JOURNAL OF ENGINEERING AND MANAGEMENT IN INDUSTRIAL SYSTEM VOL. 10 NO. 2 YEAR 2022
e-ISSN 2477-6025
DOI: 10.217776/ub.jemis.2022.010.02.2

EMPLOYING TECHNOLOGICAL SUPPORT TO IMPROVE SMES LOGISTIC PERFORMANCE: A CASE STUDY ON THE GRAVITY LOCATION MODELS APPROACH FOR SMES IN INDONESIA

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Abstract *CV. JAMAN, a business organization and an SME (Small to Medium Enterprise), is a distributor of Stick Jelly in FC and NJ branded packaging. Its distribution covers the Malang Raya area, Indonesia. This company often encounters logistical problems, that is delivery delays. Despite having made a delivery target and schedule based on the number of each customer's requests, its vast marketing area often results in non-punctual delivery time. CV. JAMAN is located too far from its customers; thus, it complicates the daily distribution flow. This study attempts to solve this problem by providing technological support to determine the appropriate location for its buffer warehouse/branch. The Gravity Location Models Approach is used by knowing each customer's coordinates, the number of requests, and shipping costs. With this approach, the right coordinate point is obtained for establishing a subsidiary branch. Based on the results of calculations and simulations, as well as the location of the buffer, it was found that there was a shipping time saving and an increase in the distribution process efficiency value up to 48%.*

Keywords: Gravity Location, Indonesia, Model Knowledge and Technology Transfer, SMEs

1. Introduction

Distribution and transportation networks play an important part in a company as they allow products to be distributed from production sites to consumer locations based on distance and time. Moreover, for companies engaged in distribution, superiority in distribution and transportation networks is an indispensable condition. Failure to meet customer demand in terms of delivery time in a product distribution process will affect the competitive advantage of the company. Distribution and transportation costs are often taken into consideration, especially in a large product distribution area. It affects the distributor location which is one of the main factors impacting the shipping process [1]. Besides helping to reduce carbon footprint, it is also one of the green or environmentally friendly approaches [2–4]. To overcome this problem, the logistics system optimization is needed through establishing a new branch.

2. Logistic Problems

CV. JAMAN, which is a distributor of Stick Jelly, covers the Malang Raya area, located in the East Java Province of Indonesia; this area specifically includes Lawang, Singosari, Tumpang, Lowokwaru, and Kepanjen. It is an area of 3,882 km^2, which is equivalent to 2 times the width of London city. Furthermore, there are many customers of CV. JAMAN in the area spread over 11 different locations with long distances, different requests, and demands to fulfill their orders on schedule. To deal with this, CV. JAMAN set a target in meeting the demands of its customers. The target was made based on the number of requests from each customer, but in reality, the distribution of these products experienced delays quite frequently.

The vastness of the area made it difficult to achieve the desired distribution performance. Therefore, CV. JAMAN planned to add a buffer location to simplify and accelerate the distribution of its products by establishing warehouses/sub-branches to serve customers in several sub-districts in Malang,

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Published online at

Site this Article as: Handoko, F., et al (2022) EMPLOYING TECHNOLOGICAL SUPPORT TO IMPROVE SMES LOGISTIC PERFORMANCE: A CASE STUDY ON THE GRAVITY LOCATION MODELS APPROACH FOR SMES IN INDONESIA. *Journal of Engineering and Management in Industrial System, 10 (2), p 6-10*
Paper Accepted : 29th November 2022
Paper Published : 27th December 2022

e-ISSN 2477-6025
DOI: 10.217776/ub.jemis.2022.010.02.2

which were Lawang, Singosari, Tumpang, Lowokwaru, and Kepanjen. By the construction of a buffer location, it is expected that CV. JAMAN can optimally serve all customers. The Transfer of Knowledge and Technology (KTT) was performed to assist CV. JAMAN in selecting the right method to deal with the issue; this could increase user capacity [2, 3, 5–7], improving knowledge in hardware/machinery [8] or in environment [9, 10] or in this study is in specific knowledge and technology. This study aimed to asist the company in solving its problems by providing input on selecting the appropriate location to establish a warehouse/subsidiary branch using the Gravity Location Models approach; the calculation was done using the pull force of each coordinate point on each customer. With this method, it is expected to minimize distance, time, and cost.

3. The Gravity Location Models

Quantitative approaches are often used to design logistic networks. Many Global Positioning System approaches and related equipment have been conducted in previous research [5, 11, 12]. One of them is the Gravity Location Models, which are used to determine the location of a facility (for example, a warehouse or a factory) that serves as a link between supply sources and several market locations [13]. The aim is an optimization to achieve efficiency. This approach uses the following assumptions: (1) Transportation costs are assumed to rise linearly in proportion to the volume transferred, and (2) Location and supply of markets can be determined on a map with clear x and y coordinates. There are a few things to consider when using this approach, such as: (1) transportation costs per unit; (2) each unit load-distance from all supply positions to the candidate location of the facility and from the candidate to all target locations; (3) (unit) volume to be transferred; (4) coordinates of the supply and destination locations. This is to obtain the appropriate location of the facility that can minimize the total shipping costs; according to Pujawan and Mahendrawathi [13], it can be calculated with the formulations as follows:

$$TC = \sum i Ci\ Vi\ Ji \ldots \quad (1)$$

in which:

Ci (IDR)= Transportation costs per unit load per kilometer from a candidate facility to market location or source of supply location.

Vi = Unit load to be transferred from the facility to the supply source or location source.

Ji = Coordinates calculation.

While the distance between the two locations in this model was calculated as the geometric distance between the two locations; according to Pujawan and Mahendrawathi (2010), the formula is as follows:

$$Ji = \sqrt{((x_{awal} - x_i)^2 + (y_{awal} - y_i)^2)} \ldots \quad (2)$$

in which:

(x_i, y_i) = x and y coordinates are for market location or source of supply of i.

(x_u, y_u) = candidate coordinates of the facility under consideration.

As explained by Pujawan and Mahendrawathi (2010), the following steps are performed to obtain the optimal value (x_u, y_u), which is to minimize the total TC shipping costs: (1) calculate the distance Ji for all i (between the locations of the candidate facility and the source of supply or market i); (2) determine location coordinates using the following formula:

$$x_{un} = \frac{\sum_i \frac{C_i V_i x_i}{J_i}}{\sum_i \frac{C_i V_i}{J_i}} \ldots . \quad (3)$$

$$y_{un} = \frac{\sum_i \frac{C_i V_i x_i}{J_i}}{\sum_i \frac{C_i V_i}{J_i}} \ldots \quad (4)$$

In which $x_{un} y_{un}$ and are the x and y coordinates generated in this iteration. When two successive iterations generate almost the same coordinates, the iteration is stopped and the coordinates are used as the location of the facility. If not, repeat the iteration from step 1.

4. Research Methods

Primary data sources were collected through interviews and direct observations of research objects related to the studied phenomena and problems: (1) customer data (2) distribution tools (3) related area and location data, and (4) data related to costs.

The following steps were included in data processing of this study: (1) Identifying the

e-ISSN 2477-6025
DOI: 10.217776/ub.jemis.2022.010.02.2

coordinates to find out the coordinates of each customer by using the results of the coordinate conversion and input into Microsoft Excel; (2) Calculating distances; after the coordinates were obtained, they were formulated into a formula to figure out the distance between the candidate location of the facility and the source of the supply; (3) Calculating the optimum point, which was the calculation of the existing coordinate points using the Gravity Location Models approach, to obtain the optimum location point.

Accordingly, the steps to determine the location using this approach were: (1) Calculating the distance of Ji for all i (which was between the location of the candidate facility and the location of the source of supply or market / market i); (2) determining the coordinates of the location, which was calculated to determine new coordinates. If two successive iterations generate almost the same coordinates, the iteration is stopped and the coordinates are used as the location of the facility. If not, repeat the iteration from step 1

5. Results and Discussion

The determination of customer/consumer coordinates used the Gravity Location Models method. The data obtained were entered into Microsoft Excel and outputted in the form of x and y coordinates points. After obtaining the coordinate points from each customer, they were calculated using the formula until 2 consecutive iterations were obtained and it generated almost the same coordinates, as presented in Table 1.

Table 1. Iteration

Iteration	Coordinate	
	X	Y
Iteration 1	686474,8396	9132064,919
Iteration 2	683471,3545	8979083,721
Iteration 3	682319,6434	9117619,531
Iteration 4	682261,5922	9118748,58

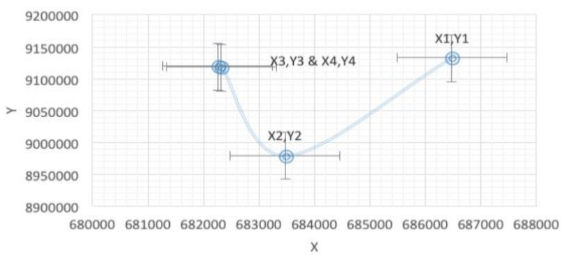

Fig 1. Coordinates X and Y

In Figure 1, the 4th iteration shows the results of the coordinates that are close to the 3rd iteration, so that the iteration is stopped at the 4th iteration. The x and y coordinate points at the 4th iteration are the final results of this calculation and the location points selected as the new alternative locations, which can be seen in Figure 2. The selected location is on Alalak Street, Malang City, located not far from the highway; thus, it is easy to access.

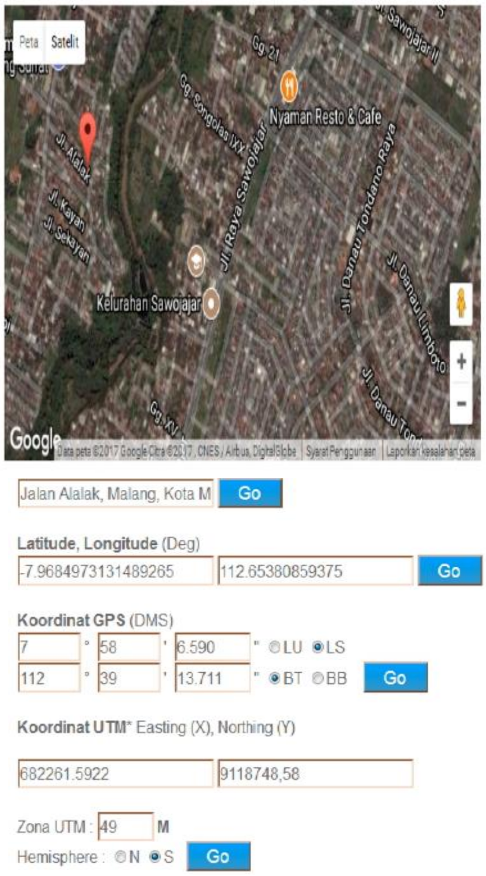

Fig 2. The Alternative Warehouse Locations

Discussion

Costs Comparison

Based on the results of determining the new location, the following comparison is obtained:

Initial Distribution Costs

In this study, the calculation of distribution costs can be simulated in Table 2:

e-ISSN 2477-6025
DOI: 10.217776/ub.jemis.2022.010.02.2

Table 2. Initial distribution costs per 1 delivery cycle

No.	Explanation	Number	Per Unit Cost IDR	Total Cost IDR
1	6 days of labor	2 person	70,000 / person/ day	840,000
2	Food and snack costs	6 days	15,000 / person/ day	180,000
3	Fuel Costs	6 days	150,000	900,000
4	Loading-Unloading Costs			158,000
	Total			2,078,000

Table 2 displays the average cost for the distribution of cycle I, which is: IDR. 2,078,000. Furthermore, these costs became the input in determining the location of points based on gravity models.

Distribution costs after the establishment of buffer locations

With the establishment of the buffer locations, the results of the simulated calculation show that the distribution which was initially completed within 6 days could be completed in 3-days delivery only. The costs are shown in Table 3.

Table 3. Distribution Costs After the establishment of buffer locations

No.	Explanation	Number	Per Unit Cost (IDR)	Total Cost (IDR)
1	3 days of labor	2 persons	70,000/ person/ day	420,000
2	Food and snack costs	3 days	15,000/ person/ day	45,000
3	Fuel Costs	3 days	150,000	450,000
4	Loading -Unloading Costs			158,000
	Total			1,073,000

Table 3 indicates the comparison of before and after the establishment of buffer locations, as well as the comparison of distribution costs per cycle before and after the construction of a new branch. After constructing the buffer location, an additional value of 48%efficiency from the distribution process was obtained.

Table 4. Comparison of the total costs

Initial Cost (IDR)	Cost after the establishment of buffer locations (IDR)	Cost Saving (IDR)	Saving Percentage
2,078,000	1,073,000	1,005,000	48%

This demonstrates that the location of the new branch determined based on the Gravity Location Models approach can optimize the product distribution process by giving up to 48%efficiency per delivery cycle.

7. Conclusion

By providing knowledge and technology transfer, this research contributes support in the form of information technology that can be adapted and applied to overcome the problems of SMEs engaged in distribution related to determining the location of a buffer, a warehouse, or a supporting branch. The buffer location is used to optimize the SME distribution system. With the Gravity Location Models approach, we can determine the location of the buffer which can bring up to 48% optimization of distribution and efficiency This approach is expected to be adopted by SMEs in Indonesia with similar problem characteristics.

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