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Optimizing Distribution Center Network Design for a Cosmetic Manufacturer: A Case Study on Lightening Series Package Product

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ABSTRACT

Ensuring customer satisfaction while maintaining optimal cost efficiency is paramount in designing a successful supply chain structure. This study explores the vital role of service quality and delivery efficiency in achieving customer satisfaction and a superior overall experience through a cost-effective supply chain structure. Furthermore, the strategic positioning of Distribution Centers (DC) and the geographical distribution of consumers serve as additional determinants in the quest to devise the most effective DC scheme that meets consumer expectations. Four simulation scenarios, each with measurable parameters including response time, lead time, and operational costs, were evaluated to identify the most cost-efficient and responsive solution. These parameters encompassed the performance metrics of the supply chain structure model, namely response time and lead time, in conjunction with the total operational cost of each scenario. Our findings reveal that scenario 1 emerges as the most cost-effective with the lowest distribution costs and shortest customer lead time. This scenario consistently maintains the lowest distribution costs from the first to the seventh year. Despite a surge in forecasted demand in the 7th year, resulting in an increase in total distribution costs to Rp. 3,392,793,440, scenario 1 still prevails with overall vehicle costs decreasing and the smallest percentage cost at 17.50%, thus yielding the most economical outcome compared to alternative scenarios. Scenario 4 offers a similar outcome to scenario 1 but incurs higher daily vehicle operating costs. The cost-effectiveness demonstrated by scenario 4 further highlights the significance of strategic DC placement in achieving optimal supply chain outcomes.

Kata Kunci : simulation, distribution center, supply chain, cosmetic manufacturing

INTRODUCTION

Markets are becoming more volatile and difficult to predict, and the focus of supply chain management must "shift from the idea of cost as an order winner to responsiveness as the market winner" [1]. One of the strategies to become the winner is optimizing the cost and response time. Therefore, agile supply chains are faced with the dual pressures of providing greater responsiveness while keeping costs low [2]. Meanwhile, customers expect more flexible and prompt delivery services than ever before. Moreover, market competition is forcing supply chain enterprises to either provide novel-value-added services or streamline current operations to meet customer needs [3]. To enable adaptable delivery, it's essential to establish multiple central or regional warehouses strategically located to reduce customer proximity. Furthermore, ensuring appropriate product distribution among these warehouses involves factoring in customer preferences in respective regions [4].

Distribution involves the transportation and storage of a product from its origin with the supplier to its destination with the customer within the supply chain. It plays a pivotal role in determining a company's profitability as it significantly influences both supply chain expenses and customer satisfaction levels [5][6]. Thus, to maximize profits, enhancing customer satisfaction is necessary when designing an efficient and effective supply chain structure, while optimizing cost. The quality of service and delivery is an essential factor in creating a good experience and customer satisfaction. The product characteristics of the project will also affect the supply chain strategy used to increase customer satisfaction. Notably, the locations of the Distribution Center (DC) and the consumers determine the design of the most effective DC scheme to meet the needs and expectations of consumers. Choosing the optimal distribution channel among multi-channel distribution networks is one of the most difficult challenges in distribution network design. Customers' orders can be received from any facility through these distribution channels (supplies, retailer warehouse). Moreover, it is necessary to consider sustainability objectives such as cost reduction, environmental impact reduction, and increased job opportunities [7].

Alongside prioritizing customer satisfaction, companies must integrate principles of operational excellence to streamline costs. A significant challenge faced by companies lies in effectively managing the supply chain amidst limited resources, necessitating answers to key questions such as whether all distribution centers (DCs) need daily operation, how DC operations can be optimized, what the optimal distribution costs are for meeting diverse city demands, and which strategies can establish the most efficient supply chain structure. This research aims to address these queries by offering recommendations for optimizing DC utilization schemes to maximize customer satisfaction through appropriate efforts and strategies, ultimately achieving optimal value for money.

Furthermore, the company's current DC utilization scheme lacks optimization, despite operating various types of DCs across Indonesia, including National DCs (NDC), Regional DCs (RDC), and city-based DCs. However, there is room for improvement in terms of cost and response time efficiency for all these DCs. By assessing the potential reach of each DC and aligning operations with individual capacities, significant improvements can be made. In the digital age, leveraging all DCs may not be necessary to meet consumer expectations, leading to potential cost efficiencies through savings in facility operating expenses. Moreover, resource allocation in product distribution requires attention, as the current allocation does not adequately match demand, especially concerning the number of vehicles utilized. Collaborating with third-party logistics providers (3PL) could help the company better align with consumer needs and improve distribution efficiency.

Simulations are particularly useful for analyzing complex multivariable problems, and to obtain realistic results that are similar to real conditions. To determine the most effective DC schemes, the most suitable simulation method is discrete event simulation (DES), which can model a system that is always evolving because of the changes in variables under dynamic conditions. In this study, SCM Globe software was used for the simulation because it provides accurate supply chain modeling.

Supply chain network modeling has gained a great research interest. Research conducted by [10] used a heuristic method for designing supply chain networks and determined the optimal strategy for distributing products from the factory to the warehouse and from the warehouse to the customer. On the other hand, [11] delivered the product to retailers but focused on determining the number of required plants and warehouses and their locations. Another study from [12] proposed a forward and reversed integrated distribution network in 3PL companies, and an integer linear programming model was presented. Heuristic solving methods, including a genetic algorithm and two greedy algorithms, were used because of the problem's complexity and constraints. Moreover, [13] determined the appropriate locations of warehouse and DCs using multi-criteria fuzzy optimization. The study considered the planning of a multi-product, multi-period, and multi-echelon supply chain network consisting of several existing plants in fixed locations, some warehouses and DCs in undetermined locations, and several given customer zones. A multi-objective mixed integer linear program was used to build the supply chain model, seeking to achieve several conflict objectives, including minimizing the total cost, increasing decision robustness in various product demand scenarios, increasing local incentives, and decreasing total transport time. Additionally, the design and operation of DCs were studied by [2], addressing the role of DCs within an agile supply chain, through nine studies of how individual business units design and operate DCs to respond rapidly to their market. Likewise, [7] focused on the design of a supply chain

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distribution model using a multiple-criteria integer programming model to select the best way of configuring the existing customers so that profit is maximized. It considers the other conflicting criteria, such as lead time, power, credit performance, and distributor's reputation). Additionally, [14] proposed a multiple-criteria integer programming model for designing a supply chain network comprising multi-product production facilities with shared production resources, warehouses, DCs, customer zones, and time-varying uncertainty demand. The model includes several manufacturing plants, where each plant manufactures multiple products. Similarly, [15] developed a framework using Discrete Event Simulation (DES) to devise a resilient layout for a cross-docking Distribution Center (DC), ensuring the system remains resilient against supply uncertainties and maintains consistent parts provision to the downstream assembly plant. Their suggested approach offers valuable insights into system dynamics and aids in pinpointing operational configurations that mitigate the effects of supply uncertainty on the cross-docking facility's performance.

This study simulates four supply chain scenarios with measurable parameters, such as the response time, lead time, and total operating costs, to determine the most optimal scenario for a cosmetic manufacturing company, which minimizes the cost of logistics while maximizing customer satisfaction. Previous research discussed more about modelling and simulations to provide optimized distribution routes with supply uncertainty that aimed to minimizing the total cost and the maximum unmet demand. Section 2 discusses the details of the problem statement in a cosmetic manufacturing company in Indonesia. Section 3 explains the method for model simulations of supply chain scenarios. Section 4 reveals the simulation results and analysis. Finally, section 5 presents several conclusions.

PROBLEM STATEMENT

This study considers several conditions in a cosmetics manufacturing company.

1. Decision validation for choosing a supply chain management strategy

Service quality and delivery are important factors to consider when creating a good customer experience. Customer satisfaction is the beginning of customer loyalty, which supports long-term sales. The primary goal of designing an efficient supply chain structure is to meet consumer expectations using the minimum cost. In addition to increasing customer satisfaction with good service, companies must apply principles of operational excellence to optimize costs. One of the most difficult and interesting challenges for a company is determining how to manage the supply chain to meet customer expectations while using limited resources.

- Do all DCs need to be operated every day?
- What DC operations can be optimized?
- What is the optimal amount of distribution costs in meeting the demands of various cities?
- What strategies can be used to establish the most efficient supply chain structure?

This research will answer these questions by providing a recommendation for an efficient DC utilization scheme to achieve optimal customer satisfaction with appropriate efforts and strategies to achieve the highest value for money.

2. The company's distribution center (DC) utilization scheme is not optimal

Based on data collected and confirmation to stakeholders, the company utilizes various types of DCs, such as National DCs (NDC), Regional DCs (RDC), and DCs spread across 40 cities in Indonesia. However, in reality, all these DCs can be improved in terms of the cost and response time. Improvements can be made if the company knows the potential reach of each DC and adjusts the operations to meet each DC's capacity. In the current digital era, companies do not need to use all of their DCs to meet consumer expectations and needs, and thus, there may be considerable increases in cost efficiency because of the savings in facility operating costs.

3. Resource allocation in product distribution

The company's current condition is not proportional to the demand, considering the number of vehicles being employed.

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METHOD

Supply chain network modeling has received significant attention in the past couple of decades. Research from [16] studied the perspectives and relationships in supply chain simulation to develop a meta-analysis of the potential perspectives in modelling and simulation for supply chains. Furthermore, [17] proposed a multi-period decision model considering locating and adjusting DCs within a dynamically fluctuating market in terms of demand of distributed retailers. In the study, numerical experiments were conducted to validate the effectiveness of the proposed model. Additionally, [18] developed a mathematical framework for the structural planning of a pharmaceutical supply chain, aiming to minimize both total expenses and the highest level of unfulfilled demand. More recently, [19] introduced a dependable hub-and-spoke configuration employing consolidation hubs while considering risks of disruption and product perishability, tailored to a pharmaceutical distribution network. They framed the issue as a dual-objective model tasked with determining the placement, quantity, and reinforcement of primary and secondary product ordering points to concurrently decrease supply chain network costs and time. Similarly, [20] proposed a technique for selecting third-party reverse logistics partners (3PRLPs) and distributing orders within the cellphone industry. This approach focused on 3PRLP selection and order distribution across the new network, employing a two-phase framework. The initial phase integrated data envelopment analysis with a distinct evolutionary algorithm. In the subsequent phase, these efficiency ratings were utilized to allocate orders to 3PRLPs using a multi-objective model.

The present study aims to reduce the total network logistics cost in a cosmetic manufacturing company by simulating four scenarios to determine the most optimal one. The simulation considers several measurable parameters, including the performance of the supply chain structure of the model (response time, lead time) and the total cost of operation.

Simulation

Entity Identification

Several entities need to be determined to implement the simulation using SCM Globe. The variables that must be input into the simulation process include product identification, demand identification, and facility identification.

1. Product Identification

For simulation needs, one example product is used to determine the parameters of the conceptual model scenario, which has relatively consistent demand across various regions. The "Lightening Series Package" product, with product specifications based on the reference shown in Table 1.

Table 1. Product Specification "Lightening Series Package"

Specification	Information
Product name	Lightening Series Package
Product Price	Rp100.000
Product Weight	1 Kg
Product Dimension	27 cm x 27 cm x 25 cm

2. Demand Identification

In this study, 15 cities were determined for observation, and their details were input into the simulation. Based on the demand data obtained from the company, the first identification is the percentage contribution of the total demand from each of the 15 cities. The comparisons will be based on the percentage of demand in each city. The total percentage contribution of demand from the 15 cities is 52.51% of the total demand from the company. Figure 1

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shows the percentage distribution of demand in each city, which will be the basis for distinguishing the weighting of each city in the simulation process.

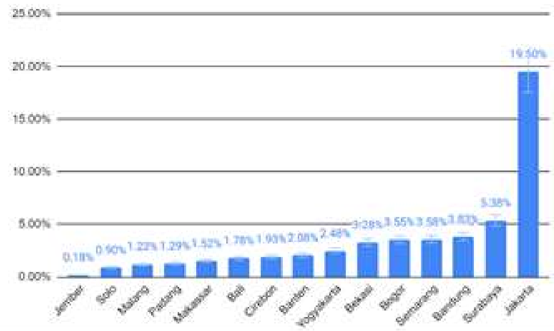

Figure 1. Percentage Distribution of Demand

It is necessary to identify the location points for the delivery destinations to consumers from each city. In real conditions, the point of delivery will not be at one fixed location. Thus, there are limitations in the method if all the delivery destination points are not realistic. Therefore, to keep adjusting to real conditions, the location points in each city are divided into two categories, inside and outside the city. Within the cities are the points that cover an area starting from the center of each city to a distance under 1 hour away from the city. Outside the city is considered to be any area that is still within the scope of the city but has a distance of more than 1 hour from the city center. For example, at a point in the city of Bandung, in the simulation, it is divided into two scopes, within the city (called "Bandung Greater") and outside the city (called "Bandung'). "Bandung Greater" is a point of demand whose coverage area is the city of Bandung, Lembang area, and other areas that are less than 1 hour away from the Bandung city center. The scope outside the city, namely "Bandung" and the areas of Cimahi City, West Bandung Regency, Sumedang, and other areas that are still within the scope of Bandung city but have a distance of more than 1 hour away from Bandung city center. Table 2 shows the percentage of demand distribution data within and outside the city 3.

Table 2. Percentage of Demand Distribution Data Inside and Outside the City

No	City	Within City	Outside City	(%) Demand Within City	(%) Demand Outside City
1	Bali	Bali Greater	Bali	**68.58%**	31.42%
2	Bandung	Bandung Greater	Bandung	22.58%	**77.42%**
3	Banten	Banten Greater	Banten	**68.34%**	31.66%
4	Bekasi	Bekasi Greater	Bekasi	34.56%	**65.44%**
5	Bogor	Bogor Greater	Bogor	28.84%	**71.16%**
6	Cirebon	Cirebon Greater	Cirebon	27.74%	**72.26%**
7	Jakarta	Jakarta Greater	Jakarta	**99.95%**	0.05%
8	Jember	Jember Greater	Jember	21.86%	**78.14%**
9	Makassar	Makassar Greater	Makassar	**71.98%**	28.02%
10	Malang	Malang Greater	Malang	**51.90%**	48.10%
11	Padang	Padang Greater	Padang	48.80%	**51.20%**
12	Semarang	Semarang Greater	Semarang	**58.84%**	41.16%
13	Solo	Solo Greater	Solo	31.13%	**68.87%**
14	Surabaya	Surabaya Greater	Surabaya	**83.20%**	16.80%

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15	Yogyakarta	Yogyakarta Greater	Yogyakarta	**53.91%**	46.09%

The data used for the simulation is taken from forecasted demand data based on historical sales data (per day and per month) for the next seven years, which can be seen in **Table 3**. This data is then used as input data in the simulation, which then allocates the distribution of the demand data in accordance with the percentage of demand in each city.

Table 3. Forecasted Demand for Simulation Input Data

Forecast	Average orders per day, year -						
	1	2	3	4	5	6	7
Realistic	183	832	2,165	4,053	7,272	10,386	12,305
Optimism	220	998	2,598	4,864	8,726	12,463	14,766
Pessimistic	137	624	1624	3040	5454	7790	9229
Forecast	Average orders per month, year -						
	1	2	3	4	5	6	7
Realistic	5,490	24,960	64,950	121,590	218,160	311,580	369,150
Optimism	6,588	29,952	77,940	145,908	261,792	373,896	442,980
Pessimistic	4,118	18,720	48,713	91,193	163,620	233,685	276,863

3. Facility Identification

Next, the facilities are identified to determine the company's capability to meet customer demand. This variable significantly affects the simulation results because it is closely related to the determination of the supply chain structure model, the DC selection, the determined routes, and the number of resources used. To meet the demands of the 15 cities, **Table 4** shows the list of DCs that were used as input data in the simulation, and **Figure 2** shows the DC mapping in the SCM Globe software. The optimal scenario exhibits the best combination of high performance and low costs using several DCs to meet the demands of the 15 cities.

Table 4. Distribution Center for Simulation

NDC	**RDC**	**DC**
NDC Banten (Tangerang)	RDC Bandung RDC Jember RDC Kediri EDC Makassar RDC Pekanbaru RDC Solo RDC Tegal	DC Bali DC Banten (Cikande) DC Bekasi DC Bogor DC Cirebon DC Jakarta DC Padang DC Semarang DC Surabaya DC Yogyakarta

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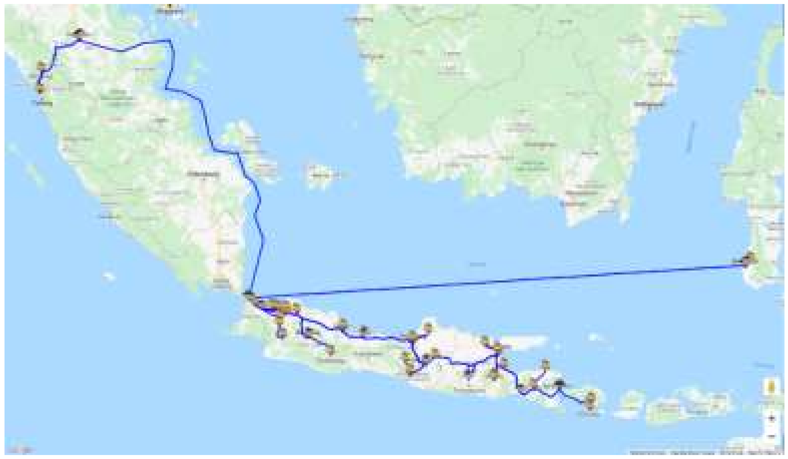

Figure 2. DC Mapping in SCM Globe

Simulation Models

According to [21], simulation is the process of designing a mathematical or logical model of a real system and conducting experiments on the model using a computer to describe, explain, and predict the system's behavior. It can also be described as a collection of methods and applications used to imitate or represent the behavior of a real system, which is usually done on a computer with certain software [22]. Then, according to [23], a simulation can also be interpreted as an application process to build a model of a real system or proposed system, conduct experiments with the model to explain system behavior, study system performance, or build a new system according to the desired performance.

In this study, four scenarios were simulated:

1) **Scenario 1**. Each city is covered by a DC in that city (1 DC for 1 city). **Figure 3** shows the conceptual model f or scenario 1.
2) **Scenario 2.** Delivery to consumers is conducted from the specified RDC. **Figure 4** shows the conceptual mode l for scenario 2.
3) **Scenario 3.** Delivery to consumers is conducted from RDCs, which then transits to the DC first. **Figure 5** show s the conceptual model for scenario 3.
4) **Scenario 4.** Delivery to consumers is done from selected DCs (Tegal, Kediri, Pekanbaru, and Makassar). **Figur e 6** shows the conceptual model for scenario 4.

Before the simulation, the assumptions and limits are determined to answer the uncertainty factors affecting the simulation results in the four predetermined scenarios. The following assumptions and limitations have been determined:

1. Assumptions:

i. The simulated number of days is 25 working days.
ii. The demand data per day is taken based on the forecasted demand.
iii. The percentage of domestic and foreign demand is taken from the demand profile that has been formed.
iv. The breakdown of the vehicle operating cost per km is shown in **Table 5**.

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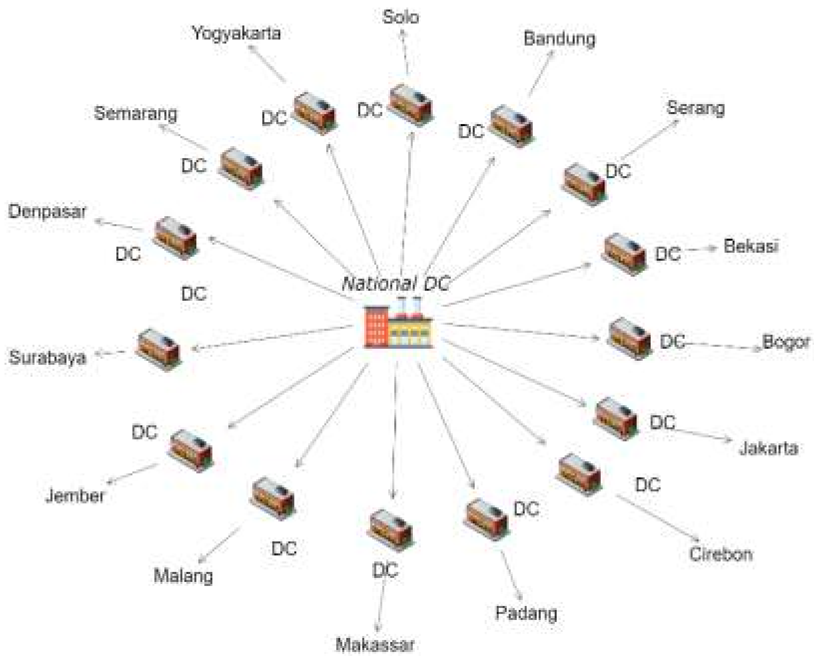

Figure 3. Conceptual Model Scenario 1

Figure 4. Conceptual Model Scenario 2

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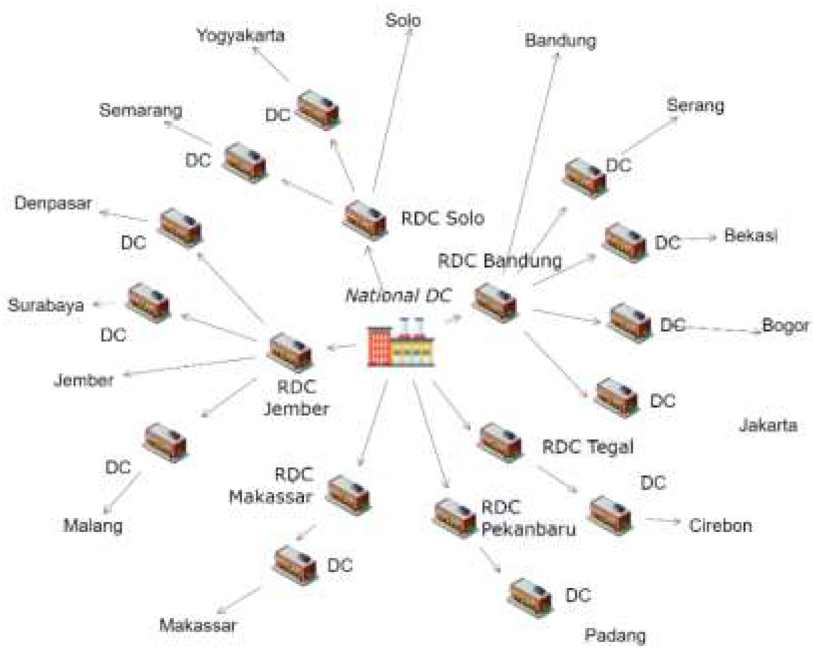

Figure 5. Conceptual Model Scenario 3

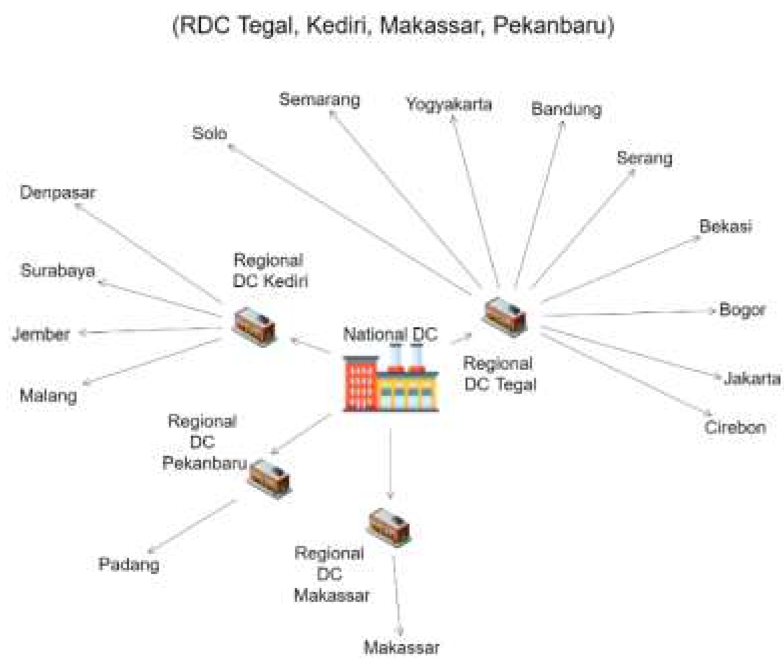

Figure 6. Conceptual Model Scenario 4

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Table 5. Details of vehicle cost in the form of cost per km

Variables	Cost/km
Gasoline (diesel)	Rp950
Toll	Rp1,000
Others (Driver, Maintenance, etc.)	Rp5,000
Total	**Rp6,950**

v. The shipping costs are calculated in USD and converted to IDR.
vi. The percentage of the number of deliveries to various cities is taken based on the demand profile.
vii. The storage capacity of RDC/DC is taken from the company's data.
viii. The on-hand inventory at every DC on the first day is full.
ix. The cost and lead time 3PL matrix is used as an initial consideration in route selection.
x. The choice of the main road for logistics infrastructure in each region is also a consideration in route selection.
xi. The vehicle specifications are assumed to be similar to the vehicle specifications at the company.
xii. The minimum delay between departure is assumed to be 3 hours (Break, Loading in, Loading Out).
xiii. The facility operating costs for each DC are assumed to be the same per m^3.

2. Limitations:
i. The simulation results will be analyzed based on the distribution cost.
ii. The aspects that make up the distribution cost include the fuel used, the driver's power, and the cost of the toll r oad used.
iii. The simulation results are intended to determine the best scenario that can be implemented based on a comparis on between scenarios, not to analyze the overall operating costs of the scenario.
iv. The input data and determining the final result are done manually based on the data generated. SCM Globe can not generate solutions automatically.

RESULT AND DISCUSSION

Based on the scenario model, assumptions, limitations, and the input data that have been determined, **Table 6** shows the simulation results with the outputs in the form of a comparison of distribution costs in each scenario for the next seven years. Based on the simulation results in **Table 7**, scenario 1 (every city is covered by a DC in that city) is the optimal scenario with the smallest distribution cost from 1st year until 7th year. Because the forecasted demand in the 7th year increases, the total distribution cost in the 7th year increases to Rp. 3,392,793,440. However, overall vehicle costs still decrease, resulting in the lowest cost compared to the other three scenarios. In addition, the percentage of the cost to sales continues to decrease until the 7th year. Compared to other scenarios, scenario 1 generates the smallest percentage cost on the 7th year at 17.50%, so this scenario demonstrates long-term potential. By utilizing 1 DC for 1 city, the vehicle cost is the lowest compared to other scenarios. Additionally, scenario 1 has the lowest lead time to the customer, so customer satisfaction and expectations are guaranteed because the possibility of delivery delays is minimized. An interesting result was also observed for scenario 4, with the use of selected DC (Tegal, Kediri, Pekanbaru, and Makassar) for covering demand in 15 cities. This scenario produces a total distribution cost that is not too different from scenario 1 because of the low cost needed to distribute products from the NDC to other DCs. There are only four locations (Tegal, Kediri, Pekanbaru, Makassar); thus, the vehicle costs are low compared to other scenarios.

Scenarios 2 and 3 are not recommended due to several factors. In Scenario 2, the entire RDC is not utilized to meet the demand for the 15 cities. This underutilization of resources leads to inefficiencies and increases the per-unit cost of distribution. On the other hand, Scenario 3 involves both RDCs and DCs, resulting in a supply chain that is longer and more complex. This elongated supply chain increases transportation costs, inventory holding costs, and overall operational expenses. In particular, scenario 3 stands out as it generates the highest cost compared to other

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scenarios. The forecasted cost for the 7th year in Scenario 3 amounts to Rp. 4,605,152,907. This substantial cost is a result of the intricate supply chain structure, involving multiple distribution points and longer transportation routes. Such high costs are not aligned with the company's objective of reducing distribution costs. The inclusion of both RDCs and DCs in Scenario 3 further complicates the supply chain, leading to increased coordination efforts, higher inventory levels, and potentially more frequent stockouts or overstock situations. These factors contribute to the overall inefficiency and higher costs associated with scenario 3. Therefore, considering the company's goal of cost reduction in distribution, Scenario 3, with its significantly higher costs and complex supply chain structure, is not suitable. Instead, the company should focus on scenarios that optimize resource utilization, minimize transportation distances, and streamline the supply chain to achieve cost efficiency and meet customer demands effectively.

Table 6. Simulation Results of 4 Scenarios for 7 Years

	Average orders per month 4 Scenarios for 15 Cities, year -						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Forecasted Demand	**2,883**	**13,106**	**34,105**	**63,847**	**114,556**	**163,611**	**193,841**
Sales	**Rp288,279,900**	**Rp1,310,649,600**	**Rp3,410,524,500**	**Rp6,384,690,900**	**Rp11,455,581,600**	**Rp16,361,065,800**	**Rp19,384,066,500**
Vehicle Cost (Scenario 1)	Rp164,570,400	Rp290,885,714	Rp640,182,387	Rp1,157,556,701	Rp2,045,693,393	Rp2,861,108,656	Rp3,392,793,440
%-Vehicle Cost to Sales	57.09%	22.19%	18.77%	18.13%	17.86%	17.49%	17.50%
Vehicle Cost (Scenario 2)	Rp173,756,205	Rp297,782,778	Rp674,657,373	Rp1,198,683,743	Rp2,100,348,473	Rp2,948,974,137	Rp3,506,945,484
%-Vehicle Cost to Sales	60.27%	22.72%	19.78%	18.77%	18.33%	18.02%	18.09%
Vehicle Cost (Scenario 3)	Rp192,820,635	Rp396,946,861	Rp862,971,313	Rp1,577,476,613	Rp2,758,853,928	Rp3,876,521,553	Rp4,605,152,907
%-Vehicle Cost to Sales	66.89%	30.29%	25.30%	24.71%	24.08%	23.69%	23.76%
Vehicle Cost (Scenario 4)	Rp167,584,800	Rp336,856,996	Rp693,417,647	Rp1,262,968,268	Rp2,189,953,897	Rp3,080,508,047	Rp3,664,631,259
%-Vehicle Cost to Sales	58.13%	25.70%	20.33%	19.78%	19.12%	18.83%	18.91%

Table 7 shows several differences in the resources used in each scenario. The number and type of facilities are different in each scenario and there are differences in locations and routes used to meet the demands of the 15 cities. The differences in the number and types of facilities reflect variations in the scale, scope, and distribution network design across scenarios. The type of DC varies across scenarios based on the unique requirements of each scenario. For

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instance, some scenarios may involve centralized DCs serving multiple cities, while others may employ decentralized DCs located within each city. This adaptation ensures that the distribution network aligns with the specific characteristics and constraints of each scenario, optimizing operational efficiency and responsiveness to customer demand. The vehicle resources used in each scenario are different based on each scenario's delivery route. For example, scenario 1 only uses two types of vehicles because this scenario does not require a vehicle for delivery from RDCs to DCs. After all, in this scenario, the focus of delivery is to fulfill demand only from each DC from each city. Differences in vehicle costs and lead times from NDC to RDC/DC or DC to consumers occur because of differences in delivery points, mileage based on the required model, number of destinations, and the vehicle used. Every scenario created takes into account the existing conditions of the Company, and the three scenarios are developed based on verification results with the Company. The simulation results using SCM Globe focus solely on a specific product chosen as the subject of this study, based on discussions with experts. For other types of products, it is necessary to consider the demand quantity and develop a different model to achieve the most optimal outcome.

Table 7. Comparison of Several Aspects Against The 4 Scenario

Description	SCENARIO				INFORMATION	
	1	2	3	4		Description
Facility Resources	1 NDC, 4 RDC, 11 DC, 15 City Hub	1 NDC, 6 RDC, 15 City Hub	1 NDC, 6 RDC, 11 DC, 15 City Hub	1 NDC, 4 RDC, 15 City Hub	Vehicle 1	Big trucks from NDC to RDC/DC
Vehicle Resources	Vehicle 1,3	Vehicle 1,2,3	Vehicle 1,2,3	Vehicle 1,2,3	Vehicle 2	Medium trucks from RDC to DC
Vehicle cost from NDC to Other DC	3*	2*	4*	1*	Vehicle 3	Trucks to meet the demand of the greater city and surrounding
Vehicle cost from RDC/DC to Customer	1*	4*	2*	3*	1* - 4*	Rating size from lowest to highest **(1* = Lowest; 4* = Highest)**
Lead time from NDC to Other DC	3*	2*	4*	1*		

CONLUSIONS

This paper simulates four scenarios to determine the most optimal scenario with measurable parameters, including the performance of the supply chain structure of the model (response time, lead time) and the total cost of operating the scenario. The results show that scenario 1 is the optimal strategy based on the lower total vehicle cost. Conversely, the delivery cost from NDC to each point becomes more expensive because more points need to be covered. However, the daily vehicle operating cost in this scenario is much lower than in other scenarios. Scenario 4 has a fairly similar result to scenario 1. Although the delivery cost from NDC becomes cheaper because of fewer inter-points compared to scenario 1, the daily vehicle operating cost in scenario 4 is higher. The recommendation for future research based on some limitations of this study, such as exploring the impact of external variables like market demand fluctuations or regulatory changes could offer valuable insights into enhancing supply chain resilience and adaptability. Another recommendation is considering the environmental sustainability aspect by assessing the carbon footprint and implementing green logistics practices could contribute to creating more environmentally responsible supply chain strategies.

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