

Optimizing Reusable Packaging Production Decisions and Return Logistics in E-commerce

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Increasing environmental concerns and the growth of e-commerce necessitate sustainable practices in the retail industry. In collaboration with an industry partner, we introduce an optimal control framework for managing reusable packaging logistics in online retail. From the perspective of a reusable package producer, we consider a dynamic system integrating production decisions and return logistics. We focus on optimizing the number of reusable packages to produce and the decision to collect returned packages from a collection point. The flow starts with the initial production of reusable packages, followed by a visit to the collection center, allocation to retailers, and delivery to customers. Subcontracted delivery services facilitate the delivery and retrieval of packages from retailers to a collection point, forming a semi-open supply chain network due to potential losses during customers or transportation. The core of our study is the decision to collect packages from collection points to the producer's warehouse, where the total time a package spends through the retailer to the collection point is assumed to be exponentially distributed. We model this problem as a Markov Decision Process, considering sequential production and collection decisions to minimize overall costs, including production, logistics, and inventory costs. To solve this complex problem, we propose heuristic methods to manage the system's high-dimensional state space. Our solutions aim to outperform traditional approaches, providing near-optimal strategies for reusable package management and offering insights into sustainable practices in online retail logistics.