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Simultaneous pickup and delivery model suggestion for personnel transportation in COVID-19 pandemic conditions

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Abstract

The impact of COVID-19 on the transportation costs of a large-scale company has been examined. Before the pandemic, shift personnel were transported to the factory by shuttles, and after a quick shift change, other shift personnel were transported back to their homes. However, with the implementation of laws mandating the reduction of shuttle seat capacities, transportation costs have risen significantly. To address this issue, a new simultaneous pickup and delivery model is proposed as an alternative to the separate transportation of shift workers. The results of this study indicate that the proposed model provides a substantial advantage in terms of both the number of vehicles used and the total distance traveled, leading to a significant reduction in costs. This research underscores the importance of effective operations research practices for the profitability of companies, particularly in extraordinary circumstances such as the COVID-19 pandemic.

Keywords: *optimization, mathematical modeling, vehicle routing, simultaneous pickup problem, delivery problem*

1. Introduction

Transportation is a significant issue for both management and personnel within an enterprise. Despite advancements in transportation networks and means, personnel transportation remains a cost-inducing problem. The transportation of personnel, particularly from their homes to workplaces and vice versa, poses a challenging problem for many businesses, particularly those located in urban areas or those with a large number of personnel.

The transportation of personnel is a costly and labor-intensive endeavor, made increasingly complex by the ongoing pandemic. Vehicle routing, which typically involves a detailed optimization process and

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has a complex structure, has become even more challenging during this time. This study examines the personnel transportation problem of a large-scale company operating in the Kayseri Free Zone. The company operates on a two-shift schedule, with day-shift workers being transported to the company via intuitively created routes and night-shift workers being transported using the same vehicles after a short shift change. Currently, no optimization method is used in the determination of routes and stops.

To address this issue, this study was conducted in two stages. In the first stage, optimal routes were determined to collect and distribute day and night shift workers separately, adhering to the existing planning. Results indicate that the vehicle routing models created for this purpose significantly reduce transportation costs compared to the current situation. In the second stage, a new simultaneous pickup and delivery model was proposed, which would collect and distribute workers simultaneously rather than at separate times. Results indicate that this new model provides significant savings both in the number of vehicles used and in transportation costs, providing a potential solution to the transportation problem faced by the company.

2. Motivation

The COVID-19 global pandemic had a devastating impact on various sectors, including the transportation sector. Due to social distancing and mandatory health measures, vehicle capacities, which were previously utilized to their fullest, have been limited. As a result, companies have had to allocate a larger budget for personnel transportation in proportion to the number of vehicles required.

This study aims to address this issue by examining a real-life problem and demonstrating, through the use of real data, the effectiveness of successful operations research applications in reducing transportation costs, a problem faced by many companies. The proposed mathematical models are flexible and can be easily implemented by companies operating in different sectors. It is believed that this study will make significant contributions to the literature and provide a potential solution to the real-life problem of transportation costs during the COVID-19 pandemic.

3. Literature review

The vehicle routing problem (VRP) is a type of optimization that aims to meet the demands of a certain number of customers from one or more warehouses with minimum cost. The VRP was first introduced by Dantzig and Ramser in 1959 [7] and is considered an NP-hard problem. Many VRP studies have been published with various objectives such as reducing the number of vehicles, and travel time, shortening travel distances, increasing the capacity utilization rate, or providing fuel savings, etc. Additional constraints can also be added to the problem, such as the length of the road, capacity of the vehicle and/or the depot, time windows, or use of certain types of vehicles, etc.

The vehicle routing problem with simultaneous pickup and delivery (VRPSPD) is a variant of the classical VRP in which the vehicles serve a set of customers demanding both pickup and delivery services at the same time. The VRPSPD was first introduced by Min in 1989, in which he addresses a real-life problem of book distribution and collection from a central library to 22 remote libraries and implements a cluster-first and route-second method to solve the problem [20].

The VRPSPD is relevant in transportation systems involving both distribution and collection operations. In recent years, the VRPSPD has attracted research interest due to its applicability in many logistics systems involving both distribution and collection operations. The original formulation of the VRPSPD assumes a homogeneous fleet of vehicles to serve the customers. However, in many practical scenarios, there are different types of vehicles available to perform pickup and delivery operations. To address this issue, the original VRPSPD model has been extended to include a heterogeneous fleet of vehicles, referred to as the Heterogeneous VRP with simultaneous pickup and delivery (HVRPSPD). The HVRPSPD has a unique place in the literature of the VRP and has been widely studied in recent years.

There are various extensions of the VRPSPD problem present in the literature. One such extension is the study of the VRPSPD with a heterogeneous fleet with a configurable vehicle capacity, which was conducted by Qu and Bard. In this study, the problem was modeled as a mixed-integer formulation, and an adaptive large neighborhood search (ALNS) algorithm was developed to solve it. The algorithm employed several randomized procedures to generate feasible solutions, which were later improved by problem-specific removal and insertion operators. This extension of VRPSPD provides a valuable solution for real-world scenarios where different types of vehicles are available for performing pickup and delivery operations [24].

Avci and Topaloglu integrated threshold adjusting mechanism within tabu search for the heterogeneous VRPSPD [2]. Majidi et al. considered a fuzzy green variant of the VRPSPD [19], Nadizadeh and Kafash considered a fuzzy variant in a capacitated location-routing problem with simultaneous pickup and delivery demands [22].

Jadczak presented the possibility of using evolutionary algorithms to optimize the VRPSPD [14]. Zhang et al. described a multi-commodity many-to-many variant of the VRPSPD arising at a fast fashion retailer in Singapore [33]. Šedivý et al. and Stopka used the VRPSPD to optimize beer distribution and city logistics distribution routes, respectively [25, 27].

Kim and Kim considered power consumption rate and wind effects in the routing problem of drones [16], while Vural et al. considered weather effects in the location and routing of unmanned aircraft systems [30]. Hornstra et al. dealt with a fleet of vehicles operating from a depot to serve all customers, which have both a delivery and a pickup demand [13].

Gong et al. extended the general VRPSPD with time windows and left-over cost considerations to reduce the total delivery cost [9]. Golsefidi and Jokar proposed a mixed-integer linear programming model to reduce the total cost of the system by incorporating production-reproduction setups, quantities of the production-reproduction, visiting/not-visiting the retailers, supplier inventory management, retail inventory management under the vendor-managed inventory (VMI) policy, the quantity of the defect-free products delivered to retailers and that of the defective products collected from them at the same time, and vehicle routing in each period [8]. Ancele et al. proposed a multi-threaded metaheuristic based on simulated annealing to solve a rich VRPSPD problem, considering the frequent exchange of containers via multiple cross-docks in supply chain operations [1]. Sherif et al. investigated the two-echelon supply chain network of the battery manufacturing industry, by proposing an integrated optimization procedure for solving the green transportation problem, inventory problem in the first echelon, and capacitated multi-depot heterogeneous VRP with simultaneous pickup and delivery in the second echelon [26].

Newly emerged omnichannel retailing has also provided important insight into distribution management [12, 18]. Optimization approaches are used in the studies showing the importance of effective logistics regarding robust distribution management for perishable goods [4, 6, 11, 31].

4. Vehicle routing problems

VRPs are a critical area of study in transportation and logistics. The basic VRP problem involves the use of one or more vehicles of the same type and capacity to serve a group of customers. In this scenario, each customer is served by a single vehicle, and each vehicle follows a single route [28]. The routes start and end at a warehouse, and it is designed in such a way that the total demand of all customers on the route does not exceed the vehicle capacity [29]. VRP falls under the category of combinatorial optimization problems, with the majority of problems in this class being known as NP-hard. As a result, it is not possible to find an optimal solution for large-scale problems [3]. VRP can be classified based on various features. A classification of VRP based on its building blocks is presented in Figure 1.

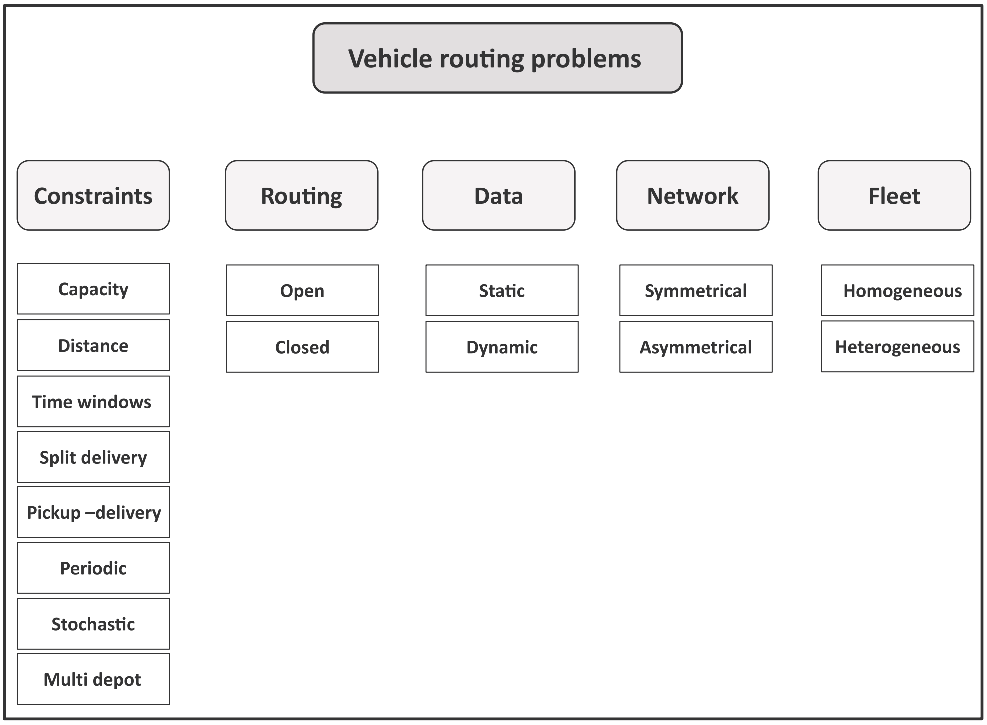

Figure 1. Types of vehicle routing problems

The pickup and delivery VRP involves the transportation of goods from warehouse(s) to demand points and the subsequent pickup of goods from those demand points and return to the warehouse(s) using a single vehicle [17, 32]. Examples of this type of VRP include the delivery of blood from blood centers to hospitals, the transportation of automotive spare parts from factories to regional dealers, and the collection and recycling of used parts from factories. It is important to note that in pickup and delivery VRP, the goods collected from demand points are not typically delivered to other demand points. Instead, all goods are either delivered directly to their designated demand point or picked up and returned to the warehouse(s) [23]. Additionally, pickup and delivery VRPs can be further divided into three distinct categories, as illustrated in Figure 2.

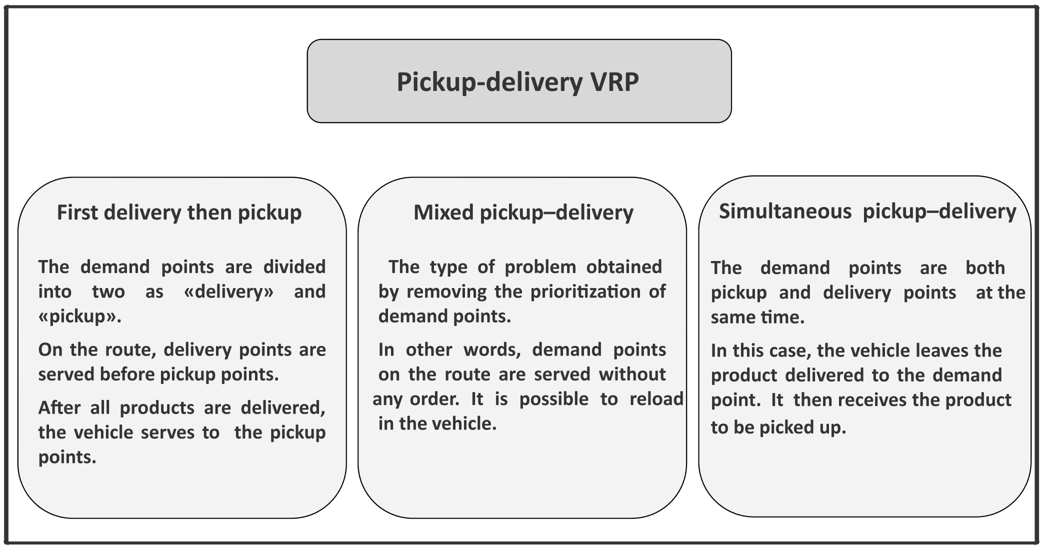

Figure 2. Types of vehicle routing problems

Various types of VRP can be modeled by adhering to the same notation. The model proposed by Montané and Galvão [21] is considered the base model in this study and extended by incorporating heterogeneity due to the pandemic. In constructing the model, we referred to relevant models from Yu et al. [32], Hendalianpour [10] and Chen et al. [5], as the assumptions and objectives of these models are similar to our problem. We then formulated the mathematical model for our problem by combining the parameters and decision variables from the aforementioned models, and by taking into account the unique characteristics of the problem and real-world observations of employee transportation. The objective function and constraints were also constructed based on these considerations.

In this part of the study, mathematical models for pickup, delivery, and simultaneous pickup and delivery vehicle routing problems are explained, respectively. The definitions of sets and parameters used in mathematical models are as follows:

- $G(N,\, A)$ – a directed graph, where N is a set of vertices and A is a set of arcs with associated costs.
- $N = 0,\, 1,\, 2,\, \ldots,\, n$ – numbers from 1 to n denote customers, while 0 denotes warehouse $A = \{/i,\, j) : i,\, j \in N, i \neq j\}$ set of arcs.
- B – different types of vehicle EET, $B = \{1,\, 2,\, 3,\, \ldots,\, b\}$.
- For each k vehicle there are defined f_k cost of use, π_k unit distance travel cost, and Q_k carrying capacity.
- Every $i \in N$ customer has a p_i demand (to be picked up from demand point to warehouse) where $0 \leq p_i \leq Q_k$, $\exists k \in B$ and $p_0 : 0$.
- In graph G, I_{ij} denotes the length of $(i,\, j)$ arc and satisfies triangle inequality $(I_{ij} + I_{jr} \geq I_{ir}, \forall i,$ $j,\, r \in N, i \neq j \neq r)$.
- Since the unit cost of each $k \in B$ vehicle is different, each arc $(i,\, j)$ has a cost $(c_{ijk} = Q_k I_{ij})$ depending on the type of vehicle traveling on that arc.

The definitions of decision variables and the mathematical model used in VRP, where there is only one warehouse, and the vehicles leaving the warehouse pick the products (persons) from the nodes to the warehouse, are as follows:

- $X_{ijk} - 1$ if $k \in B$ vehicle travels on arc $(i,\, j) \in N$, and 0 otherwise.
- Y_k – number of vehicle $k(k \in B)$ used in the solution.
- m – number of tours.
- t_{ij} – the amount of goods picked up by vehicle k until reaches the j^{th} node given that arc $(i,\, j) \in N$ is traveled by vehicle k,

$$\min Z = \sum_{i \in N} \sum_{\substack{j \in N \\ i \neq j}} \sum_{k \in B} C_{ijk} X_{ijk} + \sum_{k \in B} f_k Y_k \tag{0}$$

$$\sum_{j \in N \setminus \{0\}} \sum_{k \in B} X_{0jk} \leq m \tag{1}$$

$$\sum_{j \in N \setminus \{0\}} \sum_{k \in B} X_{i0k} \leq m \tag{2}$$

$$\sum_{\substack{i \in N \\ i \neq j}} \sum_{k \in B} X_{ijk} = 1, \quad j \in N \setminus \{0\} \tag{3}$$

$$\sum_{\substack{i \in N \\ i \neq j}} X_{ijk} = \sum_{\substack{i \in N \\ i \neq j}} X_{jik}, \quad j \in N \setminus \{0\}, k \in B \tag{4}$$

$$t_{ij} \leq \sum_{k \in B} Q_k X_{ijk}, \quad i,\, j \in N, i \neq j \tag{5}$$

$$\sum_{\substack{j \in N \\ i \neq j}} t_{ij} - \sum_{\substack{j \in N \\ i \neq j}} t_{ji} = p_i, \quad i \in N \setminus 0 \tag{6}$$

$$\sum_{k \in B} p_i X_{ijk} \leq t_{ij}, \quad i,\, j \in N, i \neq j \tag{7}$$

$$t_{ij} \leq \sum_{k \in B} (Q_k - p_j) X_{ijk}, \quad i,\, j \in N, i \neq j \tag{8}$$

$$t_{0j} = 0, \quad i,\, j \in N \setminus \{0\} \tag{9}$$

$$\sum_{k \in B} Y_k \leq m \tag{10}$$

$$Y_k \leq U_k, \quad k \in B \tag{11}$$

$$\sum_{j \in N \setminus \{0\}} X_{0jk} = Y_k, \quad k \in B \tag{12}$$

$$Y_k \geq 0 \text{ and integer}, \quad k \in B \tag{13}$$

$$m \geq 0 \tag{14}$$

$$t_{ij} \geq 0, \quad i,\, j \in N \tag{15}$$

$$X_{ijk} \in \{0, 1\}, \quad i,\, j \in N, k \in B \tag{16}$$

In this model, the objective function (constraint (0)) seeks to minimize the total costs associated with transportation and vehicle usage. Constraint (1) ensures that most m vehicles leave the warehouse, while constraint (2) ensures that the same number of vehicles return to the depot. Constraint (3) enforces that a given node can only be reached from one other node. Constraint (4) stipulates that the vehicle visiting and leaving a node must be the same. Constraint (5) ensures that the vehicle capacity is not exceeded. Constraint (6) ensures that the load collected from the i^{th} node is equal to the difference between the vehicle's capacity before and after visiting that node. Constraints (7) and (8) set lower and upper limits for the load collected by the vehicle and have an increasing step function structure. Constraint (9) sets the initial load the vehicle collects to zero. Constraint (10) ensures that at most m vehicles can be selected, while Constraint (11) ensures that each vehicle type can be selected up to its maximum capacity. Constraint (12) ensures that the total number of k-type vehicles departing from the warehouse is equal to the number of selected k-type vehicles. Finally, constraints (13)–(16) are sign constraints that enforce the non-negativity of variables.

The model described above can be adapted to represent a VRP in which products (or individuals) are distributed from the warehouse to various demand points, with some necessary modifications.

The decision variables and constraints used in this distribution model are as follows: Z_{ij} is the amount of goods to be delivered by vehicle k until reaches the $j\text{th}$ node given that arc $(i,\, j) \in N$ is traveled by vehicle k,

$$Z_{ij} \leq \sum_{k \in B} Q_k X_{ijk}, \quad i,\, j \in N, i \neq j \tag{5a}$$

$$\sum_{\substack{j \in N \\ i \neq j}} Z_{ji} - \sum_{\substack{j \in N \\ i \neq j}} Z_{ij} = d_i, \quad i \in N \setminus 0 \tag{6a}$$

$$\sum_{k \in B} d_j X_{ijk} \leq Z_{ij}, \quad i,\, j \in N, i \neq j \tag{7a}$$

$$Z_{ij} \leq \sum_{k \in B} (Q_k - d_i) X_{ijk}, \quad i,\, j \in N, i \neq j \tag{8a}$$

$$Z_{i0} = 0, \quad i,\, j \in N \setminus \{0\} \tag{9a}$$

$$Z_{ij} \geq 0, \quad i,\, j \in N \tag{15a}$$

The objective function remains unchanged, and it still aims to minimize the total transportation and vehicle usage costs. Constraint (5a) is introduced to ensure that the vehicle capacity is not exceeded. Constraint (6a) is introduced to ensure that the load delivered to the $i\text{th}$ node is equal to the difference in vehicle capacity before and after visiting that node. Constraints (7a) and (8a) are introduced to set lower and upper limits for the vehicle. Equation (9a) is introduced to set the delivery load of the vehicle to zero at the end of the route. Constraint (15a) is a sign constraint.

The heterogeneous simultaneous pickup and delivery vehicle routing problem (HSPD-VRP) is a combination of the heterogeneous vehicle routing problem and the simultaneous pickup and delivery vehicle routing problem [15]. In this problem, vehicles with different characteristics perform pickup and delivery simultaneously. When the vehicles arrive at customers, they meet demands and also collect goods that are supposed to be returned to the warehouse. The mathematical model developed for HSPD-VRP is created by incorporating the constraints (1)–(4), (6)–(16), (6a)–(9a), and (15a) from the PVRP and DVRP models, along with an additional constraint

$$Z_{ij} + t_{ij} \leq \sum_{k\in B} Q_k X_{ijk}, \quad i,\, j \in N, i \neq j \tag{5b}$$

Constraint (5b) is introduced to ensure that the vehicle capacity is not exceeded while the objective function remains unchanged. It aims to minimize the total transportation and vehicle usage costs.

5. Application

The primary objective of personnel transportation in any business is to transport employees from their residences to their place of work and vice versa, by legal regulations, while minimizing costs. The present study examines the personnel transportation problem of a large-scale company operating within the Kayseri Free Zone. The operations of the company are conducted in two shifts. During the day shift, employees are picked up from designated points on routes that have been intuitively created, and transported to the company. After a brief shift change, the same shuttles then transport the night shift employees. It is noteworthy that no optimization method is employed in the determination of the routes and stops.

The number of personnel working in shifts varies, and the pick-up and delivery operations are conducted separately. As a result, different types of vehicles are utilized for these transactions. The company possesses two types of vehicles: 17-seated and 27-seated. However, due to pandemic regulations, the capacity of the 17-seated vehicle is limited to 8 passengers, and the capacity of the 27-seated vehicle is limited to 13 passengers. This reduction in vehicle capacity, as a result of the pandemic conditions, has further increased the already high cost of personnel transportation operations for the company. To evaluate this situation, constraints (5a)–(8a) are adapted accordingly.

The company in question alternates its employees between night and day shifts every week, and service planning is accordingly devised every week. The firm, using weekly staff lists, intuitively determines the routes, vehicles, and stops. Due to this intuitive planning approach, there may be instances where more vehicles are utilized than necessary or where the number of personnel exceeds the capacity of the vehicles. Furthermore, as the routes are not determined through any optimization method, fuel, and time costs are significantly elevated. To mitigate these issues, it has been decided to employ vehicle routing techniques, which have been widely studied in the literature. The scope of the study is limited to the Talas region, where the majority of the employees reside. The study is conducted in two stages. In the first stage, similar to the current practice, the problems of picking up the personnel working in the morning shift and delivering the personnel who leave the night shift to their homes are handled separately, and efforts are made to determine the optimal vehicle routes and the optimal number of vehicles. In the second stage, the problem of simultaneous pickup and delivery of personnel working night and day shifts is examined. All mathematical models developed in the study are solved using GAMS release 24.4.1 and CPLEX 12.6.1.0 on an Intel Core i5-2400 CPU @ 3.10 GHz with 8 GB RAM.

Currently, there are 5 vehicles of varying capacities utilized for the transportation of personnel residing in the Talas district. Two of the vehicles have a capacity of 13 passengers, while the remaining three have a capacity of 8 passengers. In the Talas region, 20 designated stops have been established for the collection of personnel who will be working in the morning shift. The number of personnel to be picked up from each stop is presented in Table 1.

Table 1. Number of personnel to be picked up by stops

Stop	Persons	Stop	Persons	Stop	Persons	Stop	Persons
1	5	6	1	11	1	16	1
2	1	7	1	12	3	17	3
3	2	8	3	13	1	18	1
4	0	9	0	14	2	19	1
5	0	10	2	15	1	20	3

The distances between the designated stops were determined utilizing Google Earth, and a distance matrix was created accordingly. The daily fixed costs for the large-capacity vehicles are 169 TRY, and for the smaller vehicles are 104 TRY. The fuel consumption per meter for the large vehicles is 4.27 TRY, and for the small vehicles is 3.89 TRY.

The study aims to investigate the advantages of using operations research techniques in contrast to heuristic approaches in the process of personnel transportation to the company. To this end, the pickup VRP problem, as detailed in Section 4, is solved using the GAMS program, yielding an optimal objective function value of 5,393.8 TRY. The results indicate that 3 vehicles are sufficient for the optimal solution. The capacity of vehicles 1 and 2 is 13 passengers, while the capacity of the third vehicle is 8 passengers. Vehicles 1 and 2 are utilized at full capacity, while vehicle 3 is used at 75% capacity. The routes utilized by the vehicles are presented in Table 2.

Table 2. Pickup VRP vehicles and routes

Vehicle	Capacity	Route
1	13	0–15–12–4–18–11–1–14–5–0
2	13	0–7–16–13–2–6–3–10–19–17–0
3	8	0–9–8–20–0

In the current scenario, 5 vehicles are utilized to transport the personnel leaving the night shift to their homes. Two of the vehicles have a capacity of 13 passengers, while the remaining three vehicles have a capacity of 8 passengers. There are 20 designated stops along the route, and the number of personnel delivered to each stop is presented in Table 3.

Table 3. Number of personnel to be picked up by stops

Stop	Persons	Stop	Persons	Stop	Persons	Stop	Persons
1	8	6	2	11	0	16	0
2	1	7	1	12	3	17	5
3	1	8	1	13	1	18	1
4	1	9	2	14	0	19	1
5	2	10	2	15	1	20	1

To assess the potential improvement in the delivery process, the delivery VRP, as described in Section 4, is employed, and the optimal objective function value is calculated as 4,821.6 TRY. The results indicate that 3 vehicles are sufficient for the optimal solution. The capacity of vehicles 1 and 2 is 13 passengers, while the capacity of the third vehicle is 8 passengers. All vehicles are utilized at full capacity. The routes utilized by the vehicles are presented in Table 4.

Table 4. Pickup VRP vehicles and routes

Vehicle	Capacity	Route
1	13	0–17–15–12–4–18–19–20–0
2	13	0–5–6–1–11–7–0
3	8	0–14–10–2–13–3–16–8–9–0

Currently, the company employs 5 vehicles for both the collection and distribution processes, covering a total distance of 2,420 km. When the pickup and delivery processes are optimized, the number of vehicles used decreases from 5 to 3, and the distances covered are 1,159.6 km and 1,129.1 km, respectively. The results demonstrate that a significant savings of approximately 66% can be achieved in the number of vehicles used and 6% in the total distance covered.

During interviews with company officials, it was revealed that the personnel working in the day and night shifts could be transported simultaneously with a slight modification. To further reduce transportation costs, a new mathematical model, as outlined in Section 4, is proposed to simultaneously transport the personnel working in day and night shifts, unlike the current practice implemented by the company. When the HSPD VRP model is solved using the GAMS program with the same parameters, the optimal objective function value is obtained as 48,880. This model indicates that 2 large-capacity vehicles and 1 small-capacity vehicle are sufficient. The optimal routes utilized by the vehicles are presented in Table 5.

Table 5. Simultaneous pickup and delivery VRP vehicles and routes

Vehicle	Capacity	Route
1	13	0–17–15–2–6–10–19–20–0
2	13	0–9–13–3–1–11–14–7–0
3	8	0–5–18–4–12–16–8–0

Table 6. Comparison of the results

Definition	Type	Vehicles	Total distance covered [km]	Total cost [TRY]
Current situation planed by transportation company	pickup	5	1210	6011,7
	delivery	5	1210	6011,7
Current situation solved by optimality	pickup	3	1159.6	5393,8
	delivery	3	1129,1	4821,6
Proposed simultaneous pickup and delivery VRP	simultaneous pickup and delivery	3	1175.3	5460,7

A comparison of the current situation with the results obtained within the scope of the study is presented in Table 6. Upon examination of the results shown in Table 6, it can be observed that in the current situation, the total distance covered for the pickup and delivery process is 2,420 km. When the collection and distribution problems are optimized separately, the total distance traveled is reduced to 2,288.7 km, resulting in a savings of 131.3 km. Furthermore, with the proposed new simultaneous pickup and delivery system, the total distance covered is 1,175.3 km, which is 1,244.7 km less than the current situation.

In addition, while 10 vehicles are required in the current situation, only 3 vehicles are sufficient in the proposed simultaneous pickup and delivery model. These gains were calculated for a single exchange process, but considering that the same transactions are repeated 2 times a day, 7 times a week, the weekly savings are 91,877.8 TRY. According to this calculation, the annual savings will be 4,777,645.6 TRY which is a significant amount considering the size of the company.

6. Results and suggestions

The cost of personnel transportation has emerged as a significant concern for businesses. The planning of personnel transportation becomes both complex and challenging due to the diversity of vehicles and fluctuating shifts, coupled with advancements in technology. Attempting to intuitively solve such a complex problem leads to an increase in the distance traveled and an over-utilization of vehicles.

In this study, the intuitive planning approach employed by a real-world company that undertakes its personnel transportation process has been examined. According to the company's planning, personnel transportation is conducted with a fleet of vehicles with heterogeneous capacities. During the day shift, personnel are picked up from stops closest to their homes and transported to the factory. After a brief shift change, the same fleet is then used to transport the night shift personnel to their homes. The cost of transportation is high as planning is conducted intuitively, and personnel working during the day and night shifts are transported during separate time slots.

To mitigate the burden of transportation costs, an HSPD VRP Model is proposed. This model consists of two stages: firstly, the number of vehicles and optimal routes are determined using the VRP method. Secondly, a simultaneous pickup and delivery model is proposed as an alternative to the separate transportation of shift workers. By solving the models using the GAMS program in a reasonable time frame, it is observed that an annual saving of 4,777,645.6 TRY, approximately 66% in the number of vehicles used and 6% savings in the total distance covered can be achieved compared to the existing system. Based on the results obtained, it is recommended that the company should carry out personnel transportation simultaneously, rather than picking and delivering separately.

This study aims to demonstrate the potential savings that can be attained through successful optimization applications in medium large-sized companies. It is hoped that the results of this study will encourage companies to increase their confidence in scientific methods and to conduct their activities based on scientific methods rather than relying on traditional methods. This research has several potential avenues for an extension. One possibility is to further investigate the proposed model by incorporating the stochasticity of personnel numbers and/or vehicle capacity. Additionally, future research could explore determining the optimal transshipment routes while taking into account time window constraints.

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