

# Research and Statistical Application of Fuzzy Comprehensive Evaluation of Green Development Level of Logistics Enterprises in China Based on Driver-Pressure-State-Impact-Response Framework

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**Abstract**—Green and sustainable development will become the mainstream of The Times. Logistics, as a service industry closely related to the people, should vigorously promote green development. How to evaluate the green development degree of an express delivery enterprise needs not only qualitative explanation, but also quantitative objective evaluation. In this paper, DPSIR method is applied to construct the evaluation index system of green development of logistics enterprises. After in-depth investigation and understanding of relevant enterprises, this paper analyzes the life cycle of logistics, such as receiving, packaging sorting, transportation, storage and distribution processes. By using the analytic Hierarchy Process (AHP) and fuzzy comprehensive evaluation method, we collected data from some companies and used relevant statistics for analysis, then the development degree of green logistics is quantified, and the green development degree of China's logistics enterprises is quantitatively analyzed.

**Keywords**-component; Green logistics; DPSIR; AHP; Fuzzy comprehensive evaluation

## 1 INTRODUCTION

With the rapid development of China's e-commerce, the development of China's express industry is also advancing by leaps and bounds. However, while we enjoy the convenience of express delivery to our life, the waste of resources and pollution emissions brought by the logistics industry have also caused great damage to our living environment. At present, the study of green and sustainable logistics is still in the stage of continuous improvement, and there is no unified conclusion on the concept and elements of sustainable supply chain. At the same time, due to the rapid growth and change of express services in China, the analysis of green and sustainable environment has been challenged.

Scholars all over the world generally believe that the sustainable development of green logistics is to improve the best logistics services for both supply and demand with the least consumption of resources and the least emission of pollution. Wang ChangQiong<sup>[1]</sup> analyzed the major effects of modern logistics activities on the environment, puts forward the sustainable development for

environmental requirements of the logistics activity. Yang GuoChuan <sup>[2]</sup> believes that green logistics involves sustainable economic development, ecological economics and ecological ethics. Zheng WeiYan <sup>[3]</sup> believes that the development of green logistics is mainly aimed at excessive packaging and packaging recycling mechanism. Hu HuiHui <sup>[4]</sup> through detailed study the concept, related theory and features of city logistics, comprehensive analysis of the city logistics green power and inner meaning of sustainable development, comprehensive analysis of the factors influence the sustainable development of city green logistics members. Zhang Peng <sup>[5]</sup> from the level of ecological green packaging, green transportation, and green logistics technology utilization, green reverse logistics level from four aspects to construct the express industry evaluation index system of green logistics system life attitude, and use the analytic hierarchy process (ahp) to measure the contribution of each index. Drumwright <sup>[6]</sup> proposes that enterprises should properly assume their social responsibilities. They should not only pursue economic benefits, but also pay attention to social benefits, and organize their production and operation activities accordingly. Michael <sup>[7]</sup> proposes that appropriate environmental regulations can encourage enterprises to carry out more innovative activities, which will improve the productivity of enterprises, offset the costs brought by environmental protection and improve the profitability of enterprises in the market. But there are no compelling studies showing how universal it is.

At present, the study of green and sustainable logistics is still in the stage of continuous improvement, and there is no unified conclusion on the concept and elements of green logistics. Therefore, the DPSIR (Driver - Pressure - State - Impact - Response) evaluation index system model is applied to the strategic environment analysis of sustainable development of logistics enterprises in this paper, and the logical causal relationship between the development of logistics industry and economy, ecology and society is linked. Through consulting relevant information and research, this paper establishes a set of authoritative, portable and compatible fuzzy performance evaluation theory for green and sustainable development of logistics enterprises. And this paper uses the analytic Hierarchy Process (AHP) and fuzzy comprehensive evaluation method of the theory, the development of green logistics to quantify the degree of green development of China's logistics enterprises.

The G20 Summit, the 19th National Congress of the Communist Party of China (CPC) and the 14th Five-year Plan have all highlighted the concept of green development. China has been promoting green development in all walks of life, which shows that green development is a top priority in China's economic construction. It is expected that this set of evaluation indicators and methods can help measure the degree of green development of Chinese express enterprises, and it is hoped that the results of this paper can help Chinese express enterprises to better move towards the road of green development.

## **2 EVALUATION INDEX SYSTEM AND WEIGHT CALCULATION OF GREEN AND SUSTAINABLE DEVELOPMENT OF LOGISTICS ENTERPRISES**

### **2.1 Construction of green logistics evaluation index System based on DPSIR model**

The existing evaluation index system for green and sustainable development of logistics enterprises is relatively simple. Most of them adopt general indicators to carry out performance appraisal, mainly examining common evaluation indicators such as economy, environment, resources, technology and society, and rarely considering the internal relationship between these indicators. DPSIR framework is short for the "Driver - Pressure - State - Impact - Response" model. Driver is determined by human needs and represents the power that can promote human development <sup>[8]</sup>. Pressure is the negative impact or destruction of natural and artificial environment caused by human activities. State reflects the current environment; Impact is the impact of the current situation of the environment on human beings, usually negative impact; Response is the feedback of improvement actions taken after human beings are affected. DPSIR framework has strong logic and can reasonably explain the process of human development and the causal relationship between indicators, so it has been widely used in the field of sustainable development in the world. Karen et al. <sup>[9]</sup> used DPSIR framework to analyze the underground environmental problems in Asian cities such as Bangkok, Jakarta, Manila and Osaka. Sarmin et al. <sup>[10]</sup> used DPSIR framework to analyze the causes of mangrove felling in Johor, Malaysia.

Based on the research characteristics of evaluation index system in domestic and foreign literature, this paper introduces DPSIR method to construct evaluation index system. According to the basic principle of DPSIR model and the green and sustainable characteristics of logistics enterprises, DPSIR of green and sustainable development evolution of logistics enterprises can be understood as follows:

D is the endogenous demand driving force for the economic development of logistics enterprises and the most primitive factor that promotes the development of logistics industry, including the expectation of economic growth and improvement of life quality. Among them, social and economic development, interest driving of logistics industry and growth of e-commerce are the main driving force for the development of express industry. Therefore, the driving force indicators selected are mainly in social and economic development, industrial economic benefits and the scale of e-commerce.

P is the pressure of production and work of logistics enterprises on the ecological environment system. With the increasing demand for express delivery, the scale of express delivery enterprises is increasing, express waybills, express packaging bags, packaging boxes, the number of private trucks, fuel consumption, land and other resources are also increasing. Therefore, the index selected is the consumption of packaging, fuel oil, land and other resources.

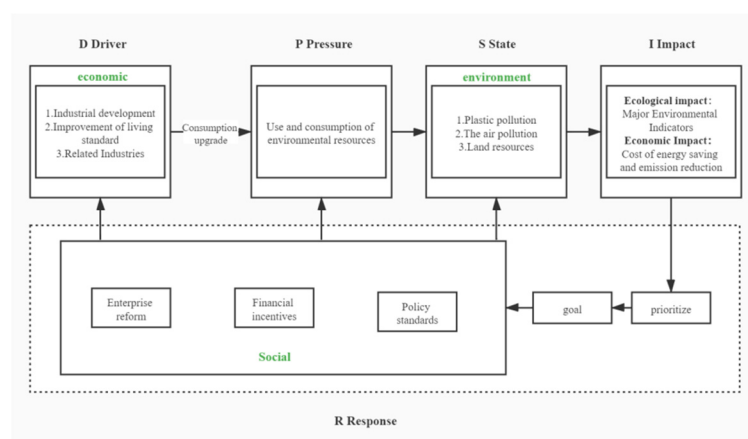
S refers to the development status of the logistics industry and the status of the system under the driving force and pressure, and the status represents the changes in the development status of the logistics industry. In terms of the logistics industry itself, the specific status indicators can be considered from the following aspects: first, the scale of the logistics industry, including the total number of parcels in the logistics industry, the gross product value and the proportion of logistics practitioners; The second is the structure of the logistics industry. The index that can

be selected is the ratio between the production and operation facilities of traditional logistics and the production and operation of modern intelligent logistics. The third is the development speed of the logistics industry. The selected indicators are the proportion of the output value of the logistics industry in GDP and the growth rate of parcel volume. From the system level, it should also include social economy, ecological environment and other contents, comprehensively elaborate the current situation brought by the development of logistics industry, including per capita express delivery, single package evaluation price, automobile exhaust, noise emission and so on.

I is the impact of logistics production activities in this state on the economy and ecological environment, mainly the negative impact. The specific indicators can be determined from the environmental level, corporate income and the impact of stakeholders. In the process of the rapid development of logistics industry, the loss of enterprises and society and the impact of human health are caused by the operation of non-environmental protection, unscientific planning and non-energy-saving operation. It includes the increase of receiving cost, the direct economic loss caused by pollution, the long-term economic benefits of enterprises, and the adverse impact on human beings caused by public facilities such as roads. Therefore, the selected indicators are the increase of single cost of paper surface, direct economic loss from pollution, dry road traffic pressure level, and increase of long-term storage cost, etc.

R refers to the adjustment measures taken by enterprises, governments, the public and stakeholders to the current situation and influence of the express delivery industry and system in order to promote the green and healthy development of the express delivery industry after the logistics industry is affected by the above mentioned influence. The selected indicators are divided into internal and external indicators. The selectable indicators within the industry include: Degree of enterprise informatization, investment in green logistics R&D, training of green logistics talents, use of green logistics schemes, etc.; The indicators outside the industry include policy incentives, the perfection of laws and regulations, and the public's recognition of green logistics.

The above theoretical analysis can be clearly shown in Figure 1.



**Fig.1** DPSIR analysis model for green development of logistics enterprises

According to the above analysis from the five aspects of driving force, pressure, state, impact and response, I have read a large number of domestic and foreign literatures related to the evaluation of sustainable development of green logistics. After visiting several logistics enterprises, the evaluation index system was developed according to the above framework in combination with various links involved in logistics production activities, such as sending and receiving, packaging sorting, transportation, storage and distribution, as shown in Figure 2.



Fig.2 Evaluation index system of green development of logistics enterprises

## 2.2Ahp was used to construct the weight of performance evaluation indicators

According to the index system and the characteristics of green logistics, ahp is used to determine the weight of each index. To index weight is scientific, practical and advanced, we set up by the enterprise management personnel, technical personnel, the jury of experts, a total of 20 people at colleges and universities, the weights of evaluation indicators, through the solicit opinions from the jury members, determine the pair of comparative judgment matrix, among them Table 1 is the judgment matrix of the first layer. By calculation, all the consistency of judgement matrix are all passed the inspection. The weight of each index obtained by analytic hierarchy process is shown in Table 2. Where, the weight is the eigenvector of the corresponding judgment matrix, and  $\lambda$  is the maximum eigenroot.

Among them(1)(2)

$$CI = \frac{\lambda - n}{n - 1} \quad (1)$$

$$CR = \frac{CI}{RI} \quad (2)$$

**TABLE.1** A-B<sub>i</sub> RELATIVE IMPORTANCE COMPARISON

A	B1	B2	B3	B4	B5	Weight	Consistency
B1	1	3	5	1	3	0.3548	$\lambda=5.2456$
B2	1/3	1	1/2	1/5	1/3	0.0674	CI=0.0614
B3	1/5	2	1	1/2	1/3	0.0964	RI=1.12
B4	1	5	2	1	2	0.3017	CR=0.0548
B5	1/3	3	3	1/2	1	0.1797	CR<0.1, pass

**TABLE.2** WEIGHT COEFFICIENT OF COMPREHENSIVE BENEFIT INDEX OF GREEN LOGISTICS

Total indicator	First-level indicator	Weight	Secondary index	Weight
Degree of green and sustainable development of logistics enterprises	Driver	0.3548	Growth rate of logistics investment	0.5816
			GDP per capita	0.1095
			Online retail scale	0.3090
	Pressure	0.0674	Consumption of paper sheet	0.1047
			Consumption of plastic packaging materials	0.6370
			Fuel consumption	0.2583
	State	0.0964	Warehouse floor area	0.1095
			The amount of plastic waste produced	0.5816
			Transport vehicle exhaust emissions	0.3090
	Impact	0.3017	White pollution index	0.5954
			Air quality of traffic section	0.1283
			Direct economic losses from pollution	0.2764
	Response	0.1797	Input into green development of logistics enterprises	0.6483
			Policy incentive degree	0.2297
			Degree of perfection of laws and regulations	0.1220

It can be seen from the weight coefficient table of green logistics comprehensive benefit index that the driving force has the greatest impact on the green and sustainable development of China's express delivery enterprises, followed by the impact of the environmentally unfriendly express delivery operation mode and the response of enterprises and governments.

### 3 CONSTRUCT FUZZY COMPREHENSIVE EVALUATION METHOD TO EVALUATE PERFORMANCE QUALITATIVELY AND QUANTITATIVELY

Chinese scholar Wang Peizhuang put forward fuzzy comprehensive evaluation method to solve the problems that traditional evaluation methods can not or difficult to solve. The decision target unit is evaluated by synthesizing index weight matrix and newly established membership matrix, which includes the determination of membership matrix and composition operator. Among them, membership matrix is composed of membership degree, and the determination methods are distributed statistics, typical function method, fuzzy statistics method, etc. The synthetic operator method consists of common matrix multiplication and Chad operator. The following mainly introduces the steps and process of how to use fuzzy comprehensive evaluation method to evaluate the green and sustainable development degree of logistics enterprises.

Step one: Determine the set theory domain of evaluation indicators  $U$ ,  $U=\{u_1, u_2, \dots, u_n\}$ , among them  $u_i(i=1, 2, \dots, n)$  is the same level of evaluation factors.

Step two: Determine the set theory domain of comments  $V$ :  $V=\{v_1, v_2, \dots, v_n\}$ ( $n$  is the number of rating).

Step three: Determine the weight allocation fuzzy vector  $A$ :  $A=\{a_1, a_2, \dots, a_m\}$ ( $m$  is the number of index items), according to AHP method to determine the weight of each evaluation factor.

Step four: Single factor evaluation. Forming evaluation fuzzy matrix  $R_i=\{r_{ij}\}$ , among them,  $r_{ij}$  is the expression of the proportion of a certain evaluation grade taken by the expert group established by logistics industry managers and professors, in that way, the comprehensive evaluation membership judgment matrix of category  $i$  ( $i=1, 2, \dots, n$ ) is(3)

$$R_{ij} = \begin{pmatrix} r_{i11} & \dots & r_{i1m} \\ \vdots & \ddots & \vdots \\ r_{in1} & \dots & r_{inm} \end{pmatrix} \quad (3)$$

The single factor comprehensive evaluation result is  $B_i = W_i * R_i$ , furthermore(4)

$$B_i = W_i * R_i = (w_{i1}, w_{i2}, \dots, w_{in}) \begin{pmatrix} r_{i11} & \dots & r_{i1m} \\ \vdots & \ddots & \vdots \\ r_{in1} & \dots & r_{inm} \end{pmatrix} \quad (4)$$

Step 5: Comprehensive multi-level evaluation. Create a higher level evaluation matrix  $R$ , then the comprehensive evaluation matrix  $B$  is(5)

$$B = W * R = (w_1, w_2, \dots, w_n) \begin{pmatrix} r_{11} & \dots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{n1} & \dots & r_{nm} \end{pmatrix} \quad (5)$$

In the formula, n is the number of evaluation index set, m is the number of evaluation grades.

Step six: Normalize the final B.

Step seven: Evaluate and judge the degree of green and sustainable development of logistics enterprises according to the maximum membership degree method.

#### 4 THE EXAMPLE ANALYSIS

This paper selects a logistics enterprise in Beijing and makes an empirical analysis of its green and sustainable development.

(1) Collect relevant expert grading questionnaire. In order to carry out the evaluation, we invited 30 logistics industry managers, scholars and government related personnel to form an expert panel to score the indicators of this logistics enterprise. In this paper, the evaluation grade V is divided into four grades: excellent, good, pass and flunk. Combined with the experts' scoring of qualitative indicators and referring to the quantitative data provided by relevant departments, the experts' scoring is normalized and the corresponding data is calculated by Excel.

(2) According to the expert group scoring evaluation results, combined with the actual situation of the logistics enterprise. To sum up, the fuzzy comprehensive evaluation hierarchy of green and sustainable development of logistics enterprises is shown in Table 3.

**TABLE.3** HIERARCHY STRUCTURE TABLE OF FUZZY COMPREHENSIVE EVALUATION OF A LOGISTICS ENTERPRISE

Total indicator	First-level indicator	Weight	Secondary index	Weight	Rating V (Proportion of experts)			
					excellent	good	pass	flunk
Degree of green and sustainable development of logistics enterprises	Driver	0.3548	Growth rate of logistics investment	0.27	0.50	0.17	0.07	0.27
			GDP per capita	0.67	0.20	0.13	0.00	0.67
			Online retail scale	0.60	0.27	0.13	0.00	0.60
	Pressure	0.0674	Consumption of paper sheet	0.17	0.20	0.23	0.40	0.17
			Consumption of plastic packaging materials	0.03	0.17	0.23	0.57	0.03
			Fuel consumption	0.07	0.20	0.27	0.47	0.07
	State	0.0964	Warehouse floor area	0.20	0.23	0.23	0.33	0.20
			The amount of plastic waste produced	0.03	0.27	0.27	0.43	0.03
			Transport vehicle exhaust emissions	0.03	0.23	0.27	0.47	0.03
	Impact	0.3017	White pollution index	0.10	0.33	0.33	0.23	0.10
			Air quality of traffic section	0.03	0.47	0.27	0.23	0.03
			Direct economic losses from pollution	0.10	0.27	0.43	0.20	0.10



	Response	0.1797	Input into green development	0.23	0.40	0.23	0.13	0.23
Policy incentive degree			0.17	0.50	0.23	0.10	0.17	
Degree of perfection of laws and regulations			0.13	0.43	0.33	0.10	0.13	

(3) Construct the second-level indicator membership judgment matrix R1(6):

$$R1 = \begin{pmatrix} 0.27 & 0.5 & 0.17 & 0.07 \\ 0.67 & 0.2 & 0.13 & 0 \\ 0.60 & 0.27 & 0.13 & 0 \end{pmatrix} \quad (6)$$

(4) Calculate the second-level fuzzy evaluation B1(7):

$$B1 = W1 * R1 = (0.5816, 0.1095, 0.3090) \begin{pmatrix} 0.27 & 0.5 & 0.17 & 0.27 \\ 0.67 & 0.2 & 0.13 & 0 \\ 0.60 & 0.27 & 0.13 & 0 \end{pmatrix} \quad (7)$$

According to the above methods, the calculation results of the secondary fuzzy evaluation of other indicators at layer B are calculated and summarized. The calculation results of the green development degree of the logistics enterprise are shown in Table 4.

**TABLE.4 RESULTS OF A LOGISTICS ENTERPRISE SECONDARY FUZZY COMPREHENSIVE EVALUATION**

Factor set of Layer C	The evaluation results			
	excellent	good	pass	flunk
Driver Driver	0.4134	0.3951	0.1527	0.0388
Pressure Pressure	0.0559	0.1788	0.2419	0.5234
State	0.0516	0.2527	0.2630	0.4327
Impact	0.0914	0.3320	0.3524	0.2241
Response	0.2058	0.4270	0.2455	0.1216

(5) The first-level comprehensive evaluation is(8):

$$B = (0.3548, 0.0674, 0.0964, 0.3017, 0.1797) \begin{pmatrix} 0.4134 & 0.3951 & 0.1527 & 0.0388 \\ 0.0559 & 0.1788 & 0.2419 & 0.5234 \\ 0.0516 & 0.2527 & 0.2630 & 0.4327 \\ 0.0914 & 0.3320 & 0.3524 & 0.2241 \\ 0.2058 & 0.4270 & 0.2455 & 0.1216 \end{pmatrix} \quad (8)$$

(6) Normalized(9):

$$B = (0.22, 0.3535, 0.2463, 0.1802) \quad (9)$$

So far, the results of DPSIR evaluation index system based on the construction of this logistics enterprise are obtained, as shown in Table 5.

**TABLE.5** EVALUATION RESULTS OF GREEN DEVELOPMENT DEGREE OF A LOGISTICS ENTERPRISE

Degree of green development of the logistics enterprise	The evaluation results			
	excellent	good	pass	flunk
Membership	0. 2200	0. 3535	0. 2463	0. 1802

It can be seen that under the evaluation index system constructed based on DPSIR, the overall green and sustainable development degree of the logistics enterprise is good. Apart, it can be seen from this evaluation that the consequences of the non-green development of the logistics enterprise in the past are still further affecting the green development of the enterprise, but the driving force and response of the green development of the enterprise are relatively positive. If the logistics enterprise hopes to achieve green development faster, further attention should be paid to the "pressure" and "state" of the above evaluation index system, such as "consumption of plastic packaging belt".

## 5 CONCLUSION

In today's society, the development strategy of "lucid waters and lush mountains are invaluable assets" has been widely accepted, and green and sustainable development has become a development model recognized by the international community. China's logistics industry is constantly expanding its development scale and market, but they must also think about their future development direction. This paper creatively combines DPSIR evaluation model with logistics industry, from collection sorting, packaging, transportation, warehousing and distribution based on DPSIR model is constructed the evaluation index system of the sustainable development of green logistics industry of our country, and use the APH analytic hierarchy process (ahp) to determine the weight of each index, the results show that the influence of the driving force for China's express delivery enterprises the influence degree of the sustainable development of the green is the biggest of all. Then the fuzzy comprehensive evaluation method is used to construct qualitative and quantitative evaluation of green development performance. Finally, a logistics enterprise in Beijing is selected for empirical analysis. The results show that the overall green development degree of the logistics enterprise is good, and suggestions are put forward for the green development of the enterprise through this evaluation.

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