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Operating Efficiency-Based Data Mining on Intensive Land Use in Smart City

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ABSTRACT The discordance between the operation of rail transit and surrounding land use is highlighted with the rapid construction of rail transit in China. The related research on coupling relationship is well needed. Taking 13 typical commercial service rail transit stations in Xi'an as the example, this article established the evaluation indicator of coordinated relationship between rail transit station operating efficiency and land use, and a data envelopment analysis (DEA)model was used to evaluate the coupling degree between them. According to the research results, the coupling development between operating efficiency and land use in Xi'an commercial service rail transit station is at a low level and there exists a huge difference between the two. Moreover, this research identified the key indexes that influence the coupling development of the two, namely Class-A, Class-B, and Class-R land use proportion, plot ratio, land use mixture and parking facility control, and determined the reasonable control range of these four indices. The research promotes the intensive use of land around Xi'an rail transit station and better supports the sustainable operation of rail transit.

INDEX TERMS Commercial service rail transit station, operation efficiency, intensive land use, DEA.

I. INTRODUCTION

With the rapid development of urban rail transit in China, urban diseases represented by traffic jam turn increasingly severe under the combined functions of high-density development, growing urban size and high popularity of vehicles [1]. In the meantime, the contradiction between transportation and land use also becomes more prominent. When cities in China enter the stage of stock development, a fast, comfortable and large-capacity rail transit mode greatly contributes to the relief of traffic congestion [2]. However, without systematic and entire development strategies in urban planning construction, land use planning severely deviates from rail transit planning. At present, many built rail transit stations haven't reached predetermined passenger flow requirements, and surrounding land use functions and development intensity do not consider the connection between stations. This greatly affects rail transit operating efficiency so that rail transit can't authentically alleviate urban traffic congestion. While as a major functional type of rail transit station, commercial service rail transit station is generally built in downtown area featured by massive land use for commercial service facilities, clustering of population and great economic vigor. As a result, against the background of fast development of rail transit, it seems in particular necessary and urgent to discuss the coupling relation between commercial service rail transit station and surrounding intensive land use, improve station operating efficiency and better support the sustained development of rail transit.

At present, more and more scholars at home and abroad are devoted to the research on the relation between rail transit operating efficiency and land use, and have gained brilliant achievements in theory and empirical model [3]–[6]. In respect of theory, it has been proved that rail transit operating efficiency and surrounding intensive land use mutually affect and constrain each other [7]–[10]. On the one hand,

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rail transit improves land use accessibility, and attracts urban residents and workers to gradually settle in places close to rail transit stations, which enriches the commercial and employment activities in downtown area and promotes intensive land use in urban space and surrounding land plots [11], [12]. On the other hand, in need of massive passenger flow, it heavily relies on surrounding land development, and requests high-density land development and clustering of population and workplace to increase operating efficiency. Among them, Pan suggested that urban public activity centers could ensure high rail transit rate and thus sustained the economical objective of rail transit. At the same time, changes of land around rail transit stations affected the traffic volume of rail transit and further passenger flow of rail transit stations [13]. CHOI suggested that mixed land use reduced vehicle transportation, and increased rail transit passenger flow [14]. Tan found that reinforced land development intensity could attract more passenger flow for rail transit stations, and the increase of passenger flow in turn promoted surrounding land development [15]. Wang thought land use as the source of urban transportation, and judged that land use mode and functional layout determined gross transportation demands [16].

In terms of the evaluation model of the coupling relationship between urban rail system and land use, represented by domestic scholars shao and Yang [17], a special study was carried out on the quantitative evaluation of the coupling between urban rail system and land use, including the system cloud gray model, distance coordination model, DEA model, fuzzy-AHP model, hybrid genetic algorithm, etc. [18]–[21]. Among them, DEA model is the evaluation about DMU (Decision Making Unit), applicable for the same input-output system with multiple inputs and outputs. While assessing urban transportation and land use, such multi-indicator sophisticated systems demonstrate irreplaceable advantages over traditional ones [22]–[25]. Pan employed DEA method to plan the coordinated development of land and rail transit [13]. Peng resorted DEA method to observe the interaction between rail transit and urban space use system, judging main influential factors of system coupling, and building an urban rail transit demand forecast model to investigate the influence of land use changes on passenger flow [26].

By reference to above analysis on literature review, it can be easily found that both domestic and foreign scholars overlook discussion about the coupling degree between rail transit station operating efficiency and surrounding intensive land use. At the same time, the quantitative research on the coordination between them is still in its infancy. Therefore, future studies should perceive main factors affecting the coordinated development of urban rail transit stations and surrounding land use, point out the rational quantitative control scope of all indicators to better instruct future planning regulation. This paper chooses 13 commercial service stations and surrounding land in Xi'an as the research subject to explore rail transit station operating efficiency and surrounding land use conditions. Then it takes DEA method to build a coupling development and evaluation model for rail transit station operating efficiency and surrounding land use, and explore the land intensive use indicator control scope that can promote the fast development of commercial service rail transit stations, therefore achieving the coordinated development between rail transit operating efficiency and surrounding intensive land use.

II. SELECTION OF RESEARCH SUBJECT

In order to speed up rail transit construction and alleviate traffic congestion, Xi'an subway was put into use in 2011. There were altogether 18 long-term planning lines (Line1-4 in operation, Line 5-6 under construction) which covered the entire city in a checkerboard radial pattern. Line 1, 2 and 3 are backbone lines, connecting main commercial facilities and residents' travel dense districts in Xi'an built-up area, and Line 4, 5 and 6 are auxiliary lines which connect main districts of the city and create greatest convenience to residents together with Line 1-3. Line 1, 2 and 3 mentioned in this research now have built 63 stations, including 3 transfer stations. Specific passenger flow varies from station to station. Surrounding land near to stations involves all districts across Xi'an city. Moreover, these districts are also greatly varied from one another in population, land property, land economic profits, and other aspects.

For convenience of research, the paper classifies the 63 rail transit stations of Line 1, 2 and 3 in Xi'an according to "site-orientated" classification system, and supplements it with comprehensive transportation indicators [27], [28]. Afterwards, SPSS clustering analysis method is employed to conclude station classification results with a series of input indicators. Finally, the classification results of seven types of stations are obtained, including central commercial service station, general public service station, commercial service station, university education station, general station with low population density, industrial storage station, general station with high population density and station to be developed. Since the indicators of intensive land use of the first three types of stations have little difference in the quantitative relationship, they are combined into one category for analysis, collectively referred to as "commercial service rail transit station", for further research and discussion. Therefore, the commercial service rail transit station in this paper specifically refers to the large proportion of public service and commercial service land, the large population density and strong economic vitality, and is located at the core of the downtown area of city.

The research takes the intensive land use system and station operating efficiency system in 13 commercial service rail transit stations in Xi'an city as the decision-making unit of evaluation (Figure 1). As to the classification of area of coverage, the research selects the area within 10-15 walking distance, i.e. 500m-800m to rail transit stations as the criterion of selection. At the same time, according to the influence intensity of stations on surrounding land, it defines the circle with a radius of 500m as primary influence area and the circle

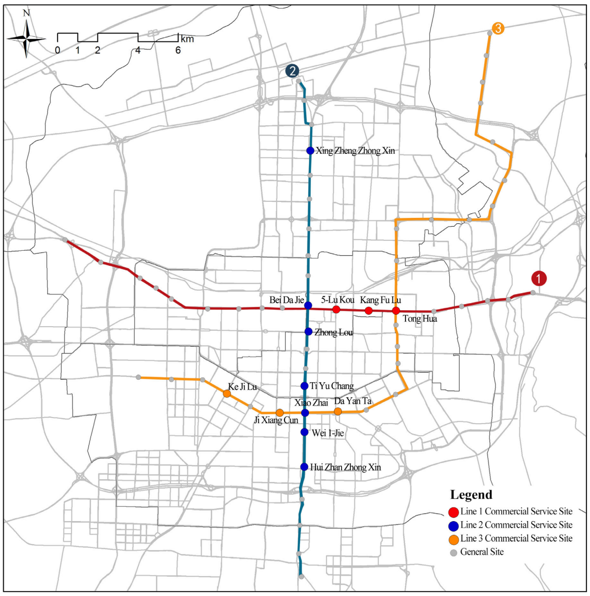

FIGURE 1. Xi'an commercial service rail transit station.

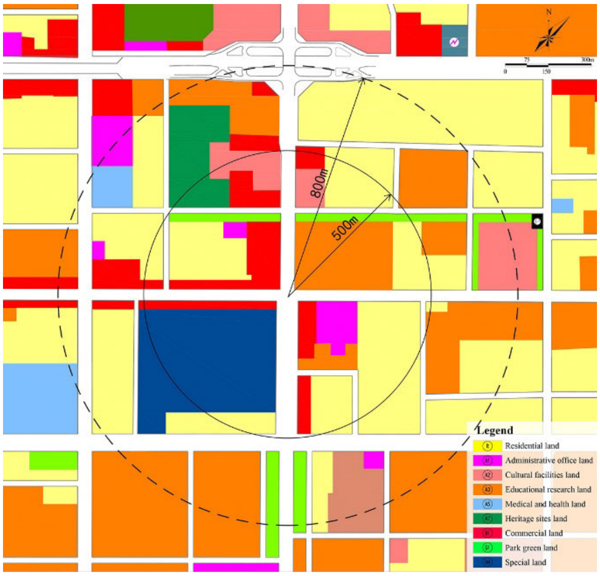

FIGURE 2. Primary and secondary influential scope (taking Xiaozhai Station for example).

formed with two concentric circles with a radius of 500m and 800m as secondary influence area (Figure 2).

III. RESEARCH METHOD AND INDICATOR SYSTEM

A. ANALYSIS FRAMEWORK

Based on the literature review above, since there is a feedback relationship between the rail transit station operating efficiency and the surrounding intensive land use, it can be regarded as the input-output relationship of each other, so the data envelopment analysis can be used to quantitatively evaluate the coupling relationship between the two subsystems.

DEA (data envelopment analysis) refers to a nonparametric statistics analysis method especially applicable for the relative validity evaluation about same input-output systems with multiple inputs and outputs (known as decision-making units, short for DMU). DEA evaluation method can effectively avoid subjective weight analysis, reduce errors and simplify algorithms, improve the accuracy of evaluation results, and has significant objectivity and simplification advantages. The basic thought of DEA is to firstly view each evaluation unit as one DMU, and form the assessed group by multiple DMU. Secondly, pursuant to the comprehensive analysis on input and output ratio, it takes the weight of each DMU input and output indicator as the variable and employs linear planning technology in evaluation and operation to determine valid production front. Next, in accordance with the distance between each DMU and valid production front, it determines if each DMU is effective, and illustrates the cause of non-DEA efficiency or weak DEA efficiency and pertinent improvement direction and degree with the projection method. The main steps of DEA evaluation method consist of evaluation objective determination, input and output indicator system building, modeling establishment and solution, and comprehensive evaluation analysis.

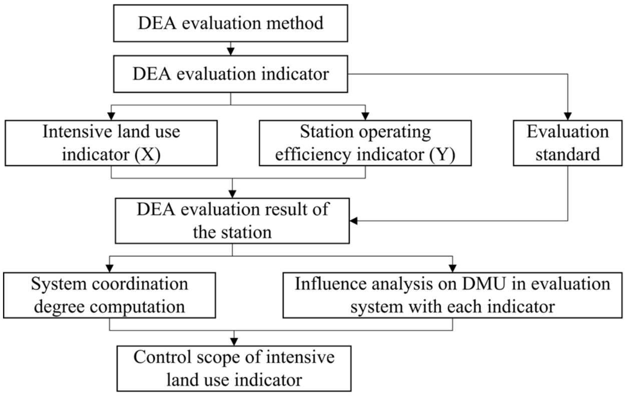

FIGURE 3. Analysis framework.

The overall analysis framework of DEA evaluation method of coupling development is shown in Figure 3. Firstly, DEA evaluation indicator was constructed, which is divided into intensive land use indicator (X) and station operating efficiency indicator (Y). At the same time, a four-level coupling evaluation standard is established. Secondly, the DEA evaluation result of the station is divided into two steps: system coordination degree computation and influence analysis on DMU in evaluation system with each indicator. Finally, the proposed control scope of intensive land use indicator around the station is determined.

B. EVALUATION INDICATOR

1) BUILDING PRINCIPLE OF EVALUATION INDICATOR SYSTEM

The evaluation indicator should fully reflect rail transit operating efficiency-oriented intensive land use characteristics so as to determine whether station operating condition conforms to surrounding land development condition and whether it is possible to maintain balance of supply and demand. It avoids

TABLE 1. Evaluation indicator definition.

Indicator classification	Indicator name	Indicator code	Computation method
Intensive land use indicator (X)	Plot ratio	X1	Building are/Land area
	Building density	X2	Building floor area/ Building area
	Land use mixture	X3	$HL = -\sum_{i=1}^{n} P_i \ln P_i$ P_i: Percentage of ith land area in gross land area in the district n: Number of land use type in the district
	Class-A land use proportion (%)	X4	Class-A land use proportion/ gross land area in the district
	Class-B land use proportion (%)	X5	Class-B land use proportion/ Gross land area in the district
	Class-R land use proportion (%)	X6	Class-R land use proportion/ Gross land area in the district
	Gross facility POI density	X7	Gross POI/Gross land area in the district
	Facility POI mixture	X8	$HP = -\sum_{i=1}^{n} P_i \ln P_i$ P_i: percentage of ith facility POI number in gross land area in the district n: Facility POI number in the district
	Bus line density	X9	Bus line gross length/ Gross land area in the district
	Parking lot density	X10	Number of parking lots/Gross land area in the district
	Bike density	X11	Mobike number/Gross land area in the district
Station operating efficiency indicator (Y)	Number of average daily passengers of the station	Y1	—
	Number of average daily stops	Y2	—
	Number of average daily vehicles	Y3	—
	Number of average daily stations	Y4	Average daily stations/ Average daily passengers

low operating efficiency caused by insufficient development, and meantime prevents excessive development for fear that transportation demand exceeds rail transit stations' supply ability. While ensuring the diversity of evaluation indicator, attention should be paid to avoiding the strong relation between station operating efficiency or intensive land use indicator, and ensuring the easy access and quantitative processing potential of indicator data.

2) SELECTION OF EVALUATION INDICATOR

On the premise of following evaluation indicator selection principle, the research constructs the coupling relation evaluation indicator between station operating efficiency and intensive land use as shown in Table 1.

C. DEA EVALUATION MODEL

1) SYSTEM COORDINATION DEGREE COMPUTATION

The research chooses classical C^2R model for computation [29]. As the basic model of DEA, C^2R model is an ideal method used to observe multi-input and multi-output DMU and also scale validity and technology validity. Supposing decision-making unit DMU_j $(j=1,2,\ldots,n)$; input vector, output vector $X_j = (x_{1j}, x_{1j}, \ldots, x_{mj})^T, x_j \geq 0, j = 1, 2, \cdots, m$, weight vector of m inputs $V = (v_1, v_2, \ldots, v_m)^T, v_i \geq 0, i = 1, 2, \cdots, m$, weight vector of s inputs $U = (u_1, u_2, \ldots, u_s)^T, u_i \geq 0, i = 1, 2, \cdots, s$. The DMU input-output model of output vector determines DMU_{j0} input and output as (x_{j0}, y_{j0}) (short for (x_0, y_0)), then each DMU evaluation indicator model is as shown by Formula (1).

$$h_{j0} = \frac{u^T Y_0}{v^T X_0} \tag{1}$$

In the validity evaluation on DMU_{j0}, the research chooses u and v as the variable, $(u^T Y_0)/(v^T X_0) \leq 1$ as the constraint, and maximum efficiency indicator of $DMU_{j0}(\max h_{j0})$ as the objective to build DMU efficiency indicator optimal model as shown in Formula (2) and (3).

$$\max h_{j0} = \frac{u^T Y_0}{v^T X_0} \tag{2}$$

TABLE 2. Coupling evaluation standard.

Evaluation grade	No coupling	Basic coupling	Coupling	Complete coupling
Indicator scope	[0,0.6)	[0.6,0.8)	[0.8,1)	1

$$s.t. \ \frac{u^T Y_0}{v^T X_0} \leq 1 \tag{3}$$

Throughout Charnes-Cooper conversion for efficiency indicator model, the research gains the equivalent linear planning model of Formula (4)-(7).

$$\min \theta \tag{4}$$

$$s.t. \ \sum_{j=1}^{n} x_j\lambda_j + s^{-} = \theta x_0 \tag{5}$$

$$\sum_{j=1}^{n} y_j\lambda_j - s^{+} = y_0 \tag{6}$$

$$\lambda_j \geq 0 \quad (j = 1, 2, \cdots, n), \qquad \theta \in R, \quad s^{-} \geq 0, \ s^{+} \geq 0 \tag{7}$$

In the formula, θ is the degree of coordination between intensive land use around rail transit stations and station operating efficiency, and λ_j represents the combined weight of the n_{th} rail transit station, $\sum_{j=1}^{n} x_j\lambda_j$ and $\sum_{j=1}^{n} y_j\lambda_j$ are the input and output vectors of rail transit stations combined according to this weight respectively.

If $(D^I_{C^2R})$ optimal solution satisfies the condition $\theta^0 < 1$, then DMU $_{j0}$ indicates non-DEA validity.

If $(D^I_{C^2R})$ optimal solution satisfies the condition $\theta^0 = 1$, and $\sum_{j=1}^{n} y_j\lambda_j^0 = y_0$ (i.e., $s^{0-} = 1$, $s^{0+} = 1$), then DMU $_{j0}$ indicates weak DEA validity.

Input model C^2R is later adopted to assess the coupling degree between rail transit station intensive land use indicator (X) and station operating efficiency indicator (Y). The combined efficiency of X against Y is $\theta_i.\theta_i(\theta_i \leq 1)$, while combined efficiency of Y against X is $\theta_i'(\theta_i' \leq 1)$. The mutual coordinated development level of coupling degree between two sub-systems - rail transit station i intensive land use and station operating efficiency is θ_{XYi} as shown in Formula (8).

$$\theta_{XYi} = \frac{min\ (\theta_i, \theta_i')}{max\ (\theta_i, \theta_i')} \tag{8}$$

Greater value of θ_{XY} ($\theta_{XY} \leq 1$) suggests higher coupling degree of the mutual development level between station intensive land use condition and station operation condition.

2) INFLUENCE ANALYSIS ON DMU IN EVALUATION SYSTEM WITH EACH INDICATOR

In order to analyze the influence of certain input or output indicator on the coordinated development of (X) and (Y), the research uses D to represent primitive evaluation indicator system, D^i to represent the indicator evaluation indicator system after removing ith indicator from D, and $\theta_j(D)$ and $\theta_j\left(D^i\right)$ to represent the coordinated development indicator of (X) and (Y) respectively under D and D^i in the jth DMU evaluation indicator system as shown in Formula (9).

$$\theta_j(D) - \theta_j\left(D^i\right) \geq 0, \quad j = 1, 2, \ldots, n \tag{9}$$

$\theta_j(D)$ indicates the jth DMU coordinated development indicator of D in evaluation indicator system, and $\theta_j\left(D^i\right)$ indicates the jth DMU coordinated development indicator of D in evaluation indicator system.

For DMU_j, $S_j(i)$ indicates changes of the evaluation system coordinated development index after removing the i indicator as shown in Formula (10).

$$S_j(i) = \frac{\theta_j(D) - \theta_j\left(D^i\right)}{\theta_j\left(D^i\right)}, \quad j = 1, 2, \ldots, n \tag{10}$$

Greater $S_j(i)$ indicates greater significance of ith indicator to the coordinated development of evaluation system.

D. EVALUATION STANDARD

In accordance with the coupling evaluation standard between rail transit station operating efficiency and surrounding intensive land use in Xi'an (Table 2), the research divides commercial service rail transit station and surrounding intensive land use with bi-system coupling development.

Higher coupling evaluation results indicate higher coupling degree between station operating efficiency and surrounding intensive land use, and stronger support given by surrounding intensive land use to sustained station development, and also stronger support given by stations to surrounding intensive land use development. Lower evaluation results indicate lower coupling degree between station operating efficiency and surrounding intensive land use and weaker support given by surrounding intensive land use to sustained station development, and also weaker support given by stations to surrounding intensive land use development.

IV. DATA AND ANALYSIS RESULTS

A. DATA SOURCE

By collecting data from metro operation statistical department and related mobile phone signaling data provided by Smart Footprint Data Science and Technology Company, Ltd, the research accesses the daily number of passengers of each rail transit station in Xi'an in November 2017, and eventually draws related indicator data as shown in Table 3 as below.

TABLE 3. Primitive survey data.

Station	Indicator value														
Name	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	Y1	Y2	Y3	Y4
5-Lu Kou	2.32	0.42	2.18	21.23	29.51	27.59	29.80	1.44	80.93	147.31	6.24	645923	436099.1	460.3	6.75
Kang Fu Lu	2.42	0.37	1.64	44.16	10.74	43.56	16.58	1.14	41.40	49.96	5.32	56052.8	372908.8	460.3	6.66
Tong Hua Men	2.92	0.47	1.53	19.64	27.52	47.23	23.09	1.26	83.15	97.15	7.19	52168.8	5306142	603.4	10.17
Xing Zheng Zhong Xin	1.01	0.19	2.11	22.62	11.62	24.15	4.70	1.37	36.02	50.08	7.20	82782	4613072	603.4	5.57
Bei Da Jie	2.52	0.45	1.86	37.64	14.99	43.42	21.29	1.44	48.05	88.45	6.06	127710	7625683	603.4	5.97
Zhong Lou	3.01	0.58	2.09	21.42	34.32	35.40	40.67	1.42	68.40	128.47	6.64	48764.1	3126542	603.4	6.41
Ti Yu Chang	2.59	0.35	1.91	51.68	10.42	35.73	14.00	1.48	53.75	104.06	6.53	1496662	9112782	603.4	6.09
Xiao Zhai	2.37	0.35	1.82	45.01	14.95	39.32	34.44	1.38	47.31	97.99	6.75	37704.1	2657502	603.4	7.05
Wei 1-Jie	1.87	0.30	1.41	68.21	7.06	23.53	10.29	1.45	39.34	58.46	5.23	716053	5824093	603.4	8.13
Hui Zhan Zhong Xin	2.10	0.27	2.00	30.52	10.45	41.79	11.64	1.44	48.25	89.04	4.42	570949	468798	450.3	8.21
Ke Ji Lu	2.20	0.33	1.92	13.20	29.65	45.02	23.40	1.44	35.48	156.53	7.25	395847	277706	450.3	7.02
Ji Xiang Cun	2.51	0.36	1.60	42.05	10.03	47.55	20.22	1.41	44.65	97.80	6.72	44544.8	2989108	450.3	6.71
Da Yan Ta	1.52	0.28	1.88	38.99	14.82	29.08	11.45	1.39	39.23	54.82	3.55	44544.8	2989108	450.3	6.71

TABLE 4. Coupling degree evaluation results.

DMU	θ	θ'	θ_{XY}
5-Lu Kou	0.725102	1	0.725102
Kang Fu Lu	0.785295	1	0.785295
Tong Hua Men	0.73209	1	0.73209
Xing Zheng Zhong Xin	1	0.829102	0.829102
Bei Da Jie	0.824616	1	0.824616
Zhong Lou	1	1	1
Ti Yu Chang	0.753888	1	0.753888
Xiao Zhai	1	1	1
Wei 1-Jie	0.856573	1	0.856573
Hui Zhan Zhong Xin	0.915938	0.817026	0.89201
Ke Ji Lu	0.677602	1	0.677602
Ji Xiang Cun	0.627017	1	0.627017
Da Yan Ta	0.670284	1	0.670284

B. STATION DEA EVALUATION RESULTS

By applying input C^2R model in the evaluation of rail transit station surrounding intensive land use system (X) and station operating efficiency system (Y) coupling degree, the research concludes the coupling degree evaluation results about the mutual coordination development level between rail transit station operating efficiency and surrounding intensive land use as shown in Table 4.

According to above classification standards, the research divides DMU in 13 commercial service stations in Xi'an. Please refer to Table 5 for specific statistical results.

It has been found that commercial service stations have low coupling degree and there exists a huge difference among these stations. Some of them have complete coupling DMU, and also a large number of basic coupling DMU. While basic coupling DMU outnumbers coupling DMU. In complete coupling DMU, the mutual coordination degree between station intensive land use system and station operation system is at a high level, which proves promotion between the two. In complete coupling stations, both intensive land use level and station operating level are in a favorable state. As surrounding intensive land use condition near to stations fails to coordinate with rail transit operation, intensive land use doesn't proactively facilitate the development of rail transit as expected.

C. STATION $\sum S_j(i)$ AND $\sum S_j'(i)$ RESULT ANALYSIS

In this research, $S_j(i)$ takes intensive land use system (X) as the input system, and rail transit operation system (Y) as the output system, and determines ith indicator as the

TABLE 5. **DMU coupling degree statistics.**

Evaluation standard	Indicator range	Number of DMU
Complete coupling	1	2
Coupling	[0.8,1)	4
Basic coupling	[0.6,0.8)	7
No coupling	[0,0.6)	0

TABLE 6. **$\sum S_j(i)$ and $\sum S'_j(i)$ computation statistics.**

Indicator	$\sum S_j(i)$	$\sum S'_j(i)$
X1 Plot ratio	7.5×10^{-15}	0
X2 Building density	0.090701	0
X3 Land use mixture	0.308832	0.073112
X4 Class-A land use proportion	0.118202	0.235694
X5 Class-B land use proportion	1.06×10^{-14}	2.4×10^{-15}
X6 Class-R land use proportion	0.106592	0.032359
X7 Gross facility POI density	0.088701	0
X8 Facility POI mixture	0.508395	0.001952
X9 Bus line density	0.013748	2.29E-14
X10 Parking lot density	0.000129	0.000345
X11 Bike density	0.036434	0.073705
Y1 Average daily passengers of the station	0.507263	0.025693
Y2 Average daily stops of the station	0.00084	0
Y3 Average daily bus lines of the station	0.188092	0.046428
Y4 Average daily stops of the station	1.6×10^{-15}	0.250423

contribution to coordination degree in X-Y input-output system. By contrast, $S'_j(i)$ later takes rail transit operation system (Y) as the input system, and intensive land use system (X) as the output system, and determines ith indicator as the contribution to coordination degree in Y-X input-output system. Please refer to Table 6 for $\sum S_j(i)$ and $\sum S'_j(i)$ computed as the sum of commercial service station system coordinated development indicators.

As proved by intensive land use input indicators near to rail transit stations, X8 facility POI mixture cumulative sum is the maximum, and X1 plot ratio cumulative sum is the minimum. This implies that commercial type mixture POI information entropy in reaction station influence zone has made greatest contribution to the coordinated development of land system and station system, while land development intensity has made least contribution to such coordinated development.

As proved by rail transit operation output indicator, X1 average daily passenger sum is the maximum, and X4 average daily stop sum is the minimum. This implies that station surrounding intensive land use condition generates maximum influence on average daily passengers, and generates minimum influence on average daily passengers' number of stops.

As proved by rail transit operation input indicator, X4 average daily number of stops is the maximum and X2 average daily number of stops is the minimum. This implies that station passengers' average number of stops has made greatest contribution to land system coordinated development, while average daily passengers' gross number of stops has made least contribution to land system coordinated development.

As proved by rail transit station surrounding intensive land use output indicator, X4 Class-A land use proportion cumulative sum is the maximum, X1 plot ratio, X2 building density, and X7 gross facility POI density cumulative sum is the minimum. This implies that station operation condition generates maximum influence on Class-A land use proportion in station influence zone, but generates minimum influence on building density, land use plot ratio, and all commercial types' distribution density.

TABLE 7. Land planning indicators of station.

Control indicators	Primary influence zone （0-500m）			Secondary influence zone （500-800m）		
	Class-A public service land	Class-B commercial service land	Class-R residential land	Class-A public service land	Class-B commercial service land	Class-R residential land
Proportion	≥30%	≥30%	≤30%	≥25%	≥25%	≤35%
Plot ratio	≥3.0	≥5.0	2.0-3.5	≥2.0	≥3.0	2.0-3.5
Land use mixture	--	--	Mixed commercial proportion 20%-30%	--	Mixed residential proportion 20%-30%	Mixed commercial proportion 10%-20%
Parking facility control	0.8/100m^2	2.0/100m^2	0.8/100m^2	0.9/100m^2	1.6/100m^2	0.9/100m^2

D. ANALYSIS ON EVALUATION RESULTS

Based on sampling stations' intensive land use indicators, the research combines with the research results of DEA evaluation model, and related requirements on building land functions and building intensity in rail transit station influence zone prescribed in *Guidelines for Planning Design of Regions along Urban Rail Transit Lines*, the paper primarily proposes planning control indicator requirements for public management and public service land (A), commercial service facility land (B), residential land (R) in rail transit influence zone. Class-A, Class-B and Class-R types of land have most intimate relation with rail transit as the prime construction land types fulfilling housing, employment and daily living functions. Compared with other types of land, they are more important to the benign development of rail transit. Under the category of operational land, rationally planned and controlled Class-A, Class-B and Class-R types of land can more excavate the potential value of land near to rail transit stations.

1) GENERAL IDEA

Primarily develop Class-B commercial service facility land, then develop Class-A public management and public service land, and rationally control the proportion of Class-R residential land.

2) LAND USE PROPORTION

Set up the land development lower limit of Class-B commercial service land and Class-A public service land, with 30% primary influence zone and 25% secondary influence zone. Set up the land development upper limit of Class-R residential land, with 30% primary influence zone and 35% secondary influence zone.

3) PLOT RATIO CONTROL

The plot ratio lower limit of Class-B commercial service land within the primary influence zone is 5.0, and that of Class-B commercial service land within the secondary influence zone is 3.0. The lower limit of residential land plot ratio is set to build high-rise buildings (middle and high-rise building plot ratio upper limit in Xi'an), and its upper limit is 3.5 (rising by 25% than Xi'an high-rise building plot ratio control standard).

4) LAND USE MIXTURE

Considering the strong commercial service functions in the station, residential land in primary influence zone should increase mixed proportion of commercial land. Commercia land is not proper for mixed residential land. In secondary influence zone, the two types of land both increase mixed use proportion. Moreover, it is suggested that commercia mixed residential proportion should be moderately increased to reinforce job-housing balance.

5) ECONOMIC VIGOR

Facility density inside the zone should be maintained at a high level, better reaching 35 hm^2. Likewise, mixed information entropy of all sorts of facilities had better reach 1.35.

6) REGULAR BUS TRANSFER

Bus station density inside the zone should not be lower than 7.5 km^2, and bus line density had better be kept above 55 km^2.

7) PARKING FACILITIES

Rigorous transportation demand management policies should be executed. Instead of setting up public parking lot in the city, it is better to increase the parking lot construction proportion in commercia land so that surrounding residents can easily take rail transit and travel by P+R mode. The parking lot construction indicators should be reduced on the basis of urban construction indicators, with the aim of encouraging residents in rail transit station influence zone to travel by rail transit.

8) SHARING BIKE SETTING

Sharing bikes should be provided according to demand saturation capacity on the premise of not intervening pedestrians.

V. CONCLUSION

Taking 13 commercial service rail transit stations and surrounding land in Xi'an as the research subject, the paper analyzes present operation conditions and takes DEA evaluation model to perform coupling evaluation, therefore determining the rational control range of four indicators, namely public service land, commercial service land, residential land use proportion in different influence zones, plot ratio, mixed use of land, and parking facility. The research expects to offer rational reference to the favorable development of Xi'an rail transit and surrounding intensive land use.

A. IT CONCLUDES THAT COMMERCIAL SERVICE RAIL TRANSIT STATIONS' COUPLING DEVELOPMENT IN XI'AN CITY IS AT A LOW LEVEL AND GREATLY DISCREPANT

DEA evaluation method is taken to determine station surrounding intensive land use indicator system and rail transit station operating efficiency indicator system, and subsequently build rail transit surrounding intensive land use system and station operating efficiency system coupling evaluation model. From evidence mentioned above, a conclusion is reached that the coupling development level between station and entire land in Xi'an is not very high and greatly discrepant.

B. IT BUILDS A SET OF CONTROL INDICATOR SYSTEM WITHIN TWO MAJOR INFLUENCE ZONES OF COMMERCIAL SERVICE RAIL TRANSIT STATION

Throughout analysis, the research sums up the rational control range of four indicators, namely public service land, commercial service land, residential land use proportion in 0-500m and 500-800m influence zones, plot ratio, mixed use of land, and parking facility of 13 stations and surrounding land in Xi'an. The aim of the research is to promote land use near to rail transit stations and better support the sustained development of rail transit.

The paper will reflect related population data proportional relation of Xi'an according to geometric expansion of Unicom user data. There must be some errors in need of further improvement. Moreover, as the research just focuses on the coordination between commercial service rail transit station operating efficiency and surrounding land, future research work should pay more attention to related research on other types of rail transit stations and surrounding land use.

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