Application of Big Data Analysis in Demand Forecasting and Path Optimization of Cold Chain Logistics

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Abstract: This article discusses the application of big data analysis in the field of cold chain logistics. At present, cold chain logistics is developing rapidly, but it faces the problems of inaccurate demand forecast and unreasonable path planning. This article aims to improve the accuracy of cold chain logistics demand forecasting and the efficiency of path optimization with the help of big data analysis. In this article, literature research is used to sort out the relevant theoretical achievements, and a theoretical framework for the application of big data analysis in cold chain logistics is constructed through theoretical derivation. It is found that big data analysis can help cold chain logistics in many ways. In demand forecasting, through extensive data sources and preprocessing, a suitable forecasting model is constructed and the results are optimized. In the aspect of path optimization, strategies are formulated and algorithms are implemented according to big data. However, the application process faces challenges such as data security, technology integration and talent shortage. This article puts forward targeted countermeasures to promote the effective application of big data analysis in cold chain logistics and improve the overall efficiency of the industry.

1. Introduction

With the sustained development of the global economy, the cold chain logistics industry is rising rapidly. People's demand for fresh food, medicine and other cold chain products is increasing day by day, and the importance of cold chain logistics is becoming more and more prominent [1]. Because of its particularity, cold chain logistics faces many challenges in its operation, among which inaccurate demand forecast and unreasonable path planning are extremely prominent problems [2]. It is difficult to predict the demand of cold chain logistics. This is because its demand is influenced by many complicated factors. Consumers' purchasing behavior, seasonal changes, market competition situation and unexpected events all influence the demand of cold chain products to varying degrees [3]. Traditional forecasting methods are mostly based on historical data and simple statistical models, and it is difficult to capture the dynamic changes of these complex factors comprehensively and accurately, resulting in a big deviation between the forecasting results and the actual demand [4]. This deviation will not only waste resources, but also lead to the problem of insufficient or excessive supply of products, which will further affect the economic benefits and market reputation of enterprises.

Path optimization is also a key link in the operation of cold chain logistics. Cold chain transportation has strict requirements on time and temperature, which makes the route selection directly related to the quality and cost of products [5]. Unreasonable path planning may lead to too long transportation time and increase the risk of product deterioration; Or the transportation cost is too high, reducing the profit space of enterprises [6]. Traditional path planning methods generally focus on the single goal of shortest distance or optimal time, and fail to fully consider the special needs of cold chain logistics, making it difficult to maximize the overall benefits. The rise of big data analysis technology provides new ideas and powerful means to solve the above problems of cold chain logistics. Big data can comprehensively collect and integrate data information of all aspects of cold chain logistics, covering order data, transportation data, inventory data and environmental data

[7]. Through the deep mining and analysis of these rich data, we can gain a more accurate insight into the changing trend of consumer demand, discover the laws and patterns hidden behind the data, and thus build a more accurate demand forecasting model. In terms of path optimization, big data analysis can obtain dynamic data such as road information, weather conditions and traffic control in real time, and combine with the special requirements of cold chain transportation, use advanced algorithms for comprehensive analysis, and formulate a more scientific and reasonable path planning scheme [8]. This not only helps to improve transportation efficiency and reduce costs, but also effectively guarantees the quality and safety of cold chain products.

At present, the application research of big data analysis in the field of cold chain logistics is still in the development stage. Although some practical explorations have been made, there are still many problems that need to be further studied and solved. In view of this, it is of great practical value to discuss the application of big data analysis in cold chain logistics demand forecasting and path optimization in order to promote the efficient and sustainable development of cold chain logistics industry.

2. Application of big data analysis in cold chain logistics demand forecasting

The big data of cold chain logistics comes from a wide range of sources, covering the sales terminal data, and recording the sales time, place and quantity of various cold chain products in detail; Logistics transportation data; And market environment data. These data are diverse in form and complex in structure, and can only be used for analysis after preprocessing [9]. The pretreatment process includes data cleaning, removing duplicate, error and incomplete data, and improving data quality; Data integration to realize unified management of data; Data conversion, which standardizes and normalizes the data to meet the requirements of the analysis model.

Based on the preprocessed big data, an appropriate prediction model can be selected. The traditional time series analysis model can capture the changing law of demand with time according to historical sales data. Machine learning algorithms, such as neural network and support vector machine, have strong nonlinear processing ability and can mine the potential relationship between complex factors [10]. When building the model, it is necessary to carefully select the characteristic variables and optimize the model parameters to improve the prediction accuracy. The average absolute error, root mean square error and other indicators are used to evaluate the accuracy of the prediction results. If the evaluation result is not ideal, it can be optimized from many aspects. On the one hand, adjust the model parameters and find the optimal parameter combination through repeated experiments; On the other hand, the characteristic variables are re-screened, redundant or irrelevant variables are removed, and valuable new variables are added. We can also try to integrate various models, give full play to the advantages of different models, improve the forecasting performance, and make the forecasting results more suitable for the actual cold chain logistics needs.

3. Application of big data analysis in cold chain logistics path optimization

In the field of cold chain logistics, path optimization is very important for ensuring product quality and controlling costs. Big data analysis plays an indispensable role in it, which is mainly reflected in problem description, optimization strategy and algorithm implementation.

The path planning of cold chain logistics faces many complicated factors. Temperature control is one of the key factors. Different cold chain products have different temperature requirements during transportation. For example, pharmaceutical products need to be transported in a specific low temperature range to ensure drug efficacy. Transportation time is also extremely important. Too long transportation time may lead to product deterioration and affect quality. The load limit of vehicles, road conditions and traffic rules are all constraints that cannot be ignored. The goal of path optimization is to minimize transportation cost, maximize transportation efficiency and minimize product loss under the premise of satisfying these complex constraints, so as to measure the advantages and disadvantages of path planning. Big data provides rich and real-time information for path optimization. By integrating traffic big data, we can grasp road information in real time, avoid

congested road sections, choose smoother routes and reduce transportation time. Weather big data is also critical. Bad weather such as rainstorm, snow and ice will affect road traffic conditions and vehicle speed. Planning the route in advance according to weather information can reduce the adverse impact of weather factors on transportation. Use big data to analyze the distribution of distribution outlets and order density, rationally adjust distribution plans, optimize vehicle scheduling, improve distribution efficiency and reduce costs.

Many algorithms are widely used to optimize the cold chain logistics path. Genetic algorithm simulates the process of biological evolution, and finds a better solution among many path schemes through operations such as selection, crossover and mutation. Ant colony algorithm uses the foraging behavior of ants for reference, and guides the path search through the pheromone concentration left by ants on the path, and gradually finds the optimal path. In practical application, these algorithms should be adjusted and optimized according to the specific characteristics and needs of cold chain logistics.

4. Challenges and countermeasures in the application of big data analysis

4.1. Data security and privacy protection challenges and countermeasures

(1) Challenges

Cold chain logistics involves a lot of sensitive data, including customer information, product characteristics, transportation routes and so on. Once these data are leaked, it may lead to the invasion of customer privacy and the disclosure of business secrets, which will bring serious losses to enterprises and customers. There are data security risks in all aspects of data collection, storage, transmission and analysis. Figure 1 lists the common types of data security risks and their possible impacts in detail.
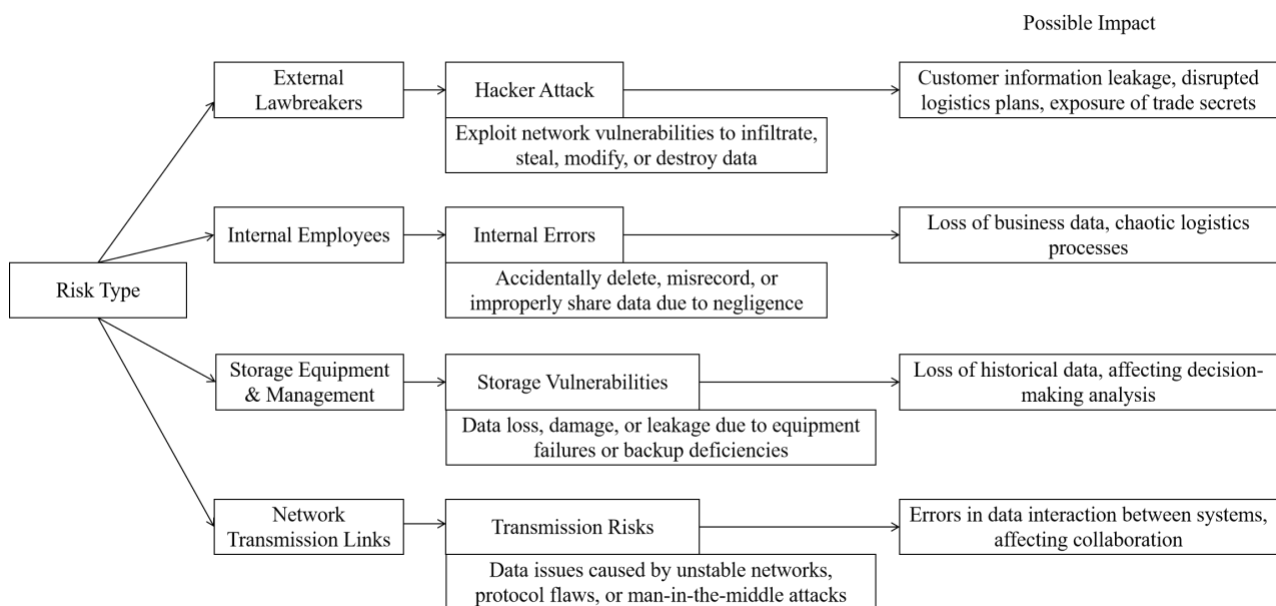

Figure 1 Types of Data Security Risks in Cold Chain Logistics

(2) Countermeasures

In order to meet the challenges of data security and privacy protection, a series of comprehensive measures need to be taken. In the data collection stage, the original data is encrypted to ensure the security of data during transmission and storage. Adopt advanced encryption algorithm, such as AES (Advanced Encryption Standard), to encrypt sensitive data. Clarify the data access rights of different personnel, and only authorized personnel can access specific data. At the same time, the data access behavior is recorded in detail so that problems can be traced back. In addition, regular data security audits are conducted to check the security loopholes of the system, and potential problems are found and repaired in time.

4.2. Challenges and countermeasures of technology integration

(1) Challenges

Cold chain logistics enterprises usually have a set of more complex information systems, including storage management system, transportation management system and so on. Integrating big data analysis technology into existing information systems to achieve seamless docking and collaborative work faces many technical problems. The data formats and interface standards of different systems are inconsistent, which may make it difficult to share and interact with data. Big data analysis requires a lot of computing and storage resources, and the existing hardware facilities may not meet the demand. Figure 2 shows the common problems and their specific manifestations in the process of technology integration.
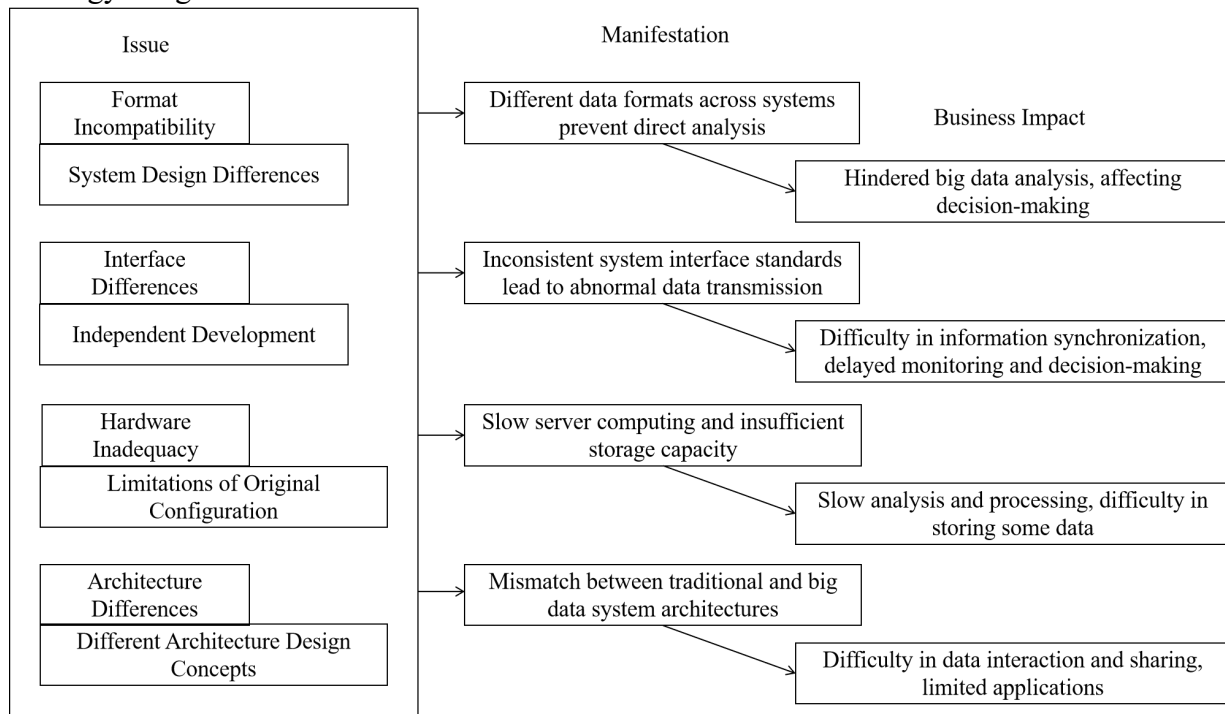

Figure 2 Issues and Manifestations in Cold Chain Logistics Technology Integration

(2) Countermeasures

To solve the problem of technology integration, it is necessary to start from multiple aspects. Enterprises should work together with industry associations to formulate a unified format and interface standard for cold chain logistics data, so as to ensure the smooth interaction of data between different systems. System designers and technical teams, in accordance with the requirements of big data analysis, should optimize the overall system architecture and enhance system compatibility and scalability. For example, using cloud computing technology, some computing tasks are migrated to the cloud to solve the problem of insufficient hardware resources. At the same time, data middleware is introduced to realize data conversion and transmission between different systems and reduce the coupling between systems.

4.3. Shortage challenges and countermeasures

(1) Challenges

The application of big data analysis in the field of cold chain logistics requires compound talents who understand both cold chain logistics business and big data analysis technology. At present, there is an extreme shortage of such talents in the market. On the one hand, the cold chain logistics industry is highly professional, which requires high industry knowledge and practical experience. On the other hand, big data analysis technology is rapidly updated, and it is necessary to constantly learn and master new algorithms, tools and technologies. Ordinary logistics talents lack big data analysis skills, and big data analysis talents have insufficient understanding of cold chain logistics business, which is difficult to meet the actual needs of enterprises.

(2) Countermeasures

In order to alleviate the shortage of talents, enterprises can take various measures. First, enterprises should strengthen internal training, carry out big data analysis technology training for existing employees, and provide cold chain logistics business knowledge training for big data analysts to enhance employees' comprehensive ability. The second is to cooperate with universities and training institutions to carry out customized talent training projects. Colleges and universities can add specialized courses combining cold chain logistics with big data analysis in curriculum setting, so as to train professional talents for enterprises. The third is to attract external talents, and attract outstanding compound talents in the industry to join the enterprise by providing competitive salary and good career development space.

5. Conclusions

This article discusses the application of big data analysis in cold chain logistics demand forecasting and path optimization. In demand forecasting, big data, with its massive and diverse data sources, can help to build an accurate forecasting model after pretreatment. Through scientific evaluation and continuous optimization, the accuracy of forecasting is significantly improved, providing a reliable basis for the rational allocation of cold chain logistics resources. In terms of path optimization, the rich information such as real-time road conditions and weather provided by big data, combined with special optimization strategies and algorithms, can effectively solve complex problems such as temperature control, transportation time and cost in cold chain logistics path planning, and maximize transportation efficiency and benefits. However, it cannot be ignored that big data analysis faces many challenges in the application of cold chain logistics. Data security and privacy protection are related to the core interests of enterprises and customers. Technology integration needs to break through the compatibility problem of existing systems, and the shortage of talents is the key factor restricting the application and promotion. In view of these challenges, this article puts forward specific countermeasures, including strengthening data encryption and access control, formulating unified standards and upgrading the system, and strengthening internal training and school-enterprise cooperation.

Big data analysis has brought new opportunities for the development of cold chain logistics. Despite the challenges, through effective response, big data analysis is expected to push the cold chain logistics industry towards intelligence and efficiency, enhance the competitiveness of the industry, meet the growing market demand and achieve sustainable development.

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