Study on the optimization selection of cross-border E-commerce logistics distribution path under the O2O mode

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Abstract. The rapid development of cross-border e-commerce in online to offline (O2O) mode has brought more opportunities and challenges to the development of logistics industry. Aviation logistics is the most important way of cross-border logistics, the optimization of which plays an important role in e-commerce enterprises and logistics enterprises. This study studied the types of aircraft and the arrangement of air routes in the process of aviation logistics. The route optimization of passenger cabin and full cargo transportation was discussed respectively. A model was established and the optimization method was designed. Finally example analysis was performed. The results showed the designed method could achieve the maximum profit and the optimization of distribution routes. This study provides some references for the optimization of logistics distribution of cross-border e-commerce and is beneficial to the further development of the cross-border e-commerce logistics industry.

Keywords: O2O, logistics distribution, path optimization.

1. Introduction

Online to offline (O2O) mode can improve the efficiency of commodity sales and the consumption experience of users [1]. It breaks the barrier between traditional enterprises and the Internet and promotes the integration of online and offline businesses. Logistics distribution is a very important part of the O2O mode, and its optimization can effectively improve the competitive edge of enterprises. Site selection of experience shops and logistics distribution path planning are important parts of the O2O mode. Whether the distribution path is reasonable will directly affect the delivery time and efficiency [2]. Therefore, the problem of route optimization is very important in logistics distribution [3].

Deng et al. [4] proposed the hybrid genetic tabu search algorithm for the minimization of total cost of logistics transportation and route optimization and found that the method had high convergence speed and calculation efficiency through simulation experiments. Wang et al. [5] studied cold-chain logistics distribution, analyzed route optimization based on hybrid genetic algorithm, and proved the effectiveness of the method through numerical simulation.

Jiang et al. [6] proposed a logistics distribution path optimization method based on genetic algorithm and ant colony optimization algorithm, and verified the effectiveness of the method through simulation experiments, indicating that this method can effectively optimize the logistics distribution path. Chen et al. [7] proposed a hybrid cuckoo search (HCS) algorithm for vehicle distribution path optimization, compared it with other existing algorithms through MATLAB.

The results showed that the algorithm was significantly superior to other traditional algorithms in terms of optimal solution and average solution, and could effectively optimize the logistics distribution path. In the O2O cross-border e-commerce, the traditional vehicle delivery can no longer meet the needs of cross-border logistics. The cross-border logistics industry includes aviation logistics, overseas warehouses and so on. Compared to the traditional land transportation, aviation logistics is faster and more convenient in picking up the goods, which can satisfy the requirements of cross-border logistics better.

As the main form of cross-border logistics, the optimization of aviation logistics is of great significance to the e-commerce enterprises and logistics enterprises. In the field of air cargo transportation, price is an important part that affects corporate attitude [8]. Only by reducing their own logistic transportation costs can the logistics enterprises provide the client companies with lower prices and attract more business. In order to reduce the transportation cost and improve the transportation efficiency, aviation logistics needs to consider the aspects of air transportation, aircraft model selection, route arrangement and ground distribution. Aiming at the problems of aircraft type loading and route arrangement, this study studied two transportation modes of passenger plane belly compartment carrying and full cargo plane carrying, and verified the validity of the model through model construction and concrete example analysis.

2. Overview of O2O mode

O2O mode refers to the combination of online and offline. Through online purchase and offline consumption, merchants can publicize their products through the advantages of the Internet and provide more convenient services for consumers. As a new business mode, the O2O mode has developed rapidly with the development of economy and Internet technology. It combines online and offline perfectly, which not only provides consumers with a convenient and fast platform, but also provides offline experience stores that can be experienced personally, helping consumers to feel the quality of products better.

3. Logistics distribution under O2O mode

3.1 Distribution mode classification

3.1.1 Direct distribution

Direct distribution means that the e-commerce company sets up logistics distribution system for distribution in order to meet the needs of its own products. The advantages of direct distribution are that it can not only provide consumers with better distribution services and make the enterprise control the distribution system better, but also can protect the safety of enterprise information and avoid information leakage. The disadvantage is that the investment cost of the direct distribution is relatively high, which requires a large amount of manpower, material and financial input. These investments aggravate the cost burden for enterprises, especially in the case of small distribution demand, which is easier to drag up the cost and reduce the benefits. The flow chart of direct distribution mode is shown in Figure 1.

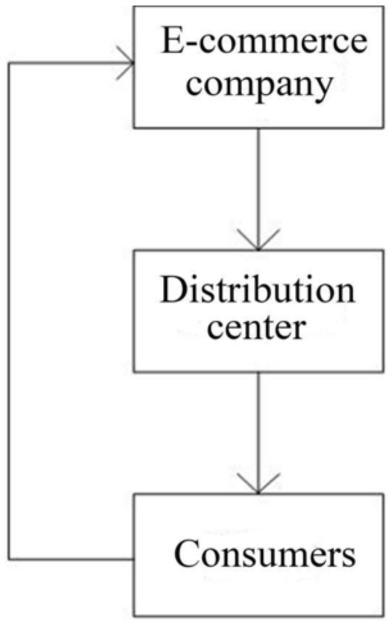

Figure 1: Flow chart of direct distribution mode

3.1.2 Third party distribution

Third party distribution means that the e-commerce enterprise cooperates with the third party logistics enterprise, entrust the logistics business of the company to logistics enterprises, and let the logistics companies complete the distribution of products of the e-commerce enterprise. The advantages of third party distribution are that it can not only reduce the expenditure in logistics and logistics cost, but also increase the core competitiveness of the enterprise and improve the service efficiency of the enterprise and the customer service experience. The disadvantage is the lack of logistics control. It is difficult for the enterprise to timely obtain information under the third party distribution, and the enterprise is faced with the problems of fund risks and information security. The flow chart of third party distribution is shown in Figure 2.

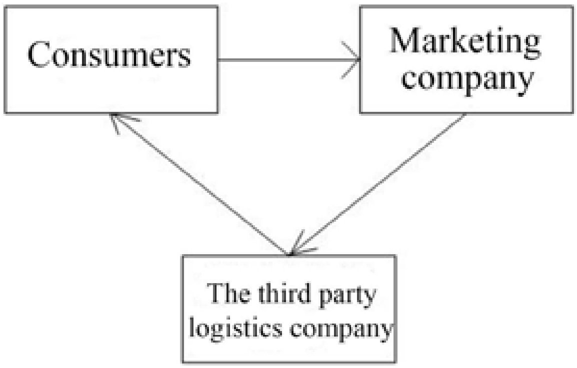

Figure 2: Flow chart of third party distribution

3.1.3 Mixed distribution

The mixed distribution mode refers to the combination of direct distribution and third-party distribution, which develops strengths and avoids weaknesses, and achieve the effect of strong alliance. The comprehensive use of both methods can not only minimize the investment cost in logistics, but also meet the needs of logistics distribution, so as to gain competitive advantages. The disadvantage of mixed distribution lies in the difficulty of unified management and the problem of information security. However, compared with its advantages of high efficiency and low cost, mixed distribution is still favored by many e-commerce enterprises.

3.2 Development status of cross-border e-commerce logistics and distribution

The development prospect of O2O cross-border e-commerce is very promising, but there are also some problems in logistics distribution, such as:

(1) Low consumer satisfaction. Most cross-border e-commerce enterprises use international express to deliver goods to overseas consumers. The high delivery cost and long delivery time, as well as the adverse factors such as customs seizure, bring unpleasant shopping experience to consumers.

(2) Difficulties in goods replace and return. Once the need to return and replace goods purchased across the border occurs, it is a relatively difficult thing to deal with. High logistics costs and long time have caused inconvenience to

return and replace goods, which has done more harm than good to both sellers and buyers.

(3) Goods are easy to lose. Due to the large number of logistics operation procedures and long distance, problems can easily occur in the delivery process, especially in some less developed countries and regions. Once the goods are lost, it is difficult to regain them according to the logistics information.

4. Distribution path optimization model construction

Cross-border logistics distribution is mainly based on aviation logistics. Aviation logistics is a high speed and efficient method of transportation. It transports goods by cargo plane or passenger plane, flies on the established routes and realizes the spatial displacement of goods. Aviation logistics includes the whole process of goods transportation from the beginning to the end, which also means the whole process of air transport, logistics transit and ground distribution. This study only focus on the optimization of the air transport route.

The arrangement of cargo transport routes can greatly affect the cost and time of cargo transport. On the premise of meeting the transportation requirements of e-commerce enterprises and delivering goods within the specified time, airlines can obtain the maximum transportation profits through reasonable arrangement of routes.

At present, there are mainly two ways of air transportation: one is passenger plane belly compartment carrying, the other is full cargo plane carrying. These two transportation methods include different types of aircraft, and the transportation capacity of different aircraft types is quite different. Therefore, it is necessary to discuss these two methods separately.

4.1 Path optimization of passenger plane belly compartment carrying

4.1.1 Model Construction

Before establishing the model, it is assumed that all the goods can be loaded into the aircraft, and the transportation is carried under ideal conditions without considering the loss of the goods or other interference factors in the transportation process.

The parameters involved in model construction are as follows:

A stands for airport set, $a \in A$; T stands for time set, t_j stands for a specific time, $t_j \in T$; M stands for the aircraft type geometry, $m \in M, u^m$ stands for total number of aircraft type m, and d^m stands for the transportation capacity of m. Space-time network node is:$n = (e, s, t)$; h_{mat} stands for the number of aircraft type m in the airport a at t_j ; L stands for segment set, $l \in L; I(n)$ stands for the segment of flying into the space-time network node n; $O(n)$ stands for the segment of flying out of node n; F_l stands for the total flight time of segment l; f^m stands for maximum daily utilization of aircraft type m; G stands for goods set, $g \in G, B^g$ stands for the total demand for cargo g; C_i^m stands for the total operating costs to segment l of aircraft type m; $\mathcal{V}_Q$ stands for unit variable cost of cargo transshipment in airport a; $r_l^{g.m}$ stands for unit revenue of cargo g in aircraft type m and segment l; p_i^m stands for passenger revenue of aircraft type m in segment l; $y_a^{\boldsymbol{g},m}$ stands for transshipment volume of cargo g of aircraft type m in hub airport a, $a' \in A; y_i^{g,m}$ stands for the volume of cargo g transported by aircraft type m on segment l; x_i^m stands for whether to use aircraft type m to fly on segment l, $x_1^m \in \{0, 1\}; y_i^g$ stands for the transportation volume of cargo g on segment l.

From the above parameters specifications, the following equations can be obtained.

The maximum return is:

$$\max Z = \sum_{m \in M} \left[\sum_{g \in G} \left(\sum_{l \in L} y_l^{g,m} r_l^{g,m} - \sum_{a \in A} y_{a'}^{g,m} v_{a'} \right) \right.$$
$$\left. + \sum_{l \in L} \sum_{m \in M} p_l^m x_l^m - \sum_{l \in L} \sum_{m \in M} c_l^m x_l^m \right]. \tag{4.1}$$

Aircraft flow balance constraint is:

$$h_{m,a,t_{j-1}} + \sum_{l \in I(n)} x_l^m = h_{m,a,t_{jt}} + \sum_{l \in O(n)} x_l^m,$$
$$n = (m, a, t_j), a \in A, m \in M, t_j \in T. \tag{4.2}$$

Aircraft quantity constraint is:

$$\sum_{a \in A} h_{m,a,z_n} + \sum_{l \in O(ct)} x_l^m \leq u^m, m \in M. \tag{4.3}$$

Aircraft utilization rate is:

$$\sum_{l \in \mathcal{L}^m} F_l x_l^m \leq 7 u^m f^m, \text{m} \in \text{M}. \tag{4.4}$$

Flight coverage constraint is:

$$\sum_{m \in M} x_l^m = 1, l \in L, \sum_{g \in G} \sum_{l \in L} y_l^{g,m} \leq d^m x_l^m, m \in M. \tag{4.5}$$

The cargo volume of aircraft type m is smaller than the total volume of the airplane:

$$\sum_{m \in M} \sum_{l \in L} y_l^{g,m} \leq B^g, g \in \text{G}. \tag{4.6}$$

Volume of cargo g in aircraft type m cannot exceed the maximum demand:

$$y_l^{g,m} \geq 0, x_l^m \in \{0, 1\}, m \in M, l \in L, g \in G. \tag{4.7}$$

4.1.2 Benders decomposition algorithm

The Benders decomposition algorithm was used for calculation, the aircraft type selection was taken as the main problem, and the path optimization is solved as the sub-problem respectively.

Suppose the variable $\overline{x}_l^m$ satisfies the constraint condition of type selection, then

$$\max \sum_{g\in G}\left(\sum_{l\in L} r_l^g y_l^g - \sum_{d'\in A} y_{a'}^{g;a} v_{a'}\right),$$

$$\sum_{g\in G}\sum_{l=L} y_l^g \le d^m \overline{x}_l^m, m\in M,$$

$$\sum_{m\in M}\sum_{l\in L} y_l^g \le B^g, g\in G,$$

$$y_l^g \ge 0, g\in G, l\in L.$$

Suppose $\pi_l, l\in L$ and $\delta^g, g\in G$ are dual variables of the sub-problem, then the following equations can be obtained:

$$\min \left[\sum_{l\in L}\sum_{m\in M} \left(d^e \overline{x}_l^m\right)\pi_l + \sum_{g\in G} B^g \delta^g\right]_{,t^*},$$

$$\sum_{l\in L} \pi_l + \delta^k \ge r_l^m, g\in G,$$

$$\pi_l, l\in L, \delta^g \ge 0, g\in G.$$

The following equation can be obtained according to the dual theorem:

$$\text{Max}\left\{\min \left[\sum_{l\in L}\sum_{m\in M} \left(d^e \overline{x}_l^m\right)\pi_l + \sum_{g\in G} B^g \delta^g\right] + \sum_{l\in L}\sum_{m\in M} p_l^m x_l^m - \sum_{l\in L}\sum_{m\in M} c_l^m x_l^m\right\}.$$

Suppose the optimal vertex of feasible domain is , then the following equations can be obtained:

$$\text{Max}\left(\eta + \sum_{l\in L}\sum_{m\in M} p_l^m x_l^m - \sum_{l\in L}\sum_{m\in M} c_l^m x_l^m\right),$$

$$\eta \le \sum_{l\in L}\sum_{m\in M} \left(d^m \overline{x}_l^m\right)\pi_l + \sum_{g\in G} B^g \delta^g,$$

$$h_{m,a,t_{j-1}} + \sum_{l\in I(n)} x_l^m = h_{m,a,t_{j+1}} + \sum_{l\in O(n)} x_l^m, n = (m,a,t_j), a\in A, m\in M, t_j\in T,$$

$$\sum_{a\in A} h_{m,a,t_n} + \sum_{l\in O(ct)} x_l^m \le u^m, m\in M,$$

$$\sum_{l \in L^n} F_l x_l^m \leq 7u^m f^m, m \in M,$$

$$\sum_{m \in M} x_l^m = 1, l \in L,$$

$$x_l^m \in \{0,1\}, l \in L, m \in M.$$

4.1.3 Case analysis

Some flights of an airline were randomly selected for the study. Five sets of data are shown in Table 1.

Table 1: Related data

No.	A	B	C	D	E
Passenger segment	60	100	500	1400	1400
Cargo segment	0	0	200	200	200
Passenger aircraft type	6	6	6	6	6
Cargo aircraft type	0	0	1	1	1
Cargo carrying capacity (piece)	6300	10000	30000	55000	64000

The cost of aircraft shipment, transport and passenger revenue are based on the average level of domestic airports. Assume that the average passenger seating rate capacity of an aircraft is 70 percent, and that passengers carry 10 kilograms of luggage. Aircraft type parameters are shown in Table 2.

Table 2: Aircraft type parameters

Aircraft type	A318	B737-300	B737-500	B737-900	B757-300	B777-200
Cargo loading volume (cubic metre)	21.21	30.2	23.3	52.5	114.1	162.0
Number of passengers	107	149	108	215	280	0
Payload (ton)	3	3	2.5	6.5	9	100

Five sets of data were calculated according to the model and algorithm, and the results are shown in Table 3.

Table 3: Related data

No.	A	B	C	D	E
Calculated time (second)	2.3	3.1	15.6	100.7	116.3
Error rate (%)	0.01	0.05	0.06	0.07	0.08
Objective function value (yuan)	2705600	4306000	19500000	48657200	55042100

As can be seen from the above table, the algorithm in this study could complete the calculation of the data in a relatively short time, and the error rate was also small, which proved the reliability of the algorithm. By comparing the data, the fifth group got the greatest benefit. It showed that this method can significantly improve the income of airlines in the premise of fully considering the cargo transportation demand.

4.2 Path optimization of full cargo plane carrying

(1) Model construction

x_{ij} stands for the number of planes in the aircraft flow network arc (i,j); y_{ij}^{n} stands for transport volume of the n-th batch goods transported on the cargo flow network arc (i,j) ; N stands for the goods set, n stands for the goods of the specified batch, $n \in N$; C_{ij} stands for the cost on the arc (i,j); T_{ij}^{n} stands for the transportation cost of the n-th batch goods on the arc (i,j); E_{ij}^{n} stands for unit revenue of the n-th batch goods on the arc (i,j); U_i stands for unit handling cost of goods i; AF stands for total available flights; FF stands for set of festival of flight ; CF stands for flight ring set; BF_n stands for the total demand for the n-th batch goods; K stands for the maximum capacity of an aircraft; SA stands for airport set; NF stands for aircraft flow network arc set; NP_n stands for the set of arcs for the transport of the n-th batch goods.

From the above parameters specifications, the following equations can be obtained.

The maximum return is:

$$\begin{aligned} \max Z = & \sum_{n\in N}\sum_{ij\in NP_n} E_{ij}^{n} y_{ij}^{n} \\ & - \left[\sum_{ij\in NF} C_{ij}x_{ij} + \sum_{n\in N}\sum_{ij\in NP_n} T_{ij}^{n} y_{ij}^{n} + \sum_{n\in N}\sum_{ij\in NP_n} y_{ij}^{n}\left(U_i + U_j\right) \right]. \end{aligned}$$

Aircraft flow balance constraint is:

$$\sum_{j\in NF} x_{ij} - \sum_{k=NF} x_{ki} = 0, \forall i \in NF.$$

Cargo flow balance constraint is:

$$\sum_{j\in NP_n} y_{ij}^{n} - \sum_{k\in NP_n} y_{ki}^{n} = 0, \forall i \in NP_n, \forall n \in N.$$

Operating aircraft cannot exceed the total number of aircraft:

$$\sum_{ij\in CF} x_{ij} \le AF.$$

The total amount of transported cargo must be less than the maximum load capacity of the aircraft:

$$\sum_{n\in N} y_{ij}^{n} \le K x_{ij}, \forall ij \in FF.$$

The volume of transported cargo cannot exceed the total demand:

$$\sum_{n\in N}\sum_{ij\in NP_n} y_{ij}^n \leq \sum_{n\in N} BF_n.$$

$$x_{ij} \in 1, \forall ij \in NF, y_{ij}^n \geq 0, \forall ij \in NP_n.$$

CPLEX optimization software was used to obtain the results.

(2) Case analysis

Suppose there are three Boeing 747-200s that carry out 30 times cargo transportation between 8 cities. Each aircraft has a load capacity of 100 tons. The routes are short-distance routes of 1,500 kilometers and long-distance routes of 3,000 kilometers. The transportation modes were divided into short-distance transportation, medium-distance transportation and long-distance transportation. Short-distance transportation means direct transportation. Medium-transportation can be carried out directly or in one transshipment. Long-distance transportation can be carried out directly, in one transshipment or multiple times transshipment, i.e., a mixed transportation method, which is also called the hybrid scheme. According to the model and software, the four schemes were calculated, and the results are shown in Table 4.

Table 4: Related data

Scheme	The number of aircraft	Flight frequency	Average loading rate	Transshipment rate	Optimal value (yuan)	Calculated time (second)
Direct transportation	3	28	60.1%	0	21007000	4.1
One transshipment	3	28	65.3%	5.8%	22080600	13.5
Multiple times transshipment	3	28	67.8%	9.7%	22809700	1100
Hybrid scheme	3	28	66.9%	9.3%	23001200	402

According to the calculation results, the benefit of direct transportation was the worst. Although the efficiency was high, it was not conducive to the full utilization of the aircraft. The loading rate and income of one transshipment were improved, but the effect was slightly lower than that of multiple times transshipment and hybrid scheme. The hybrid scheme had the most advantages. According to the hybrid scheme, the flight routes of the three aircraft are shown in Figure 3.

5. Discussion

With the development of economic globalization, cross-border e-commerce is developing rapidly, which is an important means for enterprises to carry out international trade [9], and is also an important driving force for the growth of China's foreign trade [10, 11]. In cross-border e-commerce enterprises, cross-border logistics is an important part. Only by reducing the cost of international logistics and improving the satisfaction of consumers can the development of cross-border e-commerce enterprises be better promoted.

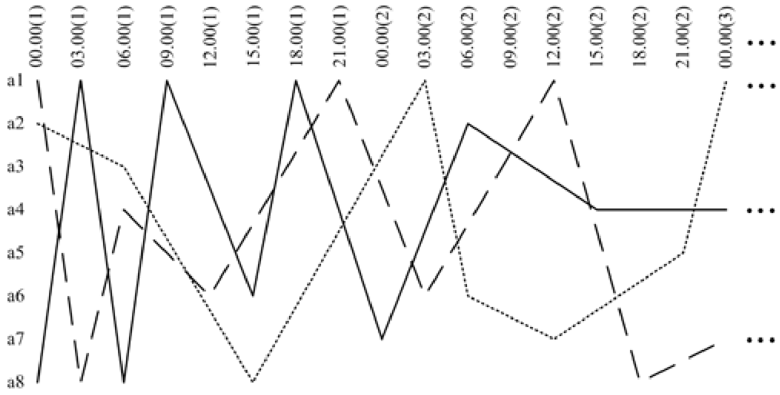

Figure 3: The flight routes of aircraft in the hybrid scheme

In the O2O model, cross-border e-commerce directly faces consumers, reduces the intermediate links of transactions through Internet communication, reduces the cost of transactions [12], and the transaction speed is also relatively fast. However, there are many problems in logistics transportation, such as long transportation time, high logistics cost, difficulties in return and replacement, etc. The current cross-border e-commerce mainly adopt the international express delivery, overseas warehouse and other modes. International express delivery is mainly by air and sea. Aviation logistics is a fast and convenient logistics mode, which is favored by cross-border e-commerce enterprises. In order to meet the requirements of e-commerce enterprises, aviation logistics enterprises must vigorously improve customer satisfaction and gain advantages in the fierce competition. Air logistics not only refers to the transportation of goods in the air, but also to the transshipment, ground distribution and other links. The optimization of route paths is of great significance to reduce cost and improve efficiency. The optimization of distribution path is aimed at reducing transportation cost [13]. Li et al. [14] combined GA and ACA to build a logistics distribution model, which achieved good results. Wang et al. [15] improved the ant colony algorithm, solved the problem of collaborative allocation of forward logistics and reverse logistics, and verified its effectiveness in the optimization of distribution path.

In this study, two cargo transport methods of passenger plane belly compartment carrying and passenger plane belly compartment carrying were used for optimization research respectively. Through the model construction of two cargo transport methods, the calculation method of maximum benefits was obtained, and then different schemes were used for calculation in the actual analysis. The case analysis showed that the proposed method in this study has shorter calculation time and lower error rate, which proved the effectiveness of the method. Then, in terms of the aircraft type selection and route arrangement, it was also proved that different aircraft types and route selection will greatly affect the earnings of airlines. Therefore, calculating the two and finding the best solution will play an important role in reducing transportation costs and increasing logistics revenue.

6. Conclusion

In the O2O model, cross-border e-commerce cannot leave the support of aviation logistics. The aircraft type selection and route arrangement of the passenger plane belly compartment carrying and the full cargo plane carrying are studied in this study. The validity of the method was proved by the model construction and calculation. The method in this paper can produce results in a short period of time and has good practicability, which also demonstrates the impact of aircraft type selection and route arrangement on revenue. Through reasonable aircraft type selection and route arrangement, it is possible to reduce transportation costs, improve transportation efficiency, and effectively improve the competitive advantage of aviation logistics enterprises in the premise of meeting the logistics needs of e-commerce enterprises.

References

[1] L.F. Lin, Y.M. Li, *A social recommendation mechanism for enhancing O2O E-commerce*, Iiai International Congress on Advanced Applied Informatics, IEEE Computer Society, 2017, 401-406.

[2] Z. Fan, M. Ma, *Research on the optimization of vehicle distribution routes in logistics enterprises,* IOP Conference Series: Earth and Environmental Science. IOP Conference Series: Earth and Environmental Science, 2018, 052007.

[3] M. Lai, H. Yang, S. Yang, et al., *Cyber-physical logistics system-based vehicle routing optimization,* Journal of Industrial & Management Optimization, 10 (2017), 701-715.

[4] Y. Deng, Z. Yao, J. Li, *Route optimization model in collaborative logistics network for mixed transportation problem considered cost discount based on GATS,* Journal of Ambient Intelligence & Humanized Computing, 2018, 1-8.

[5] S.Y. Wang, F.M. Tao, Y.H. Shi, *Optimization of location-routing problem for cold chain logistics considering carbon footprint,* International Journal of Environmental Research and Public Health, 15 (2018), 86.

[6] G. Jiang, Y. Pan, F.Y. Hu, et al., *Research on logistics distribution route based on genetic algorithm and ant colony optimization algorithm,* Computer Engineering & Applications, 2015, 758-762.

[7] X. Chen, J. Wang, *A novel hybrid cuckoo search algorithm for optimizing vehicle routing problem in logistics distribution system,* Journal of Computational & Theoretical Nanoscience, 13 (2016), 114-119.

[8] N.A.B.A. Rahman, M.F. Mohammad, S.A. Rahim, et al., *Shipper's perceptions of aviation logistics service quality (LSQ) of air freight provider,* Journal of Engineering & Applied Science, 12 (2017), 699-704.

[9] J. Yang, B. Zheng, L. Yang, *Research on cross-border E-commerce index system based on factor analysis,* Finance & Trade Economics, 35 (2014), 94-102.

[10] N. Chen, J. Yang, *Mechanism of government policies in cross-border e-commerce on firm performance and implications on m-commerce,* International Journal of Mobile Communications, 15 (2017), 69.

[11] Y. Wang (W. Avery), Y. Wang, S.H. Lee, *The effect of cross-border E-commerce on China's international trade: an empirical study based on transaction cost analysis,* Sustainability, 9 (2017), 2028.

[12] E. Gomez-Herrera, B. Martens, G. Turlea, *The drivers and impediments for cross-border e-commerce in the EU,* Information Economics & Policy, 28 (2014), 83-96.

[13] K. Zhang, B. Qiu, D. Mu, *Low-carbon logistics distribution route planning with improved particle swarm optimization algorithm,* International Conference on Logistics, Informatics and Service Sciences. IEEE, 2017, 1-4.

[14] X. Li, W. Jianguo, J. Yuan, *A New logistics distribution route optimization algorithm for fresh agricultural products based on the fusion of genetic algorithm and ant colony algorithm,* C E Ca, 42 (2017), 2428-2432.

[15] J. Wang, Y. Yang, N. Zhang, et al., *Optimization of logistics collaborative distribution routing based on improved Ant Colony Algorithm,* International Conference on Industrial Technology and Management, IEEE, 2017, 36-40.

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