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Supply Chain Model Following Individual Demand Forecast of Online Consumers

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Abstract. The individual demand of consumers puts higher requirements for the existing supply chain of enterprises in the context of online shopping. In order to meet consumer demand and improve competitiveness of the enterprises, a supply chain model with high efficiency and flexibility is established on the basis of the individual demand forecast. The decision tree classification algorithm is adopted to predict the types of products that consumers need. And the regression analysis algorithm is employed to predict the quantity of products that consumers need. On that basis, the result enters the 0-1 mixed supply chain model. With the goal of minimizing costs, the supply chain nodes will be determined.

1. Introduction

As online shopping system maturing and the individual demands growing[1], improvements in product categories, delivery time, and the accuracy of distribution are desired. Yet the existing supply chain fails to fully satisfy the demand for various and small batch products brought by individuation. Customer satisfaction and loyalty will decline due to long delivery time and shortage of stock, which directly affects the survival and development of enterprises[2]. Thus, building a product supply chain that can fully satisfy individual needs of online consumers is essential to improve market competitiveness.

Zhongjun Tang systematically explicated the connotation, classification and characteristics of individual needs[3]. Bartezzaghi and Joanne delved into the methods and models for forecasting the individual demands[4-5]. However, so far, there are few empirical researches focusing on the relevant topic and the existing results of demand forecasting do not apply to the supply chain to optimize production and distribution. With regard to supply chain research, scholars have long been aware of changes in consumer demand. However, the focus of the study is how to strengthen the links between supply chain partners to deal with the uncertainty from the market[6]. In 2005, scholars confirmed that it is possible to combine individual demand with supply chain in terms of enterprise operation[7]. However, e-commerce was not popular at that time and the individual needs of consumers took on low extent, so demand results were primarily stemmed from customer orders, failing to satisfy the delivery requirements of online consumers. Subsequently, some scholars proposed that predicting and fully responding to the specific needs of customers can bring excellent competitiveness to the company from the perspective of strategic integration[8]. At present, with the development of mobile networks, improving the dynamic response capabilities of the supply chain based on the individual needs of

consumers has become a hot topic of research[9-10]. And seeking consumer demand and responding in a cost-effective way through the supply chain has become an important way to improve business value[11].

In foundation of the existing researches, this paper quantitatively presents the individual demand information of online consumers and establishes a forecast model of the types and quantities of individual products. On this basis, a product supply chain model suitable for online shopping is established to better satisfy consumer needs and to improve competitiveness.

2. Individual demand collection and forecast

2.1. Individual demand information collection
Given the state dependence and memory accessibility advantage taken on by customer purchase decision, the information contained in previous purchase orders are capable of serving as the forecast basis for the next purchase[12]. From a general perspective, individual demand information includes customer attributes and product attributes. Selected sales data on a product of a company in a certain period are stemmed from a particular business platform. Subsequently, the data is saved according to different categories of consumer attributes and product attributes.

2.2. Individual demand information metrics
The collected demand information is first proceeded before adopting in the forecast algorithm. Customer attributes are listed first as attributes with preconditions, and product attributes are listed as the resulting attributes of the customer purchasing a individual product. As a result, the attribute information vector of a certain individual product purchased by a consumer at one time can be defined as:

$$X = (x_1, x_2, \dots, x_n, x_{n+1}, x_{n+2}, \dots, x_{2n}, C)^T$$

Where $x_1, x_2, \dots, x_n, x_{n+1}, x_{n+2}, \dots, x_{2n}$ denote the customer attributes, and C represents the individual product attribute.

2.3. Individual product category forecast
Using the decision tree classification algorithm, decision tree of customers purchasing a specific product is established and rules of IF - THEN classification are generated. The decision tree takes all customer attributes as variables (independent variables), individual product attributes as a single target variable (the dependent variable). The string of attribute value of the products favored by customers shall be forecasted for every customer.

2.4. Individual product quantity forecast
Through the regression analysis, the quantity of individual products is predicted. Specific steps are presented as follows. Step 1: For historical data of individual product in a region, sketch the corresponding scatter diagram. Step 2: Observe the scatter plot to check whether it has a linear trend or a non-linear trend, and select appropriate curve to fit. Step 3: Acquire the forecast error.

3. Supply chain model building

3.1. Supply chain network chain structure model
To satisfy the new requirements of the supply chain with shorter response time, merely three supply chain nodes, i.e. supplier, manufacturer and end user, are factored in by this paper, and the manufacturer node is split into production center node and assembly center node. Accordingly, a supply chain network structure model is established incorporating with I suppliers, 1 manufacturers (J production centers and K assembly centers) and L end-users, as illustrated in Figure 1:
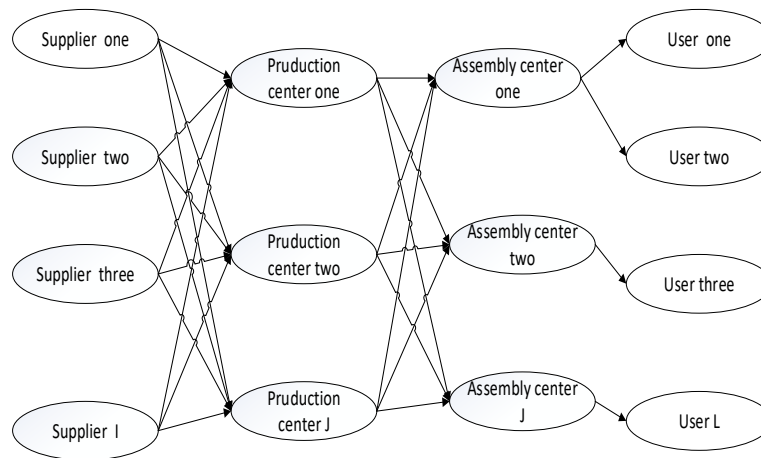
Figure 1. Supply chain network structure model

3.2. Supply chain network structure mathematical modeling

This model primarily seeks to select the appropriate supply chain node for minimizing the entire supply chain cost of the core enterprise. The target items and constraints of the model are anatomized on the basis of the selected enterprise. The target items of the model include procurement costs, production costs, logistics costs of raw materials and spare parts (principally factoring in transportation costs and warehousing costs), assembly cost, and costs of constructing production centers and assembly centers. The constraints of the model are comprised of supply capability constraints, production capacity constraints, assembly capacity constraints, distribution capacity constraints, and supply demand equilibrium capabilities constraints. The concrete 0-1 mixed integer programming model is established as follows:

$$\text{Min } Z = \sum_{i=1}^{I} \sum_{j=1}^{J} \sum_{r=1}^{R} (p_{1ijr} + c_{1ijr} + c_{2jr} + p_{2jr}) q_{1ijr} + \sum_{j=1}^{J} c_{2j} + \sum_{j=1}^{J} \sum_{k=1}^{K} \sum_{s=1}^{S} (c_{2jks} + d_{ks}) q_{2jks} +$$

$$\sum_{k=1}^{K} \sum_{l=1}^{L} \sum_{t=1}^{T} (p_{3kt} + f_{kt} + c_{3klt}) q_{3klt} + \sum_{k=1}^{K} c_{3k}$$

s.t.

$$\sum_{j=1}^{J} q_{1ijr} \leq Q_{1ir}$$

$$\sum_{k=1}^{K} q_{2jks} \leq Q_{2js}$$

$$\sum_{l=1}^{L} q_{3klt} \leq Q_{3kt}$$

$$\sum_{j=1}^{J} c_{2j} \leq F_{1}$$

$$\sum_{k=1}^{K} c_{3k} \leq F_{2}$$

$$W_{1rs} \sum_{k=1}^{K} q_{2jks} \leq \sum_{i=1}^{I} q_{1ijr}$$

$$W_{2st} \sum_{l=1}^{L} q_{3klt} \leq \sum_{j=1}^{J} q_{2jks}$$

$$(1 - x_{i}y_{j}) q_{1ijr} \leq 0$$

$$(1 - y_{j}) c_{2j} \leq 0$$

$$y_{j}(F_{2j} - c_{2j}) \leq 0$$

$$(1 - y_{j}z_{k}) q_{2jks} \leq 0$$

$$(1 - z_{k}) q_{3klt} \leq 0$$

$$(1 - z_{k}) c_{3k} \leq 0$$

$$z_{k}(F_{3k} - c_{3k}) \leq 0$$

$$D_{lt} \leq \sum_{k=1}^{K} q_{3klt}$$

$$x_i, y_j, z_k = 0 \ 或 \ 1$$

Where,

i: supplier number, i = 1, ..., I;

j: production center to be selected location number, j = 1, ..., J;

k: assembly center to be selected position number, k = 1, ..., K;

l: user number, l = 1, ..., L;

r: the number of kinds of raw materials, r = 1, ..., R;

s: number of parts, s = 1, ..., S;

t: the number of individual species of the same product, t = 1, ..., T;

Q_{1ir}: a period of time, i-th supplier to supply the r kinds of raw materials, the maximum number;

Q_{2js}: the maximum number of s-th parts and components produced in the j-th production center over a period of time;

$Q_{3k}t$: a certain period of time, the k-th assembly center to assemble the first t-type of individual products, the maximum number;

q_{1ijr}: the supply quantity of the r-th raw material from the i-th supplier to the j-th production center;

p_{1ijr}: the unit price of the r-th material from the i-th supplier to the j-th manufacturing center;

c_{1ijr}: transportation cost of the r-th raw material from the i-th supplier to the j-th production center;

W_{1rs}: the unit consumption of the r-th raw material required for producing the s-th kind of spare parts;

q_{2jks}: the actual supply of the s-th kind of spare parts from the j-th production center to the k-th assembly center;

p_{2jr}: the j-th production center for the production of the r-type raw materials, a single piece of production costs;

c_{2jks}: s type of spare parts transportation costs from the j-th production center to the k-th assembly center;

W_{2st}: The unit consumption of the s-th kind of spare part required to produce the t-th kind of product;

q_{3klt}: k-th assembly center to the first user of the first t kinds of product supply quantity;

c_{3klt}: k-th assembly center to the l-th user's t-th product supply unit shipping costs;

p_{3kt}: the k-th assembly center assembly t type of individual product unit operating costs;

c_{2j}: cost of constructing the j-th production center;

c_{3k}: cost of constructing k-th assembly center;

c_{2jr}: the unit inventory cost of the r-th raw material in the j-th production center;

d_{ks}: unit inventory cost for the s-th part of the k-th assembly center;

f_{kt}: unit inventory cost for the t-th individualized product in the k-th assembly center;

D_{lt}: a period of time, the l-th user base on the t-th individual product demand forecast number, the value of this parameter comes from the individual demand forecasting model results;

F_1: the highest total budget for building all production centers;

F_{2j}: the minimum total cost of building each production center;

F_2: the highest total budget for building all assembly centers;

F_{3k}: the maximum total cost of building each assembly center;

$$x_i = \begin{cases} 1 & i\text{ - th kind of supplier reserved} \\ 0 & , \text{otherwise} \end{cases}$$

$$y_j = \begin{cases} 1 & j\text{ - th production center reservations} \\ 0 & , \text{otherwise} \end{cases}$$

$$z_k = \begin{cases} 1 & k\text{ - th assembly center reserved} \\ 0 & , \text{otherwise} \end{cases}$$

All parameters are non-negative, and i, j, k, l, r, s, t, W_{1rs} and W_{2st} are positive integers.

3.3. Solution of model

In this paper, an algorithm is presented to exclusively solve the supply chain design model under the individual demand of online consumers. The flow chart of the algorithm is illustrated in Figure 2. Based on the algorithm design Lingo code to solve.
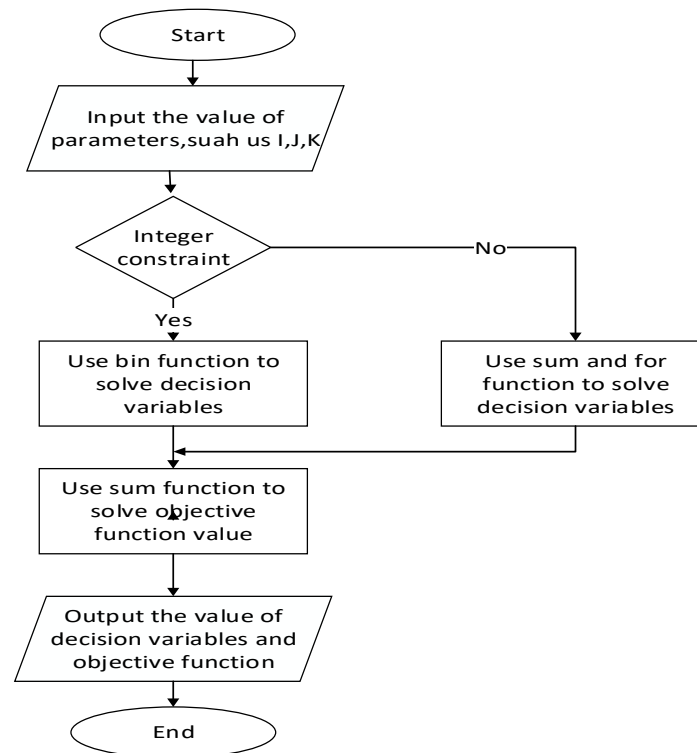

Figure 2. Algorithm flow chart

4. Conclusion

The paper predominately forecasts the individual demand given that the individual consumer demand is progressively enlarged. On this basis, the supply chain model is re-established. However, some deficiencies remain in the research: When establishing the supply chain model, the research only reckon with the network marketing supply chain design in some industries, whereas the differences laying between different industries in different product supply chain are factored out. The research requires to be delved into: To study the supply chain design of individual demand of online consumers in different industries and different products; to probe into the method of individual demand forecasting taking on higher accuracy.

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