Multiobjective Analysis of the Multi-Location Newsvendor and Transshipment Models

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ABSTRACT

Unlike the Newsvendor model, a system based on lateral transshipments allows the unsold inventories to be moved from locations with surplus inventory to fulfill more unmet demands at stocked out locations. Both models were thoroughly studied and researches were usually confined to cost minimization or profit maximization. In this paper, the authors proposed a more realistic multiobjective study of both multi-location Transshipment and Newsvendor inventory models. The aggregate cost, the fill rate, and the shared inventory quantity are formulated as conflicting objectives and solved using two reference multiobjective evolutionary algorithms (SPEA2 and NSGA-II). The proposed models take into account the presence of storage capacity constraints. The obtained Pareto fronts revealed interesting information. When transshipments are allowed, both low aggregate cost and high fill rate levels are ensured. The required shared inventory may have an important variability. The considered objective functions are conflicting and very sensitive to local storage capacities.

Keywords: Evolutionary Algorithms, Inventory Pooling, Multiobjective Optimization, Newsvendor Model, Transshipment Model

LITERATURE REVIEW

There is a considerable amount of Supply Chain Management in the last past decades. Some papers provided interesting surveys. Pokharel (2008) indicated that various objectives could be considered for strategic decision making on Supply Chain Network: (1) increasing service level, (2) decreasing warehouse costs, (3) decreasing total fixed and variable costs, (4) decreasing lead time (order processing and supply lead times), (5) consolidating supplier base, (6) increasing supplier reliability, (7) increasing capacity utilization and, (8) increasing total quality of supply. In the same work, Pokharel (2008) developed a two-objective decision-making model for the choice of suppliers and warehouses for a supply chain network design.

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Arshinder et al. (2008) presented a systematic literature review on the importance of Supply Chain coordination. They reported various perspectives on Supply chains coordination issues and explained various mechanisms available for coordination.

Multiple objectives were investigated and diverse optimization approaches were used. Liao and Rittscher (2007) simultaneously considered the optimization of the total cost, the quality rejection rate, the late delivery rate and the flexibility rate in their stochastic supplier selection problem while involving constraints of demand satisfaction and capacity. Zhou et al. (2003) studied the bi-criteria allocation problem involving multiple warehouses with different capacities using a genetic algorithm based solution procedure. Liberopoulos and Koukoumialos (2005), numerically investigated tradeoffs between near-optimal base stock levels, numbers of kanbans, and planned supply lead times in base stock policies and hybrid base stock/kanban policies.

Special interest in the Newsvendor has increased since the nineties. Abdel-Malek et al. (2008) presented a series of articles addressing issues regarding the newsboy models. They developed new models to extend the existing ones and designated them as the Gardener Problem. The models are based on the application of Lagrange multipliers, Leibniz’s rule and Newton’s method to obtain the optimum solution for the considered random yield and probabilistic demand situations. Other newsvendor extensions in situations of strategic interaction have previously been considered as well, but in different contexts. Parlar (1988) and Lippman and McCardle (1997) considered models with more than one newsvendor where the demand is transferable. In other words, in their models, if a newsvendor is stocked out, it is the customer who moves to a rival newsvendor. Khouja (1999) studied a variation of the Newsvendor Problem based on the analysis of Cost-Volume-Profit optimization. Other researchers have also examined the effectiveness of lateral transshipment and centralized coordination as modern inventory management strategies. Sharma and Jana (2009) presented a multiobjective transshipment planning model for the petroleum refinery industry. The considered objectives were to minimize the total transshipment cost, maximize production, satisfy storage requirements at depots and meet the demand for oil in these sales areas. The goals are defined in a fuzzy sense and a Fuzzy Goal Programming (FGP) model is developed. Olsson (2008) optimized the ordering policies for normal replenishment in systems where lateral transshipments are used as emergency supply in case of stock out. The difference with other models was that the rule for lateral transshipsments is predefined. Köchel and Nieländer (2004) proposed a successful simulation optimization approach where a simulator is combined with an appropriate optimization tool to define optimal policies in very general multi-echelon inventory systems. Xu et al. (2003) estimated customer service in a two-location continuous review inventory model with emergency transshipments. Evers (1997) used a simulation model to examine whether emergency transshipments outperform split orders. These recent researches were based on some early and basic inventory models such as the well-known study of Gross (1963) where it was determined both optimal redistribution and replenishments policies for a two-store inventory system. Later, Krishnan and Rao (1965) considered the analytical determination of optimal base stock levels that would minimize the one-period inventory and transportation costs for inventory systems with emergency transshipments. Tagaras and Cohen (1992) discussed the possible effects of replenishment lead times on pooling policies. They performed a simulation analysis on different pooling policies for a two-location inventory system.

THE MODELS

In this section, we establish a mathematical formulation for both Newsvendor and Transshipment based inventory models showing the analytical relation between them. A bi-objective model is outlined based on cost and fill rate
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