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IMPROVING THE OPTIMIZATION OF DATE DISTRIBUTION THROUGH COST EFFICIENCY USING THE TRANSPORTATION METHOD APPROACH: CASE STUDY AT PT. XYZ

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Abstract

PT. XYZ faces several challenges in optimizing the distribution of dates, especially in terms of costs and delivery allocation. In the efficiency of the cost of distribution of dates, companies need to reduce operational costs associated with distribution activities. The research objective to be achieved is to analyze the minimum cost of distributing dates at PT. XYZ with the approach of transportation methods. The transportation methods used in this study are Vogel's Approximation Method, Least Cost, North-West Corner, and Stepping Stones. Vogel's Approximation Method, Least Cost, and North-West Corner are used to find the initial solution. While the Stepping Stones method is used to find the final solution. Data processing is carried out using Cbom-Atozmath and POM-QM to obtain fast, detailed, and accurate results. Data processing using the VAM (Vogel's Approximation Method) method results in a total date distribution cost of IDR 171,983,5100.00. Data processing using the NWC (North-West Corner) method resulted in a total date distribution cost of IDR 171,983,5100.00. Data processing using the LC (Least Cost) method resulted in a total date distribution cost of IDR 1,719,835,100.00. The results of calculations using the Cbom-Atozmath and POM-QM software also show the same results. The use of transportation methods to streamline the cost of distributing dates to the Company resulted in savings of Rp. 69,224,000.00. The total cost of distribution of dates by PT. XYZ before efficiency using the transportation method was Rp. 1,789,059,100. The total cost of distribution of dates by PT. XYZ after efficiency using the transportation method was Rp. 1,719,835,100.00.

Keywords: *Efficiency of distribution costs, Distribution Optimization, Transportation Methods*

INTRODUCTION

Dates are an agricultural product that is in high demand both in local and international markets. The sales and distribution of dates in Indonesia is an important sector considering that dates are a food product that is in high demand, especially during the months of Ramadan and Idul Fitri. In the sales and distribution industry, cost optimization and distribution efficiency are important factors in achieving the company's operational success.

PT. XYZ faces several challenges in terms of efficiency in the delivery of dates, especially in terms of cost and delivery time. To increase the efficiency of the distribution of dates, companies should consider improving service quality and reducing operational costs associated with distribution operations. Operational costs within the company are sales costs including marketing costs and distribution and logistics costs. Distribution/logistics costs are affected by the price of fuel oil (BBM). The increase in fuel prices will have a direct impact on the business world, especially on production and operational costs. Fuel costs contribute 40% -50% to transportation costs (Hadijah, 2022).

According to Hadijah (2022), the main factors that affect transportation fares are distance, weight, and density. Distance is the main factor that determines the cost of transportation. In general, transportation costs are driven by distance. Transportation distance will contribute directly to variable costs such as driver power, fuel and oil costs, and vehicle maintenance costs. The transportation method required by PT. XYZ to optimize the cost of transporting date palm commodities from various source areas (date fruit storage warehouses) to various destination areas (date fruit wholesale stores) owned by PT. XYZ. The increase in fuel prices also caused retail companies' operational costs to increase. Transportation and delivery of goods from suppliers to stores or warehouses become more expensive, which can lead to increased logistics costs.

Transportation methods can help companies to determine the most efficient distribution costs. The transportation method is an optimization technique used to determine the optimal route and resource allocation in the distribution process. This method considers various factors such as transportation costs, freight capacity and customer demand to plan the most efficient route. However, in the history of the management of PT. XYZ, there is no research that specifically applies transportation methods in an effort to increase the efficiency of date distribution and optimize operational costs. Therefore, this study aims to fill the knowledge gap by conducting a case study in the company. In this case study, the research will involve collecting data regarding the operational costs associated with the distribution of dates at PT. XYZ, including costs for buying dates, warehouse costs, transportation costs, retail store costs, administrative costs, and other costs. This data will be analyzed and used as a basis for identifying optimal solutions in terms of determining efficient date distribution routes and appropriate resource allocation.

Optimizing the cost of distributing dates through a transportation method approach can increase the operational efficiency of PT. XYZ, reduce unnecessary operational costs, and provide fast service. In addition, the results of this study can also contribute to the field of operations management, especially in the use of optimization methods to improve distribution efficiency in the product sales and distribution industry. Based on this explanation, the research objective to be achieved is to analyze the minimum cost of distributing dates at PT. XYZ with the transportation method approach.

LITERATURE REVIEW

According to previous research, such as research by Kankarofi et al (2021) in a research journal on the Fertilizer Transportation Problem Using the Vogel Approximation Method. The aim of this study was to optimize the distribution process of fertilizers from the Kano State Agriculture supply company, Kasco in Nigeria. The usual transportation problems are due to the poor nature of the roads to several destinations in the Kano state of Nigeria. The method used is the Vogel Approximation Method. The result that can be concluded from this study is that transportation costs are optimized to be ₦ 15,939,500. Vogel's approach provides a better solution providing a cost savings of ₦492,300.

Ardhyani's research (2017) in a research journal entitled Optimizing the Cost of Feed Distribution Using the Transportation Method (Case Study at PT. X Krian). The purpose of this research is to optimize the transportation costs incurred, by selecting the optimum distribution route with the transportation method. Before the transportation method was used, the cost of distributing animal feed at PT. X Krian felt that it was still inefficient, so researchers researched to minimize distribution costs. The methods used are the North West Corner Method, the Least Cost Method, and Vogel's Approximation Method. The results that can be concluded from this study are the research at PT. X by using the transportation method, the use of the right method to optimize the cost of distribution of animal feed is for an initial feasible solution using the VAM (Vogel's Approximation Method) method with the minimum results compared to the NWC and LC methods, which is Rp. 43,089,578,434, - and an optimization test was carried out using the Stepping Stone and MODI methods, the most optimal distribution costs were: Rp. 43,087,656,564, -. The results of the distribution of products that have been carried out by PT. X in August 2010 of Rp. 43.205.135.468, -. While the results of the calculation of the distribution of products using the transportation method are Rp. 43,087,656,564, -. From this analysis, PT. X can optimize distribution costs for August 2010 of Rp. 117,478,904, -.

Distribution Cost

According to Mulyadi (2009), Distribution costs are part of the overall marketing costs which include transportation costs. Transportation costs themselves are a collection of costs which include public transportation costs and contracts such as train costs, truck rental fees, fleet maintenance costs, air freight costs and sea freight costs Distribution costs. According to Mulyadi, distribution costs are part of the overall marketing costs carried out by the company. Distribution costs are costs used by producers to distribute goods that were last produced to consumers, either in the form of a transfer of rights to transfer of ownership of an item. Distribution costs here are used for shipping or distributing goods to individual consumers and large agents.

According to Subagyo (2018), Distribution costs are the total costs of distribution channels which include all activities related to activities to deliver company-produced goods to consumers. Distribution costs are costs that will be used by companies in the process of marketing products from factories to consumers. According to Putra (2016), distribution costs are costs incurred by companies that aim to market or ship a product. Halim (2012) also states that distribution costs are included in the cost of selling and shipping a product that is marketed by the company.

Operation Research

Operations Research is the application of scientific methods to problems arising in the direction and management of a large system of people, machines, materials and money in industry, business, government and defence. This particular approach aims to establish a scientific model of the system, incorporating measures of factors such as opportunity risk, to predict and compare the results of several decisions, strategies or controls. The goal is to help decision-makers determine their policies and actions scientifically (Mulyono, 2004).

According to Harsono (2016), Operations Research is a technique for solving the problem of a decision problem in conditions of limited resources while still trying to determine the best course of action. Operations Research can be viewed as both a science and an art. The aspect of science can be seen from the provision of mathematical techniques and algorithms used to solve problems, while as an art it can be seen from the level of success of a person in taking a mathematical model solution which is very dependent on one's creativity and ability to make decisions.

Eficiency

According to Sedarmayanti (2014), Efficiency is a measure of the level of use of resources in a process. The more efficient or less use of resources, the process is said to be more efficient. An efficient process is characterized by process improvements so that it becomes cheaper and faster. Meanwhile, according to Tamtomo (2018), efficiency is an activity that reduces waste to get maximum results with a minimum amount of input. Therefore, productivity is obtained from effectiveness and efficiency activities.

According to Yahya (2014), the procedure for solving efficiency problems is to model the problem into a mathematical model and then solve it using the transportation method. By using the method of transportation distribution problems can be solved to create cost efficiencies.

Transportation Problems

The transportation problem is a special form of the linear programming problem which deals with allocating a single commodity from several sources to several destinations. Transportation problems can be found in industry, communication networks, scheduling, delivery services, and others. Based on the fact that different shipping routes will result in different shipping costs, the purpose of solving the transportation problem is to determine how much of a kind of commodity must be sent from each source to several destinations so that the demand from each destination is met with a minimum total shipping cost (Taufiq, 2017).

In general, the transportation problem is related to the distribution of a single product from several sources, with limited supply, to several destinations, with certain requests, at minimum distribution costs. The transportation problem is the problem of distributing several products or commodities from several sources of distribution (supply) to several destinations (demand) adhering to the principle of distribution costs (Purnomo, 2004).

METHOD

This research conducted at PT. XYZ Surabaya, Indonesia. The determination of the research area was carried out purposively (intentionally). The research location was chosen because of PT. XYZ is the most complete retail and wholesale centre for dates and souvenirs for Hajj and Umrah in Surabaya. The use of transportation by companies as a means of distributing date fruit products certainly requires shipping costs. Of course, this shipping cost depends on the price of fuel oil because the transportation used is land transportation. The increase in the price of fuel oil (BBM) also has an impact on the transportation costs of PT. XYZ. This is evidenced by the increased transportation costs after the increase in fuel. Of course, a strategy is needed to reduce transportation costs for the company so that the company can incur the minimum costs for the distribution of date products. Based on the explanation above, the location of PT.XYZ is considered quite appropriate as the location of this research.

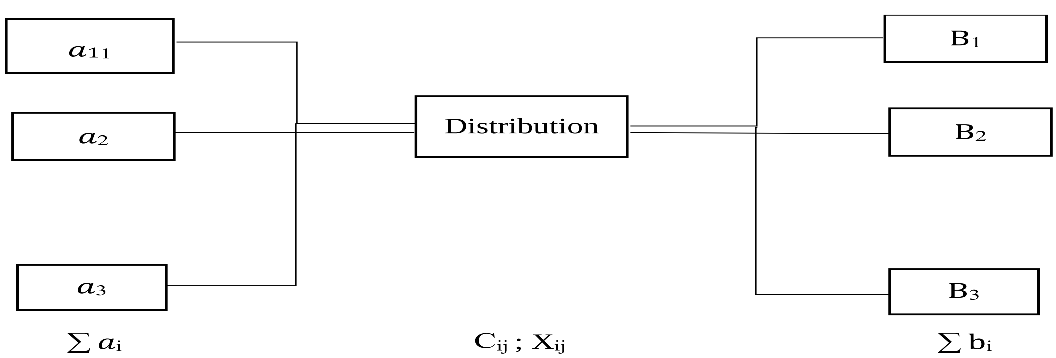

Figure 1 Transportation Model Diagram

The transportation model is essentially looking for and finding a plan for shipping goods (single commodity) from the place of origin to the destination, with a minimum total transportation cost. Therefore, in total transportation costs there are three variables, namely as follows:

1. The number of goods available at the place/source of origin, namely the delivery capacity.
2. Accommodation capacity in the area or destination, namely the capacity of the destination.
3. Transportation costs per unit of goods will be sent.

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If there are *x* pieces of goods sent, while the cost per unit is *b* rupiah, it means that the shipping cost is *x* X *b* rupiah or Rp *x* X *b*. However, because there are many sources, for example the source of goods i sent to various destinations j, the total cost will be $x$ij × $b$ij or Rp $x$ij × $b$ij. Because the total cost of shipping from the source of goods i to the various destinations j must be minimum, the mathematical model becomes:

$$Z=\sum_{i}^{m} = 1 \sum_{j}^{n} = 1\ x_{ij} \times b_{ij}$$

$$\sum_{i}^{m} = 1\ x_{ij} \geq P_j, \text{ Where i } = 1,2, \ldots n$$

So that it can be formulated in the transportation model as follows:

$$\text{Objective function } Z=\sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij} \times b_{ij}$$

With constraint function:

$$\sum_{i=1}^{m} x_{ij} \leq S_i, \text{ where j } = 1,2, \ldots n$$

$$\sum_{i=1}^{m} x_{ij} \geq P_j, \text{ where i } = 1,2, \ldots n$$

where:

S_i = supply capacity (S) of goods from the place of origin (source) *i*

P_j = demand capacity (P) of goods from destination *j*

x_{ij}= units sent from source *i* to destination *j*

b_{ij}= freight cost per unit from source *i* to destination *j*

If the number of goods sent from the place of origin *i* is equal to the number of goods requested by the destination *j*, then the mathematical sentence is

$$\sum_{i=1}^{m} x_{ij} = S_i, \text{ where j } = 1,2, \ldots n$$

$$\sum_{i=1}^{m} x_{ij} = P_j, \text{ where i } = 1,2, \ldots n$$

This condition is called a balanced transportation model (balance transportation model). (Prawirosentono, 2005)

RESULTS AND DISCUSSION

In its trading activities, PT. XYZ has several warehouses for storing dates to meet shop demand. PT. XYZ has 3 warehouses for storing dates. The three warehouses have different storage capacities. The date inventory capacity in each warehouse can be seen in Table 1 below

Table 1 Company warehouse capacity in 2023

No	Warehouse	capacity
1	Danakarya	4500
2	Perak	5400
3	Kebomas	4200

From Table 1 it is known that the total supply of dates in the Danakarya warehouse is 4500 Kg, in the Perak warehouse is 5400 Kg, and in the Kebomas warehouse, there is 4200 Kg. The total capacity of the three warehouses is 14.1 tons.

This research requires company date demand data. The request data in question is the number of units of goods requested from each destination that must be fulfilled by the company's warehouse. The demand data taken is the date demand data in 2023. Dates demand data from each warehouse to each consumer store can be seen in Table 2

Table 2 Date Request Table

Warehouse	Number of Requests for each store			Supply
	Gayungsari	Nyamplungan	Kramatandap	
Danakarya	2150	1500	850	4500
Perak	5000		400	5400
Kebomas			4200	4200
Demand	7150	1500	5450	14100

The transportation cost incurred by the company is the cost of sending each sack from several warehouses owned by the company to several stores. In distributing dates, the company uses ground transportation services, namely trucks. The transportation costs for each warehouse to each consumer store can be seen in Table 3.

Table 3 Distribution Cost

Gudang	Biaya Pengiriman tiap Kg Kurma		
	Gayungsari	Nyamplungan	Kramatandap
Danakarya	117.996	112.386	141.966
Perak	143.666	120.036	117.996
Kebomas	153.866	135.166	114.426

The data obtained from PT. XYZ is made into a transportation matrix or table, the purpose of which is to summarize and present the data. Data processing for problem-solving at this writing is carried out in several stages. Based on Table 3, there is a shipping fee per kg, so the overall data obtained will be formulated into a mathematical model as follows:

Minimize:

$$Z = \sum_{i}^{m} = 1 \sum_{j}^{n} = 1 \, x_{ij} \times b_{ij}$$

$$Z = 117.996 X_{11} + 112.386 X_{12} + 141.966 X_{13} + 1143.666 X_{21} + 120.036 X_{22} + 117.996 X_{23} + 153.866 X_{31} + 135.166 X_{32} + 114.426 X_{33}$$

with the provision of:

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$$\sum X_{ij}$$

$$X_{11} + X_{12} + X_{13} = 4.500$$

$$X_{21} + X_{22} + X_{23} = 5.400$$

$$X_{31} + X_{32} + X_{33} = 4.200$$

$$\text{All } X_{ij} \geq 0$$

With:

Si = total inventory of goods from the place of origin as much as *i*

Pj = the number of requests for goods from various destinations as much as *j*

X*ij* = unit of goods to be sent from source *i* to destination *j*

bij = freight cost per unit of goods from source *i* to destination *j*

Date transportation costs by PT. XYZ is IDR 1,789,059,100

Furthermore, from the data obtained, the initial solution will be sought using the VAM, LC, and NWC methods, and then the optimum solution will be sought using the Stepping Stones method.

Table 4 Transportation Matrix

Toko Gudang	Gayungsari	Nyamplungan	Kramatandap	Persediaan
Danakarya	117.996	112.386	141.966	4500
Perak	143.666	120.036	117.996	5400
Kebomas	153.866	135.166	114.426	4200
Permintaan	7150	1500	5450	14100

Finding Solution using Vogel's Approximation Method, also finding optimal solution using stepping stone method.

Based on the transportation matrix that has been processed, calculations are carried out to find the initial solution using Vogel's Approximation Method. Calculations are performed using Cbom-Atozmath to determine the iteration of the transportation method. Then POM-QM for Windows software is used to validate.

Table 5 Iteration 1 VAM

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply	Row Penalty
Danakarya	117.996	112.386	141.966	4500	5610 = 117996-112386
Perak	143.666	120.036	117.996	5400	2040 = 120036-

					117996
Kebomas	153.866	135.166	114.426	4200	20740 = 135166-114426
Demand	7150	1500	5450		
Column Penalty	25670 = 143666-117996	7650 = 120036-112386	3570=117996-114426		

The maximum penalty, 25670, occurs in column Gayungsari. The minimum *Cij* in this column is C_{11}=117996. The maximum allocation in this cell is min(4500,7150) = 4500. It satisfy supply of Danakarya and adjust the demand of Gayungsari from 7150 to 2650 (7150 - 4500 = 2650).

Table 6 Iteration 2 VAM

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply	Row Penalty
Danakarya	117.996 (**4500**)	112.386	141.966	0	--
Perak	143.666	120.036	117.996	5400	2040=120036-117996
Kebomas	153.866	135.166	114.426	4200	20740=135166-114426
Demand	2650	1500	5450		
Column Penalty	25670=143666-117996	7650=120036-112386	3570=117996-114426		

The maximum penalty, 20740, occurs in row Kebomas. The minimum *cij* in this row is *c*33=114426. The maximum allocation in this cell is min(4200,5450) = **4200**. It satisfy supply of Kebomas and adjust the demand of Kramatandap from 5450 to 1250 (5450 - 4200=1250).

Table 7 Iteration 3 VAM

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply	Row Penalty
Danakarya	117.996 (**4500**)	112.386	141.966	0	--
Perak	143.666	120.036	117.996	5400	2040=120036-

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					117996
Kebomas	153.866	135.166	114.426 (**4200**)	0	--
Demand	2650	1500	1250		
Column Penalty	143.666	120.036	117.996		

The maximum penalty, 143666, occurs in column Gayungsari. The minimum c_{ij} in this column is c_{21}=143666. The maximum allocation in this cell is min(5400,2650) = **2650**. It satisfy demand of Gayungsari and adjust the supply of Perak from 5400 to 2750 (5400 - 2650=2750).

Table 8 Iteration 4 VAM

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply	Row Penalty
Danakarya	117.996 (**4500**)	112.386	141.966	0	--
Perak	143.666 (**2650**)	120.036	117.996	2750	2040=120036-117996
Kebomas	153.866	135.166	114.426 (**4200**)	0	--
Demand	0	1500	1250		
Column Penalty	--	120.036	117.996		

The maximum penalty, 120036, occurs in column Nyamplungan. The minimum c_{ij} in this column is c_{22}=120036. The maximum allocation in this cell is min (2750,1500) = **1500**. It satisfies demand of Nyamplungan and adjust the supply of Perak from 2750 to 1250 (2750 - 1500=1250).

Table 9 Iteration 5 VAM

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply	Row Penalty
Danakarya	117.996 (**4500**)	112.386	141.966	0	--
Perak	143.666 (**2650**)	120.036 (**1500**)	117.996	1250	117996
Kebomas	153.866	135.166	114.426 (**4200**)	0	--
Demand	0	0	1250		
Column Penalty	--	--	117.996		

The maximum penalty, 117996, occurs in row Perak. The minimum c_{ij} in this row is c_{23}=117996. The maximum allocation in this cell is min (1250,1250) = **1250**. It satisfies supply of Perak and demand of Kramatandap.

Table 10 Iteration 6 VAM

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply	Row Penalty
Danakarya	117.996 (**4500**)	112.386	141.966	4500	5610|--||--||--||--|
Perak	143.666 (**2650**)	120.036 (**1500**)	117.996 (**1250**)	5400	2040|2040||2040||2040||117996|
Kebomas	153.866	135.166	114.426(**4200**)	4200	20740|20740||--||--||--|
Demand	7150	1500	5450		
Column Penalty	25670 10200 143666 -- --	7650 15130 120036 120036 --	3570 3570 117996 117996 117996		

The minimum total transportation cost =117996 × 4500 + 143666 × 2650 + 120036 × 1500 + 117996 × 1250 + 114426 × 4200 = 1719835100. The number of allocated cells = 5 is equal to m + n - 1 = 3 + 3 - 1 = 5. This solution is non-degenerate.

Table 11 Allocation Table

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**4500**)	112.386	141.966	4500
Perak	143.666 (**2650**)	120.036 (**1500**)	117.996 (**1250**)	5400
Kebomas	153.866	135.166	114.426(**4200**)	4200
Demand	7150	1500	5450	

Optimality test using stepping stone method.

Iteration-1 of optimality test

1. Create closed loop for unoccupied cells

Table 12 Closed Loop for Unoccupied Cells

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Unoccupied cell	Closed path	Net cost change
DanakaryaNyamplungan	DanakaryaNyamplungan → DanakaryaGayungsari → PerakGayungsari → PerakNyamplungan	112386 - 117996 + 143666 – 120036 = 18020
DanakaryaKramatandap	DanakaryaKramatandap → DanakaryaGayungsari → PerakGayungsari → PerakKramatandap	141966 - 117996 + 143666 – 117996 = 49640
KebomasGayungsari	KebomasGayungsari → KebomasKramatandap → PerakKramatandap → PerakGayungsari	153866 - 114426 + 117996 – 143666 = 13770
KebomasNyamplungan	KebomasNyamplungan → KebomasKramatandap → PerakKramatandap→ PerakNyamplungan	135166 - 114426 + 117996 – 120036 = 18700

Since all net cost change ≥ 0. So final optimal solution is arrived.

Table 13 Final Optimal Solution

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**4500**)	112.386	141.966	4500
Perak	143.666 (**2650**)	120.036 (**1500**)	117.996 (**1250**)	5400
Kebomas	153.866	135.166	114.426(**4200**)	4200
Demand	7150	1500	5450	

The minimum total transportation cost using Vogel's Approximation Method and Stepping Stones Method is =117996 × 4500 + 143666 × 2650 + 120036 × 1500 + 117996 × 1250 + 114426 × 4200 = 1719835100.

Finding Solution using North-West Corner method, also finding optimal solution using stepping stone method. According to table 4 The rim values for Danakarya = 4500 and Gayungsari = 7150 are compared. The smaller of the two i.e. min (4500,7150) = **4500** is assigned to Danakarya Gayungsari. This exhausts the capacity of Danakarya and leaves 7150 – 4500 = 2650 units with Gayungsari

Table 14 Iteration 1 NWC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**4500**)	112.386	141.966	0
Perak	143.666	120.036	117.996	5400
Kebomas	153.866	135.166	114.426	4200
Demand	2650	1500	5450	

Move vertically, the rim values for Perak=5400 and Gayungsari=2650 are compared. The smaller of the two i.e. min (5400,2650) = **2650** is assigned to Perak Gayungsari. This meets the complete demand of Gayungsari and leaves 5400 - 2650=2750 units with Perak.

Table 15 Iteration 2 NWC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**4500**)	112.386	141.966	0
Perak	143.666(**2650**)	120.036	117.996	2750
Kebomas	153.866	135.166	114.426	4200
Demand	0	1500	5450	

Move horizontally, The rim values for Perak=2750 and Nyamplungan=1500 are compared. The smaller of the two i.e. min (2750,1500) = **1500** is assigned to Perak Nyamplungan. This meets the complete demand of Nyamplungan and leaves 2750 - 1500=1250 units with Perak.

Table 16 Iteration 3 NWC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**4500**)	112.386	141.966	0
Perak	143.666(**2650**)	120.036(**1500**)	117.996	1250
Kebomas	153.866	135.166	114.426	4200
Demand	0	0	5450	

Move horizontally,the rim values for Perak=1250 and Kramatandap=5450 are compared. The smaller of the two i.e. min (1250,5450) = **1250** is assigned to Perak Kramatandap. This exhausts the capacity of Perak and leaves 5450 - 1250=4200 units with Kramatandap.

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Table 17 Iteration 4 NWC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**4500**)	112.386	141.966	0
Perak	143.666(**2650**)	120.036(**1500**)	117.996	0
Kebomas	153.866	135.166	114.426	4200
Demand	0	0	4200	

Move vertically, the rim values for Kebomas=4200 and Kramatandap=4200 are compared. The smaller of the two i.e. min (4200,4200) = **4200** is assigned to Kebomas Kramatandap

Table 18 Iteration 5 NWC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**4500**)	112.386	141.966	0
Perak	143.666(**2650**)	120.036(**1500**)	117.996	0
Kebomas	153.866	135.166	114.426 (**4200**)	4200
Demand	0	0	4200	

Table 19 Initial Feasible Solution Using NWC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**4500**)	112.386	141.966	4500
Perak	143.666 (**2650**)	120.036 (**1500**)	117.996 (**1250**)	5400
Kebomas	153.866	135.166	114.426(**4200**)	4200
Demand	7150	1500	5450	

Because the allocation table and the results of the minimum distribution costs using the NWC method are the same as the allocation tables and the results of the minimum distribution costs using the VAM method, it is not necessary to carry out an optimum test using the Stepping Stones method.

Finding Solution using Least Cost method, also finding optimal solution using stepping stone method. According to table 4, the smallest transportation cost is 112386 in cell DanakaryaNyamplungan. The allocation to this cell is min (4500,1500) = **1500**. This satisfies the entire demand of Nyamplungan and leaves 4500 - 1500=3000 units with Danakarya.

Table 20 Iteration 1 LC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996	112.386 (**1500**)	141.966	3000
Perak	143.666	120.036	117.996	5400
Kebomas	153.866	135.166	114.426	4200
Demand	7150	0	5450	

The smallest transportation cost is 114426 in cell KebomasKramatandap. The allocation to this cell is min (4200,5450) = **4200**. This exhausts the capacity of Kebomas and leaves 5450 - 4200=1250 units with Kramatandap.

Table 21 Iteration 2 LC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996	112.386 (**1500**)	141.966	3000
Perak	143.666	120.036	117.996	5400
Kebomas	153.866	135.166	114.426 (**4200**)	0
Demand	7150	0	1250	

The smallest transportation cost is 117996 in cell Danakarya-Gayungsari. The allocation to this cell is min (3000,7150) = **3000**. This exhausts the capacity of Danakarya and leaves 7150 - 3000=4150 units with Gayungsari

Table 22 Iteration 3 LC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996	112.386 (**1500**)	141.966	0
Perak	143.666	120.036	117.996	5400
Kebomas	153.866	135.166	114.426 (**4200**)	0
Demand	4150	0	1250	

The smallest transportation cost is 117996 in cell Perak-Kramatandap. The allocation to this cell is min (5400,1250) = **1250**. This satisfies the entire demand of Kramatandap and leaves 5400 – 1250 = 4150 units with Perak.

Table 23 Iteration 4 LC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**3000**)	112.386 (**1500**)	141.966	0
Perak	143.666	120.036	117.996 (**1250**)	4150
Kebomas	153.866	135.166	114.426 (**4200**)	0
Demand	4150	0	0	

The smallest transportation cost is 143666 in cell Perak-Gayungsari. The allocation to this cell is min (4150,4150) = **4150**.

Table 24 Iteration 5 LC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**3000**)	112.386 (**1500**)	141.966	0
Perak	143.666 (**4150**)	120.036	117.996	0
Kebomas	153.866	135.166	114.426 (**4200**)	0
Demand	0	0	0	

Table 25 Initial Feasible Solution Using LC

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**3000**)	112.386(**1500**)	141.966	4500
Perak	143.666 (**4150**)	120.036	117.996 (**1250**)	5400
Kebomas	153.866	135.166	114.426(**4200**)	4200
Demand	7150	1500	5450	

Optimality test using stepping stone method

Create closed loop for unoccupied cells

Table 26 Iteration 1 Closed Loop for Unoccupied Cells

Unoccupied cell	Closed path	Net cost change

DanakaryaKramatandap	DanakaryaKramatandap → DanakaryaGayungsari → PerakGayungsari → PerakKramatandap	141966 - 117996 + 143666 - 117996=49640
PerakNyamplungan	PerakNyamplungan → PerakGayungsari → DanakaryaGayungsari → DanakaryaNyamplungan	120036 - 143666 + 117996 - 112386=-18020
KebomasGayungsari	KebomasGayungsari → KebomasKramatandap → PerakKramatandap → PerakGayungsari	153866 - 114426 + 117996 - 143666=13770
KebomasNyamplungan	KebomasNyamplungan → KebomasKramatandap → PerakKramatandap → PerakGayungsari → DanakaryaGayungsari → DanakaryaNyamplungan	135166 - 114426 + 117996 - 143666 + 117996 - 112386=680

Select the unoccupied cell having the highest negative net cost change i.e. cell PerakNyamplungan=-18020. Draw a closed path from PerakNyamplungan. Closed path is PerakNyamplungan→PerakGayungsari→DanakaryaGayungsari→DanakaryaNyamplungan. Closed path and plus/minus allocation for current unoccupied cell PerakNyamplungan.

Table 27 plus/minus allocation

Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**3000**) (+)	112.386(**1500**) (-)	141.966	4500
Perak	143.666 (**4150**) (-)	120.036 (+)	117.996 (**1250**)	5400
Kebomas	153.866	135.166	114.426(**4200**)	4200
Demand	7150	1500	5450	

Minimum allocated value among all negative position **(-)** on closed path = 1500. Substract 1500 from all **(-)** and Add it to all **(+)**

Table 28 Allocation after substract

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Store / Warehouse	Gayungsari	Nyamplungan	Kramatandap	Supply
Danakarya	117.996 (**4500**)	112.386)	141.966	4500
Perak	143.666 (**2650**)	120.036 (**1500**)	117.996 (**1250**)	5400
Kebomas	153.866	135.166	114.426(**4200**)	4200
Demand	7150	1500	5450	

Iteration-2 of optimality test.

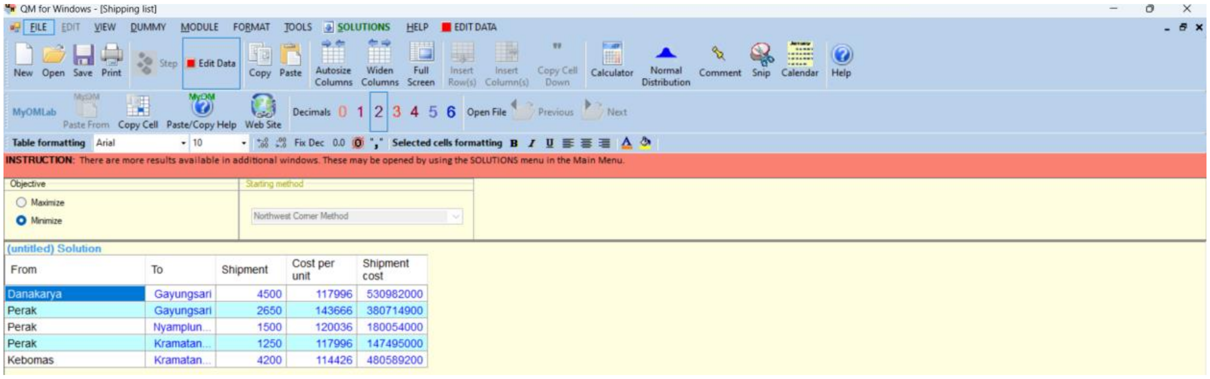
Create closed loop for unoccupied cells

Table 29 Iteration 2 Closed Loop for Unoccupied Cells

Unoccupied cell	Closed path	Net cost change
DanakaryaNyamplungan	DanakaryaNyamplungan → DanakaryaGayungsari → PerakGayungsari → PerakNyamplungan	112386 - 117996 + 143666 - 120036=18020
DanakaryaKramatandap	DanakaryaKramatandap → DanakaryaGayungsari → PerakGayungsari → PerakKramatandap	141966 - 117996 + 143666 - 117996=49640
KebomasGayungsari	KebomasGayungsari → KebomasKramatandap → PerakKramatandap → PerakGayungsari	153866 - 114426 + 117996 - 143666=13770
KebomasNyamplungan	KebomasNyamplungan → KebomasKramatandap → PerakKramatandap → PerakNyamplungan	135166 - 114426 + 117996 - 120036=18700

Since all net cost change ≥ 0. So final optimal solution in table 27 is arrived. The minimum total transportation. Cost = 117996 × 4500 + 143666 × 2650 + 120036 × 1500 + 117996 × 1250 +1 14426 × 4200 = 1719835100.

Figure 2 Result Using POM-QM



Based on Figure 2, the Optimal Cost results obtained from the VAM (Vogel's Approximation Method), NWC (North-West Corner), LC (Least Cost) method using POM-QM Software are Rp. 171,983,5100.00. These results are in accordance with the calculation of the minimum distribution costs that have been done previously.

PT. XYZ is advised to distribute dates from Danakarya Warehouse to Gayungsari shop in the amount of 4500 kg, Perak Warehouse to Gayungsari shop as much as 2650 kg, Perak Warehouse to Nyamplungan shop in the amount of 1500 kg, Perak Warehouse to Kramatandap shop as much as 1250 kg, Kebomas Warehouse to Kramatandap shop as much as 4200 kg.

The results of the analysis of the use of transportation methods to optimize the cost of distributing dates to companies show the total costs of distributing dates by PT. XYZ after efficiency using the transportation method was Rp. 1,719,835,100.00. So by using the transportation method, the company can save the cost of distributing dates by Rp. 69,224,000.00.

CONCLUSION

Distribution activities carried out are PT. XYZ distributed 2150 kg of dates from the Danakarya warehouse to the Gayungsari store, 1500 kg from the Danakarya warehouse to the Nyamplungan store, 850 kg from the Danakarya warehouse to the Kramatandap store, 5000 kg from the Perak warehouse to the Gayungsari store, 5000 kg from the Perak warehouse to the Kramatandap store. as much as 400 kg, and from the Kebomas warehouse to the Kramatandap store as much as 4200 kg. Distribution activities that should be carried out by PT. Bersaudara's main business is to distribute dates from the Danakarya warehouse to the Gayungsari store in the amount of 4500 kg, from the Perak warehouse to the Gayungsari store in the amount of 2650 kg, from the Perak warehouse to the Nyamplungan store in the amount of 1500 kg, from the Perak warehouse to the Kramatandap store in the amount of 1250 kg, and from the Kebomas warehouse to the Kramatandap shop as much as 4200 kg.

The use of transportation methods to streamline the cost of distributing dates to the Company resulted in savings of Rp. 69,224,000.00. Total cost of distribution of dates by PT. XYZ before efficiency using the transportation method was Rp. 1,789,059,100. Total cost of distribution of dates by PT. XYZ efficiency using the transportation method was Rp. 1,719,835,100.00.

REFERENCE

Ardhyani, I. W. 2017. *Mengoptimalkan Distribusi Pakan Ternak Dengan Menggunakan Metode Transportasi*. Teknika: Engineering and Sains Journal, Volume 1, No. 2, pp. 95-100.

Hadijah. 2022. *Efek Harga BBM, Pengusaha Hitung Kenaikan Harga Produk*. CNBCIndonesia. Diakses melalui: https://www.cnbcindonesia.com/news/20220905173311-4-369558/efek-harga-bbm-pengusaha-hitung-kenaikan-harga-produk. Diakses pada 20 Juli 2023 (04.45 WIB).

Harsono, Subambang. 2016. *Riset Operasi*. Medan: STIE Graha Kirana

Kankarofi, R. H., Ayakubu, U., Sulaiman, I. M., Mamat, M., Sukono, & Saputra, M.P.A. 2021. *Fertilizing Transportation Problem Using Vogel Approximation Method*. IOP Conference Series: Materials Science and Engineering, 1115(1), 012005.

Mulyadi. 2009. *Akuntansi Biaya (Edisi 5)*. STIE YPKPN.

Mulyono, T. 2004. *Teknologi Beton*. Andi, Yogyakarta.

Purnomo. 2004. *Riset Operasional Konsep-Konsep Dasar*. PT Rhineka Cipta

Sedarmayanti. 2014. *Manajemen Sumber Daya Manusia Reformasi Birokrasi dan Manajemen Pegawai Negeri Sipil*. Bandung: Refika Aditama.

Subagyo, dkk. 2018. *Akuntansi Manajemen Berbasis Desain*. Yogyakarta: Gadjah Mada University Press.

Taufiq, Achmad. 2017. Penerapan Metode Modified Distribution (MODI) Dalam Meminimalisasi Biaya Transportasi Pengiriman Barang di PT. Tirta Makmur. *JMSA Vol. 7*

Yohanes Yahya. 2014 . *Pengantar Manajemen*. Jakarta:Bumi Aksara.