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Research on sales and pricing optimization of vegetable category based on ARIMA model and exponential smoothing method

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Abstract: Fresh food superstores play a crucial role in people's lives, providing people with a variety of fresh ingredients. While ensuring that customers' needs are met, this paper investigates how to carry out reasonable pricing and replenishment, so as to maximize the superstore's total revenue. In order to solve this problem, this paper establishes a time series forecasting model, including ARIMA model and exponential smoothing method, which is used to forecast the total sales of each vegetable category in the coming week. Based on this, the pricing of each category of vegetables was calculated by cost-plus pricing method. Then, the practical constraints of the superstore are considered: the total number of saleable items is controlled at 27-33, and the order quantity of each item satisfies the minimum display quantity of 2.5 kg. Based on these constraints, the objective benefit maximization function is constructed to screen out the eligible individual items, and the daily replenishment and pricing strategies for these items are calculated. Through the study, the conclusion of this paper is that superstores should flexibly adjust their daily replenishment plans based on forecasted replenishment and actual sales to ensure that inventory meets customer demand while avoiding inventory backlogs and waste. Attracting customers to buy products packaged in per-serving bundles increases single sales, thus maximizing profits.

1. Introduction

Vegetables are an indispensable source of nutrition in people's daily life, and with the improvement of people's living standards, people's demand for fresh food is becoming more and more prosperous, and the requirements for quality and freshness are getting higher and higher[1]. Fresh food supermarkets play a vital role in people's lives, providing people with a variety of fresh ingredients. There are two kinds of replenishment methods in major supermarkets, namely, pre-opening replenishment and after-opening replenishment, because vegetables, meat, fruits and other commodities will gradually deteriorate over time, so for fresh products or fresh superstores, they often use pre-opening replenishment, usually around three or four o'clock in the morning into the goods.

In order to ensure its quality, freshness and good quality, the merchant takes into account the revenue, loss rate, supermarket space and other factors, so that it needs to be based on the previous sales volume of goods as well as the demand for the forecast of the day's purchase of categories and quantities to get a reasonable stocking program and sales mix.

In order to ensure the satisfaction of customer demand at the same time, this paper investigates if reasonable pricing and replenishment are carried out to maximize the total revenue of the superstore. Previously Nie Yuxuan explored the expected utility maximization model of a fresh food superstore under consideration of risk aversion and used MATLAB to solve the optimal decision of superstore's freshness level, order quantity and retail price[2]. Wei Zihang investigated the impact of quality changes of fresh food on the profit model of retail chain and proposed that the joint decision of pricing and shelf allocation can utilize resources more rationally, reduce losses and improve retailer profits[3]. Pan Xiaofei et al took the inventory control of community fresh food retail terminals as the research object, established an inventory control model considering the influence of customer flow on demand, aimed at maximizing revenue, and applied the MOIRCGA algorithm to solve the inventory control model[1]. Yang Shuai et al, on the other hand, focused on the pricing and replenishment decision of vegetable goods in fresh food superstores, and by establishing an ARIMA prediction model, predicted and analyzed the replenishment quantities and pricing strategies of each vegetable category in the coming week in fresh food superstores, and optimized the model by using nonlinear programming combined with greedy algorithm to achieve the maximum revenue[4]. Liu Xiaoyun used Apriori algorithm and Kmeans++ algorithm to study the consumer purchasing behavior for the sales data of vegetable categories distributed by a superstore to provide a new perspective for the strategy development of fresh food supermarkets[5] . Overall, these studies cover many aspects of the fresh food retail industry, exploring how to optimize decision-making and improve efficiency from different perspectives, as well as analyzing the impact of consumer behavior on retail strategies.

Comprehensive consideration of pricing strategy, inventory control and consumer purchasing habits is an important direction for fresh food retail research. By establishing a suitable theoretical framework and in-depth empirical research, it can provide theoretical guidance and practical support for the development of the fresh food retail industry. At the same time, further attention needs to be paid to emerging fresh food retailing models and technology applications to explore more effective management strategies and business models to meet the growing needs of consumers.

Cost-plus pricing and the incoming replenishment volume of an item are highly relevant to the profitability of a supermarket. This paper aim to explore the intrinsic relationship between total sales volume and cost-plus pricing and forecast accordingly, focusing on predicting the replenishment volume of a single item on a specific date based on constraints and formulating pricing strategies accordingly. By finding this relationship, superstores can more effectively develop pricing strategies, optimize inventory management, and maximize profitability, and accurately forecast demand for individual items, thus avoiding inventory backlogs or stock-outs.

This paper argue that the sales data of the month prior to the forecast period can be used to calculate the total sales volume of each category on each day as well as the cost-plus pricing, which provides the basis for subsequent analysis and forecasting. Further, this paper establishes a constraint planning model based on constraints with the goal of maximizing profits. Through in-depth analysis and modeling, this paper can provide valuable references for superstores in terms of total sales forecast, replenishment volume decision-making, pricing strategy development, etc., so as to formulate more scientific and reasonable business strategies and improve market competitiveness.

2. Research methods and data sources

The purpose of this paper is to help superstores maximize profits through two aspects of strategy optimization. First, the optimization of category-based replenishment and pricing strategies. In order to enhance the profitability of hypermarkets, this paper first focuses on category-based replenishment strategies. Through an in-depth analysis of the total sales volume and cost-plus pricing of each vegetable category, the purpose of this paper is to reveal the intrinsic connection between the two and to provide accurate market trend forecasts for big box retailers. Based on these forecasts, paper will formulate the total daily replenishment amount for each vegetable category for the coming week (July 1 to July 7, 2023) for the superstores, and develop the pricing strategy accordingly to ensure the reasonableness of the inventory and meet the market demand at the same time, so as to achieve a win-win situation in terms of both sales and profits. Second, maximize the profit under the constraints. Supermarkets often face a variety of practical constraints in the course of their operations. To meet these challenges, this paper set a series of optimization goals. Ensure that the total number of saleable items is controlled between 27 and 33 to maintain the richness of product assortment and ease of management. Paper also required each item to be ordered with a minimum display quantity of 2.5 kg to ensure neat and aesthetically pleasing shelf displays, and to ensure sufficient supply of merchandise. In addition, this paper gives due consideration to the number of varieties sold during this period in order to meet customer demand for all types of vegetables and to ensure customer satisfaction. Through the optimization of these two strategies, this paper aims to provide a set of comprehensive and systematic solutions for superstores to help them achieve greater profits in the fierce market competition.

2.1. Research methods

2.1.1. Cost-plus pricing

Cost-plus pricing, also known as markup pricing, is a common strategy used by companies to set the selling price of a product or service. The strategy centers on adding a predetermined profit margin (or markup) to the total cost of the product. This method is not only simple and easy to use, but it is also effective in ensuring that companies cover their costs while achieving their desired profit goals. Through cost-plus pricing, companies are able to ensure economic viability while flexibly adjusting their pricing strategy in response to market changes.

Category pricing is calculated using the cost-plus pricing method, and the detailed formula is as follows:

$$P_i = C_i(1+b_i) \tag{1}$$

Where P_i is the cost-plus pricing of the category, C is the cost of the category and b_i is the profit margin. After that, the fitting of the total sales and cost-plus pricing curves for each vegetable category was carried out in MATLAB to determine whether it is a linear relationship or not.

2.1.2. Time series modeling

Time series forecasting models include the following two: the ARMA model is a linear model that models observations based on a linear combination of autoregression (AR) and moving average (MA) of the observations; the exponential smoothing method is a nonlinear model based on weighted averages that uses decreasing weights over time to smooth and forecast observations.

Since profits are maximized when supply is less than demand, i.e., replenishment is less than or equal to that day's sales, benefits can be maximized, and category sales for the next seven days are derived from the forecasted volume:

$$S_{\text{ij}} = f(d_{ij}) \tag{2}$$

When production and sales are in equilibrium, so that the superstore profit is maximized, i.e., the difference between revenue and cost is maximized.

The maximum profit function model is constructed to derive the relationship between maximum profit and replenishment and the markup rate in the cost-plus pricing method to derive the optimal pricing strategy.

$$W = (SP - C_i)S_{ij} \tag{3}$$

$$W = [SP - P_i(1 + bi)]S_{ij} \tag{4}$$

where W is the profit, Sij denotes the sales volume of the ith vegetable category on day j, SP is the unit selling price of the category, Ci is the cost of the category, Pi is the cost-plus pricing of the category, and b is the profit margin.

2.1.3. Objective functions and constraints

The constraints are as follows:

1) The average sales volume of each item is greater than the minimum display volume of 2.5 kilograms.

2) The sales items are available from June 24th to 30th. 3.

3) The total number of items is between 27-33.

4) The total replenishment of individual items is less than or equal to the category replenishment.

Then construct the objective benefit maximization function. The sales of each product on each date are subtracted from the replenishment volume and multiplied by the pricing of the product minus one to calculate the profit for each individual product on each date.

$$Maximize = SUM\,(PRICE(P) - 1) * SALES(P, D) - RECTOCK(P, D) \tag{5}$$

The replenishment quantity is greater than or equal to the minimum display quantity multiplied by the replenishment indicator variable, which is used to determine whether the individual item is replenished.

$$RESTOCK(P, D) \geq MIN\_STOCK * RESTOCK\_IND(P, D) \tag{6}$$

$$27 \leq n \leq 33 \tag{7}$$

$$24 \leq DATES \leq 33 \tag{8}$$

Finally the objective function and its constraints can be expressed:

$$s.t \begin{cases} RESTOCK(P, D) \geq MIN\_STOCK * RESTOCK\_IND(P, D) \\ 27 \leq n \leq 33 \\ 24 \leq DATES \leq 33 \\ MIN\_STOCK = 2.5 \\ RESTOCK\_IND(P, D) = [1, 0] \end{cases} \tag{9}$$

Due to the short shelf life of vegetables, most items cannot be sold on the next day, Therefore, this paper uses the attrition rate data to establish a correlation with the shelf life, the lower the attrition rate, the longer the shelf life, so that we can fill the average daily sales of small items in the case of display volume greater than 2.5. The mean value of the attrition rate is 9.43% and the standard deviation is 0.052, according to which the model is established: correlation model between attrition rate and shelf life:

$$B\begin{cases}1, S > 9.43\% \\ -\dfrac{S}{S_m}+2, S \leq 9.43\%\end{cases} \tag{10}$$

Where the wastage rate is S, the average wastage rate of the sample is Sm, B is the corrected shelf life, and the corrected shelf life can be

Directly on the average daily sales volume, i.e., only need to satisfy B * Ms > T (T is the minimum display volume of 2.5 kg)

After the single product is screened out, formula (9) is used to calculate to determine the single product single day replenishment and pricing.

2.2. Data sources

The data for the study were obtained from the official website of the National Student Mathematical Modeling Competition at http://www.mcm.edu.cn. The data included commodity information for six vegetable categories; sales flow breakdown data; wholesale prices for vegetable commodities; and recent wastage rates for vegetable commodities.

2.3. The determination of the number of network layers

BP neural network is back propagating, mainly composed of three parts: input layer, middle layer and output layer. The number of nodes in the input and output layers is relatively easy to determine, but the determination of the number of nodes in the hidden layer is a very important and complex problem.

3. Results and analysis

3.1. Cost-plus pricing projections

The first step is to determine the relationship between each vegetable category and cost-plus pricing, using Excel to count the total sales of each category for the first thirty days and to fit its relationship with cost-plus pricing, to derive the fitted curve and to determine the linear relationship.

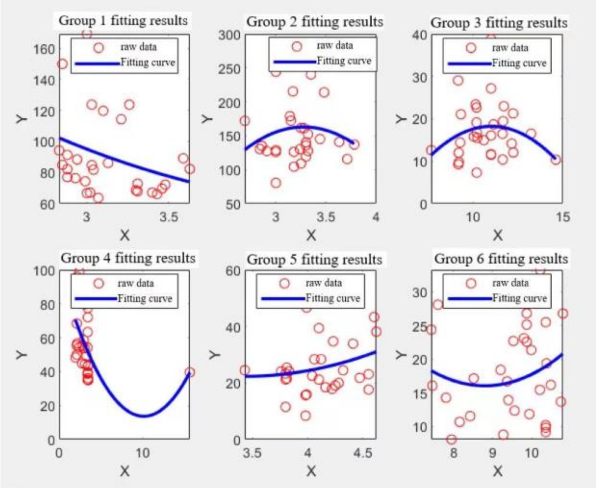

Figure 1: Total volume vs. cost-plus pricing fit for each category

From Figure 1, it can be seen that the total sales volume and cost-plus pricing of each category of vegetables have a non-linear relationship; the ARMA model is applicable to a variety of time series, including non-seasonal data and data with stochasticity, and can better explain and capture the correlation and trend of the data; the exponential smoothing method is applicable to moderate to weak trend and seasonal data, and is usually used for short-term forecasting and smoothing of data, which is suitable for data with insignificant cyclical variations. Exponential smoothing methods are suitable for medium to weakly trending and seasonal data, and are usually used for short-term forecasting and smoothing of data.

Since the type of model is different for each individual product, the prediction is made using the recommended model given automatically by SPSS. The total sales of vegetables in each category for the next seven days are then predicted using time series analysis, which can lead to a prediction curve.

From Fig. 2, the trend of total sales volume of each type of vegetables for the next seven days can be derived, from which we can see that the predicted curves of chili peppers and edibles as well as the predicted curves of leafy vegetables and cauliflower are basically the same, and the correlation between chili peppers and edibles as well as that between leafy vegetables and cauliflower is very significant in known correlations between the categories, so that it can be concluded that there is a trend of the sales volume of each type of vegetable associated with the correlation between the categories correlation trend. After that, the replenishment was calculated based on the sales volume of the categories for the next seven days.

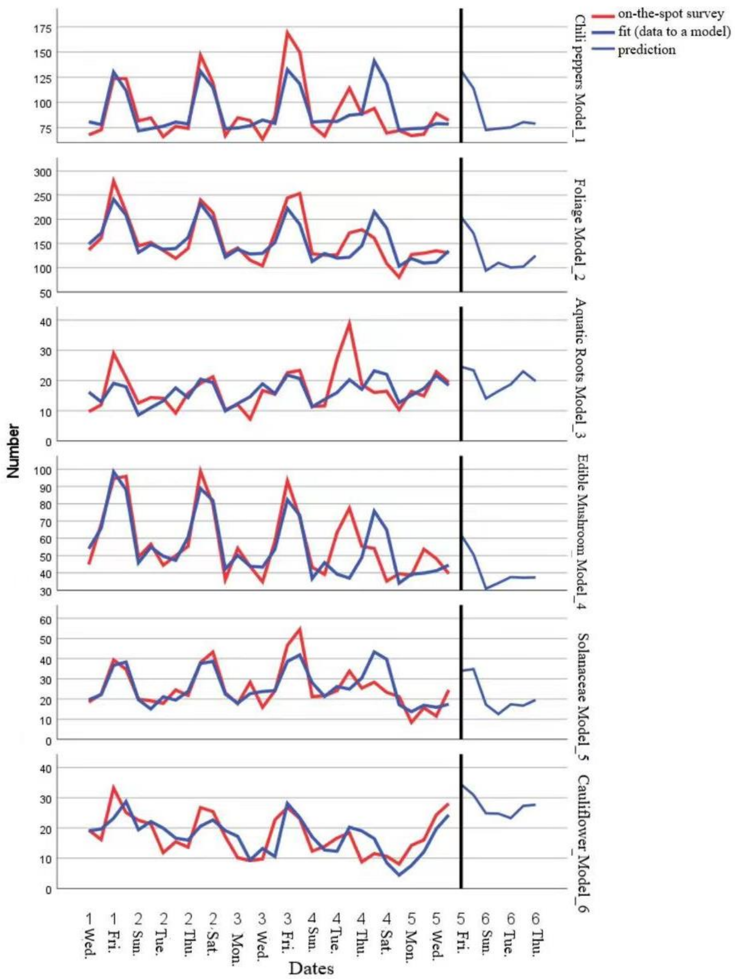

Figure 2: Forecast of daily sales volume of vegetables by category

Table 1: Forecast of replenishment for each category of vegetables

Date\category replenishment (kg)	Peppers	Foliage	Aquatic Roots	Edible Mushrooms	Solanaceae	Cauliflowers
2023/7/1	131.72	204.83	24.59	62	34	34.41
2023/7/2	113.95	171.35	23.42	50.64	34.85	30.92
2023/7/3	72.76	93.91	14.08	30.93	17.25	24.87
2023/7/4	74.07	110.17	16.52	34.13	12.56	24.76
2023/7/5	75.25	100.42	18.77	37.6	17.37	23.27
2023/7/6	80.46	102.17	23.05	37.25	16.73	27.29
2023/7/7	79	125.15	19.84	37.44	19.54	27.71

Forecast of replenishment for each category of vegetables is shown in Table 1. In order to maximize the revenue of the superstore, the balance of production and sales is extremely important, when the replenishment is less than or equal to the sales volume, the superstore revenue is maximized, so the total daily replenishment is predicted using the total daily sales volume, which can be derived from the above table of the daily replenishment of each category for the next seven days. Calculate the daily cost of each category, using time series forecasting method to predict the cost of each category for the next seven days:

Table 2: Daily cost projections for each category of vegetables

Cost per day for each category	Peppers	Foliage	Aquatic Roots	Edible Mushrooms	Solanaceae	Cauliflowers
2023/7/1	73.01	70.05	79.91	46.7	22.6	22.75
2023/7/2	85.42	104.28	90.61	46.7	22.6	22.75
2023/7/3	74.37	72.88	78.78	46.7	22.6	22.75
2023/7/4	71.96	66.74	97.27	46.7	22.6	22.75
2023/7/5	72.21	57.89	92.64	46.7	22.6	22.75
2023/7/6	65.74	54.03	108.43	46.7	22.6	22.75
2023/7/7	66.73	63.52	102.61	46.7	22.6	22.75

As shown in Table 2 the cost per day for the coming week for both the chili and cauliflower categories reaches its maximum on July 2 at $85.42 and $104.28, respectively. The Aquatic Roots category reaches its maximum on July 7. The daily costs of the Edible Mushrooms, Eggplant, and Cauliflower categories remain unchanged for the coming week. The pricing strategy for each vegetable category can be found by calculating the maximum profit margin for each category for the next seven days after arriving at the costs (Table 3).

Table 3: Pricing by category for the week ahead

Pricing for the coming week	Peppers	Foliage	Aquatic Roots	Edible Mushrooms	Solanaceae	Cauliflowers
2023/7/1	3.73	5.10	6.99	3.52	3.26	4.28
2023/7/2	3.68	4.58	7.22	3.28	3.38	4.36
2023/7/3	2.84	4.40	8.51	3.50	3.40	4.28
2023/7/4	3.81	5.48	6.82	2.88	3.64	4.06
2023/7/5	4.02	4.81	7.21	3.93	3.71	3.90
2023/7/6	3.85	5.21	7.63	3.44	4.11	3.94
2023/7/7	3.59	4.99	6.67	3.70	3.93	4.38

3.2. Daily replenishment of individual products and pricing strategy

According to the 61 items available for sale on June 24-30, and according to the problem of short shelf-life caused by high wastage rate, 49 items were left after using the calculation of wastage rate in the modeling to filter out the items unsuitable for sale, and then 13 items represented by yellow cabbage (code 102900005116790) were filtered out according to the minimum display quantity after the comprehensive comparison. In the end, there are 36 items left to choose from. The above subsection predicts the replenishment quantity of each category of vegetables on July 1. The replenishment quantity of individual products on July 1 in this summary should be less than or equal to the replenishment quantity of each category (Table 4).

Table 4: July 1 Restocking Forecast by Category

Date\category replenishment (kg)	Peppers	Foliage	Aquatic Roots	Edible Mushrooms	Solanaceae	Cauliflowers
2023/7/1	7.1	131.72	204.83	24.59	62	34

Table 5: Restocking Volume and Profit Table for July 1 for Each Individual Product

Vegetable Single Name	spinach	Yunnan romaine lettuce	Shanghai bok choy	choy sum	Yunnan lettuce	baby bok choy(1)	sweet potato tips
July 1st Replenishment	14.99	1.67	3.86	1.27	0.73	4.9	4.51
Unit profit ($/kg)	2.59	2.57	3.06	0.77	2.35	1.89	2.10
margins	38.78643	4.2971188	11.798569	0.977646	1.712195	9.26149	9.4569288
Vegetable Single Name	Bamboo Leaf Lettuce	Milk Cabbage	Amaranth	Yunnan romaine lettuce (portion)	Baby Lettuce	Yunnan lettuce (portion)	Small Cracked Peel (portion)
July 1st Replenishment	13.3	6.42	8.92	32.29	10.43	25	11.29
Unit profit ($/kg)	1.26	2.42	1.26	0.87	1.76	1.28	1.15
margins	16.781381	15.560026	11.258717	27.992976	18.3568	32.06895	12.956483
Vegetable Single Name	Capsicum annuum(portion)	Wuhu Green Pepper(1)	Screw Pepper(portion)	Xixia Shiitake Mushroom(1)	White Jade Mushroom(bag)	Agaricus blazei(box)	Flammulina velutipes
July 1st Replenishment	21.43	14.23	11.29	9.66	1.39	10	16.14
Unit profit ($/kg)	3.22	2.21	0.86	6.72	3.98	2.10	0.54
margins	68.949996	31.429659	9.6850813	64.868832	5.5388637	21.0322	8.7716865
Vegetable Single Name	Broccoli	Lotus Root(1)	Eggplant	Purple Eggplant(2)	Green Eggplant(1)	Screw Pepper	
July 1st Replenishment	17.62	6.03	4.21	10.9	1.82	6.84	
Unit profit ($/kg)	4.80	4.39	4.58	1.97	1.67	3.12	
margins	84.581427	26.475318	19.28659 9	21.46580 6	3.0394	21.373413	

Each of the individual products in each category is calculated independently, the sales of the individual products are forecasted in a time series, the daily replenishment of the individual products is derived, the profit of the individual products in the first seven days is counted, and the profit per unit of each individual product on July 1 is calculated according to Equation (9), so as to find out the total profit (Table 5).

The total profit on July 1 was $597.763 On this basis, since none of the vegetables in some of the categories reached the previously forecasted July 1 replenishment, the maximum profit was obtained by scaling up the number of individual items in the category in equal parts (Table 6).

Table 6: Optimization table of replenishment volume and profit on July 1 for each individual product

Vegetable Single Name	spinach	Yunnan romaine lettuce	Shanghai bok choy	choy sum	Yunnan lettuce	baby bok choy(1)	sweet potato tips
July 1st Replenishment	22.0353	2.4549	5.6742	1.8669	1.0731	7.203	6.6297
Unit profit ($/kg)	2.59	2.57	3.06	0.77	2.35	1.89	2.1
margins	57.01605	6.316765	17.3439	1.43714	2.516926	13.61439	13.9227
Vegetable Single Name	Bamboo Leaf Lettuce	Milk Cabbage	Amaranth	Yunnan romaine lettuce (portion)	Baby Lettuce	Yunnan lettuce (portion)	Small Cracked Peel (portion)
July 1st Replenishment	19.551	9.4374	13.1124	47.4663	15.3321	36.75	16.5963
Unit profit ($/kg)	1.26	2.42	1.26	0.87	1.76	1.28	1.15
margins	24.66863066	22.87324	16.55031	41.14967	26.9845	47.14136	19.04603
Vegetable Single Name	Capsicum annuum(portion)	Wuhu Green Pepper(1)	Screw Pepper(portion)	Xixia Shiitake Mushroom(1)	White Jade Mushroom(bag)	Agaricus blazei(box)	Flammulina velutipes
July 1st Replenishment	42.86	28.46	22.58	9.66	1.39	10	16.14
Unit profit ($/kg)	3.22	2.21	0.86	6.72	3.98	2.10	0.54
margins	137.8999927	62.85932	19.37016	64.86883	5.538864	21.0322	8.771687
Vegetable Single Name	Broccoli	Lotus Root(1)	Eggplant	Purple Eggplant(2)	Green Eggplant(1)	Screw Pepper	
July 1st Replenishment	35.24	24.12	8.42	21.8	3.64	13.68	
Unit profit ($/kg)	4.80	4.39	4.58	1.97	1.67	3.12	
margins	169.1629	105.9013	38.5732	42.93161	6.0788	42.74683	

From Table 6, we can see that the replenishment of each individual item as well as the total profit on July 1 was $1036.316 dollars.

4. Conclusions and recommendations

4.1. Conclusions

Fresh food superstore replenishment plan for vegetable commodities by procurement costs, transportation losses, freshness period is limited by a variety of factors, and some of the characteristics related to time, this paper is based on the sales of a fresh food superstore in different categories and single product of the historical consumption information to establish a regression analysis model, the maximum profit model, etc. to predict the replenishment volume and develop pricing strategies. First of all, the sales volume and data of each category of vegetables are analyzed in a cycle of 30 days, and the total sales volume and cost-plus pricing of each vegetable category are fitted with a function using a linear function, and it is found that the total sales volume and cost-plus pricing of each category of vegetables are in a non-linear relationship, and then based on the ARMA model, it is predicted that the replenishment of various types of vegetables will be replenished over the next seven days, and finally, a model of the maximum profit function is constructed, which results in a maximum profit and replenishment volume and the relationship between the markup rate in the cost-plus pricing method to formulate the pricing strategy. Finally, in order to improve the accuracy and applicability of the model, in addition to meeting the above constraints, and at the same time need to meet the total number of single products, the sale volume, the total replenishment volume of a certain condition, screened out 27 kinds of vegetable single products, the objective function is the maximum daily profit of each vegetable single product, the decision variable is the replenishment volume of the daily replenishment of each vegetable single product and the corresponding pricing strategy, and the combination of regression equations and the ARIMA model predicts the daily sales volume of the future of each vegetable single product Combined with the regression equation and ARIMA model to predict the future daily sales of each vegetable item. Based on the predicted sales volume, the optimal replenishment quantity and pricing strategy are adopted to meet the market demand and maximize the profit.

4.2. Recommendations

According to the data in Table 6 Restocking Volume and Profit Optimization Table for each individual product on 7.1, it can be concluded that: millet pepper, spinach, broccoli, and net lotus root (1) have higher unit profit and relatively larger restocking volume, and it is recommended that supermarkets increase the restocking volume of spinach in order to meet the potential market demand, and may consider slightly increasing the pricing in order to increase the level of profit. It was found that selling Yunnan lettuce (portion) and Yunnan oilseed rape (portion) in bundled packages by portion compared to selling Yunnan lettuce and Yunnan oilseed rape in bulk individually, despite the lower profit per unit, the replenishment per day was correspondingly higher due to the high volume of sales, which led to an increase in the total profit. Therefore, supermarkets should attract customers to buy the bundled products by portion to increase the unit sales and thus maximize the profit.

References

[1] Pan Xiaofei, Xie Zhiheng, Wang Shuyun. Optimization decision of fresh food superstore preservation efforts and pricing considering loss aversion[J]. Highway Transportation Science and Technology, 2022, 39(06):177- 185+190.

[2] Nie Yuxuan. Research on automatic pricing and replenishment strategy of fresh commodities based on ARIMA prediction optimization model--taking vegetable commodities as an example[J]. Commercial Exhibition Economy, 2024(05)

[3] Wei Zihang. Association analysis of fresh vegetables purchase based on Apriori algorithm[J]. Software, 2024, 45(01): 131-133.

[4] Yang Shuai, Huang Xiangmeng, Wang Junbin. Research on joint optimization strategy of shelf allocation and pricing for fresh food [J]. Supply Chain Management, 2022, 3(08):49-59.

[5] Liu Xiaoyun. Research on inventory control of community fresh food retail terminal considering the change of customer flow [D]. Hangzhou University of Electronic Science and Technology, 2023.