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# Analysis of Goods Delivery Routes Using Saving Matrix and Clarke & Wright Savings Methods

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**ABSTRACT**

Distribution routes are distribution delivery routes that are created taking into account distance traveled, transport equipment capacity, and delivery capacity so that distribution costs are minimal. To date, there are 14 routes with 32 delivery points. Of the 14 existing routes, there are drop points through which several routes pass. So, companies need to evaluate the routes currently used. This problem arises as a result of the increase in shipping capacity over time. The general objective of this final research is to obtain alternative distribution routes in the process of distributing goods and analyze route improvements by comparing company routes and alternative routes obtained using the Saving Matrix and Clarke & Wright Savings methods. The research results showed that alternative distribution routes using the Saving Matrix method experienced an increase in costs of 5.4% from the original costs. Meanwhile, using the Clarke & Wright Savings method, distribution costs decreased by 3.6% per day. The improvement proposal given is an alternative distribution route using the Clarke & Wright Saving method, which has 11 routes and a savings of 3.6%.
**Keyword:** Distribution Routes, Distribution Costs, Transport Equipment Capacity, Delivery Capacity

**ABSTRAK**

Rute distribusi adalah jalur pengiriman distribusi yang dibuat dengan pertimbangan jarak tempuh, kapasitas alat angkut, dan kapasitas pengiriman agar biaya distribusi yang dikeluarkan minimum. Sampai saat ini, rute yang dimiliki adalah 14 rute dengan 32 titik pengantaran. Dari 14 rute yang telah ada, terdapat drop point yang dilalui beberapa rute. Sehingga perusahaan perlu melakukan evaluasi terhadap rute yang digunakan saat ini. Permasalahan ini muncul akibat dari peningkatan jumlah kapasitas pengiriman seiring berjalannya waktu. Tujuan umum penelitian tugas akhir ini adalah mendapatkan rute distribusi alternatif dalam proses pendistribusian barang untuk menganalisis perbaikan rute dengan membandingkan rute perusahaan dan rute alternatif yang didapatkan memanfaatkan metode Saving Matrix dan Clarke & Wright Savings. Perolehan penelitian memperlihatkan rute distribusi alternatif memanfaatkan metode Saving Matrix mengalami peningkatan biaya sebanyak 5,4% dari biaya semula, sedangkan dengan metode Clarke & Wright Saving mengalami penurunan biaya distribusi sebesar 3,6% per hari. Sebagai usulan perbaikan yang diberikan yaitu rute distribusi alternatif menggunakan metode Clarke & Wright Saving yang memiliki 11 rute dan penghematan sebesar 3,6%.
**Keyword:** Rute Distribusi, Biaya Distribusi, Kapasitas Alat Angkut, Kapasitas Pengiriman

## 1. Introduction

The industrial sector in Indonesia is growing rapidly. This industrial development has triggered all companies in Indonesia to find new strategies that are more effective and efficient so that every resource they have can be fully utilized and is expected to provide optimal results. Optimal results can be obtained by improving work systems, especially production systems and supporting systems. One of the supporting systems is the distribution system [1]. Logistics management is a strategic management process for the transfer and storage of goods, spare parts, and finished goods from suppliers [2].

The distribution system is one of the most important parts of a company's operations. The distribution of production results to warehouses in several regions will affect the company's profits. Companies can also compete and provide the best service to customers if this distribution system is carried out effectively and efficiently. In an effort to obtain optimal time and costs, vehicle routes and scheduling are components that must be considered. The travel route in a mode of transportation plays a very important role in the delivery and logistics distribution process of goods so that service improvements to consumers are always maintained. Innovative strategies are the most important factor in the logistics function to maintain a company's competitiveness [3].

The Vehicle Routing Problem (VRP) is a combinatorial optimization challenge that considers dynamic economic factors within a logistics system. VRP involves determining the most cost-efficient routes from a depot to various agents with differing demands. The objective is to create routes that ensure each agent is visited exactly once by a single vehicle. All routes must begin and end at the depot, and the total demand on any route must not exceed the vehicle's capacity [4].

The Vehicle Routing Problem (VRP) is a problem involving depot-based vehicle routing that serves dispersed consumers with certain requests. The goal of VRP is to serve a number of existing consumers at the minimum cost [5]. VRP is a problem that includes the construction of routes for a number of vehicles, starting from a main depot to the location of a number of consumers with a certain number of requests. The aim is to minimize total costs without exceeding vehicle capacity. VRP is goods distribution management that pays attention to service, a certain time period, and a group of consumers with a number of vehicles located in one or more depots run by a group of drivers using the appropriate road network [6].

The deliveries made are divided into two types of delivery, namely primary delivery and secondary delivery. Primary delivery is sending goods to drop points in each sub-district in the city of Medan. Secondary delivery is the delivery of goods to every district or city in the East Sumatra region. The problem is the distribution route, which has 14 routes for 32 drop points or delivery points. Distribution routes that have the same drop points are caused by increasing delivery capacity over time, so that each route that should only go through one drop point in one delivery day is passed by another route. Judging from delivery capacity, several drop points with relatively close distances are created on different routes. As a result of this phenomenon, the company wants to carry out an analysis of improvements to the routes currently used. Designing a vehicle route optimization strategy can reduce minimum costs to the consumer's location so that each route starts and ends at the right location so that consumers must be passed by one vehicle only once [7]. The right strategy for managing the delivery of goods to consumers can improve company performance [8].

Ineffective goods delivery routes greatly affect the distribution costs incurred by the company, where ineffective distribution routes can increase the number of means of transportation and also the distance traveled. Mileage is also very influential in calculating distribution costs, where mileage and fuel consumption are directly proportional. This is also related to the number of transport equipment and vehicle rental costs, which are also directly proportional. Based on the problems of JNE's Medan main branch, alternative distribution routes must consider the distance traveled, the capacity of the transport equipment used, delivery capacity, and also distribution costs. As previously explained, distribution routes can become ineffective due to the distance traveled. So, to create alternative distribution routes, distance savings must be made for each route and also reduce the number of existing routes. Apart from that, adjustments must be made between shipping capacity and the capacity of the transport equipment to be used. Therefore, to get an alternative distribution route, the method that can be used is the Saving Matrix method. The Saving Matrix method is a method used to determine product distribution paths or routes to outlets by determining the route that must be taken and the number of transportation equipment based on the capacity of the transportation equipment. The Saving Matrix method is essentially a method for minimizing distance, time, and costs by considering existing constraints [9].

The goal of the saving matrix method is to reduce the total travel distance for all vehicles while also minimizing the number of vehicles needed to serve all stops. The method begins by assigning each stop to a separate route, where each vehicle starts at the depot, serves one stop, and returns to the depot. This setup represents the maximum travel distance for the routing problem. Subsequently, stops are paired into a single route, thereby reducing the number of vehicles required and decreasing the total travel distance [10].

## 2. Methods

This research is categorized as descriptive research, where it is carried out by collecting data either directly or indirectly to solve existing problems. The data source used in the research is secondary data. Secondary data used includes distribution information, distance between district or city branch offices, distance between the main warehouse and each district or city branch office, speed of unloading goods, distribution route data, number of drop points, capacity and type of transport equipment, and data distribution costs.

The data processing methods used in this research are the savings matrix and Clarke & Wright savings.

### *2.1. Saving Matrix*

1. Identifying the distance matrix. The distance between each district or city branch office owned by the company is used in determining goods distribution routes. To create this distance matrix, the distance between the warehouse (ATC) and each district or city branch office is needed, as is the distance between each district or city branch office. An example of a distance is ATC – BRT = 65 km.

2. Identify the savings matrix. In this step, it is assumed that each KPC will be served by a dedicated fleet, resulting in 32 separate routes. Each Saving Matrix represents the potential cost savings achieved by merging two or more KPCs into a single route. The distance savings can be determined using a specific equation.

$$S(Kx, Ky) = J(ATC, Kx) + J(ATC, Ky) - J(Kx, Ky) \quad (1)$$

Where S(Kx, Ky) is the distance savings between Kx, Ky; J(ATC, Kx) is the distance from ATC to Kx; J(ATC, Ky) is the distance from ATC to Ky; J(Kx, Ky) is the distance Kx to Ky; Kx, Ky is KCx, Kcy. The following example demonstrates the calculation of distance savings between Berastagi (BRT) and Kabanjahe (KBJ) KC using the specified formula above:

$$S(BRT, KBJ) = J(ATC, BRT) + J(ATC, KBJ) - J(BRT, KBJ) \quad (2)$$

3. Allocate Regency/City Branch Offices (KC) to Routes. In the initial stage, each district/city branch office was allocated to a different route. Of the 32 routes formed, combinations can be carried out up to the limit of the fleet capacity used. The merger is performed based on the highest savings value. The largest savings begin at 610 km, representing the distance reduction achieved by merging PSL and KP. The combined total load is: Total load = PSL load + KP load = 2925.

4. Sort branch offices into established sub-routes. After the allocation of branch offices to sub routes is carried out, the next step is to determine the order of visits. In principle, the purpose of this sorting is to minimize the distance traveled by means of transport. The method used is the nearest insert method. The nearest insertion method operates on the principle of choosing a store that, when added to an existing sub-route, leads to the smallest possible increase in distance. Initially, the sub route only had a trip from ATC to ATC with zero distance. Next, we see how much distance occurs by adding each KC to the existing sub-route.

5. Determination of Sub-Route Transportation Costs. The transportation costs for vehicles include operational expenses (fuel costs) and maintenance costs. However, maintenance costs are excluded from comparison as they are not the focus of this study. For the distribution process, the company utilizes vehicles with a capacity of 4500 kg. These vehicles consume fuel at a ratio of 1:5, meaning they can travel 5 km using 1 liter of fuel. Sub Route Transportation Costs = Fuel Costs + Fleet Rental Price.

### *2.2. Clarke & Wright Savings*

1. The initial stage of determining the sub route is determining distribution routes data, and transport car capacity. This data can be seen in the data collection.

2. Create a distance matrix between ATC and KC and between KC and KC.

3. Calculating the savings matrix. The calculation of the saving value can be found in the equation (1), where S(Kx, Ky) is defined as the distance savings between Kx, Ky; J(ATC, Kx) is the distance from ATC to Kx;

J(ATC, Ky) is the distance from ATC to Ky; J(Kx, Ky) is the distance Kx to Ky; and Kx, Ky is KCx, Kcy.

4. Sort the savings matrix values, namely by ranking the savings matrix values from largest to smallest.
5. Based on the saving matrix value ranking table, sub routes are formed by selecting the largest saving value. Combining KC into sub-routes does not exceed the available transport car capacity, namely 4500 kg.
6. Calculate the total distribution time for sub-routes and the number of transport cars required. Distribution time = vehicle set-up time + total travel time + ATC loading time + unloading time for sub routes.
7. Calculating sub route distribution costs; Price of fuel (bio diesel) is IDR 6,800 per litre; Fleet rental price is Rp. 1,200,000 per day (car + driver); Fuel cost is "mileage x fuel price" / "5; and Subroute Transportation Costs is Fuel Costs + Fleet Rental Price.

## 3. Result and Discussion

### *3.1. Distribution Sub-Route Analysis*

Comparison between the distribution sub routes used by the company and the distribution sub routes proposed using the Saving Matrix and Clarke & Wright Savings methods.

Table 1. Comparison of Distribution Sub routes

| Subroutes | Company Routes | Proposed Route | |
|---|---|---|---|
| | | Saving Matrix (I) | Clarke & Wright Savings (II) |
| | KC Sequence | KC Sequence | KC Sequence |
| 1 | ATC - SPR - AKK - MRB - RTP - PSL - KP - ATC | ATC - BRT - KBJ - ATC | ATC - PSL - KP - SPR - IP - ATC |
| 2 | ATC - KBJ - BRT - ATC | ATC - SPR - RTP - ATC | ATC - RTP - BD - AKK - ATC |
| 3 | ATC - SPR - AKK - MRB - RTP - PSL - KP - ATC | ATC - AKK - BD - PSL - KP - ATC | ATC - KSR - TJB - DMR - ATC |
| 4 | ATC - KSR - TJB - ATC | ATC - MRB - GL - BP - SER - DMS - ATC | ATC - SDK - SB - SL - ST - PB - PN - SRD - PRY - BP - GL - ATC |
| 5 | ATC - SER - TBT - ATC | ATC - IP - KSR - TJB - ATC | ATC - DMS - TBT - SER - ATC |
| 6 | ATC - DMS - DMR - PST - ATC | ATC - TBT - DMR - ATC | ATC - PG - SBT - PBR - ATC |
| 7 | ATC - GL - BP - SRD - PRY - ATC | ATC - BNJ - ATC | ATC - BNJ - ATC |
| 8 | ATC - BRT - KBJ - PB - PN - ATC | ATC - SRD - PRY - ST - SDK - SB - PB - SL - PN - ATC | ATC - KBJ - BRT - ATC |
| 9 | ATC - SB - ST - SDK - SL - ATC | ATC - PG - SBT - PBR - ATC | ATC - PST - ATC |
| 10 | ATC - GL - BP - SRD - PRY - ATC | ATC - BNJ - ATC | ATC - BNJ - ATC |
| 11 | ATC - PG - BNJ - SBT - PBR - ATC | ATC - LP - ATC | - |
| 12 | ATC - LP - ATC | - | - |
| 13 | ATC - LP - SER - TBT - PST - ATC | - | - |
| 14 | ATC - IP - KSR - TJB - ATC | - | - |

From Table 1, it can be seen that there has been a reduction in sub routes formed on the distribution routes proposed using the Saving Matrix and Clarke & Wright Savings methods compared to the sub routes run by the company so far. The distribution route proposed by Saving Matrix has 1 sub route; the distribution route proposed by Clarke & Wright Savings has 10 routes; and the company's distribution route has 14 sub routes. This can happen because, in forming the proposed sub-route, the travel distance and the capacity of the transport equipment used in distributing goods are taken into account.

### *3.2. Mileage Analysis*

The determination of the optimal distribution route is heavily impacted by the distance covered during the distribution of goods. A longer travel distance results in more time required for the transport vehicle, while a shorter distance reduces the time needed to complete the distribution process.

It can be said that the route created has a shorter total distance compared to the route used by the company, where the distance savings is 1375 km and the distance savings percentage is: Distance savings = "Total initial distance - total proposed distance" / "Total initial distance" x 100% = 37.7%. This occurs because there is a reduction in sub-routes that are formed, which has an impact on reducing the total distance of the route taken in carrying out the distribution process.

Table 2. Comparison of Distribution Distances

| Subroutes | Company Routes | Proposed Route | |
|---|---|---|---|
| | | Saving Matrix (I) | Clarke & Wright Savings (II) |
| | Mileage (km) | Mileage (km) | Mileage (km) |
| 1 | 672 | 150 | 670 |
| 2 | 150 | 572 | 571 |
| 3 | 672 | 762 | 347 |
| 4 | 350 | 222 | 622 |
| 5 | 134 | 348 | 194 |
| 6 | 228 | 134 | 183 |
| 7 | 384 | 228 | 64 |
| 8 | 380 | 625 | 150 |
| 9 | 356 | 181 | 228 |
| 10 | 302 | 62 | 62 |
| 11 | 180 | 52 | - |
| 12 | 52 | - | - |
| 13 | 260 | - | - |
| 14 | 346 | - | - |
| Total | 4466 | 3336 | 3091 |

*3.3. Distribution Time Analysis*

The process of determining the most efficient distribution route is significantly affected by the distance covered during goods delivery. Longer distances result in extended travel times for the transport vehicles, whereas shorter distances reduce the time needed to complete the distribution process.

Table 3. Comparison of Distribution Times

| Subroutes | Available Time (Minute) | Distribution Times | | | Estimated Feasibility |
|---|---|---|---|---|---|
| | | Company Routes | Proposed Route | | |
| | | | Saving Matrix (I) | Clarke & Wright Savings (II) | |
| 1 | 840 | 672 | 180 | 710 | Feasible |
| 2 | 840 | 150 | 602 | 606 | Feasible |
| 3 | 840 | 672 | 802 | 382 | Feasible |
| 4 | 840 | 350 | 267 | 692 | Feasible |
| 5 | 840 | 123,69 | 383 | 229 | Feasible |
| 6 | 840 | 228 | 164 | 218 | Feasible |
| 7 | 840 | 329 | 253 | 94 | Feasible |
| 8 | 840 | 380 | 685 | 180 | Feasible |
| 9 | 840 | 328,61 | 216 | 253 | Feasible |
| 10 | 840 | 258,85 | 87 | 87 | Feasible |
| 11 | 840 | 196,36 | 77 | - | Feasible |
| 12 | 840 | 44,57 | - | - | Feasible |
| 13 | 840 | 260 | - | - | Feasible |
| 14 | 840 | 296,57 | - | - | Feasible |
| Total | 4289 | 3716 | 3451 | | |

Based on the calculation results, it can be seen that the Clarke & Wright Savings method has the minimum distribution time, namely 3451 minutes, with a savings percentage of: Time savings = "Total initial time-total proposed time" / "Total initial time" x 100% = "4289.79 - 3451" / "4289.79" x 100% = 19.5%.

*3.4. Distribution Cost Analysis*

The proposed sub-route using the Clarke & Wright Savings method has lower distribution costs than the sub-route used by the company and the Savings Matrix method because the distance traveled in the goods distribution process is shorter. The closer the distance, the more savings in transportation costs will occur. Therefore, there is a savings in the company's initial costs compared to the costs of the selected proposal.

Table 4. Comparison of Distribution Cost

| Method | Distribution Cost per Day (Rp) |
|---|---|
| Company | 16.818.405 |
| Saving Matrix | 17.736.960 |
| Clarke & Wright Savings | 16.203.760 |

Therefore, there is a savings in the company's initial costs compared to the costs of the selected proposal. The distance savings for the proposed costs are: "Total initial costs-total proposed costs" / "Total initial costs" x 100% = "16,818,405 - 16,203,760" / "16,818,405" x 100% = 3.6%. From the calculations mentioned earlier, it is evident that there is a 3.6% reduction in distribution costs compared to the company's initial distribution expenses.

### *3.5. Analysis of the Number of Transport Cars*

The allocation of transport vehicles by the company depends on the total time needed for the vehicles to deliver products and the available operating time. The shorter the total time required for distribution, the fewer transport vehicles are needed for the process. By using the Saving Matrix and Clarke & Wright Savings methods, Branch center can save distribution costs by allocating only 10 transport vehicles out of 14 existing vehicles. The analysis points are as follows: (a) The Clarke & Wright Savings method resulted in a shorter total distance (3091 km), indicating that it can optimize the route for minimum travel distance; (b) It also showed the minimum total distribution time (3451 minutes), suggesting that it effectively minimizes the time required for distribution; (c) With a minimum cost of Rp16.203.760, the Clarke & Wright Savings method proves to be cost-effective compared to the Saving Matrix method; (d) By requiring only 10 transport cars, it optimizes the number of vehicles needed for distribution; (e) The Clarke & Wright Savings method might be more complex to implement compared to the Saving Matrix method, as it involves iterative procedures for route optimization; (f) The effectiveness of the Clarke & Wright Savings method can be influenced by the initial conditions and assumptions made during the process, potentially leading to suboptimal results if not set up correctly; (g) It might require more computational resources and time compared to the Saving Matrix method due to its iterative nature.

## 4. Conclusion

Based on the analysis of data processing and discussion, several conclusions can be drawn, namely: (a) Formation of sub routes on the proposed route using the Saving Matrix and Clarke & Wright Savings methods, the shortest distance was selected, namely the Clarke & Wright Savings method which resulted in a distance of 3091 km; (b) Distribution time using the Saving Matrix and Clarke & Wright Savings methods. The best method was chosen, namely the Clarke & Wright Savings method because it has a minimum total time of 3451 minutes; (c) Distribution costs using the Saving Matrix and Clarke & Wright Savings methods, the best method was chosen, namely the Clarke & Wright Savings method because it has a minimum cost of Rp16.203.760; (d) The number of transport cars obtained using the Saving Matrix and Clarke & Wright Savings methods, the best method was chosen, namely the Clarke & Wright Savings method with 10 transport cars; (e) The development of sub-routes in the proposed route, utilizing the Clarke & Wright Savings method, results in 10 sub routes which are more optimal in terms of travel distance efficiency of 30.7%, distribution time of 19.5%, and distribution costs of 3,6% per day.

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