A new eco-friendly initiative for last food mile delivery in urban areas

BAHADORI, Ramin <http://orcid.org/0000-0001-6439-7033>, SAAD, Sameh <http://orcid.org/0000-0002-9019-9636>, BADAKHSHAN, Ehsan, PERERA, Terrence and GUNATHILAKA, Ranjika

---

Published version

BAHADORI, Ramin, SAAD, Sameh, BADAKHSHAN, Ehsan, PERERA, Terrence and GUNATHILAKA, Ranjika (2023). A new eco-friendly initiative for last food mile delivery in urban areas. In: BRUZZONE, Agostino G., JANOSY, Janos Sebestyen, NICOLETTI, Letizia and ZACHAREWICZ, Gregory, (eds.) Proceedings of the 11th International Workshop on Simulation for Energy, Sustainable Development & Environment (SESDE 2023). CAL-TEK srl.

11th International Workshop on Simulation for Energy, Sustainable Development & Environment
20th International Multidisciplinary Modeling & Simulation Multiconference

2724-0061 © 2023 The Authors.
doi: 10.46354/i3m.2023.sesde.005

A new eco-friendly initiative for last food mile delivery in urban areas

Ramin Bahadori*, Sameh M Saad, Ehsan Badakhshan, Terrence Perera and Ranjika Gunathilaka

Industry & Innovation Research Institute (I2Ri), Sheffield Hallam University, Sheffield, S1 1WB, United Kingdom

*Corresponding author. Email address: R.Bahadori@shu.ac.uk

Abstract

The last food mile delivery involves the final step of delivering food products to the end customers. By developing e-commerce channels, home delivery is considered the final mile of food delivery. However, although home food delivery has received much welcome from consumers, it is still one of the costliest and most polluting segments in the food supply chain, and its optimisation is highly felt. Thus, this paper proposes a new initiative to reduce the environmental impacts of home food deliveries from retailers in urban areas. Last food mile models for both the conventional approach in which each retailer has its own dark store and for a proposed approach in which all retailers have only one common dark store for home food delivery are developed. A Vehicle Route Problem with Time Window (VRPTW) and heterogeneous fleet are developed to minimise both CO2 emission and transportation cost simultaneously and implemented using a simulated annealing algorithm that is programmed in MATLAB software. The obtained results revealed that the proposed initiative's application can significantly impact the reduction of both CO2 emission and transportation costs.

Keywords: Last food mile, Vehicle Route Problem with Time Window (VRPTW), simulated annealing algorithm, food retail supply chain, modelling and simulation

1. Introduction

Urban logistics plays a significant role in making urban freight systems more efficient, safe, and eco-friendly. Many strategic measures such as urban consolidation centres, access control rules for urban centres, off-peak hours delivery, and low greenhouse gas emissions areas have been applied in cities around the world to achieve the objectives of urban logistics, including "mobility, sustainability and liveability" be achieved (Taniguchi, Thompson & Yamada, 2014). Urban freight has irreparable effects on the environment; consumption of resources, toxic effects on ecosystems and humans, noise and emissions of greenhouse gases (GHG) and pollutants are examples of these risks. Apart from these negative effects, emissions of greenhouse gases and carbon dioxide (CO2) are directly linked to the health of the community and indirectly to the destruction of the ozone layer (Bektaş & Laporte, 2011). Thus, the need to minimise these dangerous emissions is highly felt due to their high exposure levels to populations living and working in urban areas.

Modelling plays a vital role in facilitating urban logistics, which is very useful for understanding urban freight distribution and providing better insights into stakeholder behaviour and identification of the effects of policy actions. These models are also useful for understanding the gap between the current level of productivity in logistics operations and optimal solutions. Vehicle Routing Problem (VRP) is one of the most important models widely studied and used in practice in urban freight distribution to minimise the costs of vehicle operations (Lagorio, Pinto & Golini, 2016). VRP is part of a series of problems that are associated with determining a set of routes in which each vehicle starts moving from a certain depot, serving a set of specified customers, and returning to the same depot. This problem was first introduced by Dantzig and Ramser (1959) and solved using mathematical methods. In the form of the graph theory, it is defined as, suppose that G (V, A) represents the graph in which $V= \{0, 1, ..., n\}$ demonstrates n+1 nodes; node 0 corresponds to the depot with zero demand where vehicles are located there and other nodes $\{1, ..., n\}$ corresponds to n customers with nonnegative demand. $A= \{(i,j)\,|\,i, j\}\in V$ and $i\neq j\}$ demonstrates sets of edges (i, j) of each route, which are in graph G. Following that, Laporte (1992) developed various branch and bound method approaches to solving the vehicle routing problem and Clarke and Wright (1994) proposed a savings algorithm for solving VRP, which was the basis for any further research. With recent advances in solving these problems, and considering more complex assumptions and constraints, metaheuristic methods such as the Genetic algorithm (Wang, Lan & Zhao, 2017), Tabu Search algorithm (Gómez, Pacheco & Gonzalo-Orden, 2015), Hybrid ant colony optimisation algorithm (Euchi & Mraihi, 2012), Simulated annealing (Kokubugata & Kawashima, 2008; Saad & Bahadori, 2018) and Particle swarm optimisation (Norouzi, Sadegh-Amalnick & Tavakkoli-Moghaddam, 2017) were developed and adapted to urban logistics problems.

Currently, e-commerce channels provide the opportunity for customers to make purchases electronically without visiting stores and receive the purchased food at their home delivery address. In this regard, the last food mile definition can be developed as the main step of the order fulfilment process, which means delivering the online purchased foods to the end customers' physical address (e.g., home) from the place where the food items are kept (e.g., dark store). In this paper, the vacancy of optimisation modelling to reduce the environmental impacts of food deliveries from retailers to end customers is well understood and has been the main driver of this research.

As shown in Figure 1, conventionally, each food retailer has a dark store -which refers to a retail outlet or distribution centre that caters exclusively for online shopping- within the demand region where vehicles depart to deliver online purchased foods to customers' homes. In this research, a new model for the last food mile approach is proposed, in which instead of each retailer having its own dark store, a single common 3PL (Third-party logistics) dark store is set to deal with all the retailers' last food mile deliveries (see Figure 2).

To evaluate the effectiveness of the proposed approach, stochastic last food mile models for both approaches are developed and compared to each other through two performance measures; transportation cost and CO2 emission. A Vehicle Route Problem with Time Window (VRPTW) and heterogeneous fleet are developed to minimise both the transportation cost and CO2 emission and implemented using a simulated annealing algorithm which is programmed in MATLAB software. An integer linear programming mathematical model of the problem is described in the section 3.

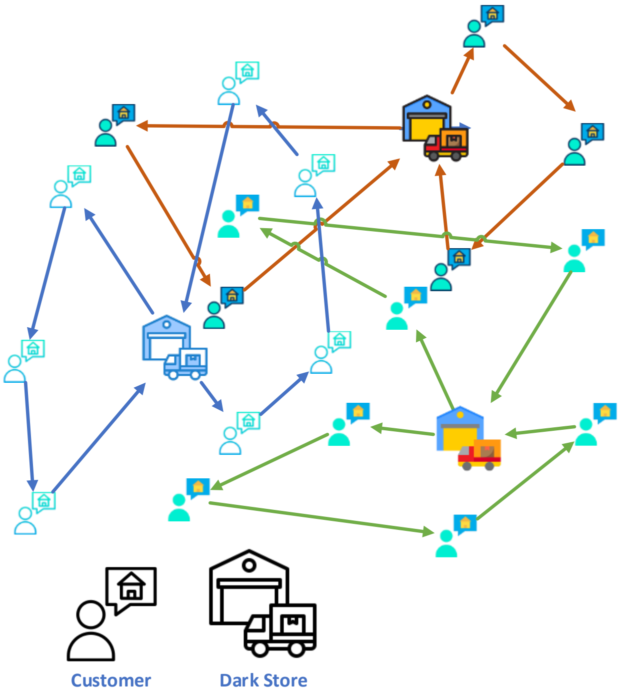

Figure 1. Conventional home food delivery approach

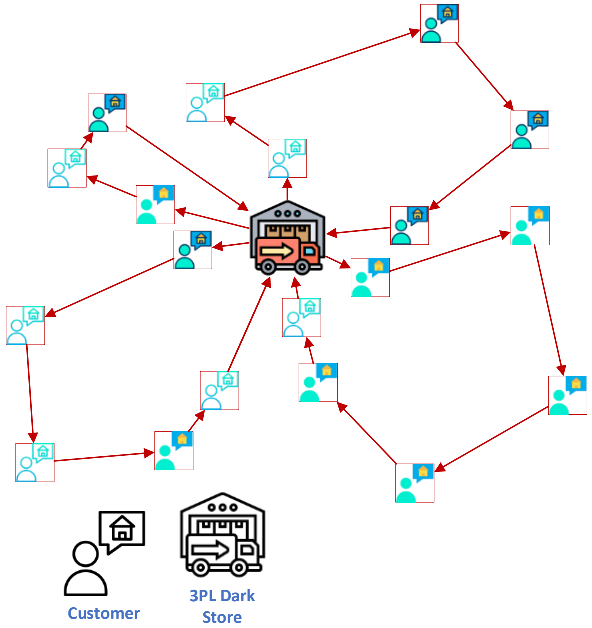

Figure 2. Proposed home food delivery approach

2. Research Background

Recently, increasing volumes and environmental impacts of urban food deliveries have raised much attention. A notable concept has been the discussion of the "last food mile" or "final food mile". Morganti (2011) defined the last food mile as the final delivery of food products to urban grocery stores and food retailers. Delivery of food at the last mile stage is characterised by high frequency and is one of the costliest and the highest polluting segments and its optimisation has become a significant challenge for operation managers within the food supply chains (Kijewska & Iwan 2016). In the following, the most current literature will be reviewed to provide a better understanding of the existing body of knowledge on the sustainability practices of last food mile delivery in urban areas.

Melkonyan et al. (2020) evaluated the sustainability of last mile logistics and distribution strategies in the context of local food networks. The study explored how different strategies employed in the last mile delivery of food products impact environmental, social, and economic aspects of sustainability. The authors utilised a comprehensive assessment framework to evaluate various distribution strategies and provide insights into the potential benefits and challenges associated with each approach. The findings of the study revealed that an integration of the two players into a distributed network strategy based on a crowd logistics concept is the most feasible and environmentally friendly choice. Aljohani & Thompson (2018) investigated the effects of moving Melbourne's wholesale fruits and vegetables market to suburban locations on two key factors: vehicle kilometres travelled and distribution costs. To analyse these impacts, the researchers employed a geographical information system (GIS) software tool and gathered data through semi-structured interviews. The findings of the study provided insights into the relationship between the location of logistics facilities and the efficiency of last food mile delivery. The paper highlighted the importance of considering the geographical placement of wholesale markets and its impact on reducing transportation distances and costs. Stelwagen et al. (2021) utilised empirical data and a case study approach to develop a comprehensive model that considers various parameters such as delivery distances, vehicle types, routing, and traffic conditions that can be used to assess and optimise the environmental impact of the last food mile delivery in an urban context. The authors identified the factors that contribute to emissions and energy consumption and discuss potential mitigation strategies. The research highlighted the importance of adopting sustainable practices in last mile delivery to reduce carbon footprints and energy consumption. Saad and Bahadori (2018) analysed the sustainability aspects of last mile food delivery by comparing two delivery methods: pickup point using lockers and home delivery. Through a simulation-based evaluation, they considered factors such as delivery distances, vehicle types, order sizes, and operational costs to explore the sustainability performance of pickup point lockers versus home delivery. The findings of the study provided insights into the sustainability implications of different last food mile delvery approaches. The authors discussed the environmental benefits and economic considerations of using pickup point lockers, such as reduced emissions and transportation costs. Bjørgen, Bjerkan, & Hjelkrem (2021) focused on the integration of e-grocery delivery services into city planning strategies by considering various factors, including delivery modes, vehicle types, logistics networks, and urban design. The findings of the study revealed the potential of e-groceries to improve last mile distribution in terms of reducing congestion, emissions, and delivery costs. Sakhuja, Soni & Sharma (2022) explored the potential benefits and challenges of implementing urban consolidation strategies in the context of food and beverage distribution in Singapore. The authors analysed factors such as transportation costs, delivery efficiency, and environmental sustainability to assess the feasibility and effectiveness of urban consolidation. The article provided valuable insights and recommendations for stakeholders in the food and beverages industry looking to optimise their distribution processes in urban environments.

In addition, in order to reduce the environmental impacts of food deliveries from wholesale in urban areas, various consolidation and optimisation projects have been implemented. One of the most successful projects was implemented at Parma's fruit and vegetable market where 40 tons of food products are managed by the market's authority to be distributed to 250 food businesses and services in Parma using 16 transport operators and carriers. The project took advantage of eco-friendly delivery vehicles and an ICT platform is used to optimise the routes. The results revealed up to a 25% reduction in total pollutant emissions (Morganti & Gonzalez-Feliu, 2015). Providing the sustainable delivery transport service by Lowhub Transport Company, at London's New Covent Garden Market and Borough Market can be mentioned as another successful project in which different orders by retailers from the wholesale market are consolidated into efficient multi-drop deliveries utilising small trucks run with biofuels and electricity (Estrada-Flores & Larsen 2010).

3. Vehicle route optimisation mathematical model

For a better articulation of the mathematical model, first, input parameters and decision variables of the model are provided, and then, the objective functions and their constraints are presented. Also, essential descriptions of the details of the mathematical model are provided.

3.1. Input parameters

V= a Total number of customers; with vertex set $V= \{0, 1, \dots, n\}$; Where node 0 corresponds to the depot and the other nodes in this set of a vertex represents the customers.

A= sets of edges; $A= \{(i,j) \mid i, j\} \in V$ and $i \neq j\}$.

K= Number of available vehicles; $K= \{1, \dots, k\}$.

Q_k= Capacity of k^{th} vehicle ($k \in K$).

D_i = Customers demand ($i \in V$).

d_{ij} = Length of the edge between the nodes i and j $(i,j) \in A$

At_{ik}= Arrival time of the k^{th} vehicle to i^{th} customer

$t1_i$= Lower bound in the hard time window of i^{th} customer

$t2_i$ = Upper bound in the hard time window of i^{th} customer

C_{ijk} = CO_2 emission of moving k^{th} vehicle ($k \in K$) between the nodes *i* and *j*
Where:
$C_{ijk} = \left((TW_k + W_{ijk}) \times E_k\right) \times d_{ij}$
And
TW_k =Tare Weight of *kth* vehicle, which is the weight of the empty vehicle.
W_{ijk} = Weight of shipments on board of k^{th} vehicle between the nodes *i* and *j*
E_k= CO_2 emission rate of k^{th} vehicle
TC_{ijk} = Transportation Cost of moving k^{th} vehicle ($k \in K$) between the nodes *i* and *j*
Where:
$TC_{ijk} = (dij \times cf) \times AC$
And
cf= Average circuity factor
AC= Average transportation cost per km

3.2. Decision variables

$$x_{ijk} = \begin{cases} 1 & \text{if } j^{th} \text{ customer is served by } k^{th} \text{vehicle after } i^{th} \text{ customer} \\ 0 & \text{otherwise} \end{cases}$$

y_{ik}= The quantity of the demand of i^{th} customer which is delivered by the k^{th} vehicle.

3.3. Formulation

The objective functions represent the minimisation of the total CO_2 emission and total transportation cost generated by using the transportation fleet can be written as follows:

$$Min \sum_{i=0}^{n} \sum_{j}^{n} \sum_{k=1}^{K} C_{ijk} x_{ijk} \,, \quad i \neq j \tag{1}$$

$$Min \sum_{i=0}^{n} \sum_{j}^{n} \sum_{k=1}^{K} TC_{ijk} x_{ijk} \,, \quad i \neq j \tag{2}$$

The model constraints are:
Constraints (3) ensure that each customer is visited exactly once.

$$\sum_{i=0}^{n} \sum_{k=1}^{K} x_{ijk} = 1, \qquad j = 0, \ldots, n, \tag{3}$$

Constraints (4) are about entrance and exit flows (*p*), where if node *i* is visited by vehicle *k*, then the amount of product from vehicle *k* that enters and leaves that node must equal the demand at that node. Conversely, if node *i* is not visited by vehicle *k*, then the amount of product from vehicle *k* that enters and leaves that node must be 0. In fact, these constraints guarantee that any vehicle entering each node will definitely leave it.

$$\sum_{i=0}^{n} x_{ipk} - \sum_{j=0}^{n} x_{pjk} = 0 \,, \;\; p = 0, \ldots, n; \; k = 1, \ldots, K, \tag{4}$$

Constraints (5) ensure that the i^{th} customer's demand is completed if exactly one vehicle passes through it.

$$y_{ik} = D_i \sum_{j=0}^{n} x_{ijk} \,, \quad i = 1, \ldots, n; \; k = 1, \ldots, K \tag{5}$$

Constraints (6) indicate that all customers' demands are entirely fulfilled.

$$\sum_{k=1}^{K} y_{ik} = D_i, \qquad i = 1, \ldots, n \tag{6}$$

Constraints (7) impose that the loading process on any route should not exceed the capacity of the vehicle.

$$\sum_{i=1}^{n} y_{ik} \leq Q, \qquad k = 1, \ldots, K \tag{7}$$

Constraints (8) present the sub-tour elimination constraints where (*S*) refers to any collection of customers having at least two and at most *n*-1 members.

$$\sum_{i,j \in S} x_{ijk} \leq |S| - 1, (S \subset \{1, \ldots, n\}); \; |S| \geq 2 \tag{8}$$

Equation (9) indicates the hard time window constraints.

$$t1_i \leq At_{ik} \leq t2_i, \qquad i = 1, \ldots, n; k = 1, \ldots, K \tag{9}$$

Equation (10) guarantees the decision variables x_{ijk} to be binary.

$$x_{ijk} \in \{0,1\}, \qquad i = 0, \ldots, n \,; \; j = 0, \ldots, n; k = 1, \ldots, K \tag{10}$$

Equation (11) guarantees that the decision variable y_{ik} is positive.

$$y_{ik} \geq 0, \qquad i = 1, \ldots, n; \; k = 1, \ldots, K \tag{11}$$

4. Last food delivery models development

4.1. Conventional home food delivery model

In the development of a conventional home food delivery approach (see Figure 1), Customer points (locations) for each retailer are randomly three different food retailers (i.e., R1, R2 and R3) are considered. generated for a different number of customers equal to 100, 200, 300, 400, and 500 within a square demand region with a side of 15 (km) separately. Customer demands also are randomly generated from 10 kg to 30 kg. Each retailer has a single dark store which is located at the centre of the movement in a demand area based on weight and distance by using the centre-of-gravity technique (Ghadge et al., 2016):

$$x = \frac{\sum_{i=1}^{n} x_i D_i}{\sum_{i=1}^{n} D_i} \qquad (12)$$

$$y = \frac{\sum_{i=1}^{n} y_i D_i}{\sum_{i=1}^{n} D_i} \qquad (13)$$

Where

x, *y*= coordinates of the depot at the centre of gravity

x_i, y_i= coordinates of existing customer *i* on the area's map

There are two types of vehicles; type A and type B, which are distributed among each retailer's dark store randomly with the following attributes as given in Table 1.

Table 1. Transportation fleet attributes.

Vehicle type	Type A	Type B
Tare weight (kg)	1570	2205
CO_2 emission rate (kg per km)	0.00082	0.00108
Average transportation cost per km (£)	1.5	1.4
Capacity (kg)	40 per cent of lorry tare weight	40 per cent of lorry tare weight

Moreover, an average distance circuity factor (*cf*) of 1.4 based on the England road system is considered (Ballou et al. 2002) which allows for determining approximate actual travel distances.

Customer request delivery times are randomly generated through four categories:

- 9:00 am to 12:00 pm
- 12:00 pm to 3:00 pm
- 3:00 pm to 6:00 pm
- 6:00 pm to 9:00 pm

The obtained results from MATLAB Software for each retailer model through a different range of customers are displayed in Figures 3- 5 which are cumulated in Table 2.

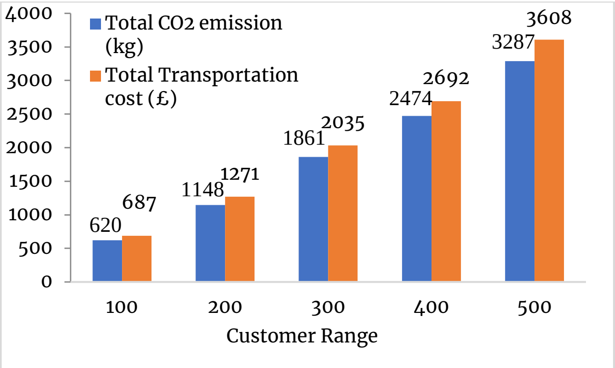

Figure 3. Vehicle Route Optimisation Results for (R1) through a different range of customers.

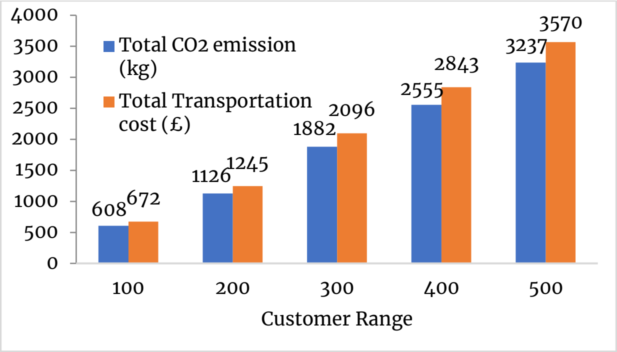

Figure 4. Vehicle Route Optimisation Results for (R2) through a different range of customers.

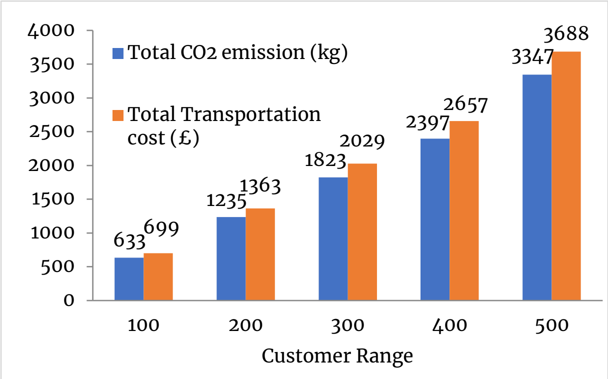

Figure 5. Vehicle Route Optimisation Results for (R3) through a different range of customers.

Table 2. Cumulated total transportation costs and CO_2 emissions are generated through all retailer's activities.

Customer range	Total transportation cost (£)	Total CO_2 emission (kg)
300	2058	1861
600	3879	3508
900	6159	5565
1200	8192	7426
1500	10865	9871

4.2. Proposed initiative home food delivery model

In the following, the proposed home food delivery approach (see Figure 2) is modelled. In this case, instead of that, each retailer has its own dark store, a single common 3PL dark store is considered to deal with the three retailer's customers' last food mile deliveries. The centre-of-Gravity technique is used to determine 3LP dark store location (see equations 12 and 13).

The obtained results from MATLAB Software for the proposed approach are displayed in Figure 6.

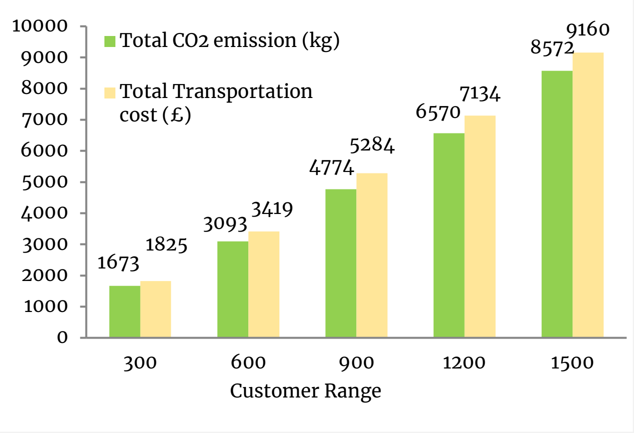

Figure 6. Vehicle Route Optimisation Results for the common 3PL dark store through a different range of customers

5. Sustainability comparison results: conventional food home delivery versus proposed initiative home food delivery

Table 3 displays that in all customer ranges, the obtained values from the proposed model are improved in terms of both transportation cost and CO2 emission:

- In the customer range of 300, the values obtained from the proposed model in terms of both criteria, the transportation costs and CO2 emissions were reduced by 11.32% and 10.10% respectively.
- In the customer range of 600, there was also an improvement in both the transportation costs and CO2 emissions by 11.86% and 11.83% respectively.
- In the customer range of 900, both the transportation costs and CO2 emissions were reduced by 14.21%.
- In the customer range of 1200, both the transportation costs and CO2 emissions were improved by 12.92% and 11.53% respectively.
- Finally, both the transportation costs and CO2 emissions were reduced by 15.69% and 13.16% in the customer range of 1500.

Table 3. Comparison between conventional and proposed approaches for home food delivery

Performance Measure	Customer Range	Conventional approach	Proposed initiative approach	Improvement (%)
CO_2 emission (kg)	300	1861	1673	10.10
	600	3508	3093	11.83
	900	5565	4774	14.21
	1200	7426	6570	11.53
	1500	9871	8572	13.16
Transportation cost (£)	300	2058	1825	11.32
	600	3879	3419	11.86
	900	6159	5284	14.21
	1200	8192	7134	12.92
	1500	10865	9160	15.69

6. Conclusions and future work

In this paper, a new initiative for last-food mile delivery was proposed to reduce the environmental impacts of home food deliveries from retailers in urban areas.

Last food mile models for both the conventional approach in which each retailer has its own dark store and for the proposed approach in which all the retailers have only one dark store for home food delivery were developed.

To evaluate the effectiveness of the proposed approach, the mathematical model to represent both conventional and proposed approaches for home food delivery was developed. A Vehicle Route Problem with Time Window (VRPTW) and the heterogeneous fleet was also developed to minimise the CO2 emission and transportation cost simultaneously and implemented using a simulated annealing algorithm which was programmed in MATLAB software.

The obtained results revealed that the application of the proposed initiative led to a reduction in both CO2 emission and transportation costs for all customer ranges considered in this study.

As with any study, this research work has some shortcomings. However, these shortcomings can be a route and map for our future research. In this regard, the vehicle route model with a limited number of delivery vehicles should be developed for further evaluation of its effectiveness. Moreover, optimisation of the fleet type selection in food home delivery could be another area for future research focus. In this research, the green aspects of the proposed initiative received the authors' focus, but it is necessary to investigate other factors or challenges such as the required level of coordination and its associated cost, information infrastructure, data privacy etc.

References

Aljohani, K. & Thompson, R.G. (2018). The impacts of relocating a logistics facility on last food miles–The case of Melbourne's fruit & vegetable wholesale market. *Case studies on transport policy*, *6*(2), 279-288.

Ballou, R.H., Rahardja, H. & Sakai, N. (2002). Selected country circuity factors for road travel distance estimation. *Transportation Research Part A: Policy and Practice*, *36*(9), 843-848.

Bektaş, T. & Laporte, G. (2011). The pollution-routing problem. *Transportation Research Part B: Methodological*, *45*(8), 1232-1250.

Bjørgen, A., Bjerkan, K.Y. & Hjelkrem, O.A. (2021). E-groceries: Sustainable last mile distribution in city planning. *Research in Transportation Economics*, *87*, 100805.

Clarke, G. & Wright, J.W. (1964). Scheduling of vehicles from a central depot to a number of delivery points. *Operations research*, *12*(4), 568-581.

Dantzig, G.B. & Ramser, J.H. (1959). The truck dispatching problem. *Management Science*, *6*(1), 80-91.

Estrada-Flores, S. & Larsen, K. (2010). *Best Practice Food Distribution Systems*. Food Chain Intelligence and Victorian Eco-Innovation Lab.

Euchi, J., & Mraihi, R. (2012). The urban bus routing problem in the Tunisian case by the hybrid artificial ant colony algorithm. *Swarm and Evolutionary Computation*, 2, 15-24.

Ghadge, A., Yang, Q., Caldwell, N., König, C. & Tiwari, M.K. (2016). Facility location for a closed-loop distribution network: a hybrid approach. *International Journal of Retail & Distribution Management*, 44(9), 884-902.

Gómez, J.R., Pacheco, J. & Gonzalo-Orden, H. (2015). A Tabu Search Method for a Bi-Objective Urban Waste Collection Problem. *Computer-Aided Civil and Infrastructure Engineering*, *30*(1), 36-53.

Kijewska, K. & Iwan, S. (2016). Analysis of the functioning of urban deliveries in the city centre and its environmental impact based on Szczecin example. *Transportation Research Procedia*, *12*, 739-749.

Kokubugata, H. & Kawashima, H. (2008). Application of simulated annealing to routing problems in city logistics. In *Simulated Annealing*, 131-154. InTech. Vienna, Austria.

Lagorio, A., Pinto, R. & Golini, R. (2016). Research in urban logistics: a systematic literature review. *International Journal of Physical Distribution & Logistics Management*, *46*(10), 908-931.

Laporte, G. (1992). The vehicle routing problem: An overview of exact and approximate algorithms. *European journal of operational research*, *59*(3), 345-358.

Melkonyan, A., Gruchmann, T., Lohmar, F., Kamath, V. & Spinler, S. (2020). Sustainability assessment of last-mile logistics and distribution strategies: The case of local food networks. *International Journal of Production Economics*, *228*, 107746.

Morganti, E. (2011). *Urban food planning, city logistics and sustainability: The role of the wholesale produce market. The cases of Parma and bologna food hubs*. Ph.D.Thesis. Italy: Alma Mater Studiorum-University of Bologna.

Morganti, E. & Gonzalez-Feliu, J. (2015). The last food mile concept as a city logistics solution for perishable products. *Enterprise Interoperability: Interoperability for Agility, Resilience and Plasticity of Collaborations (I-ESA 14 Proceedings)*, 202-206.

Norouzi, N., Sadegh-Amalnick, M. & Tavakkoli-Moghaddam, R. (2017). Modified particle swarm optimization in a time-dependent vehicle routing problem: minimizing fuel consumption. *Optimization Letters*, *11*(1), 121-134.

Saad, S., & Bahadori, R. (2018). Sustainability evaluation of last mile food delivery: pick up point using lockers versus home delivery. In: *FoodOPS2018: Proceedings of the International Food Operations and Processing Simulation Workshop: held at the 15th International Multidisciplinary Modelling and Simulation Multi-conference (I3M 2018)*: Budapest, Hungary, 17-19 September 2018, 37-42.

Sakhuja, S., Soni, U. & Sharma, C. (2022), March. Urban Consolidation: A Case for Food and Beverages Industry in Singapore. In *2022 International Conference on Decision Aid Sciences and Applications (DASA)* (pp. 254-257). IEEE.

Stelwagen, R.E., Slegers, P.M., de Schutter, L. & van Leeuwen, E.S. (2021). A bottom-up approach to model the environmental impact of the last-mile in an urban food-system. *Sustainable Production and Consumption*, 26, 958-970.

Taniguchi, E., Thompson, R.G. & Yamada, T. (2014). Recent trends and innovations in modelling city logistics. *Procedia-Social and Behavioral Sciences*, *125*, 4-14.

Wang, K., Lan, S. & Zhao, Y. (2017). A genetic-algorithm-based approach to the two-echelon capacitated vehicle routing problem with stochastic demands in logistics service. *Journal of the Operational Research Society*, *68*(11), 1409-1421.