ISSN: 2307-0692, Volume 9, Issue 4, August, 2020

Evaluation and Analysis of China Railway Operational Efficiency based on DEA

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Abstract: This paper introduces data envelopment analysis (DEA) into the evaluation of China's railway transportation performance, By collecting data on relevant indicators of the entire railway transportation industry of China Railways from 2001 to 2016, the indicators include: operating mileage, employment, number of passenger cars, number of trucks, number of locomotives, passenger turnover, freight turnover, using DEAP2.1 software to evaluate the efficiency of the data, and to compare and analyze the results, and concluded that although China's railway transportation industry has improved in technology, but the operation Efficiency has still not been significantly improved, passenger and freight capacity has failed to meet market development needs, and China's railway operation efficiency still needs to be improved. Finally, it puts forward specific countermeasures and suggestions for improving the efficiency of China's railway operations.

Keywords: China railway; Operational efficiency; Data envelopment analysis (DEA); Evaluation research

1. Introduction

With the gradual transformation of China's economic development from high-speed growth to high-quality development, the country has also put forward new requirements for railway development. As the most important transportation method in comprehensive transportation, railway transportation plays a vital role in the national transportation system. According to China's "Medium and Long-Term Railway Development Plan", by 2020, the nation's railway business mileage will reach more than 120,000 kilometers, and the average annual growth of the railway in the next few years is expected to remain at around 4,000 kilometers [1]. The rapid development of China's railway transportation industry. While the scale of railway operations is growing at a high speed, the performance of railway operations is growing slowly, unable to adapt to the pace of development of the railway transportation market, passenger and freight transport capacity has failed to meet market development needs, logistics service capabilities and levels need to be further improved, operating management systems and related supporting facilities The measures are not perfect. How to improve the efficiency of railway operations in such a large country with a large population and operating mileage has become an urgent problem to be solved [2]. Scientific and reasonable evaluation of railway operation efficiency can provide theory and decision-making reference for railway operation enterprises to improve their logistics operation management system and rational resource allocation, and to improve the market competitiveness of enterprises, improve the quality and efficiency of their own logistics supply services, and promote the railway transportation industry. The overall economic development has important practical significance.

This paper uses the data envelopment analysis (DEA) to evaluate the efficiency of China's railway operation from 2000 to 2016, and analyzes its development characteristics and trends, so as to put forward corresponding countermeasures and suggestions for the operation and development of railway transportation enterprises, so that railway transportation enterprises Better realize the institutionalized, standardized and modern operating system.

2. Research Methods and Data Sources

2.1. Research methods

DEA is short for Data Envelopment Analysis, which was created by Charles and Cooper from the United States in 1978 [3]. The basic research idea of the model is to set an output project indicator used as an evaluation to a DMU (decision unit), and many DMUs form a relatively complete evaluation overall, and the input and output variables are relatively effective through the DEA model. Analysis to determine whether each DMU is DEA effective [4].

Since the DEA method uses a relatively efficient evaluation method, the evaluation structure is more scientific and is widely used in the performance evaluation of modern enterprises. Through DEAP2.1 software, we can further calculate the relaxation variable value of each decision-making unit and the expected value of the input variable when the DEA is effective, find the input variable with unreasonable resource input in the invalid decision-making unit and clarify the improvement direction.

Commonly used DEA models mainly include the CCR model and the BBC model. The CCR model is based on the constant returns of the decision unit, and measures the comprehensive efficiency value of the decision unit, that is, evaluates the comprehensive effectiveness of a system. The BBC model is based on the variable return of the decision-making unit, and then the comprehensive efficiency of the decision-making unit is converted into scale efficiency and pure technical efficiency. Comprehensive efficiency = scale efficiency * pure technical efficiency. Pure technical efficiency refers to whether the resources invested by the enterprise Being effectively used, scale efficiency refers to whether the scale of the company's input meets the needs of the company's development [5]. So the BBC model is more suitable for researching enterprises Whether the resource allocation is effective and whether the scale of the enterprise is more in line with the needs of enterprise development.

The traditional BCC model is as follows:

Suppose there are DMUs with n decision units, each decision unit has m types of inputs and s types of outputs, and input vectors is $X_j=\left(X_{1j},X_{2j},\ldots X_{mj}\right)>0$, $j=1,2,\ldots,n$ .The output vector is $Y_j=\left(Y_{1j},Y_{2j},\ldots Y_{sj}\right)>0$, $j=1,2,\ldots,n$, The expression of the BBC model is:

$$\min\ (q)$$

$$\text{s.t.}\quad \sum_{j=1}^{n} X_j l_j + S^- = q X_{j_0},$$

$$\sum_{j=1}^{n} Y_j l_j - S^+ = Y_{j_0},$$

$$\sum_{j=1}^{n} l_j = 1$$

$$l_j \ge 0, S^- \ge 0, S^+ \ge 0$$

X_{ij} is the j th decision unit and the i th input indicator, Y_{ij} is the i th output index of the j th decision unit, S^-,S^+ are the relaxation variables of input and output, q is pure technical efficiency value, $0<q<1$,the closer the value of q is to 1, the higher the pure technical efficiency of the decision unit.

Solving the above linear relationship, whether the decision unit obtained by the BBC model is effective depends mainly on S^-,S^+,q ,There are the following discrimination rules:

If the value of q is 1, and the value of S^-,S^+ is 0, it means that the decision unit DEA is valid;

If the value of q is 1, but one of the values of S^-,S^+ is not 0, it is said that the decision unit is effective for weak DEA;

If the value of q is less than 1, it indicates that the decision unit DEA is invalid, and analysis of relaxation variables and expected values can be performed.

2.2. Selection of evaluation indicators and data sources

2.2.1. Selection of evaluation indicators

This paper selects the indicator data related to the input-output indicators for the fifteen years of 2001-2016. Because there are few decision-making units, according to the selection principle of DEA efficiency evaluation, it is generally considered that the number of elements is not less than twice the total number of input and output indicators. Therefore, it is not advisable to choose too many input-output indicators, otherwise, the difference of decision-making units will become small. The selection of input indicators should try to choose the indicators that are most relevant to the railway transportation enterprise. The indicators should be more realistic and more suitable. Society should reflect the technical level of railways more. The selection of output indicators should be based on the actual needs of the society for transportation products, and be more in line with the economic benefits of railway transportation enterprises. At the same time, after considering the availability of statistical data, the final selection The input indicators are the mileage of China's railway transportation operations, the number of people employed, the number of locomotives, the number of passenger cars, the number of trucks, and the output indicators are selected as China's railway transportation freight turnover and passenger turnover.

2.2.2. Data sources

The statistical data used in this article are all from the "China Statistical Yearbook" compiled by the National Bureau of Statistics. The status of the national railway indicators from 2001 to 2016 is summarized in Table 1.

Table 1. 2001-2016 National relevant data statistics table

Years	Operating mileage	employed population	Number of locomotives	Number of buses	Number of trucks	Passenger turnover	Freight turnover
	10,000/km	Ten thousand	Station	Station	Station	100 million people/km	100 million tons/km
2001	7.01	178.9	14955	38780	453620	766	14694
2002	7.19	175.8	15159	39438	459017	4969	15658
2003	7.30	172.8	15456	40487	510327	4788	17246
2004	7.44	169.9	16066	41353	526894	5712	19288
2005	7.54	166.6	16547	40328	541824	6061	20726
2006	7.71	165.3	16904	42659	564899	6622	21954

2007	7.80	174.1	17311	44243	577521	7216	23797
2008	7.97	173.3	17336	45076	593793	7778	25106
2009	8.55	185	17825	49354	601412	7878	25239
2010	9.12	175.6	18349	50391	622284	8762	27644
2011	9.32	176.2	19590	54731	651175	9612	29465
2012	9.76	179.3	19625	57221	670801	9812	29187
2013	10.31	179.6	19686	56841	715492	10595	29173
2014	11.18	190.3	19990	60629	716578	11241	27530
2015	12.10	187.4	21366	67706	768516	11960	23754
2016	12.40	187.4	22453	70872	764783	12579	23792

3. Empirical Analysis

3.1. Calculation results of the model

The data collected in Table 1 is run through DEAP software to obtain the results as shown in Table 2.

Table 2. Model calculation results

Years	Comprehensive efficiency	Scale efficiency	Pure technical efficiency	Relative effectiveness	Scale effectiveness	Technical effectiveness
2001	0.716	0.716	1.000	DEA is invalid	Increasing scale	Effective
2002	0.754	0.754	1.000	DEA is invalid	Increasing scale	Effective
2003	0.773	0.773	1.000	DEA is invalid	Increasing scale	Effective
2004	0.844	0.844	1.000	DEA is invalid	Increasing scale	Effective
2005	0.923	0.923	1.000	DEA is invalid	Increasing scale	Effective
2006	1.000	0.924	1.000	DEA works	Increasing scale	Effective
2007	0.969	0.969	1.000	DEA is invalid	Increasing scale	Effective
2008	1.000	1.000	1.000	DEA works	Proper scale	Effective
2009	0.944	0.958	0.985	DEA is invalid	Increasing scale	Invalid
2010	1.000	1.000	1.000	DEA works	Proper scale	Effective
2011	1.000	1.000	1.000	DEA works	Proper scale	Effective
2012	0.993	0.999	0.994	DEA is invalid	Increasing scale	Invalid
2013	1.000	1.000	1.000	DEA is invalid	Proper scale	Effective
2014	1.000	1.000	1.000	DEA works	Proper scale	Effective
2015	1.000	1.000	1.000	DEA works	Proper scale	Effective
2016	1.000	1.000	1.000	DEA works	Proper scale	Effective

3.2. Basic efficiency evaluation

From the evaluation results in Table 2, it can be seen that the comprehensive efficiency values in 2001-2005, 2007, 2009, and 2012 are less than 1, indicating that DEA is invalid in recent years. Among them, the pure technical efficiency value in 2001-2005 and 2007 is equal to 1, and the scale efficiency value is less than 1. It shows that the resources invested in these 6 years are effective at the current technical level, and the scale efficiency is less than 1, indicating that the input and output do not match the scale, the input and output scale does not reach the optimal state, we need to increase or decrease Scale to make the evaluation unit DEA effective. According to the software operation results, we should increase the scale to match the input and output level with the scale. In 2009 and 2012, the scale efficiency and pure technical efficiency were both less than 1, and the pure technical efficiency value was less than 1, indicating that the input and output of the railway were unreasonable, and the optimal allocation of resources was not achieved. The scale efficiency was less than 1, indicating the scale of the railway transportation enterprise If the optimal state is not reached, the size of the enterprise needs to be adjusted. In 2009, the pure technical efficiency value was 0.985 and the scale efficiency value was 0.958. The large pure technical efficiency value and the scale efficiency value indicate that scale efficiency has a greater influence on the production efficiency of the enterprise. Therefore, we should focus on expanding the scale of the enterprise to improve the transportation efficiency of the enterprise. In 2012, the scale efficiency was 0.999, the pure technical efficiency was 0.994, and the pure technical efficiency was less than the scale efficiency, indicating that we need to focus on adjusting the industrial structure to achieve the optimal allocation of resources. By analyzing the scale returns of Chinese railways, the scale returns of 2001-2007, 2009, and 2012 show an increasing trend, indicating that railway transportation companies will have higher returns on the basis of appropriately increasing investment. The scale returns in the remaining years are appropriate and do not need to be Adjust the size of the enterprise.

3.3. Analysis of relaxation variables and expected values

By calculating the slack variables for the input-output decision-making unit, the adjustment range and direction can be determined for non-DEA effective decision-making units. According to the relevant theoretical analysis of the DEA model, the slack variable of the input variable is not zero, indicating that the resources of the input variable are not It can play its due role. The greater the amount of input redundancy, the lower the efficiency of the input resources. The resources are not fully utilized and there is a waste of resources. At the same time, you can determine which year's input indicators are redundant based on the software operation results, and determine the specific adjustment direction according to the expected value.

The expected value input redundancy of the input variables run by DEAP2.1 is shown in Tables 3 and 4.

Table 3. Expected values of input variables

Decision unit years		Expected value of input variables				
		Operating mileage	employed population	Number of locomotives	Number of buses	Number of trucks
DMU1	2001	7.010	178.900	14955.000	38780.000	453620.000
DMU2	2002	7.190	175.800	15159.000	39438.000	459017.000
DMU3	2003	7.300	172.800	15456.000	40487.000	510327.000
DMU4	2004	7.440	169.900	16066.000	41353.000	526894.000
DMU5	2005	7.540	166.600	16547.000	40328.000	541824.000
DMU6	2006	7.710	165.300	16904.000	42659.000	564899.000
DMU7	2007	7.800	174.100	17311.000	44243.000	577521.000
DMU8	2008	7.970	173.300	17336.000	45076.000	593793.000
DMU9	2009	8.394	174.571	17554.902	46826.243	592298.948
DMU10	2010	9.120	175.600	18349.000	50391.000	622284.000
DMU11	2011	9.320	176.200	19590.000	54731.000	651175.000
DMU12	2012	9.588	177.208	19498.192	54937.614	666466.576
DMU13	2013	10.310	179.600	19686.000	56841.000	715492.000
DMU14	2014	11.180	190.300	19990.000	60629.000	716578.000
DMU15	2015	12.100	187.400	21366.000	67706.000	768516.000
DMU16	2016	12.400	187.400	22453.000	70872.000	764783.000

Table 4. Input redundancy

Decision unit years		Investment redundancy				
		Operating mileage	employed population	Number of locomotives	Number of buses	Number of trucks
DMU1	2001					
DMU2	2002					
DMU3	2003					
DMU4	2004					
DMU5	2005					
DMU6	2006					
DMU7	2007					
DMU8	2008					
DMU9	2009	0.026	7.625		1779.907	
DMU10	2010					
DMU11	2011					
DMU12	2012	0.109	0.933		1913.649	
DMU13	2013					
DMU14	2014					
DMU15	2015					
DMU16	2016					

The results from the input variables in Table 3 show that the slack variables of the input indicators such as the number of locomotives and trucks are 0, indicating that these input variable indicators have been fully utilized, but the operating mileage, employment and the number of trucks have not been fully utilized. 4 The expected value of the input variable can be seen, the operating mileage should be reduced from 85,500 kilometers to 83,900 kilometers, the number of employees should be reduced from 1.85 million to 1.75 million, and the number of passenger cars should be reduced from 49,354 to 46,826 to improve the enterprise Transportation production efficiency. At the same time, in 2012, the pure technical efficiency value was 0.994 less than the scale efficiency value of 0.999, so we should focus on improving the management and institutional level of the enterprise and the technical level of the enterprise. At the same time, from the slack variable of the input variable, the operating mileage, the number of employees and the The number of trucks is not fully utilized. According to the expected value of the input variable, the operating mileage should be reduced from 97,600 kilometers to 95,900 kilometers, the number of employees should be reduced from 1.793 million to 1.772 million, and the number of trucks should be reduced from 670801 to 666466. As mentioned above, we can see that China's railway transportation has fewer technical problems, only in 2009 and 2012 there are certain problems, so we should put the adjustment center of the enterprise on the scale of the enterprise, and the scale returns The increasing year should appropriately expand the scale of the railway enterprise, so as to achieve economies of scale, and then improve the efficiency of the enterprise. The year of decreasing scale returns can appropriately reduce the size of the enterprise, indicating that the existing enterprise scale does not match its own strength and technical level. We should appropriately reduce it Enterprise scale to achieve economies of scale and to achieve optimal operating efficiency.

3.4. Recommendation

According to the current situation of China's railway operation performance and the conclusions of this study, the following suggestions are proposed in future construction: first, the operating mileage of railway transportation should be appropriately expanded, and at the same time, separate passenger and freight transportation should be implemented on the main transportation trunk lines, which can effectively improve The speed of railway transportation also facilitates passenger travel and eases the shortage of capacity. Secondly, it is also crucial to open up new investment channels. The source of funds for China's railway transportation mainly depends on the state's fiscal expenditures. However, compared with high-speed rail and civil aviation, these emerging industries, China's investment in railway transportation has been difficult to continue to increase. This means that it is necessary to open up new investment channels. Railway transportation can learn from the financing methods of high-speed rail civil aviation, loans from banks, and hair market securities are all effective financing methods. After a certain percentage of financing, railway transportation investment Orientation is also a key issue. For example, investment orientation focuses on expanding operating mileage, optimizing transportation equipment, and improving the rating system, which can achieve practical results in the short term, effectively improve railway transportation capacity, and improve railway operating efficiency.

4. Conclusion

It can be seen from the data analysis results that China's railway operation has not reached the optimal state of input and output in individual years, and the operating mileage invested, the number of employees, the number of locomotives, and the number of passenger cars are all inadequate Take advantage of the phenomenon. Except that the scale returns in individual years are appropriate, the scale returns in most years are increasing, so we can adjust the scale of operations to achieve the purpose of improving operational efficiency. Although there are certain problems with China's railway transportation, there is still some distance to go compared to developed countries, but the gap is gradually narrowing. I believe that after the country's reasonable adjustment policies and effective operational measures and means are implemented, China's railway transportation development Will break past bottlenecks.

5. Acknowledgments

Graduate Research and Innovation Project of Beijing Institute of Materials Science and Technology (0541900727).

References

[1] Xing Xiaoqin. Research on my country's railway transportation efficiency. Beijing: Beijing Jiaotong University. 2007.

[2] Wei Quanling. Data Envelopment Analysis. Chinese Ence Bulletin. 2001, 46(16).

[3] Charnes A., Cooper W.W., Wei Q.L., Huang Z.M. Cnoe ratio data envelopment analysis and multi-objective programming. International Journal and Systems Science. 1989, 20(7), 1099-1118.

[4] Wang Lei, Xue Guoliang, Zhang Hongli. Research on the efficiency of modern logistics in northern Xinjiang based on DEA analysis method. Resources Science. 2014, 36(7), 1425–1433.

[5] Li Meijuan, Chen Guohong. Research and Application of Data Envelopment Analysis (DEA). Engineering Science of China. 2003, 5(6), 90.