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Research on the Measurement of Green Logistics Development Level in Liaoning Province

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Abstract: With the development of the logistics industry, the exhaust emissions caused by transportation, the unreasonable location of goods transportation and the layout of delivery outlets lead to the repeated routes of goods, which increase the energy consumption of vehicles, strengthen the noise pollution and waste pollution, and the centralized treatment and rapid delivery of goods have a certain impact on the environment. Therefore, it can be seen that green logistics is getting more and more attention. However, external factors are difficult to realize, internal factors inhibit the development of green logistics, and there are many difficulties in its implementation. This paper mainly studies the influence on the development level of green logistics in Liaoning Province. By consulting the data, it selects the indicators that affect the measurement of the development level of green logistics in Liaoning Province, including infrastructure, economy, energy and operation management, calculates the weight of each indicator by entropy method, obtains the development level of green logistics in Liaoning Province in recent 15 years, and draws corresponding conclusions.

1. Introduction

In recent years, with the solution of "the last mile" and the construction of modern logistics park, the logistics industry has become inseparable from daily life. The rapid development of e-commerce such as Taobao and JD.COM has promoted the position of logistics industry in traditional industries. In 2020, under the severe situation of global epidemic situation and partial supply shortage, China enterprises took the lead in resuming work and production, effectively making up for the shortage of some medical and epidemic prevention materials, masks and various daily necessities in the international market. Under the requirement of strictly controlling the population density in public areas such as shopping malls, the logistics industry has made outstanding contributions to economic recovery. Since the five development concepts were put forward, the importance and attention of green development have been increasing day by day, and all walks of life have put forward the direction of "green development". "Green logistics" is based on the healthy economic development of the logistics industry, and puts forward the requirements of environmental protection and energy saving for the high-quality development of the logistics industry. Under the background of the new economic normal, green development is an important direction and standard for industrial upgrading and transformation, and the realization of eco-friendliness in the logistics industry has become the benchmark for industrial upgrading. Since the concept of "green logistics" was put forward, many

scholars have put forward their own research and views on the upgrading, transformation and green development of logistics industry, which has provided a certain theoretical basis for the development of logistics industry in Liaoning Province. The promotion of the construction of "green logistics" system has made great contributions to the improvement of energy consumption, energy conservation and emission reduction in logistics.

2. Literature Review

With the trend of green logistics industry becoming more and more common, many scholars put forward their own opinions on green logistics. Xing Xiaomeng [1] put forward that urban green logistics is the inevitable trend of urban logistics development and one of the important contents to realize the sustainable development of urban economy. Zhang Xue [2] thinks that green logistics is a concept that integrates logistics management, environmental science, ecological economics and other multi-disciplinary knowledge. Chang Xuemei [3] and Zhang Linqiang [4] think that green logistics is a model for the development of logistics industry in view of the current environmental protection and green ecological problems; Liu Zhenrong [5] proposed that economy and resources can be used as indicators to evaluate the development level of green logistics; Chen Hounan [6] takes energy consumption, emission level, industry development scale and industry operation status as the secondary indicators for measuring and evaluating the green development level of logistics industry; Yingfei Yang [7] shows that the performance of infrastructure and green logistics has a beneficial impact on service trade and the environment through the evaluation and measurement model. Dangkhoa Huynh and Thibich Nhungtran [8] generally believe that green logistics can be defined as the distribution of goods in a sustainable way by production, taking into account environmental and social factors; Peng Jiang, Guangdong Liu [9] and Zhang Nana [10] think that modern logistics has a significant relationship with economic growth, and the rapid economic growth can stimulate the rapid growth of the logistics industry; Tian Hongyan [11] pointed out that the backward level of infrastructure construction can also cause the slow development of green logistics; Cheng Xiaohe [12] thinks that green logistics is to promote the greening of logistics activities by reducing the environmental pollution and resource consumption caused by logistics activities;Sun Kaiyang [12] proposed that the carbon reduction effect of logistics transportation can be reflected by the carbon reduction of transportation tools; The green logistics put forward by Xia Fu [13] can meet people's needs and benefit the future in today's social development. Jiang Xiaoru [14] pointed out that the development of big data has played an increasingly important role in green logistics.

To sum up, through reference literature and expert discussion, four indicators, namely, infrastructure, economy, energy and operation management, are mainly used to measure the development level of green logistics in Liaoning Province, and the infrastructure is measured by the sum of railway operation mileage of logistics industry, highway opening mileage of logistics industry, inland waterway mileage and regular mileage of civil aviation. The added value of logistics industry, fixed assets investment in logistics industry, foreign direct investment in logistics industry and financial expenditure of logistics industry are used to measure the economy; Measure energy by energy consumption of logistics industry; The logistics industry on-the-job personnel, the total amount of cargo transportation to measure the operation and management.

3. Research Design

3.1 Construction of Measurement Index System

3.1.1 Infrastructure

The infrastructure of the logistics industry mainly includes means of transport, which can be measured by railway operating mileage, highway traffic mileage, inland waterway mileage, and civil aviation regular mileage. Therefore, the secondary indicator is measured by the sum of logistics railway operating mileage, logistics highway traffic mileage, inland waterway mileage, and civil aviation regular mileage.

3.1.2 Economy

Using economy to measure logistics can be manifested in many aspects, specifically, the added value of logistics industry. The added value of logistics industry can represent the gross production value of logistics industry in recent years. The investment in fixed assets of logistics industry, the more investment in fixed assets, the better the development of logistics industry. Besides, the more foreign direct investment in logistics industry, the faster the industry runs and the better its development, including the financial expenditure of logistics industry. If the financial expenditure is more, it shows that the government will bring a promoting effect to the development of logistics industry.

3.1.3 Energy

As a measure of green logistics, energy plays a vital role. First of all, logistics will involve the environmental problems of exhaust emissions and air pollution in the transportation process, that is, energy can be used as a measure of the development of green logistics, and the development level of green logistics is mainly measured by the energy consumption of logistics.

3.1.4 Operation Management

Table 1: Evaluation Index System of Green Logistics Development Level in Liaoning Province

First level indicator	Second level indicator	symbol	direction
Infrastructure	logistics railway operation mileage, logistics highway traffic mileage, inland waterway mileage, civil aviation regular mileage/10000 km	R_1	forward
Economics	Added value of logistics industry/100 million yuan	R_2	forward
	Growth rate of fixed assets investment in logistics industry/%	R_3	forward
	Foreign direct investment in logistics industry/10000 US dollars	R_4	forward
	Financial expenditure of logistics industry/100 million yuan	R_5	forward
energy	Energy consumption of logistics industry/10000 tons of standard coa	R_6	reverse
operation management	On duty personnel in logistics industry/10000	R_7	forward
	Total cargo transportation volume/10000 yuan	R_8	forward

The operation and management of logistics industry also plays an important role in the green

development of logistics. Good operation and management can drive the green development of logistics industry. On-the-job personnel and total cargo transportation of logistics industry can represent the quality of operation and management. The more on-the-job personnel and total cargo, the better the operation and management, which will also have an impact on the implementation of green logistics.

To sum up, this paper has set up four first level indicators and eight second level indicators to measure the development level of green logistics in Liaoning Province. The specific indicators are shown in Table 1.

3.2 Model Building

3.2.1 Calculate Positive and Negative Indicators

In this paper, entropy method is used to calculate the development level of green logistics in Liaoning Province. The first step is to determine the weight. The operation step is to first standardize the data. The greater the energy consumption of the first level indicator, the more difficult the green logistics will be. Therefore, this indicator is a reverse indicator; Infrastructure, economy and operation management indicators are positive indicators. The size and dimension of the initially selected indicator data are different, so the first step is to standardize the data. The standardized formula is shown in (1) and (2).

The indicator symbol is X_{ij}, where i=1, 2, 3,..., 15 represents the year; J=1,2,..., 8 represents the number of indicators, M_j represents the minimum value of indicators in 15 years, and M_j represents the maximum value of indicators in 15 years.

Positive indicators are treated according to Formula (1):

$$x'_{ij} = \frac{x_{ij} - m_j}{M_j - m_j} \tag{1}$$

Reverse indicators shall be treated according to Formula (2):

$$x'_{ij} = \frac{M_j - x_{ij}}{M_j - m_j} \tag{2}$$

3.2.2 Index Proportion

The original data of green logistics development level is dimensionless processed. Formula (3) of the calculation method for the ith year under the jth indicator, P_{ij} is the indicator proportion symbol.

$$P_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{n} x_{ij}} \tag{3}$$

3.2.3 Calculate Entropy

Calculate the entropy value of the development level of green logistics, as shown in Formula (4) of the jth index, the symbol of entropy value is e_j, and n represents the number of years.

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \tag{4}$$

3.2.4 Solve the Difference Coefficient

Calculate the difference coefficient of each indicator, as shown in Formula (5), and the symbol of the difference coefficient is g_i.

$$g_i = 1 - e_j \tag{5}$$

3.2.5 Calculate Index Weight

Calculate the weight of each indicator of the green development level and the green logistics development level, as shown in Formula (6), the indicator weight symbol is w_j..

$$w_j = \frac{g_j}{\sum_{i=1}^{m} g_j} \tag{6}$$

3.2.6 Calculation of the Development Level of Green Logistics

The development level of green logistics is determined by the product of weight and dimensionless data. The development level of green logistics is shown in Formula (7). The symbol of the development level of green logistics is l_i.

$$l_i = \sum_{i=1}^{8} w_j * x'_{ij} \tag{7}$$

4. Empirical Analysis

4.1 Data Source

The data are all from the Statistical Yearbook of Liaoning Province and the National Bureau of Statistics. The data from 2006 to 2020 are selected for analysis. The data of the eight indicators in recent 15 years are shown in Table 2.

Table 2: Evaluation Index Data of Green Logistics Development Level in Liaoning Province

particular year	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
2006	10.24	511.1	81.7	9211	17.76	1147.07	32.7	109140
2007	10.27	611.2	5.6	11970	26.92	1381.56	32.7	10615.2
2008	10.57	649.5	35.7	31017	37.25	1374.72	32.7	126938.7
2009	10.57	662.7	-5.8	22499	106.6	1445.64	31	139541.3
2010	10.62	654.5	42.7	31424	140.29	1597.03	29.5	163303.2
2011	10.87	778	16	8658	220.53	1746.4	32.4	190329
2012	11.1	848	17.7	67133	256.1	1879.08	32.3	212956
2013	11.65	884.5	50	143036	302.51	1775.4	37	215375
2014	12.09	953.7	12.8	211107	310.89	1919.24	37.1	231743
2015	12.66	1045.3	-30.1	30018	269.98	1847.67	35.5	208562.7
2016	12.66	1200	-47.7	61208	188.37	1966.59	34.5	215989
2017	12.9	1255.7	-9	62515	215.16	2049.35	35	220916.4
2018	12.99	1304.4	-17.9	9086	211.9	2072.04	32.4	229695.7
2019	13.17	1311.2	-20.4	2427	188.51	2069.91	32.5	184954
2020	13.79	1209.6	3.6	5399	190.01	1863.46	30.2	179199

Data source: Statistical Yearbook of Liaoning Province

4.2 Dimensionless Processing of Data

The results of dimensionless processing of all data are shown in Table 3.

In order to give meaning to the zero value, it is necessary to translate the dimensionless data as a whole, and the translation unit should be as small as possible. This value is usually taken as 0.0001,

and the data in Table 3 can be obtained by translating all the dimensionless results 0.0001 units to the right.

Table 3: Dimensionless Treatment Results

particular year	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
2006	0.0001	0.0001	1.0001	0.0326	0.0001	1.0001	0.4212	0.0001
2007	0.0086	0.1252	0.4120	0.0458	0.0313	0.7466	0.4212	0.0937
2008	0.0931	0.1731	0.6446	0.1371	0.0666	0.7540	0.4212	0.1453
2009	0.0931	0.1896	0.3239	0.0963	0.3032	0.6773	0.1975	0.2481
2010	0.1071	0.1793	0.6987	0.1391	0.4181	0.5136	0.0001	0.4419
2011	0.1776	0.3337	0.4924	0.0300	0.6918	0.3522	0.3817	0.6623
2012	0.2424	0.4212	0.5055	0.3102	0.8132	0.2087	0.3685	0.8469
2013	0.3973	0.4668	0.7551	0.6739	0.9715	0.3208	0.9869	0.8666
2014	0.5212	0.5533	0.4676	1.0001	1.0001	0.1653	1.0001	1.0001
2015	0.6818	0.6678	0.1361	0.1323	0.8605	0.2427	0.7896	0.8110
2016	0.6818	0.8611	0.0001	0.2818	0.5821	0.1141	0.6580	0.8716
2017	0.7494	0.9307	0.2992	0.2880	0.6735	0.0246	0.7238	0.9118
2018	0.7747	0.9916	0.2304	0.0320	0.6624	0.0001	0.3817	0.9834
2019	0.8255	1.0001	0.2111	0.0001	0.5826	0.0024	0.3948	0.6185
2020	1.0001	0.8731	0.3965	0.0143	0.5877	0.2256	0.0922	0.5715

4.3 The Solution of Entropy

The data from 2006 to 2020 are selected from the Statistical Yearbook of Liaoning Province and the National Bureau of Statistics to analyze the data of eight indicators in recent 15 years, and the dimensionless data are calculated according to the formula, as shown in Table 4.

Table 4: Entropy value of evaluation index of green logistics development level in Liaoning

First level indication	Second level indicator	Entropy
Infrastructure	logistics railway operation mileage, logistics highway traffic mileage, inland waterway mileage, civil aviation regular mileage/10000 km	0.867265489
Economics	Added value of logistics industry/100 million yuan	0.908784432
	Growth rate of fixed assets investment in logistics industry/%	0.930829906
	Foreign direct investment in logistics industry/10000 US dollars	0.765935909
	Financial expenditure of logistics industry/100 million yuan	0.916850138
Energy	Energy consumption of logistics industry/10000 tons of standard coa	0.855846244
Operation management	On duty personnel in logistics industry/10000	0.925424986
	Total cargo transportation volume/10000 yuan	0.926453311

The number of entropy value is less than 1. The understanding of entropy value is that the larger the entropy value is, the greater the weight represented by the green logistics development index is, and the greater the impact on the green logistics evaluation results. The largest entropy value is the growth rate of fixed assets investment in the logistics industry, which indicates that the growth rate of fixed assets investment in the logistics industry has the largest impact on the green logistics development, the growth rate of fixed asset investment can well reflect the growth rate of green logistics.

4.4 Solution of Weight

The weight represents the role of each indicator on the development level of green logistics. The calculated results are shown in Table 5. In infrastructure, it is the sum of railway operating mileage, highway opening mileage, inland waterway mileage and civil aviation regular mileage in the logistics industry. The weight is 0.147056394. In the economy, including the added value of the logistics industry, the growth rate of fixed asset investment in the logistics industry, foreign direct investment in the logistics industry, and financial expenditure in the logistics industry, the growth rate of foreign direct investment accounts for the highest proportion and has a strong representative ability. Energy is expressed by energy consumption, with a weight of 0.159707761. In terms of operation management, it includes the total amount of logistics personnel and goods transportation, with the weight of 0.164,103,845. The weight of logistics personnel is slightly higher than the total amount of goods transportation, indicating that the logistics personnel are more representative than the total amount of goods transportation.

Table 5: Index weight of green logistics development level in Liaoning

First level indicator	Weights of primary indicators	Second level indicator	Secondary index weight
Infrastructure	0.147056394	logistics railway operation mileage, logistics highway traffic mileage, inland waterway mileage, civil aviation regular mileage/10000 km	0.147056394
Economics	0.529132	Added value of logistics industry/100 million yuan	0.101057611
		Growth rate of fixed assets investment in logistics industry/%	0.076633458
		Foreign direct investment in logistics industry/10000 US dollars	0.259319305
		Financial expenditure of logistics industry/100 million yuan	0.092121626
energy	0.159707761	Energy consumption of logistics industry/10000 tons of standard coa	0.159707761
operation management	0.164103845	On duty personnel in logistics industry/10000	0.082621562
		Total cargo transportation volume/10000 yuan	0.081482283

The development status of each indicator of green logistics development level in Liaoning Province is shown in Figure 1.

According to the development level of green logistics in Liaoning Province from 2006 to 2020, the length of transportation lines has been growing by a small margin; The growth rate of fixed asset investment in the logistics industry has shown a downward trend as a whole, and the growth rate has approached zero in 2015 and 2016; The financial expenditure of the logistics industry has been in a stable state from 2006 to 2020, with only small fluctuations; The on-the-job personnel in the logistics industry showed a stable trend from 2006 to 2020, rising slowly from 2006 to 2013, and declining slowly from 2013 to 2020; The added value of the logistics industry shows a slow upward trend from 2006 to 2020; Foreign direct investment in the logistics industry tended to be stable from 2006 to 2011, increased significantly from 2011 to 2014, decreased significantly from 2014 to 2015, and stabilized from 2015 to 2020; The energy consumption of the logistics industry shows a small downward trend from 2006 to 2020; The total volume of freight transport has a slight upward trend from 2006 to 2014, and a downward trend from 2014 to 2020.

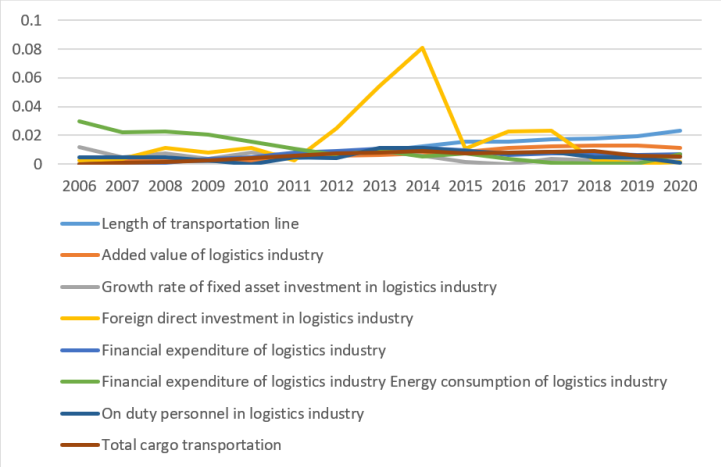

Figure 1: Elements of Green Logistics Development in Liaoning

4.5 Measurement Results

The development level of green logistics in Liaoning Province from 2006 to 2020 can be obtained by multiplying the weight of each index by the dimensionless data. The data results are shown in Table 6.

Table 6: Measurement Results of Green Logistics Development Level in Liaoning

particular year	Development leve	particular year	Development leve
2006	0.279659484	2014	0.710395183
2007	0.221923415	2015	0.46183849
2008	0.289313173	2016	0.457597442
2009	0.255262097	2017	0.501957768
2010	0.280044784	2018	0.412799202
2011	0.310811246	2019	0.375727701
2012	0.405072387	2020	0.413773515
2013	0.631106161		

Draw the result into a line chart as shown in Figure 2.

It can be seen from Figure 2 that the development level of green logistics in Liaoning Province has roughly increased from 2006 to 2020.

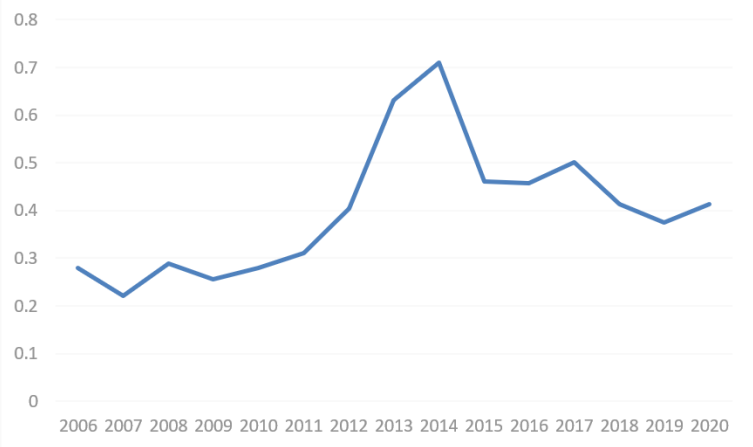

Figure 2: Trend of Green Logistics Development in Liaoning

5 Conclusions

5.1 The Development Level of Green Logistics in Liaoning Province is Mainly Influenced by the Economy.

Among all the elements of the development level of green logistics in Liaoning Province, the length of transportation lines has kept a small increase during the third period; The growth rate of fixed assets investment in logistics industry shows a downward trend as a whole; The financial expenditure of the logistics industry has been in a stable state; On-the-job personnel in the logistics industry are generally showing a steady trend; The added value of logistics industry shows a slow upward trend; Foreign direct investment in the logistics industry shows a small increase, with a substantial increase in 2004, and then tends to be stable. The energy consumption of the logistics industry shows a downward trend; The total amount of transportation shows a slight upward trend. According to the index weight, the development level of green logistics in Liaoning Province is mainly affected by economic indicators.

5.2 The Development Level of Green Logistics in Liaoning Province is Developing Towards a Good Trend.

From the trend chart of the development level of green logistics in Liaoning Province, it can be seen that 2012-2013 saw the fastest growth and the most obvious increase, reaching the highest value in nearly 15 years in 2014. From 2014 to 2015, it showed a significant downward trend until 2015 to 2020, but it was not lower than the level of green logistics in 2011. From this, it can be seen that the development level of green logistics in Liaoning Province increased slowly from 2006 to 2020, except for the significant increase from 2002 to 2005, which indicates that the development level of green logistics in Liaoning Province is developing in a good trend.

5.3 The Construction Level of Green Logistics Infrastructure Needs to be Improved.

In recent years, the logistics infrastructure in Liaoning Province has been improved, and the government's investment in infrastructure construction has also been improved. In the era of big data, the transportation information network system is gradually improving. For logistics companies in Liaoning Province, the transportation system is incomplete, and the basic resources cannot be effectively utilized, which will lead to the slow growth of green logistics.

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References

[1] Xing Xiaomeng. (2020) Research on the coordinated development of urban green logistics and economic growth in Dalian. Dalian Jiaotong University.
[2] Zhang Xue. (2019) Research on China's green logistics performance and its influencing factors. Beijing University of Posts and Telecommunications.
[3] Chang Xuemei. (2021) S Express Company Green Logistics Development Strategy Research. Shandong Normal University.
[4] Zhang Linqiang. (2017) Performance evaluation of regional green logistics and analysis of influencing factors. Jiangxi University of Finance and Economics.
[5] Liu Zhenrong. (2021) Research on the development of green industry in Enshi. Hubei University for Nationalities.

[6] Chen Hounan. (2021) Measurement of green development level of logistics industry in Hebei Province and analysis of influencing factors. Hebei University.
[7] Yingfei Yang et al. (2022) Green logistics performance and infrastructure on service trade and environment-Measuring firm's performance and service quality. Journal of King Saud University - Science, 34(1)
[8] Dang Khoa Huynh and Thi Bich Nhung Tran. (2020) Green logistics application to reduce operating costs for Vietnam logistics enterprises. Business & IT, 10(1): 2-11.
[9] Peng Jiang, Guangdong Liu. (2018) Key factors of green logistics development-based on the empirical study of Liaoning Province. Ecological Economy, 34(07):137-142+161
[10] Zhang Nana. (2021) Research on Green Efficiency of Yunnan Logistics Industry. Kunming University of Science and Technology
[11] Tian Hongyan. (2018) Performance evaluation of green logistics and analysis of its influencing factors. Jiangxi University of Finance and Economics.
[12] Cheng Xiaohe. (2020) Evaluation of green development level of logistics enterprises. Anqing Normal University.
[13] Sun Kaiyang. (2021) Evaluation of the carbon reduction effect of Xiong'an Green Logistics under the market trading mechanism. Shijiazhuang Tiedao university.
[14] Xia Fu. (2022) Green logistics theory and its development path. China Logistics and Purchasing, (02):116.
[15] Jiang Xiaoru. (2021) Research on the development path and countermeasures of green logistics in China. Logistics Engineering and Management, 43(11):16-18.