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Research Paper

Research on Evaluation of Logistics Providers for Cross-border Export E-commerce

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ABSTRACT: *In this paper, an evaluation indicator system for cross-border export e-commerce logistics providers is proposed. The indicator system considers four dimensions: company profile, service capability, service quality, and degree of informatization. And it incorporates objective criteria with strong industry characteristics to improve the practical applicability. A combined weighting model is proposed based on the Bayesian best-worst method (BBWM) and the entropy weight method. The grey relational TOPSIS method is then applied to evaluate logistics providers. Empirical results indicate that service capability is the most critical factor, followed by service quality and company profile, while the impact of degree of informatization is minimal. Key criteria such as customs clearance agent in destination country and self-operated vehicle fleet in destination country should be given particular attention. While large-scale logistics providers generally perform better, companies with stringent cost control requirements may also consider small-scale logistics providers with competitive strengths in individual dimension of logistics capability.*

KEYWORDS: *Cross-border Export E-commerce, Logistics Provider Evaluation, Bayesian Best-Worst Method, Combination Weighting, Grey Relational TOPSIS*

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I. INTRODUCTION

Under the dual impetus of global economic integration and digital transformation, the cross-border e-commerce sector has experienced explosive growth. According to statistics from China Customs, the total value of China's cross-border e-commerce exports reached RMB 1.84 trillion in 2023, marking a year-on-year increase of 20.2%. This rapid expansion presents vast opportunities for cross-border e-commerce companies. However, the completion of transactions heavily depends on cross-border logistics system, which is inherently more complex and challenging than domestic logistics. High-quality and reliable logistics providers can significantly reduce logistics costs, improve operational efficiency, and enhance customer satisfaction, thereby strengthening the companies' competitive advantage. Therefore, the scientific and rational evaluation and selection of logistics providers is of critical importance for cross-border export e-commerce companies.

In the relevant literature on logistics provider evaluation, Reference [1] evaluated green cold chain logistics service providers by considering service quality, service cost, service capability, green competitiveness, and operation status of enterprises. The Best-Worst Method (BWM) and the CRITIC method were employed to determine the combined weights of the evaluation criteria, and a cloud model-based evaluation approach was proposed. Reference [2] proposed a grey PSI-LOPCOW-MACONT framework, and considered criteria such as skilled workforce, financial strength, IT/IS competence, design and technological competence, and human resources, to address the multidimensional 3PL selection decision problem for automotive businesses. In the context of cross-border export e-commerce logistics providers, Reference [3] considered transportation time, transportation cost, and transportation reliability, using entropy weight method to determine weights of criteria and utilizing the ELECTRE method to select cross-border logistics providers. Reference [4] evaluated logistics providers based on four dimensions: logistics distribution cost , logistics distribution quality , logistics distribution capability and logistics value - added service. The maximum deviation method was introduced into the intuitionistic fuzzy set to determine weights of criteria, and the TOPSIS method was used to evaluate logistics providers. Reference [5] considered criteria such as company credit, service price, and operational

management costs. AHP and CRITIC method were adopted to obtain subjective and objective weights, and a comprehensive evaluation model for logistics providers based on fuzzy evidence reasoning was established.

In summary, relevant studies on the evaluation of logistics providers for cross-border export e-commerce are relatively scarce. Moreover, current evaluation indicator systems tend to be highly theoretical, lacking sufficient reflection of industry-specific practical characteristics. Most studies use a single method for assigning weights to criteria, which makes it difficult to address the complex decision-making environment of cross-border export e-commerce logistics. Therefore, the study refers to relevant literature to obtain academic perspectives, and combines the insights from cross-border e-commerce platforms, third-party evaluation agencies, and industry experts to establish an evaluation indicator system for cross-border export e-commerce logistics providers. Referring to research methods used in the evaluation of logistics providers in other fields, the study applies a combination weighting method to the evaluation indicator system and subsequently conducts a comprehensive evaluation of logistics providers serving the cross-border export e-commerce companies.

II. EVALUATION INDICATOR SYSTEM AND EVALUATION PROCESS

2.1 Evaluation Indicator System

In the study, an evaluation indicator system is developed through a multi-source approach. Social network analysis is employed to extract perspectives from the academic literature. These are then integrated with criteria adopted by cross-border e-commerce platforms and third-party evaluation agencies. In addition, expert opinions are gathered through interviews with academic experts specializing in cross-border e-commerce logistics as well as staff members from the industry. Following the principles of comprehensiveness, relevance, and operability, the study proposes an evaluation indicator system for cross-border export e-commerce logistics providers, structured around four dimensions: company profile, service capability, service quality, and degree of informatization. The evaluation indicator system is presented in Table 1.

Table 1: Evaluation indicator system for cross-border export e-commerce logistics providers

Dimensions	Criteria	Description
Company Profile (B1)	Annual Revenue (C11)	Revenue from cross-border logistics operations within the past year (in billions of RMB).
	Financing Stage (C12)	five levels: Unfunded, Series A, Series B, Series C, and IPO.
	Number of Employees (C13)	Number of formally employed staff.
	Business Coverage (C14)	Number of regions the company can deliver to (e.g., North America, Europe, Southeast Asia).
	Supported Major Platforms (C15)	Number of major e-commerce platforms the provider collaborates with (e.g., Amazon, AliExpress).
	Number of Business Type (C16)	Classified into international express, dedicated small-parcel lines, and overseas warehousing.
Service Capability (B2)	Delivery Timeliness (C21)	Number of days from pickup by the provider to successful delivery.
	Maximum Daily Processing Volume (C22)	Maximum number of parcels the logistics system can handle daily (in 10,000 items).
	Door-to-Door Pickup (C23)	Whether pickup from specified locations is supported.
	Space Booking Capability (C24)	Whether the provider can directly book space with shipping or airline carriers on key routes
	Customs Clearance Agent in Destination Country (C25)	Whether the provider operates its own customs clearance agency in the destination country.
	Overseas Warehousing (C26)	Area of self-owned or long-term leased warehouses in the destination country (in 10,000 m²).
	Self-Operated Fleet in Destination Country (C27)	Whether the provider owns and operates transport vehicles and driver teams in the destination country.
	Reverse Logistics Capability (C28)	Ability to provide convenient and efficient reverse logistics services (5 levels).
	Special Cargo Handling Capability (C29)	Number of special cargo types handled (e.g., hazardous goods, cold chain, fragile items).
Service Quality (B3)	24-Hour Order Response Rate (C31)	(Orders responded to within 24 hours ÷ total orders) × 100%
	On-Time Delivery (C32)	Whether goods are delivered on time (5 levels).
	Accurate and Intact Delivery (C33)	Whether goods are delivered with no damage, errors, omissions, or losses (5 levels).
	Customer Feedback Channels (C34)	Number of feedback channels available (e.g., customer system, online chat).
	Responsiveness to Customer Requirements (C35)	Speed and professionalism in responding to customized client needs (5 levels).
	Emergency Response Capability (C36)	Efficiency in handling various emergencies (5 levels).
	VIP Delivery Discount in Destination Country (C37)	Whether delivery partners in the destination country provide the logistics provider with premium accounts that offer high discount rates and low surcharges.
Degree of	Information Security Capability (C41)	Measures taken to protect customer data (5 levels).

Informatization (B4)	Automated Cost Estimation (C42)	Whether the system can automatically quote prices to ensure price transparency.
	End-to-End Tracking Visibility (C43)	Whether visualized tracking enables end-to-end query, exception alerts, and key-node notifications.
	Data Integration Capability (C44)	Whether standardized APIs are available for real-time data exchange (5 levels).
	Website Information Completeness (C45)	Whether key service information is available on the official website (5 levels).
	Smart Warehousing (C46)	Whether the provider employs smart warehousing technologies to enhance storage efficiency.

Based on expert recommendations, the study incorporates a set of criteria that reflect practical operational requirements within the cross-border logistics process, such as the space booking capability, customs clearance agent, self-operated fleets and VIP delivery discounts in destination country. These additions contribute to the development of a comprehensive, systematic, and highly practical evaluation indicator system for cross-border export e-commerce logistics providers, characterized by strong alignment with industry practices and real-world applicability.

2.2 Evaluation Process

The study determines the subjective and objective weights of criteria using the Bayesian best-worst method (BBWM) and the entropy weight method, respectively. These weights are then integrated through the combination weighting method of game theory. Based on these, the grey relational TOPSIS method is applied to evaluate cross-border export e-commerce logistics providers. The evaluation process is illustrated in Figure 1.

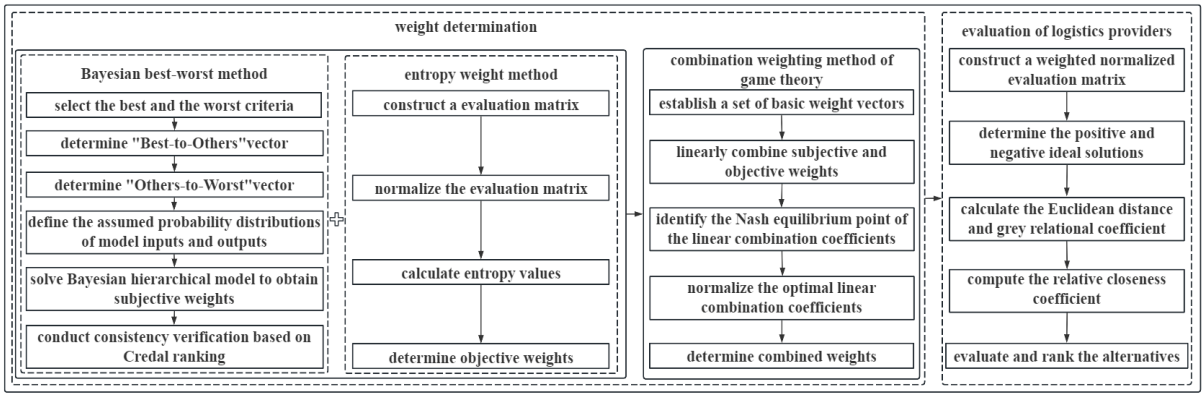

Figure 1: Evaluation process for cross-border e-commerce logistics providers

2.3 Empirical Cases

To conduct a comprehensive study of cross-border export e-commerce logistics providers, the study selects ten logistics providers as the subjects of empirical analysis. Among them, Providers A, B, C, D, and E rank among the top ten in various industry annual rankings published by multiple third-party evaluation agencies. In 2023, each of these providers reported annual revenues exceeding RMB 4 billion and had undergone multiple rounds of financing, thus qualifying as large-scale logistics providers. In contrast, Providers V, W, X, Y, and Z each reported annual revenues below RMB 500 million in 2023 and had either not received any financing or had only completed a Series A round, thereby representing small-scale logistics providers.

III. WEIGHT DETERMINATION

3.1 Determining Subjective Weights Using the Bayesian Best-Worst Method

The Bayesian best-worst method, proposed by Mohammadi and Rezaei in 2020, is an improved version of the best-worst method (BWM) [6]. The original BWM calculates weights of criteria based on the judgment of a single expert, and when multiple experts are involved, it simply averages the weights derived from each expert, which makes the results sensitive to outliers. In contrast, BBWM, by combining the Bayesian hierarchical model and using probabilistic modeling, could find the aggregated final weights of criteria for a group of decision-makers at once. This method not only improves efficiency but also reduces subjectivity and enhances the credibility of the weights.

In the study, three academic experts specializing in this field, three representatives from cross-border export e-commerce logistics providers, and four staff members from cross-border export e-commerce companies were invited to participate. Each expert was asked to select the best and the worst criteria and conducted pairwise comparisons between them and other criteria. The evaluation indicator system includes one set of dimensions and four sets of criteria under each dimension, requiring experts to perform five rounds of weight determination. Taking the set of dimensions as an example, the pairwise comparison results between the best

criterion and the other criteria, as well as between the other criteria and the worst criterion, are shown in Tables 2 and 3, respectively.

Table 2: The pairwise comparison results between the best criterion and the other criteria

Expert	The Best Criterion	Comparison Criteria			
		B1	B2	B3	B4
1	B2	3	1	1	2
2	B3	4	2	1	3
3	B3	5	2	1	8
4	B2	3	1	2	8
5	B3	3	1	1	5
6	B2	6	1	2	5
7	B2	4	1	2	3
8	B2	3	1	2	3
9	B1	1	3	2	4
10	B2	3	1	2	2

Table 3: The pairwise comparison results between the other criteria and the worst criterion

Expert	The Worst Criterion	Comparison Criteria			
		B1	B2	B3	B4
1	B1	1	4	4	2
2	B1	1	4	5	2
3	B4	4	6	7	1
4	B4	5	7	6	1
5	B4	2	4	4	1
6	B1	1	7	5	3
7	B1	1	4	3	2
8	B4	1	3	2	1
9	B4	4	2	3	1
10	B1	1	3	2	2

In the tables, the number 1 indicates that the two criteria are equally important, while the number 9 indicates that the former is extremely more important than the latter. Using the open-source code provided by Reference [6], the aggregated subjective weights derived from all experts were calculated, and a consistency verification was conducted. Since all Credal ranking values exceed the threshold of 0.5 set by Reference [6], further discussion is deemed unnecessary. The Credal ranking values are shown in Figure 2.

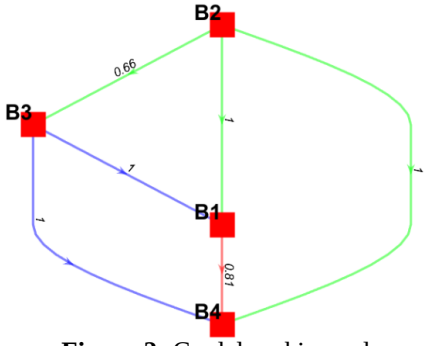

Figure 2: Credal ranking values

By applying the same method to four sets of criteria under each dimension, the subjective weights for the entire evaluation indicator system were determined. The subjective weights are listed in the second and sixth columns of Table 5.

3.2 Determining Objective Weights Using the Entropy Weight Method

The entropy weight method is a data-driven approach to determining weights based on the principle of information entropy. By applying this method, the influence of subjective judgment can be minimized, allowing for an objective determination of the importance of each criterion. This provides a scientific basis for the evaluation and selection of cross-border export e-commerce logistics providers.

In the study, original data for each logistics provider were obtained through multiple channels, including information published on their official websites, telephone inquiries, and consultations with experts, etc. The collected data are presented in Table 4. Based on this data, an evaluation matrix was constructed and normalized. Subsequently, the entropy values and corresponding weights for each criterion were calculated. The objective weights are listed in the third and seventh columns of Table 5.

Table 4: Original data

Logistics Providers \ Criteria	C11	C12	C13	C14	C15	C16	C21	C22	C23
A	228	4	5000	13	4	3	4	150	1
B	110	4	10000	13	3	3	6.5	1000	1
C	400	4	14285	13	1	3	7	500	1
D	44.3	3	500	7	5	1	13.5	10	1
E	97.7	4	3758	13	3	2	8.5	500	1
V	5	0	200	10	6	2	7	100	1
W	1.36	1	150	2	2	2	7	100	0
X	0.15	0	30	9	2	2	5	15	1
Y	0.2	0	50	10	3	1	4	50	1
Z	0.1	0	150	10	2	2	6.5	80	1
Logistics Providers \ Criteria	C24	C25	C26	C27	C28	C29	C31	C32	C33
A	5	3	185	1	4	5	99.9	5	5
B	5	5	100	1	4	0	99.5	5	5
C	2	5	80	0	4	2	99.9	5	5
D	5	3	50	1	3	3	99.7	5	5
E	2	3	0	0	3	3	99.7	5	5
V	5	3	30	0	5	2	90	4	5
W	4	5	45	0	3	2	90	3	3
X	3	5	2	1	3	0	80	4	3
Y	1	3	8	0	4	1	60	3	3
Z	5	3	15	0	4	2	90	4	3

Logistics Providers \ Criteria	C34	C35	C36	C37	C41	C42	C43	C44	C45	C46
A	6	4	4	1	5	1	1	5	5	1
B	5	4	4	1	5	1	1	5	5	1
C	7	4	4	0	5	1	1	5	5	1
D	5	4	4	1	5	1	1	5	5	1
E	4	4	4	1	5	1	1	5	5	0
V	5	3	3	0	5	1	1	5	3	1
W	4	3	3	1	3	1	1	3	4	1
X	4	3	3	1	4	1	1	5	2	0
Y	6	4	5	0	5	1	1	5	4	1
Z	5	3	3	0	4	1	1	5	3	1

3.3 Determining Combined Weights Using Combination Weighting Method of Game Theory

Given the complexity of decision-making in the cross-border export e-commerce logistics, it is essential to integrate both expert judgment and data. To achieve more reasonable weighting results, the study employs combination weighting method of game theory to merges subjective and objective weights. Based on the principle of game theory, this method treats the subjective weights derived from the BBWM and the objective weights obtained through the entropy weight method as two players in a game. The goal is to find a Nash equilibrium that maximizes the collective benefit by minimizing the deviation between the combined weights and the respective subjective and objective weights. This approach ensures the complementarity of subjective and objective weighting methods.

In the study, a linear combination of subjective and objective weights was conducted to identify the Nash equilibrium point of the combination coefficients, followed by normalization of the results. The normalized combination coefficient for the subjective weights is 0.245672, while that for the objective weights is 0.754328. The combined weights are listed in the fourth and eighth columns of Table 5.

Table 5: Weights of criteria for logistics providers

Dimensions	Subjective Weights	Objective Weights	Combined Weights	Criteria	Subjective Weights	Objective Weights	Combined Weights
B1	16.40%	27.96%	25.11%	C11	2.51%	8.19%	6.79%
				C12	1.85%	5.26%	4.42%
				C13	1.89%	8.37%	6.78%
				C14	2.98%	1.22%	1.65%
				C15	3.68%	2.36%	2.68%
				C16	3.48%	2.56%	2.79%
B2	36.52%	39.61%	38.85%	C21	4.83%	1.13%	2.04%
				C22	4.51%	6.29%	5.85%
				C23	3.36%	0.96%	1.55%
				C24	4.95%	1.88%	2.63%
				C25	4.78%	8.31%	7.44%
				C26	4.66%	4.83%	4.79%
				C27	4.08%	8.31%	7.27%
				C28	2.49%	5.03%	4.41%
				C29	2.86%	2.87%	2.87%

B3	33.61%	26.66%	28.37%	C31	4.70%	1.14%	2.01%
				C32	7.01%	2.46%	3.58%
				C33	5.93%	4.63%	4.95%
				C34	3.44%	4.14%	3.97%
				C35	4.39%	4.63%	4.57%
				C36	3.31%	5.03%	4.61%
				C37	4.83%	4.63%	4.68%
B4	13.47%	5.80%	7.68%	C41	3.04%	1.24%	1.68%
				C42	2.67%	0.00%	0.66%
				C43	2.97%	0.00%	0.73%
				C44	2.19%	0.96%	1.26%
				C45	1.51%	1.58%	1.56%
				C46	1.09%	2.02%	1.79%

IV. EVALUATION OF LOGISTICS PROVIDERS

The technique for order preference by similarity to ideal solution (TOPSIS) method calculates the Euclidean distance between each cross-border export e-commerce logistics provider and the ideal solution, thereby reflecting the absolute numerical differences among the providers. Meanwhile, grey relational analysis (GRA) quantifies the degree of association among criteria to assess the similarity in trends between each provider and the ideal solution. The grey relational TOPSIS method integrates both approaches, simultaneously considering the relative closeness in terms of distance and pattern between the providers and the ideal solution. This fusion enhances the comprehensiveness and accuracy of the evaluation results. In the study, the grey relational TOPSIS was applied to conduct both individual dimension evaluations and overall evaluation of cross-border export e-commerce logistics providers. The results are presented in Table 6.

Table 6: Relative closeness coefficient and rankings of logistics providers

Logistics Providers	Company Profile	Ran-king	Service Capability	Ran-king	Service Quality	Ran-king	Degree of Informatization	Ran-king	Overall Evaluation	Ran-king
A	0.5774	2	0.5496	2	0.7224	1	0.7402	1	0.5932	2
B	0.5740	3	0.6660	1	0.6876	3	0.7402	1	0.6392	1
C	0.7024	1	0.5049	4	0.6269	5	0.7402	1	0.5929	3
D	0.3755	5	0.4485	5	0.6878	2	0.7402	1	0.5042	4
E	0.4758	4	0.3391	9	0.6464	4	0.5255	8	0.4789	5
V	0.3405	6	0.4031	7	0.4112	7	0.6058	6	0.4131	7
W	0.2778	9	0.4416	6	0.3556	9	0.4307	9	0.4024	8
X	0.2782	8	0.5178	3	0.3737	8	0.3711	10	0.4398	6
Y	0.2656	10	0.3250	10	0.4563	6	0.6682	5	0.3909	9
Z	0.2832	7	0.3617	8	0.2889	10	0.5458	7	0.3528	10

The higher the relative closeness coefficient, the closer the cross-border export e-commerce logistics provider is to the optimal situation. Among all the providers evaluated, Provider B demonstrates the overall best performance, followed by Providers A and C. Therefore, cross-border e-commerce companies could select one or two providers from this group. In contrast, Provider Z has the lowest relative closeness coefficient and should be avoided in the selection process.

The empirical research results indicate that service capability is the most important dimension in evaluating and selecting logistics providers, followed by service quality and company profile, while the impact of degree of informatization is minimal. Service capability encompasses the provider's integrated operational abilities across the entire logistics chain, including pickup, line-haul, customs clearance, warehousing and distribution in the destination country, and reverse logistics. Among the criteria, customs clearance agent in destination country, self-operated fleet in destination country, maximum daily processing volume, overseas warehousing, and reverse logistics capability all exert significant influence on the evaluation results. Service quality reflects performance across the entire order fulfillment process, from order response to final delivery. In this empirical study, logistics providers of similar scale exhibit comparable levels of service quality. However, there are substantial disparities in service quality between large-scale and small-scale logistics providers. The company profile reflects a provider's overall strength, development potential, and risk resistance capacity. Accurate evaluation of logistics providers requires the integration of this dimension with other dimensions. The degree of informatization has minimal impact on evaluation, primarily due to the phenomenon of homogenization, particularly among large-scale logistics providers. When comparing logistics providers of different scales, those with larger scale generally demonstrate superior overall performance. Thus, where economic conditions permit, large-scale logistics providers are the preferred choice. However, in individual dimension evaluations, some small-scale providers outperform or closely match certain large-scale providers, demonstrating a notable level of competitiveness. Therefore, for cross-border e-commerce companies with strict cost control requirements, it is also viable to consider smaller logistics providers that demonstrate strong capabilities specifically in the dimension of service capability.

V. CONCLUSION

The study constructs an evaluation indicator system for cross-border export e-commerce logistics providers based on a comprehensive review of academic literature, as well as insights from cross-border e-commerce platforms, third-party evaluation agencies, and industry experts. The system comprises 28 criteria across four dimensions. Subjective and objective weights are determined using the Bayesian best-worst method and the entropy weight method, respectively. These are then integrated using a combination weighting method of game theory to derive the combined weights, and the grey relational TOPSIS method is employed to conduct evaluation, enhancing the objectivity and accuracy of the results and providing a scientifically grounded reference for decision-making by cross-border export e-commerce companies. Future research could focus on specific countries or regions. Since different logistics providers have varying strengths across different markets, evaluations could target providers specializing in a particular country, thereby supporting more precise and context-specific provider selection decisions.

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