Analyzing Collaborative Development of E-Commerce and Logistics Based on DEA

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Abstract

In order to know the current collaborative development situation and relationship of E-commerce and logistics, the paper evaluates the whole collaborative development level of Chinese E-commerce and logistics from 2008 to 2014 using the DEA model. Fund, infrastructure, labor and collaborative development are evaluated and analyzed in this model. The research indicates that E-commerce facilitates the logistics development but logistics can't support E-commerce development well due to the lag effect which leads to lower collaborative development level. So optimizing the ratio of logistics investment and output, promoting logistics service quality and accelerating logistics development have been the key factors for promoting the collaborative development of E-commerce and logistics.

Keywords

E-Commerce, Logistics, EDA Model, Collaborative Development, Assessment

1. Introduction

E-commerce is a new commerce circulation form with the development of Internet, electronic information technology and telecommunications industry. The E-commerce with various products and convenient payment process promotes rapid increase of correspond logistics need. Meanwhile, the development of logistics can facilitate circulation efficiency and customer service which support the development of E-commerce. However, the gap between E-commerce and logistics is becoming large due to incomplete logistics system, backward information level and weak infrastructure. The development speed of our national E-commerce is 200% to 300% but the increase rate of logistics development is only 40% according to the data from China E-commerce research center. The unbalanced phenomenon has caused many problems such as the lose of parcels

and spoilage of commodities. So balancing and assessing the relationship between them are essential to form a synergistic development effect.

Now scholars mainly focus on the following three aspects: Firstly, the mutual effect between E-commerce and logistics. About logistics influence on E-commerce: Aldin, N. [1] analyzed how marketing channels and logistics operation promoted E-commerce development. Colin, J. [2] states logistics which connects sellers and customers is important to push commodities circulation under E-commerce. And about E-commerce influence on logistics, Chen and Zhang [3] think E-commerce enlarges logistics needs and enhances logistics industry status. Wu [4] analyzes influence of E-commerce on logistics from four angles include distribution form, information condition, technology level and service scale; secondly, logistics development strategies under E-commerce environment. Lu and Cheng [5] put forward strategies from society recognition, infrastructure, development institution and talent based on the analysis between E-commerce and logistics. Cheng and Yang [6] analyzed current problems existed in E-commerce logistics and suggested to build an open, interactive and economic socialization distribution system from the perspective of the whole industry; thirdly, the collaborative development models about E-commerce and logistics [7] [8]. At the beginning of the research, scholars focus more on concrete operation aspects. For example, integrate supply chain, coordinate logistics network and operate different logistics models at the same time. With the deeper research, Jun [9] adds the strategy and policy aspects to the collaborative analysis which perfects system between E-commerce and logistics. In short, now scholars pay more attention to explore effect factors and development models based on qualitative analysis but ignore quantitative analysis such as specific effect size and degree of collaborative development.

On the base of current practical development status and research achievement author takes the collaborative development status and factors as the main research content. In order to assess collaborative development objectively DEA model is used to analyze investment and output efficiency of two industries, relevant data are collected and assessment indicator system is built. In general, the paper provides theoretical and practical value for pushing collaborative development between E-commerce and logistics.

2. The Assessment Model of E-Commerce and Logistics Collaborative Development

2.1. DEA Collaborative Assessment Model

A. Charnes and W. Wcopper [10] put forward a new statistical approach DEA based on relative efficiency. This model has the advantage of evaluating relative efficiency facing many input and output data which have the identical unit. Currently, there are C^2R and C^2GS^2 two common models which were used to collaborative assessment for many times. Yang and Li [11] used it to do an empirical analysis about the logistics collaborative efficiency in Beijing, Tianjin and Hebei Province three areas. He and Ma [12] used it to do a comparison research

between regional logistics and economics of Sichuan province in recent 10 years. This paper evaluates E-commerce and logistics collaborative development using DEA and summarizes development future at different time. Reasons and improvement measures are presented according to the assessment result in order to advance two industries collaborative development.

Assuming in a production activity the DEA input vector is $x = (x_1, x_2, \cdots, x_m)^{\mathrm{T}}$, output vector is $y = (y_1, y_2, \cdots, y_s)$. So (x, y) can be used to denote the whole activities.

Assuming that the number of decision making units $\mathrm{DMU}_j (1 \le j \le n)$ for *n*, there are corresponding input and output variables:

$$x_j = (x_{1j}, x_{2j}, \cdots, x_{mj})^{\mathrm{T}} > 0 \quad j = 1, 2, \cdots, n,$$

$$y_j = (y_{1j}, y_{2j}, \cdots, y_{sj})^{\mathrm{T}} > 0 \quad j = 1, 2, \cdots, n,$$

$$x_{ij} > 0, \; y_{rj} > 0, \; i = 1, 2, \cdots, m, \; r = 1, 2, \cdots, s.$$

This means that each decision unit has m types of input and s types on output x_{ij}, y_j are *j* decision making unit in volume of the *i* type of input and output of the *r* type of output capacity.

2.1.1. C^2R Comprehensive Validity Assessment Model about *A* System to *B* System

E-commerce and logistics depend on and promote each other mutually, so the relationship between them can be regarded as the relationship between input and output. In the evaluation using the model [8], the "relative efficiency" of the *A* system input to the *B* system output is regarded as the integrated development validity of *A* system relative *B* system, Where *u, v* represents the input and output weight vector. The concrete assessment formula as follow:

$$\max h(A/B) = \frac{u^{\mathrm{T}} y_B}{v^{\mathrm{T}} x_A},$$

$$s.t. \frac{u^{\mathrm{T}} y_B}{v^{\mathrm{T}} x_A} \le 1, \tag{1}$$

$$j = (1, 2, \cdots, n), v \ge 0, u \ge 0.$$

In C^2R model, objective function is the efficiency indicator of j_0 decision making unit and constraint condition is efficiency index of all the decision making units. At the same time slack variable *s+* and the surplus variable *s−* are brought into linear programming *D* on the basis of Charnes-Cooper. The collaborative development validity of system *A* to system *B* is $\theta(A/B)$.

$$(D) \begin{cases} \min \theta_0 (A/B) \\ s.t. \sum_{j=1}^{n} \lambda_{A/Bj} x_{Aj} + s^+ = x_{A0} \theta_0 (A/B) \\ \sum_{j=1}^{n} \lambda_{A/Bj} x_{Bj} - s^- = y_{B0} \\ \lambda_{A/Bj} \ge 0, \; s^+ \ge 0, s^- \ge 0, \; j = 1, 2, \cdots, n \end{cases} . \tag{2}$$

1) If the optimal value of Equation (2) is $\theta_0 = 1$ and $s^{0-} = 0$, $s^{0+} = 0$, DMU_{j_0} is efficiency. It means that the inputs and outputs of each DMU reach the optimal state.

2) If the optimal value of Equation (2) is $\theta_0 = 1$, DMU_{j_0} is weak efficiency. It shows the need for further adjustment between the two system inputs and outputs.

3) If the optimal value of Equation (2) is $\theta_0 < 1$, DMU_{j_0} is under have no efficiency.

2.1.2. C^2GS^2 Collaborative Validity and Developmental Validity Assessment Model about A System to B System

C^2R is used to measure comprehensive validity of collaborative development between two systems which include technology validity and scale validity. Concrete reason can't be identified caused by technology invalidity or scale invalidity when the decision making unit j_0 is invalid. So C^2GS^2 must be introduced to further determine the invalid condition [13]. In this paper, the technical efficiency and scale efficiency are used to represent the collaborative and developmental validity of the system, and to judge whether there is scale restriction and low resource utilization in the collaborative of E-commerce and logistics. In order to achieve the purpose of promoting collaborative development, for A and B systems, if the input of system A corresponds to the output of system B, the collaborative validity of system A to system B is $\sigma(A/B)$, the model as follows:

$$(D)\begin{cases} \min \sigma_0(A/B) \\ s.t. \sum_{j=1}^{n} \lambda_{A/Bj} x_{Aj} + s^+ = x_{A0} \sigma_0(A/B) \\ \sum_{j=1}^{n} \lambda_{A/Bj} y_{Bj} - s^- = y_{B0} \\ \sum_{j=1}^{n} \lambda_{A/Bj} = 1 \\ \lambda_{A/Bj} \geq 0, \ s^+ \geq 0, \ s^- \geq 0, \ j = 1, 2, \cdots, n \end{cases} \qquad (3)$$

1) If the optimal value of Equation (3) is $\sigma_0 = 1$ and $s^{0-} = 0$, $s^{0+} = 0$, DMU_{j_0} is collaborative efficiency. It shows that the optimal allocation of resources and technology utilization.

2) If the optimal value of equation is $\sigma_0 = 1$, DMU_{j_0} is weak collaborative efficiency. It shows that collaborative resources are underutilized.

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The development validity of system A to system B is $\varphi_S(A/B)$:

$$\varphi(A/B) = \frac{\theta(A/B)}{\sigma(A/B)}. \qquad (4)$$

2.1.3. Collaborative Development Model between Two Systems

Analyzing the collaborative development validity about A to B according to the above model calculation, collaborative development validity about B to A can be calculated when changing the input and output data. If we want to get the whole

collaborative development evaluation between two systems we need to combine above two results using DEA model and sustainable development assessment theory [14] among different systems.

$$\theta(A,B) = \frac{\min\{\theta(A/B), \theta(B/A)\}}{\max\{\theta(A/B), \theta(B/A)\}}.$$ (5)

2.2. Building Indicators of Collaborative Development System

In order to measure the collaborative development level of Chinese E-commerce and logistics during different period of time. Two industries need to be divided into correspond subsystem and corresponding indicator system should be built. Firstly, the amount of indicators which can reflect system characteristics comprehensively need to be simplified; secondly, building the index system preliminary by referring analysis of Huo [15] and He [12], then selecting the most representative index. Finally, we consider current situation of E-commerce and then add mobile internet factor. The eventual index system is made up of five dimensions. They are fund, labor, infrastructure, the whole consumption level and the scale of industry development which were used to measure input and output situation of these two industries (Table 1).

Table 1. Assessment index of collaborative development between E-commerce and logistics.

System category	Index category	Name of index	Variables
E-commerce system	Input index	Fixed assets investment of Information transmission, computer service and software	X1
		Resident consumption	X2
		Internet interface	X3
		The amount of mobile phone	X4
		The number of E-commerce employees	X5
	Output index	Total volume of E-commerce trade	X6
		Transaction scale of mobile E-commerce	X7
		Market scale of mobile E-commerce	X8
		Market scale of cross-border e-commerce	X9
Logistic system	Input index	Fixed asset input of transportation, warehousing and mail business	Y1
		Retail amount of social consumer goods	Y2
		Transportation mileage	Y3
		Total energy consumption of mail business, transportation and warehousing	Y4
		Logistics employees	Y5
	Output index	Total amount of social logistics	Y6
		The volume of goods circulation	Y7
		Volume of freight traffic	Y8
		Added value of transportation, warehousing and postal service	Y9

3. The Analysis of Collaborative Situation between E-Commerce and Logistics

3.1. Abbreviations and Acronyms

Collaborative development between logistics and E-commerce during 2008 to 2014 will be analyzed and assessed. All the date come from *China Statistical Yearbook*, *Logistics Statistical Yearbook*, I Research and China E-Business Research Center. However, there is lack of complete statistics in logistics filed; individual data that cannot be obtained requires a simple calculation: transportation mileage is calculated by the sum of railway operating mileage, highway mileage, inland waterway mileage and regular flight routes. The whole logistics employees can be presented by direct employees from transport service, storage service and mail business.

3.2. Analysis of Synergy Conditions

The paper use DEA method to calculate the input-output efficiency and find out the effect between E-commerce and logistics industry through software DEAP2.1. In this process, according to the characteristics of the two industries, DEAP2.1 software in the ins file is set to INPUT and VRS for the development of the level of collaboration [16]. The paper can judge that E-commerce and logistics show collaborative development tendency when these two situation are DEA validity.

(1) Select E-commerce indicator as input data and logistics as output. The analysis result as shown in Table 2.

Evaluation index of comprehensive efficiency, pure technical efficiency and scale efficiency are all one in DMU model from 2008 to 2014 according to Table 3, which means every evaluation unit shows DEA validity. One phenomenon can be concluded that our country get equivalent increase of logistics scale and relative revenue when enlarge investment to E-commerce. During this process there is no phenomenon of resource waste and insufficient output. During these seven years the origin and development of E-commerce promote logistics development no matter in logistics transportation ability and in logistics market need.

(2) Select logistics indicator as input data and E-commerce as output. The analysis result as shown in Table 3. Specific redundant balance of investment

Table 2. Analysis result of collaborative development situation.

DMU	θ (A/B)	σ (A/B)	φ_S (A/B)	Returns to scale
2008	1	1	1	No change
2009	1	1	1	No change
2010	1	1	1	No change
2011	1	1	1	No change
2012	1	1	1	No change
2013	1	1	1	No change
2014	1	1	1	No change

Table 3. Analysis result of collaboration development situation.

DMU	$\theta (A/B)$	$\sigma (A/B)$	$\Phi_s (A/B)$	Returns to scale
2008	0.484	1.000	0.484	Increase
2009	0.566	1.000	0.566	Increase
2010	0.582	1.000	0.582	Increase
2011	0.684	0.995	0.687	Increase
2012	0.805	1.000	0.805	Increase
2013	0.894	0.974	0.918	Increase
2014	1.000	1.000	1.000	No change

and insufficient balance of output as shown in Table 4.

Comprehensive efficiency is rising continually and input and output efficiency is improving gradually during the whole process, which means collaborative circumstance is optimizing gradually according to the Table 3. Specifically, only 2014 DEA is valid which means relative efficiency of input and output resource reaches balanced state in this system. There is no waste of input resource and deficiency of output resource in 2014. But during 2008 to 2013 DEA is invalid which means the infrastructure, technology, management and scale can't meet the development need of modern logistics. This phenomenon confines the E-commerce development.

In view of the ineffective year of DEA, it is necessary to further investigate the influence of the pure technical efficiency and scale efficiency on the comprehensive efficiency. From the point of view of scale benefit, the state of scale income is increasing from 2008 to 2014 which shows Chinese logistics level can't meet E-commerce development. We can see the comprehensive efficiency and scale efficiency are less than one and the data shows the scale incomes increasing during 2008, 2009, 2010 and 2012, which means logistics confines E-commerce development. It's essential to enlarge resource investment of logistics. From the point of view of technology efficiency, the number of 2008, 2009, 2010 and 2012 are all one, which means the situation of resource allocation and technology utilization is well. Comparing with 2012 and 2013, DEA pure technology efficiency is invalid which indicates the utilization of resource is bad and collaborative validity is slow. In order to deal with this problem we'd better to adjust the ratio of input and output. From Table 4, We can find on 2013 fixed assets investment of transportation, warehousing and postal service declined by, the total volume of consumption retail sales decrease by, transportation mileage reduce by, the energy consumption reduce by, logistics employees reduce by and at the same time shipment turnover volume increase by, volume of goods transported increase by, transportation, storage and postal service increase by. The output efficiency of E-commerce caused by logistics will get efficient promotion and achieve DEA validity.

(3) Collaborative development result between *E*-commerce and logistics as shown Table 5.

Table 4. Input redundancy and under capacity.

Category	Variables	2008	2009	2010	2011	2012	2013	2014
Redundant balance of logistics input	X1	0	0	0	144.12	0	960.595	0
	X2	0	0	0	6220.758	0	13787.502	0
	X3	0	0	0	49.602	0	22.693	0
	X4	0	0	0	145.362	0	2192.289	0
	X5	0	0	0	3.376	0	55.138	0
Deficit of E-commerce output	Y1	0	0	0	261.189	0	0	0
	Y2	0	0	0	1185.25	0	1300.745	0
	Y3	0	0	0	702.857	0	3222.008	0
	Y4	0	0	0	0	0	811.114	0

Table 5. Comprehensive analysis of collaboration between E-commerce and logistics.

DMU	$\theta(A/B)$	$\theta(B/A)$	$\theta(A/B)$	Coordinated growth
2008	1.000	0.484	0.484	-
2009	1.000	0.566	0.566	16.9%
2010	1.000	0.582	0.582	2.8%
2011	1.000	0.684	0.684	17.5%
2012	1.000	0.805	0.805	17.7%
2013	1.000	0.894	0.894	11.1%
2014	1.000	1.000	1.000	11.9%

On the support of relative policy, fund and infrastructure E-commerce has improved rapidly during 2008 to 2014 according to Table 5. In order to enlarge the needs of logistics and push it develop healthily we must enhance the efficiency of logistics service. Even though the comprehensive efficiency is rising the DEA is still invalid overall. So there is hysteresis effect in logistic development which can't support E-commerce development.

There exist development speed and scale differences between E-commerce and logistics which lead to worse collaborative level. According to the comprehensive analysis of cooperation, logistics can't follow up E-commerce development which confines E-commerce development. From the point of view of collaborative speed, collaborative difference between E-commerce and logistics is becoming smaller with the high value from government. Now government takes different actions to greatly improve logistics operation ability, circulation efficiency and service quality. The synergy degree is developing rapidly at the rate of more than 10% except 2010. And eventually E-commerce and logistics development achieved an ideal situation where they promote collaboratively and mutually.

4. Conclusion

This paper does quantitative analysis and assessment about collaborative development level of E-commerce and logistics using DEA model and relative data

from 2008 to 2014. The result indicates lower rate of resource utilization and collaborative development. Standing at technology and scale perspective, we find development efficiency and scale of logistics are the key factors for synergy development. In order to advance logistics and E-commerce collaborative development, the process of building logistics infrastructure and information Internet should be sped up; the usage efficiency of resource and logistics service quality should be enhanced; logistics service scale should be enlarged; input and output ratio of logistics system should be improved and collaborative development model should be optimized.

Project Funding

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