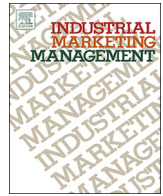




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Research paper

## E-commerce logistics distribution mode in big-data context: A case analysis of JD.COM

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## ABSTRACT

This paper analyzes the existing distribution modes adopted by China's e-commerce enterprises. Based on the empirical analysis of the electronic mall at JD.com (Jing-Dong), this paper compares and investigates the different logistics distribution modes faced by e-commerce enterprises embracing the new features, new challenges, and new advantages of big data. The Analytic Hierarchy Process (AHP) method and entropy value are applied to investigate the e-commerce enterprise distribution choice mode and the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method is used to verify the model. Our research analysis and results bear strong managerial insights for e-commerce logistics distribution practitioners.

## 1. Introduction

Business consumers in the digital age have become increasingly informed, challenging industrial marketing and sales teams to adapt their traditional marketing strategies to fully embrace buyers' preferences and expectations. Forrester, in its latest research report, predicts that > 20% of companies will begin to apply modern technologies in their industrial marketing platforms in order to optimize the engagement between business buyers and sellers (Robertson et al., 2018).

Technologies such as artificial intelligence (AI) and big data analytics have created unprecedented opportunities for companies to exploit their data assets for business-to-business (B2B) market initiatives. For instance, incorporating Lattice Engine's predictive analytics into its marketing initiatives, the industrial marketing team at Akamai was able to better segment its customers and to send personalized messages, sextupling its lead-to-opportunity conversion rate (Anderson 2018). In addition, companies including Google, Amazon, Facebook, and Apple have all made great efforts in the field of industrial marketing through collecting and utilizing big data. All of this underlines the importance of big data as a crucial factor in global marketing operations (Miguel & Casado 2016).

Data also plays a key role in making different decisions about business supply chains and logistics operations that are closely related to the industrial marketing field. Supply chain management deals with creating and maintaining linkages between different entities with

specific responsibilities, ranging from raw material procurement to end-user product interactions. Logistics management ensures that relevant work support methods, such as traffic management, warehouse management, inventory management, packaging, and order tracking, are in place. Employing a large and diverse range of data in logistics and supply chain management, companies can understand the needs and preferences of their customers. Electronic commerce (e-commerce) giants such as Amazon, Flipkart, and Snapdeal have been collecting and exploring data from customers, orders, inventory, and other information (Meena, 2017). The success of e-commerce companies now depends largely upon how efficiently they capture, store, and use data.

The advent of the big-data era has further strengthened the relationship between logistics distribution and e-commerce, and this presents new opportunities, such as the expansion of enterprise information, the sharing of distribution channels, and the integration of data resources. Particularly, e-commerce enterprises can accurately predict the future needs of customers and can fulfill personalized services to customers. In addition, they can organize and coordinate the distribution activities beforehand in a well-planned way, allowing for better selection and innovation of distribution modes. Now, companies can reduce the cost of logistics delivery, improve the efficiency of logistics delivery, and meet the diversified and high-quality delivery needs of customers.

Recent years have witnessed the emergence of successful e-commerce enterprises in China. A large market share, dominated by JD.com

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(Jing Dong), Tmall.com, SuNing.com, dangdang.com, and other e-commerce giants, shows the fierce competition in the e-commerce market. E-commerce enterprises are continuously seeking innovative ways to improve their relationships with customers, so as to enhance their competitive advantage.

As an e-commerce enterprise's logistics ability has become an important indicator of its competitiveness, the choice of a logistics distribution mode directly affects the enterprise's quality and costs of distribution as well as its supply chain coordination. There are three primary logistics distribution modes for an e-commerce enterprise. These include self-built logistics, third-party logistics, and the joint (hybrid) distribution mode. In order to meet the development requirements of e-commerce and to improve customer satisfaction, it is imperative that e-commerce enterprises thoroughly understand and investigate the advantages and disadvantages of all kinds of logistics distribution modes and select the most appropriate one, so as to improve their users' experience and to promote the sustainable and healthy development of e-commerce enterprises. For instance, Meituan, the largest online meal ordering platform in China, built a scientific distribution system with both professional logistics and crowd-sourced distribution in order to avoid the cost pressure brought about by self-established logistics. Meituan believes that a reasonable choice of distribution mode is an important way to effectively save its costs (Borak, 2018).

In China, the information utilization rate of logistics distribution centers is low, and nearly half of logistics enterprises lack the support of information systems. Logistics delivery plans are usually formulated by staff through market research or experience, and they cannot meet the needs of the era of big data. Due to this lack of scientific and reasonable planning and analysis of logistics distribution lines, the cost of the modern logistics industry in China is too high, and the efficiency of the delivery of its goods is low, resulting in the waste of a large number of distribution resources.

Although recent studies have investigated various factors that help enterprises to identify appropriate logistics providers (e.g., Bai & Sarkis 2018; Vaidyanathan 2005; Vijayvargiya & Dey 2010; Wang, Pauleen, & Chan 2013), very few prior studies have systematically analyzed the existing logistics distribution modes using a real-world example in a big-data context. Our research attempts to address this gap. In the context of big data that develops new opportunities for e-commerce enterprises, this paper makes contributions by studying the distribution modes of real e-commerce enterprises. In particular, JD.com, also known as Jing Dong, is identified as the e-commerce enterprise for our analysis object. JD.com is the largest online retailer in China with 320 million annual active customers and the net revenue of 67.2 billion US dollars in 2018 (JD.com, 2019). The Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) methods are then employed to investigate JD.com's choice of logistics distribution modes for the stores selling at JD. Specifically, the subjective weight of each scheme is first determined with the AHP method. Then, the objective weight of each scheme is computed with the method of legibility value. Finally, the TOPSIS method is applied, to verify whether the hierarchical structure model constructed is reasonable and can provide a basis for selecting the distribution mode of e-commerce enterprises.

The rest of the paper proceeds as follows. The next section reviews prior literature related to our research by focusing on the following two streams: (1) the collecting and use of big data in various scenarios, and (2) the choice of logistics distribution mode. Section 3 outlines the methodologies of this research. Section 4 details the analysis by presenting both the case and the results from the AHP and TOPSIS methods. The final section concludes the paper with managerial insights.

## 2. Literature review

This section reviews prior literature, by focusing on the challenges and applications of big data as well as on the choice of logistics distribution mode. In addition, the differences of our research from prior studies are highlighted, in order to indicate how our work contributes to the existing literature.

### 2.1. Collecting and use of big data

Big data has posed many new challenges to organizations, due to its unique characteristics. Focusing on the features of big data and its analysis methods, McAfee, Brynjolfsson, Davenport, Patil, and Barton (2012) point out that such characteristics are derived from the differences in the amount, speed, and kinds of data because now, data generated per second via the Internet is larger than that of 20 years ago, and all of the data is stored on the Internet. From a big data mining perspective, Fan and Bifet (2013) note the need to explore new techniques because of the amount, variability, and speed of big data; in fact, the big data challenge is one of the most exciting opportunities for businesses. Sagioglu and Sinanc (2013) introduce the characteristics of big data by illustrating the important role of big data in providing useful information to companies or organizations. Furthermore, they outline the content, scope, instances, methods, advantages, and challenges of big data. Weinberg, Davis, and Berger (2013) compile the definition of big data and find that big data can be viewed as deadlines, processes, and data from a variety of channels with multiple structures or forms and locations that represent a particular period of time. Jin, Wah, Cheng, and Wang (2015) summarize the challenges of big data initiatives from three aspects of complexity: data, computational, and system complexity. Vassakis, Petrakis, and Kopanakis (2018) argue that the major challenges in collecting and analyzing big data in organizations are mostly management- and culture-related and include leadership, talent management, the decision making process and quality, the data-driven culture, new technology utilization, and data privacy.

To address the challenges of big data and to exploit its advantages effectively, researchers have studied ways to effectively construct and utilize big data applications. For instance, Singh and Reddy (2015) discuss the different big data analysis applications available by investigating detailed descriptions of software frameworks within different big data hardware platforms and IT task support. Conducting a literature review for systems of the big data analysis platform, Hu, Wen, Chua, and Li (2014) provide a complete picture for non-expert readers by presenting big data in four sequential module decompositions of a system framework; the four modules are data generation, data acquisition, data storage, and data analysis. Trifunovic, Milutinovic, Salom, and Kos (2015) address the issue of big data applications, along with the relevant calculation mode and the programming model transformation. Raguseo, Pigni, and Piccoli (2018) develop a Digital Data Stream (DDS) readiness index to indicate how companies have prepared themselves to derive values from real-time streamed big data.

Recent research in logistics and supply chain management has also shifted its focus to big data. For instance, investigating big data and its applications in operations and supply-chain management, Addo-Tenkorang and Helo (2016) explore the main issues of big data in these areas and propose an extended framework through the integration of the Internet of Things and value-added services. Reviewing and classifying relevant literature, Wang, Gunasekaran, Ngai, and Papadopoulos (2016) propose a framework of supply chain analytics by highlighting the role of big data in supply chain and logistics management and by summarizing big data techniques and applications. In similar research, Tiwari, Wee, and Daryanto (2018) review the impact of big data in supply chain management and demonstrate how big data in supply chains is collected, processed, and analyzed. Choi, Wallace, and Wang (2018) summarize the big data methods that can be applied to inventory management, transportation management, and supply

chain management, and discuss big data strategies that can overcome the challenges in those areas.

Although big data has become a hot topic in logistics and supply chain management, prior research mainly emphasizes the role of big data in the field. Very few studies have investigated any real-world big data applications. Our research makes the difference by studying current logistics and distribution problems through the application of big data in a real e-commerce enterprise. In particular, our study is linked to the big data context by its use of JD's big data platform, with which our research data was collected through screening the stores at JD's mall that met our criteria. In 2018, the number of registered accounts at JD's mall reached 300 million, and the number of users using JD's financial platform and enterprise research platform reached 100 million (JD.com, 2018). Based on the huge number of stores and users, JD developed its big data platform as a carrier to collect, calculate, and process its massive data. Although collected raw data is not directly available, the big data platform provides opportunities for users to access the processed data and its associated information. Taking advantage of JD's big data platform, this study surveyed merchants with stable business performance who had been with JD for more than three years.

## 2.2. Choice of logistics distribution mode

The choice of distribution management in e-commerce enterprises can be divided into two parts (Hertz & Alfredsson, 2003). Some enterprises set up their own logistics distribution websites to fulfill their own distribution requirements, whereas others choose to cooperate with third-party enterprises, such as distribution companies, to accomplish the logistics distribution of e-commerce enterprises.

The self-supporting distribution mode has several advantages: good time control, professional logistics distribution, an enhanced user experience and customer loyalty, the continuous purchasing power of products, effective monitoring of product quality, rational allocation of resources, improved speed of commodity inventory turnover, and accelerated flow of enterprise capital (Chen & Hua, 2013). However, e-commerce enterprises suffer from problems as they build their own logistics distribution websites. First, e-commerce enterprises are not good at managing the related activities of logistics distribution. Due to a lack of management experience and relevant professional management personnel, the self-built logistics distribution departments of e-commerce enterprises may not be appropriate (Vendrell-Herrero, Bustinza, Parry, & Georgantzis, 2017). Self-conducting logistics will force companies to devote their efforts to deal with unfamiliar territory, which can jeopardize their core business advantages. Second, self-established logistics and distribution cost a lot of money, which can result in great pressure and may even cause the need for capital turnover (Yu, Wang, Zhong, & Huang, 2017). The need to increasingly invest in fixed assets, in storage equipment, in transportation equipment, and in logistics personnel can take up most of the firm's capital, can reduce the amount of investment available for other important departments, and can eventually lead to a weakened competitive advantage of the enterprise. Third, the lack of professional departments for the self-built logistics distribution management may cause huge resistance to a department's operation and development goals (Xiao, Liu, & Zhang, 2012).

The third-party distribution mode is based on the use of third-party logistics providers, which typically specialize in the consolidated services of inventory, warehouse, and transportation management – services that can be customized, based on the specific needs of clients and their products. Third-party logistics providers offer value-added services that create mutual benefits between themselves and their customers (Shi, Zhang, Arthanari, Liu, & Cheng, 2016). Advancements in technology further enable third-party logistics providers to increase productivity and to lower logistics costs, in order to facilitate the growth of supply chains (Vaidyanathan, 2005). Recent studies show that maintaining a collaborative relationship between third-party

logistics providers and their clients helps to reduce risks (Govindan & Chaudhuri, 2016) and to balance the tradeoff between innovation and resource allocation (Sinkovics, Kuivalainen, & Roath, 2018). Factors such as quality control, operational flexibility, and geographical service coverage all influence the performance of third-party logistics providers (Govindan & Chaudhuri, 2016). A three-dimensional (activities, decision, and actors) framework that incorporates all such factors can comprehensively measure the performance of a third-party logistics provider (Domingues, Reis, & Macário, 2015). Furthermore, criteria related to uncertainty, order frequency, and transaction volume can be used to evaluate the value and the benefit derived from third-party logistics providers (Shi et al., 2016).

Some e-commerce enterprises choose to collaborate with third-party logistics companies to develop their logistics operations (Aguiezoull, 2014), due to the advantages such as the higher degree of specialization, rich experience, and wide range of distribution channels, which can effectively help enterprises to save logistics investment costs and to reduce their potential risks (Marasco, 2008). Cooperating with third-party logistics companies may also result in some potential problems in logistics distribution. First, a necessary distribution management information system may not always be available to help clients to track the real-time information of their orders (Rushton, Croucher, & Baker, 2014). For instance, some of the third-party distribution enterprises in China have not yet set up their logistics management information systems, so they cannot fulfill the complete processes of logistics information management. Second, a mature and complete logistics distribution system may be lacking (Goetschalckx, Vidal, & Dogan, 2002). Collaboration with a large number of enterprises will make it difficult to manage e-commerce activities, to unify the corporate image, and to maintain consistent service levels. In order to avoid being too dependent upon one carrier, the same e-commerce enterprise can use many different express companies to provide logistics and delivery services in the same area.

The co-distribution mode, with which multiple enterprises establish strategic alliances in order to quickly respond to the frequent changes in the market, to effectively coordinate the fluctuations of supply and demand, to develop synergy in action, and to reduce the risks of enterprises, has become popular among enterprises in recent years (Leitner, Meizer, Prochazka, & Sihn, 2011). However, such type of distribution mode requires a higher degree of coordination among enterprises, which may not be applicable or available to some companies.

In summary, very few prior studies have systematically analyzed the existing logistics distribution modes with a real-world example in a big-data context. Our research addresses the gap by studying the choice of logistics distribution mode in a big-data context. Specifically, based on the empirical data collected from the big data platform at JD.com, this paper compares and analyzes the different logistics distribution modes faced by e-commerce enterprises as they embrace the new features, new challenges, and new advantages of the era of big data. Focusing on how to turn data into comprehensive considerations of economic and strategic factors, this study applies the AHP method and entropy value to investigate the electronic commerce enterprise distribution choice mode, and uses the TOPSIS method to verify the model.

## 3. Methodologies

This section outlines the research methodologies employed by this study. Our research identifies JD.com as the e-commerce enterprise for our case analysis target. Since prior research has not specifically explored the existing logistics distribution modes using a real-world example in a big-data context, it is appropriate to conduct a detailed case analysis to address the research gap and derive managerial insights. Besides, the AHP and TOPSIS methods are employed to investigate JD.com's choice of logistics distribution modes. The AHP method helps to determine the subjective weight of each distribution mode implemented by JD. Then, the TOPSIS method verifies the robustness of

the hierarchical structure model constructed with the AHP method.

### 3.1. Case analysis

Based on the case study research methodology recommended by Yin (2003), JD.com, the largest online e-commerce retailer in China, was selected as the e-commerce enterprise, in order to gain insights and to study the logistics distribution mode in a big-data context.

The price paid for the orders made at JD.com reached 159.8 billion yuan on November 11, 2018, during the annual November 11 shopping festival (JD.com, 2018). Under enormous pressure and competition, JD.com reached this height through the use of its whole data-dependent process. The resilience of virtual machines and the derived transaction data enable JD.com to deploy their operations in multiple locations, based on big data.

With the ability to effectively use big data, JD.com ensures that each step will improve the user experience, reduce the cost of the entire supply chain, promote efficiency, increase sales, and improve productivity. For instance, JD.com's personalized recommendation system considers different users in different environments, in order to improve user experience. JD.com has made great efforts in in-depth learning. Through machine learning, the technology of the user portrait, and the processing ability of natural language, JD.com has enabled just-in machine entry; > 50% of its conversations are now handled by machine entry and follow-in, and the speed of this method is still increasing.

A large number of commodities offered poses a great challenge to JD.com. At JD.com, many goods are automatically replenished; according to the sales situation, the market expectations, and the prediction model, when the inventory level reaches a certain threshold, the system will automatically generate orders. Big data is also used in the field of distribution at JD.com. By analyzing the distribution personnel, warehouses, and geographical relations between users, JD provides the optimal distribution route for logistics personnel, so as to improve the distribution speed and the user experience (Wu, Xu, and Zeng, 2018).

As the core competency of retail enterprises, the supply chain is also the central area of JD.com's technology, R&D, and innovation. JD.com is committed to improving the ability and the agility of its supply chains. The advantages of artificial intelligence, user research, inventory management, precise marketing, and other aspects of the business have been fully exploited at JD.com by its use of big data. This has allowed JD.com to further explore and build its online, multi-platform, and integrated supply chain solutions, which constantly improve the company's retail supply chain efficiency. For example, by the end of, 2017, the automatic replenishment of JD.com's consumer products covered > 86% of the purchase scenarios, with the distribution data all collected from JD.com's big data platform (JD.com, 2017).

This research uses the big data platform from JD.com to collect relevant data about its e-commerce logistics distribution modes and then uses the AHP and TOPSIS method to study JD.com's distribution mode choice. All of the data in this study were obtained through an in-depth interview and questionnaire survey from JD.com.

### 3.2. AHP

Proposed by Saaty (1981), the Analytic Hierarchy Process (AHP) is a method that considers a complicated multi-objective decision-making problem as a system. Through decomposing a target and by forming multi-level goals or standards, this method applies a fuzzy quantitative method to calculate the level of a single order and the total order. As a multi-objective decision-making system, this method is used to solve non-mathematical model decision-making problems, using the following several primary steps. In summary, the analytical process is divided into four stages: (1) establishing the hierarchical substructure model; (2) constructing all of the judgment matrices in each level; (3) checking the hierarchical single ordering and consistency; and (4) checking the total hierarchical ordering and consistency.

The AHP method has been widely applied in studies of supply chain management (Barker & Zabinsky, 2011; Mehralian, Moosivand, Emadi, & Asgharian, 2017), marketing (Li, Liu, & Li, 2014; Wind & Saaty, 1980), operations (Mangla, Govindan, & Luthra, 2017; Partovi, Burton, & Banerjee, 1990), and many other related fields (Chen, 2006; Ho and Ma, 2017). In particular, Bai, Wei, and Yan (2017) have used the AHP method to study the factors affecting logistics by analyzing the changes in e-commerce transaction scales across recent years. Our research uses this method to study the appropriate choice of logistics distribution mode.

### 3.3. TOPSIS

The TOPSIS method was first proposed by Hwang and Yoon (1981), and it is now commonly used to improve the idea that the compromised solution of Zeleny should be the closest to the ideal solution (Opricovic & Tzeng, 2004). The point of this method is to sort by detecting the distance between the evaluation object, the optimal solution, and the worst solution. Among these three, each index value of the optimal solution reaches the optimal value of each evaluation index, and each index value of the worst solution reaches the worst value of each evaluation index. As a comprehensive evaluation method, the TOPSIS method is mainly used in the multi-objective decision analysis of finite schemes, because of the many advantages that it offers. Some advantages include the convenience of application, no requirements for the sample size or the user, no impact from a reference sequence of choice, a wide application range, and small flexible information distortion.

The TOPSIS method has also been extensively applied in research fields such as supply chain management (Boran, Genç, Kurt, & Akay, 2009; Sari & Suslu, 2018), marketing (Prior, 2015; Wu, Lin, & Lee, 2010), and e-commerce (Chen, Kou, Shang, & Chen, 2015; Rouyendegh, Topuz, Dag, & Oztekin, 2018). Also, the TOPSIS method, in combination with the AHP method, has been applied in logistics research. It has been used to study reverse logistics adoption (Prakash & Barua, 2015) as well as outsourcing logistics services (Bottani & Rizzi, 2006). Our research uses the TOPSIS method to verify the AHP model of selecting an appropriate e-commerce logistics distribution mode.

## 4. Analyzing E-commerce distribution mode in a big-data context: a case analysis of JD.Com

This section details our analysis of the e-commerce distribution mode in a big-data context through the case analysis of JD.com. Specifically, the first subsection analyzes the data sources and the distribution modes from JD.com, and then the next three subsections (§4.2, §4.3, and §4.4) determine the subjective weight of each scheme using AHP, the objective weight of each scheme using the method of legibility value, and the comprehensive weight of each scheme using the weight vector synthesis method. In addition, subsection §4.5 demonstrates the verification, using with the TOPSIS method. The final subsection discusses the implications of our analysis and results.

### 4.1. Analysis of data sources and distribution modes

JD.com fully covers a variety of business activities, from purchasing and selling to e-business processes such as distribution and customer service. Offering superior applications in data mining with its complete landscape in e-commerce, JD.com has built up a series of big-data-based applications, such as user portraits, mining tools, and a knowledge system, and has applied them to each link of the JD.com business processes (Liu, 2018).

Through questionnaire surveys and interviews, this study obtained its data from JD.com's self-established logistic distribution mode, a third-party logistics distribution mode, and the co-distribution modes of JD.com's direct merchants and partners.

The self-management logistic distribution mode refers to the mode in which all of the links of enterprise logistics distribution are constructed and managed by the enterprise itself, in order to realize the distribution of internal and external goods. The mode has been adopted by JD for the supermarket, fresh products, self-supporting products, and small e-commerce enterprises that use its selling platform (Zhang, 2018).

The third-party logistics distribution mode refers to the logistics operation mode that is completed by a third party other than the supplier or the demander of logistics services. At JD, this distribution mode is used for the large flagship products that sell at JD.com, such as L'Oréal Paris, Estee Lauder, Timberland, and some furniture brands (Xu, 2018).

The co-distribution mode refers to the logistics distribution patterns of cooperation. For JD.com, generally, this mode is used for branded goods to be distributed on JD's platform. However, these goods do not normally come from flagship stores, but through stores with relatively small sizes. For instance, there are 618 partners in the electricity section at JD.com (Wang, 2018).

The related data of the logistics modes in this research was collected from JD.com's big data service platform (see Figs. 1, 2, and 3). Based on its more than ten million active users, JD.com has its own questionnaire and survey data platform to launch online research projects (Fig. 1). JD.com's survey data platform provides its investigators with mass and precise data that can be used to develop an in-depth understanding of user requirements. With the aid of this data platform, one that offers a sample database of hundreds of millions of consumers as well as a huge library, investigators can identify accurate research objects to direct their questionnaires according to consumer features. At the same time, users answer the questionnaires to win a JD.com reward, which motivates them to complete the survey.

All of the data in this paper came from the data research platform of JD.com. To ensure its reliability and its relevancy to our study, the data was collected between November 1, 2017, and December 31, 2017, as this period covered JD.com's annual sales season in November and December. The respondents to the questionnaire were merchants who had operated on the JD.com platform for more than three years. Stores selling special fresh food and medicine were excluded, as well as those having both physical and online storefronts, because they may have different distribution strategies (due to the goods that they are selling)

or because they may focus on their offline distribution channels. A total of 103 questionnaires were issued and 86 valid questionnaires were selected. There were 40 questions on the questionnaire, requesting basic information of merchants, as well as their usage of three logistics modes, their profitability, and customer satisfaction. The interviewees were mainly general management personnel, logistics management personnel, and logistics distribution personnel at JD.com's Ningbo warehouse. The interview questions focused on the service advantages and disadvantages of the three logistics distribution modes.

JD.com's big data platform also provides additional professional logistics research data (Figs. 2 and 3). Mainly relying on JD.com's commodity circulation statistics platform, this study obtained the data of the three logistics distribution modes primarily used in JD.com's self-management and cooperating merchants. Meanwhile, the distribution profit and loss of these selected merchants were compared. On the data platform of JD.com, in-depth research on cooperative merchants was conducted through both online and offline interviews. Through this platform, a total of 92 self-run and cooperating merchants were investigated, and 48 business executives participated in in-depth interviews.

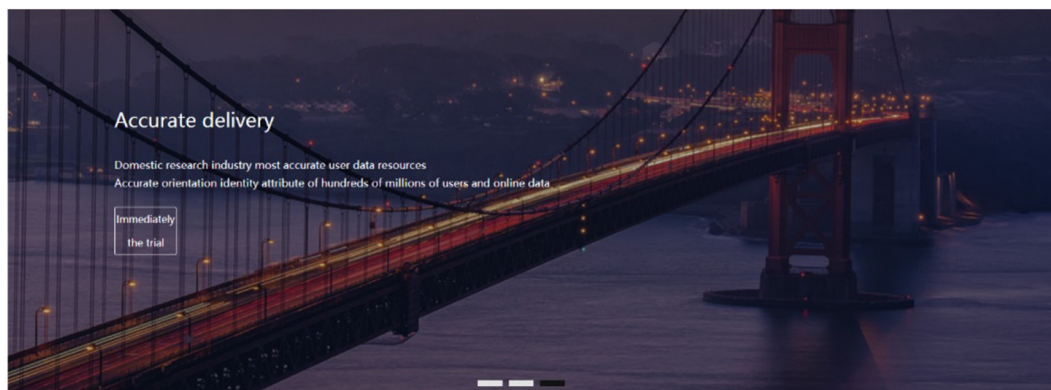
Based on the data collected, this study uses the AHP and TOPSIS method to study JD.com's logistics distribution mode choice.

#### 4.2. Determine the subjective weight of each scheme with AHP

Considering the economic and strategic factors faced by e-commerce enterprises in a big-data context, our research analyzes the influential factors of the existing distribution mode and then determines the following four factors: logistics cost (Zeng & Rossetti, 2003), enterprise strength (Sun & Xue, 2015), distribution quality (Gil-Saura, Servera-Francés, & Fuentes-Blasco, 2010), and information processing ability (Ritchie-Dunham, Morrice, Anderson Jr, & Dyer, 2007).

##### (1) Build the distribution mode selection structure model.

Fig. 4 shows that the decision-making problem of JD.com's e-Mall distribution modes is classified into three levels: the top level is the target level; the lowest layer is the scheme layer and includes three delivery modes; and the middle layer is the criterion layer and includes four influencing factors.



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Fig. 1. JD.com's big data service platform.



Fig. 2. JD.com's big data service platform.

(2) The criteria layer builds the judgment matrix for the target layer.

The criterion layer builds the judgment matrix for the target layer according to the importance of factors influencing different delivery modes (as shown in Table 1).

The calculated maximum Eigenvalue is  $w_0 = (0.54, 0.27, 0.12, 0.06)^T$ , The feature vectors are  $\lambda_0 = 1.55$ ,  $CR = 0.07 < 0.1$ , which pass the conformance test.

(3) The criterion layer constructs the judgment matrix for the scheme layer and is solved to construct the judgment matrix, according to the importance of factors that influence the enterprise distribution scheme (as shown in Table 2).

By the calculation,  $w_1 = (0.60, 0.20, 0.20)^T$ ,  $\lambda_1 = 3.00$ ;  $w_2 = (0.59, 0.25, 0.16)^T$ ,  $\lambda_2 = 3.05$ ;  $w_3 = (0.44, 0.3, 0.17)^T$ ,  $\lambda_3 = 3.02$ ;  $w_4 = (0.55, 0.21, 0.24)^T$ ,  $\lambda_4 = 3.02$ . They all pass the consistency test. Then, the subjective weight is calculated by the maximum Eigenvalue and eigenvector  $\mu_3 = (0.57, 0.18, 0.25)^T$ .

4.3. Determine the objective weight of each scheme with the method of legibility value

The calculation shows that the objective weight  $K = \frac{1}{\ln 3} = 0.91$ . We then compute the child value of each attribute  $e_j$ , the internal information divergence  $d_j$ , and the weights of attributes  $w_j$  (as shown in Table 3). Therefore, the objective weight of each program is

$$w_j = (0.56, 0.25, 0.19)^T.$$

4.4. Determine the comprehensive weight of each scheme with the weight vector synthesis method

The comprehensive weight of each scheme is then calculated according to the subjective and objective weight of each scheme (as shown in Table 4).

It can be seen from Table 4 that the self-supporting logistics distribution mode is the best scheme, followed by the third-party logistics distribution mode, and finally by the joint distribution mode.

4.5. Verification by TOPSIS method

The TOPSIS method is the most commonly used multi-attribute group decision-making method. The conventional TOPSIS method is to represent the decision information in the decision matrix by a precise number, a fuzzy number, an interval number, an intuitionistic fuzzy number, an interval intuitionistic fuzzy number, and a hesitating fuzzy element.

Table 2 to Table 5 show that the positive ideal solution is  $V^+ = (0.20, 0.16, 0.17, 0.21)^T$ , and the negative ideal solution is  $V^- = (0.60, 0.59, 0.44, 0.55)^T$ .

In addition, Table 5 demonstrates the distance from the target to the positive ideal solution  $S^+$ , the distance from the target to the inverse ideal solution  $S^-$ , and the closeness of the ideal solution  $C^*$  for all three distribution modes.



Fig. 3. JD.com's logistics big data service platform.

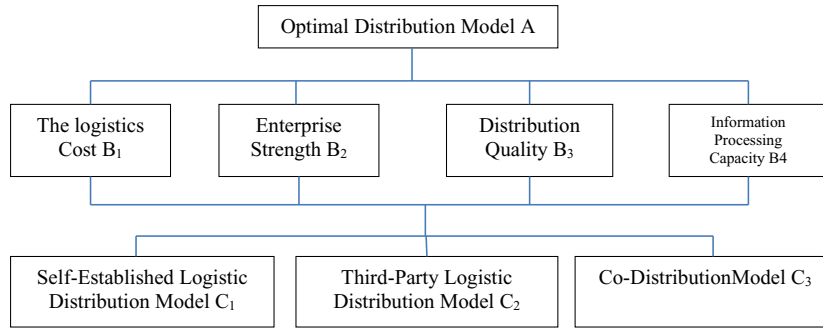


Fig. 4. Hierarchical selection structure of distribution mode (note: 82 valid pieces of data obtained from the questionnaire survey of JD.com electronic mall were used for specific analysis)

Table 1  
Criterion layer judgment matrix about the target layer.

A	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>
B <sub>1</sub>	1	3	4	7
B <sub>2</sub>	1/3	1	3	5
B <sub>3</sub>	1/4	1/3	1	2
B <sub>4</sub>	1/7	1/5	1/2	1

Table 2  
Judgment matrix of scheme layer on criterion layer.

B <sub>1</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	B <sub>2</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>
C <sub>1</sub>	1	3	3	C <sub>1</sub>	1	3	3
C <sub>2</sub>	1/3	1	1	C <sub>2</sub>	1/3	1	2
C <sub>3</sub>	1/3	1	1	C <sub>3</sub>	1/3	1/2	1
B <sub>3</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	B <sub>4</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>
C <sub>1</sub>	1	1	3	C <sub>1</sub>	1	3	2
C <sub>2</sub>	1	1	2	C <sub>2</sub>	1/3	1	1
C <sub>3</sub>	1/3	1/2	1	C <sub>3</sub>	1/2	1	1

Table 3  
Attribute entropy, inner divergence, and attribute weight.

	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>
e <sub>j</sub>	0.86	0.87	0.94	0.91
d <sub>j</sub>	0.14	0.13	0.06	0.09
w <sub>j</sub>	0.32	0.32	0.15	0.21

Table 4  
Objective weight, subjective weight, and comprehensive weight of each scheme.

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>
w <sub>j</sub>	0.56	0.25	0.19
μ <sub>j</sub>	0.58	0.24	0.19
λ <sub>j</sub>	0.77	0.14	0.19

Table 5  
The degree of similarity of each scheme.

	Self-supporting distribution mode	Third-party distribution mode	Co-distribution mode
S <sup>+</sup>	0	0.63	0.72
S <sup>-</sup>	0.73	0.22	0.03
C <sup>*</sup>	0	0.74	0.96

4.6. Discussion and suggestions

The results of our analysis (see Table 5) show that the self-

supporting logistics distribution mode is the best scheme for use at JD.com, followed by the third-party logistics distribution mode, and finally by the joint distribution mode. The calculated results are consistent with those obtained by using AHP and Topsis methods. Therefore, JD.com should first choose the self-built logistics distribution mode, then the third-party distribution mode, and finally the joint distribution mode, in order to achieve distribution efficiency, maximization of distribution, and its aim of cost minimization.

This result is based on the ranking of the four chosen factors: logistics cost, enterprise strength, distribution quality, and information processing ability. The judgment matrix in Table 1 shows that the logistics cost is the most important factor to be considered during the decision-making process, followed by enterprise strength, distribution quality, and information processing ability. If an e-commerce enterprise has a different rank order for these four factors, the final choice of logistics distribution mode may be different. In addition, other factors may also influence the choice of a distribution mode. For instance, status monitoring (Garver, Williams, Stephen Taylor, & Wynne, 2012), location (Verhetsel et al., 2015), and “end-of-life product organizational roles” (Meade & Sarkis, 2002) may be considered. No matter which factors e-commerce enterprises want to include in their decisions, our research offers a viable method to help them choose the appropriate logistics distribution mode. Our proposed method can effectively avoid the use of subjective judgment during the decision-making process. It also provides a quantitative analysis framework that guides users to make their choices of a distribution mode based on data analysis.

No matter which logistics distribution mode is chosen, e-commerce enterprises are always seeking innovative solutions to further enhance the quality of distribution, to improve the information processing ability, and to reduce logistics costs. The following suggestions are some emerging strategies that can be used to substitute or to improve the existing three primary logistics distribution modes. These distribution strategies can be incorporated into self-supporting, third-party, or co-distribution logistics distribution modes, in order to enhance their performance.

4.6.1. The nearest distribution mode

By using a big data statistical analysis of consumer demand and by integrating a high-quality distribution path of consumers, putting a supplier's products into the nearest distribution center will help to implement the intelligent distribution, as well as to improve the efficiency and quality of distribution and to reduce the logistics cost and delivery time (Sun, 2015). The nearest distribution mode can be incorporated into all three logistics distribution modes discussed in this study (the self-supporting, third-party, and joint distribution mode). The location and the ownership of the nearest distribution center may influence the final choice of distribution mode. For instance, the e-commerce enterprise that originally chooses the self-supporting distribution mode due to primary low-cost consideration may switch to the joint distribution mode by utilizing the nearest distribution center from

a third-party logistics provider, in order to further reduce its logistics cost.

#### 4.6.2. The virtual distribution mode

Based on a virtual logistics network (Clarke, 1998; Chang et al., 2003), virtual distribution centers no longer put goods in storage after their arrival but offer them directly to the demand of their customers for distribution. With the help of big data analysis, data distribution phases can be analyzed accurately to make reasonable arrangements for distribution modes (Hong, Qian, & Tang, 2013). Based on the analysis of their distribution phases, enterprises can assess their potential for adopting the virtual distribution mode, which is essentially an enhanced mode of the three modes under discussion. If an enterprise does not have a supportive network, it may utilize the virtual logistics network from third-party logistics providers, or it may work with them to launch such a distribution mode.

#### (1) One-stop distribution mode

The one-stop distribution model varies for different enterprises in developing and deploying their distribution centers to fulfill one-stop deliveries (Trappey, Trappey, Chang, Lee, & Hsu, 2016). Considering the number of goods to be distributed, combined with the big data analysis, distribution centers can be established based on the reasonable arrangement of the number of vehicles, the distribution path, and the concentration and distribution of the goods (Yao, 2017). Similar to the previous two modes, the one-stop distribution mode can also be considered, as an enhancement. Adopting such a distribution mode requires enterprises to consider how to develop one-stop distribution centers based on the three primary (self-supporting, third-party, joint) distribution modes.

## 5. Conclusion

Recent years have seen the quick development of China's e-commerce under the backdrop of big data. Logistics has become an important indicator of an e-business enterprise's competitive ability. The choice of logistics distribution mode directly affects an e-commerce enterprise's distribution costs and coordination. When meeting the development requirements of e-commerce and to improve customer satisfaction, the choice of e-commerce logistics distribution mode is of great importance. Nevertheless, very few prior studies have systematically analyzed the existing logistics distribution modes by offering a real-world example in a big-data context. Our research addresses this research gap by studying the distribution modes of the e-commerce giant, JD.com.

Specifically, this study proposes a method for e-commerce enterprises to choose their logistics distribution modes based on the analysis of big data. Since it avoids subjective judgment, this method provides an effective way for e-commerce enterprises to choose an appropriate logistics distribution mode through quantitative analysis. As a good representative of mature e-commerce enterprises, JD.com has been successfully deploying three major logistics distribution modes: self-supporting, third-party, and co-distribution. By analyzing JD.com's big data platform, our research proposes a method for enterprises to select their logistics distribution modes based on four primary influential factors: logistics cost, enterprise strength, distribution quality, and information processing quality.

Our proposed method effectively absorbs the results of qualitative analysis, while giving full play to the advantages of quantitative analysis. It includes subjective logical judgment and analysis as well as objective accurate calculation and deduction, so that the decision-making process can be highly organized and scientific. In addition, our method is based on AHP, which regards the problem as a system, and the entire process embodies the systematic thinking mode of decomposition, judgment, and synthesis, as well as the dialectical principle of

systematic thinking. Since the AHP method is subjective in determining the weight, this study uses the TOPSIS method to effectively verify the correctness of the subjective weighting. When the weight division problem is verified, the weight of AHP can be effectively corrected, and an ideal logistics distribution mode can be finally selected.

Our research analysis and results bear great managerial insights for e-commerce logistics distribution practitioners. First, e-commerce enterprises should choose the right logistics distribution mode, based on the specific situation of the enterprise and its own development. And e-commerce enterprise's choice of a particular logistics distribution mode must be derived from the company's financial conditions and operating conditions, embedded in the understanding of its logistics distributions. Secondly, the e-commerce logistics distribution mode should be improved to unclog all of the aspects of information in order to make e-commerce logistics delivery more efficient. E-commerce logistics distribution should be developed to enhance the quality of the whole logistics management process and to strengthen the communication of information, in order to provide evidence for the selection of the appropriate logistics distribution mode. In addition, relevant information should be updated in a frequent manner, in order to improve the timeliness of information, so that scientific and accurate judgment can be made.

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