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Research on the Evaluation Mechanism of Platform Companies to Complementors in Building New E-Supply Chains[1]

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Abstract. This paper takes B2C platform enterprises as the main subject of evaluation and considers the construction of e-supply chains among complementary roles of the platform as the research object. It considers distributors-retailers-consumers as each ring of e-supply chains and uses supply chain flexibility, supply chain performance, supply chain risk, supply chain credit, and supply chain competitiveness as indicators to comprehensively evaluate multiple e-supply chains on the same type of platform enterprises. Innovations: (a) It focuses on the micro-environment of the e-supply chain where the platform enterprises and complementary players are located. (b) Combining the entropy method "from cause to effect" and the fuzzy comprehensive evaluation method "from cause to effect," combining objective and subjective empowerment and dividing the expert interviewees into roles in the supply chain. (c) Unlike the traditional evaluation mechanism, where the analysis target is independent of the supply chain, this paper focuses on analyzing the overall and comprehensive performance of the e-supply chain built by complementary platform roles in various dimensions.

Keywords. Platform Enterprise, E-Supply Chain, Fuzzy Comprehensive Evaluation Method, Entropy Weight Method

1. Introduction

The development of e-supply chains is based on extensive network technology. The deep integration of supply chain actors with the Internet of Things (IoT) has become the focus of research in e-supply chains. On the one hand, blockchain frameworks are built to enable product and technology traceability in supply chain management[1], realizing innovation at the technological level. On the other hand, it reflects in many aspects, such

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as supplier selection, product outsourcer judging, the construction of delivery trust mechanism, the forecast of order demand, the share of inventory data, the feedback from customer evaluation, reverse logistics services and others.

Meanwhile, with the speedy development of commerce, logistics, and capital flows, the dynamic cooperation relationship between platform companies and complementary roles profoundly affects the degree of complementary participation, which eventually affects the initial start-up effect of platform enterprises (Lai et al.,2019)[2]. . A direct manifestation of the impact on complementary participation is that complementary roles will take many factors, including the cost of joining the platform companies and the degree of control the platform companies, into consideration, which will decide whether the complement joins the platform enterprise or not (Miron et al.,2018)[3]. Conversely, the way that the platform enterprise enters the complementary space can exert pressure on complements to enter the complementary space. The entry mode into the complementary space is related to the platform governance approach (Young et al.,2022)[4]. Thus, the dynamic partnership and evaluation results between platform firms and complements influence the future behavioral orientation of each subject.

Theoretically, this study focuses on the micro-environment- the e-supply chain in which platform firms and complementary roles are located. In contrast to previous researches which focus on evaluation object in the traditional mechanism as an individual player in the supply chain, this study analyses the overall performance of the e-supply chain constructed by the platform complementary players under different indicator dimensions. By combining the entropy method "from cause to effect" and the fuzzy comprehensive evaluation method "from cause to effect", objective empowerment and subjective empowerment are combined; in practical terms, the scientific evaluation of the comprehensive situation of the supply chain is conducive to the platform enterprises' clarification of the e-supply chain synergy situation of the complementaries, the benchmarking of similar enterprises, and the provision of a basis for decision-makers to judge the comprehensive benefits of the e-supply chain.

2. Literature Review

Most of the existing literature is on flexibility, performance, risk, credit, and competitiveness in evaluating supply chains. This study addresses the issue of constructing evaluation mechanisms for e-supply chains, and Table 1 compares the domestic and international supply chain evaluation perspectives and related references.

Table 1. Domestic and international supply chain evaluation perspectives and related references[3]

No.	Evaluation Perspective	Related references	Number
1	Flexibility	Chirra & Kumar(2018) Huo & Gu & Wang(2018) Rojo &Stevenson &Montes &Maria(2018) Luo &Wang & Lu & Guan(2020) Li & Chen & Sun& Cui(2020) Maqueira & Novais & Bruque(2020) Lima-Junior & Carpinetti(2017)	39
2	Performance	Ran & Hu & Fu(2021) Hosseini & Najmeh & Ahad(2021) Zhang& Qu &Chen(2021) He & Bo(2022)	5014

[3] Data Source: China National Knowledge Infrastructure (CNKI) search data, 2022/7/26 (18:08)

		Wu & Jia & Li & Song& Xu & Liu(2019)	
		Chen &Ding &Ma(2020)	
3	Risk	Martino & Fera & Mira(2020)	695
		Chi(2021)	
		Phi-Hung(2022)	
		Liu&Gao(2021)	
4	Credit	Qian & Huang(2022)	798
		Gu&Liu&Ye(2022)	
		Wang(2017)	
5	Competitiveness	Yan & Zhuo & Li (2019),	366
		Verma & Nisha (2018)	

Supply chain flexibility evaluation focuses on the synergy status among enterprises within the supply chain and the degree of adaptation of the supply chain to cope with the complex and dynamic external environmental factors. Li(2021) applied the fuzzy hierarchical analysis method (FAHP) to explore the supply chain flexibility status of apparel enterprises in four dimensions: logistics flexibility, production flexibility, information system flexibility, and resource flexibility[5]. Luo et al. (2020) considered the dynamic characteristics of supply chain operations and used the theory of object element analysis to evaluate the supply chain flexibility model[6] comprehensively. In addition to the existing domain-specific studies mentioned above, the increase in uncertainty has complicated supply chain models and reduced the scope of flexibility analysis[7]. As a result, scholars need to focus on the mechanism by which supply chain flexibility affects the overall effectiveness of the supply chain.

The state of supply chain performance directly determines the existing development of supply chain firms and whether they are sustainable in the future. Sun(2022) established an evaluation index system for fresh produce e-commerce from four dimensions: efficiency, cost, quality, and customers[8]; while Zhang(2022) combined the characteristics of pharmaceutical enterprises in building green supply chains, selected suitable performance evaluation indexes and built a complete evaluation system[9]. The evaluation indexes were established and confined to the industry characteristics of the evaluated objects and influenced by the endogenous factors of supply chain enterprise development and their interrelationships.

Supply chain risk control is not absolute stability, leading to improved supply chain performance. When internal and external risks tend to be infinite, supply chain companies' product innovation decreases and their ability to cope with internal and external risk challenges becomes 'burned out and diminished[10]. Giada et al.(2020) argue that the short product life cycle, rapid iterations and high demand uncertainty in the fashion apparel retail sector make supply chain risk evaluation necessary[11]. The above evaluation results help supply chain managers to identify potential risks and take preventive measures.

Supply chain credit evaluation is about the foundation of cooperation. Gu et al.(2022) proposed the integrated learning model BO-XGBoost-Bagging (BXB) to solve the credit risk control problem of SME financing[12]. Also, for SMEs, Liu et al. (2020) cut into the supply chain financing model with an e-commerce platform to improve the credit evaluation system of small and micro enterprises and solve the financing difficulty[13]. It can be seen that when the scale of supply chain members is not equal, core enterprises should pay more attention to trust rating and determination, aiming to ensure the overall cooperation and stability of the supply chain. For this study, the platform enterprise's trust evaluation of the complementary supply chain directly determines the end sales experience, distribution supply timeliness, and platform supervision input strength.

Supply chain competitiveness evaluation refers to evaluating the heterogeneity

capability of the supply chain in its dominant market. Supply chain competitiveness is influenced by internal resource retention, learning and updating capabilities, competitive strategy formulation options, human resources, and academic support. Yan et al. (2019) used expansion theory to evaluate the competitiveness of agricultural supply chains[14]. Verma et al.(2018) used AHP as an analytical tool to analyze the competitiveness of Indian manufacturing supply chains using multi-criteria decision-making[15]. The results of these evaluations can provide a basis for decision-making on the competitiveness of supply chain enterprises and also compare the supply chain competitiveness of the evaluated subjects.

This paper chooses the entropy weight method combined with the fuzzy comprehensive evaluation method in selecting evaluation method. The entropy method can deeply reflect the distinguishing ability of indicators, assigning objective weights with high credibility; the fuzzy evaluation deals with fuzzy evaluation objects through precise numerical means, which can make a more scientific, reasonable and close to the actual quantitative evaluation of the information that contains information presenting fuzzy nature. This paper combines the fuzzy comprehensive evaluation method. It relies on the expert scoring method to give full play to the advantages of the entropy method, which is in line with the specific theme of platform enterprises' evaluation of the e-supply chain of complementary players.

The existing supply chain evaluation studies are relatively comprehensive, but there are still research gaps. (a) Most of the studies are focused on a specific analysis of a particular product or a particular area, and there are relatively few systematic evaluations of supply chains; (b) there are few studies on the evaluation of supply chains in the micro area of platform enterprises and complementaries; (c) the construction of e-supply chains is mainly studied at the technical level, and there are few studies on the evaluation mechanism of e-supply chains as a whole, without considering the differences in technical levels. (d) The evaluation methods are single and have problems in terms of methodological adaptability.

Therefore, this study selects five dimensions as evaluation indexes, namely supply chain flexibility evaluation, supply chain performance evaluation, supply chain risk evaluation, supply chain credit evaluation and supply chain competitiveness evaluation, and uses the entropy weight method and fuzzy comprehensive evaluation method to analyze the status of e-supply chain constructed by complementary players.

3. Evaluation Mechanism Construction

3.1 The Entropy Method

The entropy method measures the weight assigned to an evaluation object. It draws on the physics concept of disorder in the thermal movement of matter to describe the degree of dispersion of the measured indicator. In the information theory perspective, each indicator's degree of dispersion represents each indicator's information entropy. The variability of the evaluation indicators is proportional to the entropy weight value, and the modified entropy weight reflects the objectivity of the evaluation indicator weights in a certain sense and reduces the subjectivity of the assigned weights. The basic steps are as follows.

Step 1. Set the number of evaluation years as i ,the number of evaluation indicators as j

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1j} \\ \vdots & \ddots & \vdots \\ a_{i1} & \cdots & a_{ij} \end{bmatrix} \tag{1}$$

Step 2. Data standardisation

$$M = \begin{bmatrix} \breve{M}_{11} & \cdots & \breve{M}_{1m} \\ \vdots & \ddots & \vdots \\ \breve{M}_{n1} & \cdots & \breve{M}_{nm} \end{bmatrix} \tag{2}$$

$$\tilde{M}_{nm}^{+} = \frac{a_{ij} - min\left\{a_{1j}, a_{2j}, \ldots, a_{ij}\right\}}{max\left\{a_{1j}, a_{2j}, \ldots, a_{ij}\right\} - min\left\{a_{1j}, a_{2j}, \ldots, a_{ij}\right\}} \tag{3}$$

$$\tilde{M}_{nm}^{-} = \frac{max\left\{a_{1j}, a_{2j}, \ldots, a_{ij}\right\} - a_{ij}}{max\left\{a_{1j}, a_{2j}, \ldots, a_{ij}\right\} - min\left\{a_{1j}, a_{2j}, \ldots, a_{ij}\right\}} \tag{4}$$

Step 3. Solve for the probabilities required for relative entropy and construct the matrix

$$p_{nm} = \frac{\tilde{M}_{nm}}{\sum_{n=1}^{i} \tilde{M}_{nm}} \tag{5}$$

$$Q_{nm} = \begin{bmatrix} P_{11} \ln\left(p_{11}\right) & \cdots & P_{1m} \ln\left(p_{1m}\right) \\ \vdots & \ddots & \vdots \\ P_{n1} \ln\left(p_{n1}\right) & \cdots & P_{nm} \ln\left(p_{nm}\right) \end{bmatrix} \tag{6}$$

Step 4. Calculate the information entropy of each indicator.

$$H = \left[H_1 \ H_2 \ldots H_m\right] \tag{7}$$

$$H_m = -\sum_{n=1}^{i} p_{nm} \ln\left(p_{nm}\right) / \ln i \qquad (m = 1, 2, \ldots, j) \tag{8}$$

Step 5. Solving for information utility values.

$$D_m = 1 - H_m \tag{9}$$

Step 6. Normalization process to derive the entropy weight of each indicator

$$e_m = \frac{D_m}{\sum_{m=1}^{j} D_m} \tag{10}$$

3.2 Fuzzy Comprehensive Evaluation Method

The fuzzy integrated evaluation method is based on fuzzy mathematics, a comprehensive evaluation analysis of the affiliation status of multiple factors that cannot be easily quantified. In analyzing the affiliation status, two or even three levels of factors can be designed and evaluated, analyzing systematization characteristics. This method is in line with complementaries' complexity and supply chains. The basic steps are as follows.

Step 1. Determine the set of fuzzy comprehensive evaluation factors, where the number of evaluation indicators set is the same as in the entropy weighting method, and the actual meaning of the indicators is the same.

$$U = \{U_1, U_2, ..., U_m\} \tag{11}$$

Step 2. Determine the fuzzy comprehensive judgment evaluation set.

$$V = \{V_1, V_2, \ldots, V_z\} \tag{12}$$

Step 3. A single-factor fuzzy judgement is performed to obtain a judgement matrix R (determined using the expert method).

$$R = \begin{bmatrix} R_1 \\ R_2 \\ R_3 \end{bmatrix} = \begin{bmatrix} \frac{a_{11}}{Q} & \cdots & \frac{a_{1n}}{Q} \\ \vdots & \ddots & \vdots \\ \frac{a_{m1}}{Q} & \cdots & \frac{a_{mn}}{Q} \end{bmatrix} \tag{13}$$

Step 4. Use the results of the entropy weighting method to establish the weight of each indicator factor.

$$e = [e_1, e_2, \ldots, e_m] \tag{14}$$

Step 5. Building a Judging Model

Table 2. M-operator evolutionary process matrix

e^T	R_1	R_2	R_3	R_4
e_1	R_{11}	R_{12}	$\cdots$	R_{1n}
e_2	R_{21}	R_{22}	$\cdots$	R_{2n}
$\vdots$	$\cdots$	$\cdots$	$\vdots$	$\cdots$
e_m	R_{m1}	R_{m2}	$\cdots$	R_{mm}
$B = e * R$	B_1	B_2	$\cdots$	B_n

$$B = e^*R = [e_1, e_2, \ldots, e_m]_{1m} * \begin{bmatrix} R_{11} & \cdots & R_{1n} \\ \vdots & \ddots & \vdots \\ R_{m1} & \cdots & R_{mn} \end{bmatrix}_{mn} \quad (c = 1, 2, \ldots, n) \tag{15}$$

$$B_c = Max\left\{\min\left\{e_1, R_{1c}\right\}, \min\left\{e_2, R_{2c}\right\}, \ldots, \min\left\{e_m, R_{mc}\right\}\right\} \tag{16}$$

Step 6. Normalization

$$P_n = \frac{B_n}{\sum B_n} \tag{17}$$

$$B' = \left\{P_1, P_2, \ldots, P_n\right\} \tag{18}$$

The results of this evaluation show that. The evaluation subject evaluates this object as " V_1 " for P_1 , " V_2 " for P_2 , ..., and " V_z " for P_n . "

3.3 Evaluation Mechanism Construction Process

Taking Alibaba as an example, this study analyses the company's financial report data. It applies the entropy weighting method to determine the weights of the five indicators to analyze the weighting of the focus on the above five dimensions among successful B2C platform companies, as shown in Table 3

Table 3. Quantification and interpretation of evaluation indicators

Factor set	Rating Indicators	Definition of Indicators	Reference basis
U_1	Flexibility	Responsiveness to market changes	Number of sub-sectors covered by the platform(pcs)
U_2	Performance	Level of business operations	Total Transaction GMV[4] (billion yuan)
U_3	Risk	Ability to control internal and external risks	AACA rights holders[5](pcs)
U_4	Credit	Measurement of capital flow turnover	Net profit from financing activities(in millions)
U_5	Competitiveness	Share of market share	Number of active consumers[6](billion)

U_1 :The platform ecology covers the number of constituent businesses under each service area. According to Almeida et al.(2018), the broader the area of operations covered, the more members a supply chain firm is exposed to and the less flexible the supply chain.

U_2 :Total turnover GMV reflects the state of supply chain performance.

U_3 :The ability to protect IPRs in crucial technology areas based on the e-supply chain. The higher the number of ACCA IPR rights, the higher the ability to deal with risks such as counterfeit products, IPR infringement and brand stigmatization.

U_4 :The difference between the cash inflows and outflows formed during the financing process of the enterprise, the financing capacity reflects the degree of creditworthiness of the e-supply chain constructed by the complementary players.

[4] Statistic value is Alibaba China retail marketplace GMV (excluding international marketplace transactions)
[5] AACA, the Alibaba Anti-Counterfeiting Alliance, was founded in July 2017. Dedicated to working with domestic and international rights holders to defend their intellectual property rights
[6] Counts annual active consumers from China across Alibaba's China retail marketplace, digital media, and entertainment platforms

U_5 :Use the number of active users to evaluate the platform companies' popularity and market competitiveness status.

4. Evaluation Analysis

Collating data from Alibaba's (2018-2022)financial results yields Table 4. Harmful normalization and positive normalization of the remaining indicators

Table 4. Statistics for each reference of evaluation indicators[7]

Rating Indicators / Year	U_1	U_2	U_3	U_4	U_5
2018	27	48200	105	20359	5.52
2019	28	57270	132	7392	6.54
2020	28	65890	179	70853	7.80
2021	31	74940	190	30082	8.91
2022	32	79760	210	64449	9.03

Table 5. Standardization of evaluation indicators

Standardized Indicators / Year	U_1	U_2	U_3	U_4	U_5
2018	1	0	0	0.20433	0
2019	0.8	0.287389	0.257143	0	0.290598
2020	0.8	0.56052	0.704762	1	0.649573
2021	0.2	0.847275	0.809524	0.357542	0.965812
2022	0	1	1	0.899088	1
SUM(U_I)	2.8	2.695184	2.771429	2.46096	2.905983

Moreover, based on Table 5, to derive different sample probabilities under different indicators, to find the information entropy and information utility value, the final entropy weight value is shown in Table 6.

Table 6. Information entropy and entropy weights

Rating Indicators / Measured values	e_1	e_2	e_3	e_4	e_5
Information entropy	0.790394	0.805821	0.805296	0.758459	0.806713
Information utility value	0.209606	0.194179	0.194704	0.241541	0.193287
Entropy weights[8]	0.202848	0.187918	0.188426	0.233753	0.187055

The results show that Alibaba has a 20.28% supply chain flexibility status, 18.79% of supply chain performance status, 18.84% of supply chain risk status, 23.38% of supply chain credit status and 18.71% of supply chain competitiveness status. Supply chain flexibility and credit status accounted for the highest percentage. Affected by the COVID-19, the uncertainty factors in the Chinese market increased in 2019-2022; the physical circulation was affected, and the electronic platform B2C enterprises are susceptible to this change, the game between the platform and the complementary players is gradually "manifested".

Combined with the above analysis, Alibaba's entropy is in line with the current situation of platform enterprises' operations. Assuming that there are four dimensions of indicators, "excellent," "good," "moderate," and "poor," and three characters, including distributors, retailers, and consumers, to select, we issue a questionnaire to evaluate the construction of an e-supply chain by J platform enterprises to a complementary party.

[7] Data Source: Alibaba FY 2020-2022 Report, 2018 Alibaba Anti-Counterfeiting Alliance Report.

[8] SUM(D_m)= 1.033318

The evaluation results were obtained, as shown in Table 7.

Table 7. Expert method findings

Evaluation set / Factor set	V_1 Excellent	V_2 Good	V_3 Moderate	V_4 Poor	Number
U_1	2	5	6	2	
U_2	1	2	9	3	
U_3	0	2	4	9	15
U_4	1	3	8	3	
U_5	4	5	5	1	

Table 8. Evaluation matrix and normalization results

e^T	R_1	R_2	R_3	R_4
0.2028	133333	0.333333	0.4	0.133333
0.1879	0.066667	0.133333	0.6	0.2
0.1884	0	0.133333	0.266667	0.6
0.2338	0.066667	0.2	0.533333	0.2
0.1871	0.266667	0.333333	0.333333	0.066667
B	0.187055	0.202848	0.233753	0.2
Normalization results[9]	0.227103	0.246278	0.283799	0.24282

The results of this study, using the M(∧,∨) fuzzy synthetic operator, show that 22.71% of the respondents rated it as "excellent," 24.63% rated it as "good," 28.38% rated it as "fair," and 24.28% rated it as "poor." "24.28% rated it as "poor." With a total of over 50% "good" and "poor," the e-supply chains built by complementary players generally meet the requirements of J-Platform companies but are rated poorly in terms of performance and risk and credit: external uncertainty, weak economic growth in the overall market and difficulty in financing. The problems in the supply chain, such as the delivery response times, exception handling rates, differentiated demand fulfillment, and inventory and out-of-stock rates, fall far below expectations. However, respondents are confident in the state of supply chain competitiveness.

5. Conclusion

This study uses B2C platform enterprises as the evaluation subject. Based on the characteristics of platform enterprises focusing on the end of the supply chain, the three-level role of distributor-retailer-consumer is used to evaluate the status of the e-supply chain in which they participate. The entropy weighting method was used to determine the evaluation index weights (supply chain flexibility, supply chain performance, risk, supply chain credit, and supply chain competitiveness), taking Alibaba as an example. Its entropy weighting value was used to construct a set of factors for constructing the e-supply chain status of J platform enterprises to a complementary player. The results of the survey of 15 participants in the three-level role are determined as the evaluation set. The comprehensive e-supply chain operation condition constructed by the complementary is determined through the evaluation matrix, which provides the platform enterprise with the basis for the complementary's e-supply chain decision.

There are three shortcomings in this study that could be studied in depth. (a) The

[9] SUM(B)= 0.823656

evaluation indicators only involve the primary indicator layer. The evaluation process can be iterated based on these five evaluations in the future to refine the weighting of the secondary element layer (b) The questionnaire does not involve suppliers and manufacturers. (c) The study has only researched public, for-profit platform enterprises. The evaluation mechanism of specific non-profit platform organizations has not been involved.

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