Evaluation Model of Urban-Rural Transportation Integration Development Level

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Abstract. Promoting the urban-rural transportation integration, promoting the extension of public transport facilities to the countryside and the coverage of public transport services to the countryside, are also important measures to promote the construction of new urbanization and achieve a well-off society in an all-round way. The research on the evaluation of the development level of urban-rural transport integration can help us to understand the development status of urban-rural transport integration more clearly, which can promote and guide the urban-rural transport system to achieve coordinated development. By establishing the evaluation index system of the development level of urban-rural transport integration, this paper puts forward the evaluation method of the development level of urban-rural transport integration, objectively and accurately evaluates the development level of urban-rural transport integration, and provides theoretical support and basis for effectively promoting the development of urban-rural transport integration.

1. Introduction
As the pioneer of social and economic development, transportation is the link of urban and rural development, which plays a very important role in coordinating urban and rural development, promoting urban and rural integration, realizing the equalization of public services and eliminating the imbalance between urban and rural development. Integrating transportation resources to promote the urban-rural transport integration, constructing a smooth connection, resource sharing, rational layout, structural optimization, convenient, fast, smooth and orderly, high-quality service system for urban-rural transportation, promoting the extension of public transport services to the countryside, the coverage of public transport services between urban and rural areas are urgent requirements for implementing the policy of “agriculture, countryside and farmers”, speeding up the overall coordination of urban and rural areas, and narrowing the gap in regional development. They are also important measures for promoting the construction of new urbanization and achieving a well-off society in an all-round way.

However, there is a lack of evaluation research on the development level of urban-rural transport integration, which can not objectively and accurately evaluate the development level of urban-rural transport integration, and can not deeply understand the implementation effect of urban-rural transport integration, which seriously affects the improvement of the service level of urban-rural transport integration. Based on this background, this paper will establish an evaluation index system for the development level of urban-rural transport integration, define the evaluation methods, to accurately and
meticulously judge the actual development level of urban-rural transport integration, and provide theoretical support and basis for judging the development level of urban-rural transport integration.

2. Concept intension
Integration of urban and rural transport is to take urban and rural transport as a whole and system, breaking through the existing administrative divisions, institutional boundaries and departmental boundaries, coordinating and optimizing the allocation of urban and rural transportation resources. Through the integration of planning and construction, management policy and standards, which can promote the coordinated development of urban and rural transport, improve the overall efficiency and service level of urban and rural transport, and provide comprehensive and multi-level transport services for the development of urban and rural residents. It can be seen that the development latitude of urban-rural transport integration mainly includes the integration of urban-rural transport planning and construction, the integration of urban-rural transport management policies, and the integration of urban-rural transport laws and standards.

3. Development goals
The integration of urban and rural transportation is an inevitable process with the integration of urban and rural economy and the development of transportation. The weak link is in the countryside. Therefore, the ultimate goal of the integrated development of urban and rural transport is to break the regional boundaries between urban and rural areas, coordinate the development of urban and rural transport, optimize the structure of urban and rural transport infrastructure network and effectively link up, so that urban and rural residents can enjoy equal road travel conditions and transport services. Thus, the gap between urban and rural transportation can be narrowed, the equitable allocation and use efficiency of urban and rural transportation resources can be maximized, the development of urban and rural transportation and the integration of urban and rural development can more adapt to and complement each other, and the ability of sustainable development can be significantly enhanced, ultimately making urban and rural residents enjoy high-quality, convenient and fast transport services.

4. Evaluation index
In order to objectively evaluate the development level of urban-rural transport integration, dynamically monitor the gap between the development goals, thoroughly analyze the existing problems in the process of development and clarify the future development direction, it is necessary to build a set of perfect evaluation index system for the development level of urban-rural transport integration, which scientifically reflects the development level of urban-rural transport integration.

4.1. Thoughts and principles
The main purpose of promoting the integration of urban and rural transportation is to increase the effective supply of public services for urban and rural transportation, accelerate the integration of urban and rural transport infrastructure, urban and rural passenger transport services, urban and rural freight logistics services, and strive to create an integrated development environment for urban and rural transportation, then achieving urban-rural coordination and resource sharing. Therefore, around the four aspects of infrastructure construction integration, urban-rural passenger transport service integration, freight logistics service integration and urban-rural traffic management integration, this paper follows the principles of systematicness, scientificity, objectivity, concise applicability and operability, and selects indicators to establish an evaluation index system for the development level of urban-rural transport integration.

4.2. Construction of evaluation index system
The indicators of the evaluation system for the development level of urban-rural transport integration involve infrastructure construction, passenger and freight transport services, urban-rural traffic management and other aspects. The evaluation indicators are various and numerous. Therefore, this
paper divides the key elements of urban-rural transport integration into three levels: target level, criterion level and index level. By using objective decomposition method and expert consultation method, the four indicators of infrastructure construction integration, urban-rural passenger transport service integration, freight logistics service integration and urban-rural traffic management integration are taken as the target level of the evaluation index system of urban-rural transport integration development level. According to the working measures, the 4 target-level indicators are further decomposed into 13 criterion-level indicators, and then 22 target-level indicators are further decomposed and implemented.

4.3. Determination of Index Weight
Considering that the hierarchical and lateral structure of all levels of indicators in the evaluation index system is obvious, and the content of each index layer can judge the relative importance subjectively. In this paper, Delphi method and analytic hierarchy process are used to establish a judgment matrix to determine the weights of the evaluation index of urban-rural transport integration development level. The steps to determine the weights of evaluation indicators are as follows:

4.3.1. Design questionnaire. According to the evaluation index system of the development level of urban-rural transport integration questionnaire was designed to evaluate the relative importance of multi-level evaluation indicators. The relative importance of the questionnaire was assessed on a scale of 1-9.

4.3.2. Expert inquiry. Questionnaires were sent to many experts in urban and rural transportation field, and different indicators i and j were selected. According to the 1-9 scale method, each independent expert gave a comparative score of index i relative to index j, and then the average score of each expert was extracted as the value of the judgment matrix $a_{ij}$.

4.3.3. Constructing the judgment matrix. For $n$ elements, the judgment matrix of pairwise comparison is $C = (C_{ij})_{n \times n}$. The judgment matrix is in the following form:

$$
\begin{array}{cccc}
B_k & C_1 & C_2 & \ldots & C_n \\
C_1 & C_{11} & C_{12} & \ldots & C_{1n} \\
C_2 & C_{21} & C_{22} & \ldots & C_{2n} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
C_n & C_{n1} & C_{n2} & \ldots & C_{nn} \\
\end{array}
$$

4.3.4. Consistency test. The consistency test of the judgment matrix is carried out. Negative average values of other eigenvalues besides the maximum eigenvalue of the judgment matrix are introduced as an index to measure the deviation consistency of the judgment matrix. The smaller the $CI$ value, the better the consistency of the judgment matrix. The larger the $CI$ value, the greater the deviation of the judgment matrix from the complete consistency.

$$
CI = \frac{\lambda_{max} - n}{n - 1}
$$

4.3.5. Hierarchical ordering. Computing the relative importance of a factor at a certain level relative to a factor at a higher level, the maximum eigenvalue and eigenvector of the judgment matrix are obtained.

(1) Calculate the product $M_i$ of each row element in the judgment matrix.

$$
M_i = \prod_{j=1}^{n} a_{ij} \quad i=1,2,\ldots,n \quad (1)
$$

(2) Calculate the $n$-th root $\overline{W_i}$ of $M_i$. 

3
\[ W_i = \sqrt{M_i} \quad (2) \]

(3) Normalized vector \( W_i \).

\[ W_i = \frac{\sqrt{M_i}}{\sum_{j=1}^n \sqrt{M_j}} \quad (1) \]

Then \( W = [W_1, W_2, \ldots, W_n]^T \) is the eigenvector required.

(4) Computing the Maximum Eigenroot \( \lambda_{\text{max}} \) of Judgment Matrix. According to the hierarchical structure, the ranking values of the relative importance of the lowest level relative to the highest level can be calculated from the upper level to the lower level.

\[ \lambda_{\text{max}} = \sum_{i=1}^n \left( AW \right)_{ii} \]

According to the above steps, the weight values of target layer, criterion layer and index layer of urban-rural transport integration are calculated in turn, as shown in Table 1 below.

| Target Layer A | Criterion Layer B | Index Layer C |
|---------------|------------------|---------------|
| Infrastructure Construction Integration A_1 (0.1504) | Road Network Facilities B_11 (0.6667) | Hardening Road Rate of Constructed Village C_{111} (0.5571) |
| | | Rural Highway Maintenance Rate C_{112} (0.3202) |
| | | Excellent and Medium Rate of Rural Highway C_{113} (0.1226) |
| | Hub Station System B_{12} (0.3333) | Coverage Rate of Urban-Rural Passenger Stations C_{121} (0.6651) |
| | | Coverage Rate of Rural Logistics Network C_{122} (0.1038) |
| | Operational Service Network B_{21} (0.1655) | Convenience Rate of Passenger Station Transfer C_{123} (0.2311) |
| Urban-Rural Passenger Transport Service Integration A_2 (0.4306) | Urban-Rural Passenger Transport Service B_{22} (0.3662) | Constructed Village Passenger Train Rate C_{211} (1.0000) |
| | | Bus Operation Ratio of Urban-Rural Passenger Transport C_{221} (0.2500) |
| | Travel Information Service B_{23} (0.2866) | Travel Passenger Service Responsiveness C_{222} (0.7500) |
| | | Travel Information Service Level C_{231} (1.0000) |
| | Passenger Transportation Safety Guarantee B_{24} (0.1295) | Vehicle Safety Facility Completeness Rate C_{241} (0.6667) |
| Freight Logistics Service Integration A_3 (0.2804) | Rural Logistics Service B_{31} (0.6232) | Traffic Accident Mortality C_{242} (0.3333) |
| | | Integrated Service Capability of Node Facilities C_{311} (0.2395) |
| | | Rural Logistics Specialized Equipment Allocation Rate C_{312} (0.1373) |
5. Fuzzy comprehensive evaluation model

Urban-rural transportation system is a highly coordinated cooperative structure. The evaluation of the development level of urban-rural transportation integration is a multi-level comprehensive evaluation, which needs to establish a multi-level comprehensive evaluation model. Therefore, this paper uses the fuzzy comprehensive rating method based on the analytic hierarchy process to evaluate the development level of urban-rural transport integration.

5.1. Establishing factor gather

Urban-rural transportation integration development level fuzzy comprehensive evaluation factor set as shown in table 2 below.

Table 2. Fuzzy Comprehensive Evaluation Factor Set of Urban-Rural Transportation Integration Development Level

| Target Layer | Criterion Layer | Index Layer |
|--------------|----------------|-------------|
| $U_1 = \{u_{11}, u_{12}\}$ | $u_{11} = \{u_{111}, u_{112}, u_{113}\}$ | Information Level of Rural Logistics $C_{313} (0.6232)$ |
| $U_2 = \{u_{21}, u_{22}, u_{23}, u_{24}\}$ | $u_{21} = \{u_{211}\}$ | Postal Express Service $B_{32} (0.2395)$ |
| $U = \{U_1, U_2, U_3, U_4\}$ | $u_{22} = \{u_{221}, u_{222}\}$ | Postal Rate of Constructed Villages $C_{321} (0.6667)$ |
| $U_3 = \{u_{31}, u_{32}, u_{33}\}$ | $u_{23} = \{u_{231}\}$ | Express outlet coverage $C_{322} (0.3333)$ |
| $U_4 = \{u_{41}, u_{42}, u_{43}, u_{44}\}$ | $u_{24} = \{u_{241}, u_{242}\}$ | Rural Logistics Inter-industry Integration Operation Level $C_{331} (1.0000)$ |
| $U_1 = \{u_{11}, u_{12}\}$ | $u_{12} = \{u_{121}, u_{122}, u_{123}\}$ | Cross-industry Integration Development $B_{33} (0.1373)$ |
| $U_2 = \{u_{21}, u_{22}, u_{23}, u_{24}\}$ | $u_{21} = \{u_{211}\}$ | Government Attention $C_{411} (0.5000)$ |
| $U = \{U_1, U_2, U_3, U_4\}$ | $u_{22} = \{u_{221}, u_{222}\}$ | Coordination Linkage Mechanism $C_{412} (0.5000)$ |
| $U_3 = \{u_{31}, u_{32}, u_{33}\}$ | $u_{23} = \{u_{231}\}$ | Urban-Rural Traffic Management Integration $A_4 (0.1386)$ |
| $U_4 = \{u_{41}, u_{42}, u_{43}, u_{44}\}$ | $u_{24} = \{u_{241}, u_{242}\}$ | Urban-Rural Traffic Management Integration $A_4 (0.1386)$ |
| $U = \{U_1, U_2, U_3, U_4\}$ | $u_{31} = \{u_{311}, u_{312}, u_{313}\}$ | Fund Safeguard $B_{42} (0.2027)$ |
| $U_1 = \{u_{11}, u_{12}\}$ | $u_{32} = \{u_{321}, u_{322}\}$ | Funding Channels $C_{421} (1.0000)$ |
| $U_2 = \{u_{21}, u_{22}, u_{23}, u_{24}\}$ | $u_{33} = \{u_{331}\}$ | Support Policy $B_{43} (0.2590)$ |
| $U = \{U_1, U_2, U_3, U_4\}$ | $u_{33} = \{u_{331}\}$ | Supporting Policies $C_{431} (1.0000)$ |
| $U_3 = \{u_{31}, u_{32}, u_{33}\}$ | $u_{41} = \{u_{411}, u_{412}\}$ | Supervision & Regulation $B_{44} (0.1057)$ |
| $U_4 = \{u_{41}, u_{42}, u_{43}, u_{44}\}$ | $u_{42} = \{u_{421}\}$ | Operation Supervision and Management $C_{441} (1.0000)$ |
| $U = \{U_1, U_2, U_3, U_4\}$ | $u_{43} = \{u_{431}\}$ | Transport Service Supervision $C_{441} (0.6667)$ |
| $U_4 = \{u_{41}, u_{42}, u_{43}, u_{44}\}$ | $u_{44} = \{u_{441}, u_{442}\}$ | |
5.2. Defining remark collection
In order to reflect the development level of urban and rural transportation comprehensively and truly, this paper establishes a corresponding commentary set based on the evaluation that experts may make. The commentary set is divided into five grades: higher, high, medium, low, lower. The corresponding indicators are semantically transformed, and the evaluation criteria for the integrated development of urban and rural transportation are established.

\[ V = \{v_1, v_2, v_3, v_4, v_5\} \]

Where, \( V \) is a collection of comments. \( v_1, v_2, v_3, v_4, v_5 \) are higher, high, medium, low, lower, respectively.

5.3. Fuzzy Comprehensive Evaluation
Through the three-level fuzzy comprehensive evaluation, the expert acceptance degree of the evaluation index of the development level of urban-rural transport integration is judged, and the development level of urban-rural transport integration is evaluated.

6. Conclusions
Taking the integration of urban and rural transport as the research object, this paper constructs the evaluation index system of the integration of urban and rural transport development, and puts forward a fuzzy comprehensive evaluation model of the integration of urban and rural transport development level, which can objectively and accurately evaluate the integration of urban and rural transport development level and level. The research results are helpful to understand the development status of urban-rural transport integration, and are of great significance to promote the coordinated development of urban-rural transport system.

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