ACTA INFOLOGICA 2022;6(2):209-218
dergipark.org.tr/acin

DOI: 10.26650/acin.1104460

RESEARCH ARTICLE

An Integrated Model of Continuous Review Inventory and Vehicle Routing Problem with Time Windows

Glisina Dwinoor Rembulan[1], **Filscha Nurprihatin**[2], **Febrian Surya Kristardi**[3]

[1] (Assist. Prof.), Universitas Bunda Mulia, Department of Industrial Engineering, Jakarta, Indonesia
[2] (Assist. Prof.), Sampoerna University, Department of Industrial Engineering, Jakarta, Indonesia
[3] (B. Eng.), Universitas Bunda Mulia, Department of Industrial Engineering, Jakarta, Indonesia

ORCID: G.D.R 0000-0001-7983-1138;
F.N. 0000-0002-4528-2465;
F.S.K. 0000-0002-4156-3577

Corresponding author:
Glisina Dwinoor REMBULAN
Universitas Bunda Mulia, Department of Industrial Engineering, Jakarta, Indonesia
E-mail address: rglisina@gmail.com

Submitted: 16.04.2022
Revision Requested: 12.07.2022
Last Revision Received: 13.07.2022
Accepted: 20.07.2022
Published Online: 08.11.2022

Citation: Rembulan, G.D., Nurprihatin, F. & Kristardi, F.S. (2022). An integrated model of continuous review inventory and vehicle routing problem with time windows. *Acta Infologica, 6*(2), 209-218. https://doi.org/10.26650/acin.1104460

ABSTRACT

Item stock-out or shortage is a great issue for customer satisfaction and can be countered by providing safety stocks. This study discusses an authorized distributor of smartphone and tablet computer products in Indonesia. Currently, the company is considering a plan to take over the role of a logistics service company to reduce the total logistics costs that must be incurred by making improvements in terms of inventory management. Inventory management can also protect the company from the impact of inflation and price increases that will impose logistics costs. This study has assumed that the vehicle travel speed or travel time between two nodes is fixed. This study contributes to minimizing total logistics costs by integrating the concept of a continuous review lot size-reorder point (*Q, R*) inventory model with lost sales and vehicle routing problems with time windows (VRPTW). Continuous review (*Q, R*) inventory model with lost sales shows the retailers' cycle demand ranges from 130 to 234 units. This condition leads to the value of the expected average annual inventory cost IDR 27.263.204.625,59. Based on the VRPTW calculation, the total distribution cost per trip is IDR 445.631.642,7. Based on the current total distribution costs, it was found that the total distribution costs were IDR 849.454.616,2, so there is a decrease in distribution costs of 47.54%. The total logistics cost that must be incurred by the company to deliver smartphone products to 10 retailers in Jakarta and its surrounding areas is IDR 27,708,836,268.29.

Keywords: Continuous Review, Vehicle Routing, Logistics Cost

1. INTRODUCTION

In the real world, each business industry wants more profit and achieves high customer satisfaction at a more negligible cost. By aligning strategies for marketing and sales, the manufacturers can have a value added in terms of a delivery service to the customers (Christian et al., 2021). In terms of the quality cost, quality control model should be developed (Montororing & Nurprihatin, 2021). When it comes to the supply chain cost, a cross-docking strategy in truck scheduling was constructed (Nurprihatin, Elvina, et al., 2021). Moroever, it is necessary to establish a stable, reliable, sustainable, environmentally friendly, and an optimal resource-supply chain (Dzhelil et al., 2022). Regarding the inventory cost, item stock-out or shortage is a significant issue for customer satisfaction and can be countered by providing safety stocks (Dey et al., 2019). Besides, the completeness of the product sold is one of the other important things that requires attention (Tannady et al., 2018). Therefore, inventory decision is a critical part when it comes to smooth business operations. In other words, the inventory is taken as the stock of any goods or resources used in a company or an organization (Nurprihatin, Gotami, et al., 2021).

This study discusses an authorized distributor of smartphone and tablet computer products in Indonesia, which has been established and operating since 2007. Apart from being the authorized distributor of smartphone products, the company has also established retail gadgets in several cities in Indonesia such as Jakarta, Bandung, Samarinda, Bekasi, Pontianak, and Bogor. Smartphone users are increasing from time to time. In 2020, 62.84 percent of the Indonesian population used a cell phone (Statistics Indonesia, 2021). The high number of smartphone users will result in soaring demand for smartphones from every operating smartphone retailer. Therefore, the required demand is a challenge for every retailer. However, historical data shows stock-outs from several retailers that are run by a particular authorized distributor.

Table 1 shows stockout data for each retail from January to December 2018. The unavailability of smartphone product stock is caused by several reasons, including the volume of demand for each retail higher than supplies, frequent returns of goods to distributors, and the occurrence of purchases massively by other smaller retailers.

Table 1
Stock-out for smartphones in 2018

No	Retail Locations	Stock-out in 2018 (units)												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	Aeon Mall, Tangerang	15	24	21	16	29	45	21	27	24	18	29	35	304
2	Mall Metropolitan, Bekasi	19	28	22	27	37	67	27	24	27	21	17	25	341
3	Cibinong City Mall, Bogor	25	28	35	31	19	58	35	22	15	19	28	32	347
4	Mall Taman Anggrek, West Jakarta	21	28	11	19	15	27	19	14	19	11	23	27	234
5	E-center Supermal Karawaci	28	16	12	17	23	36	23	16	26	22	25	38	282
6	Mall Artha Gading, North Jakarta	32	14	19	25	27	42	25	19	29	21	25	31	309
7	Tangerang City Mall	18	25	11	14	19	30	16	12	17	19	14	24	219
8	Plaza Blok M, South Jakarta	12	29	18	17	12	33	19	17	20	22	17	38	254
9	Lippo Mal Kemang, South Jakarta	16	13	25	12	15	23	11	19	23	11	19	32	219
10	Metropolitan Mall Cileungsi, Bogor Regency	28	24	28	19	24	29	15	21	18	12	13	21	252
Total Stock-out		214	229	202	197	220	390	211	191	218	176	210	303	2761

Currently, the company is considering a plan to take over the role of a logistics service company to reduce the total logistics costs that must be incurred by making improvements in terms of inventory management. In this study, it is assumed that product shipments are only for smartphone products that cover the Jakarta area and its surroundings. Currently, the planned distribution route is only concerned with meeting the demand from each retailer, but has not considered logistics costs and also the optimal route or total distance. Moreover, the different operating hours of each retailer become a problem that needs to be resolved in supply and distribution management.

Total logistics costs will be higher when the amount of cargo carried on a vehicle is not optimal or in a relatively small amount. In addition, the activity of distributing products or goods is also influenced by the factor of the route of delivery of goods, which must be efficient and can save time and costs. In the end, inventory management can also protect the company from the impact of inflation and price increases that will impose logistics costs and anticipate fluctuations in consumer demand for retail companies (Heizer et al., 2020).

This study contributes to minimizing total logistics costs by integrating the concept of a continuous review lot size-reorder point (*Q, R*) inventory model with lost sales and vehicle routing problems with time windows (VRPTW). The (*Q, R*) inventory model with lost sales is a method to reduce total inventory costs by determining the optimum number of orders so that the company has product inventories or reserves. If at any time the product is needed, there is still availability of product stock at a minimum cost. Meanwhile, the VRPTW is used because it can minimize the total logistics costs which are influenced by optimal order requests, vehicle capacity, and product delivery time. These two methods are used to minimize the total logistics costs by considering the EOQ calculation in a (*Q, R*) inventory model with lost sales. The integration of these two methods can provide with proposed shipping routes that are efficient in terms of cost, distance, and travel time.

2. LITERATURE REVIEW

Under a stochastic and dynamic supply chain environment, a study utilized simulation-based optimization on a multi-echelon inventory system (Xu et al., 2019). Another contributive study discussed the uncertain demand using the Monte Carlo simulation (Nurprihatin et al., 2020). This condition leads to uncontrolled total inventory costs. The major inventory costs considered in this study include holding cost, setup cost, and shortage cost.

The continuous review model has been developed under the various distributions of the demand and the demand during lead time. One study assumed the demand is following the lognormal distribution (Gholami & Mirzazadeh, 2018). One of the important assumptions for the inventory model is the distribution of the demand during lead time (Gholami & Mirzazadeh, 2018). The demand during lead time is assumed to follow the Normal distribution (Mukherjee et al., 2019) or Poisson distribution (Dey et al., 2019; Kouki et al., 2019).

There exist two main categories of the allowable shortage models in the inventory management literature, which are backorder and lost sales (Gholami & Mirzazadeh, 2018). For the backorder, the assumption is that all customers will wait up to receiving the next order quantity, while all customers relinquish the systems during the shortage situation under a lost sales scenario (Gholami & Mirzazadeh, 2018).

The inventory policy has been integrated with the production policy assuming the random capacity follows a gamma-type distribution (Gholami & Mirzazadeh, 2018). When it comes to the production policy, setup times and product defects can be reduced by performing extra investments (Dey et al., 2019; Gholami & Mirzazadeh, 2018; Liu et al., 2020). Also, the scheduling issue has been tackled to minimize the number of tardiness (Nurprihatin et al., 2020). The manufacturers need to pay attention to the delivery schedules so that there will be no tardy distribution (Gunawan et al., 2020). Any tardiness would lead to lossess to the manufacturers (Andiyan et al., 2021).

The routing decision has been presented along with the network location decision, along with the feasibility study (Nurprihatin, Octa, et al., 2019). Many different types of VRP such as VRP with Time Windows, Stochastic VRP, Multi Depot VRP, Periodic VRP, Dynamic VRP, and different combinations of these have been studied (Demirbilek, 2021). A study discussed the developed variant of VRPTW called the time-dependent vehicle routing problem with time windows (TDVRPTW) (Liu et al., 2020). Another study developed the Vehicle Routing Problem Model with Multiple Trips, Time Windows, Split Delivery, Heterogeneous Fleet, and Intermediate Facility (VRPMTTWSDHFIF) as an advanced model (Nurprihatin & Lestari, 2020). In this paper, the routing decision is integrated with the inventory policy, as shown in Table 2. When VRP is combined with time window constraint, the problem is termed VRPTW (Dixit et al., 2019). The aim of VRPTW involves the minimization of the number of vehicles and the total travel distance (Dixit et al., 2019). In this paper, the objective is to minimize the distribution cost, referring to the previous research (Gmira et al., 2021; Keskin et al., 2021). The distribution cost was traditionally approximated by the travel distance (Nurprihatin, Andry, et al., 2021; Nurprihatin & Tannady, 2018) and by the stochastic travel time (Nurprihatin, Elnathan, et al., 2019; Nurprihatin & Montororing, 2021). However, a previous study utilized the real distribution cost given by third-party logistics (Nurprihatin, Regina, et al., 2021). Meta-learning has been used to select meta-heuristics to solve VRPTW (Gutierrez-Rodríguez et al., 2019).

Table 2
Related works

	Inventory model	**Assumption**	**Demand**	**Lead time**	**Demand during lead time**	**Distribution model**	**Objective function**
(Mukherjee et al., 2019)	(*Q*, *R*) policy	Backorder	Normal distribution	Constant	Normal distribution	No	Minimizing inventory cost
(Kouki et al., 2019)	(*Q*, *R*) policy	Lost sales	Poisson distribution	Poisson distribution	Poisson distribution	No	Minimizing inventory cost
(Gmira et al., 2021)	No	Stochastic travel times	No	No	No	VRPTW	Minimizing dıstribution cost
(Keskin et al., 2021)	No	Stochastic waiting times	No	No	No	VRPTW	Minimizing dıstribution cost
This paper	(*Q*, *R*) policy	Lost sales	Normal distribution	Constant	Normal distribution	VRPTW	Minimizing inventory cost. Minimizing distribution cost.

3. METHODS

3.1. Continuous Review (*Q, R*) Inventory Model with Lost Sales

The initial step in (*Q, R*) inventory model is calculating the EOQ using the formula shown in Equation (1) (Nahmias & Olsen, 2021). The Cycle Service Level (CSL) or in-stock probability for lost sales situation is calculated using Equation (2) (Chopra & Meindl, 2016; Nahmias & Olsen, 2021). A further calculation is calculating the *Q* using Equation (3) (Nahmias & Olsen, 2021). An iterative calculation using Equation (2) and Equation (3) should be performed until the value of *Q* and CSL from the *n* iteration is equal to the *n*-1 iteration. Reorder point can be calculated using Equation (4) (Nahmias & Olsen, 2021). In the end, the expected average annual cost formula is shown in Equation (5) (Nahmias & Olsen, 2021). The expected average annual cost consists of the holding cost, setup cost, and shortage cost.

$$EOQ = Q = \sqrt{\frac{2K\lambda}{h}} \tag{1}$$

$$CSL = F(R) = 1 - \frac{Qh}{(Qh + p\lambda)} \tag{2}$$

$$Q = \sqrt{\frac{2\lambda[K + p\sigma L(z)]}{h}} \tag{3}$$

$$R = \lambda\tau + ss = \mu_{DDL} + z(\sigma_{DDL}) \tag{4}$$

$$G(Q,R) = \frac{(Q + R - \lambda\tau)}{2}(h) + \frac{\lambda}{Q}(K) + \frac{p\lambda\sigma L(z)}{Q} \tag{5}$$

where:

Q = Economic Order Quantity (units)

K = Setup cost (per order)

λ = Demand rate (units per year)

h = Holding cost (per unit per year)

CSL = Cycle Service Level

p = Stock-out cost (per unit per year)

σ = Standard deviation of demand

$L(z)$ = Standardized loss function

R = Reorder Point

τ = Lead time

ss = Safety stock

μ_{DDL} = Average demand during lead time

σ_{DDL} = Standard deviation demand during lead time

$G(Q, R)$ = Expected average annual cost

The next stage is calculating the shortest route with a specific capacity of transportation mode. VRPTW is run with Lingo 18 software and this application is usually used to solve and help optimization problems in the industrial and government fields. The required inputs include distance matrix, time matrix, service time, and the opening and closing time of the retail. From the previous calculation, which is the continuous review (Q, R) inventory model, the cycle demand data (is equal to Q^*) from each retailer can be obtained.

After obtaining the results of the EOQ calculation, reorder point, safety stock, and expected average annual cost from each retailer, the calculation continues to choose a route with a certain type of vehicle. The route starts from the Distribution Center (DC) to ten retailers in Jakarta and its surrounding areas.

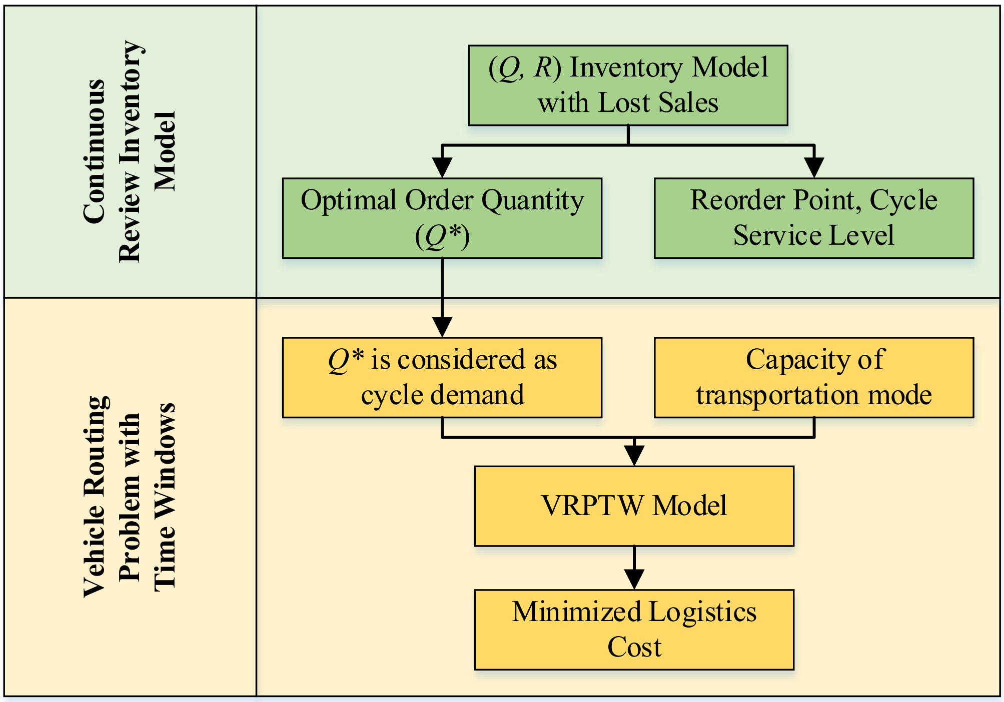

Figure 1. Research procedure

3.2. Vehicle Routing Problem with Time Windows (VRPTW) Model

The VRPTW model is presented in the form of one objective function and seven constraints, as follows.

Objective function:

$$Min\ Z_{VRPTW} = \sum_{i \in N} \sum_{j \in N} d_{ij} x_{ij} \tag{6}$$

Subject to:

$$\sum_{i \in N} x_{ij} = 1 \qquad \forall_i \in C \qquad (7)$$

$$\sum_{j \in N} x_{0j} = 1 \qquad \forall_j \in C \qquad (8)$$

$$\sum_{i \in N} x_{ih} - \sum_{j \in N} x_{hj} = 0 \qquad \forall_h \in C \qquad (9)$$

$$\sum_{i \in N} x_{i(n+1)} = 1 \qquad \forall_i \in C \qquad (10)$$

$$m_i + s_i + t_{ij} - R(1 - x_{ij}) \leq m_j \qquad \forall_{i,j} \in N \qquad (11)$$

$$a_i \leq s_i \leq b_i \qquad \forall_i \in N \qquad (12)$$

$$x_{ij} \in \{0,1\} \qquad \forall_{i,j} \in N \qquad (13)$$

Equation (6) is the objective function of the mathematical model to minimize the distance traveled by the vehicle. Constraint (7) states that each customer is visited exactly once, constraint (8), constraint (9), constraint (10) state the path or route traversed by the vehicle departing from the depot (DC), then visits one of the customers, where after visiting the customer, the vehicle will visit other customers until the vehicle returns to the depot (DC). Equation (11) states that the vehicle is not allowed to arrive at customer *j* before $m_i + s_i + t_{ij}$ or before the start of service time plus service time for customer 1 and plus service time from *i* to *j*, and *R* is a real number of large value. Constraint (12) is used to ensure that the time window constraint is met. Constraint (13) states that the decision variable x_{ij} is a binary decision variable in the form of 0 or 1.

4. RESULTS AND DISCUSSION

Table 3 provides information on the results of the continuous review (*Q, R*) inventory model with lost sales. Coincidentally, the ten locations reach their optimal point in the third iteration. In another case study, the possible number of iterations may vary depending on the variability in the demand data. The more varied the request data, the more iterations will be. Later on, the value of $Q*$ will be considered as a cycle demand that must be distributed for each shipment. The calculation results also show the expected average annual cost for all locations reaches IDR 27,263,204,625.59.

Table 3
Continuous review (Q, R) inventory model with lost sales results

Location	Iteration	Q* (units)	R (units)	α	Z(α)	L(z)	τ (years)	ss (units)	G(Q, R)(IDR)
	1st	823	173	0.1957	0.86	0.108	0.08		
1	2nd	825	173	0.1961	0.86	0.108	0.08	4	2,693,013,696.96
	3rd	825	173	0.1961	0.86	0.108	0.08		
	1st	952	234	0.1737	0.94	0.0933	0.08		
2	2nd	955	234	0.1742	0.94	0.0933	0.08	7	3,596,354,664.27
	3rd	955	234	0.1742	0.94	0.0933	0.08		
	1st	855	185	0.1898	0.88	0.1042	0.08		
3	2nd	857	185	0.1902	0.88	0.1042	0.08	5	2,903,842,891.97
	3rd	857	185	0.1902	0.88	0.1042	0.08		
	1st	923	219	0.1781	0.93	0.095	0.08		
4	2nd	926	219	0.1785	0.93	0.095	0.08	6	3,385,718,197.84
	3rd	926	219	0.1785	0.93	0.095	0.08		
	1st	885	201	0.1844	0.9	0.1004	0.08		
5	2nd	887	201	0.1848	0.9	0.1004	0.08	5	3.111.998.564,97
	3rd	887	201	0.1848	0.9	0.1004	0.08		
	1st	781	157	0.2042	0.83	0.114	0.08		
6	2nd	783	157	0.2046	0.83	0.114	0.08	4	2.426.638.428,41
	3rd	783	157	0.2046	0.83	0.114	0.08		

Table 3
Continuous review (Q, R) inventory model with lost sales results

Location	Iteration	Q^* (units)	R (units)	α	$Z(\alpha)$	$L(z)$	τ (years)	ss (units)	$G(Q, R)$(IDR)
	1st	746	143	0.2118	0.81	0.1181	0.08		
7	2nd	747	143	0.2120	0.8	0.1202	0.08	4	2.215.683.335,12
	3rd	747	143	0.2120	0.8	0.1202	0.08		
	1st	712	130	0.2197	0.78	0.1245	0.08		
8	2nd	713	130	0.2199	0.78	0.1245	0.08	3	2.019.748.650,21
	3rd	713	130	0.2199	0.78	0.1245	0.08		
	1st	761	150	0.2084	0.82	0.116	0.08		
9	2nd	764	150	0.2091	0.81	0.1181	0.08	6	2.305.566.856,19
	3rd	764	150	0.2091	0.81	0.1181	0.08		
	1st	809	167	0.1983	0.85	0.11	0.08		
10	2nd	811	167	0.1987	0.85	0.11	0.08	4	2.604.639.339,65
	3rd	811	167	0.1987	0.85	0.11	0.08		
				Total					**27.263.204.625,59**

The route selection is based on EOQ data from each retailer so that recommendations can be given regarding the number of vehicles to be used and the selected route. Data related to the retail operational and service time is shown in Table 4. Table 5 shows the distance matrix by converting the coordinates obtained via Google Maps into the Euclidean formula while Table 6 represents the time traveled.

Table 4
Operational hours

Location	Opening Hour	Opening Minutes	Closing Hour	Closing Minutes
DC	08.00	480	22.00	1320
1	10.00	600	22.00	1320
2	09.30	570	22.00	1320
3	09.00	540	23.00	1380
4	10.00	600	22.00	1320
5	10.00	600	22.00	1320
6	10.00	600	22.00	1320
7	10.00	600	22.00	1320
8	10.00	600	22.00	1320
9	10.00	600	22.00	1320
10	10.00	600	22.00	1320

Table 5
Distance matrix (km)

Locations	1	2	3	4	5	6	7	8	9	11	11
1	0.00	44.70	21.10	41.90	13.80	41.50	5.60	33.40	17.50	19.50	38.30
2	44.70	0.00	49.43	61.27	46.78	60.99	45.05	55.80	48.00	48.77	58.86
3	21.10	49.43	0.00	46.91	25.21	46.56	21.83	39.51	27.41	28.73	43.73
4	41.90	61.27	46.91	0.00	44.11	58.97	42.27	53.58	45.41	46.22	56.77
5	13.80	46.78	25.21	44.11	0.00	43.73	14.89	36.14	22.29	23.89	40.71
6	41.50	60.99	46.56	58.97	43.73	0.00	41.88	53.27	45.04	45.85	56.47
7	5.60	45.05	21.83	42.27	14.89	41.88	0.00	33.87	18.37	20.29	38.71
8	33.40	55.80	39.51	53.58	36.14	53.27	33.87	0.00	37.71	38.68	50.82
9	17.50	48.00	27.41	45.41	22.29	45.04	18.37	37.71	0.00	26.20	42.11
10	19.50	48.77	28.73	46.22	23.89	45.85	20.29	38.68	26.20	0.00	42.98
11	38.30	58.86	43.73	56.77	40.71	56.47	38.71	50.82	42.11	42.98	0.00

Table 6
Time traveled matrix (minutes)

Locations	1	2	3	4	5	6	7	8	9	10	11
1	0.00	53.64	25.32	50.28	16.56	49.80	6.72	40.08	21.00	23.40	45.96
2	53.64	0.00	59.32	73.52	56.14	73.19	54.06	66.96	57.60	58.52	70.64
3	25.32	59.32	0.00	56.30	30.25	55.87	26.20	47.41	32.90	34.48	52.47
4	50.28	73.52	56.30	0.00	52.94	70.77	50.73	64.30	54.49	55.46	68.12
5	16.56	56.14	30.25	52.94	0.00	52.48	17.87	43.37	26.74	28.67	48.85
6	49.80	73.19	55.87	70.77	52.48	0.00	50.25	63.93	54.05	55.02	67.77
7	6.72	54.06	26.20	50.73	17.87	50.25	0.00	40.64	22.05	24.35	46.45
8	40.08	66.96	47.41	64.30	43.37	63.93	40.64	0.00	45.25	46.41	60.98
9	21.00	57.60	32.90	54.49	26.74	54.05	22.05	45.25	0.00	31.44	50.53
10	23.40	58.52	34.48	55.46	28.67	55.02	24.35	46.41	31.44	0.00	51.57
11	45.96	70.64	52.47	68.12	48.85	67.77	46.45	60.98	50.53	51.57	0.00

Assuming the vehicles' speed is assumed to be 50 km/hour, the current plan for product delivery is considered large because the total distance is 491.3 and the total time taken is 589.7 minutes, while the total distribution cost itself is IDR 849,454,616.2. Table 7 presents the total distribution cost, which consists of the fuel consumption, labor cost, commission per visit, and fixed costs of the vehicle used, referring to the previous study (Liu et al., 2020). As additional components, this paper also considers the feasibility study and parking fee.

Through calculations using the integration of the continuous review (*Q, R*) inventory model with lost sales and VRPTW, to meet the volume of demand from 10 retailers, product shipments were carried out 3 times a year. Based on the established routes, it is proposed to procure 3 units of vehicles to accommodate all three routes simultaneously. It is necessary to conduct a feasibility test for the three vehicles before being operated as a condition of travel in Indonesia. The calculation results show the total distribution cost is IDR 445.631.642,7 per trip. Based on the current total distribution costs, it was found that the total distribution costs were IDR 849.454.616,2, so there is a decrease in distribution costs of 47.54%.

Table 7
Total distribution cost per trip

Vehicle	Route	Total Distance (km)	IDR					
			Fuel Price	Labor Cost	Commission per Visit	Feasibility Test	Vehicle Price	Parking Fee
1	DC-4-9-8-6-DC	87,86	43.008,39	400.000	100.000	75.000	148.300.000	16.000
2	DC-7-10-2-DC	149,05	72.961,54	400.000	75.000	75.000	148.300.000	12.000
3	DC-5-1-3-DC	205,66	100.672,7273	400.000	75.000	75.000	148.300.000	12.000
Total		442.57	216.642,6573	1.200.000	250.000	225.000	444.900.000	40.000
					445.631.642,7			

5. CONCLUSION

In this integration model, the calculation begins by identifying the EOQ value, reorder point, safety stock, and total expected average annual inventory cost, followed by determining the distribution route and the number of vehicles needed using VRPTW to get the total distribution cost. Continuous review (*Q, R*) inventory model with lost sales shows the retailers' cycle demand range from 130 to 234 units. This condition leads to the value of the expected average annual inventory cost IDR 27.263.204.625,59.

Based on the VRPTW calculation, the total distance and travel time per trip are 442.57 km and 531.08 minutes, respectively. Therefore, the total distribution cost per trip is IDR 445.631.642,7. This affects the efficiency level of the total distribution cost obtained, which is 47.54%.Total logistics cost is defined as total inventory costs plus total distribution costs. The total logistics cost that must be incurred by the company to deliver smartphone products to 10 retailers in Jakarta and its surrounding areas is IDR 27,708,836,268.29.

While this study has assumed that the vehicle travel speed or travel time between two nodes is fixed, further research can consider the stochastic time travel as discussed in the previous paper (Liu et al., 2020).

Peer-review: Externally peer-reviewed.
Conflict of Interest: The authors have no conflict of interest to declare.
Grant Support: The authors declared that this study has received no financial support.
Author Contributions: Conception/Design of Study- G.D.R., F.N., F.S.K.; Data Acquisition- F.S.K.; Data Analysis/Interpretation- F.S.K., F.N.; Drafting Manuscript- G.D.R., F.N.; Critical Revision of Manuscript- G.D.R., F.N.; Final Approval and Accountability- G.D.R., F.N.; Material and Technical Support- F.S.K., F.N.; Supervision- G.D.R..

Hakem Değerlendirmesi: Dış bağımsız.
Çıkar Çatışması: Yazarlar çıkar çatışması beyan etmemişlerdir
Finansal Destek: Yazarlar finansal destek beyan etmemişlerdir.
Yazar Katkıları: Çalışma Konsepti/Tasarım- G.D.R., F.N., F.S.K.; Veri Toplama- F.S.K.; Veri Analizi/Yorumlama- F.S.K., F.N.; Yazı Taslağı- G.D.R., F.N.; İçeriğin Eleştirel İncelemesi- G.D.R., F.N.; Son Onay ve Sorumluluk- - G.D.R., F.N.; Malzeme ve Teknik Destek- F.S.K., F.N.; Süpervizyon- G.D.R.

References

Andiyan, Putra, R. M., Rembulan, G. D., & Tannady, H. (2021). Construction project evaluation using CPM-crashing, CPM-PERT and CCPM for minimize project delays. *Journal of Physics: Conference Series*, *1933*(1), 1–7. https://doi.org/10.1088/1742-6596/1933/1/012096

Chopra, S., & Meindl, P. (2016). *Supply chain management: strategy, planning, and operation* (6th ed.). Pearson Education.

Christian, M., Dewi, D., Rembulan, G. D., Indriyarti, E. R., Wibowo, S., & Yuniarto, Y. (2021). Business performance determinants of salted fish distribution in Kapuk during the COVID-19. *Journal of Distribution Science*, *19*(6), 29–39. https://doi.org/10.15722/jds.19.6.202106.29

Demirbilek, M. (2021). A-static-periodic solution strategy for dynamic vehicle routing problem with simultaneous pickup and delivery. *Acta Infologica*, *5*(1), 1–12. https://doi.org/10.26650/acin.831973

Dey, B. K., Sarkar, B., Sarkar, M., & Pareek, S. (2019). An integrated inventory model involving discrete setup cost reduction, variable safety factor, selling price dependent demand, and investment. *RAIRO - Operations Research*, *53*(1), 39–57. https://doi.org/10.1051/ro/2018009

Dixit, A., Mishra, A., & Shukla, A. (2019). Vehicle routing problem with time windows using meta-heuristic algorithms: A survey. *Advances in Intelligent Systems and Computing*, *741*, 539–546. https://doi.org/10.1007/978-981-13-0761-4_52

Dzhelil, Y., Mihalev, T., Ivanov, B., & Dobrudzhaliev, D. (2022). Mathematical modeling and optimization of supply chain for bioethanol. *Acta Infologica*, *6*(1), 33–42. https://doi.org/10.26650/acin.817655

Gholami, A., & Mirzazadeh, A. (2018). An inventory model with controllable lead time and ordering cost, log-normal-distributed demand, and gamma-distributed available capacity. *Cogent Business and Management*, *5*(1), 1–17. https://doi.org/10.1080/23311975.2018.1469182

Gmira, M., Gendreau, M., Lodi, A., & Potvin, J. Y. (2021). Tabu search for the time-dependent vehicle routing problem with time windows on a road network. *European Journal of Operational Research*, *288*(1), 129–140. https://doi.org/10.1016/j.ejor.2020.05.041

Gunawan, F. E., Wilujeng, F. R., Rembulan, G. D., & Tannady, H. (2020). Service quality analysis of SMEs tempe in province of Jakarta, Indonesia. *Technology Reports of Kansai University*, *62*(7), 3827–3833.

Gutierrez-Rodríguez, A. E., Conant-Pablos, S. E., Ortiz-Bayliss, J. C., & Terashima-Marín, H. (2019). Selecting meta-heuristics for solving vehicle routing problems with time windows via meta-learning. *Expert Systems with Applications*, *118*, 470–481. https://doi.org/10.1016/j.eswa.2018.10.036

Heizer, J., Render, B., & Munson, C. (2020). *Operations management: sustainability and supply chain management* (13th ed.). Pearson.

Keskin, M., Çatay, B., & Laporte, G. (2021). A simulation-based heuristic for the electric vehicle routing problem with time windows and stochastic waiting times at recharging stations. *Computers and Operations Research*, *125*, 1–15. https://doi.org/10.1016/j.cor.2020.105060

Kouki, C., Babai, M. Z., Jemai, Z., & Minner, S. (2019). Solution procedures for lost sales base-stock inventory systems with compound Poisson demand. *International Journal of Production Economics*, *209*, 172–182. https://doi.org/10.1016/j.ijpe.2018.01.021

Liu, C., Kou, G., Zhou, X., Peng, Y., Sheng, H., & Alsaadi, F. E. (2020). Time-dependent vehicle routing problem with time windows of city logistics with a congestion avoidance approach. *Knowledge-Based Systems*, *188*. https://doi.org/10.1016/j.knosys.2019.06.021

Montororing, Y. D. R., & Nurprihatin, F. (2021). Model of quality control station allocation with consider work in process, and defect probability of final product. *Journal of Physics: Conference Series*, 1–12. https://doi.org/10.1088/1742-6596/1811/1/012013

Mukherjee, A., Dey, O., & Giri, B. C. (2019). An integrated imperfect production–inventory model with optimal vendor investment and backorder price discount. *Advances in Intelligent Systems and Computing*, *699*, 187–203. https://doi.org/10.1007/978-981-10-7590-2_14

Nahmias, S., & Olsen, T. L. (2021). *Production & operation analytics* (8th ed.). Waveland Press Inc.

Nurprihatin, F., Andry, J. F., & Tannady, H. (2021). Setting the natural gas selling price through pipeline network optimization and project feasibility study. *Journal of Physics: Conference Series*, 1–6. https://doi.org/10.1088/1742-6596/1811/1/012008

Nurprihatin, F., Elnathan, R., Rumawan, R. E., & Regina, T. (2019). A distribution strategy using a two-step optimization to maximize blood services considering stochastic travel times. *IOP Conference Series: Materials Science and Engineering*, *650*(1). https://doi.org/10.1088/1757-899X/650/1/012043

Nurprihatin, F., Elvina, Rembulan, G. D., Christianto, K., & Hartono, H. (2021). Decision support system for truck scheduling in logistic network through cross-docking strategy. *Journal of Physics: Conference Series*, 1–10. https://doi.org/10.1088/1742-6596/1811/1/012009

Nurprihatin, F., Gotami, M., & Rembulan, G. D. (2021). Improving the performance of planning and controlling raw material inventory in food industry. *International Journal of Research in Industrial Engineering*, *10*(4), 332–345. https://doi.org/10.22105/riej.2021.306872.1250

Nurprihatin, F., Jayadi, E. L., & Tannady, H. (2020). Comparing heuristic methods' performance for pure flow shop scheduling under certain and uncertain demand. *Management and Production Engineering Review*, *11*(2). https://doi.org/10.24425/mper.2020.133728

Nurprihatin, F., & Lestari, A. (2020). Waste collection vehicle routing problem model with multiple trips, time windows, split delivery, heterogeneous fleet and intermediate facility. *Engineering Journal*, *24*(5), 55–64. https://doi.org/10.4186/ej.2020.24.5.55

Nurprihatin, F., & Montororing, Y. D. R. (2021). Improving vehicle routing decision for subsidized rice distribution using linear programming considering stochastic travel times. *Journal of Physics: Conference Series*, 1–8. https://doi.org/10.1088/1742-6596/1811/1/012007

Nurprihatin, F., Octa, A., Regina, T., Wijaya, T., Luin, J., & Tannady, H. (2019). The extension analysis of natural gas network location-routing design through the feasibility study. *Journal of Applied Research on Industrial Engineering*, *6*(2), 108–124. https://doi.org/10.22105/jarie.2019.174164.1082

Nurprihatin, F., Regina, T., & Rembulan, G. D. (2021). Optimizing rice distribution routes in Indonesia using a two-step linear programming considering logistics costs. *Journal of Physics: Conference Series*, 1–8. https://doi.org/10.1088/1742-6596/1811/1/012010

Nurprihatin, F., & Tannady, H. (2018). An integrated transportation models and savings algorithm to minimize distribution costs. *Proceeding of the 1st Asia Pacific Conference on Research in Industrial and Systems Engineering*, 216–221. https://www.researchgate.net/publication/335231165

Statistics Indonesia. (2021). *Telecommunication statistics in Indonesia 2020*.

Tannady, H., Nurprihatin, F., & Hartono, H. (2018). Service quality analysis of two of the largest retail chains with minimart concept in Indonesia. *Business: Theory and Practice*, *19*. https://doi.org/10.3846/BTP.2018.18

Xu, G. Y., Feng, J. H., Chen, F. L., Wang, H., & Wang, Z. F. (2019). Simulation-based optimization of control policy on multi-echelon inventory system for fresh agricultural products. *International Journal of Agricultural and Biological Engineering*, *12*(2), 184–194. https://doi.org/10.25165/j.ijabe.20191202.2834