Strategies for Selecting a New Warehouse Location by the AHP Method, A Case Study of ABC Company

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Abstract

ABC Co., Ltd. is a cosmetic sales company that sales both domestically and internationally. Currently, the company rents a private warehouse in Lat Krabang area. Due to increased costs and insufficient warehouse space, the company has lost opportunities to meet customer demand which may lead to the dissolution of the company if not addressed. To overcome this issue, the company has decided to build a new warehouse of their own. The objective of this study is 1) To select a suitable location for the new warehouse 2) To find out factors involved in choosing a new location, and 3) To determine the cost for transportation from the new warehouse to the customer. The researcher employed the Center of Gravity Theory, to identify a new suitable location. Then, the Analytical Hierarchy Theory (AHP) from https://bpmsg.com/academic/ahp.php was used to analyze the importance of various factors with new warehouse options. Finally, the cost of transportation for each alternative warehouse to the customer was calculated and compared to get a more appropriate answer. After calculating the location using the Center of Gravity method, the location was obtained at a longitude value of 14.5151 and a latitude value of 100.547, indicating a location around Bang Prahan District, Phra Nakhon Si Ayutthaya Province. Then, four factors were applied at the given weight assigned by the management team. The four factors are, transportation costs (51%), Labor (11.2%), Rent (29.5%), and Equipment (8.3%), for the assessment from the management team. To ensure the chosen location is the most realistic for the company, all four locations were considered: Bang Prahan District, Nong Khae, Rama Road, and Lat Krabang. The study found that the most suitable locations were Rama 2 Road, Nong Khae District, Bang Prahan District, and Lat Krabang warehouse, respectively. Furthermore, comparing the new Rama 2 Road warehouse to the old Lat Krabang warehouse showed a decrease in transportation costs by 18.02%. Future research could consider additional alternative factors and incorporate more statistical data, such as economic indicators like inflation and unemployment rates.

Keywords: *Center of Gravity, AHP, Alternative warehouse*

1. Introduction

ABC Co., Ltd. is an established cosmetic export company having been in operation since 1999. Its head office is located on Ratchadapisek Road, and the company has continued to expand its business until now. Currently, the company rents a private warehouse on Lat Krabang Road that has proven to be costly, and the size of the warehouse is inadequate to meet the growing demand from customers. As the result, the company has lost several opportunities, incurred high distribution costs, experience the decrease in net profit, lost customers, inability to compete with competitors in the future. Moreover, the company may have to increase the product's sales prices compared to its competitors, leading to the loss of competitive power. Therefore, the executives have decided to construct a new warehouse for reduction those weaknesses of the present warehouse.

Prior to conducting the studies on warehouse selection, the researchers can gain insights into the various factors and methods that have been used in similar studies shown in Table 1.

Table 1 Literature review on location selection.

Author	Study area	Method	Factors
Wongjun and Treesuwan (2022)	Warehouse selection	AHP	access to customers, ease of transportation, cost of transportation, labor, and availability of utilities

Author	Study area	Method	Factors
Hongsaphanat (2017)	Select a resort location	Expert Choice program	land price, near tourist attractions, travel, near the community, near public transport station, the water source, and near the place to sell consumer goods
Pimpatchim, Supattananon, and Akararungrunngkul (2020)	Warehouse selection	Center of gravity location and AHP	cost, infrastructure, society, and environment
Hikmah, Riyadi, Fahriza, and Nasution (2021)	Distribution center	AHP	infrastructure, government, and market

Four different studies have been summarized to show the method used to select a warehouse, resort location, or distribution center. The first study, conducted by Wongjun and Treesuwan in 2022, used the Analytical Hierarchy Process (AHP) to assess factors such as access to customers, ease of transportation, cost of transportation, labor, and availability of utilities for warehouse selection. The second study, Hongsaphanat (2017) utilized the Expert Choice program to select a resort location based on factors such as land price, nearness to tourist attractions, travel, nearness to the community, proximity to public transport stations, access to water sources, and proximity to places that sell consumer goods. The third study, conducted by Pimpatchim, Supattananon, and Akararungrunngkul in 2020, used both the Center of Gravity Location and AHP methods to assess the cost, infrastructure, society, and environment for warehouse selection. The fourth study, reported by Hikmah, Riyadi, Fahriza, and Nasution in 2021, used the AHP method to evaluate infrastructure, government policies, and market conditions for the selection of a distribution center. Overall, the previous studies demonstrate that AHP is the most frequently method used for selecting a warehouse, resort location, or distribution center. Hence, the AHP method and Center of gravity location were employed in this study due to its effectiveness and importance in the decision-making process for the selection of warehouses, resort locations, and distribution centers.

2. Objectives
1) To choose the right location of the warehouse.
2) To find factors for choosing the location of the warehouse.
3) To determine the cost of transporting goods from the new warehouse to the customer.

3. Materials and Methods
3.1 Research framework
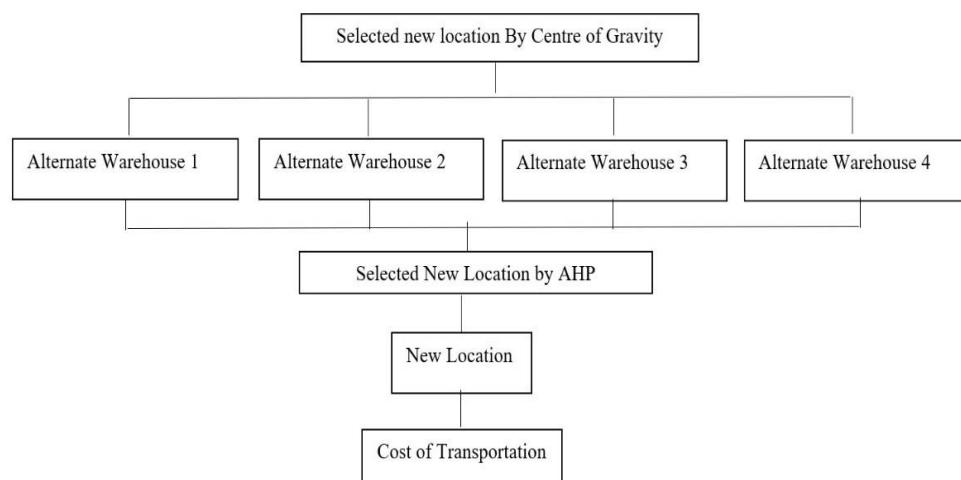
Figure 1 Research framework

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The researcher employed the Center of Gravity Theory to identify a new suitable location. Then, the Analytical Hierarchy Theory (AHP) was used to analyze the importance of various factors with new warehouse options. Finally, the cost of transporting each alternative warehouse to the customer was calculated and compared to get a more appropriate answer. The research framework is shown in Figure 1.

3.2 Data Collection: The primary and secondary data were collected to study the current problem of the company. The data source used for this study were latitude and longitude location data, as well as the demand for products of 26 customer groups.

3.3 Scope of study: The study focused on collecting freight cost data only for 6-wheel trucks and the amount of product demand in 2021. The customer location was determined using google map.

3.4 Weight of the factors: To elucidate the weight of the selected four factors, namely, 1) Transportation costs 2) Labor (11.2%) 3) Rent, and 4) Equipment, three members of the management team were interviewed, namely the Managing Director, Head of Transportation, and Head of Warehouse. Inclusion factors information were retrieved via the website (https://bpmsg.com/academic/ahp.php).3.5 The method used to calculate the center of gravity was based on a mathematical formula, which can be represented as follows (Sutaji & Hasibuan, 2021).

$$\bar{X} = \frac{\sum XiQi}{\sum Qi} \qquad \bar{Y} = \frac{\sum YiQi}{\sum Qi}$$

When,

Qi is the quantity of goods delivered to destination i.
Xi is the X-axis position of destination i.
Yi is the Y-axis position of destination i.

Table 2 Customer Location information, Latitude, Longitude, and Product demand per year.

Rank	Address	Transportation cost (THB) Per Years	Number of boxes (Unit/Years)	Latitude	Longitude
1	Customer Location at Bangkok area 1	180,000	25,000	13.83	100.54
2	Customer Location at Ayutthaya	75,000	19,000	14.35	100.58
3	Customer Location at Bangkok area 2	85,000	14,500	13.66	100.4
4	Customer Location at Chonburi area 1	75,000	15,000	13.34	100.97
5	Customer Location at Chiang Mai	320,000	10,500	18.77	98.97
6	Customer Location at Chumphon	120,000	2,600	10.49	99.17
7	Customer Location at Chanthaburi	97,000	6,000	12.6	102.11
8	Customer Location at Songkhla	18,600	5,700	7.01	100.47
9	Customer Location at Khon Kaen	120,000	8,000	16.41	102.81
10	Customer Location at Kamphaeng Phet	130,000	11,500	16.46	99.53
11	Customer Location at Nakhon Sawan	160,000	10,000	15.69	100.12
12	Customer Location at Nakhon Si Thammarat	190,000	5,500	8.42	99.96
13	Customer Location at Narathiwat	135,000	3,700	6.42	101.81
14	Customer Location at Phitsanulok	150,000	5,200	16.44	102.79
15	Customer Location at Pathum Thani	55,000	4,500	14.09	100.6
16	Customer Location at Chonburi area 2	70,000	4,200	12.93	100.89
17	Customer Location at Rayong	75,000	4,100	12.68	101.24
18	Customer Location at Samut Sakhon	55,000	5,400	13.57	100.3
19	Customer Location at Surat Thani	180,000	5,000	9.12	99.32
20	Customer Location at Samut Prakan	40,000	2,300	13.6	100.86
21	Customer Location at Ubon Ratchathani	70,000	1,300	15.24	104.82
22	Customer Location at Udon Thani	95,000	5,300	17.38	102.75

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Rank	Address	Transportation cost (THB) Per Years	Number of boxes (Unit/Years)	Latitude	Longitude
23	Customer Location at Nong Khai	220,000	8,000	17.82	102.7
24	Customer Location at Tak	624,000	17,000	16.7	98.52
25	Customer Location at Chiang Rai	243,500	9,000	20.17	99.54
26	Customer Location at Trat	30,000	3,000	12.59	101.38

Table 2 shows lists of customer locations and product demands used for analyzing the center of gravity.

3.6 Cost of freight: The cost of freight from the new warehouse to the customer was calculated using a formula:

Freight cost = Freight cost per kilometer x Distance of delivery.

3.7 The selection of a new warehouse location was determined using hierarchical analysis technique which involves the creation of a priority chart of factors for decision making process. The decision-making method was based on Sameer and Duanne's (2020) study shown in Figure 2.
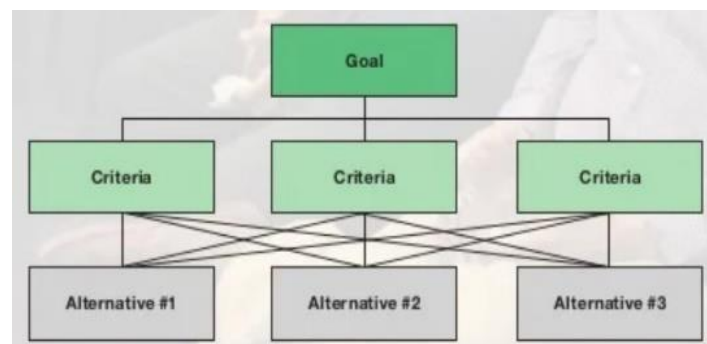

Figure 2 Selection Factor Diagram based on Sameer and Duanne's (2020) study

To select a suitable location for the new warehouse, the researchers used a location selection calculator on the website https://bpmsg.com/academic/ahp.php, which employs the AHP method. The next step was to identify the factors relevant to selecting a new location through interviews with the management team consisting of three people. These factors included transportation cost, labor, rent, and equipment. The researchers then entered this information into the website and presented the questions to the management team again, allowing them to assign weights to each factor and ultimately determine the optimal location for the new warehouse.

Analysis process with AHP program from the website is listed.

1) Enter optional factors.

2) Determine the weight of each factor.

3) Get results on the importance of each factor.

Figure 3 Step 1


Figure 4 Step 2

Figure 5 Step 3

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4. Results and Discussion

4.1 Results of location selection using the center of gravity technique.

After applying the Center of Gravity method, the researchers obtained the latitude and longitude of the new warehouse location as 14.5151 and 100.547, respectively. This location was determined to be in Bang Pahan District, Phra Nakhon Si Ayutthaya Province, as illustrated in Figure 6.
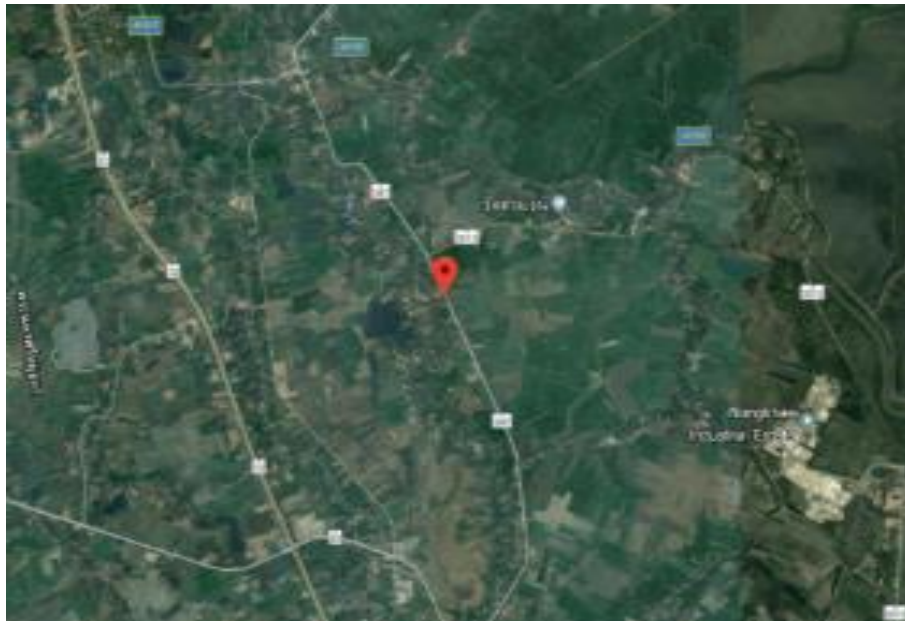
Figure 6 Location in Bang Pahan District, Phra Nakhon Si Ayutthaya Province

The Center of Gravity technique was used to determine potential locations for additional warehouses. The researchers identified two areas within a 200-kilometer radius of Bang Pahan District. The results were pointed out at Nong Khae District, and Saraburi Province. Based on the company۹s needs, Rama Road in Bangkok was also selected to be one of the choices. Therefore, four options were considered for the new warehouse location, listed below.

1) Lat Krabang District, Bangkok, original warehouse
2) Bang Pahun District, Ayutthaya
3) Nong Khae District, Saraburi
4) Rama 2 Road, Bangkok

To determine the most suitable location, the researchers considered various factors, including transportation costs, which were calculated based on the actual distance traveled (freight cost per kilometer multiplied by the distance traveled). Table 3 shows the cost of transporting products from all four warehouse locations to customers.

Table 3 Cost of Transporting Goods from 4 Locations to the Customer.

| Rank	Address	Lat Krabang	Bang Pahan	Nong Kae	Rama II
1	Customer Location at Bangkok area 1	189,000	30,807	40,049	99,609
2	Customer Location at Ayutthaya	224,000	123,228	99,951	41,076
3	Customer Location at Bangkok area 2	35,000	14,181	13,447	17,359
4	Customer Location at Chonburi area 1	301,000	246,015	229,194	157,702
5	Customer Location at Chiang Mai	48,000	38,142	35,208	6,161
6	Customer Location at Chumphon	128,000	83,716	85,281	7,041

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Rank	Address	Lat Krabang	Bang Pahan	Nong Kae	Rama II
7	Customer Location at Chanthaburi	72,000	62,274	58,753	41,149
8	Customer Location at Songkhla	65,100	64,181	61,442	43,985
9	Customer Location at Khon Kaen	4,825	48,997	15,110	8,361
10	Customer Location at Kamphaeng Phet	435,000	384,354	363,816	435,699
11	Customer Location at Nakhon Sawan	315,000	257,898	245,135	283,864
12	Customer Location at Nakhon Si Thammarat	48,000	50,684	48,631	45,550
13	Customer Location at Narathiwat	70,000	46,552	42,102	34,401
14	Customer Location at Phitsanulok	456,000	380,001	430,173	483,132
15	Customer Location at Pathum Thani	132,000	108,558	218,583	138,484
16	Customer Location at Chonburi area 2	273,000	169,731	204,059	235,844
17	Customer Location at Rayong	402,500	352,593	567,411	395,332
18	Customer Location at Samut Sakhon	272,000	309,659	303,008	261,443
19	Customer Location at Surat Thani	240,500	337,238	331,835	293,375
20	Customer Location at Samut Prakan	210,000	260,832	256,725	230,025
21	Customer Location at Ubon Ratchathani	108,000	241,370	238,240	218,876
22	Customer Location at Udon Thani	356,200	254,569	125,890	65,630
23	Customer Location at Nong Khai	351,560	452,620	254,639	256,389
24	Customer Location at Tak	123,605	125,630	85,260	178,610
25	Customer Location at Chiang Rai	256,360	235,689	425,360	189,642
26	Customer Location at Trat	168,520	136,587	256,831	163,520
	Sum	5,285,170	4,816,106	5,036,133	4,332,259

According to the data presented in Table 3, the transportation cost is lowest for the warehouse located on Rama 2 Road, followed by those in Bang Pahan, Nong Khae, and Lat Krabang, in that order.

4.2 The results of finding alternative factors for new warehouse locations.

To obtain a more realistic selection of the new warehouse location, the researchers used the transportation cost data obtained from their calculations. The management team was then allowed to determine the weight of the remaining factors using the AHP method to select the optimal location. The relative importance weight of each factor is presented in Figure 7.
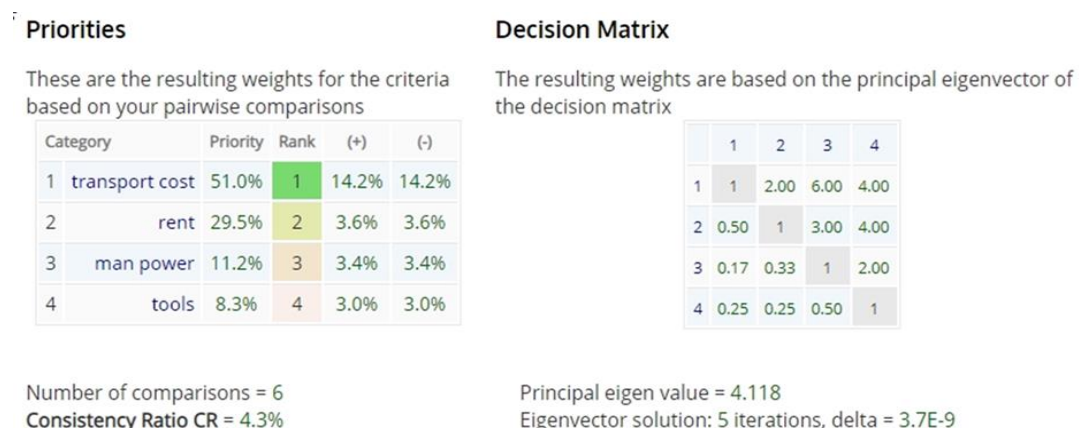
Figure 7 Weight results calculated from the AHP Program

Figure 7 displays the weightings assigned by the management team to the various factors affecting the selection of a new warehouse location. The team placed the highest priority on transportation costs,

which received a weighting of 51%, followed by rent (25.5%), labor (11.2%), and equipment (8.3%). Four potential locations, namely Lat Krabang, Bang Pahan, Nong Khae, and Rama 2, were evaluated based on a scale of 1 to 9, with the actual data used for comparison. Figure 8 displays the results of this analysis.

Figure 8 Results from Alternative Warehouse Assessments

The results obtained from the AHP program for the alternative warehouse locations are presented in Figure 8, which indicates that the optimal location is on Rama 2 Road, followed by Nong Khae District, Bang Pahan District, and Lat Krabang District, in that order.

4.3 Result of transportation cost from new warehouse to customer.
Table 4 presents a comparison of transportation costs for the old Lat Krabang warehouse and the new Rama 2 warehouse.

Table 4 Comparison of shipping costs between existing warehouse and new alternative warehouse.

Truck size	Ladkrabang warehouse (old)	Warehouse Rama 2 (new)	reduce%
6 wheel truck	5,285,170	4,332,259	18.02

The data shows that the cost of delivering goods from the Lat Krabang warehouse to the customers would be 5,285,170 baht, whereas the cost of transportation from the new Rama 2 warehouse would be 4,332,259 baht. This represents a reduction in costs of 18.02%.

5. Conclusion

After using the Center of Gravity Method, a suitable location was identified in the Bang Pahan District, Phra Nakhon Si Ayutthaya Province with a longitude of 14.5151 and a latitude of 100.547. A radius of 200 kilometers was then measured from this location, which led to the identification of a second potential location in Nong Khae District, Saraburi Province. However, the company team preferred a specific location on Rama 2 Road, resulting in four potential locations being considered: Bang Prahan District, Nong Khae District, Rama 2 Road, and the original Lat Krabang warehouse. The importance of each factor in the selection decision was analyzed using the hierarchical analysis technique, with transportation costs, rental costs, labor costs, and equipment costs being given weightings of 51%, 29.5%, 11.2%, and 8.3%, respectively. These weightings were then used as alternative factors in the AHP program available on a website to allow the management team to determine the most suitable location. The resulting order of locations was Rama 2 Road, Nong Khae District, Bang Prahan District, and Lat Krabang warehouse. The cost of freight was calculated by comparing the new Rama 2 Road warehouse with the old Lat Krabang warehouse, revealing a reduction in transportation costs of 18.02%. Future research could explore additional alternative factors and incorporate more statistical data, such as economic indicators like inflation and unemployment rates.

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