International Journal of Business and Management; Vol. 11, No. 11; 2016
ISSN 1833-3850 E-ISSN 1833-8119
Published by Canadian Center of Science and Education

The Optimization of Reservoir Based on the Combination of ABC Classification Method and Linear Programming Method

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Received: August 19, 2016 Accepted: September 18, 2016 Online Published: October 27, 2016

doi:10.5539/ijbm.v11n11p156 URL: http://dx.doi.org/10.5539/ijbm.v11n11p156

Abstract

With the optimization objective of all the goods' delivery time, this article presents reasonable storage optimum proposal through analysis of the order data of an enterprise warehouse. Firstly, establish a mathematical model by linear programming method in order to get an ideal and accurate storage program and secondly on this basis, combine practical storage location to reach final storage program by optimizing storage location reached by ABC classification method.

Keywords: ABC classification, linear programming, method, reservoir optimization

1. Introductory Remarks

ABC classification method, also known as Pareto classification method, its core idea is to draw a clear distinction between the primary and the secondary, to identify the key minority factors determining an object as well as the subordinate but majority factors, that is the key minority and average majority, and is also 80/20 rule as mentioned. ABC classification method is the use of mathematical statistics method, statistics, arrangement and classification of various attributes of things and dividing into three parts of A, B, C, respectively given key, general, secondary corresponding management. ABC classification is a simple inventory control method. Although it is relatively easy to operate, the shortcomings are obvious. When using this method, it also needs to consider the importance of each kind of goods and other factors to warehouse management. Classification criteria of ABC classification method is too single, it is based on the number of funds accounted for the number of items to classify without considering the difficulty of purchasing, procurement lead time, the monopoly, production dependence and other factors. That is why it has a certain one-sided. Therefore, this paper combined with the linear programming method to establish a mathematical model and provide a scientific basis for accurate calculation. In this paper, the ABC classification method and linear programming method are combined to preserve the accuracy of the linear programming method and inherit the practicability of the ABC classification method. At the same time, it also overcomes the limitation of the hypothesis condition in the linear programming and avoids the ABC classification standard is too single defect.

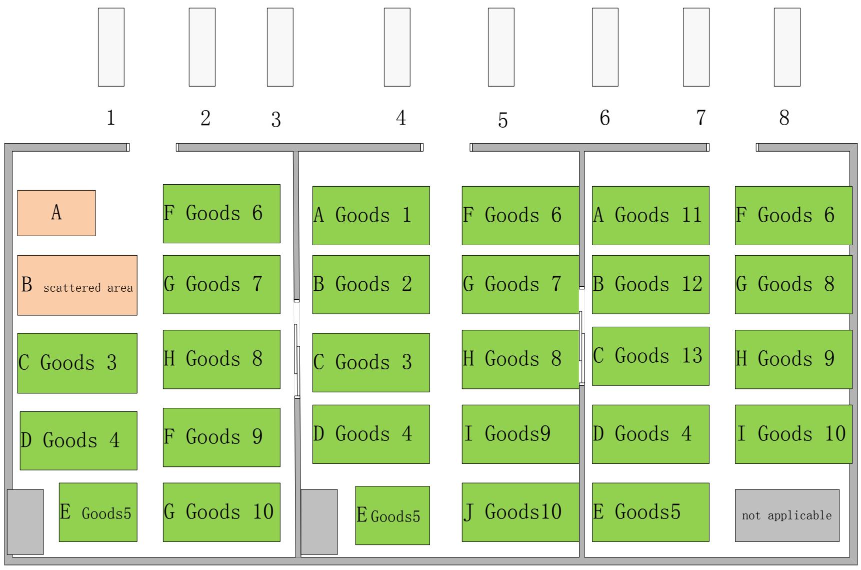
As the most basic, widely used branch of operations research, the linear programming method is to find the extreme value of the linear function satisfying the linear constraints. It is also the basis for other operations research. Under certain conditions, the research of linear programming is to arrange the resources of manpower and material resources reasonably, so as to achieve the best economic effect. Generally, the problem of finding the maximum or minimum value of the linear objective function under linear constraints is called a linear programming problem. Many practical problems are abstracted as mathematical models, which can be classified as solving linear programming problems, so there is a strong practical application of linear programming problems. It can provide the optimal solution for the allocation of production and other operating ranges.

2. Determine the Optimization Objectives

We get the business warehouse orders in April 2016 after field research (as following table):

Order number	Goods name	Outgoing quantity (piece)
20110708	goods7	950
	goods 8	50
	goods 11	100
	goods 14	10
20110710	goods 8	1250
	goods 7	2000
20110711	goods 5	1200
	goods 11	2000
	goods 8	250
	goods 1	60
	goods 10	60
20110712	goods 12	450
	goods 11	150
	goods 8	500
	goods 1	10800
	goods 12	6000
	goods 9	15
	goods 7	500
	goods 14	10
20110715	goods 11	300
	goods 7	800
	goods 8	250
	goods 1	450
	goods13	1430
20110717	goods14	7060
	goods7	150
	goods11	340
	goods8	100
20110718	goods14	2880
	goods9	60
	goods8	50
	goods7	250
20110719	goods7	700
	goods8	50
	goods11	450
	goods5	560
	goods15	1660
20110714	goods8	110
	goods14	4500
	goods7	300
	goods1	1500
	goods12	9700
	goods6	5700
		65704.6

According to goods correlation, outbound quantity and unloading frequency in orders of April 2016, reorganize the storage location on first floor (as following picture) by eight forklifts operating with the constant speed at four operational platforms, adjust the goods storage distribution, this article finds that it meets the storage requirement of all 13 kinds of representative goods from the order of April 11. Further, it also enhances storage utilization efficiency and shortens the delivery time.



According to the requirements of this case, the existing storage capacity meets the requirements of the delivery quantity today after calculation of all the output on April 11th. Based on this, it determines the optimization target of delivery time of all the goods of the day in order to improve delivery efficiency and shorten the delivery time.

3. Establish Model by Using Linear Programming Method and Assign Storage Location

In this case, it takes the delivery time of the goods as the optimization objective, and numbers goods and storage, it turns into the linear programming problem with delivery quantity as constraint condition and with the shortest time delivering 13 kinds of goods to 27 storing places as objective function and further establishing mathematical model to solve.

First, number the storage location and goods, which means, the number is successively 1, 2, 3...... 26, 27 from left to right. The goods, according to variety, are numbered 1, 2,..... 13. This storage optimization problem is transformed into a linear optimization problem of shortest delivery time each goods, by how many quantity, reaches to each storage place. As following:

goods / time / storage	1	2	3	4	5	6	7	8	9	10	11	12	13
1	68	68	68	68	68	68	68	68	68	68	68	68	68
2	70	70	70	70	70	70	70	70	70	70	70	70	70
3	72	72	72	72	72	72	72	72	72	72	72	72	72
4	62	62	62	62	62	62	62	62	62	62	62	62	62
5	66	66	66	66	66	66	66	66	66	66	66	66	66
6	68	68	68	68	68	68	68	68	68	68	68	68	68
7	70	70	70	70	70	70	70	70	70	70	70	70	70
8	72	72	72	72	72	72	72	72	72	72	72	72	72

9	62 62 62 62 62 62 62 62 62 62 62 62 62
10	66 66 66 66 66 66 66 66 66 66 66 66 66
11	68 68 68 68 68 68 68 68 68 68 68 68 68
12	70 70 70 70 70 70 70 70 70 70 70 70 70
13	72 72 72 72 72 72 72 72 72 72 72 72 72
14	62 62 62 62 62 62 62 62 62 62 62 62 62
15	66 66 66 66 66 66 66 66 66 66 66 66 66
16	68 68 68 68 68 68 68 68 68 68 68 68 68
17	70 70 70 70 70 70 70 70 70 70 70 70 70
18	72 72 72 72 72 72 72 72 72 72 72 72 72
19	62 62 62 62 62 62 62 62 62 62 62 62 62
20	66 66 66 66 66 66 66 66 66 66 66 66 66
21	68 68 68 68 68 68 68 68 68 68 68 68 68
22	70 70 70 70 70 70 70 70 70 70 70 70 70
23	72 72 72 72 72 72 72 72 72 72 72 72 72
24	62 62 62 62 62 62 62 62 62 62 62 62 62
25	66 66 66 66 66 66 66 66 66 66 66 66 66
26	68 68 68 68 68 68 68 68 68 68 68 68 68
27	70 70 70 70 70 70 70 70 70 70 70 70 70

Make the elapsed time of the goods I to the storage J is t_ij, the amount of goods as v_ij, establish mathematical model as follows:

$$\text{Objective function: } \min T = \sum_{i=1}^{13}\sum_{j=1}^{29} t_{ij}\, v_{ij}$$

$$\text{Constraints s.t.} \begin{cases} 0 \le v_{ij} \le 3750 \\ 1 \le i \le 13 \\ 1 \le j \le 27 \end{cases}$$

Using Lingo software to program and solve, gets the final result as 3228953 seconds. In order to facilitate the operation, it takes one forklift operating by unit to simplify the practical problem of eight forklifts operating simultaneously, moreover each of which has to deliver 30 units in this model. So the final result is: 3228953 / (8 x 30 x 3600) = 3.7. That is: eight forklifts will take about 3.7 hours to finish this. The exact distribution picture describing the goods to how much volume stored in which storage can reach the shortest delivery time, calculated by software is as following,:

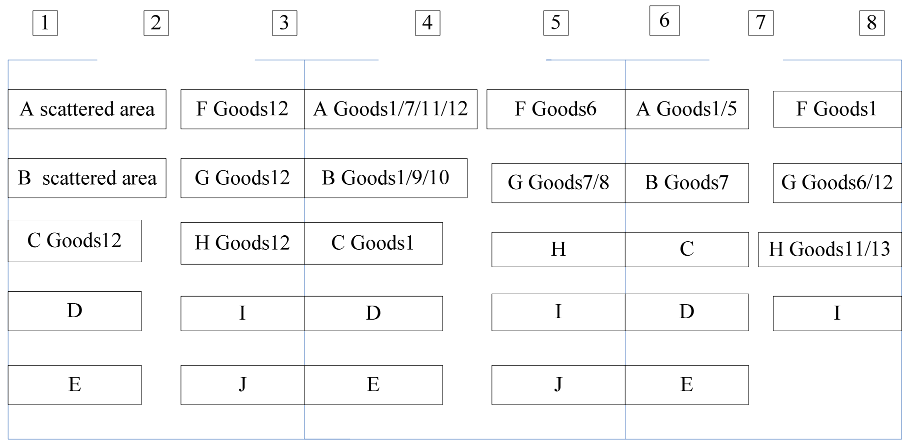


Figure 1. Preliminary layout results chart

Although the linear programming method, through the analysis of the model, can find out the optimal solution. It is a very persuasive analysis technology, and combined with LINGO software programming, it can accurately calculated which kind of goods to how much volume stored in which storage can reach the optimal functioning of the time, however, practical storage problem is often complex, with linear programming only cannot reflect the picture of warehousing activities. In order to facilitate analysis and the solution, People often take the hypothesis assumption, but it always affect the accuracy of the results. For example: because there is no time to consider the split time, and the eight forklifts operation is an ideal state, so the final distribution and the actual situation will cause error. In addition, the case requires a storage place can only store a kind of goods, so the above results do not meet the requirements. Therefore, the above results should be further optimized in accordance with the requirements.

In this case, different distance of each storage place from the door resulting in different elapsed time of the forklift truck from location to the platform. Each kind of goods shipments' outbound quantity and unloading frequency will lead to different storage time. Therefore, when carrying out the storage allocation, we should try to arrange the goods which are larger in quantity and the frequency of delivery close to the door, so as to shorten the time of delivery. So, taking X, the ratio of outbound quantity and Y, delivery frequency as classification, this article divides the goods into three categories of A, B and C, and on which to determine the distance from the goods to the exit.

Thus:

Ratio of goods to the outgoing volume X= The outbound quantity of the goods / Total output of all goods;

Delivery frequency Y= Outgoing frequency of the goods / Total outgoing frequency of all goods

In this, assume the goods which is cater for $X>20\%$, $Y>15\%$ is classed as category A; $3\% \leqslant X \leqslant 20\%$，$5\% \leqslant Y \leqslant 15\%$ of the goods as category B; $X<3\%$, $Y<5\%$ of the goods as category C. After calculation, the ratio of the volume of each cargo and the frequency of the library can be seen in the next table:

Table 1. Shipment schedule

Name of goods	Unitshipment ratio %
Goods12	32.5705965
Goods 1	25.8346341
Goods 6	11.4955047
Goods 7	11.3946669
Goods 11	6.73596238
Goods 8	5.26373108
Goods 5	3.54948916
Goods 13	2.88395994
Goods 9	0.15044994
Goods 10	0.12100531
total	100

Table 2. Goods ship frequency table

Name of goods	Outgoing frequency
Goods 8	24.32432
Goods 7	21.62162
Goods 11	16.21622
Goods 1	10.81081
Goods 12	8.108108
Goods 5	5.405405
Goods 9	5.405405
HW10	2.702703
Goods 13	2.702703
Goods 6	2.702703
total	100

Through the analysis of the ratio of the frequency and the volume of the outbound quantity, and according to the classification criteria, the following classification can be reached:

category	Name of goods
A	12, 1, 8, 7, 11
B	6, 5, 9
C	13, 10

The importance of goods determines the position of the goods at the entrance, and the relevance of the goods determines the relative position of the goods. The correlation intension among goods should be calculated after classification according to the importance of the goods.

The correlation strength between I and j = Times of the goods I and J appear in the order together / Times of the goods I appear in the order + Times of the goods appear in the order- times of goods I, and J appear in the order together.

After calculation, the goods correlation intensity can be calculated as shown in table three:

Table 3. Goods associated strength table

Goods	1	5	6	7	8	9	10	11	12	13
1		D	D	C	C	D	D	C	A	D
5	D		D	D	D	D	B	C	D	D
6	D	D		D	D	D	D	D	C	D
7	C	D	D		A	D	D	B	D	D
8	C	D	D	A		D	D	B	C	D
9	D	D	D	D	D		D	D	D	D
10	D	B	D	D	D	D		D	C	D
11	C	C	D	B	B	D	D		D	D
12	A	D	C	D	C	D	C	D		D
13	D	D	D	D	D	D	D	D	D	

It can be known from the above table, correlation strength of goods 1 and 12 as well as goods 7and 8 is A, which shows the strongest link; correlation strength among the goods 5, 7, and 11, as well as between the goods 8 and 11 is B, which shows the stronger link; correlation strength among the other goods is C or D, showing the weak link, thus excluded from this case.

4. Determine Layout Optimization Principles

The formulation of layout optimization principles is the key to conduct reservoir optimization This case was originally defined to regard the delivery time of all goods in the order of the day as the optimization target, while the outbound quantity of goods is the biggest factor to affect delivery time and the size of the outbound quantity of goods determines the importance of the goods.

This article takes "The importance of the goods determines the distance from the platform" as the first optimization principle, that is, when performing optimization of storage spaces, first of all, arrange all goods' storage position based on the importance of goods: A Class goods is nearest from platform, followed by class B goods, and then followed by C class goods. Next, the second principle: correlation of goods determines the relative position within the group. In other words, optimize the relative position of A, B, C three groups according to the size of relevant strength within the group without changing positions between groups. Finally, the third principle: whether conducts whole consignment determines the distance from unbounded area. The goods that needed to be unbundled in the order goods should be arranged in the storage space closed to the unbundled area as far as possible, but cannot change the first two principles of arrangement of storage spaces.

Optimizing and modifying the layout that obtained by applying the linear programming method according to the above three principles in the second part can obtain storage spaces layout shown below.

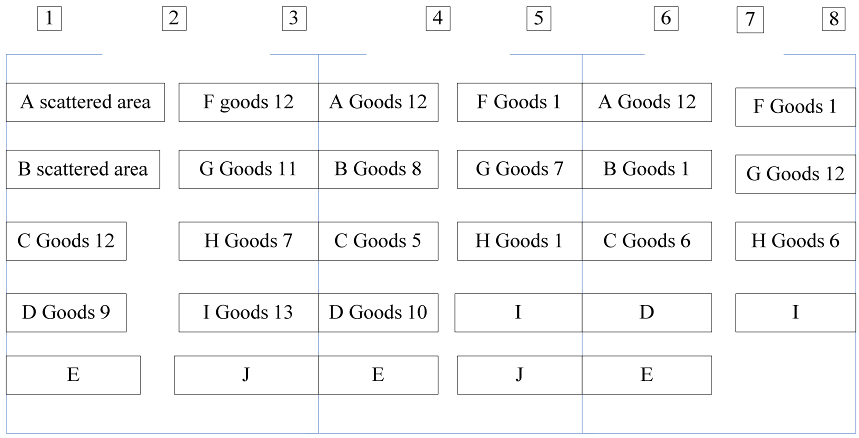


Figure 2. Final storage spaces layout

As can be seen from the final layout, the layout has been greatly improved in terms of utilization of storage spaces, the goods piled of the large outbound quantity and high unloading frequency more reasonable, and the goods that have strong relevance are stacked relatively concentrated. The layout optimization has achieved certain results.

5. Conclusion

Linear programming is an important branch of operations research featured by studying earlier, faster development, widely used method is more mature. It is also a mathematical method to assist people to manage scientifically, which provides a scientific basis for reasonably using of limited human, material and financial resources, etc. to make the optimal decision. However, various assumptions are set in order to facilitate the model operation so as not to fully take into account the actual situation. ABC classification method can save a lot of manpower, and the method is simple, easy to grasp and different measures for different classifications, which make storage management more reasonable and more optimized, but the standard of ABC classification is too single. This article combines linear programming method with ABC classification, which not only retains the accuracy of linear programming method, but also inherits the usefulness of ABC classification; not only overcomes the limitations of assumptions set in linear programming, but also avoids the detect featured by the Simplification of ABC classification standard. It is a practical approach in the aspects of warehousing and other inventory optimization.

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