Does Locker Alliance Network Improve Last Mile Delivery Efficiency? An Analysis using Prize-collecting Traveling Salesman Model

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Abstract:

The Locker Alliance Network (LAN) is a recent smart nation initiative introduced in Singapore for parcel pickup by customers, to improve the efficiency of the last mile operation. This government facility is open to all logistic service providers (LSPs) operating in the country. With more parcels being shifted to locker stations, the number of visits to home locations could be drastically reduced, and the length of the delivery trips to homes will decrease. However, in the case of LAN, the carriers have to substitute these home deliveries with visits to the locker stations, on a separate delivery trip. The challenge is to determine the appropriate size of the LAN (number and location of locker stations), since having too many or too few of these stations may increase the total length of delivery trips instead. Furthermore, given the interoperable nature of the system, how should the government design the network of locker stations to serve all LSPs operating in the city?

We develop a network design model to address these questions. For a given delivery profile, say from an LSP, we first develop a model to jointly minimize the length of the two delivery trips (to home locations and to locker stations). We show that this can be formulated as a Prize-Collecting TSP problem, and reformulated as a second-order cone problem (SOCP) under the logit choice model. We develop a heuristic policy with provable approximation guarantee based on its LP relaxation, for this class of network design problem. Our analysis shows also that there is an optimal number of locker stations needed for efficient operations, beyond which the efficiency of the last mile operations will deteriorate. More importantly, we can use the model to design the interoperable network for multiple LSPs, with possibly different delivery volumes, as long as they have similar footprints. We show that the network expands (almost) in a nested fashion in this case, i.e., the optimal networks for LSPs with smaller scale are (almost) contained in the optimal network for the larger LSPs. Therefore, the optimal interoperable network is very close to the optimal network for the largest LSP, and the optimal density of the locker network is dictated by the optimal density of the largest LSP operating in the country. Participation of the largest LSP is therefore crucial in any government-run interoperable system to increase the efficiency of last mile delivery operations.

Biography:

Dr. Guodong Lyu is an Assistant Professor of Operations Management at HKUST Business School, Hong Kong University of Science and Technology. He received his Ph.D. degree from NUS Business School, National University of Singapore. He is broadly interested in exploring the interactions between data analytics and operations research, with applications stretching from classical operations management to smart city operations and sustainable development. His focus of methodology includes online optimization, robust optimization, empirical analysis, and machine learning. In his research, he has been collaborating with different government agencies and companies, including IMDA (Singapore), P&G, Didi Chuxing, and Tokopedia.

Your attendance is most welcome!

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