A Quantitative and Comprehensive Evaluation of China's Ecological High-speed Railway Development Based on DSR Model

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Abstract. This paper evaluates the development status of China's high-speed railway from 2010 to 2018 based on the DSR (Driving force, State and Response) model, and further evaluates the ecological development status of China's high-speed railway in the future by using the analytic hierarchy process. The results demonstrate the overall trend of the development of ecological high-speed railway in China is good, but the driving force is insufficient, the proportion of state indicators decreases year by year, and the response indicators indicate an upward trend. According to the research and analysis, some suggestions are put forward for the development of ecological high-speed railway.

1. Introduction
High-speed railway exerts a crucial part in promoting economic development and social progress. Nevertheless, with the expanding of high-speed railway construction, engineering construction and humankind development, the ecological environment becomes more and more serious. Achieving the ecological development goal of high-speed railway, it has a significant influence on economic development. At present, domestic and foreign scholars' researches on high-speed railway mainly attach importance to the technical operation of high-speed railway and its impact on economic development [1-4]. Additionally, there is an army of research about the DSR model which was used for the research of ecological security and ecological civilization development level [4-7], the present literature highlighted the highspeed railway of pure technology research and its impact on economic development on the model research. In this paper, China's ecological state of the development of high-speed is studied. At present, the majority of the research pour attention into the development of green high-speed railway. And the development of high-speed railway is simply defined as the development of energy conservation and environmental protection type. Nevertheless, the ecological development of high-speed railway not only can reduce the contamination reduction, but also can improve the current national economic development and optimize industrial structure. Based on DSR (driving force, state, response) model, this paper analyses the current development of China's transportation industry and measures taken to promote the development of high-speed railway with the development of China's ecological high-speed railway.
2. Research methods and data analysis

2.1. Model method

DSR model, also recognized as “driving force-status-response” model, was first proposed in the organization for economic cooperation and development in 1996. In this model system, the first-level indicators mainly include three indicators: Driving Force, State and Response. From the perspective of establishing a quantifiable indicator, constitutes a Driving Force-State-Response model (DSR) factors include: (1) Driving Force mainly comes from three aspects of the social, economic and environment, the specific indicators have a GDP per capita(X1), the natural population growth rate(X2), such as transportation of GDP (one hundred million yuan)(X3), passenger traffic(X4), passenger volume(X5) and operating range(X6); (2) State factors are used to express the development of ecological high-speed railway, and specific indicators include the proportion of traffic expenditure of income(X7), the contribution rate of traffic to GDP(X8), the proportion of traffic property loss in GDP(X9), per capita energy consumption (100 million kilowatt hours)(X10), urban green coverage rate(X11), and equivalent noise(X12); (3) Response factor, in view of the ecological high speed railway has issued relevant policies and measures, that is to say the high contamination loss under the situation of governance policy response, and specific indicators have transportation science and technology personnel total number of laboratory (X13)and research quantity in total traffic(X14), investment of contamination control(X15), the disposal capacity of industrial solid waste(X16), environmental contamination control investment as a share of GDP(X17), a power and other energy of energy consumption (million kilowatt hours)(X18).

2.2. Data source and initial processing

The research data in this paper are mainly from China statistical yearbook 2010-2018, environmental statistical yearbook 2010-2018, official website of China statistics bureau and EPS database. In existent researching files, such as GDP per capita one hundred million yuan is used to while mileage in kilometers unit statistics, statistical units and the different methods of measuring data cannot be simply aggregated, so relevant inspection before we take the pure value of the dimensionless analysis, which benefits the data of different units can be unified process analysis, this paper adopts the main quantitative methods of the standardized methods for handling, conversion formula is as follows:

\[ P_{ij} = \frac{X_{ij} - X_{i,\text{min}}}{X_{i,\text{max}} - X_{i,\text{min}}} \]

Where, \( P_{ij} \) is the jth index value of the ith region, \( X_{ij} \) is the present value of the index, \( X_{i,\text{min}} \) is the minimum value of the relevant index, \( X_{i,\text{max}} \) and is the maximum value of the relevant index; \( n \) is the number of regions, and \( m \) is the number of indicators.

2.3. Index weight calculation method

In calculating the weight of each index, the commonly used methods include Delphi method and principal component analysis method. In order to avoid the bias is contributed by the subjective judgment, the entropy method with objective weight is used to calculate the weight of sub-indexes, so
as to ensure the objectivity of the calculation results. The analytic hierarchy process (AHP) can eliminate the uncertainty and subjectivity of indicators to a certain extent, and make use of experience, insight and intuition to analyze and study indicators, so as to better measure the relativity between indicators and indicators.

The principle is to maximize the difference between the evaluation objects, so that the total deviation sum of the data reaches the maximum value. On the basis of data standardization, data are used to calculate the weight of factors, and the formula is as follows:

term weight:

\[
S_j = \frac{P_j}{\sum_{i=1}^{n} P_i};
\]

calculate the entropy of the index

\[
e_f = -k \sum_{i=1}^{n} S_j \ln S_{ij};
\]

calculate the information utility value of the jth index:

\[
g_j = 1 - e_f;
\]

calculate the weight of the Pj indicators

\[
w_j = \frac{g_j}{\sum_{i=1}^{m} g_j};
\]

2.4 Indicators selection

Based on the constructed DSR model and combined the existing research with the development characteristics of high-speed railway and the actual situation of the research area. In addition, this paper adopts the method of AHP (analytical hierarchy process) and selects evaluation indexes from three levels of driving force, state and response according to the principle of science and reliability (table 1).

| Table 1 Chinese ecological high-speed railway development rating index system |
|----------------|----------------|---------|---------|---------|
| Goal level | Subsystem level | Factor level | Index level | Weight |
| Ecological high-speed railways | Driving force | Economic development | X1 | 0.046 |
| | | X2 | 0.051 |
| | | X3 | 0.039 |
| | | Social harmony | X4 | 0.114 |
| | | X5 | 0.048 |
| | | X6 | 0.061 |
| | | X7 | 0.068 |
| | | Social economy | X8 | 0.064 |
| | | X9 | 0.038 |
| | | X10 | 0.030 |
| | State | Eco-friendly | X11 | 0.046 |
| | | X12 | 0.027 |
| | | Technology Investment | X13 | 0.067 |
| | | X14 | 0.062 |
| | | X15 | 0.059 |
| | | X16 | 0.055 |
| | Response | Energy-saving | X17 | 0.046 |
| | | X18 | 0.077 |

3. Analysis of evaluation results

The development index of ecological high-speed railway is:

\[
\sum_{i=1}^{15} X_{ij} \times W_j
\]

where, Wj is the weight value of the Jth index, Xij is the Jth index after standardization in the Ith year,
and $A_i$ is the development index of ecological high-speed railway in the $i$th year. According to the calculation formula of ecological high-speed railway development index, we can get the following table of China's ecological high-speed railway development index and DSR ratio change chart of China's ecological high-speed railway development.

Table 2 Evaluation index of Chinese ecological high-speed railway development

| DSR Factor level | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  |
|------------------|-------|-------|-------|-------|-------|-------|-------|
| Driving force    |       |       |       |       |       |       |       |
| Economic development | 0.092 | 0.111 | 0.122 | 0.125 | 0.136 | 0.122 | 0.142 |
| Social harmony   | 0.106 | 0.117 | 0.134 | 0.104 | 0.125 | 0.130 | 0.136 |
| State            |       |       |       |       |       |       |       |
| Social economy   | 0.198 | 0.228 | 0.256 | 0.229 | 0.260 | 0.252 | 0.278 |
| Eco-friendly     | 0.150 | 0.129 | 0.141 | 0.131 | 0.131 | 0.106 | 0.111 |
| Technology Investment | 0.119 | 0.120 | 0.123 | 0.123 | 0.125 | 0.127 | 0.130 |
| Response         |       |       |       |       |       |       |       |
| Energy-saving    | 0.269 | 0.249 | 0.263 | 0.254 | 0.256 | 0.233 | 0.240 |
| Driving: State: Response | 29:40:31 | 33:36:31 | 33:34:33 | 29:32:39 | 31:30:39 | 33:30:37 | 30:26:44 |

In the state of the rule layer is contained in the social, economic and environmental friendly two factors layer by table 4. And the results represent that the index of social and economic factors layer 0.150 in 2010, and 2017 is 0.111, down 26%, another factor layer eco-friendly index increased to 0.119 in 2010 from 0.130 in 2017, although from 2010 to 2017, eco-friendly index has an increasing is not large, but rises to the state of the rule layer index pull degree also is not overwhelmingly big. According to data in ecological friendly although has made certain improvement, for example, the city's green coverage rate is increasing year by year, and the grade noise of traffic arteries is also declining.

Meanwhile, the index of driving force in the criterion layer remained relatively stable from 2010 to 2017, but the economic development and social harmony in the layer of factors were different. Among them, economic development indicators increased by 35 percent from 2010 to 2017, and social harmony increased by 22 percent from 2010 to 2017. By comparison to economic development indicators, there was a gentle change of social development, which illustrates the gross national product and natural population growth rate perform an important function in driving the economy.

Among the three indicators, the response index has a sharp change and presents an upward trend, which indicates that China's response to the development of ecological high-speed railway is constantly improving. That includes investment in science and technology and the energy conservation and environmental protection layer, both factors show a relatively significant upward trend, the investment in science and technology from 2010 to 2017 increased by about 51%, the increase is intensely big.

4. Conclusions and policy recommendations

Based on DSR (driving force, state and response) model and the AHP analytic hierarchy process (AHP) are used to analyze the ecological development of high-speed railway in China. According to the statistical data from 2010 to 2018, the calculation results show the overall trend of China's ecological high-speed railway is increasing. But the driving force is insufficient, the trend of state index continues to decline, the response index with the present growth trend but not enough to significantly improve the ecological development of high speed railway.

4.1. Increasing he financial input of ecological economy, and constructing ecological economy platform

Economic development is the basic driving force of a series of important activities. Merely by strengthening economic development can drive the development of relevant industries, and the development of ecological high-speed railway is no exception. That requires governments to increase financial input for the ecological economy, refining the financial input of the traffic, rather than a wide range of traffic financial input in the form of "beans" refine to high-speed railway financial ecosystem
must be severe, so as to achieve every penny to use on the "blade", achieving the fine development of the ecosystem of high speed railway.

4.2. Strengthening the positive transformation of ecological technology, and establishing ecological transportation platform

“When green mountains and rivers come, when green mountains and rivers go” is the code of many traffic construction projects at present, the construction of all kinds of traffic roads will destroy a large area of land, but how to minimize the damage to the ecological environment needs consideration too. Singly by increasing the transformation of ecological technology, the ecological damage can be eased, which includes optimizing the scheme of technical design of the line and establishing bridges and other forms to reduce the damage to vegetation. Topsoil is a valuable resource for the survival of animals and plants, so it is exceedingly important to build ecological restoration bases and ecological pilot projects along the ecological high-speed railway, which needs the theoretical and empirical support of ecological technology.

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