Research On Commodity Pricing and Replenishment Based on Optimization and Forecasting Algorithm

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Abstract. With the rapid development of China's commodity economy and people's growing demand for a better life, people's demand for high-quality vegetable products is gradually in-creasing, so Commodity hypermarket needs to ensure that the market's demand for richness and supply of various vegetables is met with a low loss rate. In this paper, the total replenishment amount and pricing strategy of Commodity hypermarket are analyzed and solved based on GWO-BiLSTM algorithm, aiming at providing more effective replenishment and pricing strategies for Commodity hypermarket industry to meet market demand and maximize economic benefits. The value of Pearson correlation coefficient is used to intuitively understand the correlation between sales volume and other factors, and cosine similarity is selected as the clustering method by cluster analysis, which performs well on high-dimensional data sets. The results obtained by the bidirectional long-term and short-term memory network method based on grey wolf optimization have the characteristics of high efficiency and stable output, which can effectively improve the yield. In addition, this paper also discusses the internal relationship and interaction mechanism between the total replenishment amount and pricing strategy of Commodity hypermarket, and further deepens the understanding of the importance of these two factors in the operation of Commodity hypermarket. The research conclusion has guiding significance for Commodity hypermarket to formulate a reasonable replenishment plan and pricing strategy, and is helpful to improve Commodity hypermarket's performance, meet customer needs and achieve sustainable development. At the same time, the research method of this paper can also provide reference for other retail industries.

Keywords: Pearson correlation analysis, System clustering, GWO, BiLSTM.

1. Introduction

With the prosperity of retail industry, the competition between supermarkets is becoming increasingly fierce. In order to gain an advantage in the competition, supermarkets need to constantly optimize their operation and management and improve their profitability. Among many key factors, the total replenishment [1] amount and pricing strategy [2] play a crucial role. A reasonable total replenishment can ensure that the supermarket has sufficient inventory to meet the needs of consumers, while an effective pricing strategy can help the super-market attract customers and increase sales. Therefore, it is of great significance to study the total replenishment amount and pricing strategy for optimizing operation management.

Total replenishment is an important link in supermarket operation. Too low replenishment will lead to a shortage of goods, affect consumers' shopping experience and reduce sales. Excessive replenishment will lead to inventory backlog, increase operating costs and reduce capital liquidity. Therefore, studying the influencing factors [3] of total replenishment and its influence on supermarket operation is helpful for supermarkets to make reasonable replenishment plans and improve inventory control [4] and sales performance.

Pricing strategy is another key factor in supermarket operation. Reasonable pricing can attract consumers and promote the improvement of sales performance, increase market share and profit [5] . However, excessive pricing may lead to consumer dissatisfaction and price competition. However, too low pricing may not cover the cost and achieve profitability. Therefore, studying the influence of

pricing strategy on sales, market share and profit is helpful for supermarkets to formulate reasonable pricing strategies, improve profitability and meet customer needs.

The purpose of this paper is to explore the research significance of the total replenishment amount and pricing strategy of supermarkets, in order to provide theoretical support and practical guidance for supermarket operation and management. By studying the influencing factors of the total replenishment amount and pricing strategy of Commodity hypermarket and their influence on the operation of Commodity hypermarket, we can better understand the importance of these two key factors in the operation of Commodity hypermarket. This will help Commodity hypermarket to formulate a reasonable replenishment plan and pricing strategy to improve performance, meet customer needs and achieve sustainable development. Therefore, the research of this paper has important theoretical and practical significance. (Data source: http://www.mcm.edu.cn/html_cn/node/c74d72127066f510a5723a94b5323a26.html）

2. Research on the relationship between different categories of sales volume and model solution and analysis

Considering that the sales volume is a variable that fluctuates with time, this paper ac-cumulates the sales data of all categories in the same day and draws the curve of the sales volume of each category with time. From Fig 1, it can be seen that the Anthophyllum category is obviously more than other vegetable categories in the whole year. Since the time of data collection includes three years of data, it can be seen from the time sequence in the figure that there is obvious seasonality [6] , especially for edible fungi and aquatic rhizomes.

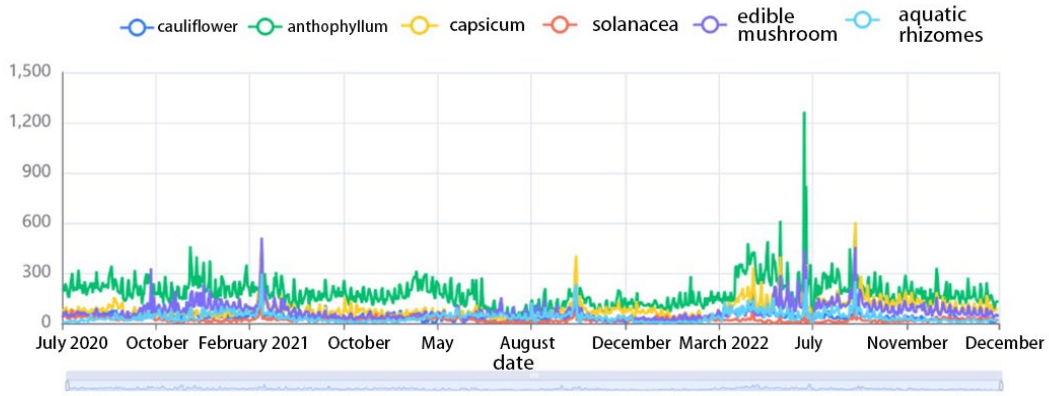

Fig 1. Line chart of sales volume of each category changing with time

This paper uses SPSSPRO [7] Pearson correlation analysis was carried out on the classified data, and six categories (cauliflower, Anthophyllum, pepper, eggplant, edible fungi and water-rooted fungi) were selected as quantitative, and time was determined. Firstly, whether there is a statistically significant relationship between XY is tested ($P<0.05$), and then the positive and negative correlation coefficient and correlation degree are analyzed. The processing results are as follows.

Table 1. Table of Category Correlation Coefficient

	Cauliflower	**anthophyllum**	**Capsicum**	**Eggplant**	**edible mushrooms**	**Aquatic rhizomes**
Cauliflower	1***	0.626***	0.551***	0.343***	0.522***	0.543***
anthophyllum	0.626***	1***	0.659***	0.314***	0.631***	0.56***
Capsicum	0.551***	0.659***	1***	0.313***	0.687***	0.614***
Eggplant	0.343***	0.314***	0.313***	1***	0.14***	0.104(0.001***)
edible mushrooms	0.522***	0.631***	0.687***	0.14***	1***	0.671***
Aquatic rhizomes	0.543***	0.56***	0.614***	0.104(0.001***)	0.671***	1***
Note: * * *, * * and * represent the significance levels of 1%, 5% and 10% respectively.						

As can be seen from Table 1, the parameter result table of model test includes correlation coefficient and significance P value. Firstly, whether there is a statistically significant relationship between XY is tested to determine whether the P value is significant (P<0.05). If it is significant, it means that there is correlation between the two variables, otherwise, there is no correlation between the two variables. Therefore, the heat map of correlation coefficient is obtained:

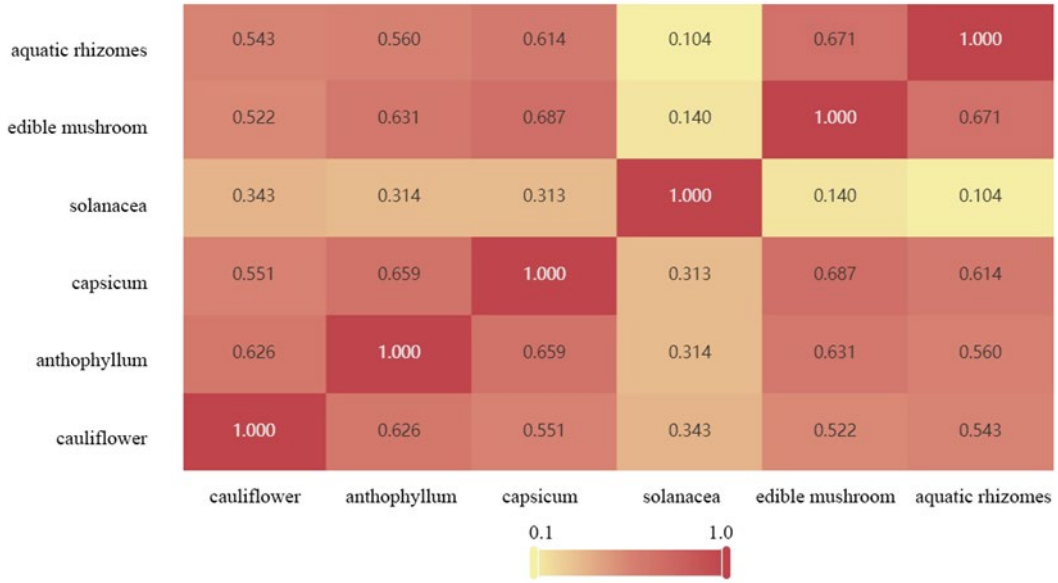

Fig 2. Thermal maps of correlation coefficients of different categories

As shown in Fig 2, the form of thermal diagram shows the value of correlation coefficient, which is mainly expressed by the depth of color.

Therefore, the Pearson correlation coefficient between various categories of data is calculated, and the heat map is drawn in order to visually present the structure. There is a strong correlation between leaves and peppers, aquatic rhizomes and edible fungi, but the correlation between deep rhizomes and eggplant is weak. These six categories can be divided into two parts, among which five categories, Anthophyllum, cauliflower, pepper, edible fungi and aquatic plants, belong to one category, with a moderate degree of correlation, while eggplant has a weak correlation with the former, so eggplant is divided into one category.

By drawing a line chart to observe the distribution law of sales between single products.

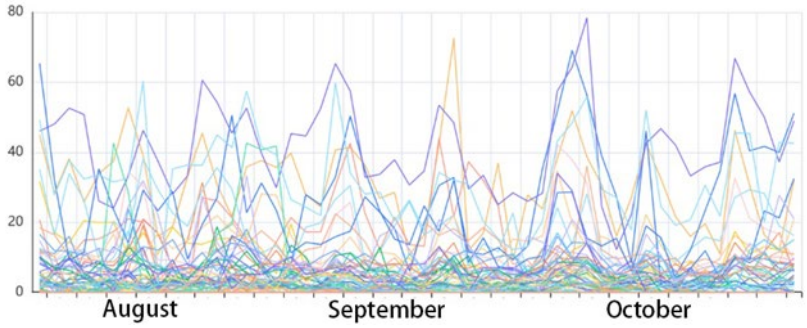

Fig 3. Line chart of single product sales volume

It can be seen that the sales volume of single products changes periodically with the seasons.

Different items are classified into different categories by using systematic clustering algorithm, so as to obtain the clustering law of vegetable sales. Through SPSS, the single item data is systematically clustered, and the variables are all kinds of vegetable commodities, and finally Fig 4 is as follows.

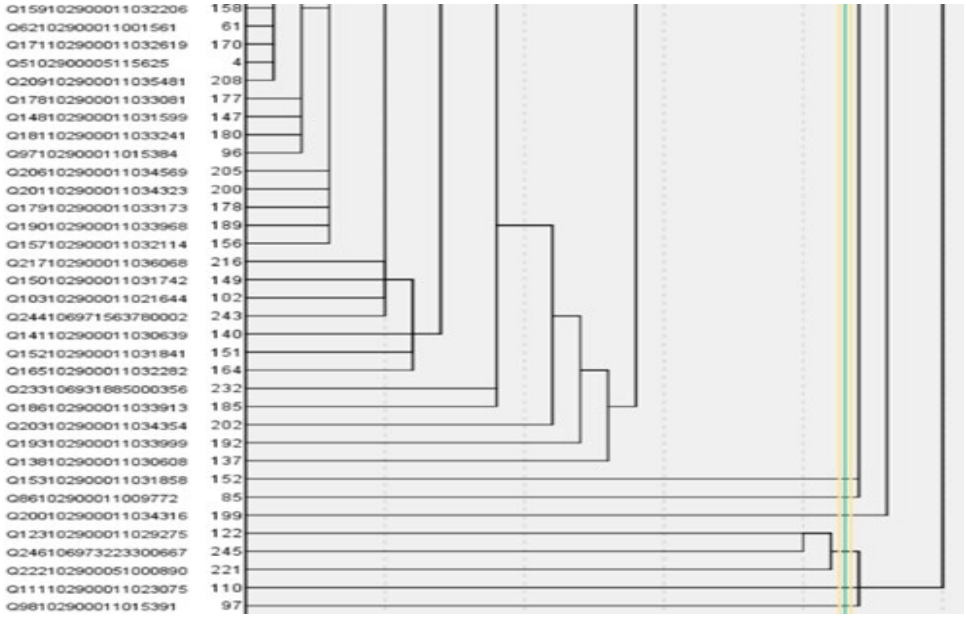

Fig 4. Cluster pedigree diagram

Through the re-scaled distance clustering combination, the single product is divided into eight categories, among which the first category is commonly purchased by users, including cabbage leaves. The second category includes live tremella. The third category includes fruit peppers (orange). The fourth category, including golden mushroom (part, steak mushroom (box)), pleurotus eryngii (bag), Artemisia caidian (part) and other dozens of species. The fifth category, including, round eggplant (2), cabbage, cabbage and other dozens of kinds. There is a sixth category, including red oak leaves, green butter and red coral (coarse leaves). The seventh category, including Chinese broccoli, cordyceps flower (box) (2), purple pepper. The eighth category, including amaranth.

3. Pricing forecast model of BiLSTM[8] based on improved GWO[9]

Firstly, the total sales volume and average sales price data processed by MATLAB were analyzed, and Fig 5 and Fig 6 were obtained respectively.

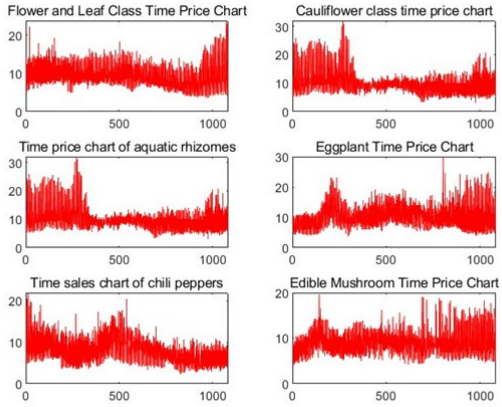

Fig 5. Curve of sales volume of vegetables pricing with time for each category of vegetables

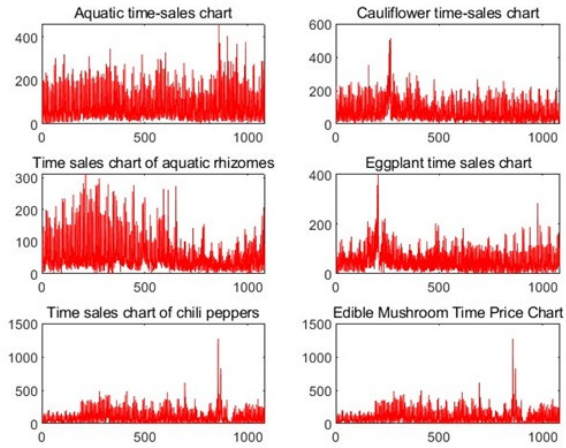

Fig 6. Variation curve of cost-plus pricing in different categories with time.

In order to explore the relationship between cost plus pricing and sales volume, the cost profit rate in cost pricing method is used as the characterization quantity, and the specific formula is as follows.

$$R = \frac{P_{\mathrm{AVG}} - C_{\mathrm{AVG}}}{C_{\mathrm{AVG}}} \tag{1}$$

$$P_{\mathrm{AVG}} = 1/n\Sigma P_{\mathrm{i}} \tag{2}$$

Where r is the cost profit rate, P_{AVG} For the average daily sales price, C_{AVG} For the average daily wholesale price, P_{i} Is the sales price of the I day.

Next, the relationship between profit margin and sales volume was explored. Taking cauliflower as an example, SPSSPRO was used to draw scatter plot and heat map, and the correlation coefficient was calculated to observe the correlation between the two. The results are as follows Fig 7

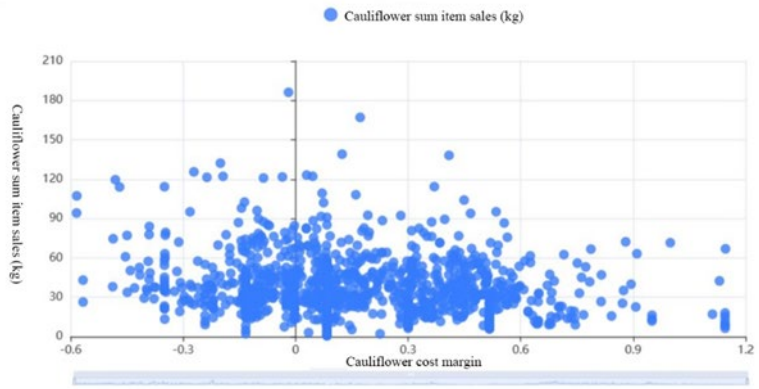

Fig 7. Relationship between cost profit rate and sales volume of cauliflower.

Table 2. Correlation coefficient table

Anthophyllum	Cauliflower	Eggplant	Capsicum	Aquatic rhizomes	edible mushrooms
0.220	0.176	0.164	0.032	0.228	0.046

As can be seen from Table 2, there is no obvious linear correlation between profit rate and total sales.

Consider using polynomial fitting method to fit the relationship between cost, pricing and total sales, so as to study the relationship between cost plus pricing and total sales.

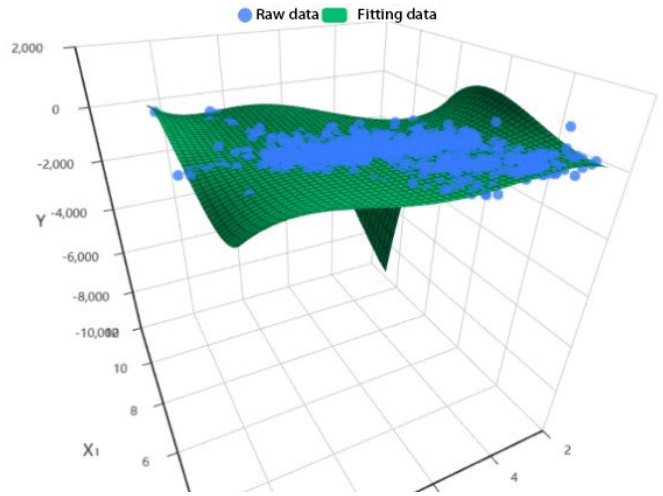

Fig 8. polynomial fitting effect diagram

As can be seen from Fig 8, the scattered points float up and down on the surface, which has a well-fitting effect.

The daily replenishment amount and pricing strategy of each vegetable category from July 1, 2023 to July 7, 2023 are obtained by the method of bi-directional long-term and short-term memory network (BiLSTM), and then the grey wolf optimization [10] algorithm is adopted. (GWO) maximizes the profit of Commodity hypermarket. The improved long-term and short-term memory network method based on grey wolf optimization algorithm is realized by MATLAB programming. The following Fig 9 and Fig 10is the model training effect.

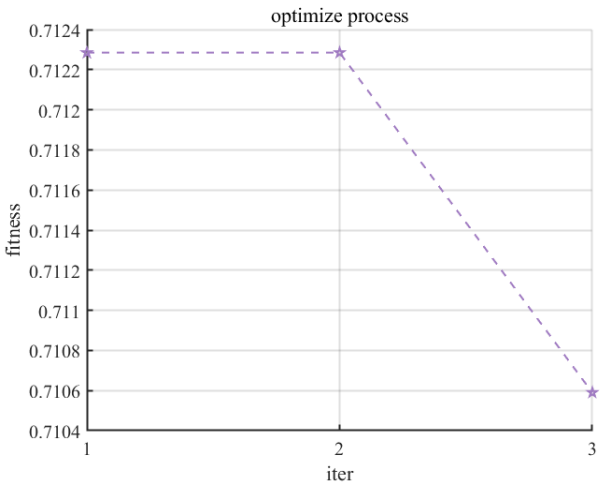

Fig 9. optimization flow chart

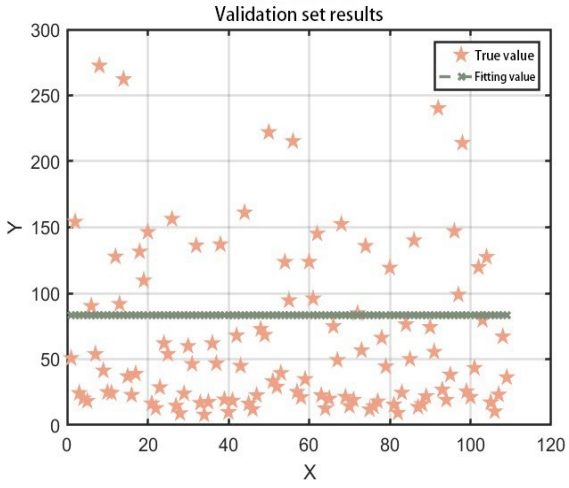

Fig 10 Verification Set Result Diagram

The setting of GWO's algorithm parameters will affect the character of the algorithm, among which Alpha, Beta and Delta represent the three best solutions in the search space. The positions of the three parameters are initialized to all-zero vectors and the scores are initialized to positive infinity. With the iteration of the algorithm, the positions and scores of the results will be updated according to the performance of the search agent, so as to find a better solution. Therefore, the following results are obtained through BiLSTM prediction. The result is shown in Table 3.

Table 3. Pricing (Selling Price) Strategy Table

	Cauliflower	**Anthophyllum**	**Capsicum**	**Aquatic rhizomes**	**Eggplant**	**edible mushrooms**
July 1st.	13.6667	6.2353	7.9268	11.3511	8.8718	9.5267
July 2nd	10.2857	3.6364	7.5849	18.4081	8. 2571	10.5381
July 3rd	14.5385	5.5518	7.3103	15.8966	9. 6667	11.5531
July 4th.	15.0200	5.1954	8.1355	11.6181	9. 2941	6.63809
July 5th	12.2778	5.6179	7.6667	18.4181	6.0811	9.8493
July 6th	14.0000	3.2877	8.3334	8.9889	8.0000	10.6233
July 7th	13.5745	3.7686	9.4234	11.3511	8.0000	10.3485

Assuming that the purchase quantity is X, the loss rate is R, and the sales volume is Y, it can be expressed as the following functional formula:

$$x = y/(1 - r) \tag{3}$$

Therefore, the total daily replenishment amount for the next 7 days is obtained through the above formula. The result is shown in Table 4.

Table 4 Total Daily Replenishment of Various Types

	Cauliflower	Anthophyllum	Capsicum	Aquatic rhizomes	Eggplant	edible mushrooms
July1st.	20.9934	176.0001	102.2338	22.3342	25.5203	59.2232
July2nd	17.4226	127.4685	74.4425	16.2441	8.7841	42.8692
July3rd	13.7548	114.9830	64.1647	14.3981	10.2837	37.7056
July4th.	15.8094	128.8703	76.5505	16.6793	9.8873	45.1288
July5th	17.5767	143.3079	83.5083	18.2429	20.9226	48.6573
July6th	19.9711	158.6067	92.3616	20.3584	22.5448	53.9854
July7th	20.0630	156.5202	92.6632	19.7662	21.8756	52.8552

4. Conclusions

In this paper, four methods are selected to find the daily replenishment amount and pricing strategy, and to analyze the distribution law and relationship of the sales volume of various vegetable categories and single products, so as to maximize the profit of Commodity hypermarket. BiLSTM, time series analysis, grey wolf optimization algorithm (GWO) and Pearson correlation coefficient analysis are used. In this paper, their performance and effectiveness are evaluated by cross-validation, division of training set and test set, and index evaluation. Based on grey wolf optimization, the optimal value of income is obtained, and the analysis result is true and reliable. The analysis results are as follows:

(1) First of all, the data is visualized, and the distribution law of each category is observed by line chart, which shows that the sales volume of each category and single product has a certain seasonal law. Secondly, Pearson correlation coefficient analysis is used to get the relationship between categories, and some categories have strong correlation. Therefore, the system clustering method is used to analyze the relationship between each item, and the items are divided into eight categories, and the items in each category have strong correlation.

(2) Therefore, the trend of total sales volume and average sales price of different categories with time is observed by using line chart, and then the relationship between cost-plus pricing and sales volume is explored by using profit rate, and its scatter plot and correlation coefficient are analyzed, and it is found that there is no obvious correlation. Consider using polynomial fitting method to fit the relationship between cost, pricing and total sales, so as to study the relationship between cost plus pricing and total sales. Secondly, the long-term and short-term memory network model based on the improvement of grey wolf optimization algorithm is established, and the daily replenishment total amount and pricing strategy of each vegetable category in the next week with the largest profit from supermarkets are obtained.

In this paper, the optimization of business operation and the improvement of profitability are studied. Through the research, we can understand the impact of the total replenishment on inventory control, sales and customer satisfaction, as well as the impact of pricing strategies on sales, market share and profits. This knowledge can help Commodity hypermarket to formulate a reasonable replenishment plan and pricing strategy, so as to improve performance, meet customer needs and achieve sustainable development.

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