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Freight Time and Cost Optimization in Complex Logistics Networks, Using a Dimensional Reduction Method and K-Means Algorithm

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Abstract : The complexity of providing timely and cost-effective distribution of finished goods from industrial facilities to customers makes effective operational coordination difficult, yet effectiveness is crucial for maintaining customer service levels and sustaining a business. Logistics planning becomes increasingly complex with growing numbers of customers, varied geographical locations, the uncertainty of future orders, and sometimes extreme competitive pressure to reduce inventory costs. Linear optimization methods become cumbersome or intractable due to a large number of variables and nonlinear dependencies involved. Here we develop a complex systems approach to optimizing logistics networks based upon dimensional reduction methods and apply our approach to a case study of a manufacturing company. In order to characterize the complexity in customer behavior, we define a “customer space” in which individual customer behavior is described by only the two most relevant dimensions: the distance to production facilities over current transportation routes and the customer's demand frequency. These dimensions provide essential insight into the domain of effective strategies for customers; direct and indirect strategies. In the direct strategy, goods are sent to the customer directly from a production facility using box or bulk trucks. In the indirect strategy, in advance of an order by the customer, goods are shipped to an external warehouse near a customer using trains and then "last-mile" shipped by trucks when orders are placed. Each strategy applies to an area of the customer space with an indeterminate boundary between them. Specific company policies determine the location of the boundary generally. We then identify the optimal delivery strategy for each customer by constructing a detailed model of costs of transportation and temporary storage in a set of specified external warehouses. Customer spaces help give an aggregate view of customer behaviors and characteristics. They allow policymakers to compare customers and develop strategies based on the aggregate behavior of the system as a whole. In addition to optimization over existing facilities, using customer logistics and the k-means algorithm, we propose additional warehouse locations. We apply these methods to a medium-sized American manufacturing company with a particular logistics network, consisting of multiple production facilities, external warehouses, and customers along with three types of shipment methods (box truck, bulk truck and train). For the case study, our method forecasts 10.5% savings on yearly transportation costs and an additional 4.6% savings with three new warehouses.

Keywords : logistics network optimization, direct and indirect strategies, K-means algorithm, dimensional reduction
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