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EDITORIAL

Data-driven demand and supply management for online-to-offline logistic services

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Over the last decade, many new online-to-offline logistics services have emerged that have generated significant interest in the research community and the public. These services include, for example, attended home delivery, bike sharing, crowd shipping, same-day delivery, and ride hailing. Today, services like Instacart, Amazon Flex / PrimeNow, Share Now, and Uber are commonplace and represent an essential part of the modern on-demand lifestyle.

The services under consideration are often characterized by the term "online-to-offline", as online platforms provide the necessary interface to book a service such as delivery, acquire a delivery person, or match a passenger and a driver. In contrast, the actual service provision takes place offline, usually by operating a number of vehicles. They can only be profitable and sustainable if service providers effectively manage supply and demand.

From a methodological point of view, managing such services is both exciting and challenging, as it usually requires taking into account the behavior of actors such as customers and drivers within sequential and stochastic decision-making processes. Consider, for example, the case of attended home delivery. Here, providers have to

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decide on fulfillment options for incoming requests without knowing exactly the number of future customers, their preferences, and their locations.

This special issue of OR Spectrum addresses the research front in online-to-offline logistics from both a theoretical and an application perspective. It contains a selection of six papers that focus on the development and application of data-driven OR methods, integrating approaches from the fields of predictive and prescriptive analytics, addressing application areas such as parcel delivery management, attended home delivery, same-day delivery, vehicle sharing systems, and airline revenue management, applying and integrating methods such as approximate dynamic programming, mixed-integer linear programming and metaheuristics, choice-based optimization, clustering and forecasting, and simulation.

Specifically, this special issue covers the following topics:

In their paper *Multitrip vehicle routing with delivery options: a data-driven application to the parcel industry*, Janinhoff et al. take a strategic perspective and deal with the design of online-to-offline services in the context of parcel delivery. They consider the case of a major European parcel provider who wants to extend its product portfolio by offering out-of-home delivery, e.g., to parcel shops, in addition to standard doorstep delivery. In this context, the provider has to decide on features of the products, like the set of feasible parcel shops depending on the customers' home locations or the prices, taking into account that customers' choice of products will depend on the features. For this purpose, they introduce a new type of vehicle routing problem. Following a data-driven approach, they solve large instances based on real-world data using a variable neighborhood search and make recommendations concerning the products' design.

Köhler et al. propose a novel approach to *Data-driven customer acceptance for attended home delivery*. The authors investigate what kind of historical data should be used to manage scarce delivery capacities efficiently. This is especially relevant for attended home deliveries, since these require the attendance of the customer during delivery, and, hence, customers and retailers usually agree on tight delivery time windows in the booking process. First, the authors present a general data-science process that transforms historical order data in input data for customer acceptance. Second, they propose a sampling-based acceptance approach that uses this data to a different extent. Based on historical order data of a German online grocery retailer, they analyze the recency and amount of booking data that leads to improving acceptance decisions as well as the retailer's revenue.

In their paper *Balancing resources for dynamic vehicle routing with stochastic customer requests*, Soeffker et al. consider a dynamic vehicle routing problem with pre-planned, already confirmed orders as well as spontaneously arriving requests. Their solution approach combines an initial routing approach for the pre-planned orders with a non-parametric value function approximation to handle the incoming spontaneous requests. The initial routing approach can be controlled by a parameter that specifies the degree to which the utilization of the fleet resources must be balanced. Regarding the value function approximation, the authors alternatively use three different levels of aggregation that differ in the way they incorporate slack as a feature. In their extensive numerical study, the authors explore the interaction between the two components of the approach. In particular, they find that sacrificing

some initial routing efficiency in favor of balanced vehicle utilization is a key factor for flexible integration of later customer requests and leads to substantial performance improvements.

As an innovative online-to-offline service, Ackva and Ulmer, in their paper *Consistent routing for local same-day delivery via micro-hubs*, investigate same-day delivery for local stores. This is challenging since there are only a few consolidation opportunities for the last mile. To alleviate this, they propose consistent routes between shared micro-hubs to simplify the distribution process for all involved stakeholders. Given that order placements vary from day to day, the challenge is to create effective routes. The authors model this problem as a two-stage stochastic program whereby the first stage determines the vehicles' schedules and the second stage the flow of orders. The goal is to satisfy as many orders as possible. They solve a time-expanded network formulation with commercial MIP-software and compare this against a practically inspired heuristic. They also show when the costs of consistency are relatively low.

In their paper *Dynamic pricing for shared mobility systems based on idle time data*, Müller et al. present a new data-driven approach to dynamic pricing. The approach is characterized by the fact that it relies on idle time data, which is often monitored by shared mobility providers anyway, making the approach very attractive for practical applications. Unlike existing work in this area, their approach is not based on myopic optimization or business rules but on a rigorous mathematical optimization model that includes anticipation of future vehicle movements in the network. The authors show that the approach is very flexible because it can handle different levels of granularity of historical idle time data that may be available in practice. They investigate the resulting variants in a comprehensive numerical study and compare them with four different benchmarks. It turns out that the current pricing practice can be significantly outperformed in terms of achievable profits.

In their paper *Outlier detection in network revenue management*, Rennie et al. propose a novel method for detecting outliers in demand data in network revenue management environments. The underlying problem is highly relevant as outliers have a significant impact on the quality of demand forecasts, which are critical to the performance of any revenue management approach. While existing outlier detection methods either consider legs in isolation or are computationally exhaustive by explicitly performing the analysis at the itinerary level, the new method is positioned in between. It is based on a clustering approach at the leg level, followed by a cross-leg aggregation approach to identify outliers in a ranked alert list. In their computational study, the authors demonstrate the robustness of the approach and its impact on resulting revenues and show its applicability using Deutsche Bahn data.

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