Reducing CO_2 emissions using Horizontal Cooperation

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Abstract
We assess the CO_2 emissions reductions that can be reached by horizontal cooperation using a location-inventory model, which minimizes facility opening, transportation, cycle inventory, ordering and safety stock costs. We conduct a large set of numerical experiments, varying several key parameters (vehicles capacity, opening, inventory and ordering costs and demand variability). Finally, we discuss our experimental results and managerial insights.

Keywords: CO_2 Emissions Reductions, Horizontal Cooperation, Location-Inventory Problem.

Environmental concerns are more and more prevalent in companies strategies and customers minds. However, environmental objectives are often in opposition with the current trend aiming at a lower stock level and a higher delivery frequency to propose a better service to customers. Indeed, this trend leads to centralize the distribution centers, increasing the distances, and underusing vehicles in order to respect short delivery times [1]. In this context, cooperation represents a rare opportunity to reduce the costs, to improve the service level and to reduce the environmental impact at the same time [2]. It allows companies to share buildings and vehicles. Customers are thus delivered from closer buildings, reducing the distances traveled. Moreover, vehicles carry products from different companies, improving the loading rates and reducing the total number of trips per period. The reduction of the traveled distances and the more efficient loading of vehicles impact positively the ecological footprint of cooperating companies, reducing the CO_2 emissions generated [3].

This work analyzes the environmental benefits for companies to use a joint supply chain network (facilities and vehicles), and investigates the market and partners characteristics that influence these benefits. For this, we propose a location-inventory model and we compare the CO_2 emissions of companies when they use independent or joint supply networks. Contrary to most studies in the horizontal cooperation literature, where the models only account for the transportation costs, we also consider other logistical costs such as the facility opening, the ordering, the cycle inventory and the safety stock costs. The transportation costs are proportional to the number of trips required and not to the quantity of products carried. This feature allows us to account for the improvement in the vehicle loading rate, and to better assess the possible cost and CO_2 emissions reductions related to transportation. In our paper, the model minimizes the total logistics cost using a location-inventory model, and then the CO_2 emissions reductions are computed, a posteriori. It simulates a company firstly aiming to reduce its supply chain costs before analyzing the environmental benefits as a consequence.

In order to understand the variations in CO_2 emissions reductions, we run a large number of experiments (26,220) with various market and partners characteristics (i.e. we vary the vehicles capacity, the facility opening cost, the inventory holding cost, the ordering cost, the demand variability, the number of partners). From these experiments, we infer valuable managerial insights to help companies assessing the potential benefits they can get when cooperating, as a function of their characteristics. The CO_2 emissions reductions range from about 0% to 36% with an average around 16%. Horizontal cooperation allows more CO_2 emissions reductions for companies with low facility opening costs, a large vehicle capacity (or small size products) and low order costs, carrying expensive products (high unit holding cost) on a vast market with a high demand uncertainty. Moreover, a higher number of partners leads to higher CO_2 emissions reductions, even if the marginal environmental benefit is smaller with each new entrant. Finally, we observe that the logistics costs and the CO_2 emissions evolve in most case in the same direction, excepted for the facility opening cost, the unit holding cost and the demand variability which have opposite effects for CO_2 emissions and cost reductions.

References

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