

Pricing And Replenishment Strategies for Vegetable Products Based on Planning Models

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Abstract. Reasonable pricing and replenishment strategies for vegetable products are crucial for maximizing profits for fresh food supermarkets. This article mainly studies the relationship between the sales volume and sales unit price of vegetable products and time, establishes a pricing and replenishment decision model based on BP neural network and mathematical programming, and provides strategies to meet the requirements of maximizing the interests of supermarkets.

Keywords: Pricing and replenishment strategies, correlation analysis, system clustering, BP neural network, planning model.

1. Introduction

In general, vegetable sales will adopt a "cost plus pricing" pricing method, while reducing the price of goods with transportation losses and product differences [1,2]. In order to maximize the benefits of supermarkets, based on reasonable market analysis. It is particularly important to make corresponding replenishment and pricing decisions.

The paper establishing a reasonable mathematical model [1]. Analyze the distribution pattern and interrelationships of sales volume among various categories and individual products of vegetables [3-5]. By analyzing the relationship between the sales volume and cost-plus pricing of individual vegetable categories, it is found that in order to meet the interests of supermarkets [6]. Under the premise of maximization, provide the daily replenishment total amount and pricing strategy for each category of vegetables from July 1 to 7, 2023. Based on the available varieties from June 24th to 30th, 2023, under the conditions of meeting the quantity of available items between 27-33, ordering quantity of items greater than or equal to 2.5 kilograms, and meeting market demand and ensuring maximum revenue, provide the replenishment quantity and pricing strategy for each item on July 1st. Analyzing which supermarkets can collect data can help better formulate vegetable replenishment and pricing decision policy [7].

2. Preliminary

2.1. Assumption

1. Supermarkets can stay open all the time.
2. There will be no events that have a significant impact on the vegetable market.
3. When maximizing profits, all goods except for the loss will be sold out.
4. To avoid prediction errors caused by a lack of specific information, it is assumed that there will be no significant changes in sales volume in the short term.

2.2. Symbol notations

Table 1 shows the symbols used in the paper.

Table 1. Symbols notations

Symbols	Description
x	Price
y	Sales
d	Costs
c	Discount
$loss$	Loss

3. Modeling

Firstly, data processing is performed on missing and abnormal values. Secondly, the total monthly sales of vegetables and the monthly sales of various vegetables are visualized and analyzed to obtain the distribution pattern of their sales. Then, use box plots and data statistics to roughly analyze the relationships between various vegetable categories. To further characterize this relationship, the Spearman method was used for correlation analysis to obtain correlation coefficients and present them as thermodynamic diagrams, thereby analyzing various positive and negative correlations. For each individual product, first use sales data in each category for systematic clustering, and the clustering results can display the similarity of data distribution between each individual product. Finally, based on the clustering results, the individual products are divided into 13 categories, and representative samples are selected to display the distribution pattern of their sales through a line chart.

3.1. Data processing

We can find that the sales volume of various types of vegetables has a certain seasonality, with the sales volume of leafy vegetables maintaining the highest state, reaching its peak in August each year, and the sales volume being relatively low and not fluctuating between February and June; The overall sales volume of cauliflower vegetables is relatively low, reaching a small peak in July, August, and January and February each year; The sales of chili peppers reach their peak in the lunar new year month each year, and at the same time, they also reach a maximum in August each year. November and December will be in a relatively low sales period; The sales of eggplants are also relatively low, with low sales from October to December throughout the year, with sales concentrated in May to September; The sales of edible mushrooms reach their peak in January or February of the lunar new year, with sales mainly concentrated from October to February of the following year; Aquatic rhizomes have the lowest sales volume from April to July each year, with the main sales concentrated from August to February of the following year. Table 2 shows the preference of the customers.

Table 2. Statistic

Vegetables	N	Minimum	Maximum	Average	Standard variance
florescent vegetables	1084	0.632	186.155	38.52993635	22.67517727
Florifolias	1085	31.298	1265.473	182.82118	86.167799
Chili peppers	1085	6.066	604.231	84.41348295	53.43602903
Solanaceae	1050	0.252	118.931	21.3636019	13.15884013
edible fungi	1085	3.012	511.136	70.12601	48.489888
Aquatic rhizomes	1085	0.926	296.792	37.40217	31.35719

It can be seen that there is a strong positive correlation between leafy and cauliflower vegetables, as well as edible fungi and aquatic rhizome vegetables. Meanwhile, through the analysis of the double tailed significance results, when the significance is at the level of 0.01, the two indicators have strong

significance, with flowers and leaves and cauliflower, edible fungi and flowers and leaves having a significant positive correlation in sales time.

The sales volume of various vegetables under different categories has similarities in time distribution. When processing data on cauliflower vegetables, we found substitutability between Zhijiang Qinggan Sanhua and Qinggan Sanhua. Therefore, we merged the sales of these two vegetables and compared them with the sales data of broccoli, and found that their sales were higher in the third and fourth quarters; The sales of three types of leafy vegetables are at their peak in the third quarter of each year, and in terms of overall distribution, their sales are decreasing year by year; Apart from the sales of Wuhu green pepper (1) in the third and fourth quarters of 2020, it can be observed that two types of chili peppers have higher sales in the first quarter of each year.

3.2. The relationship between the total sales volume of various vegetable categories and cost-plus pricing

In order to analyze the relationship between the total sales volume and cost-plus pricing of various vegetable categories, first take the flower and leaf vegetables with the most samples as an example, and roughly display the relationship between pricing and total sales volume in the form of a scatter plot. Then, the BP neural network is used to further characterize the relationship between the two; For predicting the total daily replenishment volume of each vegetable category in the next week and formulating pricing strategies, the decision variables are first determined as daily replenishment volume and pricing, and profit is taken as the objective function. Based on the relationship obtained from the first question and the maximum sales data from previous periods, a planning model is constructed to solve for vegetable pricing, replenishment volume, and maximum sales profit.

In the process of further exploring the relationship between the two, we first attempted a regression model and found that the fitting effect was not ideal. Then, considering the strong nonlinear function fitting ability of the BP neural network, we ultimately decided to use the BP neural network fitting method for our research.

If the product pricing is x and the total sales volume is y , the relationship between them can be described as $y=BPNN(x)$. Although there is no clear functional expression, if cost pricing is known, x can be incorporated into the neural network model making predictions and obtain the predicted value y .

The decision variables are the daily replenishment volume and pricing of each category of goods. In an ideal scenario, the replenishment volume of goods. When the sales volume is equal, the maximum revenue can be achieved, so the daily replenishment volume is equal to the daily sales volume. The question requires an appropriate daily replenishment volume and product pricing strategy to maximize the revenue of the mall, so it can be seen as a planning model.

Due to maximizing returns, the objective function is the negative profit of the merchant. Assuming that the specified replenishment quantity is the sales volume, that is to say, the products will be sold out every day, while considering the possibility of loss. (the loss part will be sold at a discounted price)

Using MATLAB to solve the planning model, Table 3 shows the results.

Table 3. Pricing Results of Various Vegetables

Category	Flowers	Leaves	Cauliflower	Aquatic	Roots	Stems
Price	2.97	11.55	19.03	9.54	7.97	7.55
Sales	349.9967	59.8329	61.3692	40.0840	210.7789	140.1440

The daily sales profit obtained is the largest: 6018.81 yuan, and the seven-day data fluctuates downward on the basis of the maximum value, with little change.

3.3. Predicting the best price

Firstly, it is necessary to analyze the types of ordered products, identify the items with transaction records from June 24th to June 30th, and filter out advantageous items based on sales data. Perform linear regression on the sales volume and pricing of advantageous products to obtain the relationship

between the two. Finally, with pricing and sales volume as decision variables and sales space and price constraints as constraints, a planning model for maximum profit is established to solve for the pricing, replenishment strategy, and maximum sales profit on July 1st.

We first use the first-order function in MATLAB to linearly fit the sales volume and pricing of 33 individual products and obtain the following regression equation showed in Table 4.

Table 4. Regression

Code	First-order coefficient	Zero power coefficient
9.54	7.97	7.55
40.0840	210.7789	140.1440

We use MATLAB to solve and obtain the maximum profit from sales: 3562.67 yuan.

3.4. The strategy

Firstly, it is stated from three aspects: transportation loss, display natural loss, and supply demand relationship loss; Secondly, weather conditions can also lead to natural losses of vegetables, and at the same time, weather can also affect consumer behavior; Then, analyze customer data from the consumption habits of ordinary customers and wholesale customers, and improve replenishment strategies; Finally, the analysis of product update information and substitution relationships can better formulate pricing and replenishment strategy.

The transporting loss. Statistical analysis of transportation loss volume can modify the basic dataset required for prediction based on predicting the future demand for goods, improve prediction efficiency and accuracy, and help supermarkets formulate replenishment strategies to avoid shortages or backlogs of goods caused by transportation.

Nature loss. Due to the regularity of natural losses, which also need to be considered in the replenishment volume, for replenishment strategies, by predicting the number of natural losses, we can avoid ordering too much or too little goods, thereby avoiding waste and missing items.

Loss caused by excessive replenishment. A record of excessive one-time replenishment caused by incorrect replenishment decisions can be used to correct the replenishment decision model and avoid the occurrence of waste again.

Environmental factors such as temperature and humidity can affect the natural deterioration rate of vegetables [6,7], thereby affecting the loss of vegetables during transportation and display. Therefore, the measured data includes the temperature and humidity inside the transport vehicle and the temperature and humidity inside the supermarket, which can effectively reduce vegetable loss and predict the amount of loss, helping to develop better replenishment and pricing strategies [8].

Climate. Daily weather factors can affect consumer consumption behavior [9,10], therefore, recording weather data and utilizing it can assist in developing replenishment strategies.

Customs. Assuming that ordinary customers and wholesale customers are distinguished based on whether the purchase quantity is greater than 5 kg, the sales record of ordinary customers' accounts for over 99%. Therefore, analyzing the consumption habits of ordinary users is very important. Data can be obtained from customers who frequently come to the store to analyze their consumption patterns, and precise replenishment strategies can be developed.

Demanding. The consumption of wholesale customers such as restaurants is characterized by high volume and strong regularity, making it suitable for data analysis and preparing more goods when they wholesale.

In order to better develop pricing and replenishment strategies for products, it is necessary to have real-time updated information about the product, including product quality, batch size, origin, and other information. These can help customers choose and purchase products, thus achieving the goal of improving the strategy.

4. Discussion

When exploring the interrelationships between the sales volume of each individual product, the model uses a systematic clustering method to classify the sales volume. Processing the data on individual products resulted in products with similar sales data distribution, making the results more reliable.

The paper establishes a linear regression equation between sales volume and pricing, quantifies their relationship, and obtains the optimal solution of the planning model, that is, the pricing and sales strategy are reasonable.

The flexible use of neural networks in the paper has a strong ability to fit nonlinear functions, making the results more accurate [8-9].

However, due to the multiple use of neural networks and the large number of parameters, it is more troublesome to run multiple times. When performing linear fitting, there is too much outlier data, which makes the fitting effect not very perfect.

5. Conclusion

In order to make better replenishment and pricing strategies, this article reasonably selects and applies technologies such as data analysis, visualization, and nonlinear programming, taking into account a series of factors including market demand, cost, sales volume, loss rate, and wholesale price that affect sales profits. This provides more possibilities for supermarket replenishment and pricing strategies. With the emergence and introduction of new technologies, the improvement and enhancement of old algorithms, and the continuous accumulation of experience, the decision-making optimization model in the field of fresh supermarket has great potential for development in the future, which can better meet the different needs of the market and facilitate people's operation and management. The model in this article is flexible and based on sales data, which is easy to understand. Therefore, it can be extended to other sales fields to help build pricing and replenishment decisions. The model can also optimize resource allocation without considering sales [10].

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