28773	510	622	11910	37
2013	22257.66	1043.31	458.7	3817.833	2489.731	11.05578	2509020	465.74	35.45	30277	528.9	687	12501	38.8
2014	24060.87	1057.25	422.48	3836.384	2566.667	11.74501	2690280	452.11	36.02	31795	577	775	12842	43
2015	25643.47	1425.08	759.23	3824.635	2751.32	11.14575	2839740	438.94	36.02	33230	588	841	12956	46.2
2016	28178.65	1551.87	883.81	3830.881	3078.676	8.887014	3140250	440.19	36.38	35436	617	929	13041	51

http://jtw.sh.gov.cn/jttj/index.html; http://tjj.sh.gov.cn/tjnj/20170629/0014-1000339.html.

Table 3: Results of two-factor and three-factor risk coupling calculations.

Year	E-S	E-T	S-T	E-S-T
2000	0.706848266	0.707045225	0.477653744	0.278363504
2001	0.706840272	0.707080423	0.476984636	0.277563834
2002	0.706866093	0.707103581	0.475869973	0.276825274
2003	0.706886642	0.707103555	0.47570298	0.275646204
2004	0.706991312	0.707106312	0.474370109	0.274784144
2005	0.707056031	0.707104543	0.472856308	0.273784565
2006	0.707095162	0.707106271	0.472108388	0.27301559
2007	0.707102599	0.707106736	0.470917514	0.271881172
2008	0.707057535	0.707097484	0.468729786	0.270321168
2009	0.7071	0.707103057	0.471217156	0.268368082
2010	0.707090675	0.707106759	0.470296768	0.26645825
2011	0.707030181	0.70710517	0.468724052	0.265600117
2012	0.707053756	0.707101545	0.46885766	0.264379497
2013	0.706993127	0.707085698	0.467340377	0.263035824
2014	0.706920686	0.707082975	0.466451061	0.261731552
2015	0.706743803	0.707093851	0.465277297	0.260486344
2016	0.706542267	0.707106608	0.464940613	0.25872955

Table 4: Integrated coordination of urban rail transit coupled systems, 2000–2016.

Year	Overall coordination value
2000	0.064319499
2001	0.063911727
2002	0.063578293
2003	0.06276528
2004	0.062219223
2005	0.061646665
2006	0.061083937
2007	0.060285252
2008	0.059427307
2009	0.057899301
2010	0.056771151
2011	0.056293734
2012	0.055560615
2013	0.054835764
2014	0.054052972
2015	0.053268746
2016	0.052080534

transport resources, the sharing rate, and other characteristic values are also increasing every year.

Table 3 shows the two-factor and three-factor risk coupling degree; the results show that the coupling degree of E-S and E-T, regional economic and social resources, is larger in the two factors, while the coupling degree of S-T, that is, social resources and rail transit, is small, indicating that regional economic and social resources are easy to cause accidents.

Table 3 shows the two-factor and three-factor risk coupling; its results show that the coupling in E-S as well as E-T, that is, regional economy and social resources, is larger in the two-factor risk, while the coupling in S-T, that is, social resources and rail transportation, is smaller, indicating that both, that is, regional economy and social resources, are prone to accidents.

Using (15) to calculate the integrated coordination of urban rail transit coupled system in Shanghai from 2000 to 2016, as shown in Table 4, the integrated system coordination maintains a slowly decreasing trend, indicating that the Shanghai urban rail transit system gradually develops from a disorderly state to an orderly state, and the probability of accidents gradually decreases. This is analyzed because the rapid development of Shanghai brings favorable conditions for the improvement of the safety condition of Shanghai's rail transit system.

Table 5: Results of two-factor and three-factor risk coupling coordination.

Year	E-S	E-T	S-T	E-S-T
2000	0.045464126	0.045476794	0.030722449	0.017904201
2001	0.045175382	0.045190731	0.030484912	0.017739584
2002	0.04494134	0.044956439	0.030255001	0.017600078
2003	0.044367938	0.044381553	0.029857631	0.017301011
2004	0.04398845	0.043995605	0.02951494	0.017096856
2005	0.043587646	0.043590637	0.029150014	0.016877905
2006	0.043192156	0.043192835	0.028838239	0.016676867
2007	0.042627859	0.042628108	0.028389381	0.016390425
2008	0.042018525	0.042020899	0.027855349	0.016064459
2009	0.040940596	0.040940773	0.027283144	0.015538324
2010	0.040142351	0.040143264	0.026699289	0.015127142
2011	0.039801369	0.03980559	0.026386227	0.014951622
2012	0.039284341	0.039286997	0.02605002	0.014689087
2013	0.038768508	0.038773585	0.025626967	0.01442377
2014	0.038211164	0.038219936	0.025213066	0.014147368
2015	0.037647356	0.037666003	0.024784738	0.013875781
2016	0.036797098	0.03682649	0.024214355	0.013474773

The coordination degrees between the two-factor and three-factor risk coupling were measured separately using the evaluation model proposed in Part 2, and the degree of coordination of their evolution toward the common system goal (risk) was further analyzed and evaluated objectively, as shown in Table 5. From Table 5, it can be seen that the two-factor and three-factor risk coupling coordination degrees maintain a steady decreasing trend, which represents a low degree of interaction and synergistic evolution among the factors and a low possibility of risk occurrence in the system. Meanwhile, Table 5 shows that the coupling coordinations of the two-factor E-S as well as E-T, that is regional economy and social resources and regional economy and rail transit, are both larger, while the risk coupling coordination of S-T, that is, social resources and rail transit, is smaller, indicating that both, that is, regional economy and social resources and regional economy and rail transit, are prone to accidents. E-S-T, that is, the smallest risk coupling coordination among the three factors of regional economy, social resources, and rail transportation, indicates that this scenario is the least likely to lead to accidents.

Table 6 shows the annual comprehensive risk index of urban rail transit coupling system based on TOPSIS; the higher the value, the safer the system. The results show that the Shanghai urban rail transit system was the least safe in 2000, and the safety factor of the coupled urban rail transit system is increasing year by year after 2000; that is, the system was gradually safe after 2000.

Table 6: Combined risk index and ranking of urban rail transit coupled systems, 2000–2016.

Year	TOPSIS value	Sorted
2000	0	17
2001	0.032291135	16
2002	0.055527455	15
2003	0.122951141	14
2004	0.164184398	13
2005	0.208533961	12
2006	0.255951377	11
2007	0.323101496	10
2008	0.3892544	9
2009	0.521650975	8
2010	0.612688027	7
2011	0.65000222	6
2012	0.709916021	5
2013	0.766845372	4
2014	0.830907081	3
2015	0.896998925	2
2016	1	1

In the end, the range of the evaluation value obtained by the entropy-TOPSIS-coupling coordination model is 1 and the coefficient of variation is 0.718. The larger the range and coefficient of variation, the greater the dispersion and the higher the degree of discrimination of the evaluation value, where the range reaches the maximum. Therefore, the comprehensive evaluation value of the system obtained by the entropy-TOPSIS-coupling coordination model evaluation method is more beneficial to visually assess the level of urban rail transit risk evaluation.

5. Conclusion

(1) This paper proposes an entropy-TOPSIS-coupling coordination model for urban rail transit by combining the entropy weight method, TOPSIS method, and coupling coordination model. The simulation results show that the risk of urban rail transit system can be reasonably evaluated based on this model, and the conclusions obtained are more in line with the actual situation.

(2) The following results can be obtained from the relevant data of Shanghai from 2000 to 2016: compared with other factors, regional economic and social resources are more likely to cause accidents, so managers need to focus on these two factors for reasonable control.

(3) From Table 5, it can be seen that the E-T two-factor coupling coordination degree is the highest in the factor coupling calculation, so managers should try to avoid the coupling condition of regional economic indicators and rail transit indicators.

(4) From Table 6, it can be seen that the safety factor of urban rail transit coupling system is increasing year by year, gradually developing from disorderly state to orderly state, and the risk is in a gradually increasing situation. Therefore, relevant government departments should pay attention to the urban rail transit problem and increase the strength of urban rail transit safety construction.

Subsequent improvements to the system can be carried out by decoupling methods, and theoretical approaches and practical implementation schemes to decoupling methods for urban rail transit systems should be studied in depth in the future.

Data Availability

Previously reported data are used to support this study and are cited at relevant places within the text as references.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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