

Research Article

Evaluation on Sustainable Development of Smart Urban Rail Transit

Xingqun Xue ¹, Yanjiao Zhang ², Lixia Zhang ³, Yiqi Wang ⁴, and Ruochen Hou ¹

¹School of Business, Dalian University of Technology, Panjin 124221, China

²Economic and Management School, Jilin Agricultural Science and Technology University, Jilin City 132101, China

³School of Intellectual Property, Dalian University of Technology, Panjin 124221, China

⁴School of Mechanical Engineering, Dalian University of Technology, Dalian 116024, China

Correspondence should be addressed to Yanjiao Zhang; zhangyanjiao@jlnku.edu.cn

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Objective. The purpose of the current work is to analyze how to employ intelligent technologies, for instance Internet of Things (IoT) and big data to urban rail transit industry, exhibit the effect path of new and high-tech on the intelligent urban rail transit sustainable development and establish an application system for the intelligent urban rail transit industry sustainable development. **Methods.** This paper concludes the affecting factors of intelligent rail transit (IRT) from three terms of environment, economy, and society, establishes the index system constructed from 14 factors, explores the significance together with dependence of each factor through Fuzzy-DEMATEL and ISM, and establishes a structure model of hierarchy. **Conclusion.** The study concludes that the hierarchical structure model includes five levels, and the key to IRT sustainable development is line network planning and intelligent operation. This paper builds the application system of sustainable development of smart urban rail transit, which includes government, enterprises, and users. **Contribution.** In accordance with IoT, big data, and other integrated systems, this study establishes a theoretical framework to evaluate the IRT sustainable development in the context of intelligent technology. By using the scientific method to study the theoretical framework, this paper exhibits the hierarchical effect way of the IRT sustainable development and develops a sustainable development usage system (SDUS) of IRT which can provide theoretical guidance for model application evaluation.

1. Introduction

Rail transit improved air quality, industry structure, safety and reliability, improved living standards [1], and reduced traffic congestion [2]. Although rail transit is a part of the strategy to decrease the impact on the urban environment, China's city rail transit network planning is still in an exploratory phase, and the planning methods and models are not yet perfect. There are problems such as poor consideration of key nodes, poor connection with other modes of transport, difficult connection between lines, repeated construction of common facilities, and disconnection of general equipment, which make it difficult to realize resource sharing, and it directly affects the whole function and efficiency of rail transit network. Meanwhile, often because

there is no reserved engineering condition and facility land in the early date of construction, it will make the construction more difficult, or even impossible to implement. Urban traffic is one of the important functions of a city. Convenient and efficient urban traffic will drive the progress of urbanization, but if the planning of rail traffic is unreasonable, it will also limit the development of the city. For the urban rail transit, it should also be transformed into a high efficiency and energy-saving type considering the sustainable development. Rail transit sustainable development research can not only reduce the negative impact of air pollution caused by residents' travel or safety problems, but also promote green GDP growth and sustainable urban development. As a result, it possesses great importance to explore the rail transit sustainable development. Sustainable

transport is a complex concept involving the sustainability of transport systems, social sustainability, economic sustainability, and environmental sustainability [3]. Science and technology progressed quickly, which has led to the progress of big data and brings new challenges and opportunities to all walks of life and also new ideas to the conventional IRT sustainable development.

The present work on IRT primarily emphasizes the unilateral construction of economy, society, environment, and technology. Some researchers focus on the modification of rail transit in terms of technological revolution. For example, Samanta and Jha [4] developed a genetic algorithm (GA) based on geographic information system (GIS) database and proposed an optimization method for rail transit linear planning considering variable demand cases. Some scholars from the social level, such as Yang et al. [5] studied the existing condition of urban rail transit firefighting facilities, simultaneously summarized their ubiquitous problems, and finally put forward some suggestions for improvement. Yuan et al. [6] discretized the continuous passenger movement process through modeling methods, systematically considered the coordination correlation between the strict constraints of capacity and traffic requirement, and constructed a mixed model of integer linear programming for decreasing the passengers' overall waiting time as far as possible. Some scholars have challenged the building of urban rail transit in terms of the environment. In addition, on the economic front, Wang and Deng [7] presented an approach oriented with efficiency to operational subsidy optimization to minimize the average passenger subsidy. Yap and Munizaga [8] studied the big data use in rail transit, finding that in addition to being used to display immediate passenger or social benefits, big data research may also help operators improve efficiency or increase revenue. In summary, we can see that the existing research is mostly focused on one aspect of urban rail transit optimization, lack of the systematic integration skeleton to conduct the building of intelligent rail transit. Hence, there exist many gaps in the IRT research in the context of big data.

In view of the above problems, for improving the application system of IRT, this paper carries out the following work. First, in accordance with the triple bottom line theory, in terms of sustainable research, and taking the environmental, economic, as well as social aspects of the smart technology application and promotion into account, this paper combines the intelligence and the three, with the aim of emphasizing the sustainability of the city rail transit wisdom, and a theoretical skeleton for the city rail transit sustainable development with the organic combination of society, economy, and environment is established. Second, combining with Fuzzy set theory, Interpretive Structure Model (ISM) as well as Dematel, a multi-level model for decision is constructed to evaluate the function of each index and the relationship among them, based on the stakeholder theory, an integration framework of the system is constructed to guide for the IRT sustainable development.

With this research, we come to the following conclusions: First, the IRT sustainable development skeleton can be divided into five levels, which are different in importance. At

the economic level, the most important issue is to solve the problem of intelligent operation. Second, the social level development is primarily focused on the network planning, and the sustainable improvement of environmental issues should consider social and economic benefits. Eventually, on the basis of ISM model, the paper puts forward the usage system of intelligent city rail transit around three levels, including users, enterprises, and government. The research outcomes give a theoretical reference for the IRT sustainable development.

2. Literature Review

2.1. Smart Rail Transit. Intelligent rail transit (IRT) optimizes all aspects of traditional transportation systems. Yang et al. [9] discuss the four parts of intelligent information processing: intelligent data acquisition, intelligent data fusion, intelligent data mining, and intelligent decision-making. The core of intelligent rail transit is to bring a more rapid, safe, and comfortable intelligent transportation system through modern information technology. Tsang and Zhu (2012) proposed an intelligent rail transit system architecture, which is based on intelligent rail Transit Intelligent Ground Infrastructure (SRT-IGI) and intelligent trains and takes SRT-iot as a platform for information exchange and sharing. The application system of HCA-IMDC is the top-level structure.

The existing research is more from the technical level to research the IRT. To study the safety of intelligent rail transit, Ding et al. [10] designed a device that integrates data collection hardware and algorithmic software to estimate passenger flow and realize intelligent early warning. Ding et al. [11], in accordance with IoT, propose an instant safety warning system for underground engineering to prevent accidents and share early warning information in real time, this increases the safety management level.

In the study of environmental protection of intelligent rail transit, the quick progression of IRT leads to the consumption of a large amount of electricity [12]. Researches show that rail transit uses a lot of electricity to generate large amounts of greenhouse gases [13]. Therefore, using intelligent technology to improve energy efficiency is very necessary; González-Gil et al. [14] and others summarized the energy-saving measures currently available from five aspects: the use of regenerative braking, the implementation of eco-driving strategies, minimizing traction losses, reducing energy requirements for comfort functions, and effective measurement and intelligent management of energy flows. And a two-step model of linear optimization model can decrease the total energy consumed via the train and increase the regenerative energy generated as far as possible when the train is braking. Lannuzzi and Tricoli [15] proposed an energy management control algorithm for Metro trains. The combination of energy management control and motor drive control has a good energy-saving effect for Metro trains.

In addition, for research on cost reduction, Love et al. [16] argue that the data can be captured by electrification in real-time, which increases safety, productivity, and decision-

making and decreases the emissions of carbon and costs. Smart technologies can also help provide smart assets that react to data, increasing productivity, reducing costs, and making effective decisions. Wu et al. [17] constructed a secondary index system for the safety assessment of the IRT operation in accordance with the modified CRITIC method and cloud model, giving theoretical basis and reference for the IRT operation safety planning.

2.2. Sustainability. Sustainable development should not only consider economic viability, but also consider environmental sustainability and social justice [18]. Dyllick and Hockerts [19] define the sustainability of enterprise economy, social capital, and environmental ecology with the triple bottom line. Using data from the World Bank's database of 219 countries/territories, Eustachio et al. [20] and others developed a system of indicators for sustainable development based on 47 variables of the United Nations SDG. An empirical study conducted by Saunila et al. [21] on 280 S&M enterprises demonstrates the role of sustainable development strategy in the relationship between intelligent technology and sustainable development of enterprises.

The investigation on the sustainability of projects of city rail transit can be summarized into three sides: the concept and theory of sustainability, the way to achieve sustainability, and the evaluation of sustainability. Currently, the international and domestic research focuses more on the way to achieve the sustainability for the projects of city rail transit and less on the assessment index system, evaluation content, and evaluation methods [22]. Sharma and Newman [23] discuss the importance of city rail transit in sustainable development in the developing and developed countries through case studies of cities in London, New York, Hong Kong, and India. With an aim of exploring the impact of city development density on the rail transit services financial sustainability, Wang and Lo [27] discussed the urban density threshold to guarantee the rail transit services financial sustainability. System dynamics model was established by Yang et al. [3] for studying the effect of city rail transit systems on city areas in terms of transportation, economy, environment, and society. Based on the existing research literature, Table 1 is established.

3. Research Methodology

3.1. Fuzzy-DEMATEL

Step 1: For the problems in research, an affecting factor system is established, which is set as N_1, N_2, \dots, N_n .

Step 2: The influence correction between each approach is identified based on the expert scoring approach and expressed in matrix form. Experts were invited to assess the correlation between the approaches of utilizing language operators "very strong impact (VH)," "strong impact (H)," "weak impact (L)," "very weak impact (VL)," and "no impact (N)." The initial expert assessment is transformed into triangular fuzzy number according to semantic table as displayed in Table 2.

Transformation from linguistic variable to the triangular fuzzy number.

$$w_{ij}^k = (a_{1ij}^k, a_{2ij}^k, a_{3ij}^k). \quad (1)$$

Here, K represents the experts' questionnaire, and j and i , respectively, denote the number of columns and rows in questionnaire.

Step 3: Utilizing CFCS approach, the original value of the expert score is defuzzified to acquire the n -order direct effect matrix Z . The direct effect matrix exhibits the factors' direct impact, containing the below steps:

(i) Standardize triangular fuzzy numbers

$$\begin{aligned} xa_{1ij}^k &= \frac{(a_{1ij}^k - \min a_{1ij}^k)}{\Delta_{\min}^{\max}}, \\ xa_{2ij}^k &= \frac{(a_{2ij}^k - \min a_{1ij}^k)}{\Delta_{\min}^{\max}}, \\ xa_{3ij}^k &= \frac{(a_{3ij}^k - \min a_{1ij}^k)}{\Delta_{\min}^{\max}}. \end{aligned} \quad (2)$$

Among them $\Delta_{\min}^{\max} = \max a_{3ij}^k - \min a_{1ij}^k$. In turn, we can calculate xa_{1ij}^k , xa_{2ij}^k , and xa_{3ij}^k .

(ii) Standardize right and left values

$$\begin{aligned} xls_{ij}^k &= \frac{xa_{2ij}^k}{(1 + xa_{2ij}^k - xa_{1ij}^k)}, \\ xrs_{ij}^k &= \frac{xa_{3ij}^k}{(1 + xa_{3ij}^k - xa_{2ij}^k)}. \end{aligned} \quad (3)$$

(iii) Count the clearing value following defuzzification

$$x_{ij}^k = \frac{[xls_{ij}^k(1 - xls_{ij}^k) + xrs_{ij}^k xrs_{ij}^k]}{[1 - xls_{ij}^k + xrs_{ij}^k]}, \quad (4)$$

$$z_{ij}^k = \min a_{1ij}^k + x_{ij}^k \times \Delta_{\min}^{\max}.$$

(iv) Count the mean clear value

$$z_{ij} = \frac{(z_{ij}^1 + z_{ij}^2 + \dots + z_{ij}^k)}{n}. \quad (5)$$

Step 4: The direct effect matrix Z was normalize for acquiring the direct effect matrix G after standardized

$$\lambda = \frac{1}{\max_{1 \leq i \leq n}} \sum_{j=1}^n z_{ij}, \quad (6)$$

$$G = \lambda Z.$$

TABLE 1: Interfering factor of intelligent rail transit.

Indicators		Explanation	References
N1	Smart supply chain	The use of intelligent technology for the supply chain transformation, to save the cost of enterprises	Yuan et al. [6]
N2	Smart finance	In the enterprises' financial management, the application of big data and other technologies to improve work efficiency, in-depth analysis of financial information, and improve data processing utilization	He et al. [25]
N3	Profitability	Use of big data and other technologies to optimize ticket pricing and advertising	Wang and Lo [27]
N4	Intelligent operation	Construction of electronic, digital, automated operation, and management system, can achieve efficient operation and management, reduce operating costs	Love et al. [16]
N5	Coordination of economic development	With the government data, with the rail transit development and urban economic status quo, future planning	Gonzalez et al. [26]
N6	Social satisfaction	Through big data and other technologies to collect consumer experience of rail transit, and targeted to enhance the sense of experience	Celik et al. [27]
N7	Line network planning	Making use of big data to plan station, route planning and the setting of transfer station is helpful to alleviate urban congestion	Wang [28]
N8	Intelligent operation support system	Use technical means to monitor, warn and rescue accidents before, during and after accidents, so as to reduce the hazards of accidents	Ding et al. [10]
N9	Emergency management	Collect passenger flow data for early warning of passenger flow, and prepare plans through learning past cases and daily simulation, so as to quickly analyze and invoke emergencies	Chen et al. [29]
N10	Environmental cost control	The intelligent technology is used to control the environmental cost in the construction stage, and the damage cost is counted and minimized	Li and Yin [30]
N11	Pollution control of intelligent environment	Intelligent technology will be used to monitor the reaction of the possibly affected population and take remedial measures	Song et al. [31]
N12	Proportion of new energy	Environmental effect on the production technology selection in supply chain	Sun et al. [32]
N13	Environmental protection	Using big data to reduce groundwater damage during construction	Yan [33]
N14	Energy efficiency	Through optimizing the train stop time and running time, train speed control, off-peak power control to improve energy utilization	Pan et al. [34]

TABLE 2: Semantic shift table.

Linguistic variables	Triangular fuzzy number
N	(0, 0, 0.2)
VL	(0, 0.2, 0.4)
L	(0.2, 0.4, 0.6)
H	(0.4, 0.6, 0.8)
VH	(0.8, 1, 1)

Step 5: The composite matrix T is counted through this formula

$$T = G + G^2 + \dots + G^n,$$

or

$$T = G(E - G)^{-1}. \quad (7)$$

Here, E represents an identity matrix.

Step 6: In matrix T , add the elements row by row, utilized as an effect degree D_i , and it expresses the factors' complex effect value in this line on other factors. Next, in matrix T , add the elements column after column, utilized as the effect degree R_i , which describes the factors' comprehensive effect value in this column on all other factors. This is the formula:

$$D_i = \sum_{j=1}^n t_{ij} \quad (i = 1, 2, \dots, n), \quad (8)$$

$$R_i = \sum_{i=1}^n t_{ij} \quad (i = 1, 2, \dots, n).$$

The sum of effect degree together with effect degree is known as centrality m_i , and it denotes the location of the approach in system and the degree of influence. Between the affected degree together with effect degree, the difference is known as causal degree n_i , and it reveals the causal association among effect approaches. When the causal association exceeds 0, the factor has a more significant effect on other factors, which is known as causal factor. When the causal correlation is below 0, this factor is largely influenced via other factors, which is known as result factor. The formula is

$$m_i = D_i + R_i t_{ij} \quad (i = 1, 2, \dots, n), \quad (9)$$

$$n_i = D_i - R_i t_{ij} \quad (i = 1, 2, \dots, n).$$

Step 7: In accordance with these studies, for each approaches, their significance and interaction are analyzed, and policy suggestions are proposed for the actual system.

3.2. ISM

Step 1. Count the overall effect matrix F . The formula is

$$\begin{aligned} H &= T + E \\ &= h_{ij}. \end{aligned} \quad (10)$$

Here, the matrix I denotes an identity matrix;

Step 2. The redundant information in the most compact matrix is eliminated by introducing threshold. With trial calculation, the most appropriate model of threshold calculation is acquired. The formula is

$$\lambda = \alpha + \beta. \quad (11)$$

In the above equation, α and β represent the mean together with the standard deviation for all of the elements existing in T .

Step 3. In accordance with the system's overall effect matrix and the threshold of eliminating redundancy factors, the reachability matrix M is acquired.

$$\begin{aligned} M &= [m_{ij}]_{n \times n}, \quad (i = 1, 2, \dots, n; j = 1, 2, \dots, n), \\ m_{ij} &= \begin{cases} 1, & h_{ij} \geq \lambda, \\ 0, & h_{ij} < \lambda, \end{cases} \quad (i, j = 1, 2, 3, \dots, n). \end{aligned} \quad (12)$$

In the above formula, 1 and 0 indicates that there exists or not exist the direct effect between two factors, respectively.

Step 4. For each factor, the antecedent set and accessibility set were identified, and acquire the antecedent set S_i and accessibility set R_i through hierarchical processing.

$$\begin{aligned} R_i &= \{a_j | a_j \in A, k_{ij} \neq 0\}, \quad (i = 1, \dots, m), \\ S_i &= \{a_j | a_j \in A, k_{ij} \neq 0\}, \quad (i = 1, \dots, m). \end{aligned} \quad (13)$$

Step 5. Examine the following. If true, it means that the associated factor is the basic factor and subsequently deletes the columns and rows associated with the factor in matrix M .

$$R_i = R_i \cap S_i. \quad (14)$$

Step 6. The steps 4 and 5 are repeated prior to the factor set N_q ($q = 1, 2, \dots, n$) is acquired at each degree, and next delete all the factors in the reachability matrix M .

Step 7. Based on the matrix gathered in step 6, draw the hierarchy chart of affecting factors according to the order of excluded factors.

4. Outcomes

We selected 7 experts with at least 10 years of working experience from urban construction administration and transportation planning department to obtain the original data. Then treat the original data in accordance with the CFCS approach, and evidently identify the direct effect matrix between IRT influence factors. Then according to formula (7), a composite impact matrix T is gathered, as displayed in Table 3.

Calculate the influence, affected, center, and cause as reflected in Table 4, and then create the cause-and-effect chart as displayed in Figure 1.

The 14 risk factors are classified as cause set and result set according to the positive and negative results of the formula (9). As shown in Table 4 and Figure 1, there are five cause factors, including $N1$ intelligent supply chain, $N4$ intelligent operation, $N7$ line network planning, $N8$ intelligent operation support system, and $N9$ emergency management. $N4$ and $N7$ are the main indicators of the IRT sustainable development, and the corresponding influence degrees are both over 4.5, which are the two largest among all factors; the two factors possess the largest effect on other factors. $N4$ is intelligent operation, through the establishment of electronic, digital, and automated operation management system, to achieve efficient operation management and reduce operating costs. The index is a combination of wisdom and economy. The profitability of traditional urban rail transit is poor, and the cost of follow-up maintenance is high. However, under the framework of IRT sustainable development, the operating cost is effectively reduced, and indicators must be updated. The $N7$ is a network plan that uses big data to plan sites, routes, and transfer stations to ease congestion in cities. This is the combination of wisdom and society; the planning of intelligent line network can fully exert the social attributes of city rail transit. Therefore, it should take the establishment of the theory of intelligent urban rail transit system into account.

The results were based on eight factors, including $N2$ intelligent finance, $N5$ coordinated economic development, $N6$ social satisfaction, $N10$ environmental cost control, $N11$ intelligent environmental pollution control, $N12$ new energy proportion, $N13$ environmental protection, and $N14$ energy efficient utilization. These factors have less influence on the construction of intelligent rail transit (IRT), but they are more easily affected by other factors. Hence, attention should be paid to and appropriately controlled in management to increase the prevention effect. The reachability matrix is exhibited in Table 4.

The common set and reachable set in Figure 2 intersect with $N6$, $N12$, and $N13$ factors; thus, first-order influence factors are composed of $N6$, $N12$ together with $N13$ elements. Remove the columns and rows of $N6$, $N12$ together with $N13$ mapping of effect factors existing in matrix M to gather a greater decomposition matrix. For each layer, the factor set N_q ($Q = 1, 2, \dots, 5$) is attained through multi-level division: $L1 = \{N6, N12, N13\}$; $L2 = \{N5, N11, N14\}$; $L3 = \{N2, N3, N10\}$; $L4 = \{N1, N8, N9\}$; $L5 = \{N4, N7\}$.

The analysis of ISM model shows that the intelligent operation of $N4$ and the planning of $N7$ line network are the key factors for the IRT sustainable development. To sum up, the factors that affect the IRT sustainable development are very complex, environmental, economic, and social factors interact. However, various factors have different methods, degrees, mechanisms, and influence, which forms the system integration frame of IRT sustainable development and explores the scientific application frame.

TABLE 3: The aggregate effect matrix T .

	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14
N1	0.088	0.278	0.273	0.074	0.284	0.233	0.099	0.213	0.207	0.273	0.280	0.241	0.234	0.283
N2	0.055	0.092	0.177	0.057	0.239	0.155	0.057	0.065	0.070	0.169	0.232	0.161	0.156	0.242
N3	0.064	0.214	0.106	0.063	0.264	0.171	0.062	0.110	0.067	0.210	0.260	0.178	0.172	0.262
N4	0.246	0.257	0.253	0.097	0.259	0.241	0.251	0.257	0.253	0.254	0.252	0.248	0.242	0.261
N5	0.036	0.083	0.081	0.052	0.080	0.247	0.053	0.053	0.038	0.081	0.144	0.253	0.239	0.145
N6	0.040	0.063	0.061	0.081	0.059	0.073	0.082	0.043	0.041	0.062	0.054	0.182	0.178	0.056
N7	0.246	0.257	0.253	0.246	0.259	0.241	0.102	0.257	0.253	0.254	0.252	0.248	0.242	0.261
N8	0.192	0.259	0.263	0.066	0.273	0.224	0.070	0.092	0.190	0.263	0.269	0.231	0.225	0.272
N9	0.166	0.257	0.245	0.065	0.258	0.215	0.075	0.170	0.079	0.253	0.259	0.222	0.216	0.261
N10	0.058	0.199	0.196	0.073	0.247	0.159	0.061	0.068	0.061	0.095	0.239	0.165	0.160	0.241
N11	0.034	0.080	0.078	0.051	0.173	0.226	0.051	0.039	0.035	0.078	0.071	0.244	0.238	0.153
N12	0.038	0.060	0.059	0.079	0.057	0.156	0.079	0.041	0.040	0.059	0.052	0.071	0.156	0.054
N13	0.041	0.065	0.064	0.083	0.088	0.185	0.083	0.044	0.042	0.064	0.058	0.189	0.080	0.060
N14	0.034	0.079	0.078	0.051	0.159	0.237	0.051	0.038	0.035	0.078	0.150	0.243	0.237	0.071

5. Discussions

In this work, fuzzy-DEMATEL approach is employed for dividing the factors influencing the IRT sustainable development according to three frameworks: intelligent economy, intelligent society, and intelligent environment. ISM model is applied to establish a multi-level framework of intelligent city rail transit and a systematic system of IRT sustainable development.

The IRT sustainable development is determined by the improvement of two factors: $N4$ (intelligent operation) and $N7$ (network planning). $N4$ and $N7$ are at the top level of the IRT sustainable development skeleton, representing that these two factors have a greater impact on other factors. They are in the dimensions of smart economy and smart society, respectively. The establishment of intelligent society and intelligent economy on the basis of big data possesses great effect on the IRT sustainable development. Also, urban rail transit has a high operation cost. Urban rail construction enterprises can achieve efficient operation management and reduce the cost of operation and maintenance by building electronic, digital, and automatic operation management system [16]. In addition, companies can use big data records, guide passenger traffic [35], route planning [36], reasonably planned stations, and transfer stations to ease congestion in cities.

$N1$ (intelligent supply chain), $N8$ (the support system of intelligent operation), and $N9$ (emergency management) are at the second degree of the assessment system. Urban rail transit construction enterprises can use intelligent technology to transform the supply chain to save costs [6]. For the sake of decreasing the conduction and maintenance cost, the technical means can be utilized to record the use of equipment. The study of Operation Log Information System can enhance the rail transit safety, and identify and analyze the risk, monitoring and early warning before, during, and after the accident [11], to mitigate the effects of the accident. Enterprises can also use big data and other technologies to collect passenger flow data for passenger flow early warning [10]; it also allows you to document case studies and day-to-day simulations, prepare scenarios, and quickly analyze and invoke them in an emergency [37].

TABLE 4: Comprehensive impact matrix analysis.

	D	R	m	n
N1	3.062	1.339	4.400	1.723
N2	1.927	2.243	4.171	-0.316
N3	2.201	2.187	4.388	0.013
N4	3.372	1.138	4.510	2.235
N5	1.586	2.698	4.284	-1.112
N6	1.076	2.761	3.837	-1.686
N7	3.372	1.176	4.548	2.196
N8	2.890	1.490	4.380	1.399
N9	2.740	1.412	4.152	1.329
N10	2.022	2.194	4.216	-0.172
N11	1.549	2.572	4.122	-1.023
N12	1.002	2.876	3.878	-1.875
N13	1.144	2.776	3.919	-1.632
N14	1.542	2.621	4.164	-1.079

$N2$ (smart finance), $N3$ (profitability), and $N10$ (environmental cost control) are at level 3 of the evaluation system. In the enterprise financial management, the application of big data technique can significantly improve work efficiency, and can analyse financial information in depth, improve data processing utilization. In addition, the use of smart technology can also optimize fare-setting [7], advertising, and reduce the financial pressure on enterprises. Unlike general railway construction, the construction phase of rail transit will have an impact on the city. Therefore, the environmental impact of underground lines of urban rail transit may include land subsidence and waste residue disposal, while the environmental impact of ground lines is mainly represented by vibration and noise [7] and the image of the city and the lives of its residents. The intelligent technology is used to control the cost of the surrounding environment in the construction stage, and the damage cost can be counted and minimized.

$N5$ (coordination of Economic Development), $N11$ (intelligent environmental pollution control), and $N14$ (energy efficiency) are at the fourth level of the assessment system. The establishment of urban rail transit has a huge investment and a long creation cycle, and it will expand with the improvement of the city. Enterprises can combine data from relevant government departments; it provides the

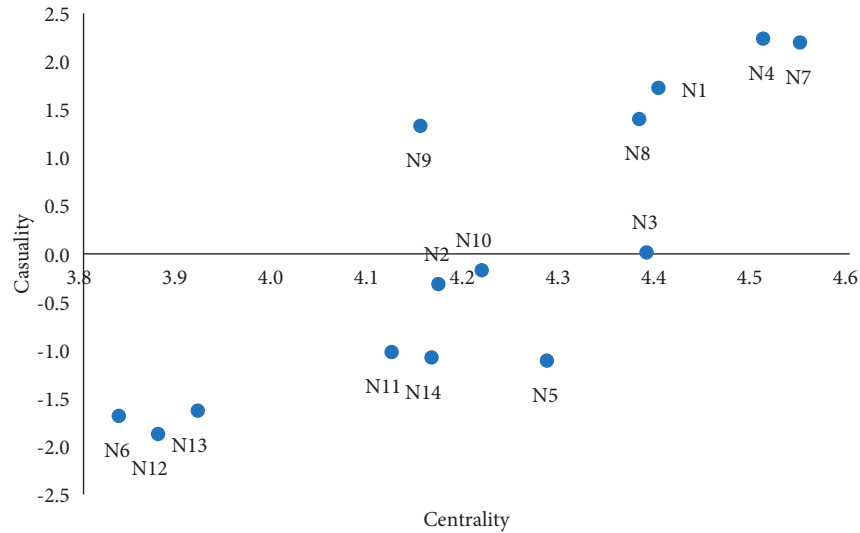


FIGURE 1: DEMATEL causal chart.

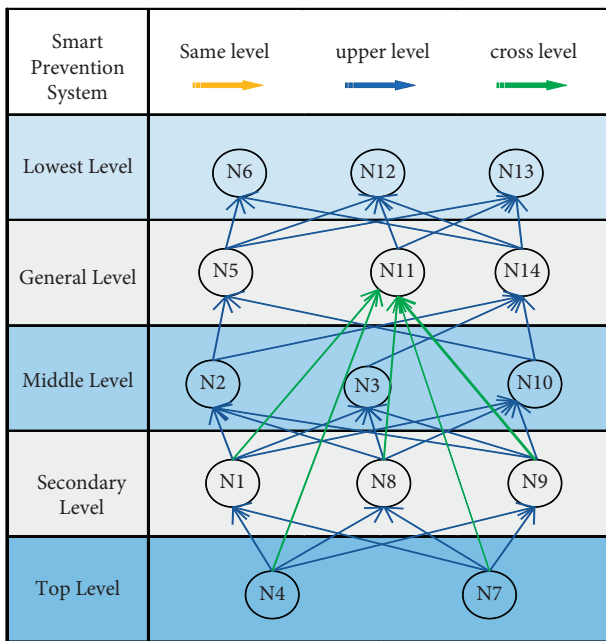


FIGURE 2: Structure image of ISM model of effect factors.

important reference for the government to optimize the urban traffic structure and advance the urban competitiveness. In addition, as the urban rail transit network expands continuously in China, as for the relevant government departments, controlling network expansion rate and budget allocation is crucial [1]. Government departments need a channel to understand and estimate the performance of the entire urban rail transit network, and after the establishment of IRT, the residents' reaction around the track can be monitored by intelligent technology, and the residents' living experience can be optimized by taking targeted remedial measures. Companies can also reduce energy use in conjunction with power stations, improve energy use by optimizing the stopping time and running time of trains [38], train speed control [39] and off-peak electricity control,

and build an energy Internet, recovery, and reuse of braking energy using distributed energy storage [14, 38].

N6 (Social Satisfaction), N12 (new energy ratio), and N13 (environmental protection) are at the fifth level of the evaluation system. Customer-centered is the trend in modern society. Through big data and other technologies, consumers' experience of rail transit is collected and targeted to enhance their sense of experience, measures such as setting up theme trains [40], setting up dedicated workshops for passengers in need, and stepping up security checks [41] to enhance the passenger experience. Urban rail transit aims to reduce congestion and reduce car emissions [42], but in practice, it consumes a lot of electricity [12]. To achieve the goal of reducing carbon dioxide, it must rely on the power industry to actively develop new energy for power generation [43]. Rail transit enterprises can introduce the concept of green supply chain [42] and pay attention to the environmental impact of the choice of production technology in the supply chain. The underground construction of rail transit may affect the trend of terrain, and then affect the flow of groundwater. The destruction of groundwater in the construction process is decreased by utilizing big data.

In order to better explain this theoretical system, we further develop a sustainable development usage system (SDUS) of IRT, which is based on stakeholder theory, as reflected in Figure 3. The model is classified into three levels, including user level, industry level, and government level. First of all, in order to make urban planning more appropriate, the traffic information can be integrated by the departments of urban construction. Transportation departments can integrate information on urban rail transit safety, for the daily situation of urban rail transit security alarm, sudden events such as fire, stampede, sudden increase in passenger flow need security maintenance, and other situations classified and handled in a timely manner. Secondly, by using the technology of blockchain to record accurately the business of the enterprise related to the rail transit, enterprises, auditing institutions, and accounting institutions can process the transaction information via

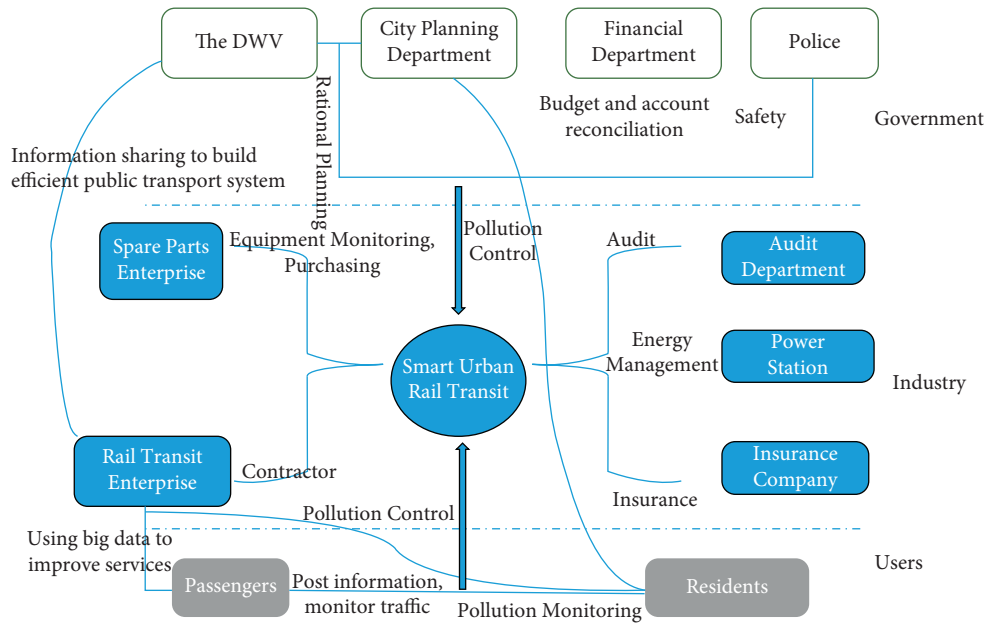


FIGURE 3: Operable structure diagram.

blockchain technique. The financial and tax authorities can audit authorized companies to make tax administration more convenient. Insurance institutions, as the third-party enterprise, can use blockchain technology to realize electronic uploading and intelligent storage of insurance contracts [44]. Internally, enterprises can use the IoT, big data, as well as other techniques to monitor the internal equipment of the enterprise and purchase the required equipment in a timely manner. Secondly, the power station as the upstream rail transit enterprises can cooperate with the enterprise to store the distribution of energy recovery. Finally, in the user layer, the user layer is divided into ordinary passengers and surrounding residents. Through collecting passenger's feedback, we can adjust the service of rail transit continuously, pay attention to the pollution that the establishment and conduction of rail transit may cause to the surrounding residents, and carry out the remedy in time to realize the benign interaction with users.

6. Conclusions

At present, there are some studies about rail transit, which focus on a particular aspect of optimization, short of an integration framework of system. In comparison with the early studies, this work integrates the intellectual background and establishes 14 index systems from the three dimensions of environment, society, and economy on the basis of triple bottom line. In accordance with the Fuzzy-DEMATEL-ISM integration approach, the interaction between the IRT sustainable development standards is analyzed, and the strength of interaction is identified. Eventually, the hierarchical model of IRT is established, and its path is exhibited. The summary of this work is on the basis of various theories. The integration of novel technologies is also regarded to contribute to the

integration together with system development of IRT, as well as the subsequent progression and guidance.

There are some limitations in this paper. First of all, although we have built a novel indicator system, it cannot be avoided that some indicators may still be missing. This needs further exploration and perfection of the future research. Secondly, according to the questionnaire data filled in by experts, the relationship between indicators and influence degree is processed and analyzed. Although the subjective bias of experts can be reduced to some extent by using fuzzy set theory in this study, there still exist errors that cannot be fully eliminated, which may possess a specific effect on the research outcomes of this study. In the future, relevant researches should solve these problems through more effective ways and means and constantly improve the thinking and research of smart urban rail transit in the context of big data.

Data Availability

All the data in this manuscript can be obtained from the corresponding author upon request through email.

Conflicts of Interest

The authors declare no conflicts of interest.

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