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An Overview of the Last-mile Distribution Development of E-commerce Logistics

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Abstract: Due to the continuous development of online shopping in recent years, the development of e-commerce logistics is more rapid. Consumers are generally sensitive to the timeliness of logistics distribution, especially in the last-mile distribution service, so it is of great significance to study the last-mile distribution of e-commerce logistics. Firstly, this paper selects the overall situation of documents from China and abroad, and expounds the key words and the trend of paper publication. Secondly, distribution is divided into direct distribution and indirect distribution to sort out the research status. Finally, this paper looks forward from two aspects of research perspective and research content.

Keywords: Ecommerce-logistics; The Last-mile Distribution; Distribution Optimization.

1. Introduction

In recent years, with the rapid development of e-commerce in China, the scale of e-commerce transaction has been expanding, and the consumption way of people has also changed. The increase of e-commerce activities has led to the continuous growth of express parcel volume, and logistics distribution has become an important indicator to measure the competitiveness of e-commerce enterprises.

Nowadays, e-commerce enterprises mainly have three distribution modes, including self-owned logistics distribution, third-party logistics distribution and the combination of two distribution modes. No matter what kind of distribution mode is adopted, e-commerce logistics mostly includes three links, namely, allocation, trunk transportation and last-mile distribution. Among them, the last-mile distribution accounts for a higher cost, and the consumers' experience is more direct.

There are many definitions of last-mile distribution in e-commerce logistics, but a common view is that it involves the last part of the overall logistics transportation of the supply chain, the process from the last distribution center to the recipient. In this service, goods are delivered to the recipient, either at the recipient's home or at a designated point of distribution. The last-mile distribution is generally considered to be the most expensive, least efficient, and most polluting part of the overall logistics transportation process, as well as one of the most challenging problems in e-commerce logistics. According to some research statistics, the cost of the last-mile accounts for more than 30% of the entire logistics transportation cost, which is due to its characteristics of high degree of cargo flow fragmentation, miniaturization of vehicles and low utilization rate of vehicle capacity. These characteristics depend on various factors such as consumer density and time window, distribution size, short routes, slow speeds, short effective driving times, space constraints and homogeneity, etc.

At present, there are few articles showing the research status and achievements of the last-mile distribution in e-commerce logistics. Therefore, this paper will summarize and comment on the research status in recent 10 years, classify and analyze the documents according to the research content, and look into the future.

2. Research Status

In the search of Wanfang data, the research keywords are distribution mode, drones, joint distribution, etc. Figure 1 shows the number of published documents on the last-mile distribution of e-commerce logistics in CNKI from 2013 to 2022. In Web of Science, we use last-mile delivery & e-commerce logistics as keywords of literature search. Foreign research focuses on business economics, engineering, computer science, etc., indicating that there are more quantitative optimization models and empirical studies. As can be seen from Figure 1, from 2015 to 2019, after the rise of domestic e-commerce led to an increase in research content, the research popularity decreased slightly and entered a relatively stable period. On the contrary, foreign scholars' research on the last-mile of e-commerce logistics continues to grow.

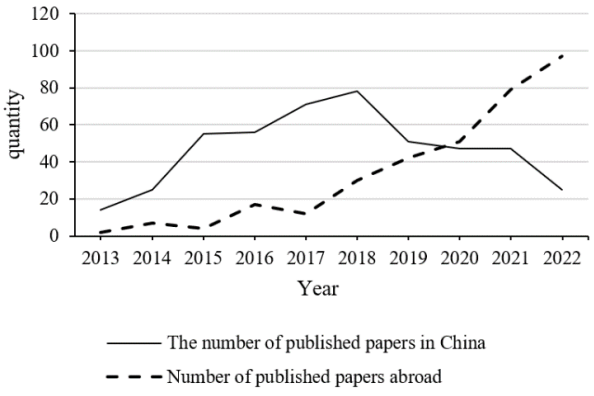

Figure 1. The number of published literatures in China and foreign journals during 2013-2022

This paper will discuss the research status of the last-mile distribution of e-commerce logistics. The last-mile of e-commerce logistics mainly focuses on distribution method, distribution time and distribution area . At present, the "last - mile" logistics distribution can be divided into two main categories: direct distribution and indirect distribution. This paper will be from the two ways of logistics distribution classification, analysis of the development of the two ways and put forward prospects for future development.

(1) Direct Distribution

Direct distribution is the traditional door-to-door distribution. Usually, in the case of direct distribution, the probability of distribution failure is higher, mainly related to the time window of distribution. From the perspective of operation, most scholars focus on how service providers reasonably set up appropriate distribution time window, VRP and location. Gawor and Hoberg's showed that standard distribution (all day) was more popular than time window distribution (a few hours) . Of course, service providers can offer multiple time Windows to give consumers more choice, Van Duin et al. The importance of properly involving clients in scheduling time Windows is highlighted. They show that first deliveries are more likely to succeed if customers are not just told a fixed window of time. However, giving consumers more choices also increases the risk of service providers, that is, service providers cannot complete distribution within the time window chosen by customers. Gevaers et al. verified the cost service tradeoff of time window management by using simulation research. One option to solve this problem is to provide incentives (e.g., distribution discounts) to prompt consumers to choose logistics providers more widely or within a specific time window. Xue et al. adopted a variety of models such as VRP and cluster analysis to optimize vehicle carbon emissions under various existing last-mile distribution modes. Zhou et al. studied the site-routing problem of multi-agent joint distribution under integrated distribution and distribution and terminal sharing. Zhao et al. studied the location of stores in the last-mile of fresh food distribution and the distribution of end demand points.

In recent years, with the continuous innovation and development of science and technology, the application of unmanned vehicles and drones in the last-mile distribution is gradually developing, and the research is also increasing. The research focuses on location selection, route optimization, UAV formation and scheduling. Murray and Chu first studied the problem of parallel UAV scheduling, and Ham optimized the deployment with pick-up and delivery options, multiple warehouses, multiple trucks, and time window decisions. Chauhan et al. not only studied the location of strategic warehouse, but also integrated the size of UAV formation. Dell 'Amico et al. studied the parallel distribution of trucks and UAVs and proposed a heuristic solution program to deal with scheduling problems. Peng et al and Fan et al used hybrid variable neighborhood search algorithm and genetic large neighborhood search hybrid algorithm respectively to establish the route optimization model of vehicle-UAV collaborative distribution and develop the logistics distribution scheme. Boysen et al. considered that trucks carry robots for distribution, and robots return to nearby robot warehouses instead of returning to trucks after distribution, so as to reduce the number of delayed deliveries. Gao Jiajing and Zhen Lu studied the routing problem of multi-truck and multi-robot joint distribution system and designed a variable neighborhood search algorithm to solve it .

In terms of specific practice, Wal-Mart, Amazon, Jingdong, SF Express and other enterprises have successfully conducted tests. Since drones and unmanned vehicles are restricted by weather, application scenarios, policies and safety, and urban roads are complicated, they also have certain requirements for running speed. Whether the use of drones and driverless cars will help handle large volumes of packages and reduce costs remains questionable. There is still a long way to go, and large-scale applications are still being tested

(2) Indirect Distribution

Indirect distribution has developed rapidly in recent years, including property collection, self-pickup cabinet (Fengchao, Jinlinbao) self-pickup, express point self-pickup, convenience store self-pickup, post station self-pickup, etc. These methods reduce the direct contact between couriers and consumers, and are more suitable for consumers who are not at home during the distribution time of the service provider. They also greatly reduce the distribution failure rate caused by consumers not at home in traditional home distribution. As these self-service concepts are further developed, direct human interaction in last-mile distribution may gradually disappear.

Domestic and foreign studies on such self-picking points mainly focus on qualitative and empirical analysis, while quantitative analysis focuses on optimizing the layout of self-picking points. Vakulenko et al. showed through empirical research that the travel distance of customers to designated parcel lockers was one of the most important factors for the operation of pick-ups and their acceptance by consumers. Deutsch and Golany studied the optimal number, location and size of parcel storage facilities by establishing a 0-1 integer linear programming model. Zhou et al. studied the integrated optimization of self-pickup location and routing planning based on mixed addresses of customer points in online retail distribution. Han et al studied the combination optimization of self-picking point service products under the concept of customization. Yu et al. studied the pricing decision of express locker service based on the traveling salesman problem, and proposed the calculation method of express locker service value under different express distribution terms and the uncertainty of the recipient at home.

The new research models of last-mile distribution mainly focus on the analysis of empirical problems and provide countermeasures and suggestions, while the strategic research based on quantitative models is relatively lacking. Akeb et al. proposed the adoption of emerging business models, including crowdsourcing logistics, as well as the mix of different business models. Kibia-janiak et al discuss newer technologies and organizational solutions such as the Internet of Things, autonomous vehicles, parcel lockers. Wang Shuang and Chen Huaili used K-means clustering and genetic algorithm to study the participation of crowdsourcing logistics in collaborative distribution of general logistics companies under the condition of uneven transport capacity, and the participation of superior logistics can reduce the cost of logistics distribution to a certain extent.

Based on the establishment of parcel lockers, Cainiao post stations and the development of unmanned technology, the direct contact between distribution behavior and people is becoming less and less. However, under the current conditions, some of these methods have solved the problem of no one receiving goods at home of some consumers, while some are still in the theoretical research stage and have not been widely applied under the current conditions. It still needs manpower to transport goods from the distribution warehouse at the last station in the city to the designated location.

3. Research prospect

First, from the research perspective, drones and emerging last-mile distribution methods remain the focus of future research: The practical application of the model still needs to be further expanded, aiming at scenarios closer to reality. The use of express cabinets has been relatively common, and few

literatures have studied from the perspective of storage pricing and charging of express cabinets. Meanwhile, the concept of crowdsourcing logistics can be considered to apply to the last-mile distribution of e-commerce logistics, so as to reduce costs and better deal with the uncertainty of demand. For the solution of the model, it can be improved on the basis of the existing algorithm or can be fused on the basis of the existing single algorithm to form an innovative hybrid algorithm. In the process of solving the single algorithm, it is easy to fall into the local optimal solution, slow convergence and other shortcomings. Therefore, it is of great significance to integrate and improve the algorithm to solve the model.

Secondly, in terms of research content, existing literatures discuss and analyze from a theoretical perspective, and propose emerging models such as drones, unmanned vehicle distribution, self-pickup point, crowdsourcing logistics, etc. Some of these methods have solved the problem of no one receiving goods at home of some consumers, while some are still in the theoretical research stage and have not been widely applied under the existing conditions. Existing quantitative literature mainly considers from the specific operational level, such as route optimization and distribution time window setting, and less optimizes the selection from the strategic level of logistics enterprises' complementary distribution capability. In the future, the selection and decision of distribution time, pricing and distribution mode can be studied from the perspective of logistics service providers.

4. Conclusion

In terms of the last-mile distribution of e-commerce logistics, the optimization in China and abroad mostly focuses on the specific operation level. The research on emerging logistics and distribution technologies, such as unmanned aerial vehicles, mostly focuses on quantitative optimization, while the research on crowdsourcing logistics, self-pickup services and other services is still in the empirical aspect, with few quantitative studies. There are few quantitative literatures on the selection of logistics distribution mode with logistics service providers as the main body, and the selection of the last-mile distribution time, price and distribution mode from a strategic perspective. In the future, emerging concepts can be integrated into the research. At the same time, the continuous improvement and combination of algorithms can get better solutions faster and promote the optimal development of the overall distribution. In the future, it is still necessary to optimize and improve the model combined with the actual situation of demand uncertainty.

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