Revenue Management Focused Capacitated Vehicle Routing Model in Supply Chain Management

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Abstract

Objectives: To propose revenue management focused model for Capacitated Vehicle Routing Problem with Simultaneous Pickup and Delivery and pursue a solution to it. In some industries, customer demand for delivery and pickup fluctuates and the vehicle capacities are limited. Existing research focuses on either Revenue Maximization or Transportation Cost Minimization. To be able to run such businesses profitably, it is necessary to consider both objectives by the help of the proposed model. Dynamic pricing will be used for revenue maximization, by booking early reservations for a lower price. Vehicle Routing Problem will determine the route to minimize the total transportation cost. **Methods:** The capacitated vehicle routing model with simultaneous pickup and delivery is combined with a revenue management model in which low price early reservations are allowed. In case the customer orders cannot be handled with existing vehicle capacities, some of the early reservation orders are canceled and a cancellation fee is incurred. The model is solved with a mixed-integer linear programming (MILP) solver. **Findings:** The proposed model is tested against a real-world data set. The result shows that unprofitable customer orders are determined by the model and rejected despite there is a cancellation fee. By applying the revenue management model, it is observed that there is an increase in the total profit. **Novelty:** To the best of our knowledge, this study proposed a revenue management focused MILP model for VRP with simultaneous pickup and delivery for the first time.

Keywords: Vehicle Routing Model, Revenue Management, Simultaneous Pick-up and Delivery, Supply Chain Management.

1. Introduction

Companies that have existed in our world where the competitive environment is highly effective and who aim to exist in the future should take various actions to manage their processes in the distribution network in the optimum direction and these actions should be the best interest of the company. In today's conditions, low-cost and timely meeting the needs of customers and product delivery takes place as a result of logistics activities. It is the routing decisions to be made to the customers from the facilities which can be counted as the first action. It is the problem of determining the least cost or optimum routes with a fleet of vehicles in order to meet customer needs. This problem, defined as Vehicle Routing Problem (VRP), has been a problem type made by numerous companies in many sectors to ensure competition. VRP is defined as minimizing the total distance traveled by the vehicle fleet from a centralized warehouse to various demand points, distribution or collection routes. The main objective is to minimize the distance traveled or transportation costs, but to produce a revenue-maximizing solution due to delivery and to propose a model to ensure competition. Transportation is an important part of the Supply Chain Management where goods and services are delivered from suppliers to suppliers and from final supplier to end customers. Transportation activities are planned together with other activities in the supply chain.

VRP, first proposed by Dantzig and Ramser in 1959, has become a study problem developed by many researchers with different mathematical models and solution methods [1].

The basic assumptions of the VRP are as follows:

* Known and specific customer demands and cannot be split,
* The distances between the warehouse and the customer are fixed and known,
* Vehicles with identical capacity and ready-to-service vehicles with known capacity and in the central warehouse.

Under these assumptions, the main purpose of VRP is to identify the least cost routes that can meet the needs of all customers in question. Routing problems have different types according to their constraints, and vehicle routing problems are NP-Hard problems [1].

The vehicle routing problem with pickup and delivery (VRPPD) is one of the important vehicle routing problems. Among the several VRPPD variants: VRP with backhauls, VRP with mixed pickup and delivery; dial-ride problem, and the VRP with simultaneous pickup and delivery. VRP with simultaneous pickup and delivery (VRPSPD) problem is a commonly used problem in the collection and delivery of goods, where delivery and pickup are done by the same vehicle on the same tour. VRPSPD was first introduced by [2–3] about thirty years ago. In this study, a real-life problem based on the intuitive method of distribution of the book collection between libraries is discussed. To solve this problem, firstly, the clustering of the customers has been made. A vehicle is then assigned to each cluster and the problem is solved for each group of customers. Then, with the help of a set of covering formulations applied to a branch and price approach for the VRPSPD. Studies on the VRPSPD problem have increased gradually in recent years.

This problem, which is frequently encountered with the rapid development of trade levels, has become of increasing importance. There are many examples of how this problem works in daily life. One of the best examples of this problem is the e-commerce virtual shopping systems, in which customers receive their orders through the internet and receive them during the day.

Unlike the conventional VRP, in the time window, there are differences from the classical VRP. In this problem, there is an obligation to serve within a defined time interval for each existing customer. Generally, products with short shelf life, distribution or short delivery time systems are represented with the Time Windows Vehicle Routing Problem (TWVRP). The distribution of non-durable consumer goods to customers can be given as an example to TWVRP. Routes to be used in this distribution process should be short-term and completed within one working day [4].

As a result of the literature review, according to the best of our knowledge, it was found that there is no depth of resources for the intersection of revenue maximization and vehicle route planning during the study process. In this study, a metaheuristic framework has been proposed for revenue management-oriented simultaneous delivery and pickup vehicle routing, and it has been applied to reach the best solution concerning revenue management on different sized test problems.

The rest of the article is summarized as follows. In the second part, the studies about VRPSPD in the literature briefly mentioned and explained. In the third section, the proposed mathematical model described in detail. In the fourth section, experimental studies on a subset of customer order data from a steel sheet service company explained and the obtained solutions shown. In the last section, the results presented, and further studies suggested.

1.1. Literature Survey

In Ref. [5], Dethloff focused on different types of backhauling problems, the vehicle routing problem with backhauls (VRPBM), and the vehicle routing problem with simultaneous delivery and pickup (VRPSDP). In his work, these two types of problems are determined as closely related, but VRPSDP problems require the application of an insertion heuristic based on the concept of "residual capacities". The study exhibited numerical results that, for certain instances, this approach is more favorable than the application of a heuristic suggested for the VRPBM in the literature.

In Ref. [6], Giaglis et al. emphasized the importance of seamless mobile and wireless connectivity between delivery vehicles and distribution facilities to real-time vehicle routing and distribution management. The advances in both the relevant research in the VR problem and the advances in mobile technologies are investigated. Further to setting requirements, they proposed the system architecture for urban distribution and real-time event-driven vehicle management.

In Ref. [7], Alvarez and Pedro studied the vehicle routing problem with time windows and multiple deliverymen (VRPTWMD). In this type of problem, service times at customers depend on the number of deliverymen assigned to the route that serves them. Their study aimed to determine the crew size for each route together with usual routing

and scheduling decisions. Companies that deliver goods to customers located in busy urban areas; need to improve the service time. Nearby customers are grouped in advance so that the deliverymen can serve all customers in a group during one vehicle stop. They proposed a hybrid method by combining a branch-price-and-cut (BPC) algorithm with two metaheuristic approaches.

In Ref. [8], Iassinovskaia et al. focused on returnable transport items (RTI) shared among the different partners of a closed-loop supply chain. In this article, they consider the distribution of goods to customers packed in RTIs and the simultaneous collection of empty RTIs by a homogeneous fleet of vehicles. They addressed a pickup and delivery inventory-routing problem within time windows (PDIRPTW) over a planning horizon. A mixed-integer linear program is developed and tested on small-scale instances. For handling more realistic large-scale problems, a cluster first-route second matheuristic is proposed.

In Ref. [9], Komijan and Delavari devised a mixed-integer programming model for a food distribution company. The transportation costs, holding, tardiness, and earliness are simultaneously taken into account. They proposed a model according to business requirements as multi-period, one for dispatching vehicles to customers and suppliers and the other for receiving customer orders. Time window and split pickup and delivery are considered for perishable products. They proposed a nonlinear model and linearized it using exact techniques. The results show that the changes in holding and transportation costs are related to changes to tardiness and earliness costs and they are not so sensitive to demand changes.

In Ref. [10], Stehling and De Souza studied different crossover operators of Genetic Algorithms on Vehicle Routing Problem with Time Window. According to the statistical analysis, they obtained results that are significantly different by applying the crossover operators.

In Ref. [11], Taha et al. worked on Vehicle Routing Problem with Time Windows and applied a hybrid algorithm that combines a discrete version of the new bio-inspired Bat Algorithm and Large Neighborhood Search framework. They obtained satisfactory performance with the algorithm on Solomon's benchmark problem instances.

In Ref. [12], Gong et al. studied the vehicle routing problem with simultaneous pickups and deliveries (VRPSPD) on a closed-loop supply chain logistics network. Three types of customers: distributors, recyclers, and suppliers taken into account. The fuel consumption is added to the optimization objectives of the proposed VRPSPD. A hybrid bee evolutionary algorithm and genetic algorithm is designed to solve the proposed VRPSPD model with three optimization objectives: minimum fuel consumption, minimum waiting time, and the shortest delivery distance. Results show that the model and the proposed algorithm are valid and able to produce feasible solutions to three test examples and a real-world example from an engineering machinery remanufacturing company's reverse logistics.

In Ref. [13], Soleimani et al. emphasized the importance of studies on vehicle routing problems, towards consumer advantage with lower transportation costs of goods and services delivery. They focused on developing solutions for VRP of original and remanufactured products. They proposed a multi-objective non-linear programming model for the green vehicle routing problem (GVRP), including original and remanufactured products

distribution (both delivery and pickup) of end-of-life (EOL) products. They implemented a fuzzy approach for linearizing the model. A considerable level of improved performance is achieved, reducing the fuel cost, distribution center set-up cost and supplying vehicles, as well as minimizing air pollution, on a real-world example.

In Ref. [14], Rojas-Cuevas et al. proposed a model named Capacitated Vehicle Routing Problem for Carriers to obtain optimal route planning. The distribution scenario they worked on deals with a fleet of vehicles depart from a vehicle storage depot, collect products from a set of customer points and deliver them to a specific warehouse before returning to the vehicle storage depot. The model is tested against the Capacitated Vehicle Routing Problem test data from the VRP Library. Besides these tests, they worked on data from a carrier company to show the economic impact of the model. The route planning obtained through the model accurately described the network flow and significantly reduced its distribution cost.

In Ref. [15], Ma et al. proposed a hybrid priority-based nested genetic algorithm with fuzzy logic controller and fuzzy random simulation for solving a variant of the vehicle routing problem. All the complex restrictions of practical reverse logistics are met by developing the mathematical model for simultaneous pickup and delivery problems with time windows and multiple decision-makers (SPDTW–MDM). They applied the algorithm to different scale instance applications in a case study and obtained efficient results.

In Ref. [16], Long et al. worked on the prize-collecting vehicle routing problem (PCVRP), which focuses on the selection of customers besides the vehicle assignment and visiting sequencing, because the available vehicles are insufficient to visit all the customers. Two types of PCVRP are taken into consideration, namely, the PCVRP in which the number of vehicles is predetermined (PCVRP-P) and that in which the number of vehicles is not predetermined (PCVRP-NP). In general, multiple optimization objectives are required to be considered in both the PCVRP-P and PCVRP-NP. A Pareto-based evolutionary algorithm devised by a genetic algorithm combined with a local search strategy is proposed for solving the multi-objective PCVRP-P. The multi-objective PCVRP-NP problem is solved by introducing a decomposition strategy for decomposing it into multiple PCVRP-P sub-problems. The proposed algorithm demonstrated superior results at several experiments on the benchmark problems.

In Ref. [17], Najian and Beheshtinia studied a combination of cross-docking and vehicle routing problem (VRP) approaches on the supply chain where suppliers are spread in different geographical zones and served by multiple shared vehicles with different speeds and capacities for transporting orders from the suppliers to a manufacturer. They proposed mathematical model of this new problem and used a developed version of a genetic algorithm based on psychological theory, named Reference Group Genetic Algorithm (RGGA) to solve the problem. The performance of the algorithm is evaluated by comparing it with the nearest problem in the literature. Also, optimum solutions by some low size test problems are compared. The RGGA exhibited good performance.

Revenue Management uses data-driven methods to help businesses decide what to sell, when to sell, to whom to sell and with which price in order to increase revenue [18]. The discipline of revenue management combines data mining and operations research with strategy, understanding of customer behavior, and partnering with the sales force

[19]. Early implementations started at airline passenger seat pricing and hotel room reservations. Today there are implementations at different sectors where there is a perishable asset inventory is in place. In VRP, vehicle capacity that is available for customer orders is also perishable. If this capacity is used for a customer order, it generates some revenue. Otherwise, if some capacity is idle, then there is no revenue received for that portion of the vehicle and some constant transportation cost is still incurred. Therefore, it is necessary to develop a dynamic pricing strategy to offer a lower price to customers for early reservations. There should be a time limit and a capacity limit for early reservations. These limits are calculated by analyzing previous customer orders and by estimating when and how much normal orders will be possibly received. Hence, potential unsold capacity is calculated and put on sale with a lower price. If there is more amount of regular orders than estimated, it is possible to cancel some of the early reservation orders by paying cancellation fees.

2. Materials and Methods

2.1. Brief Summary of the Mathematical Model

Revenue management focused, capacity constrained, simultaneous delivery and pickup vehicle routing model is about considering which customers to serve and which route to take so that each vehicle departs from central depot, visits some customers for either delivery or pickup, and returns to central depot, for purpose of generating maximum possible revenue without violating load capacity of vehicles through entire tour.

There are two types of customer orders defined in the model:

1. Early reservation customers: In order to maximize demand, customers are allowed to put orders at a low price. But early reservations cannot be made when there are fewer days to delivery date than some predefined duration. The early reservation period is any time earlier than the predefined number of days before the delivery date. One day before the delivery date, when there are more orders than the total vehicle capacity, the company may decide to reject some early reservations, resulting in payment of cancellation fee to customers.
2. Full fare customers: Customers that put orders with normal prices guarantee their delivery and their orders cannot be rejected. These customers can put orders until one day before the delivery date, even if the early reservation period is over.

2.2. Domain

n: Number of customers
N: Set of points {0, 1,…, n}(0: Central depot, 1,…,n: Customers)
N_c: Set of customers, i.e. set of points except central depot. $Nc = N \setminus \{0\}$
N_e: Set of customers that submitted an early reservation. $N_e \subseteq N_c$
N_f: Set of full fare customers. $N_f \subseteq N_c$
K: Set of vehicles that will serve the customers.

2.3. Decision Variables

Following two decisions should be made simultaneously while solving the problem:

1. Deciding which customers to serve by canceling low-profit early reservation orders according to revenue management principles
2. Which route should be taken by which vehicles in order to serve the selected customers?

Customer selection decision variable (r_i) represents which customers' orders are accepted. Some customer orders will be rejected in order to fit the vehicle capacities. Early reservations made with lower prices may be picked for rejection even if it causes payment of a cancellation fee.

r_i: 1 if the demand of customer i will be fulfilled, 0 if the order of customer i will be rejected, $i \in N_c$.

Route selection decision variable (x_{ij}^k) shows which vehicles will take which paths among all the possible trips between all nodes, including the central depot and the customer locations.

x_{ij}^k: 1 if the vehicle k will move from point i to point j, 0 otherwise, $i \in N, j \in N, k \in K$.

2.4. Objective Function

The objective of the model is both achieving the maximum profit from visited customers by optimizing the routes of the vehicles and avoiding cancellation fees while choosing profitable customers to serve.

$$max \sum_{i \in N_c} r_i v_i - \sum_{i \in N} \sum_{j \in N} \sum_{k \in K} x_{ij}^k c_{ij}^k - \sum_{i \in N_e} (1 - r_i) z_i \qquad (1)$$

(1) The aimed solution to the problem is to maximize total profit. Due to vehicle capacity constraint, some of the less profitable orders will be canceled. Canceling early reservation orders will result in cancellation fee payments to those customers. Total profit is composed of three parts, revenue, transport cost, and cancellation fee. Total transport cost of vehicles that depart from the central depot, visit customers and arrive back to the central depot, and total cancellation fee that is paid back to customers who made an early reservation and whose orders are rejected by the company, are subtracted from total revenue that will be collected from served customers. This objective is achieved by deciding which customers to serve and which routes to take.

2.5. Constraints

$$\sum_{k \in N} \sum_{j \in N_c} x_{0j}^k = \sum_{k \in N} \sum_{i \in N} x_{i0}^k = K \qquad (2)$$

$$\sum_{j \in N} \sum_{k \in N_c} x_{ij}^k = r_i \forall i \in N_c \qquad (3)$$

$$\sum_{j \in N} \sum_{k \in N_c} x_{ij}^k = \sum_{j \in N} \sum_{k \in N} x_{ij}^k \forall i \in N_c \qquad (4)$$

$$x_{ij}^k = 0 \quad \forall i \in N, \forall k \in N \tag{5}$$

$$q_0^k = \sum_{j \in N} \sum_{k \in N_c} d_j x_{ij}^k \quad \forall i \in N_c \tag{6}$$

$$q_i^k = \left(\sum_{j \in N} q_j^k x_{ji}^k \right) + \left(\sum_{j \in N} x_{ij}^k \right) (p_i - d_i) \forall i \in N_c, \forall k \in K \tag{7}$$

$$q_i^k \leq Q_{max}^k \quad \forall i \in N, \forall k \in K \tag{8}$$

$$\sum_{i \in N_e} r_i d_i \leq \delta \sum_{k \in N} Q_{max}^k \tag{9}$$

$$x_{ij}^k \in \{0,1\} \quad \forall i, j \in N, \forall k \in K \tag{10}$$

$$r_i \in \{0,1\} \quad \forall i \in N_c \tag{11}$$

$$c_{ij}^k = a u_{ij} (Q_0^k + q_i^k) \forall i, j \in N, \forall k \in K \tag{12}$$

Where,

r_i: Customer selection decision variable

r_i: 1 if the demand of customer i will be fulfilled, 0 if the order of customer i will be rejected, $i \in N_c$.

x_{ij}^k: Route selection decision variable

x_{ij}^k: 1 if the vehicle k will move from point i to point j, 0 otherwise, $i \in N, j \in N, k \in K$.

c_{ij}^k: Transportation cost for taking the trip from node i to node j by vehicle k.

The parameters and the intermediate variables are described in the next two subsections F and G.

(2) All vehicles should start their tours from the central depot and finish at the central depot, which is indicated with index 0. The total number of trips from the central depot should be equal to the number of vehicles K. Similarly, the total number of trips to the central depot should be equal to the number of vehicles K. Hence all of the vehicles would be planned.

(3) For each of the customers to be served, only one vehicle should be visiting. On the contrary, for the customers whose order is rejected, no vehicles should be planned. This constraint assures that the output of revenue management and vehicle route planning is in accordance. The vehicle route plan considers decisions made by revenue management. When the order of a customer is rejected because of low profit, the decision variable r_i will be 0 for the customer. In this case, the total number of trips to customer i and the total number of trips from customer i should be constrained to 0. For customers that will be served, the decision variable r_i will be 1 and the total number of trips to and from customer i should be equal to 1.

(4) This constraint guarantees the continuity of the route plan by setting an equal number of incoming and outgoing trips at each customer. According to the constraint (3), the number of incoming trips would be either 0 or 1. When there is an incoming trip to a customer, there should be an outgoing trip from the customer. Where there is no incoming trip to a customer, there should be no outgoing trips from the customer.

(5) Trips from a point to the same point should not be allowed. Decision variable x_{ij}^k about trips should be equal to 0 for $i = j$.

(6) The total weight of load on a vehicle at departure from the central depot should is calculated as the sum of all customers that have outbound delivery orders and will be visited by the vehicle. This total should not be greater than the vehicle's load capacity.

(7) The total weight of load on a vehicle at departure from a customer is calculated by adding the weight of pickup demand to or subtracting the weight of delivery demand of the customer from the total weight of load at departure from the previous point in the route. The previous point can be the central depot or another customer.

(8) Total weight of load on each vehicle that is calculated by equations (6) and (7) should never exceed each vehicle's load capacity at all times; departing from the central depot, departing from customers and arriving in the central depot.

(9) A preset ratio of the total vehicle capacity should be reserved for early reservation orders. Even if some orders are low profit, this constraint assures customer satisfaction by allowing low-price early reservations. When there are many early reservations above this reserved limit, some early reservation orders may be rejected.

(10) Route decision variables x_{ij}^k are integers and values are either 0 or 1. Trips among a set of points that include the central depot and customers are represented by this decision variable. If a trip from point i to point j will be taken by vehicle k, x_{ij}^k is 1, otherwise 0.

(11) Acceptance or rejection of customer orders is another set of decision variables. Decision variables r_i are binary integers. When the total capacity required by all customer orders is above vehicles' total capacity limit, some low-profit orders must be rejected. When the order of customer i will be accepted, r_i will be 1, when the order of customer i is rejected, r_i will be 0.

(12) Transportation cost is calculated as the sum of all trips' costs. For each trip from point i to point j made by vehicle k, is calculated by multiplying the distance between points i and j, by total weight of the vehicle during the trip. The total weight of a vehicle is the sum of the vehicle's weight when empty and the load on the vehicle. The load on the vehicle increases or decreases during the tour after each visit. The distance is calculated as Euclidian distance between points and a coefficient is multiplied by the distance and weight.

2.6. Intermediate Variables

q_i^k: Load (kg) that is on vehicle k while leaving point i (depot or a customer site), $i \in N$
c_{ij}^k: Cost of moving from point i to point j by vehicle k ($)

2.7. Parameters

d_i: Demand quantity (weight of load in kg) of customer I as an outbound delivery, $i \in N_c$

p_i: Demand quantity (weight of load in kg) of customer i as an inbound pickup, $i \in N_c$

v_i: Revenue (\$) that will be received from customer i, $i \in N_c$

z_i: Cancellation fee (\$) that will be paid to customer i, in case order is rejected, $i \in N_e$

δ: Ratio of total vehicle capacity that will be reserved for low-price early reservations.

Q_0^k: Empty weight of vehicle k (kg)

Q_{max}^k: Maximum load capacity of vehicle k (kg)

u_{ij}: Distance between point I and point j (km)

α: Unit transportation cost (\$ / km·kg)

3. Results and Discussion

A small subset of customer order data from a steel sheet vendor in İstanbul is used for testing the model by implementing as a Mixed Integer Linear Programming (MILP) model at MATLAB software version (R2019b). MILP solver "**intlinprog**" in MATLAB optimization toolbox is used.

The company sells steel sheets to its customers and delivers them by the company's vehicles. The company also provides additional services for its customers by picking up processed steel parts from customers' locations, heating at the company's high-temperature furnaces, and delivering back to the same customers. These pickups are also handled by the same vehicles of the company. The company needs to maximize its revenue by allowing low-price early reservations. This helps improving the utilization of both delivery trucks and high-temperature furnaces. With the help of early reservations, the company is able to get orders for periods where there are fewer orders than the company's transport and processing capacity. Customer demand is changing from period to period. The company does not plan to make new investments but utilize existing assets with better utilization.

3.1. Inputs

There are one central depot and four customers in the sample problem. The orders of these four customers are shown in Table 1. Cancellation fees may only be applied to early reservation orders. The distances between these five points are shown in Table 2. Distances are calculated by taking Euclidean distances between geographical locations. The company wants to serve these customers with two identical vehicles.

TABLE 1. Customer orders

	Unit price (\$/ton)	Quantity (ton)	Type	Cancellation fee (\$)
Customer 1	20	4.4	Inbound	–
Customer 2	15	281.4	Outbound	100
Customer 3	11	17	Inbound	30
Customer 4	20	755.1	Outbound	–

TABLE 2. Distances between points

From/to (km)	Central depot	Customer 1	Customer 2	Customer 3	Customer 4
Central depot	–	8	9	102	54
Customer 1	8	–	14	98	55
Customer 2	9	14	–	81	51
Customer 3	102	98	81	–	130
Customer 4	54	55	51	130	–

Since this problem is about transportation, the revenue here is not the actual revenue that the customer will pay for the materials. It is the company's profit excluding transportation costs.

3.2. Constants

The vehicle load capacity is 1800 kg. The weight of an empty vehicle is 2500 kg. Unit transportation cost is taken as 0.02 $/km kg.

3.3. Results

After running MATLAB MILP solver, two decision variables are output. The customer order acceptance variable is shown in Table 3. The order of Customer 3 is rejected.

TABLE 3. Customer order acceptance/rejection

	Accepted
Customer 1	1
Customer 2	1
Customer 3	0
Customer 4	1

Vehicle routes decided for two vehicles are as follows:
Vehicle 1: Central depot→ Customer 2 → Central depot
Vehicle 2: Central depot→Customer 4 → Customer 1 → Central depot

The solution concludes that the order of Customer 3 should be rejected, even if this is an early reservation and cancellation results in a cancellation fee charge. This is justified by calculating the total cost for another solution that does not reject the order of Customer 3. In case Customer 3 will be visited, the total transportation cost would increase by $7,731.58. Not paying the $30 cancellation fee, and receiving the $187 order amount ($11/ ton × 17 tons) will result in a $7,514.58 negative effect to total profit. Compared to others, Customer 3 is a faraway customer and its order quantity is smaller. Hence canceling this unprofitable customer order is reasonable.

Routes for the two vehicles cost a total of $6,446.86. The total distance traveled by vehicle 1 is 18 km and costs $950.65. Vehicle 2 will visit two customers and will travel a total of 117 km distance and the transportation cost will be $5,496.21.

3.4. Summary

The summary of the operation is shown in Table 4.

TABLE 4. Summary of the plan

	Number of customers	Total ($)
Revenue	3	19,411.00
Transportation cost		6446.86
Cancellation fee	1	30.00
Profit		12,934.14

4. Conclusion

This study considered both vehicle route planning and revenue management together, for the purpose of maximizing total profit of daily distribution and pickup operations. The proposed model states the problem as a mixed integer linear programming model. Using a commercial solver resulted in profitable decisions about which customer orders to handle, which orders to reject and which routes to take to complete the operation with the least transportation cost.

Considering the total working time of vehicles and limiting at reasonable work times is another requirement of the business. Daily transportation operations should be completed within business hours. These types of constraints will be added to this model in the future.

Another enhancement planned for the model is the consideration of the effect of the slope by putting elevation differences between service points into the calculation. The slope is an important factor in fuel consumption.

Since the problem under study is an NP-hard problem and there are many decision variables regarding customer order rejection and route selection, the tested MATLAB MILP solver did not produce results for larger problems, like 240 customers and ten vehicles. Metaheuristic algorithms, like Ant Colony Optimization, may improve solution quality and enable faster discovery of better solutions in the solution space.

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