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IMPLEMENTATION OF TRANSPORTATION METHODS IN OPTIMIZING THE DISTRIBUTION OF HIJAB PRODUCTS AT AYASHA HIJAB STORE

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Abstract

The problem of transportation costs is a problem faced by many companies, especially those that distribute goods from various places to various destinations, and Ayasha Hijab's company is no exception. The company has 3 stores and supplies Bella square veils from 3 different warehouses. This of course has an impact on the company's expenses considering the distance and the increasing number of requests. The researcher tries to find a solution by using the linear program transportation solution method. Researchers processed data from the Ayasha Hijab Company with the NWC model and then second processing to get optimal results with stepping stones and MODI. As a result, the optimal cost for the stepping stone and MODI models is IDR 5.125.000. The Stepping Stone and MODI methods get the optimal solution and can save costs around IDR. 3.350.000 from the NWC method with a cost of IDR. 8.475.000. Secondary data obtained from the calculation of "Ayasha Hijab Store" has a minimum cost of around IDR. 10.000.000. So that the Stepping Stone method and the MODI method can save Bella Square distribution costs of IDR. 4.875.000.

Keywords*: Linear programming, North West Corner (NWC), Stepping stone, MODI, Ayasha Hijab Store, Transportation method*

INTRODUCTION

Linear programming is the name of the branch of applied mathematics that deals with solving specific geometry optimization problems. A linear programming problem consists of a linear cost function (made up of certain variables) that must be minimized or maximized according to certain constraints. The constraints are the linear inequalities of the variables used in the cost function. The cost function is sometimes called the objective function. Linear programming is closely related to linear algebra. The most notable difference is that linear programming often uses inequalities rather than equality in problem statements (Schulze, 2001).

Mathematically, linear programming is also a tool for optimizing (minimizing or maximizing) a linear function of a set of decision variables while respecting multiple linear constraints (Briend et al., 2003). Linear programming has many applications within theoretical computer science, and it can be used to solve a variety of combinatorial problems that seem unrelated to linear programming. Linear programming could be very critical within side the vicinity of implemented arithmetic and has a big wide variety of makes use of and programs in lots of industries. Some cutting-edge programs include; the allocation of resources, transportation, and scheduling operations (Wulan et al., 2018).

In general, optimization can be interpreted as getting the best results from several available options (Kartika et al., 2020). Mathematically, optimization is a way to get the most extreme value, either the maximum or the minimum that arises from a certain function in the presence of a limiting factor (Sitepu, & Harianja, 2018). In the Oxford Advanced Learners Dictionary (Hornby, 2002), it stated that optimization is a process to find the best solution for a problem that has certain criteria. Optimization problems abound in various research areas, be it from traffic scheduling, maximizing production based on different variables, efficient use of electricity for neural network training, game modeling, or optimizing data science models. The goal in this state is to minimize or maximize the optimization function, where each optimum represents a possible solution. However, we don't just want a possible solution, we want the best solution, global minima or maxima (Morgan, 2021).

The recent development of distribution theory emphasizes solving problems faced by researchers and offers a variety of models so that lifetime data sets can be well evaluated and studied. In different application areas. In other words, it is necessary to introduce useful models to better explore the real phenomenon of nature. Today, the trends and practices of proposing new probabilistic models are completely different from those proposed before 1997 (Ahmad et al., 2019). The main objective is to propose, extend or generalize (models or classes), then also to explain how time-of-life phenomena occur in fields such as physics, computer science, insurance, public health, medicine, engineering, biology, industry, communications, life test, and many other areas. Well-known and fundamental distributions such as exponential, Rayleigh, Weibull, and gamma are very limited in their characteristics and cannot exhibit high flexibility. For example, the exponential distribution can be modeled with a constant danger function, while the Rayleigh distribution has only an increasing danger function. However, Weibull is very flexible and can be modeled with an increasing, decreasing, or constant risk function.

In the Indonesian dictionary, distribution is the delivery of goods to many places or people (Anwar, 2001). Tjiptono (2006) stated that distribution is a marketing activity that aims to facilitate the delivery of goods or services from providers (producers) to users (consumers). To solve this problem, we can apply the North West Corner method. Since the North West Corner method is widely used to optimize the variables used to solve transportation cost problems, it is expected that the North West Corner method can maximize the transportation cost of goods.

Another extension of linear programming, transport techniques, are special techniques that can only be used to solve specific types of problems (Abdullah, 2020). For example, if you need to minimize the cost or maximize the profit of distributing items from a set of M. It points to N receiving points. Solving the problem this way requires the following basic rules: (1) The sent total must equal the received total. (2) You must also know the transportation cost of each unit of merchandise from each source to each destination (Stéphane et al., 2013). A basic viable solution is to use 'M + N - 1' tariffs to meet source and destination capacities and requirements. Therefore, the transportation method is a method used to regulate the distribution of goods from places that have or produce certain goods with a certain capacity to places that need these goods with a certain amount of needs so that distribution costs can be kept to a minimum (Kurniawan & Haryati, 2017).

The main objective of the transport model according to (Asaolu & Nassar, 2007) is the efficient distribution of goods and services, etc. at the lowest possible cost. There are balance and unbalanced shipping problems. The situation where aggregate demand equals aggregate supply is a balancing transport problem. But the situation in which the total demand of the customer does not match the capacity of the source is called the unbalanced transport problem (Salami, 2014).

The transportation method has 2 stages that must be completed to get the best solution in the distribution of goods, 2 stages are the stage of determining the resolution of the crew that sails and testing for optimality (Vieira et al., 2020). For the given problem, we construct a mathematical description called a mathematical model to represent the situation.

Determining the initial eligible solution

North West Corner (NWC) method

The NWC method is a method for compiling the initial table by allocating the distribution of goods starting from the cell located in the upper left corner. The rules for completing this NWC method are as follows (Sudirga, 2017). Step 1: Fill in the cells/boxes starting from the top left corner and assign the minimum value of supply or demand, i.e., min (supply, demand). Step 2: If necessary, dispense the maximum (maximum) amount according to the conditions. Subtract the above minimum from Pi and Si for the appropriate row and column. Here you may get 3 choices as: (1) If Supply is equal to 0, hit that row and move to the next cell. (2) If the demand is 0, strike through this column and move to the next cell. (3) If supply and demand are 0, cross out both row and column and move diagonally to the next cell. Step 3: Move to the box on the right if there is sufficient supply, otherwise move to the box below according to demand. Keep moving until the supply runs out and the demand is met.

The formula for the cost of distribution of goods according to the North West Corner method, i.e. (Pasaribu, 2019):

$$\mathbf{F} = (\boldsymbol{A_1} * \boldsymbol{B_1}) + (\boldsymbol{A_2} * \boldsymbol{B_2}) + (\boldsymbol{A_n} * \boldsymbol{B_n}) \quad (1)$$

Information:
F = Total cost of shipping goods
A_n = Shipping price of goods specified
B_n = Needs of goods that have been determined.

Optimalization Testing

There are two methods in optimalization testing namely stepping stone method and Modified distribution method (MODI) or U-V method. Steps to solve using the stepping stone method (Shih, 1987): (1) Create a path/path starting from a non-base box whose IP will be calculated. (2) From a non-basic box, a straight line is drawn to the nearest base box provided that the contacted box has a partner in the same column/row so that the row can continue until it returns to the original box. (3) The start of the trip is coded *. (4) Calculate the IP value. Starting with the + sign then – and so on alternately. (5) Select the box to enter base or exit base. (6) Find the box with the smallest variation value, this box must come out of the base. (7) Repeat the step with Calculate IP value until you find the optimal table and calculate the optimal result.

Modified distribution method (MODI) or U-V method (Dantzig, 1963) is used to check the optimality of the basic possible solution obtained using any transport method such as NWC. This only works on non-degenerate solutions; therefore, the resulting solution is converted to an undenatured solution. If the solution is not optimal, it moves the allocation to the unallocated cell to optimize the original solution. The steps for solving the MODI method (Prasad and Singh, 2020): (1) Use a feasible initial solution result table. (2) Each table with the first feasible solution, calculate the value of U_i and V_j, with the formula: $C_{ij} = U_i + V_j$, for row $i = 1, 2, 3, \dots, m, and\ j = 1, 2, 3, \dots, n.$ assign value 0 to any arbitrary U_i to start the proses. C_{ij} is the transportation cost per unit of goods from the area of origin to the place of destination. The process starts with assigning either U_i or V_i value to 0 depending on whether the maximum assignment is in i^{th} row or j^{th}column. (3) Calculate the repair index $IP_{ij} = (U_i + V_j) - C_{ij}$, for all non-base squares. If $IP_{ij} = 0$, the solution is optimal, if $IP_{ij} \neq 0$ then continue to step (3). (4) Alternately put + and – signs on the costs of the squares that make up the path (such as the stepping stone method). (5) Variables from the box marked +, take the smallest value (minimum). This box must exit the base, while the value is placed in the box with the largest IP value (the box that enters the base). Create a new table and calculate the IP value of the box instead of the base, if everything is 0, then the solution is optimal.

METHODS

In this series, we will discuss the optimization of distribution costs for hijab products at the Ayasha Hijab store. Ayasha Hijab is one of the largest privately owned companies engaged in Muslim fashion based in Bantul, Yogyakarta. The objective of this study is to establish a network representation, mathematical formulation and analysis the case of a transportation problem. The research method is the method used by researchers in collecting research data. The research method used in this research is descriptive with a quantitative approach. The use of quantitative descriptive methods is used to analyze the results of the use of transportation methods at the Ayasha Hijab store.

RESULTS

The author obtained an overview of the distribution of one of the best seller items at the Ayasha Hijab Store, namely Hijab Bella Square along with the capacity of each warehouse and also the number of requests for goods in each branch. Ayasha Hijab has 3 main warehouses, namely Online Warehouse, Offline Warehouse, and Yogya Warehouse, and has 3 branch stores namely Gejayan, Sonosewu, and Kasihan. Each warehouse has a different amount of capacity because it is adjusted to the area of the warehouse and the needs of each branch, as well as each branch also varies the number of requests because it is adjusted to the needs of consumers. The total capacity of each warehouse and the number of requests for each branch are as follows:

Supply

Since the optimization models we develop are expected to be applicable in a wide variety of cases, this section first presents the scope of the problem and then describes the problem in detail using company-provided examples.

Table 1. Ayasha Hijab Warehouse Capacity

Warehouse	Supplay Product
Sleman	3000 Bella Square/Month
Yogyakarta City	2200 Bella Square/Month
Bantul	2550 Bella Square/ Month
Total	**7750 Bella Square/ Month**

** Warehouse capacity, Ayasha Hijab shop (stock of each character in the storage warehouse)*

The problem is to determine the optimal quantity of Ayasha Hijab stores that should be shipped from each company's warehouse to another merchant's warehouse to achieve the lowest transportation cost (Khan, 2014).

Demand

Based on the capacity of the Ayasha Hijab Warehouse, the following are requests for branch needs:

Table 2. Ayasha Hijab Branch Store Goods Request

Branch	Demand Produk
Sonosewu	2550 bella square
Gejayan	2700 bella square
Kasihan	2500 bella square

Transportation cost/product

This study also obtained about the type of transportation used by Ayasha Hijab and Transportation Costs incurred for distribution per Bella Square hijab product as well as transportation costs/Canvas cars. The distribution of Ayasha Hijab products in the Yogyakarta area uses land transportation, namely canvas cars. The transportation costs per product are:

Table 3. Ayasha Hijab Product Unit Transportation Cost

DISTRIBUTION LINE	COST / PRODUCT
Sleman – Sonosewu	1000
Sleman – Gejayan	500
Sleman – Kasihan	1000
Yogyakarta City – Sonosewu	1000
Yogyakarta City – Gejayan	2000
Yogyakarta City – Kasihan	1000
Bantul – Sonosewu	500
Bantul – Gejayan	1000
Bantul – Kasihan	500

This section shows how transportation methods are used to determine optimal transportation costs. The first step is to organize a table of initial data for the transport methods that represent the model. Once the model is implemented in the table, the next step is to use the model to find a solution. The model must identify the location of the objective function (cell), the decision variables, the nature of the objective function (maximize/minimize), and the constraints. Use the table below to solve the problem step by step.

Step I

The data obtained are entered into the transportation matrix, the following is the initial table of data:

Table 4. Initial data for transportation methods (in IDR)

Shop / Warehouse	Sonosewu	Gejayan	Kasihan	Supply
Sleman	1000	500	1000	3000
Yogyakarta City	1000	2000	1000	2200
Bantul	500	1000	500	2550
Demand	2550	2700	2500	7750

Pay attention to the table above, if the number of requests for *Pi* is the same as the amount of supply for *Si*, then there is no need to add a dummy variable. So, the next step can be done.

Step II

Specifying the Initial Table. The initial table can be determined by NWC rule.

Table 5. Nort West Corner Rule (NWC Rule)

Shop / Warehouse	Sonosewu	Gejayan	Kasihan	Supply
Sleman	1000 2550	500 450	1000	3000
Yogyakarta City	1000	2000 2200	1000	2200
Bantul	500	1000 50	500 2500	2550
Demand	2550	2700	2500	7750

Total Cost = 2550 (1000) + 450 (500) + 2200 (2000) + 50 (1000) + 2500 (500) = 8.475.000. Thus, the total cost required in distributing Ayasha Hijab products using the NWC method is IDR 8.475.000.

Step III

Determining the optimal table

Before determining the optimal solution from the existing data, the initial table needs to be checked for feasibility first. In this study, NWC can solve the initial solution is feasible because the number of cells is filled = $m + n - 1$.

✓ **Check eligibility**
- Number of filled cells = 5 (base cells)
- Number of Rows $m = 3$; Number of Columns $n = 3$
- $m + n - 1 = 3 + 3 - 1 = 5$

Determining the optimal table with the North West Corner (NWC) approach

a) Stepping Stone

Allocation of optimal solutions for the NWC approach using the Stepping Stone method:

Table 6. Iteration 1

Shop / Warehouse	Sonosewu	Gejayan	Kasihan	Supply
Sleman	1000 2550	500 450	1000	3000
Yogyakarta City	1000	2000 2200	1000	2200
Bantul	500	1000 50	500 2500	2550
Demand	2550	2700	2500	7750

Table 7. Iteration 2

Shop / Warehouse	Sonosewu	Gejayan	Kasihan	Supply
Sleman	1000 350	500 2650	1000	3000
Yogyakarta City	1000 2200	2000	1000	2200
Bantul	500	1000 50	500 2500	2550
Demand	2550	2700	2500	7750

Table 8. Iteration 3

Shop / Warehouse	Sonosewu	Gejayan	Kasihan	Supply
Sleman	1000 300	500 2700	1000	3000
Yogyakarta City	1000 2200	2000	1000	2200
Bantul	500 50	1000	500 2500	2550
Demand	2550	2700	2500	7750

$Total\ minimum\ cost$ = 300 (1000) +2700 (500) + 2200 (1000) + 50 (500) + 2500 (500) = 5.125.000. Thus, the total cost required in distributing Ayasha Hijab products using the *Stepping Stone* method is IDR 5.125.000.

b) Modified Distribution (MODI)

Allocation of the optimal solution for the NWC approach using the MODI method:

Table 9. Optimal Solution Using the MODI Method

Shop / Warehouse	Sonosewu	Gejayan	Kasihan	Supply
Sleman	1000 300	500 2700	1000	3000
Yogyakarta City	1000 2200	2000	1000	2200
Bantul	500 50	1000	500 2500	2550
Demand	2550	2700	2500	7750

$Total\ minimum\ cost$ = 300 (1000) +2700 (500) + 2200 (1000) + 50 (500) + 2500 (500) = 5.125.000. Thus, the total cost required in distributing Ayasha Hijab products using the *Modified Distribution (MODI)* method is IDR 5.125.000.

DISCUSSION

Transportation Problems a problem of transporting goods from source to destination, placing products from sources that move to destinations that require products so that transportation costs are as low as possible. The transport problem basically addresses the problem of finding the best way to meet the demand of n demand points using the capacity of m supply points. In general, variable costs or similar constraints to transport a product from a point of supply to a point of demand should be considered when trying to find the best route (Hanne & Dornberger, 2016). With the increasing consumer interest in Muslim fashion, especially for the demand for veils made of Bella Square material, Ayasha Hijab has set up 3 stores in DI Yogyakarta, namely the Sonosewu Store, the Gejayan Store, and the Pity Shop. Ayasha Hijab's 3 stores received Bella Square veils from 3 different warehouses, namely the Sleman warehouse, the Yogyakarta City Warehouse, and the Bantul warehouse.

Ayasha Hijab distributes by car and store driver but distribution costs still need to be calculated for the distance from the warehouse to the store, the number of goods, and also fuel, where the funds are allocated to the driver. The problem faced by the Ayasha Hijab store is how to optimize the distribution costs of goods so that the transportation costs incurred do not swell. Efficient algorithms have been developed to solve transportation problems when the cost factors and the demand and supply are known exactly (Cahdriyana et al., 2019). Although it is a simplex method, a more efficient solution method (algorithm) called transport engineering based on the simplex method has been developed (Iheonu & Inyama, 2016). In the explanation of the background, we found that there were problems faced by the Ayasha Hijab store, namely how the distribution flow of goods was the most optimal that the Ayasha Hijab store could do and the most optimal costs incurred by the store. By the formulation of the problem described above, our goal is to provide an overview of the most optimal distribution flow of goods that can be carried out by the Ayasha Hijab store and the most optimal costs incurred by the store. To meet this need, we are using the North West Corner method to complete a written application to the journal. This includes shipping calculations. The creation of this application is intended to help Ayasha Hijab store staff simplify the process of calculating shipping costs. To solve this problem, we can apply the North West Corner method. Because the North West Corner method is widely used to optimize the variables used to solve transportation cost problems, the North West Corner method can maximize the cost of goods transportation. Including the problem of shipping goods, commodities, or raw materials from various sources to various destinations at optimal costs (Pasaribu, 2019). Then apart from transportation methods such as the NWC method, we also use other optimization methods such as the Stepping Stone, or the Modified Distribution Method.

Based on research results and relevant theories, the researchers found a solution to minimize transportation costs and the total cost of distributing Bella Square goods from the Ayasha Hijab Warehouse to the Store Branch. The method that researchers use in solving this transportation model problem is the North West Corner (NWC) approach as the initial optimal solution with a transportation cost of IDR. 8.475.000. However, after the final optimal solution using the Stepping stone and MODI methods was obtained, different results were obtained, namely the transportation cost of IDR. 5.125.000. The Stepping Stone and MODI methods get the optimal solution and can save costs around IDR. 3.350.000 from the NWC method. Secondary data obtained from the calculation of "Ayasha Hijab Store" has a minimum cost of around IDR. 10.000.000. Therefore, the Stepping Stone method and the MODI method can save Bella Square distribution costs of IDR 4.875.000. Hence, it can be concluded that the variation in shipping costs per unit has the greatest influence on the total shipping costs.

In this study, the discussion is manual. We recommend using software such as POM-QM or LINDO to reduce errors in your calculations. Then, this profit optimization study only uses linear programming. It would be nice to be able to combine it with other analyses, such as a cost analysis, to determine net profit or find the breakeven point and determine the maximum units of production. It is necessary to develop a program for further research in order to make it easier for users in the future.

CONCLUSION

Mathematical modeling of transportation methods will produce mathematical equations that are useful for solving optimization problems if the model used is valid. In this study, the transformation method has been used, namely the initial table (NWC) as the initial optimal solution and the final table (Stepping Stone and MODI) as the final optimal solution to justify its efficiency by completing the cheapest solution. Costs where a suitable method is found to solve Bella Square distribution costs from Ayasha Hijab Warehouse to Branch Stores. Based on the simulation results, the proposed Stepping Stone and MODI methods provide significant results by ensuring minimum transportation costs.

In practice conditions like this (supply = demand) are very difficult to find, so it is advisable to do research regarding conditions where the amount of material needed is greater than the amount of material available (supply < demand) or vice versa, the amount of material available is more than the amount of material needed (supply > demand). This study highlights the applications of linear programming in an Ayasha Hijab store shipping case study. Optimal plans and solutions to minimize total transportation costs have been developed and analyzed. Undoubtedly, linear programming is an alternative decision tool available to engineers and managers to ensure that their operations are carried out efficiently and effectively at the lowest possible cost and thereby maximizing the firm's profits.

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