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A Capacitated Vehicle Routing Model for Distribution and Repair with a Service Center

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Abstract: *Background:* Distribution systems often face the dual challenge of delivering products to customers and retrieving damaged items for repair, especially when the service center is separate from the depot. An optimized solution to this logistics problem produces benefits in terms of costs, greenhouse gas emissions, and disposal reduction. *Methods:* This research proposes a Capacitated Vehicle Routing Problem with Service Center (CVRPwSC) model to determine optimal routes involving customers, the depot, and the service center. AMPL-Gurobi was used to solve the model on adapted instances and new instances developed for the CVRPwSC. Additionally, a Variable Neighborhood Search (VNS) algorithm was implemented and compared with AMPL-Gurobi. *Results:* The model was applied to a real-world case study, achieving a 40% reduction in fuel costs, a reduction from 5 to 3 routes, and a sustainable logistics operations model with potential reductions of greenhouse gas emissions and item disposals. *Conclusions:* The main contribution of the proposal is a minimum-cost routing model integrating item returns for repair with customer deliveries, while the limitation is the exclusion of scenarios where return items exceed vehicle capacity. Finally, future research will enhance the CVRPwSC model by incorporating additional constraints and decision variables to address such scenarios.

Keywords: vehicle routing; pickup and delivery; VNS

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1. Introduction

1.1. Background

In recent years, the importance of customer service has grown significantly, driven largely by the competition between local commerce and e-commerce. Today, one of the key competitive advantages for companies lies in delivering exceptional customer service, particularly by offering efficient support for item returns. However, coordinating operations between distribution centers and service centers presents several challenges that must be addressed to maintain efficiency. First, demand variability poses a significant issue, as unpredictable customer needs, such as repair or return volumes, require dynamic routing and capacity adjustments. Second, capacity constraints complicate operations, as vehicles must manage limited capacities to handle both deliveries and reverse logistics effectively. Moreover, scheduling conflicts often arise, since aligning delivery schedules with service center operations demands precise timing, and delays in repair processing or inventory restocking can disrupt the supply chain. In addition, the complexity of reverse logistics introduces additional difficulties, as items returned for repair often require