

Economic Research on the “Last Mile” in E-commerce Logistics System on the Basis of Time and Space

Chunmei Ye

School of Economics and Management
Beijing Jiaotong University
Beijing, China
14120529@bjtu.edu.cn

Abstract—Being the unique stage to face client, the "Last Mile" in e-commerce logistics is the bottleneck of e-commerce development owing to the problems of high cost and low service quality. The author attempts to analyze the delivery patterns of "Last Mile" on the basis of economics and find the appropriate model of delivery for the "Last Mile". The author uses PRN analysis framework to describe the product, resource and network economy of the "Last Mile" based on the deep analysis of various patterns of delivery of the "Last Mile", the emphasis of this paper is analyzing the effect of three new patterns of delivery, which focuses on the economies of scale, economies of scope together with saving the cost of time and space. It puts forward to build a comprehensive model of delivery consisted of socialized third-party logistics, intelligent pick-up cabinets, express-collections offered by convenience stores, supplemented by self-built branches, and door-to-door delivery service by couriers, so that not only the allocation of resources in domestic e-commerce logistics should be optimized, the cost also needs to be lowered as much as possible.

Keywords—the "Last Mile"; delivery pattern; space and time; economies of scale; economies of scope

I. INTRODUCTION

With the quick development of network information technology, the e-commerce has got a rapid improvement. In 2011, "online shopping" retail transaction summed up to 801.9 billion yuan, and it consisted of 4% of the total volume of our country's social consuming retail sale in the corresponding period. The rapid development of the e-commerce needs the support of a sound logistics system. At the same time, the development of the e-commerce will certainly improve the logistics which is based on the express delivery. Chinese express logistics development report indicated that the cumulative revenue of postal enterprises and other express companies in 2011 were about 156.15 billion yuan, a 22.3 per cent increased year-on-year. And the gross business volume achieved 160.77 billion yuan, a 25 per cent increased year-on-year. The "Last Mile" delivery is the process that the couriers deliver the express from the last logistics hubs directly to the customers [1]. E-commerce logistics has strict requirements of distribution timeliness, service quality and the traceability of the express's information. The "Last Mile" delivery serves the customers directly, which makes

it being the most important part of E-Commerce logistics delivery [2]. High cost and low quality of the "Last Mile" have restricted the development of the e-commerce logistics delivery. Therefore, what appears to be quite important is how to solve the delivery problem of the "Last Mile" effectively.

II. COMMENT ON THE EXISTING LITERATURES

Most of the existed literature on the issue of the "Last Mile" delivery of e-commerce logistics focused on analyzing the current situation and patterns of delivery, and proposing the related solution based on the analysis of the reason why the current problems or choke-points exist. Wei Yali et al. (2013) studied the existing problems in the "Last Mile" delivery of e-commerce logistics from the aspect of society. In addition, they support that the reason for these problems can be the singleness of enterprise concept, the irrationality of government policy, the low quality of logistics facility, the hardship of using labor and the overweight of self-use delivery sites of express company other than the public delivery sites, and so on [3]. In conclusion, there is a lack of deep analysis of economics on the "Last Mile".

More and more scholars used economies of scale to explore the efficiency of the logistics distribution. Western scholars used cost function to carry on a budget for the problem that whether there are economies of scale in transportation industry or not, and an American economist, Cafus applied the railway transportation cost function to the research on economies of scale in the railway companies. Ohm took an economies of scale empirical research on American airlines industry and rail industry in 19 members of the organization for economic cooperation and development. The conclusion is that there are certain kinds of scale economies in aviation and rail industry, which is consistent with the trend that many small-scale transportation enterprises combined into large-scale transportation enterprises in recent 20 years. Most Chinese scholars believe that there are economies of scale in domestic transportation, and researches on logistics enterprises' economies of scale are still in the qualitative analysis stage. On the basis of super logistic cost function, Zhou Weili (2008) used the SUR regression to estimate the economies of scale and technological progress effect of Chinese third-party logistics enterprises. The conclusion is that there is a slight uneconomical scale in the third-party

logistics enterprises as a whole, and there are economies of scale in comprehensive logistics enterprises and technological progress can reduce the cost of third party logistics industry. Chen Zhiya, Chen weiya (2007) discussed the internal and external supporting conditions in the third-party logistics' economies of scale, and put forward a development strategy for scale economy in third-party logistics from the method of solving the supporting conditions [4]. Liu Hongjuan, LeiXiaoQing (2012) discussed the restriction factors which are against with the achievements of economies of scale, and put forward that it is necessary to make full use of information technology to achieve scale economy of logistics enterprises[5]. Kong Qin (2013) thought that the third party logistics can reduce costs of distribution and optimize the distribution by forming a strategic distribution alliance based on economies of scale.

There are strong time characteristics [6] and economic characteristics in the "Last Mile". In 2011, Rong Chaohe firstly combined time with space and take the time-spatial structure of economy as the object of study [7]. He regarded the value of transport-logistic time as the core variable. He made the definition of transport-logistic time value and proposed such research methods as the alternative model of time and cost, time distance and chain, the non-uniform values of time, the requirements of solidifying the relationship of time and space, the organizations adapting to the time-spatial structure, etc. The further developments of economics and our social economy need to focus on the order of time-spatial structure [8]. Zhou Yangming (2011) argued that the lean logistics is the pursuit of higher value or benefit, together with the pursuit of space and time saving, which is the time-spatial economy [9]. The benefit of lean logistics is the real form of time-spatial economy, the goal of which is to save time and space. And it attaches great importance to saving time and space of labor, as well as saving the circulation time and circulation space, which can greatly improve the efficiency and effectiveness of logistics [10]. Li Hongchang, Kuang Xujuan (2013) proposed that the development of railway must obey the time-spatial characteristic of modern logistics such as networking, professionalization, informatization, diversification and value added [11].

III. THE DELIVERY PATTERNS OF THE "LAST MILE" AND THE COMPARISON OF THESE DELIVERY PATTERNS

A. The delivery patterns of the "Last Mile" in China

At present, the main patterns of delivery of the "Last Mile" in China are door-to-door delivery offered by couriers and self-built branches. At the same time, three new kinds of delivery pattern which are socialized third-party logistics, intelligent pick-up cabinets, collection of express offered by convenience stores are still in their infancy, but they show a strong development momentum. There are two kinds of distribution methods, one of which is attended pick-up model, another is door-to-door delivery offered by express companies. The three kinds of new distribution models adopt the delivery methods of customer self-pick-up pattern. There are five patterns of delivery of the "Last Mile" which are shown in Table I.

TABLE I. DELIVERY PATTERNS OF THE "LAST MILE"

Delivery patterns	Overview	Examples
Door-to-door delivery by couriers	Express enterprises deliver express to customers and realize the door to door service.	Most of the express enterprises have these kinds of services, such as Yuantong Express.
Socialized third-party logistics	It's a professional logistics service channel which integrating logistics, the E-commerce and customer resources. Customers can enjoy the door-to-door delivery and can take the courier by themselves.	Wheat Commune;
Intelligent pick-up cabinets	The cabinets can provide 24-hour self-service and are automatically controlled by computer. Customers can pick up their express by code and phone numbers. It's the main delivery pattern in German.	Intelligent pick-up cabinets in Jingdong; Intelligent pick-up cabinets in subway.
Collection of express offered by convenience stores	Express enterprises establish cooperation relationship with the communities, convenience stores (24-hour convenience stores, barber shops, pharmacies and so on) , and appoint them to take the express for the customer.	Rookie Inn
Self-built branches	Express enterprises set up their own branches for delivery charge.	Jingdong business hall on campus

B. The comparison of different delivery patterns

Courier door-to-door delivery and self-built branches have developed for a long time and are the main patterns of delivery in China. Although socialized third-party logistics, intelligent pick-up cabinets and the collection of express offered by convenience stores are still in the phase of exploration attempt, they have become an important way to improve the efficiency of the "Last Mile". Two kinds of the original patterns of distribution (i.e., door-to-door delivery by couriers and self-built branches) have high demands for customer volume, and mainly provide personalized express service. Their intensive degree is relatively low, and at the beginning of the development of express industry, these two types of delivery mode caused higher distribution and management costs. There are advantages in cost, efficiency, information and intellectualization for three kinds of new distribution pattern, they lower the delivery cost greatly and achieve higher delivery efficiency by information and cooperation. But at their early stage, they still have problems in management, cooperation and coordination. The customer self-pick-up model has become the main orientation of express delivery. Government, enterprises and related organizations are actively promoting the construction and development of three kinds of new distribution model, which would build a new structure of the delivery pattern of the "Last Mile" in e-commerce logistics. Table II is a comparative analysis of five kinds of delivery patterns.

TABLE II. A COMPARATIVE ANALYSIS OF FIVE KINDS OF DELIVERY PATTERNS.

Delivery patterns	Advantages	Disadvantages
Door-to-door delivery by couriers	Door-to-door delivery.	High labor delivery costs; delivery dispersion, low delivery efficiency; distribution staff service quality is not high.
Socialized third-party logistics	Achieving efficient allocation of the delivery resources, reducing delivery costs; high degree of specialization and integration; information sharing; economies of scale; reducing logistics management risks.	The customer-pickup-mode is hard to accept; the benefit and management problems is hard to coordinate between the different express enterprises; controllability is small.
Intelligent pick-up cabinets	24-hour service; a significant reduction in labor and delivery costs; informatization, internalization, automation; management flattening.	The customer-pickup-mode is hard to accept; only small size and limited number of courier are permitted; pick-up cabinets construction costs and rental costs are relatively high; hard to grasp the timeliness; the profit distribution problems is hard to coordinate; the location of container is hard to choose.
Collection of express offered by convenience stores	Channels and resources sharing; close to the customer; reducing labor distribution costs.	The customer-pickup-mode is hard to accept; the management of co-operation is of high difficulty; hard to trace the delivery information, security is difficult to be guaranteed; the service convenience stores provide may conflict with the express business (reflected in the aspect of business, storage space, personnel, etc.).
Self-built branches	A high degree of systematization; helpful for deepening the brand and increasing market share; high controllability.	The customer-pickup-mode is hard to accept; high labor costs and operating costs; large delivery time constraint;

IV. TIME-SPATIAL ECONOMIC ANALYSIS OF THE "LAST MILE"

The three core elements of the "Last Mile" service are: "door-to-door" service, time-limited service and appreciation. The first two core elements are to make a strict demand of time-spatial relation.

A. The PRN framework analysis of the "Last Mile"

PRN basic analysis framework is proposed by Rong Chaohe, who tried to establish the economics coordinates from the aspect of Product-Resource-Network economy Analysis Frameworks (aka. PRN framework) distinguished from coordinates of other sectors in basic technical features [12]. It's not only the key to understand the "Last Mile" issue, but also the basis in this field whatever economic theories and methods are used to recognize the "last kilometer" issue that understanding and grasping the

technical and economic characteristics of products, resources and networks of the "Last Mile".

1) Product analysis of the "Last Mile"

From the aspect of demand, transportation product analysis first emphasizes its integrity. From the most basic sense, complete transportation products are displacement service from starting point to the final destination which the customers need. At the same time, the whole transportation products should be the just-in time transportation service in a more complete sense. The development of transportation industry is the process which people constantly meet and promote the efficiency of just-in time in social economy.

The process of the development of express industry is the process which people provide more complete and better quality services to customers. The core function of the "Last Mile" is the cargo displacement from the last logistics distribution site to the customer, as well as a basic request of cargo transportation which is safe, reliable, convenient, economical, time-limited service, door-to-door pickup and damage compensation. With the rapid development of mobile communication technology, customers also asked for an SMS alert, phone call notification, logistics timely inquiry service. Competition in the express delivery industry also increased the competition in other additional services, such as the overall monitoring in information, express of collection, storage of express, cash on delivery, products freshness storage, after-sales service and delivery frequency.

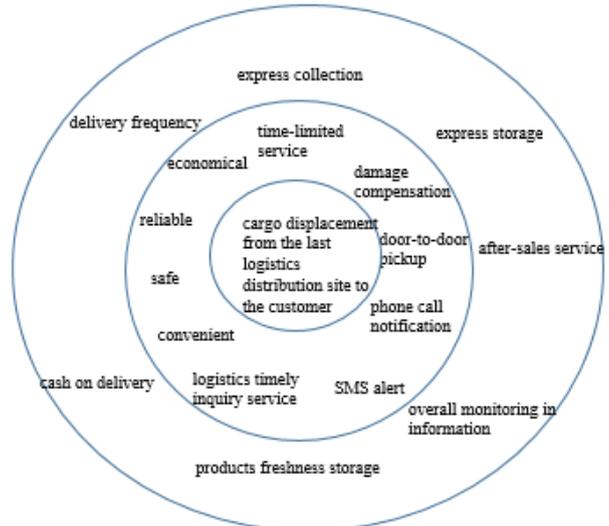


Figure 1. Hierarchical structural diagram of the "Last Mile".

2) Resource analysis of the "Last Mile"

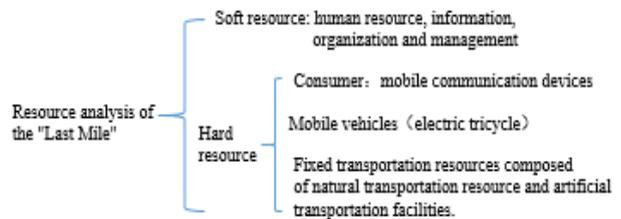


Figure 2. The classification of resource in the "Last Mile"

As a condition and mean to support the operation of the "Last Mile", resources of the "Last Mile" include soft resource and hard resource. The soft resource is mainly composed of express companies' human resource, information, organization and management, while the hard resource mainly includes consumers' mobile communication devices, mobile vehicles based on electric tricycle, fixed transportation resources composed of natural transportation resource and artificial transportation facilities. Soft resources in transportation systems such as human resource, information, organization and management system are not only necessary, but also becoming more and more important with the progress of transport industry. It is necessary to focus on how to implement efficient allocation of transport resources especially on how to help promoting the integration of the whole transportation chain by exchanging.

3) The network economy characteristics of the "Last Mile"

TABLE III. THE RELATIONSHIP BETWEEN CHARACTERISTICS OF NETWORK ECONOMIES OF THE "LAST MILE"

Division of economies of scale and economies of scope	Division of transport density economy and economies of network size	The specific performance of network economy of the "Last Mile"	
Economies of scale	Transport density economy	Road use density economy	
		The economies of express delivery capacity	
Economies of scope	Economies of network size	The economies of vehicle carrying capacity	
		Extending distance of conveyance	Economies of transport distance
		Expansion of express coverage	Multi-product economy

B. The displacement chain of the "Last Mile"

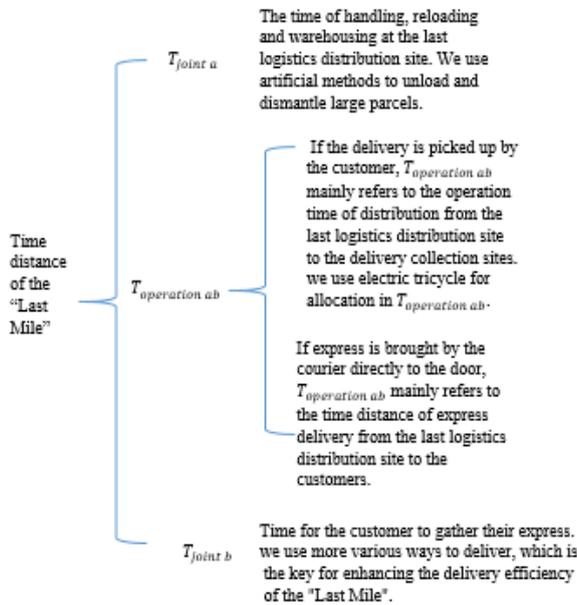


Figure 3. The time distance of the "Last Mile"

Rong Chaohe proposed to define the distance in the sense of time, and make a combination of time and space to make definition of time. Time distance narrowly can be the time of displacement which human and cargo need to achieve mobile in two places in economic activity. It can be expressed as $T_{ab} = T_{joint a} + T_{operation ab} + T_{joint b}$ here, $T_{joint a}$ and $T_{joint b}$ is the joint time at place a and b. $T_{operation ab}$ is the operation time between place a and b [13].

C. Economic analysis of the "Last Mile" delivery patterns

The "Last Mile" delivery directly serves the final consumer, so it's faced with the consumer's personalized service requirements. The core of the optimal distribution is the usage of scaled approaches to deal with the individual requirements of distribution, so as to achieve scaled economy of distribution, reduce the cost of distribution, and then to realize the cost reduction and optimal development of e-commerce logistics.

1) Economies of scale

In $T_{operation ab}$, express cargos are carried from the last logistics distribution site to the delivery charge point, and at this stage, it is transported commonly by electrical tricycle in urban area. Coupled with the urban road congestion problem, at this stage, road density of the "Last Mile" delivery and the carrying capacity is relatively low, and a round trip can only transport limited cargos, which are all the direct reasons of the high costs of the "Last mile". That in the "Last mile" delivery, electric tricycle is used as a means of transportation is determined by the low volume of the distribution of the express company. Although the total express trading volume increased rapidly, the capacity of the daily delivery in each express company and in each line is quite low, which results in a high cost per delivery. Socialized third-party logistics integrates the distribution of different express companies in the same route. With the capacity of the express carrying expanded, it is possible to use small-sized and medium-sized trucks for centralized distribution, at the same time distribution can happen at night when the traffic condition is better. By doing that, the traffic density of the same specific line and the carrying capacity of a single conveyance can be increased, which contributes to reducing the average transport costs.

The cost of the "Last Mile" mainly focus on the delivered cargos, the express companies are sparing no efforts to explore the appropriate delivery patterns of stage $T_{joint b}$. Among the five methods of distribution, door-to-door delivery by couriers has low efficiency, and the delivery cost of each cargo is quite high. Meanwhile socialized third-party logistics can achieve the comprehensive delivery of each express company. With the circumstance of the same labor costs in total, set-up cost and rental cost, it can effectively increase the volume of sending parcels per unit time and reduce delivery cost per unit express. Intelligent pick-up cabinets make use of information technology to reduce labor costs and operation expenses greatly. Although the initial construction cost of pick-up cabinets is relatively high, it is only needs to invest a small amount of maintenance costs in the latter stage. By accelerating the liquidity of the cabinet express delivery

and improving the express transport amount, it can effectively reduce the cost of unit express delivery, and then economies of scale can be achieved. Collection offered by convenience store can improve labor efficiency and storage efficiency effectively, the longer express turnover rate is, the lower the unit cost of labor and warehousing is, thus it can achieve economies of scale. Self-built branch puts forward a strict requirement of customer volume. Increased distribution volume can effectively share the rental cost of express delivery and reduce costs and thus achieve economies of scale.

2) Economies of scope

There is a rule of “cost declines with the distance” in “transport economy”, especially for the express industry whose final cost takes a relative high proportion. One of the reasons for the distribution cost of the "Last Mile" continuous staying in a high level is the short distance of delivery, so human resource and vehicle cost cannot be shared effectively. Extending the delivery route of the "Last Mile" and expanding the delivery scope of the "Last Mile" can increase the delivery volume for each time, reduce the labor and transport cost per delivery, in that way, economies of transport distance can finally be achieved, thus achieve economies of scope.

It is helpful for achieving economies of scope by making use of socialized logistics system to establish the third-party express terminal platform and expanding other business out of distribution of the "Last Mile" actively. We take the case of Wheat Commune as an example, where Wheat Commune established an integrative logistics platform by putting universities, e-commerce, and logistics resources together. With the usage of the logistics platform to extend business sectors, build B2C platform, sell the goods like apples, snacks, commodities which are in a large demand for students, the distribution of retail business can use human resources, information resources and related hardware resources of the distribution system of the "Last Mile" comprehensively. In that way, the use efficiency of related resources can be expanded, which reduces the average costs, and finally achieves economies of scope.

3) Time cost

One of the main costs of delivery of the "Last Mile" comes from the inappropriate delivery time linkage between couriers and customers. Couriers spend a lot of time in waiting for customers, which increases delivery costs of the "Last Mile". New delivery patterns like intelligent pick-up cabinets, collection of express offered by convenience stores enable customers to pick up their parcels at free time, and the pick-up point located in the customers' workplace or their residential areas. In this way, it can greatly improve the time utilization efficiency of the courier, and the courier can enhance the volume of express delivery in the unit time dramatically, which saves the time cost of couriers.

4) Space cost

Self-built branch puts forward a strict requirement for express company that they should have a sufficient number of distribution volume in one area. Whereas collection of express offered by convenience stores and socialized third-party logistics are able to utilize the express storage space effectively and comprehensively and saves the space cost of the "Last Mile".

TABLE IV. THE REALIZATION OF ECONOMIC EFFICIENCY OF DELIVERY PATTERN IN THE "LAST MILE"

Delivery patterns	The realization of economic efficiency
Socialized third-party logistics	Achievement of economies of scale: express enterprises can achieve road use density economy and the economies of express delivery capacity by concentrated distribution by small-sized and medium-sized truck at night; comprehensive distribution in different express companies and achieving the economy of vehicle carrying capacity Achievement of economies of scale: expanding other business out of distribution of the "Last Mile", using human resources, information resources and related hardware resources of the distribution system comprehensively Saving the space cost: comprehensive utilization of the storage space.
Intelligent pick-up cabinets	Achievement of economies of scale: low maintenance cost and artificial cost, high-speed turnover rate, effectively reducing the average cost of package; Saving the time cost: customers pick up the express depending on their time without wasting couriers' time.
Collection of express offered by convenience stores	Achievement of economies of scale: improving the labor efficiency, storage efficiency and express turnover rate, achieving the economies of express delivery capacity; Saving the time cost: customers pick up the express depending on their time and achieving the comprehensive utilization of time of staffs in convenience store and then saving the time cost of the customers and couriers. Saving the space cost: warehouse space cost can be reduced by using the storage space of the convenience stores.
Self-built branches	Achievement of economies of scale: saving rental cost and achieving the economies of express delivery capacity in area where there are a large quantity of express delivery.

V. CONCLUSION

The “Last Mile” in e-commerce logistics being the unique stage to face client and the high cost stage, is an important node in e-commerce logistics’ further development. The "Last Mile" has a strong time-spatial effect, and distinction of the "Last Mile" from the aspect of “time chain” is helpful for economic analysis of different displacement [14]. Through analysis, it can be seen that socialized third-party logistics, intelligent pick-up cabinets and collection of express offered by convenience stores have strong economies of scale and economies of scope, and make an outstanding contribution in saving time costs and space costs. By making a complex model of delivery of socialized third-party logistics, intelligent pick-up cabinets and collection of express offered by convenience stores, supplemented by self-built branches and door-to-door delivery by couriers, express companies can optimize the allocation of the “Last Mile” delivery resource, reduce end distribution costs, improve the quality of delivery of services and finally promote the rapid development of Chinese e-commerce logistics.

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