

Perkembangan internet dan dunia digital menyebabkan banyak perubahan gaya hidup pada manusia sekarang ini, salah satunya transaksi jual-beli yang dilakukan secara *online*. Konsumen *online shopping* ini sangat menuntut pada kecepatan waktu pengiriman dan kemurahan biaya pengantaran dari penyedia jasa logistik. Kegiatan distribusi dari penyedia jasa logistik tidak lepas dari proses *pickup and delivery* yang telah banyak menjadi fokus penelitian. Penelitian terkait pengembangan model *Pickup and Delivery Problem* (PDP) telah banyak dilakukan, mulai dari pengintegrasian dengan *time windows*, *split-delivery*, *multi-trip* dan isu *sustainability*. Namun, belum banyak penelitian yang mempertimbangkan *demand threshold* untuk menjadi keputusan waktu penjadwalan kunjungan proses *pickup and delivery*. Oleh karenanya, penelitian ini bertujuan untuk mengembangkan model rute dan penjadwalan untuk *simultaneous pickup and delivery* dengan mempertimbangkan *time windows*, *split delivery*, *multi-trip*, emisi CO₂, dan persebaran *demand* pada pelanggan menggunakan pendekatan *metaheuristics* SA dan LNS. Hasilnya penentuan rute dan penjadwalan dengan SA memberikan total biaya yang lebih tinggi dari LNS dan *existing system*. Model yang dikembangkan sensitif terhadap perubahan parameter jumlah kendaraan, kapasitas kendaraan, dan rentang *time windows*.

Kata kunci: *pickup and delivery*, *routing*, *scheduling*, *split delivery*, *multi-trip*, *demand threshold*, SA, LNS

The advancement of the internet and the digital world has resulted in numerous changes in people's lifestyles today, including online shopping. Consumers who purchase online expect logistics service providers to deliver goods rapidly and at a low cost. Logistics service providers' distribution activities are inextricably linked to the pick-up and delivery process, which is carried out at SPP Yogyakarta. However, SPP Yogyakarta's pick-up and delivery operation did not account for fluctuating pick-up demand, resulting in resource waste. Meanwhile, this demand is significant since it makes the scheduling process more adaptable, boosts resource utility, reduces delivery times, and enables for simultaneous pick-up and delivery procedures. Therefore, this study aims to develop a routing and scheduling model for simultaneous pick-up and delivery by considering time windows, split delivery, multi-trips, CO2 emissions, and customer demand thresholds using the SA and LNS metaheuristic approaches. The results show that routing and scheduling with LNS provides a lower total cost than SA and the existing system. The developed model is sensitive to changes in the parameters of vehicle number, vehicle capacity, time window range, and demand thresholds.

Keywords: pickup and delivery, routing, scheduling, split delivery, multi-trip, demand threshold, SA, LNS