We considered Boujnord city, which is the capital of north Khorasan province located in the northwest of Iran. The population of this city is about 320,000, and it is around 36 km2. National Post Company of the Islamic Republic of Iran has approximately 30 carriers for this city, who distribute 1800 parcels per day on an annual average, where the weight of 65 percent of them is below 1 lb, 30 percent of them is around 1 and 3 lbs, and 5 percent of them are heavier than 4 lbs. To prepare a realistic data instance, we randomly selected locations of 100 customers from march 2022 customers and considered 30 rendezvous locations where the truck can stop and operate the drone. Using GIS software and a municipal map, road distances for the truck between each pair of parking stations and Euclidean distances for the drone between each couple of customers or customers and parking stations are calculated. In city logistics, for each pair of parking stations, there is more than one road and it would be more practical to consider all of them. Still, our model is not a multigraph problem and only considers one road between each pair of nodes, so we randomly selected one road among all possible roads.

Due to the narrow streets of Bojnourd city, truck speed for the rise of traffic is considered 20 km per hour and for none traffic peak duration it is assumed to be 40 km per hour. Based on municipal data, there are three major traffic peaks in Boujnord city, once around 8 AM, once around 2 PM, and once around 8 PM. But considering the same peak traffic for all roads will not help us to demonstrate the performance of the model, so for each city road, we randomly selected an hour between 8 AM and 4 PM for starting and finishing the traffic peak and calculated for each pair of nodes.

Similar to (Kyriakakis et al. 2022), we assumed the capacity of the drone to be equal to *5 lbs* and converted customers' parcel weight with a coefficient of *1* *lb* and a maximum of *5* *lbs*. For example; a real parcel with a weight of *0.8 lbs* is converted to *1 lb*, and a real parcel with a weight of *4.4 lbs* is converted to *5 lbs*.

Nowadays, delivery drones can even fly at speeds more than 100 km per hour. Still, similar to (Pina-Pardo et al. 2021), we consider the drone speed equal to 60 km/hr, which is equal to (16.6 m/s). Raj and Murray (2020) presented a comparison of the flight range of a drone with different payloads and speeds, where a drone with a speed of 16.6 m/s with a payload of *5 lbs* can fly 10000 meters, and it can fly more than 20000 meters with a payload of *3 lbs*. Considering this, we assumed the flight range to be 15000 meters for all drone routes. In this paper, we assumed the drone sight radius is 1000 meters. Similar to (Murray and Raj 2020) we assumed 60 seconds for drone launch time, and 60 seconds for drone service time. We also assumed that drone recovery time for the next flight is equal to 120 seconds, which is mostly for landing and battery replacement.

Drone traveling cost per kilometer is assumed to equal 0.01$, which is mainly for maintenance and depreciation costs. Truck traveling cost per kilometer is assumed to be 0.5$, which is mainly for fuel consumption, maintenance, and depreciation costs.

Based on our evaluation of road slopes in Boujnord city, the fuel consumption of the van for none traffic peak duration is estimated at 0.12-liter diesel per kilometer and for traffic peak duration it is assumed to be 0.18-liter per kilometer. As a liter of diesel has 835 grams of carbon and to combust this carbon to CO2, 1920 grams of oxygen is needed, we assumed consuming a liter of diesel, emits 2640 grams of CO2. So, we estimated the emission of a van for none traffic peak duration equal to 0.316 kilograms per kilometer, and we estimated the emission for traffic peak duration equal to 0.475 kilograms per kilometer. Considering city congestion areas, various social penalties are assumed for rendezvous locations.

To prepare a computational experiment, we need instances of different sizes, so we generated three sets of instances including 41 instances. The instance number is demonstrated by *Sv, Mspv,* and *Lspv* where *x* is the number of customers, and *v* is the number of rendezvous locations. *S* is for small-sized instances, *M* is for medium-sized instances and *L* is for large-sized instances.

To prepare a better analysis, for each class of generated instances two conditions are considered:

1- Instances with the same number of rendezvous nodes have the same locations for rendezvous nodes and instances with the same number of customers have the same locations for customers. 2- For a fixed number of rendezvous locations, increasing the number of customers is not change the current locations of customers and just adds new customer locations. Similarly, for a fixed number of customers, increasing the number of rendezvous nodes just adds new rendezvous locations.

Due to confidentiality of customers locations, we are not allowed to share UTM of their location, so we eliminated that, and just share the parameters needed in the model. In this data, each instance folder is demonstrated with three numbers.

|  |  |
| --- | --- |
| File name | description |
| Demand | List of all customers included their demand |
| d-cc | Spatial distance among customers |
| d-cp | Spatial distance among customers and parking stations |
| rd-pp | Road distance of parking stations |
| rd-dp | Road distance of parking stations and depot |
| L2 -dp | Starting time of traffic from depot to parking stations |
| L2-pd | Starting time of traffic from parking stations to the depot |
| L2-pp | Starting time of traffic among parking stations |
| Social penalty | Social penalty for parking a truck for an hour on a defined location. |