



## A Decision Model of Field Depot Location Based on the Centrobatic Method and Analytic Hierarchy Process (AHP)

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### **Abstract**

Warehouse location is one of the most important logistics activities. The selection of the most effective warehousing mode has become a strategic study. This paper will introduce the factors influencing the decision process in selecting the warehouse locations based on gravity model approach and analytic hierarchy process. In the end, the author will summarize the methods and the results.

**Keywords:** Selection of Warehouse location, Centrobatic method, Analytic hierarchy process (AHP)

Warehouse location selection plays a very important and long-term role in corporate strategy. The selection result usually has direct impact on the mode, level, efficiency, and cost of service provided. Thus, warehouse location can potentially affect corporate profits and competitive advantage. It is safe to say that the study on warehouse selection will have significant effect on economy and society.

### **1. Analysis of factors in warehouse selection**

#### *1.1 Distribution of Sales location*

To the retailing warehouse, its major customers are supermarkets and retailing stores. These customers are usually located in metropolitan cities with large population. To enhance the level of service while lowering the distribution transportation cost, the warehouses are normally built near the customers in the areas of suburbs

#### *1.2 Transportation*

The warehouse locations have to take into consideration the current and future availability of transportation as well as the transportation development in the neighborhood areas. It is best to select the place near the highways, national arteries, and express ways. Also the location could be near the train station and harbor if the transportation is carried out by rail or ship.

#### *1.3 Land*

The selection of land must be conducted in a way that complies to the regulations of rules set by municipal or other-level government. It is usually a good choice to locate the land in major distribution centers or economic development zones. If applicable, the decision of the location should be made based on the planning of these centers or zones. In addition, the potential increase in real estate value could also play a part in the selection process.

#### *1.4 Natural environment*

It is important to acquire the knowledge of the natural environment in order to reduce the risks involved in constructing the warehouse. For example, natural conditions could be the humidity, saltiness, precipitation, typhoon, earthquake, and river.

#### *1.5 Policy environment*

If there is supporting policies available from the government, the logistics will have very favorable condition to develop. These policies could include ones such as the favorable incentives for corporate (the supply of land and reduction of

tax), municipal infrastructure planning (the development of real estate, and road construction), the policies of promoting certain local industries. Especially tax reduction could mean direct reduction in the operational expenses.

## 2. The Application of Centrobatic Method

We assume that the ultimate goal is to reduce the cost of distributing the goods to their different destination, the formula is:

$$\text{MinTC} = \sum V_i R_i d_i \quad (0)$$

Note: TC----- Total Transportation Cost;

$V_i$  -----Volume at Destination Point  $i$

$R_i$ ----- Rate of Transportation to at Destination Point  $i$

$d_i$ -----Distance from distribution centers to at Destination Point  $i$

$i$ ----- Destination Point  $i$

In the Coordinate Plane, the to-be-determined location of the warehouse is  $(X_0, Y_0)$ , then we have

$$X_0 = \frac{\sum V_i R_i X_i / d_i}{\sum V_i R_i / d_i} \quad (1)$$

$$Y_0 = \frac{\sum V_i R_i Y_i / d_i}{\sum V_i R_i / d_i} \quad (2)$$

Note  $d_i$  can be calculated from the following formula,

$$d_i = \text{SQR}[(X_0 - X_i)^2 + (Y_0 - Y_i)^2] \quad (3)$$

The process of calculating is as follows:

1. Determine the coordinates of individual destinations with a certain set of volumes and the rates of transportation;
2. Without the factor of distance, the initial destination point would be decided by the following Centrobatic Method

$$X_0 = \frac{\sum V_i R_i X_i}{\sum V_i R_i} \quad (4)$$

$$Y_0 = \frac{\sum V_i R_i Y_i}{\sum V_i R_i} \quad (5)$$

3. From formula 3,  $d_i$  could be derived from step 2;

4. With  $d_i$  known, coordinate  $(X_0, Y_0)$  can be calculated from formula (1) and (2)

5. With the revised  $(X_0, Y_0)$ , a new round of calculation

6. Repeat step 4 and 5 until variances of  $(X_0, Y_0)$  through the iterative process are within an acceptable range.

Assume the two choices of destination points A and B are known with related parameters, the calculation process could be finished through the Excel template in the appendix. To make the coordinates in the same Quadrant, we assume the warehouse location is  $(0, 30)$ . The result of the optimal coordinate is  $(12.43288, 25.13579)$ , please refer to the appendix for the result. This is in line with the choice A. Therefore, A should be the location for warehouse.

## 3. Determination of locations with AHP method

The first step is to set goals, namely determining point A and B. Then based on the experience of the decision maker, relevant factors influencing the goal should be identified out. These factors will be listed at the second layer below the goal. Now there is a need to determine the weights (priorities) of the 5 elements. Priorities will be compared in pairs, AHP will compare two of the 5 factors to assess the priorities. Consequently, every element will have its own weight relative to each other. Then the next step will analyze the overall results, arrive at a comprehensive weight, and assign each factor its degree of importance.

Insert Figure 1 here

Compare 5 elements in the second layer according to their degree of importance, a comparative matrix could be established.

Insert Table 1 here

Insert Table 2 here

Insert Table 3 here

Insert Table 4 here

In order to make judgment on consistency of the comparison results, it is needed to check the coefficient RI from the table Average Random Consistency

Insert Table 5 here

The consistency index is found 0 through calculation. Therefore the result is very satisfactory in terms of consistency.

The Weights of the five indexes:

5. Transportation

4. Policy environment

3. Land

2. Distribution of Sales location

1. Natural environment

A Comprehensive score:

$$5*0.372636+4*0.212191+3*0.164178+2*0.153579+1*0.099664= 3.8602$$

B Comprehensive scores:

$$5*0.351067+3*0.210635+4*0.197528+2*0.145624+1*0.095146= 3.5638$$

From the above, A scores higher than B does. Therefore A should be the best choice. Both approaches produce the same results that indicate A the best location. Therefore, the conclusion is A should be the place to build the warehouse.

As the important node in the network of logistics, the location selection is very important. We can not rely entirely on the complex mathematical model or on experience alone. Only by combining the two together, we can make reasonably sound decision in real life.

**References**

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Table 1. The Comparison of Each Factor in Selecting Warehouse a Location

Elements - elements of Comparison Matrix	Distribution of sales location	Transportation	Land	Policy environment	Natural environment
Distribution of Sales location	1.000	0.758	0.8334	0.4990	2.130
Transportation	1.320	1.000	5.102	2.521	3.210
Land	1.200	0.1960	1.000	2.024	0.6623
Policy environment	2.004	0.3967	0.4941	1.000	3..812
Natural environment	0.4695	0.3115	1.510	0.2623	1.000

Table 2. The Comparison of Each Factor in Selecting Warehouse B Location

Elements - elements of Comparison Matrix	Distribution of sales location	Transportation	Land	Policy environment	Natural environment
Distribution of Sales location	1.000	0.3287	9.1286	0.4537	0.9960
Transportation	3.042	1.000	3.142	3.001	2.402
Land	1.205	0.3182686	1.000	0.9794319	2.13
Policy environment	2.204	0.3332223	1.021	1.000	3.425
Natural environment	1.004	0.4163197	0.4694836	0.2919708	1.000

Table 3. Comparative matrix A after Homogenization matrix

Elements - elements of Comparison Matrix	Distribution of Sales location	Transportation	Land	Policy environment	Natural environment	Priority vectors
Distribution of Sales location	0.166847418	0.284727	0.093227	0.079127	0.196961	0.164178
Transportation	0.220238592	0.375629	0.570725	0.399759	0.296829	0.372636
Land	0.200216902	0.073623	0.111863	0.320949	0.061243	0.153579
Policy environment	0.334362226	0.149012	0.055272	0.158572	0.352496	0.209943
Natural environment	0.078334863	0.117008	0.168913	0.041593	0.09247	0.099664

Table 4. Comparative matrix B after Homogenization matrix

Elements - elements of Comparison Matrix	Distribution of Sales location	Transportation	Land	Policy environment	Natural environment	Priority vectors
Distribution of Sales location	0.118273	0.137169	0.618424	0.079237	0.100072	0.210635
Transportation	0.359787	0.417268	0.212857	0.524089	0.241334	0.351067
Land	0.142519	0.132803	0.067746	0.171046	0.214005	0.145624
Policy environment	0.260674	0.139043	0.069168	0.174638	0.344117	0.197528
Natural environment	0.118746	0.173717	0.031805	0.050989	0.100472	0.095146

Table 5. Average Random Consistency

Matrix size	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

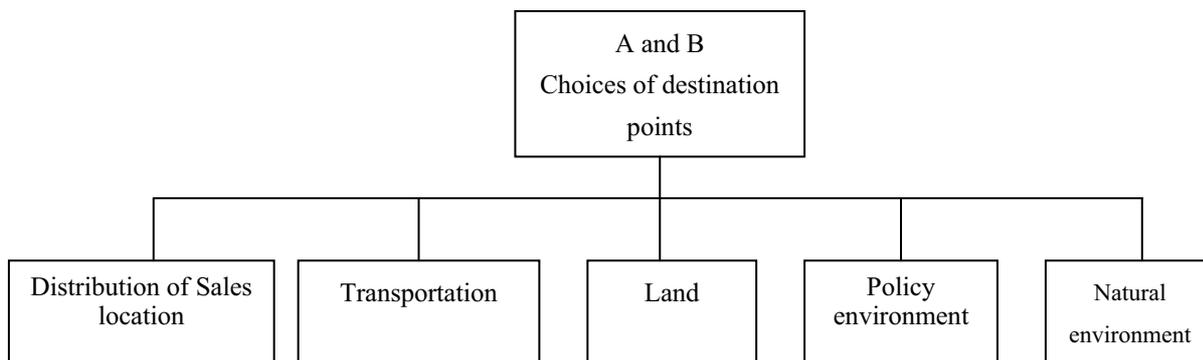


Figure 1. The factors of selection of warehouse location