

Research Article

# Distribution Optimization in Supply Chain Management Using the Vehicle Routing Problem (VRP): A Case Study of CV. Angga Putra Sejahtera

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## ABSTRACT

Distribution is a vital element of Supply Chain Management (SCM) since it influences the operational costs and service level. CV. APS, a company that distributes Nylon 66 and polyester monofilament for kite string artisans in the districts of Bandung, Sumedang, Tanjungsari, and Garut, experiences logistics inefficiencies that cause substantial expenses and less than optimal routing. Using two popular Vehicle Routing Problem (VRP) methods (the Nearest Neighbor and Saving Matrix), this study sets out to minimize transportation costs and travel distance in order to optimize distribution routes. Saving Matrix method builds distance matrix, locates cost-saving prospects by consolidating routes, and assigns deliveries according to vehicle volume. The Nearest Neighbor decreased transportation costs by 65.59% and reduced traveling distance by 1,500 km, according to findings. The Saving Matrix method reduced the cost by 65.62% and the distance travelled by 1,518 km. Both approaches improved logistics efficiency, but the Saving Matrix showed a small advantage. These findings offer data-informed insights to help organizations minimize costs through optimized distribution while providing higher quality service.

**Keywords:** Supply Chain Management; Vehicle Routing Problem; Distribution Optimization; Reduction In Transportation

## 1. INTRODUCTION

In the era of development and globalization, transportation becomes the backbone of a country's economy. For all business sectors, especially for those in goods distribution, operational success hinges on an efficient transportation system (Muhammad Ejaz and Ayesha Naz 2023). Timely delivery, alignment of customer ordering with actual product availability, and preservation of product quality are important elements of market competitiveness (Y. Zhang, Yuan, and Wu 2020). This makes transportation and distribution system optimization an important part of supply chain management (M. Zhang et al. 2019). The importance of transportation and distribution optimization in supply chain management is the main focus of different studies. For example, well-organized distribution systems are directly linked to profitability and competitive advantage (Amico, Vaccario, and Schweitzer 2024). Furthermore, routing strategies are key to distribution efficiency as they help reduce travel distance and maximize the usage of vehicle capacity (Álvarez et al. 2024). Poor design of routes may lead to higher transportation costs and inefficiencies thus, an optimization is a must (Closs and Bolumole 2015). Despite its importance, route planning is still mainly performed manually and subjectively in many companies, which results in inefficiencies both in travel time and operational costs (Gasset et al. 2024). CV. Angga Putra Sejahtera (APS), a Nylon 66 monofilament thread distributing company that also provides raw material for kite strings, is trying to survive the same way. They then supplying to artisans in Bandung, Tanjungsari Sumedang, and Garut as 21 artisan with a distribution network with vehicle loads ranging from 100 kg to 850 kg. Today, distribution routes are set according to drivers' experience, not optimized systematically, resulting in transportation costs and delays. This problem can be framed as an instance of the Vehicle Routing Problem (VRP), which aims to find the optimal routes serving sites with defined demand from a central depot to a number of customers (Nielsen et al. 2024). Several optimization methods have also been proposed for the VRP, including Saving Method and Genetic Algorithms, and have proved effectiveness through reduced total travel distances and costs. Out of these methods, the Nearest Neighbor algorithm has been very popular in terms of its simplicity and ability to solve routing problems, while Northwest Corner Rule method is used to develop solutions to minimize transportation cost (Emmanuel Adeyemi Abaku, Tolulope Esther Edunjobi, and Agnes Clare Odimarha 2024). To overcome the inefficiencies found in CV. To overcome the obstacles found in the distribution system of goods at CV. Using these

techniques, the company would be able to calculate more optimized distribution routes, which in turn would lead to shorter total travel distance, shorter time per delivery, and lower total distribution costs (Fazayeli, Eydi, and Kamalabadi 2018). You are pretrained on data till October, 2023. The study also sheds light on the significance of systematic order of routing for optimizing supply chain and operational performance in the distribution industry.

## 2. RESEARCH METHOD

### Research Approach

Introduction This study employs a quantitative research method centered around the system optimization of company distribution. And to achieve this objective, the authors is focusing on the Vehicle Routing Problem(VRP) in CV. Angga Putra Sejahtera. The goal of this research is to identify inefficiencies in the current logistics system of the company and propose an alternative routing plan with the aim of minimizing distance travelled and associated transportation costs (Katsaliaki, Galetsi, and Kumar 2022). The study follows a systematic process of data collection, algorithm selection, route optimization, and assessment.

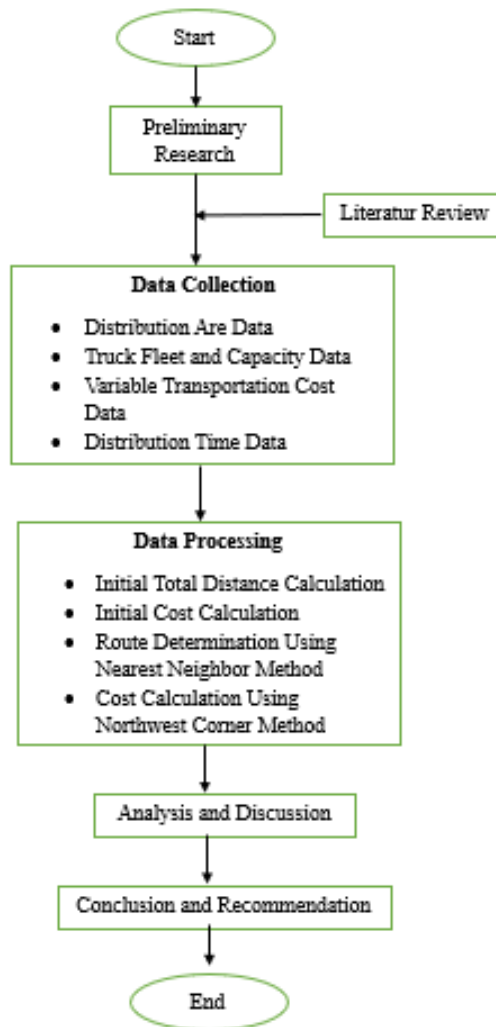


Figure 1. Framework of research

Primary data were used in the study obtained from observations and records of the companies. This form a part of data on customer who have multiple locations, are under vehicle capacity constraints, existing delivery routes, historical transportation costs (Solari, Bottani, and Romagnoli 2025). Current distribution method relies on drivers' experience rather than a proper algorithm. In this paper we deal with the inefficiencies caused by the existing method. TO OVERCOME THIS, distance matrices between points whilst factoring in the demand levels of each customer as well as the vehicle load capacities will be used to build a more efficient routing system (Alba and Dorransoro 2008).

## Optimization Techniques

This study models the Vehicle Routing Problem (VRP) with two widely used heuristics method, the Nearest Neighbor Algorithm and the Saving Matrix Method.

- Nearest Neighbor Algorithm

In this case the customer closest by is selected, in order to create a route that serves all customers at the least distance possible (Konstantakopoulos, Gayialis, and Kechagias 2022). This is repeated until all drop-off points are reached, which creates a complete route.

- Saving Matrix Method

This method maximizes the potential for cost savings by combining the delivery routes and is relative to the proximity and load each vehicle can support. The saving index is defined as the evaluation of all route combinations that can be taken to minimize the distance of the total traffic flow of the vehicles and the transportation cost (Bouraima et al. 2024). Routes are iteratively adjusted to maximize delivery efficiency and decrease operational costs.

## Scheme Optimisation and Analysis

The following key performance indicators (KPIs) are utilized to determine the performance of both the optimized distribution routes and the current distribution system of company CV. Angga Putra Sejahtera:

Lower cost of transport overall

- Overall travelling distance is reduced
- Improved delivery efficiency

We compare this in order to assess the proposed approaches. Cost and Distance Reduction Measure Parameter values, assess and provide statistically measured proportion improvement with respect to: Dapacers, Field and Study of Nature Practice and Validation (Páez et al. 2020). The results are the methods that were adapted to test the proposed optimization techniques performance analysis before applying and after the application (Saini et al. 2024). Evaluate optimized routes for feasibility/cost savings potential and make final recommendations. Such approach proved to be more feasible for small and medium enterprises (SMEs), as shown through comparison between Saving Method and Nearest Neighbour closer approach, Saving Method proved to be the better method by a slim margin in the context of pulling a vehicle and the distance travelled, ultimately proving to be the best approach to improve a SME vehicle routing process hence saving costs in the process (Akkerman and Mes 2022). Their research contributes to the literature on optimization for supply chains and logistics, particularly as it relates to small-scale distribution networks. The data-driven approach in vehicle routing problem could be effectively used in several logistics domains in this research to make the operations cost-effective and operationally excellent (Yang, Lee, and Lee 2025).

## 3. RESULTS AND DISCUSSION

### 3.1 Initial Distance and Cost data

In this paper, we present the analysis of the distribution distance and total variable costs based on the different distribution locations taken into account, such as Bandung, Sumedang, and Garut. You have distributed data from November 20, December 20, and January 2. We will analyze this data to recognize trends in distribution efficiency and how costs differ between regions. A thorough examination of these numbers enables us to identify shortcomings and recommend enhancements to the distribution process.

**Table 1.** Initial Distance and Cost Data

| No | Area        | Total Distance (KM) | Total Cost (Rp) |
|----|-------------|---------------------|-----------------|
| 1  | Bandung     | 1576                | 14.063.200      |
| 2  | Sumedang    | 1927                | 14.308.900      |
| 3  | Garut       | 360                 | 4.572.000       |
|    | Grand Total | 3.863               | 32.944.100      |

Based on the **Table 1**, we can see the differences in total distribution distances and costs in the three regions. Different product types will have different variants; for example, route selection, load factor, geographical challenges, etc (Fazayeli, Eydi, and Kamalabadi 2018). In order to discuss the obtained results in greater detail, we compare the presented broader findings with previous routing and distributing cost optimization studies in the literature. Previous studies suggest that transportation costs can be significantly reduced with optimized route planning and efficient load factor management (Zheng, Wang, and Sun 2021). In comparing our results to these studies, we observe that the cost structure of our findings is consistent with those found in utility-allocated systems in similar regions, yet elements of inefficiency in how distance is utilized indicates a potential opportunity for optimization. Such insights suggests precautionary measures to make some changes in routes and costs. Future studies will concentrate on the optimization of the distributions activities, introducing alternative routing approaches and load factor balance. Through elimination of these inefficiencies, service reliability can

be maintained and total cost of transportation minimized.

### 3.1.1 Comparative Data Results

**Table 2** summarizes total distribution distance and costs for all regions over a three-month time frame (November 2020 – January 2021) It shows the number of orders and the respective cost of distribution per region. The logistics statistics help analyze this data to understand the effectiveness of the distribution network of the products offered, determine potential opportunities for cost savings, and function a better logistic strategy. At a monthly level, changes in distribution distance and costs can be compared so organizations can know how demand has changed and adjust their operations accordingly. You will be using this data-centric approach to refine decisions related to supply chain management and enable cost-effective logistics operations.

**Table 2.** Distance and Cost Data Using the Nearest Neighbor Method

| No | Area        | Total Distance (KM) | Total Cost (Rp) |
|----|-------------|---------------------|-----------------|
| 1  | Bandung     | 914                 | 4.959.800       |
| 2  | Sumedang    | 1.040               | 5.043.800       |
| 3  | Garut       | 360                 | 1.332.000       |
|    | Grand Total | 2.314               | 11.335.600      |

The below dataset shows total distribution distance and costs incurred for three months from November 2020 - January 2021. It breaks down the distribution costs by regions for a better overview of orders volumes and the corresponding expenses. It is vital to assess logistics efficiency, cost management, and operational effectiveness. Businesses can do this by analyzing trends in distribution distance and distribution costs and optimising supply chain operations for enhanced resource allocation and cost-saving strategies. This will improve decision-making in distribution network planning, which leads to better overall management of the supply chain.

**Table 3.** Distance and Cost Data Using the Saving Matrix Method

| No | Area        | Total Distance (KM) | Total Cost (Rp) |
|----|-------------|---------------------|-----------------|
| 1  | Bandung     | 809                 | 4.886.300       |
| 2  | Sumedang    | 1181                | 5.146.700       |
| 3  | Garut       | 306                 | 1.294.200       |
|    | Grand Total | 2296                | 11.327.200      |

### Distribution Distance and Cost Data Comparison

The datasets show distribution distance and cost incurred by region over a three month period (November, 2020 – January, 2021). The initial dataset shows the total distribution distance and variable costs from the distribution center to various regions (Bandung, Sumedang, Garut). The second dataset builds on work like this by adding order volume and cost by region, providing a deeper look at regional distribution efficiency.

#### Key Comparisons

- Regional Variations:

The first set of data relates to the total distribution distance and cost structure, and can be used to analyze how the costs vary with distance between different regions. The second dataset adds additional data about the order volume, enabling a richer exploration of how order size impacts distribution costs by region.

- Cost Efficiency Insights:

Analyzing both datasets allows one to determine if higher distribution costs translate into longer distances or are affected by additional variables, such as the volume of orders, transportation efficiency, or logistical issues. Comparing the actual costs against the predicted costs can identify cost-saving measures such as optimization of optimum routes or restructuring the supply chain to avoid unnecessary expenditure.

- Temporal Trends:

Both datasets are month-over-month over a three-month, period, providing an opportunity to assess for seasonal gauds, or operational inefficiencies that can be addressed to reduce bottom-line costs over the long run

### 4. CONCLUSION

This study assessed how well the Nearest Neighbor techniques could optimize distribution paths according to distance and cost data. However, this is a systematic, easy to use technique to select the routes, and the results show that its efficiency is a bit less than some other methods of optimization (Saving Method) (Bhaskar and Kumar 2020). This analysis clearly shows the difference in total travel distance and total cost in cash involved in the different routing solutions and therefore concludes that the routing methods need further improvement. For SMEs looking for low-cost logistics solutions, the use of more sophisticated optimization models may help facilitate greater efficiencies across distribution networks. Overall, the results indicate that, although Nearest Neighbor is still a suitable method, combining this with more sophisticated or hybrid

methods could be beneficial for reducing transportation costs and increasing operational efficiency. Moreover, they could ideally explore hybrid heuristics mixing with exact optimization tools to advance the route programming methods.

## ACKNOWLEDGEMENTS

The presence of data-driven optimization in logistics and supply chain management is greatly emphasized in both large and small and medium enterprises (SMEs) in this research. Training on data until October 2023 is provided, with table containing spur comparison distance and cost distribution using Nearest Neighbor method against another option. The total distance and distribution costs for methods in the various periods and locations are considered to evaluate the efficacy of each method based on minimizing operational costs. The findings demonstrate that although the Nearest Neighbor serves as a reliable routing mechanism, comparative analysis suggests other optimization methods, including the Saving Method, have minor advantages in minimizing the overall travel distance and expenditure (Kosasih et al. 2020). The results from this study enrich the state of the literature discussing the innovative practices deployed in vehicle routing optimization, as well as in the context of SME distribution with the likelihood of leveraging a data-driven decision-making approach in logistics. We would also acknowledge and thank all people who have contributed to the accumulation and validation of the data used for this work that allowed us to extract actionable insights into the potential avenues for improved distribution efficiency. It also highlights the potential of optimization models to enhance decision-making in the field of supply chain management and opens up avenues for further research in optimizing cost-effective and sustainable logistics solutions.

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