

Multi-Depot Vehicle Routing Problem with Branch-and-Cut: An application in Short Food Supply Chains

Bilgesu Bayir, Aurelie Charles, Aicha Sekhari, Yacine Ouzrout

▶ **To cite this version:**

Bilgesu Bayir, Aurelie Charles, Aicha Sekhari, Yacine Ouzrout. Multi-Depot Vehicle Routing Problem with Branch-and-Cut: An application in Short Food Supply Chains. 23ème congrès annuel de la Société Française de Recherche Opérationnelle et d'Aide à la Décision, INSA Lyon, Feb 2022, Villeurbanne - Lyon, France. hal-03595341

HAL Id: hal-03595341
https://hal.science/hal-03595341

Submitted on 3 Mar 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Multi-Depot Vehicle Routing Problem with Branch-and-Cut: An application in Short Food Supply Chains

Bilgesu Bayir[1], Aurélie Charles[1], Aicha Sekhari[1], Yacine Ouzrout[1]

[1] University Lumière Lyon 2, DISP, EA 4570, F-69500 Bron, France
{bilgesu.bayir, a.charles, aicha.sekhari, yacine.ouzrout}@univ-lyon2.fr

***Keywords*:** Multi-Depot Vehicle Routing Problem, Integer Linear Programming, Branch-and-Cut, Short Food Supply Chains, Collaborative Product Distribution.

1 Introduction

Short Food Supply Chains (SFSCs) are the "commercialization of agricultural products through direct selling or indirect selling when only one intermediary is involved", according to French Ministry of Agriculture [1]. Improved access to better quality food with well-known origins for consumers and increased revenues for producers take place among their major expected benefits. Nonetheless, poor commercial and logistics organization often create barriers to such benefits by leading to inefficient product distribution and high operational costs [2].

In direct SFSC models, a major contributor to high operational costs is the inefficiency in product distribution to delivery points. Producers involved in such models tend to conduct their distribution operations individually, which leads to frequent trips with low vehicle utilization rates and consequently high distribution costs. This issue does not only hinder the economic and environmental sustainability of such initiatives, but also causes the producers to lose large amounts of time.

2 Methods and materials

In this study, we attempt to show the importance of horizontal collaboration for improving the direct SFSC performance. For doing so, we use a real initiative from Lyon, France as a case study. Our partner company offers an online sales platform where producers in the region sell their products directly to consumers, mostly restaurants. The company does not provide any type of logistics support. Each producer is in charge of the delivery of the orders he/she receive through the platform.

First, we classify the producers as small-, medium-, and big-sized producers. Based on producer sizes, we randomly generate the order sizes (kg) between each pair of producer-delivery point for each shipment day. We then simulate the actual functioning of the initiative where each producer performs the distribution individually with a heuristic procedure to obtain a reference model. Later, we propose a collaborative organization where producers also collect and distribute the orders of some other producers while distributing their own orders. We develop an Integer Linear Program (ILP) for a Multi-Depot Vehicle Routing Problem (MDVRP) in Java. Among the real participants of the initiative, we randomly choose 20 producers and 5 delivery points and use their real locations. We assume that each producer has a vehicle with a uniform capacity (kg), each of them agrees to collaborate, and they collaboratively ship their orders 3 times a week during a month, which results in 13 shipment days to be solved as 13 instances. For resolution, we adopt an exact approach and use a branch-and-cut algorithm for sub-tour elimination. Finally, we solve the model using the optimization solver Gurobi and compare the results of the individual model and the collaborative model to show the improvements that can be achieved by changing product distribution organization.

In addition, we use the collaborative model for testing two scenarios where (i) vehicle capacity is decreased and (ii) order sizes are increased. Scenario (i) has the purpose of simulating whether the use of multimodal transportation would be viable in direct SFSCs since the partner initiative considers using bikes for the last-kilometer distribution. Scenario (ii), on the other hand, aims at

simulating if the initiative can handle increasing consumer demand, as occurred for example during COVID-19 pandemic.

3 Results and discussion

According to the results we obtained (see Table 1), the adoption of the collaborative model decreased the average size of the vehicle fleet (nb of vehicles) per instance by 79.30%, and the average distance (km) travelled by all producers per instance by 55.01%. These results confirm that collaborating for product distribution in direct SFSCs can contribute to improving the cost efficiency and reducing the environmental impact caused by transportation. They also clearly show how the producers can save time by engaging in collaboration.

However, this study also has limitations. For example, we randomly generated the demand data due to the unavailability of real data at the time of the study. Additionally, the collaborative model we propose leads to a heterogeneous distribution of workload among collaborating producers. According to the results reached, some producers do not travel at all and some other producers travel more than 1,500 km over the 13 shipment days, whereas the average travelling distance among producers is 391.95 km, as seen on Figure 1 below.

	Average size of vehicle fleet (nb of vehicles) per instance	Average distance (km) travelled by all producers per instance
Individual	17.54	1,343
Collaborative	3.62	603

TAB. 1 – Results: Average per instance

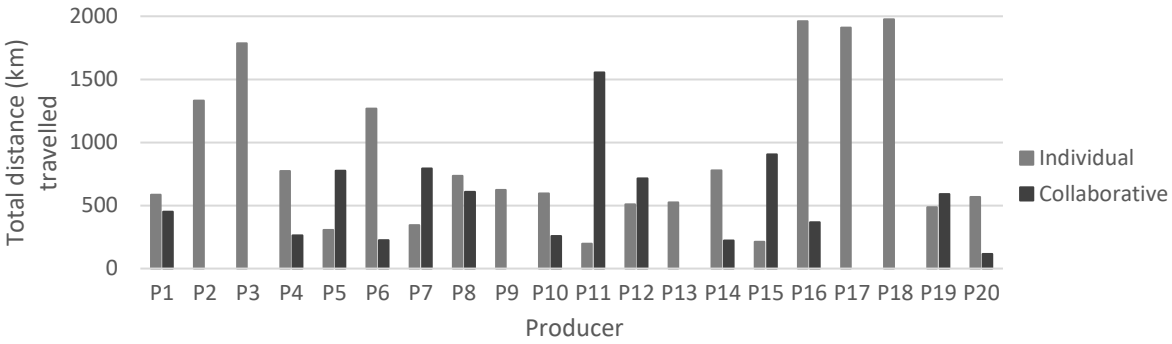


FIG. 1 – Results: Total distance (km) travelled in 13 instances per producer, showing the heterogeneous distribution of workload in proposed collaborative model

4 Conclusions and perspectives

This study shows through a real-world case study that producers in direct SFSCs can significantly reduce the money and time spent, as well as the carbon footprint caused by transportation by engaging in collaborations with other producers. Nevertheless, challenges still exist while developing collaborative models that are realistic enough, and particularly, while implementing such models in real life. To propose an organization that is fair for all participants and to avoid causing conflicts, future studies can consider social constraints as well in the modelling.

References

[1] DGCCRF Produits alimentaires commercialisés en circuits courts, Fiches Pratiques, https://www.economie.gouv.fr/files/files/directions_services/dgccrf/documentation/fiches_pratiques/fiches/produits-alimentaires-commercialises-circuits-courts.pdf June 2019.

[2] Nsamzinshuti, A., Janjevic, M., Rigo, N., & Ndiaye, A. B. (2018). Short supply chains as a viable alternative for the distribution of food in urban areas? Investigation of the performance of several distribution schemes. In *Sust. Freight Transport* (pp. 99-119). Springer, Cham.

Acknowledgment: The authors acknowledge the Erasmus+ project SUNSpACe, that is referred by "598748-EPP-1-2018-1-FR-EPPKA2-CBHE-JP" funded by the European Commission.