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The Speed Dependent Heterogeneous Fixed Fleet Vehicle Routing Problem with Backhauls and Environmental Considerations

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Abstract This paper proposes an eco-efficient speed dependent model based on a realistic variant of the Vehicle Routing Problem with time windows constraints, backhauls nodes and heterogeneous fixed vehicle fleets, in which vehicles are characterized by different capacities, costs and emission factors. The tackled problem presents a more realistic objective function that accounts not just for internal costs, but also for externalities in transport activities such as CO_2 emissions, pollutants emissions, noise and accidents. The EMEP/CORINAIR model equations are used for estimating fuel consumption, CO_2 and pollutants emissions based on the vehicle assigned speeds. Finally, this paper presents a case study analysing the results on the choice of speed dependent eco-efficiency routes, which can help to reduce the emissions of air pollutants, noises and greenhouse gases, without losing competitiveness in transport companies.

1. Introduction

Diesel emissions are a major contributor to combustion derived particulate matter air pollution, which is a significant risk factor for multiple health conditions including respiratory infections, heart disease, and lung cancer. The motor vehicle engine emits many types of pollutants including carbon dioxide (CO_2), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOC) and particulate matter (PM) among others. Other consequences associated with transport activities are noise emissions and accidents. These components have played an important role in the European Union scenario of the gross domestic product (GDP), representing a total of over 500 billion euros, about 4% of GDP, in 2008. About 77% of the external costs are caused by passenger transport and 23% by freight [2]. In this situation, governments have shown a greater interest for the preservation of the environment and the reduction of externalities. As a result, efforts to reduce pollution from mobile sources have been implemented. They include (1) Euro standards introduction, to limit the pollutant emissions of new vehicles sold in the European Union, (2) transport mode shifts, (3) increased fuel efficiency, through the use of hybrid vehicles, (4) conversion to cleaner fuels (ultra-low sulphur diesel, bioethanol, biodiesel), (5) car free zone establishments and (6) electric vehicles.

External costs do not directly affect consumer decisions and are generally not borne by transport users. They are not taken into account by the transport users when they make a transport decision. The internalization of external costs means making such effects part of the decision making process of transport users and may lead to a more efficient use of infrastructure, reducing the environmental and health costs of transport activity and providing the right incentives.

The vehicle routing problem (VRP) is one of the most widely researched problem and has mainly focused on minimizing the distance travelled, the fleet size, costs, and similar traditional parameters, not considering explicitly environmental externalities. Due to the green logistics concerns, there has been an increasing interest in introducing environmental targets into the route decision-making process.

In this paper, the VRP with realistic assumptions and a new objective function that accounts environmental costs is considered. Thus, an eco-efficiency model of the VRP with a fixed heterogeneous fleet, vehicle speed variability, time windows and backhauls is presented with a broader objective function that accounts not just for the internal costs but also for external costs. Moreover, reducing externalities in freight transportation requires using appropriate emission models within the planning process. A method for calculating CO_2 and pollutants emission based on EMEP/CORINAIR equations [6] is also introduced and applied to the present problem.

The paper is organized as follows. Section 2 reviews the literature on green logistics and fuel consumption models in VRP. The model formulation of the problem under consideration is presented in Section 3. An illustrative example is described in section 4 and section 5 presents the results and discussion.

2. Literature review

In the last years, following the Green Logistics emerging area, a number of studies on VRP considering reduction of CO_2 emissions from road transportation in their objective functions were published. Numerous energy and emission models estimated in different ways are proposed in the literature. For further information on fuel consumption models, a review can be found in Demir et al. [3].

Kara et al. [10] introduced the Energy-Minimizing VRP which is an extension of the VRP where a weighted load function (load multiplied by distance) is minimized. This approach does not reflect the real fuel consumed by a vehicle as it does not account for speed in vehicle routes. Furthermore, there are no time considerations, which are important in VRP problems. To account for this factor, Maden et al. [11]

suggest a time-dependent vehicle routing and scheduling problem with time windows in which speed depends on the time of the travel. In their analysis, they showed that taking account of time-varying speed for the roads in the network can also lead to some reductions in CO_2 emissions. Jabali et al. [9] considered a similar problem but estimated the amount of emissions based on a non-linear function of speed and other factors, finding the optimal speed with respect to emissions. This time dependency is also assumed in Figliozzi [7]. He introduced the Emissions VRP (EVRP) where the amount of emissions is a function of distance and travel speed and it will depend on the departure time in each node. He considered time windows and capacity constraints as well as time-dependent travel time.

A different method for calculating CO_2 emissions is introduced by Bektas and Laporte [1] for the pollution routing problem (PRP). They stated that the amount of pollution emitted by a vehicle depends on its load and speed, among other factors such as the engine friction factor, resistance, road angle, etc. They account for change in speed, defining a set of speed levels, and change in vehicle loads during a route. Both concepts have been considered in this paper, but also taking into account other externalities associated with transport activities such as pollutants emissions, noise and accidents. Later, Koç et al. [4] extended this problem by considering a non-limited heterogeneous vehicle fleet where the main objective is to minimize the sum of vehicle fixed costs and routing cost. Eguia et al. [5] considered average fuel consumption for estimating CO_2 emissions which were calculated based on the assumption that all carbon burned as fuel is emitted as CO_2 by a standard direct proportion. They also measured other toxic substances in vehicle emissions such as: particulate matter (PM), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOC). Oberscheider et al. [12] implemented the minimization of greenhouse gases (GHG) emissions in timber transport. They used the European Environmental Agency (EEA) speed-dependent formulas, based on COPERT model, for calculating vehicle fuel consumption and therefore CO_2 emissions. This approach is tackled in this paper but also considering the effect of speed in the NOx, VOC and PM emissions calculations.

The main contribution of this paper is considering the vehicle travel speed as a major factor for estimating fuel consumption and pollutants emissions which are significant components of the external costs associated with transport activities. Travel speeds are optimally selected between each two consecutive nodes in a route in order to minimize the sum of internal and external costs of a vehicle. Therefore, a method that depends on the speed for calculating CO_2 and pollutants emissions is introduced and applied to the presented problem, where the selected speeds depend on the vehicle engine category among other factors. Furthermore, most of the authors consider a homogeneous fleet in the routes design. This paper is distinguished by evaluating external costs under the consideration of a heterogeneous fleet. Moreover, this work not only considers CO_2 emissions as transport externalities, but also incorporates pollutants emissions, noise and accidents in the objective function.

3. Problem definition and modelling

3.1 Formal description of the HVRP with Speed Variability and environmental considerations

The problem considered in this paper is an extension of the classical Capacitated Vehicle Routing Problem, including Time Windows and Backhauls, and a fixed Heterogeneous Fleet with different vehicles and fuel types, with speed variability and environmental considerations (HVRPTWB_SP). The following assumptions are stated about the problem: (a) known fleet size, (b) heterogeneous fleet, with different vehicle capacities, fuel consumptions and categories, (c) single depot, (d) deterministic demand, (e) oriented network, (f) time windows, (g) maximum driving time, (h) backhaul nodes, and (i) vehicle speed variability.

The main contributions of this section deal with formulating a mathematical model of the HVRPTWB_SP and with considering vehicle speed in the internal and external costs calculation for the route design in the delivery activities of a company. Speed affects travel times, fuel consumption rate, and therefore CO_2 emissions, and pollutants emissions. Then the overall objective is to minimize the total costs that are composed of internal costs and external costs.

3.1.1 Internal and External Costs

The goal of the problem is to construct several routes minimizing the sum of internal and external costs. Internal costs in transport activities include: (1) cost of drivers (DRC), (2) energy costs (ENC), related to the fuel consumption, (3) fixed cost of vehicles (FXC)–depreciation, inspection, insurance-, (4) maintenance costs (MNC) and (5) toll costs (TLC).

External costs in transport activities are associated with: climate change costs (CCC), air pollution costs (APC), noise costs (NSC) and accidents costs (ACC). These four components reflect 88% of the total average external cost of freight in the European Union, excluding congestion costs [8]. The evaluation of each component of the external costs applied to the Spanish transport setting is based on the European study INFRAS/IWW [8]. Further information on internal and external costs calculation can be found in Eguia et al. [5].

3.1.2 Emission factor calculation

In EMEP/EEA [6], many formulas can be obtained to calculate (1) the fuel consumption, (2) CO_2 emissions, (3) NOx emissions, (4) NMVOC emissions and (5) PM emissions, for different types and technologies of vehicles. They depend on the type of vehicle, its maximum weight, its emission engine technology, its load factor, and the road gradient. These formulas are given in grams per kilometre (gr/Km) depending on the speed s. The diesel consumption is transformed to litres with the mean density of diesel at a temperature of 15ºC. (0,8325 Kg/l). In this work, for calculating fuel consumption, only empty vehicles expressions are considered and a factor that represents the fuel consumption per unit of additional load in a vehicle is provided. Slopes are not considered. The emission factors use up to five parameters (a, b, c, d, and e) to be calculated. These parameters are derived from statistical analyses and can be found in the annex 3 of EMEP/EEA [6]. Figure 1 shows how fuel consumptions per kilometre of two different vehicles categories vary for the valid range of driving speeds.

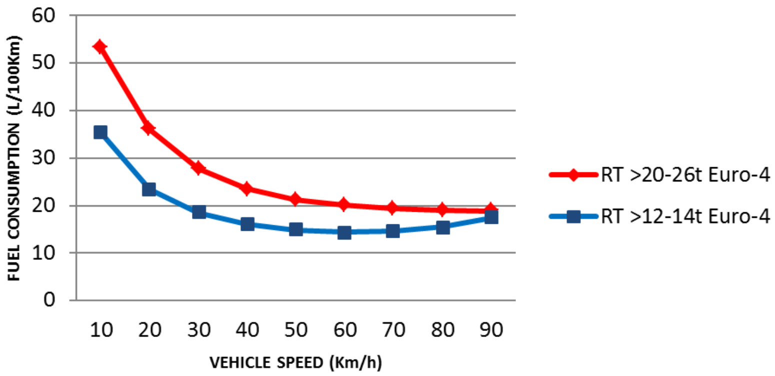

Figure. 1. Fuel consumptions (l/100Km) of different vehicles categories on roads with a gradient of 0% depending on the driving speeds.

3.2 An eco-efficiency model for the HVRPTWB_SP

The mathematical model used is derived from that used in Eguía et al. [5]. The HVRPTWB_SP is defined on a graph G={N,A} with N={0,1,…,t, t+1,…,n} as a set of nodes, where node 0 represents the depot, nodes numbered 1 to t represent delivery points and nodes numbered t+1 to n represent supply points (backhauls), and A is a set of arcs defined between each pair of nodes. A set of m heterogeneous vehicles denoted by Z={1,2,…,m} is available to deliver the desired demand of all customers from the depot node and then to pick-up the inbound products from the supply and return to the depot node. A set of v speed levels denoted by *Sp* ={s1,s2,…,sv} is provided to be assigned to vehicles when travelling throughout an arc of a route, which are identified by a maximum average travel speed. Distances between locations are all known, however, travel times depends on the assigned vehicle speed. The constructing routes of each vehicle must meet the following constraints: no vehicle carries load more than its capacity, each customer and supplier is visited within its respective time window, soft time windows are considered, therefore early vehicle arrivals are permitted, customers are not visited after any suppliers, no vehicle exceeds the maximum allowable driving time per day and one vehicle speed only is assigned between two consecutive nodes in a route.

We adopt the following notation:

- D_i : load demanded by node i ∈ {1,…,t} and load supplied by node i ∈ {t+1,…,n}
- q^k : capacity of vehicle k ∈ {1,…,m}.
- $[e_i,l_i]$: earliest and latest time to begin the service at node i.
- s_i^k : service time in node i by vehicle k.
- d_{ij} : distance from node i to node j (i ≠ j).
- t_{ij} : driving time between the nodes i and j.
- T^k : maximum allowable driving time for vehicle k.
- V^s : speeds that are set in the arcs.
- sp_{ij}^{max} : maximum average travel speed in arc (i,j).

Our formulation of the problem uses the following decision variables:

- x_{ij}^k *:* binary variable, equal to 1 if the vehicle k ∈ {1,…,m} travels from nodes i to j (i ≠j).
- y_i^k *:* starting service time at node i ∈ {0,1,…,n}; y_0^k is the ending time.
- f_{ij}^k *:* load carried by the vehicle k ∈ {1,…,m} from nodes i to j (i ≠ j).
- $v_{ij}^{k,s}$ *:* binary variable, equal to 1, if vehicle k ∈ {1,…,m} travels from node i to j (i ≠ j) at a speed s.

According to the established assumptions, the constraints of the mixed-integer linear programing model are as follows:

$$\sum_{j=1}^{n} x_{0j}^{k} \leq 1 \quad (k = 1,...,m) \tag{1}$$

$$\sum_{\substack{j=0\\j\neq i}}^{n} x_{ij}^{k} - \sum_{\substack{j=0\\j\neq i}}^{n} x_{ji}^{k} = 0 \quad (k=1,\dots,m; \quad i=1,\dots,n) \tag{2}$$

$$\sum_{k=1}^{m}\sum_{\substack{j=0\\j\neq i}}^{n} x_{ij}^{k} = 1 \quad (i=1,\dots,n) \tag{3}$$

$$\sum_{i=1}^{t} D_i \sum_{\substack{j=0\\j\neq i}}^{n} x_{ij}^{k} \le q^k \quad (k=1,\dots,m) \tag{4}$$

$$\sum_{i=t+1}^{n} D_i \sum_{\substack{j=0\\j\neq i}}^{n} x_{ij}^{k} \le q^k \quad (k=1,\dots,m) \tag{5}$$

$$\sum_{k=1}^{m}\sum_{i=t+1}^{n}\sum_{j=1}^{t} x_{ij}^{k} = 0 \tag{6}$$

$$\sum_{k=1}^{m}\sum_{j=t+1}^{n} x_{0j}^{k} = 0 \tag{7}$$

$$\sum_{s=1}^{v} v_{ij}^{k,s} = x_{ij}^{k} \tag{8}$$

$$y_i^k + s_i^k + \sum_{s=1}^{v} v_{ij}^{k,s} \frac{d_{ij}}{V^s} \psi_{ij}^{s} \le y_j^k + T^k(1-x_{ij}^k) \tag{9}$$
$$(i=1,\dots,n; \quad j=0,\dots,n; \quad j\neq i; \quad k=1,\dots,m)$$

$$\sum_{s=1}^{v} v_{0j}^{k,s} \frac{d_{oj}}{V^s} \le y_j^k + T^k(1-x_{0j}^k) \quad (j=1,\dots,n; \quad k=1,\dots,m) \tag{10}$$

$$e_i \le y_i^k \le l_i \quad (i=1,\dots,n; \quad k=1,\dots,m) \tag{11}$$

$$y_0^k \le T^k \quad (k=1,\dots,m) \tag{12}$$

$$\sum_{k=1}^{m}\sum_{\substack{j=0\\j\neq i}}^{n} f_{ji}^{k} - \sum_{k=1}^{m}\sum_{\substack{j=0\\j\neq i}}^{n} f_{ij}^{k} = D_i \quad (i=1,\dots,t) \tag{13}$$

$$\sum_{k=1}^{m}\sum_{\substack{j=0\\j\neq i}}^{n} f_{ij}^{k} - \sum_{k=1}^{m}\sum_{\substack{j=0\\j\neq i}}^{n} f_{ji}^{k} = D_i \quad (i=t+1,\dots,n) \tag{14}$$

$$f_{ij}^{k} \le (q^k - D_i) x_{ij}^{k} \quad (i=0,\dots,t; \quad j=0,\dots,n; \quad j\neq i; \quad k=1,\dots,m) \tag{15}$$

$$f_{ij}^{k} \leq (q^{k} - D_{j})x_{ij}^{k} \quad (j = t+1,...,n; \quad i = 0,...,n; \quad j \neq i; \quad k = 1,...,m) \tag{16}$$

$$D_{j}x_{ij}^{k} \leq f_{ij}^{k} \quad (j = 1,...,t; \quad i = 0,...,n; \quad i \neq j; \quad k = 1,...,m) \tag{17}$$

$$D_{i}x_{ij}^{k} \leq f_{ij}^{k} \quad (i = t+1,...,n; \quad j = 0,...,n; \quad i \neq j; \quad k = 1,...,m) \tag{18}$$

Constraints (1) mean that each vehicle departs from the depot once or doesn´t, that is, no more than m vehicles (fleet size) depart from the depot. Constraints (2) are the flow conservation on each node. Constraints (3) guarantee that each customer and supplier is visited exactly once. Constraints (4) and (5) ensure that no vehicle can be overloaded. Constraints (6) and (7) guarantee that customers are not visited after any suppliers (backhauls) and a route cannot start from a supply node. Constraints (8) guarantee that each arc is travelled at only one speed and no speeds are assigned to non-active arcs. Starting service times are calculated in constraints (9) and (10), where y_0^k is the ending time of the tour for vehicle k and the time travelled between two nodes depends on the available speed selected. Ψ_{ij}^{s} is equal to 1 if speed s is allowed in arc (i,j), that is to say $V^s \leq sp_{ij}^{max}$. These constraints also avoid sub-tours. Time windows are imposed by constraints (11). Constraints (12) avoid exceeding the maximum allowable driving time. Balance of flow is described through constraints (13) and (14), which model the flow by the amount of demand of each visited customer. Constraints (15)-(18) are used to restrict the total load a vehicle carries depending on whether it arrives or leaves a customer.

The goal of the problem is to construct several routes minimizing the sum of internal and external costs.

$$MINIMIZE \quad \begin{bmatrix} IC + EC = (\mathrm{DRC} + \mathrm{ENC} + \mathrm{FXC} + \mathrm{MNC} + \mathrm{TLC}) + \\ (\mathrm{CCC} + \mathrm{APC} + \mathrm{NSC} + \mathrm{ACC}) \end{bmatrix} \tag{19}$$

The mathematical forms of the aforementioned components shown in Equation (19) are presented below. In contrast to Bektas and Laporte [1] and Eguia et al. [5], this work considers cost of drivers as a fixed cost. We assume that drivers belong to the company and their salary not depends on the route duration.

$$DRC = \sum_{i=1}^{n}\sum_{k=1}^{m} p^{k} x_{0i}^{k} \tag{22}$$

$$ENC = \sum_{i=0}^{n}\sum_{\substack{j=0 \\ j\neq i}}^{n}\sum_{k=1}^{m}\sum_{r=1}^{R} fc^{r}\delta^{kr} d_{ij} (\sum_{s=1}^{S} fe^{k,s} v_{ij}^{k,s} + feu^{k} f_{ij}^{k}) \tag{23}$$

$$FXC = \sum_{i=1}^{n}\sum_{k=1}^{m} fx^{k} x_{0i}^{k} \tag{24}$$

$$MNC = \sum_{i=0}^{n}\sum_{\substack{j=0 \\ j\neq i}}^{n}\sum_{k=1}^{m} mn^{k} d_{ij} x_{ij}^{k} \tag{25}$$

$$TLC = \sum_{i=0}^{n}\sum_{\substack{j=0\\ j\neq i}}^{n}\sum_{k=1}^{m} tl_{ij} x_{ij}^{k} \quad (26) \qquad APC = \sum_{i=0}^{n}\sum_{\substack{j=0\\ j\neq i}}^{n}\sum_{k=1}^{m}\sum_{t=1}^{T}\sum_{p=1}^{P}\sum_{s=1}^{S} pe^{p}\gamma^{kt} ef^{\,p,t,s} d_{ij} v_{ij}^{k,s} \quad (27)$$

$$CCC = \sum_{i=0}^{n}\sum_{\substack{j=0\\ j\neq i}}^{n}\sum_{k=1}^{m}\sum_{r=1}^{R} pe^{CO2}\delta^{kr} ef^{\,CO2,r} d_{ij} \left(\sum_{s=1}^{S} fe^{k,s} v_{ij}^{k,s} + feu^{k} f_{ij}^{k}\right) \quad (28)$$

$$NSC = \sum_{i=0}^{n}\sum_{\substack{j=0\\ j\neq i}}^{n}\sum_{k=1}^{m} ne\, d_{ij}\, f_{ij}^{k} \quad (29) \qquad ACC = \sum_{i=0}^{n}\sum_{\substack{j=0\\ j\neq i}}^{n}\sum_{k=1}^{m} ae\, d_{ij}\, f_{ij}^{k} \quad (30)$$

Where the set of parameters used in the above expressions are:

- p^k : pay of driver k per unit time.
- fc^r : unit cost of fuel type r.
- $fe^{k,s}$: fuel consumption for the empty vehicle k at speed s.
- feu^k : fuel consumption per unit of additional load in vehicle k.
- δ^{kr} : equal to 1 if vehicle k uses the fuel type r.
- fx^k : the fixed cost of vehicle k.
- mn^k : costs of preventive maintenance, repairs and tires per km of vehicle k
- tl_{ij} : costs of tolls associated with arc (i,j).
- pe^{CO2} : unit price per ton of CO_2 emitted.
- $ef^{CO2,r}$: emission factor, amount of CO_2 emitted per unit of fuel r consumed.
- pe^p : unit price per ton of the pollutant p emitted.
- $ef^{p,t,s}$: amount of pollutant p emitted from technology vehicle t, at speed s, per km travelled.
- γ^{kt}: equal to 1 if vehicle k belongs to technology t.
- *ne* : costs of noise emissions per ton of load carried and per km travelled.
- *ae* : costs of accidents per ton of load carried and per km travelled.

4. An illustrative example

In this paper, an illustrative example has been developed for a leading company in the food distribution sector in Spain, with the purpose of validating the model. It is derived from Eguia et al. [5]. We will centre on the delivery activities in the council of Huelva sited in South-western Spain. In this area, the distribution network consists of 17 delivery points (supermarkets) served directly from a depot (logistic centre). The fleet of vehicles to supply these supermarkets consists of three different rigid trucks with sufficient capacity to deliver the customers' demands. The parameters associated to each vehicle of the fleet can be obtained in Eguia et al. [5] with the only difference in the drivers wage which are set to (159.12, 171.20, 159.12) € per day to vehicles 1, 2 and 3 respectively. Vehicle speeds on the road are set at seven different possible levels in kilometres per hour (30, 40, 50, 60, 70, 80 and 90) and each arc, between two nodes, has a maximum allowed speed. Service times are set to 0.5 hour in all nodes by all vehicles and there is also a maximum driving time of 8 hours for each vehicle. Time windows are not considered and there are no toll costs. Several simulations of the problem have been made varying the number of nodes (problem dimension). Problems with 8, 9, 10, 13 and 17 nodes have been solved and a computer running time has been obtained. For each class of problem, it is assumed a constant load demanded by each node of 1 ton. Table 1 shows the supermarkets belonging to each problem type. Costs of travelling between each two customers, maximum allowed speeds and distances have been obtained using the application of Google Maps. The optimal solution of the model has been found using CPLEX 11.1 with default parameters in a 3.30 GHz Intel(R) Core(TM) i5-2400 CPU.

Table 1. Nodes for the different problem types

Nº	Nodes number from Eguia et al.(2013)
8	{1,2,7,8,12,13,15,17}
9	{1,2,6,7,8,12,13,15,17}
10	{1,2,6,7,8,12,13,15,16,17}
13	{1,2,3,4,5,6,7,8,12,13,15,16,17}

The Speed dependent HVRP is NP-Hard, which means that its computational complexity exponentially increases when the problem size increases. In this case, the computer running times have been obtained for 8, 9 and 10 nodes problems and a maximum computing time of 60000 seconds has been established for 13 and 17 nodes problems. The results shown in table 2 indicate that routes are performed by vehicles with lower internal costs. Longer distances routes are assigned to less polluting vehicles and road speeds are usually set at lower emissions speeds. The effect of incorporating a maximum driving time or time windows may increase road speeds in order to find possible solutions that meet the route time constraints. This fact can be observed in 9, 10 and 13 nodes problems (Table 2), where vehicles are assigned higher speeds than their optimal speeds for fuel and emissions efficiency (60 Km per hour) to meet the maximum route duration constraint.

5. Conclusion and discussion

In this paper, a new mixed-integer linear programming model for the Vehicle Routing Problem with some realistic assumptions as Heterogeneous Fleet, Time Windows, Backhaul nodes and Speed Variability (HVRPTWB_SP) has been presented. External costs derived from freight transport (climate change, air pollution, noise and accidents) are incorporated in the model to be part of the planning and operational process in companies. We have introduced speed as a new variable not only for accurately estimating driving times, but also for modelling fuel consumptions, CO_2 emissions and pollutants emissions using the equations provided by EMEP/CORINAIR. To our knowledge, there are a few works which incorporates speed as a variable and consider pollutant emissions in a VRP with heterogeneous fleet. Moreover, we have also optimized the delivery activities from an illustrative example to validate the model. Results of the computational experiments yield that road speeds are usually set at lower emissions speeds but they may be increased by time window restrictions. Further research may lead to the development of a new metaheuristic that allows solving large-scale speed dependent problems with time windows restrictions.

Table 2. CPLEX routes solutions

Prob	Veh	Routes Nodes & Road Speeds	Time (h)	Dist (Km)	Int.C. (€)	Ext.C. (€)	Total (€)	GAP (%)	Run T (s)
8	1	0-15-8-1-13-7-17-0 60-50-40-50-60-50-60	7.50	336.70	471.63	17.43	489.06	0.01	2566
	3	0-12-2-0 60-50-60	2.53						
9	1	0-15-8-1-6-13-7-17-0 70-50-40-40-40-60-50-60	8.00	337.20	473.05	18.90	491.95	0.01	31095
	3	0-12-2-0 60-50-60	2.53						
10	1	0-15-7-8-1-6-13-16-0 70-60-40-40-40-40-50-60	7.86	390.60	483.47	21.62	505.10	0.01	148148
	3	0-2-12-17-0 60-50-60-60	4.04						
13	1	0-5-2-12-17-3-15-0 80-50-50-60-60-60-70	7.92	579.50	523.52	33.90	557.43	30.47	60000
	3	0-8-1-16-6-13-4-7-0 80-40-40-50-40-60-60-70	7.99						
17	1	0-15-7-6-13-14-4-0 60-60-60-40-30-60-60	7.68	708.40	781.82	37.17	818.99	43.38	60000
	2	0-10-11-9-8-1-16-0 90-30-30-30-40-40-90	5.55						
	3	0-5-2-12-17-3-0 60-50-50-60-60-60	6.91						

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