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A study on vegetable pricing replenishment strategy based on seasonal time series

Xinyu Liu#, Shuang Li#

School of Software, Henan Polytechnic University, Jiaozuo, 454000, China
#These authors contributed equally.

Abstract: *Vegetables play a vital role in people's daily life; however, due to the short freshness of vegetables, many vegetables that cannot be sold in a short period of time become spoiled and cannot be sold. Based on this kind of problem, the distribution law and correlation of each category of vegetables and its single product are analyzed, and the correlation size between vegetables and their optimal decisions are obtained by using Origin and other software, with the help of the time series model and the objective planning problem. Such models are characterized by stability and reliability. In this paper, in order to determine the sales distribution pattern of vegetables in supermarkets and the correlation between vegetables; firstly, the data are cleaned, and then the data are processed using the principle of classification and aggregation, and then the correlation between vegetables is calculated through the Pearson's correlation coefficient and the heat map is drawn to show it. Through visualization, it is concluded that the six categories of vegetables have an upward trend in sales, and the standing volume of aquatic root vegetables is higher than that of other vegetables, and the sales of chili peppers are cyclical (part of the results), and it is obtained by judging the heat map that except for the strong correlation between edible mushrooms and cauliflower, there is not a strong correlation between the other vegetables. By exploring the sales value and cost-plus pricing of vegetables in the superstore, the replenishment decision and pricing decision are formulated; based on this kind of problem, a time series model is used to predict the sales volume and pricing for the next seven days and the model prediction is tested to obtain a good model fit value, and then combined with the impact of cost-plus pricing and the cost of the factors to formulate the optimal pricing and replenishment decision of the superstore: aquatic rhizome replenishment of the 7-day Strategy: 38.77kg, 38.74kg, etc.*

Keywords: *Time Series, Goal Planning, Pricing Replenishment Strategy*

1. Introduction

In today's Internet era, e-commerce with goods has become a trend, in recent years vegetables and fresh food also gradually began to move towards the mode of e-commerce sales, based on the sales of fresh products, to get the supply demand for fresh agricultural products as well as to predict the future sales of fresh food e-commerce sales play an important role. Under the background of new retail, fresh food e-commerce as an e-commerce latecomer is developing rapidly, how to improve the core competitiveness of the fresh food supply chain has gradually become the focus of attention [1]. However, the rational decision-making plan needs to analyze the logistics demand to ensure the reasonable allocation of resources and achieve the purpose of promoting the rapid development of fresh agricultural products logistics in Fujian Province [2].

Fresh agricultural products (fruits, vegetables and dairy products, etc.) are different from other products, with perishable, perishable, short life cycle and other characteristics, thus increasing the difficulty of replenishment in shopping malls, and therefore more attention. For fresh agricultural products in the traditional pricing replenishment analysis method for the discussion of vegetables, fruits and other easily perishable seasonal commodities, such as price control and production and sales decision-making model in the case of oversupply [3]. In the retailing process of fresh products, there is a serious quantity loss, the demand model is difficult to fit accurately, in Qiao Xue established sales loss replenishment pricing strategy is very informative [4]. Meanwhile in Chen Zewei on agricultural products and fresh produce for storage as well as replenishment strategy is very interesting to study [5]-[6]. A quarterly time series model is developed using the forecasting method established by Wang Shaoran in [7] and the improvement of the ARIAM model mentioned by Guo Xuefei in [8]. The quarterly time series model established for the data in this paper can be referred to in the seasonal ARIMA

ISSN 2616-7433 Vol. 6, Issue 4: 97-104, DOI: 10.25236/FSST.2024.060415

optimization model, the delta function periodical superposition optimization model, and the inter-force time series model with dummy variables established in Li Janno [9]. (Data source: www.mcm.edu.cn)

2. Chronological study of fresh produce in shopping malls

2.1 Study of data

In order to determine whether the data of the checked photos are smooth, Origin software is used to visualize the data, in order to facilitate the processing, firstly, the data data of this paper will be quantified by SPSSPRO, and then the data will be examined basically; the test results are shown in Fig. 1-Fig. 4.

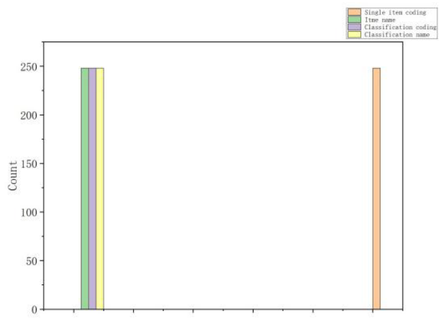


Figure 1: Data value test 1

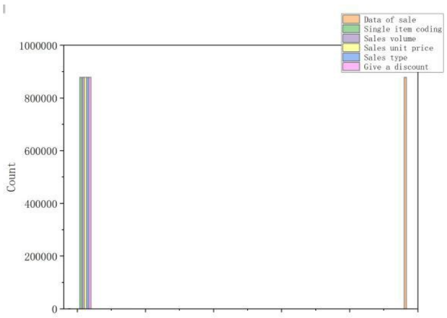


Figure 2: Data value test 2

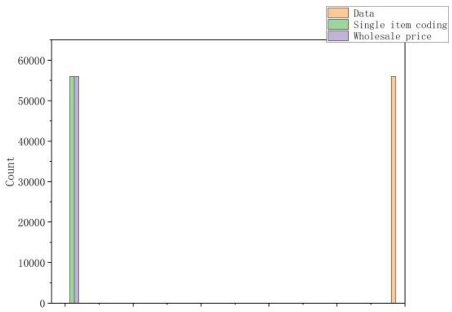


Figure 3: Data value test 3

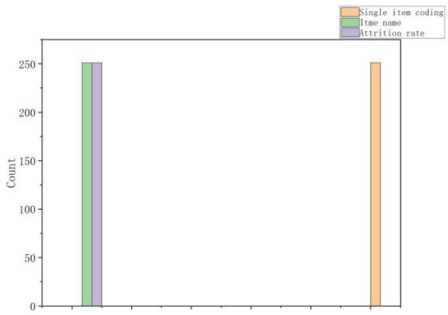


Figure 4: Data value test 4

2.2 Research on vegetable categories and their sales volume

In exploring the relationship between the sales of vegetable items and their categories and the data, the data was first processed to obtain an image of each vegetable item and its category regarding the aggregation of sales, and the visualization results are shown in Fig 5.

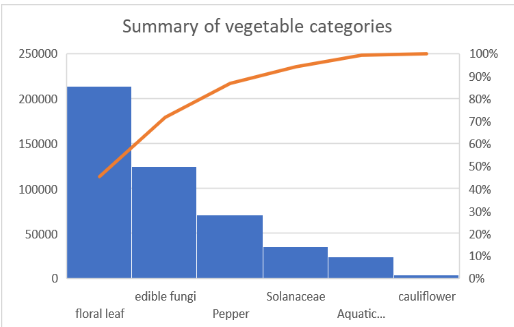


Figure 5: Total Sales Volume of Vegetable Category

2.3 Analysis of the distribution pattern of vegetable single products

In order to more easily distinguish the relationship between the total amount of sales of individual vegetable products and time (daily, monthly, quarterly), the data in the text are processed to analyze and

ISSN 2616-7433 Vol. 6, Issue 4: 97-104, DOI: 10.25236/FSST.2024.060415

summarize the distribution pattern of vegetables by drawing line graphs, and Figs 6-Fig 8 are plotted by the drawing software to represent the change in sales per day, change in sales per month, and change in sales per quarter, respectively.

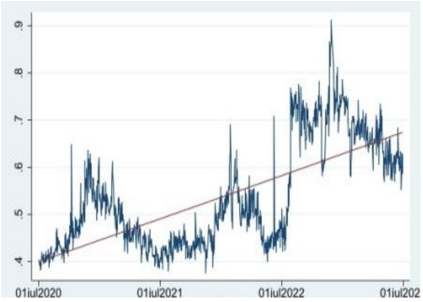


Figure 6: Daily Sales Changes

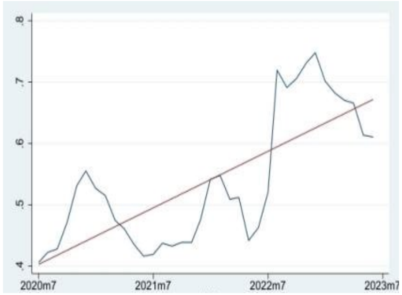


Figure 7: Monthly Sales Changes

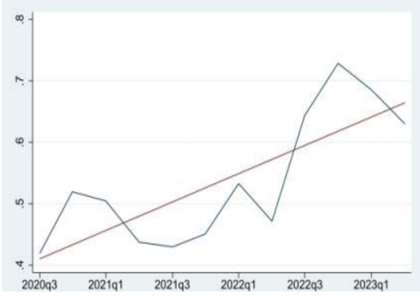


Figure 8: Quarterly Sales Changes

Fig 7 shows an image of the daily change in the sales of individual items of vegetables in supermarkets, and the analysis of this image leads to the conclusion that there is a significant change in the daily sales of individual items of vegetables with the growth of time. Fig 8 shows the changes in the total monthly sales of vegetables in supermarkets, and the following conclusions have been drawn about such changes: the total monthly sales of vegetables in supermarkets have increased across the year, and in the first half of the year, from January to June, the total sales of vegetables will begin to decrease until July and August when the decrease will stop, and then there will be an increase in the total number of sales. Fig 9 shows the results of the visualization of the quarterly total sales of vegetable items in supermarkets, and from the analysis of this Fig, it is concluded that in the first and fourth quarters of the year, the sales of vegetable items are at their highest level, and in the second and third quarters there is a decrease in the total sales.

2.4. Distribution pattern analysis of vegetable categories

According to the graph of changes in the daily sales of the vegetable category in the super market in Fig 9, it can be seen that the aquatic root vegetables have been in the leading part of the market in terms of sales, for this type of phenomenon may be related to the cheap price of aquatic root plants and other factors. The sales of chili vegetables started at a low level, and after June and July the sales of chili food started to increase, which may be related to the factor of maturity of chili peppers, because chili peppers start to be harvested in June and July, and continue to be harvested until the end of November; the total sales of chili peppers exceeded the total sales of some vegetables, such as eggplant, during this period. The daily sales curve for total sales of eggplant vegetables is relatively flat compared to other vegetables, suggesting that eggplant vegetables are more stable when it comes to sales.

According to the line graph of monthly sales of vegetable categories in supermarkets in Fig 9, it can be concluded that the sales of aquatic root vegetables have the largest and most obvious changes, and this phenomenon may be due to the aquatic root vegetables have a greater demand for natural factors such as sunshine, soil, water and so on. Flowering and leafy vegetables have better and increasing sales from March to May, and the sales of flowery and leafy vegetables start to reach the highest level from June to August, which indicates that flowery and leafy vegetables are more obviously affected by the climate. According to the seasonal changes in the sales volume of vegetable categories obtained in Fig 10, it can be concluded that the total sales volume of cauliflower vegetables peaks in the second and third quarters, and then decreases in the first and fourth quarters, and this phenomenon may be due to the growth pattern of cauliflower vegetables, and cauliflower food enters a dormant period in the first and

ISSN 2616-7433 Vol. 6, Issue 4: 97-104, DOI: 10.25236/FSST.2024.060415

fourth quarters; and edible mushrooms in the second and early in the third quarters. The sales of edible mushrooms are at their maximum in the second and early third quarters, and begin to decline in the early part of the fourth quarter.

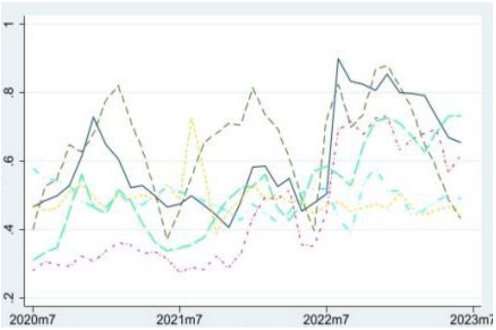


Figure 9: Variety daily sales

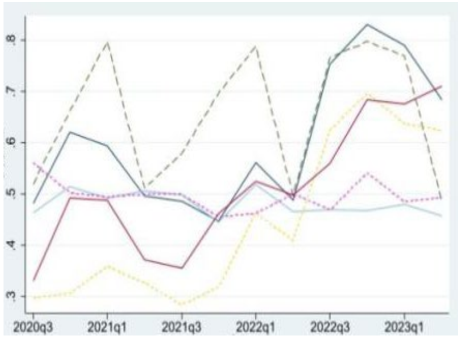


Figure 10: Category quarterly sales

3. Interrelationship modeling and solution

3.1 Vegetable category correlation

In order to facilitate the correlation analysis of the data of the six vegetable categories, the data were summarized and processed, after which the obtained data were solved by using the Pearson's correlation coefficient. The Pearson's correlation coefficient calculates and analyzes the correlation coefficients between two consecutive variables to obtain the level of linear correlation between the variables. The procedure for solving the correlation coefficient is shown below:

The numerator in (1) is the covariance between a,b and the denominator is the standard deviation of a,b ; the result obtained is the correlation coefficient.

$$R(a,b)=\frac{\sigma^2(a,b)}{\sigma(a)\sigma(b)} \tag{1}$$

The covariance in (2) is calculated as follows:

$$\sigma^2(a,b)=\frac{\Sigma(a-\overline{a})\left(b-\overline{b}\right)}{N} \tag{2}$$

In (3) is the calculation of the overall correlation coefficient for the Pearson correlation coefficient:

$$r_q(a_p,b_q)=\frac{\sum\limits_{p=1}^{n}(a_{p,q}-\overline{a})\left(b_{p,q}-\overline{b}\right)}{\sqrt{\sum\limits_{p=1}^{n}(a_{p,q}-\overline{a})\sum\limits_{p=1}^{n}\left(b_q-\overline{b}\right)}}(q=1,2,\cdots,1085) \tag{3}$$

3.2 Analysis of correlation coefficients

In Table 1 the strength of correlation is represented by the value of r ; in order to facilitate the definition of the magnitude of correlation between vegetable categories, the absolute value of r is divided, e.g., 0.0-0.1 for no correlation, 0.1-0.2 for weak correlation, 0.2-0.3 for moderate correlation, 0.4-0.6 for strong correlation, and 0.6-1.0 for strong correlation.

By calculating the correlation coefficient matrix of vegetable categories in supermarkets from the processed data, the heat map of the correlation coefficient matrix is drawn by MATLAB as shown in Fig. 15 to visualize the correlation size between vegetable categories.

ISSN 2616-7433 Vol. 6, Issue 4: 97-104, DOI: 10.25236/FSST.2024.060415

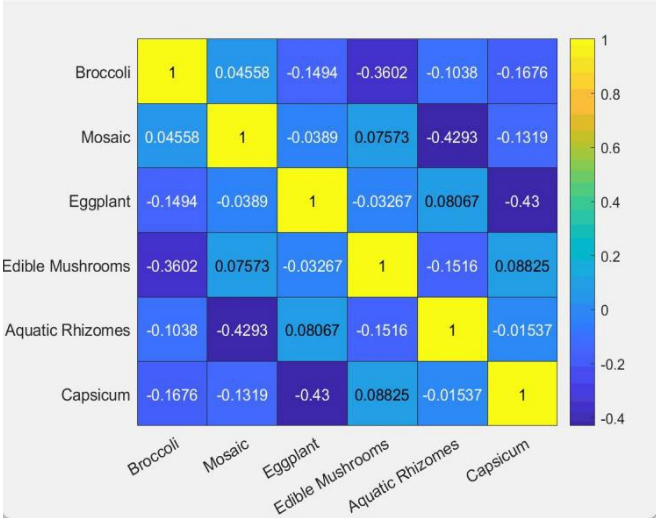


Figure 11: Matrix Heat Map

As can be seen in Fig 11, it is concluded that there is a strong negative correlation between cauliflower and pepper vegetables, a similarly strong negative correlation between aquatic rootstocks and edibles, and a more general correlation between eggplant and leafy vegetables; in addition to this there is a weaker correlation between edibles and leafy as well as cauliflower vegetables, and a weaker correlation between eggplant and pepper vegetables.

4. Time series modeling analysis

4.1 Study between cost-plus pricing and total sales volume

There is an effect between sales volume and cost-plus pricing, and generally speaking, higher cost-plus pricing leads to lower sales volume and lower sales volume, and vice versa. The reason for this phenomenon is because price is one of the most important factors in a consumer's purchasing decision, and a higher price may result in customers choosing to buy other products or buying less. When calculating cost-plus pricing, it is necessary to take into account the incoming price price as well as the wastage rate of the vegetables.

The costs of a product are categorized into fixed costs and maintenance costs. When the percentage of costs is higher, pricing often requires higher discount rates to maintain the profitability of the item. Fluctuations in the cost of vegetables are affected by the weather as well as the current year's production and market demand, and these potential factors may affect their cost individually or collectively.

4.2 Total replenishment and pricing study

ARIMA model plays a vital role in all kinds of time series data analysis and modeling. The seasonal time series model is established by referring to the seasonal time series model in Jiajun Guo [10].

The formula is shown below:

$$\left(1-\sum_{i=1}^{p}\Phi_i L^i\right)(1-i)^d X_t=\left(1+\sum_{i=1}^{q}\theta_i \mathrm{L}^i\right)\varepsilon_t \tag{4}$$

L The meaning represented is the lag operator, where p in the equation is the order and the error between the predicted and true values is denoted by ϵ_t. The test for eggplant vegetables shows that the time series of eggplant vegetables is in a steady state after first order differencing. When solving the sales volume and wholesale price based on the model, the order of each vegetable category is determined first. By calculating the number of orders to determine; the results are shown in Table 1.

ISSN 2616-7433 Vol. 6, Issue 4: 97-104, DOI: 10.25236/FSST.2024.060415

Table 1: Determination of ARIMA model parameters

kind	eggplant	capsicum	cauliflower (Brassica oleracea var. botrytis)	edible mushroom	philodendron	Aquatic rhizomes
Sales Volume Order	(3,1,1)	(1,1,3)	(3,1,1)	(0,1,3) (2,0,0) [7]	(0,1,1)	(1,1,2)
entry level	(0,1,2) (2,0,0) [7]	(0,1,2)	(2,1,0) (0,0,1) [7]	(2,1,1)	(1,1,2) (0,0,1) [7]	(1,0,1) (2,0,1) [7]

After determining the order of each vegetable category, in order to determine whether the data in the sequence is adequately utilized or not, a white noise test is performed based on such studies, and the results of the test are obtained through the use of software as shown in Table 2.

Table 2: ARIMA model evaluation indicators

kind	eggplant	capsicum	cauliflower (Brassica oleracea var. botrytis)	edible mushroom	philodendron	Aquatic rhizomes
Sales volume P-value	0.99	0.99	0.99	0.63	0.99	0.96
Incoming price P-value	0.94	0.81	0.99	0.81	0.97	0.97

From the above Table 2, it can be concluded that the lowest p-value solved is 0.63, which leads to the conclusion that the data in the series is fully utilized, and there is not much difference between the solved results and the true values, and the degree of prediction is high.

In this way the results of visualizing the individual predicted values for the vegetable category are shown in Fig 12 and 13.

(1). Results of the study on the forecasting of sales volume and inlet price of eggplant category

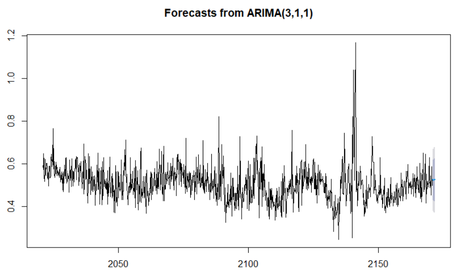


Figure 12: Eggplant Sales Forecast

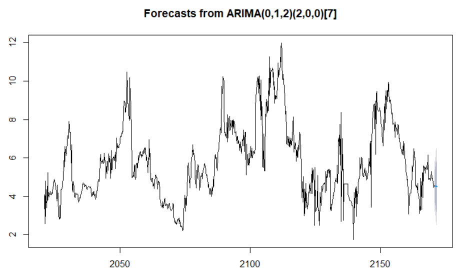


Figure 13: Eggplant Incoming Price Forecast

By eggplant sales forecast map and eggplant pricing forecast map, the wholesale price of eggplant vegetables over time is more volatile, but its sales over time is more questionable and stable, showing cyclical changes, sales among the sudden change may be due to the people realize that eggplant more to eat on the body has the benefit of the situation or super discounts and other circumstances that make the eggplant vegetables are very popular, as shown in Fig 14 and 15.

(2). Results of the study on the forecasting of sales and feeder prices of aquatic rhizomes

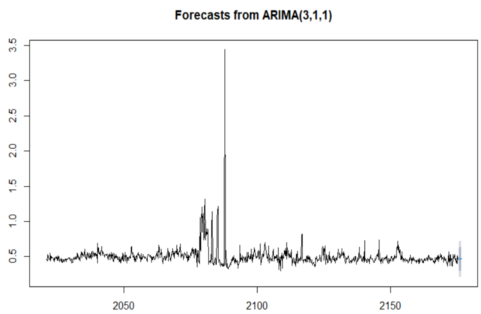


Figure 14: Forecasted sales of aquatic roots and tubers

ISSN 2616-7433 Vol. 6, Issue 4: 97-104, DOI: 10.25236/FSST.2024.060415

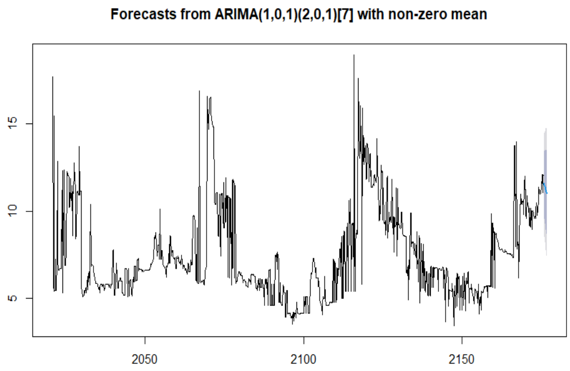
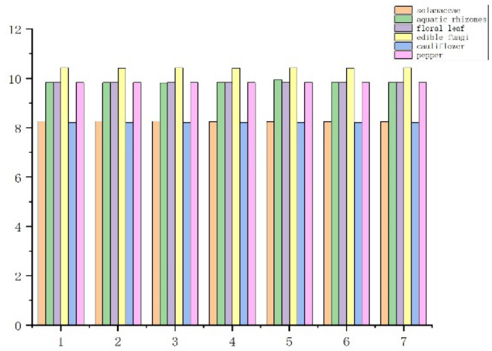


Figure 15: Incoming prices of aquatic roots and tubers

It is lowest in the second quarter and then rises. The overall trend of edible mushrooms over time is unstable, suggesting that edible mushroom food is closely related to seasonal changes in terms of sales volume as well as purchase price,as shown in Fig 16 and 17.



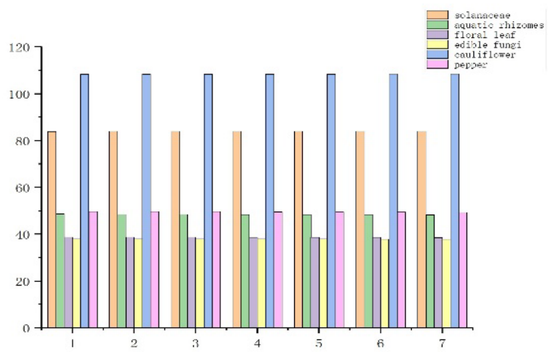


Figure 16: Vegetable Category Pricing Strategy Figure 17: Vegetable Category Replenishment Strategy

5. Conclusions

We adjusted the parameters of the seasonal time series model for each vegetable to obtain the optimal solution: the pricing strategy of eggplant vegetables fluctuates around RMB 10.42/catty for the next seven days, and the total amount of replenishment of eggplant vegetables fluctuates between 37.85-38.00kg. While the pricing strategy of aquatic root vegetables varies around $9.84/catty and the total replenishment of aquatic root vegetables varies between 38.60-38.80kg.

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