# Determination distribution center location of the carton box product using the Center of Gravity, Analytical Hierarchy Process and Transportation method

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## Abstract

The carton box industry contributes to the second largest market share (28%) in Indonesia (Indonesian Packaging Assosiation et al., 2019). Strategies in maintaining service level commitment to customers are not only from the aspect of timeliness, quality, and quantity but from the aspect of minimum transportation costs. The purpose of this research is to minimize transportation costs by determining the appropriate location of the Distribution Center (DC) using Center of Gravity (COG), Analytical Hierarchy Process (AHP) and Transportation Saving Matrix method. Calculation of the COG method obtained the DC location at the coordinate point: X:-6.314311 and Y:106.986493 located at the Bantar Gebang Market Bekasi. The AHP method selected as the DC location was location A with a weight of 0.3551, followed by location B with a weight of 0.3240, and finally location C with a weight of 0.3210. Transportation Saving Matrix method showed transportation costs was location A with a nominal value of 473.21 (K USD), location C with a nominal value of 509.17 (K USD), and location B with a nominal value of 518.96 (K USD). The conclusion that the appropriate location A (selected DC) obtained minimum transportation costs.

Keywords: distribution center location, center of gravity, Analytical Hierarchy Process, transportation cost.

## 1. Introduction

Packaging is the identity of a product inside (Ramadhan et al., 2019). The packaging design will influence consumers to make choices about buying the product (Fatmayanti, 2016). Packaging is an important focus of interaction and communication between products and buyers (Charif Hamdar, 2018). According to Indonesian Packaging Assosiation et al., (2019) market share packaging based on its type, from the largest in sequence flexible packaging (42%), paperboard packaging (28%), rigid plastic packaging (14%), woven polyolefin sack (6%), metal can packaging (5%), glass container packaging (3%), and other types (2%). This case study was conducted on a company with the second largest market share of paperboard packaging. Its production capacity reaches 30,000 tons per year. According to company data, in the last three years the volume of orders has continued to increase, so the need for the number of transportation fleets has also increased, thus the transportation cost budget has also been higher. The order volume and demand for transportation fleets are shown in Figure 1. With this increase in orders, new problems arose including problems with warehouse space, loading and unloading areas, parking lots, and loading and unloading queues. Parking space is a problem that is very concerned about transportation (Lizbetin & Bartuska, 2020). In order for the distribution of goods to run smoothly, facilities and facilities are needed, including transportation, storage of goods, loading and unloading, handling, packaging, parking lots, distribution processes, and information processing (He et al., 2018).

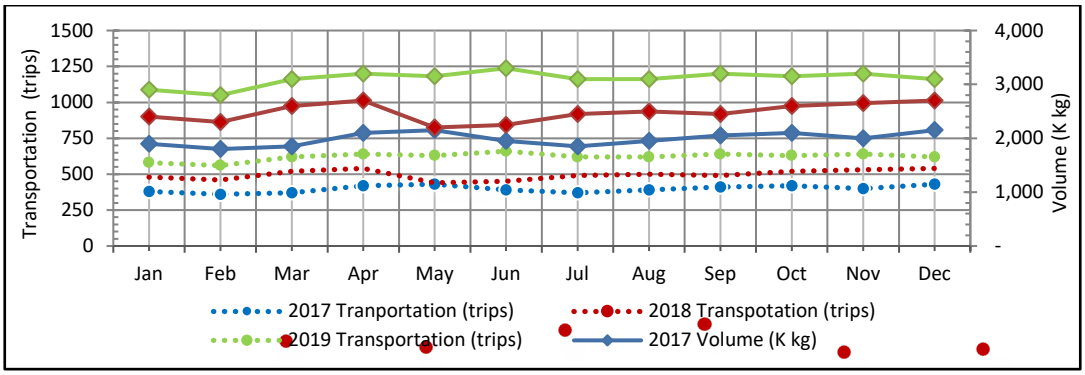


Figure 1. Order volume and demand for transportation fleets 2017-2019

In an effort to maintain service level commitment to customers not only from the aspect of timeliness in the product distribution process, of course also from the aspect of minimum transportation costs, an appropriate strategic plan is needed. The supply chain plays an important role in increasing the level of service to customers because the biggest cost of a product is in the supply chain (Ikatrinasari et al., 2020). Referring to research that the right DC location will increase the level of service to customers and save on transportation costs. According L. Li dan Zhang, (2017b) that DC location is an important aspect in increasing the efficiency of distribution of products and services towards customer satisfaction. The right DC location decision is an important infrastructure in product distribution, and saves logistical costs. DC location plays an important role in a logistic system (Zhang, 2019). Logistic location points are the main thing in solving location facility problems (Essaadi et al., 2016). The warehouse location can solve the problem of demand needs and can minimize distribution costs (Abo-Elnaga et al., 2017). The logistics center can influence the distribution model and transportation network as long as it is still in the network structure (Vieira & Luna, 2016). Logistics systems and distribution supplies to speed up delivery times, as in the e-commerce business. Therefore it is necessary to choose a warehouse location or DC to maximize delivery efficiency (Kudláčková & Chocholáč, 2017). Delivery of goods from DC locations has a major influence on logistic activities. So that the right DC location will lower transportation costs and operational costs (Gao, 2018). Fixed costs as well as variable costs are strongly influenced by DC location. The right DC location will improve the distribution system and logistics management efficiency (Irwanto & Hasibuan, 2018).

Based on several studies, the COG method can be used to determine a DC location (Cahyadi & Aulia, 2018; Irwanto & Hasibuan, 2018; Nutthamon et al., 2019; Rully & Aldenia, 2018; Sanjaya et al., 2019; Sopha et al., 2018; Sudrajat, 2019). Another supporting method is AHP (Durak et al., 2017; Harwati & Utami, 2018; Kara, 2019; Ližbetin, 2019; Susanto et al., 2018; Uyanik et al., 2020). Transportation Saving Matrix method will reduce transportation cost (Ahmad & Muharram, 2018; Haniza et al., 2019; Hudori & Madusari, 2017; Pattiasina et al., 2018; You et al., 2021).

## 2. Literature Review

### 2.1 COG

Research result Irwanto dan Hasibuan, (2018) using the COG method, the selected DC location is at coordinates (-6.257108; 106.7315), the residential area of the East Jurangmangu sub-district. The available area according to the warehousing regulations does not allow the construction of DCs in the residential area of Jurangmangu Bintaro village, an empty area is available about 4 km to the west of the location of the T8 Pakulonan Alam Sutera warehouse area, South Tangerang City. Researcher Sanjaya et al. (2019) using COG found the best location at coordinates (98.888504; 3.419406) as the proposed DC location, i.e. the results obtained show that total distribution costs can be reduced by 2.39% per day for animal feed products in Deli Serdang. Next is the researcher Cahyadi dan Aulia (2018) determine the location of the Portland Composite Cement Cement Distribution Warehouse shows that the optimal distribution center point is located at coordinates X017 = 30.85 and Y017 = 35.88 with the best distribution system is if the company uses 19 tronton vehicle or 13 trailers. If this decision is implemented, the company will pay a total cost of Rp. 299,491,892 whereas if the third party carries out the costs incurred is Rp. 752,752,000. Furthermore, researchers Sopha et al. (2018) find the best location in Berbah Sleman with the aim as DC. Researchers Nutthamon et al., (2019) found two optimal DC locations, Dong Khoi in Phetchabun Province and Nong Sai in Suratthani Province. Researchers Rully dan Aldenia, (2018) From the results of calculations using the COG method, it can be determined the location of the new warehouse with coordinates X = 122, Y = 22, which is located in Solo. With the location of the new

warehouse, it will minimize the mileage and transportation costs from the original warehouse in Bogor to the new warehouse located in Solo. Then Sudrajat, (2019) find the location of branch offices with the COG method approach to determine location options based on the coordinates of the customer PT. Unilab Perdana. The results showed that the coordinate center point at 6 ° 27 '15.0516' S and 107 ° 20 '2.9364' 'E, which is located in Mulyasejati, Ciampel, Kota Karawang Regency, West Java Province.

### 2.2 AHP

Researcher Durak et al. (2017) finding the best selection results from four suitable alternative warehouse locations in a row are Bolu, Düzce, Kocaeli, and Sakarya. Researcher Kara (2019) the results show that of the 81 sustainable alternative locations in Eskisehir province, the best are Çanakkale, Bursa, İzmir, Bilecik, Giresun, Edirne, Ankara, Rize and Manisa. Researcher Harwati dan Utami, (2018) from three alternative locations, Station (49.8%), Airport (38.5%), and Terminal (11.7%). In general, the best alternative location for product marketing locations is the station location. Then Susanto et al., (2018) alternative location selection for lubricant warehouse alternative locations PT GAC Samudra Logistics (0.353), PT Wiraswasta Gemilang Indonesia (0.344), and PT Puninar Jaya (0.304). Ližbetin, (2019) minimizes vehicle travel distance, with the closest distance to a location 150 km from the intermodal transport terminal. The AHP method is the most popular then the TOPSIS and ELECTRE methods (Uyanik et al., 2020; )

### 2.3 Transportation Saving Matrix Method

Transportation problem is an important issue from various studies. This transportation requires a minimum cost in serving the distribution of various products to meet customer satisfaction levels (Hosseini, 2017). The transportation model plays an important role in logistics and supply chain management activities in order to reduce costs and service levels (Malviya & Jain, 2018). Reducing the cost of transportation is a very interesting challenge because of the current lack of supply structure (Granda & Villarreal, 2018). Transportation problems play an important role in logistics and can create minimum costs when transporting goods from one place to another (Kavitha & Srinivasan, 2018). The Saving Matrix Method is a method to minimize distance, time, and cost to produce efficient shipping routes (Pattiasina et al., 2018). Damayanti et al., (2020) using the saving matrix method obtained the results of route savings from 18 to 9 new routes, and obtained distance savings of 752.2 km or 45.91% from the initial distance of 1638.3 km to 886.2 km. Muhammad et al., (2017) using the saving matrix method, it was obtained 2 new routes covering route 1 with a distance of 474 km and route 2 of 305.8 km with a total distance of 779.8 km. Transportation cost savings from the original route were Rp. 907,000 to Rp. 715,000 on the new route. Sutoni and Apipudin, (2019)with the saving matrix method, the results of distance and cost savings are obtained from the original 8 routes to 4 routes and the distance savings of 39.1 km. Transportation cost savings of Rp. 12,825,120 or 50% per month.

## 3. Methods

COG method for determining the coordinates of a DC location. AHP method is used to make a choice decision from the alternative DC location if the DC location of the COG method is not feasible. The transportation method is to know the comparison of the aspects of transportation costs from factory locations, DCs, and alternative locations, so that the minimum transportation costs and nominal transportation cost savings are known. To determine the location of the coordinates of the COG method using the following mathematical formula:

$$\mathrm{Cx} = \frac{\sum_i \mathrm{dix\ wi}}{\sum_i \mathrm{wi}} \tag{1}$$

$$\mathrm{Cy} = \frac{\sum_i \mathrm{diy\ wi}}{\sum_i \mathrm{wi}} \tag{2}$$

Where:
Cx = coordinate x DC location
Cy = coordinate y DC location
dix = coordinate x location of the customer-i
diy = coordinate y from location of the customer-i
wi = volume of delivery to customer-i (kg)

The AHP method has been applied in various types of industries in determining a priority selection in which in determining aspects of the criteria, input and assessment are obtained from experts (Hutagalung & Hasibuan, 2019). The formation of a hierarchical structure of criteria and sub criteria in determining DC locations by way

of discussions with experts and referring to previous research. The hierarchical structure in determining DC locations is shown in Figure 2. References to previous studies, criteria and sub-criteria in determining DC locations are shown in Table 1. According to Saaty, (2012) The grading scale on the pairwise comparison matrix has a priority value of 1-9. As an example of the comparison between the two criteria X and Y is described in Table 1.

Table 1. The priority value scale of the pairwaise

| Score | Descreptions |
|---|---|
| 1 | The two criteria are **equally important** |
| 3 | Criterion X is **slightly more important** than criterion Y |
| 5 | Criterion X is **more important** than criterion Y |
| 7 | Criterion X is **very important** compared to criterion Y |
| 9 | Criterion X is **absolutely more important** than criterion Y |
| 2, 4, 6, 8 | The level of importance falls between odd values |

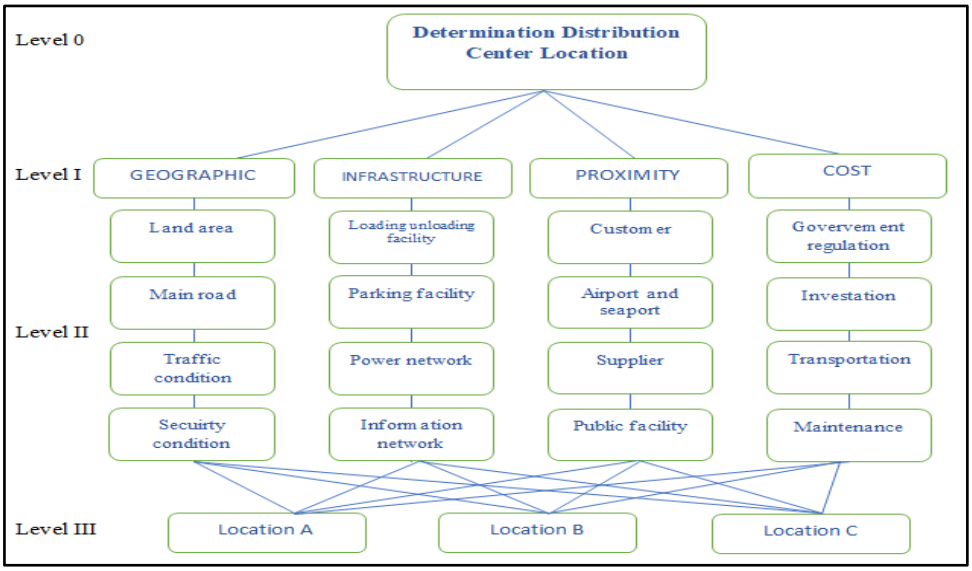


Figure 2. Hierarchical structure in determining DC location

This is to determine the consistency of the pairwise comparison matrix results from both individual and group respondents (Analytic & Process, 1980; Mfondoum Ngandam et al., 2019) it is known what is known as the Consistency Ratio (CR) using the formulas (3) and (4). If CR <10%, it means the respondent's questionnaire results are consistent, if CR> 10% it is said to be inconsistent and the questionnaire must be repeated.

Consistency Index value (CI):

$$CI = (\lambda max - n) / (n - 1) \quad (3)$$

Consistency Rasio value (CR):

$$CR = CI / RI \quad (4)$$

Where:
CI = Consistency Index
CR = Consistency Rasio
RI = Random Index
N = Matrix Order
λmax = Eigen Value

Table 2. Criteria and sub criteria in determining DC locations and references to previous research

| Criteria/Sub criteria | | Reference | Criteria/Sub criteria | | Reference |
|---|---|---|---|---|---|
| **Geographic** | | (Bagum et al., 2014);(Komchornrit, 2017);(Georgise et al., 2020) | **Infrastructure** | | (Susanto et al., 2018);(Anderluh et al., 2020);(Georgise et al., 2020) |
| G1 | Land area | (Pham et al., 2017);(Anderluh et al., 2020);(Georgise et al., 2020) | I1 | Loading unloading facility | (Bagum et al., 2014);(Komchornrit, 2017); (Anderluh et al., 2020) |
| G2 | Main road | (Guler & Yomralioglu, 2020)(Bagum et al., 2014);(Komchornrit, 2017);(Starzl, 2017);(Pham et al., 2017);(Han et al., 2020) | I2 | Parking facility | (Guler & Yomralioglu, 2020);(Susanto et al., 2018);(Wang et al., 2019);(Han et al., 2020) |
| G3 | Traffic condition | (Pham et al., 2017);(Wang et al., 2019) | I3 | Power source | (Bagum et al., 2014);(Han et al., 2020) |
| G4 | Security condition | (Sopha et al., 2018);(Anderluh et al., 2020) | I4 | Information network | (Starzl, 2017);(Snieska et al., 2019) |
| **Cost** | | (Bagum et al., 2014);(Sopha et al., 2018) | **Proximity** | | (Sopha et al., 2018); (Bagum et al., 2014);(Susanto et al., 2018);(Georgise et al., 2020) |
| C1 | Government regulation | (Bagum et al., 2014);(Bakhtiar, 2017);(Han et al., 2020) | P1 | Customer | (Bagum et al., 2014);(Komchornrit, 2017);(Sopha et al., 2018);(Starzl, 2017);(Pham et al., 2017);(Susanto et al., 2018) |
| C2 | Investation | (Guler & Yomralioglu, 2020)(Bagum et al., 2014);(Sopha et al., 2018);(Pham et al., 2017);(Anderluh et al., 2020) | P2 | Airport and seaport | (Guler & Yomralioglu, 2020);(Komchornrit, 2017);(Sopha et al., 2018);(Starzl, 2017);(Pham et al., 2017) |
| C3 | Transportation | (Bagum et al., 2014);(Komchornrit, 2017);(Starzl, 2017);(Pham et al., 2017);(Susanto et al., 2018);(Anderluh et al., 2020);(Bakhtiar, 2017) | P3 | Supplier | (Bagum et al., 2014);(Sopha et al., 2018);(Bakhtiar, 2017) |
| C4 | Maintenance | (Sopha et al., 2018);(Susanto et al., 2018) | P4 | Public facility | (Guler & Yomralioglu, 2020);(Sopha et al., 2018);(Starzl, 2017);(Susanto et al., 2018);(Han et al., 2020) |

The Transportation Saving Matrix Method processes data in 2019, which consists of 87 customers. From this data, a distance matrix is made from the factory location, location A, location B, and location C to 87 customers and the distance between customers. The distance matrix from 87 customers is a matrix order of 87x87, so for one factory location there are 7.569 distance data. After obtaining the distance matrix, a distance savings matrix is made for each location, the calculation of the Saving Matrix uses the following formula:

$$S(x,y) = D(F,x) + J(F,y) - D(x,y) \tag{5}$$

Where:
S (x, y) = Distance Saving
D = Distance
F = Factory
x = 1st customer
y = 2nd customer

The next step is to rank the distance savings score starting from the highest, to determine the route starting with the highest ranking. Determination of the route starts from the ranking of the highest distance savings score as a reference and is adjusted to the type and capacity of the truck, the route of combining the nearest neighbor location (nearest neighbor method). After obtaining a route from each alternative location, the calculation of transportation costs based on the distance and volume of each customer refers to the tariff for the type of trucks used.

## 4. Results and Discussion

### 4.1 DC Location

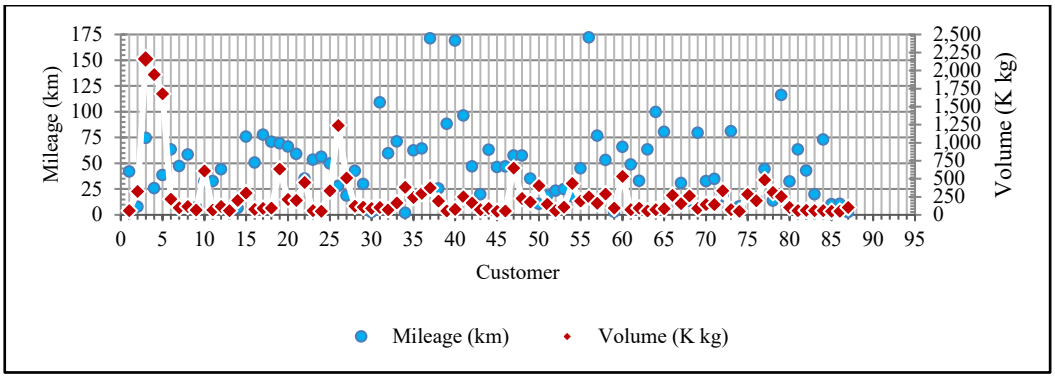


Figure 3. Volume and delivery distance to customers

Referring to Figure 3. and formulas (1), (2) the COG method, the coordinates of the DC location are determined as follows:

$$Cx = \frac{\sum_i dix\ wi}{\sum_i wi} \quad = -142{,}379{,}184.44 / 22{,}548{,}648 = -6.314311$$

$$Cy = \frac{\sum_i diy\ wi}{\sum_i wi} \quad = 2{,}412{,}400{,}782 / 22{,}548{,}648 \quad = 106.986493$$

The recommended DC location is at the coordinate point: -6.314311,106.986493 located right at the location of Bantar Gebang Market with the address Bekasi, RT.004 / RW.001, Bantargebang, Bks City, West Java 17151. Refer to research Sanjaya et al. (2019) using the COG method, the results obtained at the new coordinates as the location of the proposed distribution center, namely (98.888504; 3.419406). Furthermore, researchers Sopha et al. (2018) find the best location in Berbah Sleman with the aim as DC.

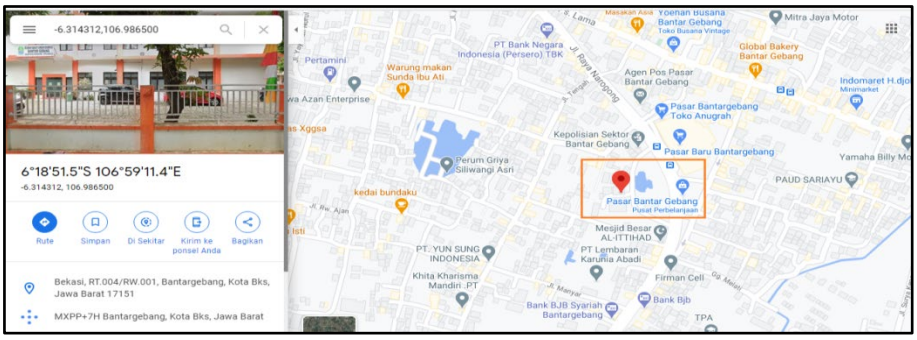


Figure 4. The DC location of the COG method results

Because the DC location is found to be not feasible, it is necessary to find an alternative location. In determining the most optimal and best alternative location among the three alternative locations will be done by making a decision using the AHP method (Amchang & Song, 2018).

From the search results, three alternative warehousing locations that are closest and feasible are found as follows:

1. Location A: ADIB Cold Logistics area Coordinate points: X: -6.329003, Y: 106.978517, Jl. Raya Narogong No.50, RT.003 / RW.005, Cikiwul, Bantargebang, Kota Bks, West Java 17152, 2.2 km from DC.
2. Location B: Mitradaya Bizpark Warehouse Complex Coordinate points: X: -6.3478578, Y: 106.981710, Jl. Pangkalan 5 No. 7500, RT.002 / RW.005, Ciketing Udik, Bantargebang, Kota Bks, West Java 17153, is 4.6 km from DC.
3. Location C: Rent Warehouse at Daiwa Logistics Center Cileungsi Coordinate points: X: -6.3729305, Y: 106.9729472, Jl. Pangkalan 10 No.113, Limus Nunggal, Kec. Cileungsi, Bogor, West Java 16820, is 7.2 km from DC.


Figure 5. Alternative locations in DC determination

## 4.2 Determination of DC location

Referring to the Consistency Ratio (CR) formula (3) and (4), the highest CR result is 4.5743% on Alternative location and cost criteria, so it can be concluded that all CR values <10% are stated to be consistent. The pairwise comparison CR is shown in Figure 6.

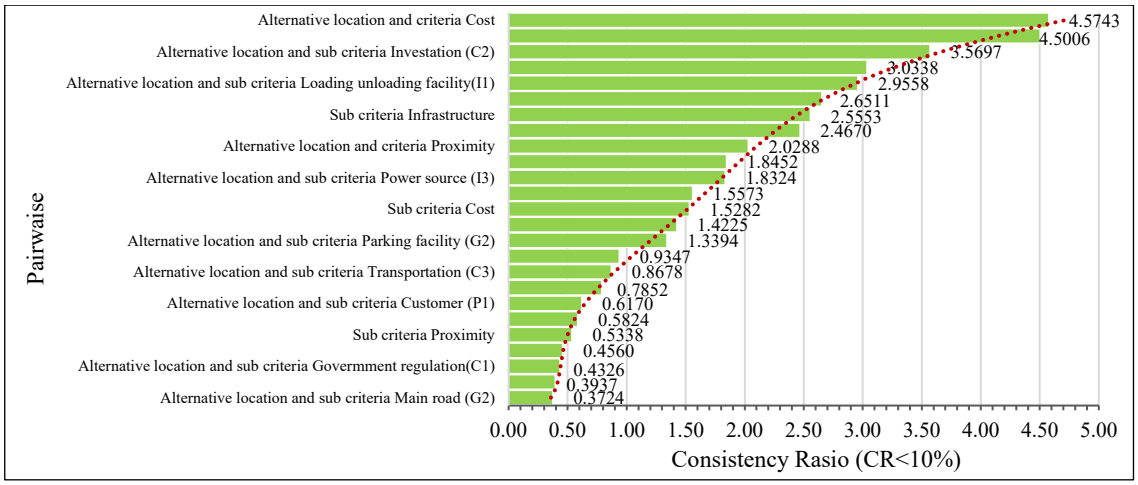


Figure 6. Consistency Ratio pairwise

Table 3. Value of priority vector and global priority in determining DC location

| LEVEL I | | LEVEL II | | | LEVEL III | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Priority Vector location | | | Global Priority location | | |
| Criteria | PV | Sub criteria | PV | Weight Sub criteria | A | B | C | A | B | C |
| Geographic | 0.2531 | Land area (G1) | 0.2195 | 0.0556 | 0.2618 | 0.3974 | 0.3408 | 0.0145 | 0.0221 | 0.0189 |
| | | Main road (G2) | 0.3510 | 0.0888 | 0.3972 | 0.3159 | 0.2869 | 0.0353 | 0.0281 | 0.0255 |
| | | Traffic condition (G3) | 0.1594 | 0.0403 | 0.4095 | 0.3415 | 0.2490 | 0.0165 | 0.0138 | 0.0100 |
| | | Security condition (G4) | 0.2701 | 0.0684 | 0.3141 | 0.4198 | 0.2661 | 0.0215 | 0.0287 | 0.0182 |
| Infrastructure | 0.2229 | Loading unloading facility (I1) | 0.3382 | 0.0754 | 0.4452 | 0.2458 | 0.3090 | 0.0336 | 0.0185 | 0.0233 |
| | | Parking facility (I2) | 0.2815 | 0.0628 | 0.4196 | 0.3194 | 0.2610 | 0.0263 | 0.0200 | 0.0164 |
| | | Power source (I3) | 0.2098 | 0.0468 | 0.3342 | 0.3926 | 0.2732 | 0.0156 | 0.0184 | 0.0128 |
| | | Information network (I4) | 0.1705 | 0.0380 | 0.2519 | 0.3167 | 0.4314 | 0.0096 | 0.0120 | 0.0164 |
| Proximity | 0.3422 | Customer (P1) | 0.4252 | 0.1455 | 0.4377 | 0.3230 | 0.2393 | 0.0637 | 0.0470 | 0.0348 |
| | | Airport and seaport (P2) | 0.1919 | 0.0657 | 0.2431 | 0.3246 | 0.4323 | 0.0160 | 0.0213 | 0.0284 |
| | | Supplier (P3) | 0.2538 | 0.0868 | 0.4377 | 0.2415 | 0.3208 | 0.0380 | 0.0210 | 0.0279 |
| | | Public facility (P4) | 0.1291 | 0.0442 | 0.2359 | 0.3182 | 0.4459 | 0.0104 | 0.0141 | 0.0197 |

| LEVEL I | | LEVEL II | | | LEVEL III | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Priority Vector location | | | Global Priority location | | |
| Criteria | PV | Sub criteria | PV | Weight Sub criteria | A | B | C | A | B | C |
| Cost | 0.1819 | Government regulation (C1) | 0.1590 | 0.0289 | 0.2181 | 0.2997 | 0.4822 | 0.0063 | 0.0087 | 0.0139 |
| | | Investation (C2) | 0.2391 | 0.0435 | 0.1878 | 0.3295 | 0.4827 | 0.0082 | 0.0143 | 0.0210 |
| | | Transportation (C3) | 0.4647 | 0.0845 | 0.4066 | 0.3279 | 0.2655 | 0.0344 | 0.0277 | 0.0224 |
| | | Maintenance (C4) | 0.1372 | 0.0250 | 0.2106 | 0.3346 | 0.4548 | 0.0053 | 0.0084 | 0.0114 |
| | | | | | **Total Global Priority** | | | **0.3551** | **0.3240** | **0.3210** |

Referring to Table 3. the comparison of global priority values from the three alternative locations shows that the one with the highest weight is location A with a value of 0.3551, followed by location B with a weight of 0.3240, and finally location C with a weight of 0.3210. The global priority value of the three alternative locations is more clearly shown in Figure 7. According to global priority value, location A was selected as a optimal DC location.

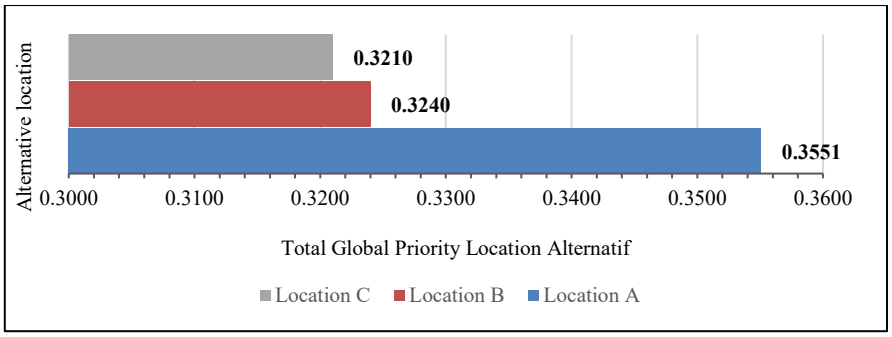


Figure 7. Total global priority value for alternative locations in DC determination

### 4.3 Comparison transportation cost COG-AHP and Saving Matrix Method

The transportation cost of the COG-AHP method is calculated by referring to Figure 3., product delivery is carried out one route from the factory location, location A, location B, location C directly to the customer without a combined route. Transportation Saving Matrix Method cost is the cost of transportation for the combined route of several of the closest customers (nearest neighbor method). The comparison of the transportation costs of the COG-AHP method and the Transportation Saving Matrix Method is shown in Figure 8.

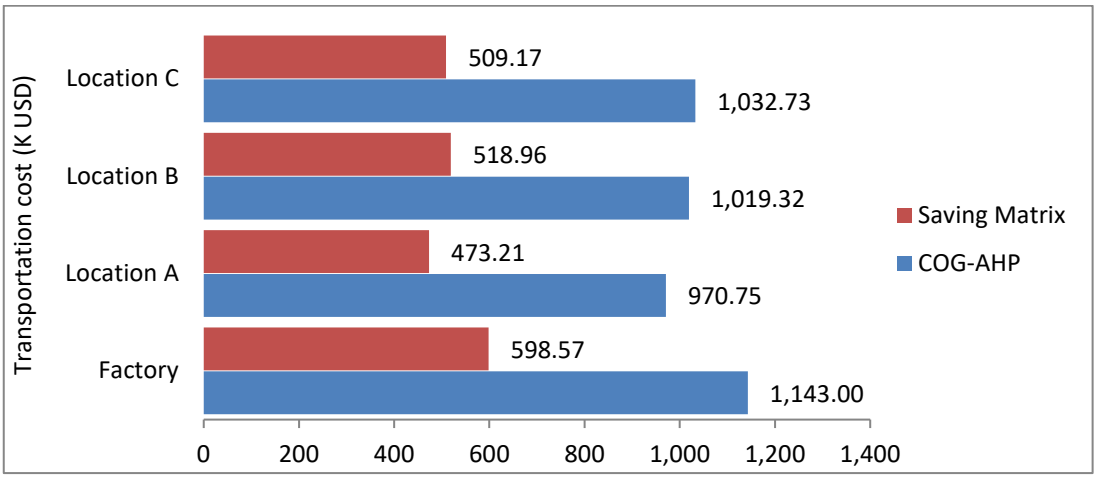


Figure 8. Transportation costs COG-AHP and Saving Matrix Method

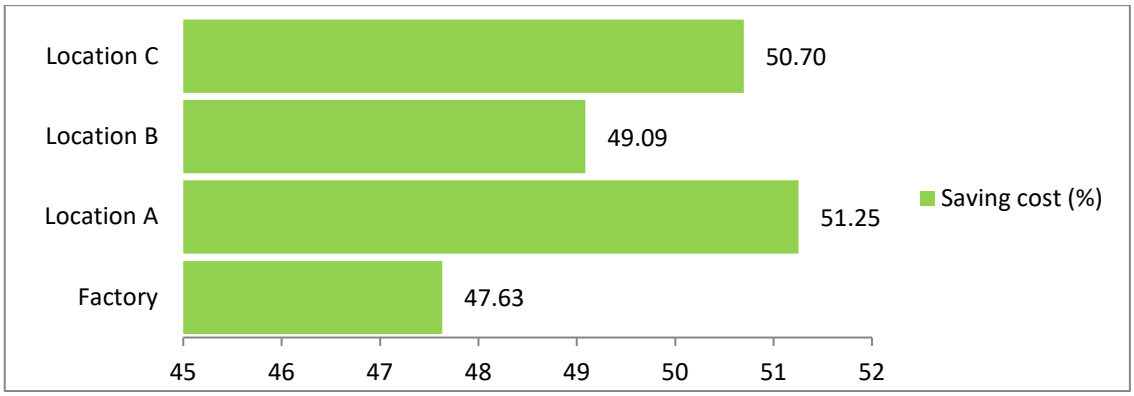


Figure 9. Transportation Saving Matrix Method savings cost

According Figure 8., COG-AHP Method, the minimum cost of transportation for location A with a nominal value of 970.75 (K USD), location B with a nominal value of 1,019.32 (K USD), and location C with a nominal value of 1,032.73 (K USD). Transportation Saving Matrix Method obtained minimum transportation costs was location A with a nominal value of 473.21 (K USD), location C with a nominal value of 509.17 (K USD), and location B with a nominal value of 518.96 (K USD). Accordig Figure 9., the percentage saving cost (saving matrix method) was location A 51.25%, location C 50.70%, location B 49.09%, factory 47.63%. Both of COG-AHP and Saving Matrix location A was selected as DC location. So it can be concluded that the appropriate DC location can save on transportation costs (Hosseini, 2017; Malviya & Jain, 2018)

According to references from previous studies including, (Perdana et al., 2020) with the Saving Matrix method, the company's distribution costs from Rp. 18,940,924 per month to Rp. 16,302,392 per month and with the nearest neighbor algorithm, saving you 16% of the cost proposed by the company. Suparjo, (2017), using the Saving Matrix method saves the number of distribution routes from 20 routes to 10 routes. Savings in Mileage from 3890 km to 2238 km (42.47%).the warehouse location can solve the problem of demand needs and can minimize the cost of distribution (Abo-Elnaga et al., 2017). The logistics center can influence the distribution model and transportation network as long as it is still in the network structure (Vieira & Luna, 2016). Logistics systems and distribution supplies to speed up delivery times, as in the e-commerce business. Therefore it is necessary to choose a warehouse location or DC to maximize delivery efficiency (Kudláčková & Chocholáč, 2017). Delivery of goods from DC locations has a major influence on logistic activities. So that the right DC location will lower transportation costs and operational costs (Gao, 2018). Fixed costs as well as variable costs are strongly influenced by DC location. The right DC location will improve the distribution system and logistics management efficiency (Irwanto & Hasibuan, 2018).

## 5. Conclusion

### 5.1 Conclusion

1. The COG method
   The recommended DC location is at the coordinate point: -6.314311,106.986493 located right at the location of Bantar Gebang Market with the address Bekasi, RT.004 / RW.001, Bantargebang, Bks City, West Java 17151.
2. AHP method
   The global priority value of the three alternative locations that has the highest weight is location A with a value of 0.3551, followed by location B with a weight of 0.3240, and finally location C with a weight of 0.3210. The minimum cost of transportation for location A with a nominal value of 970.75 (K USD), location B with a nominal value of 1,019.32 (K USD), and location C with a nominal value of 1,032.73 (K USD). Location A is determined as the selected DC location and is the best alternative location.
3. Transportation Saving Matrix method
   Obtained minimum transportation costs was location A with a nominal value of 473.21 (K USD), location C with a nominal value of 509.17 (K USD), and location B with a nominal value of 518.96 (K USD). Location A is determined as the selected DC location and is the best of minimum transportation cost.

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