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Overview of Logistics Demand Forecasting Methods

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Abstract: Accurate forecasting of logistics demand is of great theoretical significance and practical application value for the formulation of national policies and the satisfaction of actual demand in the logistics industry. From the modeling form, the existing logistics demand forecasting methods are divided into four categories: single traditional forecasting method, single intelligent forecasting method, combined forecasting method and mixed forecasting method. Among them, single traditional forecasting methods mainly include simple time series method, regression analysis, mathematical and statistical methods, etc.; single intelligent forecasting methods mainly involve gray forecasting method, neural network, support vector machine and their improved forms; combined forecasting methods are mainly summarized into three combined forms: linear combination of single forecasting results, nonlinear combination of single forecasting results, modified single forecasting results; mixed forecasting methods are mainly summarized into three hybrid forms: hybrid intelligent optimization algorithms with single prediction methods, hybrid data dimensionality reduction techniques with intelligent prediction methods, and hybrid data mining techniques with intelligent prediction methods. The four major types of forecasting methods are reviewed, and each forecasting model in the four major types of methods is evaluated in terms of modeling principles, advantages and disadvantages, and applicability, in order to find forecasting methods suitable for different logistics demand forecasting tasks for logistics demand researchers.

Keywords: Demand forecasting, Forecasting methods, Single forecasting methods, Combined forecasting methods, Hybrid forecasting methods.

1. Introduction

Logistics demand forecast is based on the historical data of logistics demand and market information, using appropriate theories and methods to make scientific analysis, estimation and inference on the future logistics demand situation. Logistics demand forecast is an important basic work for modern logistics system planning, logistics management and decision making, and the accurate forecast of logistics demand is indispensable for logistics system planning and logistics development policy making at all levels. Theoretically, the accurate forecast of logistics demand can provide an important basis for the strategic planning of logistics development, the scale of logistics infrastructure and the formulation of logistics management programs, and provide concrete and reliable quantitative support for the development of logistics industry; practically, the accurate forecast of logistics demand helps government departments to reasonably plan and control the scale of development and development speed of logistics industry, which has realistic significance for developing national economy and reducing waste. Guidance significance. Therefore, logistics demand forecasting has become one of the important research contents in logistics field, and the research on logistics demand forecasting methods is especially important.

Logistics market is a complex open system, which is influenced by various factors such as economic, social, environmental, and policy, resulting in complex non-linear, volatile, and stochastic characteristics of logistics demand, thus the accurate prediction of logistics demand has been a difficult problem in the field of logistics demand research. For a long time, many scholars at home and abroad have applied mature forecasting methods from other fields to the field of logistics demand forecasting, and developed a variety of forecasting models and methods.

According to the different modeling forms, the existing logistics demand forecasting methods can be classified into four categories: single traditional forecasting methods and single intelligent forecasting methods, combined forecasting methods and hybrid forecasting methods. This paper reviews these four categories of forecasting methods and summarizes the modeling principles, advantages and disadvantages, and applicability of each forecasting model in each of the four categories of methods, in order to help logistics demand forecasting researchers find the applicable forecasting methods when facing different logistics demand forecasting tasks.

2. Logistics Demand Forecasting Methods

According to the relevant literature at home and abroad, from the perspective of modeling form, logistics demand forecasting methods can be divided into four major categories: single traditional forecasting methods, single intelligent forecasting methods, combined forecasting methods and hybrid forecasting methods.

2.1. Single traditional forecasting methods

Traditional forecasting methods are a class of logistics demand forecasting methods that were applied earlier. This type of method is based on statistics, modeling is relatively easy, and the explanatory power of the model is strong, mainly including simple time series method, regression analysis, mathematical and statistical methods, etc.

Michael used a time series analysis model to develop a short-term forecast of rail freight volumes[1].Rodrigo used a spatio-temporal multinomial probabilistic model to forecast cargo transportation demand[2].Fite et al applied a stepwise multiple linear regression method to predict freight volumes[3].Yang et al Logistics demand forecasting using moving average method[4].Tian et al applied a time series model to forecast logistics demand[5].Fang et al[6]Zhou et al[7]used regression analysis to construct a logistics demand

forecasting model.Since these models replace complex nonlinear relationships with simple linear ones, they often do not reflect well the influence of various factors on logistics demand and are difficult to obtain satisfactory forecasting results, so such methods are gradually being replaced by other more advanced forecasting methods.

2.2. Single intelligent forecasting methods

With the development of modern intelligent control theory, information and computer science, intelligent forecasting methods are widely used in logistics demand forecasting, mainly including gray forecasting method, neural network, support vector machine and their improved forms.

With its unique advantages in dealing with small samples, poor information, and uncertainty, gray forecasting methods have been applied in short-term forecasting in many industries.Bahram forecasted aviation demand using a gray model[8].More scholars have applied univariate gray models to the field of logistics demand forecasting, and Lin[9] used gray models for regional logistics demand forecasting research. Zhou[10] constructed a residual gray forecasting model for the limitations of the gray model in terms of applicability conditions, and improved the accuracy of logistics demand forecasting by mining the regularity of the original data several times. Since the univariate gray model uses the historical data of logistics demand for extrapolation forecasting and lacks consideration of influencing factors, Gao et al[11]constructed a multivariate gray forecasting model to predict logistics demand, which is simple to calculate and can predict logistics demand and its influencing factors simultaneously, and has certain practicality, but the method cannot describe the nonlinear relationship between logistics demand and its influencing factors, and the forecasting accuracy needs to be The prediction accuracy needs to be improved. Kang et al [12] used the gray correlation model to analyze the correlation of the main factors of logistics demand, and constructed a system dynamics model to predict and simulate the regional logistics demand. Li[13]constructed a sliding unbiased gray prediction model based on the traditional gray prediction model, and analyzed and predicted the demand for agricultural cold chain logistics in Hunan Province from 2019 to 2025. Zhang[14]predicted the demand of coal mine with the help of gray prediction model.

Neural network is a more mature and widely used model with strong nonlinear fitting ability to predict logistics demand by establishing a nonlinear mapping between logistics demand and its influencing factors.Yun et al[15]applied neural networks to freight volume forecasting and concluded that the prediction accuracy of neural networks is better than that of linear statistical models. There are relatively more scholars using neural networks for logistics demand forecasting, and Rui et al[16]proposed a "regional economic-logistics demand" forecasting model based on MLP network; Geng Yong et al[17]and Guo[18]studied a logistics demand forecasting method based on BP neural network; Yin[19]applied adaptive neural network to logistics demand forecasting. The above studies show that neural networks can improve the prediction accuracy of logistics demand. However, training the neural network requires a large number of data samples, which cannot guarantee the prediction accuracy when the logistics data samples are small, and the neural network takes the empirical risk minimization as the criterion, which cannot solve the problems such as overfitting in logistics demand prediction and leads to the reduction of learning generalization performance.

Support vector machine (SVM) is a new type of neural network that overcomes the defects of neural networks better with the principle of minimizing structural risk.Carbonneau et al [20] used neural network, recurrent neural network and SVM to forecast the end logistics demand of supply chain. Hu et al [21] proposed a regression-based SVM logistics demand forecasting method starting from the relationship between regional economy and regional logistics demand; Pang et al [22] proposed a time-series-based SVM logistics demand forecasting method starting from the regional logistics demand itself. Fan et al [23] proposed a prediction model based on the composite kernel model.

Since SVM can better solve the problems of small samples, nonlinearity and local minima, it has been successfully applied in logistics demand forecasting. However, SVM also has shortcomings, which are mainly reflected in the large number of parameters of the model, which may cause overfitting problems on the one hand and increase the computation time on the other hand; there is a lack of effective methods and theoretical basis for the selection of model parameters. These shortcomings have limited the development and application of SVM to a certain extent. The least squares support vector machine (LSSVM) uses an optimization objective function different from the standard SVM and converts the solved optimization problem into a set of linear equations through equation constraints, which reduces the complexity of the algorithm and increases the computational speed. The method has been widely used for forecasting in various industries, but it is less applied in the field of logistics demand forecasting.

2.3. Combined forecasting methods

Logistics demand is a complex nonlinear system, and it is difficult for a single forecasting method to reflect the change pattern of logistics demand comprehensively due to certain limitations in assumptions and application scope. Combining the forecasting results of multiple single methods can overcome the limitations of single forecasting methods and improve the forecasting accuracy of logistics demand under certain conditions. There is little literature on the application of combination forecasting methods to logistics demand forecasting in foreign countries, and the domestic research on combination forecasting methods for logistics demand mainly combines different intelligent forecasting methods and intelligent forecasting methods with traditional forecasting methods, which can be summarized into the following three categories according to the different forms of combination:

One, linear combination of single forecasting results, i.e., linear combination of forecasting results of different methods. Chu et al[24]proposed a logistics demand forecasting method combining gray system model, regression analysis and BP neural network; Wang et al[25] established a single forecasting model of logistics demand with gray system, regression analysis and exponential smoothing, and constructed a combined forecasting model based on determining the combination weights using the coefficient of variation method; Li et al[26]used BP neural network and GM(1,1) method; Cai et al[27]used two kinds of neural network methods, BP and RBF, to build a single forecasting sub-model, and then gave different weights to each sub-model to further build a weighted combination forecasting model; Wang[28]used a combination of weight assignment method,

pooled partial least squares method, time series ARIMA method and quadratic exponential smoothing method to forecast the demand for logistics in Beijing. method to predict the demand for various types of agricultural products in cold chain logistics. Xu et al[29]used ARIMA to predict the linear part and SVM to predict the nonlinear part, and both used the inverse of variance method to calculate the weights of the combined forecasting model to construct a demand forecasting model for automotive ex-factory logistics.

Second, nonlinear combination of single forecasting results, i.e., nonlinear combination of forecasting results of different methods. Wan et al[30]used linear regression model, moving autoregressive model and SVM to forecast regional logistics demand, respectively, and then combined the forecast results nonlinearly by BP neural network; Jia et al[31]firstly used ARIMA model to forecast each index, took the forecast value of each index as input, took freight volume as expected value, and used RBF neural network model for Jilin province The development trend of logistics demand from 2014-2020 was predicted.

Third, correction of a single forecast result, i.e., the correction of one method to another method forecast result. Zhang et al[32]proposed a logistics demand forecasting model (ARIMA-BPNN) based on autoregressive moving difference model to correct the error of neural network; Li et al[33]used gray model to forecast the cold chain logistics demand of agricultural products in Hainan, and also optimized the original model by Markov chain model and made quantitative forecast; Luo[34]used SVM to forecast the logistics demand. BP neural network was used to correct the prediction residuals.

All these three types of combined forecasting methods have obtained higher forecasting accuracy than single forecasting methods, but there are no mature theories and methods for combined forecasting methods so far on how to choose a reasonable single model and how to determine the optimal weights for combined forecasting methods so that they can improve the forecasting accuracy more effectively.

2.4. Hybrid forecasting methods

The hybrid forecasting method of logistics demand is the integration of a single forecasting method and other methods to forecast logistics demand together. This type of method can give full play to the advantages of the single forecasting method and other methods, and there is no need to determine the weight of each method participating in the mixture, which has become a new direction of research in the field of logistics demand forecasting. Research on hybrid forecasting methods for logistics demand can be summarized into the following three categories according to different modeling ideas:

One of them, hybrid intelligent optimization algorithms with single forecasting methods, i.e., using different intelligent algorithms to optimize the relevant parameters of a single forecasting model to improve the forecasting accuracy of the model. Sun[35]and Li et al[36]used ant colony optimization algorithm and fruit fly optimization algorithm to optimize the LSSVM parameters, respectively, and used the optimized LSSVM to forecast the logistics demand, but these two methods only forecast through the historical data of logistics demand, and the factors affecting the logistics demand are not considered. Geng et al[37]used LSSVM with optimized parameters by fruit fly optimization algorithm (FOA) to forecast railroad freight volume; Cao et al[38]used genetic algorithm (GA) to optimize support vector regression (SVR) machine for forecasting, and used optimal parameters to construct SVR model. Li[39]used the gray GM (1,1) model as the basic method, and constructed a gray linear combination model with the help of ant colony algorithm to find out the weights of individual models to forecast the logistics demand of agricultural products in Beijing during the 13th Five-Year Plan period. Li[40]established a set of logistics demand forecasting indexes for Ningbo port through the gray correlation method and proposed an extreme gradient boosting tree model based on genetic algorithm optimization. All these hybrid methods obtained higher forecasting accuracy than the single method.

Second, hybrid data dimensionality reduction techniques and intelligent forecasting methods, i.e., mixing existing theories and methods with artificial intelligence forecasting methods to predict logistics demand. Considering that there are many factors affecting logistics demand, Liu et al[41]first used factor analysis to reduce the dimensionality of logistics demand influencing factors, and then used BP neural network to forecast; He et al[42]used fuzzy rough set to construct SVM model to forecast regional logistics demand after simplifying the input data samples. Liang et al[43]used kernel principal component analysis (KPCA) to extract nonlinear feature information of logistics demand influencing factors, and input the extracted nonlinear principal components into LSSVM for logistics demand prediction. Geng et al[44]combined GRA and KPCA to extract the nonlinear information features of logistics demand influencing factors and used them as the input of LSSVM to forecast logistics demand, which further simplified the LSSVM structure and improved the prediction accuracy.

Thirdly, hybrid data mining techniques and intelligent forecasting methods, i.e., mixing existing models for forecasting based on the characteristics of logistics demand time series. Geng et al[45]mined the regularity of railroad freight volume sequences by gray series operators, and then used the adaptive particle swarm algorithm optimized LSSVM to forecast the new sequences with stronger regularity.

Since hybrid forecasting methods can give full play to the advantages of each method, the forecasting accuracy of these three types of hybrid forecasting methods are significantly better than that of single forecasting methods. However, the hybrid forecasting methods of logistics demand are still in the primary research stage, and there are not many relevant research results, and there is a lack of research on hybrid forecasting methods for logistics demand time series.

3. Outlook of Logistics Demand Forecasting Methods

As mentioned above, the early logistics demand forecasting methods are mainly single traditional forecasting methods based on statistics, and with the gradual research in the field of logistics demand forecasting and the development of forecasting technology, a number of more complex and more accurate intelligent forecasting methods have emerged. In recent years, more literature has been published on logistics demand forecasting using a single intelligent forecasting method than a single traditional forecasting method, and more and more studies have started to combine multiple methods for forecasting. Although the existing forecasting methods have achieved better forecasting accuracy to some extent, due to the complexity of logistics demand and the adaptability of

the forecasting methods themselves, the following problems still exist in the research of logistics demand forecasting methods to be studied.

Single gray methods have limited forecasting ability for logistics demand. Single gray methods, such as gray forecasting models, residual gray forecasting models, and multivariate gray forecasting models, have good forecasting accuracy for time series data with small dispersion and approximate exponential variation patterns, but have very limited forecasting ability for data series that are nonlinear, nonstationary, and volatile like logistics demand series.

Research on hybrid forecasting methods that integrate multiple methods together. The research on the hybrid forecasting methods of logistics demand is in the initial stage, which is not systematic and deep enough. Among the existing logistics demand hybrid forecasting methods, most of them integrate two different methods, but few of them integrate multiple methods to forecast logistics demand. How to integrate multiple methods, especially the organic integration of some existing new theories and methods with advanced intelligent forecasting methods, to further improve the prediction accuracy of logistics demand, needs to be studied in depth.

In addition, there are two problems to be solved in logistics demand forecasting: first, there is no consensus in the selection of logistics demand forecasting indicators, especially in the lack of logistics statistics in China, which mainly relies on artificial selection in the selection of variables and lacks quantitative analysis; second, there are fewer research results on logistics demand forecasting from the historical data of logistics demand itself.

4. Summary

Scholars have conducted a lot of research on logistics demand forecasting methods and achieved rich research results. Based on the modeling form, this paper divides logistics demand forecasting methods into four major categories: single traditional forecasting method, single intelligent forecasting method, combined forecasting method and hybrid forecasting method. The modeling principles of each prediction model in the four major categories are summarized, the advantages, disadvantages and applicability of each are analyzed, and the research directions of logistics demand forecasting methods are given, which are expected to help logistics demand researchers to find forecasting methods adapted to different logistics demand data.

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