Data-Driven Inventory Management in Omnichannel Supply Chains

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In recent years, large e-commerce companies, such as Alibaba, JD.com, and Amazon, have being promoted a new retailing mode that integrates their on-line channel, off-line channel, buy-online-and-delivery-from-store (BODS) channel/buy-online-and-pickup-from-store (BOPS) channel ([1], [2]). This mode creates an omni-channel supply chain composed of suppliers (manufacturers or wholesalers), e-tail warehouses, and traditional retail stores located at multiple levels and different places. Figure 1 shows the structure of such a supply chain with multiple retail/e-tail channels. Key issues for successful implementation of this new retailing mode include strategic location of e-tail warehouses and retail stores, tactical inventory management at these stocking locations, and operational customer order fulfilment, where inventory management is to determine when to order and how many to order for inventory replenishment of each product at each stocking location in the supply chain. The objective is to deliver goods ordered on-line by customers from e-tail warehouses or retail stores to them quickly at lower costs. In this doctoral research project, we focus on inventory management in omni-channel supply chains.

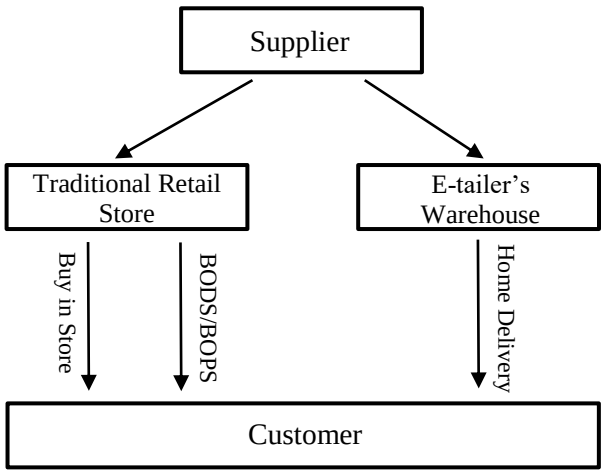

Fig. 1. Structure of an omni-channel supply chain with multiple retail/e-tail channels

In the literature, many studies have addressed inventory management. However, classical inventory models do not consider the coupling among different sales channels (on-line channel, off-line channel, BODS/BOPS channel) and assume stationary customer demands. However, the

demands of products observed by these channels are interdependent; they may be nonstationary because of their seasonality or change of customer buying patterns. Moreover, most studies on inventory management of distribution supply chains only consider a single warehouse and multiple retailers selling only one product to customers, such system is much simpler than omni-channel retailing supply chain existing in the new retail. The main challenge for effective inventory management of an omni-channel supply chain is the stochastic and non-stationary nature of customer demands and the interdependence among multiple retail/e-tail channels. For these reasons, only few studies addressed inventory management of omni-channel supply chains. There is a big gap between the theory of inventory management and its application in the new retail.

Data-driven optimization that integrates machine learning and mathematical programming for decision-making under uncertainty has recently emerged as an effective approach for inventory system optimization ([3], [4]). This approach uses observations of stochastic customer demands as direct inputs to the mathematical programming model of an inventory optimization problem. Different from the classical two-step procedure that first estimates the parameters of a given demand distribution and then solves an inventory optimization problem based on this distribution, the data-driven approach integrates demand estimation and optimization into a single model that directly predicts the optimal inventory decision from historical demand data and feature data. This approach does not require any assumption on the demand distribution and works directly with data.

This doctoral research project aims to develop effective data-driven models and methods for inventory optimization in omni-channel supply chains. More precisely, the project has the following objectives:

1. Establish data-driven mathematical programming models for optimizing inventory policies in omni-channel supply chains.
2. Develop effective and efficient data-driven optimization/machine learning algorithms to solve the models.
3. Implement the models and the algorithms in computer program and evaluate them by numerical experiments on randomly generated instances and real instances.

To well conduct the research expected in this project, a candidate should have good background in operational research/mathematical optimization and computer programming, the knowledge on probability and stochastic processes, machine learning in artificial intelligence will be a plus for his/her application.

The doctoral student will conduct his/her research in Logistics and Optimization of Industrial Systems (LOSI) team, Computer Science and Digital Society Laboratory, at University of Technology of Troyes (UTT), France. The research activities of LOSI are mainly focused on two types of systems: production systems and logistics systems. The proposed doctoral research project well fits into the strategy of LOSI to develop models and methods for effective logistics

management in supply chains. More importantly, we have collaborated with Tmall supply chain platform, Alibaba Group on inventory management under its AIR (Alibaba Innovative Research) program, so we are well aware of real issues for inventory management of supply chains in e-commerce and new detail.

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