

Determination of pharmaceutical industrial distribution center location using center of gravity method: Case study at PT JKT

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Abstrak. *Distribution Center memiliki peranan yang penting dalam sistem Supply Chain Management suatu industri untuk memudahkan dalam manajemen kebutuhan logistik sehingga dalam proses distribusi produk menjadi lancar dan cepat. Tujuan dari penelitian ini adalah untuk menentukan lokasi terbaik yang dapat digunakan dalam menentukan lokasi Distribution Center. Penelitian ini menggunakan metode Center of Gravity dalam menghitung lokasi optimal yang akan menjadi pertimbangan. Dari hasil penelitian ini, perhitungan dengan menggunakan metode Center of Gravity didapatkan titik lokasi Distribution Center yang terpilih adalah pada koordinat (-6.257108; 106.7315), yaitu kawasan pemukiman warga kelurahan Jurangmangu Timur. Area yang tersedia tersebut sesuai aturan pergudangan tidak memungkinkan dibangunnya Distribution Center pada kawasan pemukiman warga kelurahan Jurangmangu Bintaro, area kosong tersedia sekitar 4 KM ke arah barat Lokasi kawasan pergudangan T8 Pakulonan Alam Sutera Kota Tangerang selatan, kawasan ini menyediakan pergudangan dengan menawarkan konsep gabungan pusat perdagangan, sarana perkantoran dan food and beverage plaza yang terintegrasi dengan hunian memiliki kelebihan-kelebihan sebagai Distribution Center. Lokasi Distribution Center baru yang disarankan ini lokasinya berada 14 KM sebelah selatan dan 13 KM dari utara gudang yang sudah tersedia, lokasi baru yang disarankan lebih mendekati dan berada di antara lokasi area ditribusi saat ini.*

Kata kunci: center of gravity, distribution center, industri farmasi, lokasi.

Abstract. *Distribution center has an important role in an industry's supply chain management to facilitate logistics management requirements so that the product distribution process becomes smooth and fast. The purpose of this study is to determine the best location that can be used in determining the location of the distribution center in pharmaceutical industry. This research uses the center of gravity method to calculate optimal location that will be considered. From the results of this study, the calculation using the Center of Gravity method found that the location of the selected distribution center was at the coordinates (-6.257108; 106.7315), the settlement area of the village of Jurangmangu Timur. The available area according to warehousing rules does not allow the construction of the distribution center in residential area of Jurangmangu Bintaro village, empty area is available around 4 KM west of T8 Pakulonan Alam Tangerang Selatan, this area provides warehousing by offering a combined trading center, office and integrated food and beverage plaza with shelter have advantages as distribution center. The new proposed distribution center location is located 14 KM south and 13 KM from the north of the available warehouse, the new suggested location is closer to and located between current distribution locations.*

Keywords: center of gravity, distribution center, pharmaceutical industry.

1 Introduction

One of the factors driving the growth of the pharmaceutical industry is the widespread reach of participation in the Jaminan Kesehatan Nasional (JKN) and Badan Penyelenggara Jaminan Sosial (BPJS) Kesehatan (sindonews.com, 2017). This is also supported by the government to make the pharmaceutical industry as one of the priority industries in Indonesia. One of them is by launching the roadmap of the pharmaceutical and medical devices industry at the end of February 2017 (bisnis.com, 2017). According to

the International Pharmaceutical Manufacturers Group (IPMG), estimates that growth will continue is predicted to be 10% in 2017. The government is through the Regulation of the Minister of Health of the Republic of Indonesia Number 1148/MENKES/PER/VI/ 2011 concerning Good Drug Distribution or Good Distribution Practice (GDP) and applies to aspects of procurement, storage, and distribution including the return of drugs and or drug ingredients in the distribution chain.

In its development pharmaceutical distribution companies continue to grow, both PMA, BUMN and domestic investment, however, Indonesia has a national logistical problem that can be grouped into seven groups, namely the problem group of commodities, infrastructure, providers of logistics, human resources, information and communication technology, regulation and institutions. Infrastructure groups, in Indonesia have not been managed in an integrated, effective and efficient manner, especially warehousing infrastructure or Distribution Centers (kompas.com, 2010). Distribution center is a place that functions as a main commodity supporter to support the smooth flow of goods between regencies/cities and between provinces for domestic and/or foreign market objectives (Ministry of Trade of the Republic of Indonesia, 2013), or in other words distribution center of a logistics facility which is used to collect various items originating from various regions before distributing places that need it. The benefits of having a distribution center include ensuring the availability of goods, increasing the stability of the price of goods, being able to absorb new workers, and for the central government to become a means of regulating, controlling and distributing commodities. Distribution center facilities have an important role in city logistics and supply chains in general. One of the functions of the distribution center is to facilitate the product distribution process. According to Huang et al. (2011), the distribution process is the main key to the success of logistics and supply chain activities. So that the existence of a distribution center becomes very important. Distribution centers that are in the right location will be able to reduce transportation costs and improve the efficiency of the logistics system (Cui and Li, 2004). Distribution center location selection can reach all customers who are currently served by the parent warehouse. Determination of a strategic location is very important. Location greatly affects costs, both fixed costs and variable costs. Location has a major influence on company profits (Render, 2001).

The current phenomenon of principal pharmaceutical companies is so easy to move one distribution company to another distribution company to partner in a business that is truly suitable and able to meet the targets that have been charged. This condition is certainly a challenge for distribution companies to be able to provide good service so that they can partner forever. Various studies have reported that the use of the Center of Gravity method can provide information on determining the location of a new warehouse that is more optimal that can minimize costs. Previous research, Dedy Oktrianto (2017), the use of the Center of Gravity method can determine the location of waste collection of hazardous and toxic materials on the scale of East Java province with minimal transportation costs. Aldian (2015), the use of the Center of Gravity method can help determine the location of efficient food storage for food distribution based on distance traveled. Similar research was also carried out by Zhao Xue Ying (2014). In his research, the Center of Gravity method provides address recommendations for a good logistics center. In the Center of Gravity method has some limitations in the implementation because it only considers the factor of volume or weight of the goods sent and plotting maps coordinates, so that the need for other methods as a support.

2 Literature Review

Location.

Location theory from August Losch (Sofa, 2008) looks at the problem of the demand side (market). Losch said that the location of the seller is very influential on the number of consumers that can be worked on. The farther away from the seller's place, consumers are increasingly reluctant to buy because transportation costs to come to the seller's place are increasingly expensive. According to Heizer & Render (2015) the location is a driver of costs and income, then the location often has the power to create a business strategy for the company. The strategic location aims to maximize profits from the company's location. According to Kotler (2008) One of the keys to success is location, the location begins with choosing a community. This decision is very dependent on the potential for economic growth and stability, competition, political climate, and so on (Quah, 2011).

Determination of location, according to Munawaroh (2013) one of the strategies that need to be considered by the company is the location selection, either the factory location for the manufacturing company or the business location for the service/retail company or office location. Site selection is needed when the company establishes a new business, expands existing business and moves the location of the company to another location. Location determination needs to be done carefully which consists of locations for headquarters, branches and factories. In relation to the business feasibility study, the most complex and complicated thing is determining the location of the factory. The consideration is whether it is close to raw materials or markets or consumers, costs and production area (Henderson & McNamara, 2000; Kasmir, 2014). According to Azizi *et al.* (2015), selecting the best place for a factory among some proposed locations based on various indices is a decision-making multi-criteria issue.

Site selection is very important because it is related to the size of operating costs, prices and competitiveness. The purpose of the location strategy is to maximize the benefits of the company; (1) For industry, to minimize costs. The right location to close the location of the material storage warehouse with the production location can save transportation costs. (2) For retailers and service professionals to maximize revenue. Selection of retail locations and service professionals that are easily accessible to consumers allows sales in large numbers, thereby increasing company revenue. (3) For warehouse locations to maximize speed delivery and minimum costs. Warehouse distance with the right factory location will accelerate the delivery of goods while minimizing costs.

Center of Gravity.

In finding the best location to be a distribution center, the location of the market is taken into account, the volume of goods sent to the market, and the transportation costs (Kee-Yin Ng *et al.*, 2013; Heizer & Render, 2013). The center of gravity approach (Center of Gravity Approach) is used to select a location that can minimize distance or cost to existing facilities. For example, it is used to choose a warehouse location or distribution center to supply goods to several agents in a particular area. This approach chooses any coordinate center point. Center of Gravity Techniques Is a mathematical technique used to find the best location for a single distribution point that serves several shops or regions. This method takes into account the distance of the market location, the amount of goods shipped and shipping costs.

Steps to use the Center of Gravity Techniques; (1) Determine the amount of goods sent from the location to the distribution warehouse (which location will be searched for) for each period. (2) Open the map, specify a place as the origin (0.0). (3) Place market locations owned by the company in a coordinate system with the origin as the basis.

3 Method

The concept of this research is to determine the exact distribution center location to store and distribute the principal products of PT. JKT. These problems can be explained in the research variables in accordance with table 1, as follows:

Table 1 Operational variable research

Variable	Dimension	Indicator	Type Data	Source Data	Data Collection Technique
Center of Gravity (Hlayel & Alia, 2012)	Coordinate Point	Address & plotting maps	Primary	PT JKT & Customer	Observation
	Weight	Volume	Secondary	PT JKT & Customer	Validation

This data is obtained from direct measurement results plotting maps of the Google Maps application. The data taken is the coordinate point of each customer warehouse PT. JKT (branch, sub branch and sub

distributor). The research method is done through observation and direct data collection in the research location at PT. JKT. The study was determined based on a theoretical basis written on the study of the application of the method of determining the location of the Distribution Center with the method of the Center of Gravity. Map data, distance and coordinates are obtained from searching through the Google Maps application in 2018. The analysis technique used is by using the Center of Gravity method. Data processing uses POM for Windows version 3.3 software and a mathematical formula for comparison. The formula used to calculate by the center of gravity method can be seen as follows:

$$Cx = \frac{\sum_i d_{ix} w_i}{\sum_i w_i} \tag{1}$$

$$Cy = \frac{\sum_i d_{iy} w_i}{\sum_i w_i} \tag{2}$$

Source: Heizer & Render (2013)

where:

Cx = x coordinate from the center of gravity

Cy = y coordinate from center of gravity

Dix = x coordinates from location i

Diy = y coordinates of location i

Wi = volume of goods moved or from location

4 Results and Discussion

The data collected is data related to customers of PT. JKT (branch, sub branch and sub distributor), customer name, address and distribution area, coordinates and volume of each item distributed to each customer of PT. JKT. Outbound data is the distribution of goods distributed and the total volume distributed to each customer. From this data which will then be used to map the distribution area of PT. JKT and determine recommendations at locations where the Distribution Center is the most optimal. Expenditures of PT. JKT in 2017, presented by showing the total Volume Metric (Chargeable Weight) distributed to customers of PT. JKT. Grouping of distribution areas is done so that some customers who have the same warehouse location are taken by one name that has the largest volume and the total volume used is the total of all volumes of all customers in the area. Table 2, the area of distribution and volume of metrics (chargeable weight) of PT. JKT in 2017, the groupings for each distribution area are presented at Table 2.

Table 2 Distribution and Charging Weight Areas of PT. JKT in 2017

Area	Customer	Quantity	Volume Metric
Batu Ceper	Sheffi Inti Lest. PT	35,171	3,481
Bekasi Barat	Narjo. TK	28,706	2,841
Bekasi Timur	Egi. TK	59,254	5,866
Bogor Utara	PT JKT Bogor	14,229,877	1,408,757
Cakung	PT JKT Cakung	9,599,619	950,362
Cengkareng	Parjo. TK	167,785	16,610
Cikarang	PT JKT Cikarang	2,514,918	248,976
Cilincing	Rajawali. TK	90,432	8,952
Ciputat	Tri Wijaya. TK	46,380	4,591
Duren Sawit	Indah Sehat. TK	32,505	3,218
Grogol Petamburan	Royal. TK	114,986	11,383
Jagakarsa	PT JKT Jakarta 3	3,414,787	338,063
Jati Asih	Paret Tengah Pa. PT	95,180	9,422

Table 2 Continued

Area	Customer	Quantity	Volume Metric
Jatinegara	Era Sehat Sejaht. PT	1,740,747	172,333
Kampung Melayu	Sinar Sakti. TK	110,000	10,890
Karang Teng	Anugrah. TK	34,890	3,454
Karawaci	PT JKT Tangerang	23,053,970	2,282,343
Kebayoran La	Rohim. TK	457,773	45,319
Kebun Jeruk	PT JKT Jakarta 1	4,974,675	492,492
Koja	Napsi. TK	167,745	16,606
Kosambi	Mega Prosindo. PT	100,000	9,900
Kramat Jati	Intisari. TK	334,861	33,151
Mampang Prapatan	Cung. TK	75,209	7,445
Matraman	Permata Biru. TK	388,258	38,437
Neglasari	Darma. TK	99,360	9,836
Pademangan	Multihusada Far. PT	175,946	17,418
Pamulang	Kawi Jaya. TK	83,302	8,246
Pancoran	Sehati. TK	81,843	8,102
Penjaringan	Raja. TK	876,326	86,756
Periuk	Halim. TK	543,490	53,805
Pinang	Taman Sari. TK	87,810	8,693
Pulo Gadung	Selvi. TK	176,175	17,441
Senen	Kicojaya Lesatri. PT	166,744	16,507
Serang	PT JKT Serang	5,316,962	526,379
Serpong	Berkat Mahkota. PT	151,389	14,987
Setia Budi	Modern Abadi. PT	50,000	4,950
Suka Asih	Sinar Kasih. TK	223,174	22,094
Taman Sari	ABC. TK	509,539	50,444
Tambelang	Wahyu. TK	56,342	5,577
Tambora	Duta. TK	2,254,123	223,158
Tanjung Priuk	Sejahtera. TK	776,310	76,854
	Total	73,745,473	7,300,801.83

Source: Data processing results, (2018)

The names of customers related to the distribution process during 2017 can be known, based on the customer's address and then taken and determined the coordinate point using the Google Maps application tool. Google maps search data as shown in Figure 1, retrieving the coordinates of PT. JKT, as follows:

Table 2, coordinates of the distribution area of PT. JKT in 2017, presented the results of taking coordinates for each distribution area by using the google maps application.

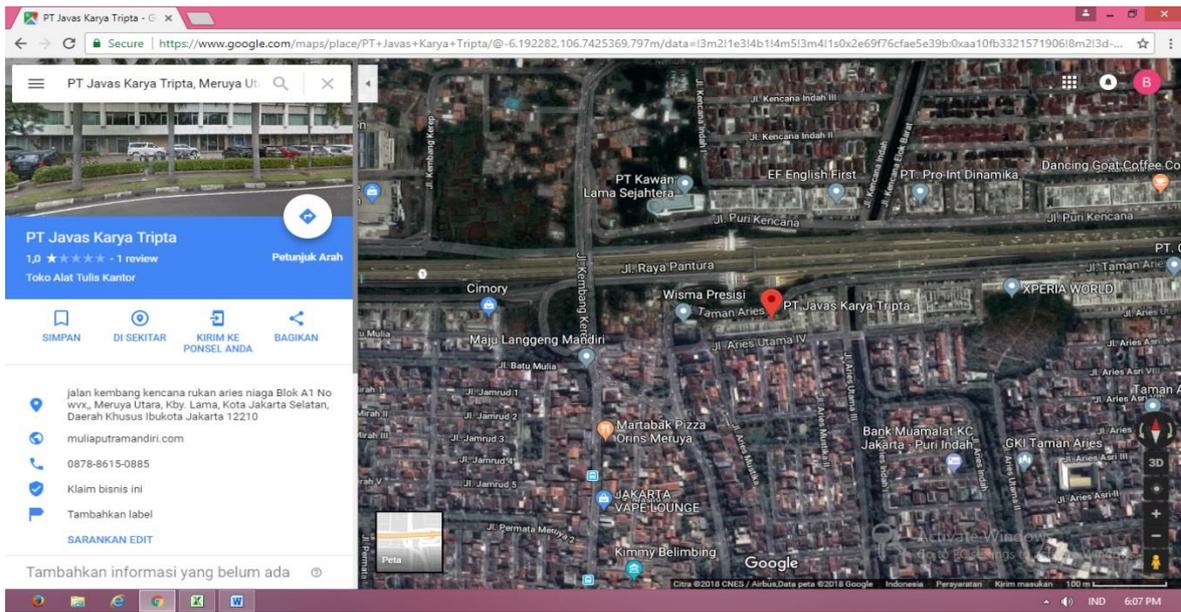


Figure 1 Retrieval of PT. JKT.

Source: Data processing (2018).

Table 3 The coordinates of the distribution area of PT. JKT in 2017

Area	Customer	Coordinate (X)	Coordinate (Y)
Batu Ceper	Sheffi Inti Lestari. PT	-6.1775571	106.6581143
Bekasi Barat	Narjo. TK	-6.2433572	106.9426216
Bekasi Timur	Egi. TK	-6.2488621	107.0019166
Bogor Utara	JKT Bogor. PT	-6.5529735	106.8149992
Cakung	JKT Cakung. PT	-6.1663404	106.9432157
Cengkareng	Parjo. TK	-6.1356821	106.7501099
Cikarang	JKT Cikarang	-6.2657164	107.1061752
Cilincing	Rajawali. TK	-6.1585029	106.9294213
Ciputat	Tri Wijaya. TK	-6.2864422	106.7647011
Duren Sawit	Indah Sehat. TK	-6.2384895	106.9012408
Grogol Petambur	Royal. TK	-6.1459221	106.7870213
Jagakarsa	JKT Jakarta 3	-6.3541681	106.8107168
Jati Asih	Paret Tengah Pati. PT	-6.2869976	106.9502802
Jatinegara	Era Sehat Sejahtera. PT	-6.2439184	106.8684433
Kampung Melay	Sinar Sakti. TK	-6.2184921	106.8572178
Karang Tengah	Anugrah. TK	-6.2242403	106.7050541
Karawaci	JKT Tangerang	-6.1853658	106.6223483
Kebayoran Lama	Rohim. TK	-6.2379029	106.7742937
Kebun Jeruk	JKT Jakarta 1	-6.1670395	106.7670171
Koja	Napsi. TK	-6.1225388	106.8912214

Table 3 Continue

Area	Customer	Coordinate (X)	Coordinate (Y)
Kosambi	Mega Prosindo. PT	-6.0846721	106.6996405
Kramat Jati	Intisari. TK	-6.2872811	106.8723743
Mampang Prapat	Cung. TK	-6.2423167	106.8256698
Matraman	Permata Biru. TK	-6.1973502	106.8551853
Neglasari	Darma. TK	-6.1497063	106.6213036
Pademangan	Multihusada Farma. PT	-6.1325922	106.8210541
Pamulang	Kawi Jaya. TK	-6.3421622	106.7289881
Pancoran	Sehati. TK	-6.2477418	106.8353528
Penjaringan	Raja. TK	-6.1383169	106.7803458
Periuk	Halim. TK	-6.1891683	106.5909293
Pinang	Taman Sari. TK	-6.2220696	106.6838429
Pulo Gadung	Selvi. TK	-6.2117053	106.8746873
Senen	Kicojaya Lesatri. PT	-6.1698221	106.8415692
Serang	JKT Serang	-6.1088277	106.1710895
Serpong	Berkat Mahkota. PT	-6.2620839	106.6652891
Setia Budi	Modern Abadi. PT	-6.2237103	106.8260766
Suka Asih	Sinar Kasih. TK	-6.1756611	106.6331021
Taman Sari	ABC. TK	-6.1326356	106.8121225
Tambelang	Wahyu. TK	-6.1948985	107.1153391
Tambora	Duta. TK	-6.1399961	106.8063983
Tanjung Priuk	Sejahtera. TK	-6.1087182	106.8914239

Source: Data processing (2018).

Data processing in this study is divided into two, namely using the Center of Gravity method. The Center of Gravity method of data processing uses POM for Windows Version 3.3 software. The Center of Gravity attribute method used in determining the exact distribution center location is the Total Volume of Metric (Charged Weight) and the coordinate point of each distribution area of PT. JKT in 2017.

Table 4 Total volume and coordinates of the distribution area of PT. JKT in 2017

Location	Area	Volume Metric	Coordinate (X)	Coordinate (Y)
Location 1	Batu Ceper	3,481	-6.1775571	106.6581143
Location 2	Bekasi Barat	2,841	-6.2433572	106.9426216
Location 3	Bekasi Timur	5,866	-6.2488621	107.0019166
Location 4	Bogor Utara	1,408,757	-6.5529735	106.8149992
Location 5	Cakung	950,362	-6.1663404	106.9432157
Location 6	Cengkareng	16,610	-6.1356821	106.7501099
Location 7	Cikarang	248,976	-6.2657164	107.1061752
Location 8	Cilincing	8,952	-6.1585029	106.9294213
Location 9	Ciputat	4,591	-6.2864422	106.7647011
Location 10	Duren Sawit	3,218	-6.2384895	106.9012408

Table 4 Continue

Location	Area	Volume Metric	Coordinate (X)	Coordinate (Y)
Location 11	Grogol Petam	11,383	-6.1459221	106.7870213
Location 12	Jagakarsa	338,063	-6.3541681	106.8107168
Location 13	Jati Asih	9,422	-6.2869976	106.9502802
Location 14	Jatinegara	172,333	-6.2439184	106.8684433
Location 15	Kampung Mel	10,890	-6.2184921	106.8572178
Location 16	Karang Teng	3,454	-6.2242403	106.7050541
Location 17	Karawaci	2,282,343	-6.1853658	106.6223483
Location 18	Kebayoran La	45,319	-6.2379029	106.7742937
Location 19	Kebun Jeruk	492,492	-6.1670395	106.7670171
Location 20	Koja	16,606	-6.1225388	106.8912214
Location 21	Kosambi	9,900	-6.0846721	106.6996405
Location 22	Kramat Jati	33,151	-6.2872811	106.8723743
Location 23	Mampang Pra	7,445	-6.2423167	106.8256698
Location 24	Matraman	38,437	-6.1973502	106.8551853
Location 25	Neglasari	9,836	-6.1497063	106.6213036
Location 26	Pademangan	17,418	-6.1325922	106.8210541
Location 27	Pamulang	8,246	-6.3421622	106.7289881
Location 28	Pancoran	8,102	-6.2477418	106.8353528
Location 29	Penjaringan	86,756	-6.1383169	106.7803458
Location 30	Periuk	53,805	-6.1891683	106.5909293
Location 31	Pinang	8,693	-6.2220696	106.6838429
Location 32	Pulo Gadung	17,441	-6.2117053	106.8746873
Location 33	Senen	16,507	-6.1698221	106.8415692
Location 34	Serang	526,379	-6.1088277	106.1710895
Location 35	Serpong	14,987	-6.2620839	106.6652891
Location 36	Setia Budi	4,950	-6.2237103	106.8260766
Location 37	Suka Asih	22,094	-6.1756611	106.6331021
Location 38	Taman Sari	50,444	-6.1326356	106.8121225
Location 39	Tambelang	5,577	-6.1948985	107.1153391
Location 40	Tambora	223,158	-6.1399961	106.8063983
Location 41	Tanjung Priuk	76,854	-6.1087182	106.8914239

Source: Data processing (2018).

Following are the calculating of center of gravity with the center of gravity formula, (a) Determining the coordinates of each customer. (b) Determine the total volume or weight of shipments to each customer. (c) $(X \text{ customer coordinates}) \times (\text{total customer demand})$ is added according to the number of customers and divided by total customer demand. (d) $(Y \text{ customer coordinates}) \times (\text{total customer demand})$ is added according to the number of customers and divided by total customer demand. (e) Customer coordinates are obtained based on the results of X and Y. The steps using POM for Window Version 3 software. As follows; (a) Determine the coordinates of each customer. (b) Determine the total volume/weight of shipments to each customer. (c) Enter the POM for Window Version 3 application. select the new location and open module for the Center of Gravity. (d) Enter customer data coordinates and total customer demand. (e) Select the (Solve) menu to run the program and the results we can get.

Based on the data and steps for using the POM for Windows Version 3.3 software, the location of the recommended coordinates is to determine the location with the Center of Gravity method at -6.257108,106.7315. The put out presented by the POM for Windows Version 3 software can be seen in Figure 3 as follows:

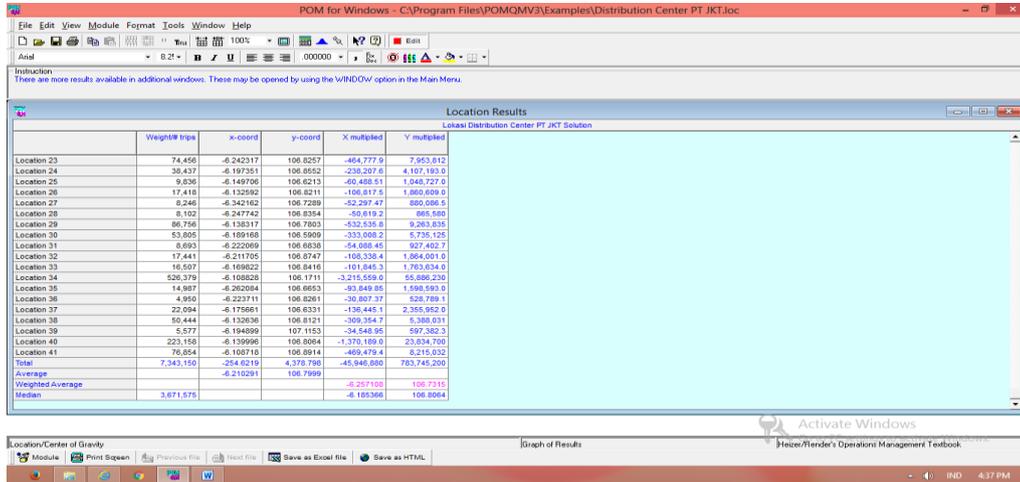


Figure 2 Results of calculation of POM for Window Version 3.3 Software.

Source: Data processing (2018).

Data processing with the Center of Gravity formula is described as follows: Cx is the result of the x coordinate from the calculation of the center of gravity, Cy is the y coordinate of the center of gravity, dix is the x coordinate of each pelanggan location PT. JKT (branch, sub branch and sub distributor), diy is the y coordinate from the location of the customer PT. JKT (branch, sub branch and sub distributor), and Wi is the volume of goods moved or from the location of the Distribution Center. So that the following calculation is obtained:

$$\begin{aligned} \text{Coordinate X} = & (-6.1775571 \times 3,481) + (-6.243357 \times 2,841) + (-6.248862 \times 5,866) + (-6.552973 \times 1,408,757) + \\ & (-6.166341 \times 950,362) + (-6.135682 \times 16,610) + (-6.265716 \times 248,976) + (-6.158502 \times 8,952) + \\ & (-6.286442 \times 4,591) + (-6.238489 \times 3,218) + (-6.145922 \times 11,383) + (-6.354168 \times 338,063) + \\ & (-6.286997 \times 9,422) + (-6.243918 \times 172,333) + (-6.218492 \times 10,890) + (-6.224241 \times 3,454) + \\ & (-6.185365 \times 2,282,343) + (-6.237902 \times 45,319) + (-6.167039 \times 492,492) + (-6.122538 \times 16,606) + \\ & (-6.084672 \times 9,900) + (-6.287281 \times 33,151) + (-6.242316 \times 7,445) + (-6.197251 \times 38,437) + \\ & (-6.149706 \times 9,836) + (-6.132592 \times 17,418) + (-6.3421622 \times 8,246) + (-6.247741 \times 8,102) + \\ & (-6.138316 \times 86,756) + (-6.189168 \times 53,805) + (-6.222069 \times 8,693) + (-6.211705 \times 17,441) + \\ & (-6.169822 \times 16,507) + (-6.108827 \times 526,379) + (-6.262083 \times 14,987) + (-6.223710 \times 4,950) + (-6.175661 \times 22,094) + \\ & (-6.132635 \times 50,444) + (-6.194898 \times 5,577) + (-6.139996 \times 223,158) + (-6.108718 \times 76,854) \end{aligned}$$

$$\begin{aligned} & 3,481 + 2,841 + 5,866 + 1,408,757 + 950,362 + 16,610 + 248,976 + 8,952 + 4,591 + 3,218 + \\ & 11,383 + 338,063 + 9,422 + 172,333 + 10,890 + 3,454 + 2,282,343 + 45,319 + 492,492 + \\ & 16,606 + 9,900 + 33,151 + 7,445 + 38,437 + 9,836 + 17,418 + 8,246 + 8,102 + 86,756 + \\ & 53,805 + 8,693 + 17,441 + 16,507 + 526,379 + 14,987 + 4,950 + 22,094 + 50,444 + 5,577 + \\ & 223,158 + 76,854 \\ & = -6.257108 \end{aligned}$$

Y calculation:

$$\begin{aligned} \text{Coordinate Y=} & (106.6581 \times 3,481) + (106.9426 \times 2,841) + (107.0019 \times 5,866) + (106.8149 \times 1,408,757) + \\ & (106.9432 \times 950,362) + (106.7501 \times 16,610) + (107.1061 \times 248,976) + (106.9294 \times 8,952) + \\ & (106.7647 \times 4,591) + (106.9012 \times 3,218) + (106.7871 \times 11,383) + (106.8107 \times 338,063) + \\ & (106.9502 \times 9,422) + (106.8684 \times 172,333) + (106.8572 \times 10,890) + (106.7051 \times 3,454) + \\ & (106.6223 \times 2,282,343) + (106.7742 \times 45,319) + (106.7671 \times 492,492) + (106.8912 \times 16,606) \\ & + (106.6996 \times 9,900) + (106.87232 \times 33,151) + (106.8256 \times 7,445) + (106.8551 \times 38,437) + \\ & (106.6213 \times 9,836) + (106.8211 \times 17,418) + (106.7289 \times 8,246) + (106.8353 \times 8,102) + \\ & (106.7803 \times 86,756) + (106.5909 \times 53,805) + (106.6838 \times 8,693) + (106.8746 \times 17,441) + \\ & (106.8415 \times 16,507) + (106.1711 \times 526,379) + (106.6652 \times 14,987) + (106.8260 \times 4,950) + \\ & (106.6331 \times 22,094) + (106.8121 \times 50,444) + (107.1153 \times 5,577) + (106.8063 \times 223,158) + \\ & (106.8914 \times 76,854) \end{aligned}$$

$$\begin{aligned} & 3,481 + 2,841 + 5,866 + 1,408,757 + 950,362 + 16,610 + 248,976 + 8,952 + 4,591 + 3,218 + \\ & 11,383 + 338,063 + 9,422 + 172,333 + 10,890 + 3,454 + 2,282,343 + 45,319 + 492,492 + \\ & 16,606 + 9,900 + 33,151 + 7,445 + 38,437 + 9,836 + 17,418 + 8,246 + 8,102 + 86,756 + \\ & 53,805 + 8,693 + 17,441 + 16,507 + 526,379 + 14,987 + 4,950 + 22,094 + 50,444 + 5,577 + \\ & 223,158 + 76,854 \\ & = 106.7315 \end{aligned}$$

So that the coordinates obtained from the calculation results using the center of gravity method at point X, Y, namely: (-6.257108,106.7315).

The results above when compared with the results obtained with mathematical calculations using the Center of Gravity formula the results are the same, namely: (-6.257108; 106.7315). This reinforces the suggested coordinate points for determining Distribution Center locations. After the coordinate points obtained are then checked using the google maps application, to know for certain the location of the location. In Figure 3 the locations of the Distribution Center locations are suggested, as follows:

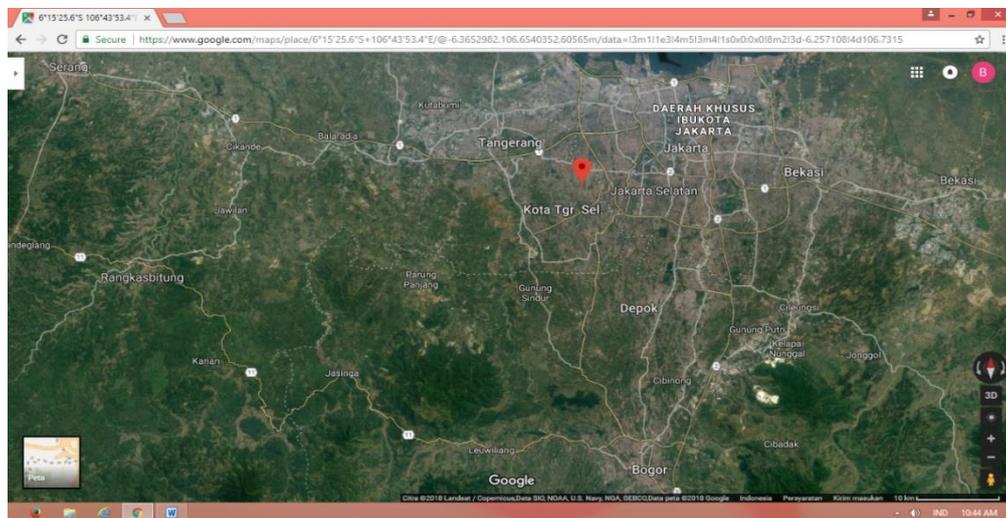


Figure 3 Recommended location coordinates of the Distribution Center
Source: Data processing (2018).

From the calculation using the Center of Gravity method, the location of the Distribution Center that is selected is the coordinates (-6.257108; 106.7315). When viewed on the Google Maps Coordinate application located in the area of Jl. Panti Asuhan, Jurangmangu Timur, Pondok Aren, South Tangerang City. Based on a direct location review, the proposed warehouse location is calculated using the Center of Gravity method in residential areas. The location of the new suggested Distribution Center is located 14 km south of the location of PT JKT Tangerang and 13 km from the north of PT JKT Jakarta 3, the new recommended location is closer to and located between the locations currently distributed. Nevertheless

the results of this study need to be followed up by considering the cost of a new warehouse investment, of course, apart from that this will be a good input for the company so that the start of its own location is good to be able to support a better distribution. The location adjacent to one of the customers who has the largest total shipping volume at this time is an advantage that can be utilized by PT. JKT. The location of the proposed Distribution Center in the city center has its own advantages and disadvantages. By being in the city center, the company can serve the needs of each customer well because the distance that must be taken becomes shorter, but in terms of legislation and urban spatial planning, further study is needed regarding the location. This is needed for provide a broader view of the company to produce good decisions. In addition, the company also must pay attention to the requirements of a good warehouse location, including (Tnunay, 2013), as follows; Paying attention to the type of goods that will be stored and the characteristics of the item. The main thing to note is whether the items to be stored are food (food) or not food (non food items) or both. The characteristics of goods that must be considered are as follows; (1) Volume of goods to be stored. (2) Frequency and size or number of shipments that will be received in the warehouse. (3) Frequency and size or number of shipments that will be sent or removed from the warehouse. (4) Warehousing environment and building conditions, this is important to ensure that the goods do not experience damage or deterioration in quality during storage. (5) Temperature sensitivity, whether the item requires a special temperature. (6) Whether the items stored are in the category of dangerous goods or not. Also raw materials from goods include dangerous goods or not.

The number of items to be stored for the calculation of the area needed, as follows: (1) The size and weight of the goods including the packaging. (2) Type of packaging. (3) Needs and special places to install new packaging, installation of labels and so on. In addition to the three things mentioned above, there are other important things that must also be considered before deciding or choosing a warehouse (Tnunay, 2013), as follows; (1) Pay attention to or consider regulations (Legislation) that apply, as follows: (a) Labor regulations. (b) Health regulations and also about labor safety. (c) Regulations concerning the storage of items that fall into the category. (2) Choosing suitable locations by considering a number of things, as follows: (a) Choosing a location that is close to the port or geographically located near the location of the factory or customer or in accordance with the needs of the company. (b) The condition of the warehouse building must be good. (c) Security, a very important aspect of warehouse facilities. The company requires a parameter for the security of the building and the surrounding environment as well as adequate protection for the contents of the warehouse, vehicles and equipment used. (d) The location of the warehouse must be free from flooding and access to the warehouse must also be able to be passed by large trucks. (e) See what facilities are available for the warehouse, for example water, electricity, telephone and other facilities needed.

The Distribution Center (Warehouse) has an important function for the company, especially in distribution companies. The purpose of this study is to determine the optimal location that can be used by PT. JKT in determining the Distribution Center location. This study uses the Center of Gravity method in calculating optimal locations that will be considered by the company. The Center of Gravity method is a quantitative and mathematical technique for finding distribution center locations that will minimize distribution costs. This has a beneficial and detrimental side that needs to be studied more deeply for the company. Because in choosing and determining the location, which is a long-term investment, requires other considerations as well as paying attention to the type of goods to be stored and the characteristics of the item, the number of items to be stored for the calculation of the area needed and the time needed to store the item and policies and desires of the company so that the chosen location can support the company's business objectives. The Center of Gravity method can be used and applied by the company as a tool to assist companies in determining the location of the establishment of a Distribution Center by considering the distance between other units. Although the Center of Gravity method ignores/does not take into account the differences in distribution and production costs for each location where in the formula, the use of the Center of Gravity method assumes that costs are directly proportional to the distance and volume of the goods transported. For that reason, in seeking location optimization it is necessary to include production costs or in the analysis, also comparing the results of the analysis using other location determination methods, so that the decisions taken are ideal and right on target.

5 Conclusion

Determining the location of the Distribution Center is a solutive solution to improve the distribution system and the efficiency of logistics management. This research was conducted with the aim of determining the location of the Distribution Center using the Center of Gravity method and the Analytical Hierarchy Process to obtain conclusions, as follows: Determination of the location of the Distribution Center by using the Center of Gravity method obtained the location of the Distribution Center selected is the coordinates (-6.257108, 106.7315) When viewed on the Google Maps Coordinate application located in the area of Jl. Panti Asuhan, Jurangmangu Timur, Pondok Aren, South Tangerang City. Suggestions for further research are expected to be able to collaborate several analytical methods in addition to the Center of Gravity can overcome the existing complications in the Distribution Center location determination criteria.

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