# Chapter 16
# Quantitative Models in Supply Chain Management

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## ABSTRACT

*A supply chain is defined as an integrated system that coordinates a series of inter-connected business processes in order to: (1) obtain raw materials and parts; (2) convert these raw materials and parts into finished products; (3) distribute these products to retailers or consumers; (5) expedite information flow among various business entities; (e.g. suppliers, manufacturers, distributers, 3PLs, and consumers). The major objective of it is to enhance the operational productivity, profitability, and competitiveness of whole supply chain members.*

*There are various classification schemes to categorize supply chain models respect to a wide spectrum of the supply chain concept.*

*Min and Zhou (2002) classified supply chain models to four categories: (1) deterministic (non-probabilistic); (2) stochastic (probabilistic); (3) hybrid; (4) IT-driven.*

*Deterministic models assume that all the model parameters are certainly known and fixed, while stochastic models take into account the uncertain and random parameters.*

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*In addition to the taxonomy developed based on the mathematical structure, the authors have classified supply chain models based on method that are utilized to model the problem. There are four categories: (1) game theory, (2) simulation, (3) met-heuristic algorithms, and (4) fuzzy models. Leng and Parlar (2005) reviewed supply chain-related game theoretical applications in five areas that are used it in this chapter.*

*Moreover, a wide review given by Terzi and Cavalieri (2004) on more than 80 papers about simulation in the supply chain context is used in this chapter. The main goal of this review is to determine which objectives simulation is used to solve the problems, which simulation models are more appropriate and useful for supporting the decision making in the supply chain.*

## GAME THEORY

Game theory is interested in the analysis of conditions that conflict and cooperation are involved. Since its development in the early 1940s game theory has found applications in various areas such as auctions, biology, business, economics, management- labor arbitration, philosophy, politics, sports and warfare. After the initial interests created by its potential applications, operations research/management science specialists more interested in game theory during the 1960s and the 1970s. However, interest of academics and practitioners on the management of supply chains was renewed in the last two decades and they emphasized on interactions among decision makers ("players") composing a supply chain. The effects of this can be explicitly see in the fast growth of publication in various journals dealing with the use of game theory in the analysis of supply chain problems. This section is devoted to overview on game theory applications in different area of supply chain management (SCM).

### Inventory Control

Inventory management problems involve competition arise in either horizontal or vertical channels. First, consider examples of competition in horizontal channels. In one of the early papers in this area Parlar (1988) developed a single-period game theoretic model of competition between two players. Wang and Parlar (1994) extended the model to describe a three person game in the same context. They also investigated the cooperation among players when switching excess inventory among the three players is and is not allowed. They showed that Nash equilibrium exists in both cases and cooperation reduces inventory. In addition, they employed the concept of core to analyze the cooperation model and demonstrated the situations for non-empty core. More recently, Avsar and Baykal-Gursoy (2002) extended Parlar's model in (1988) considering the infinite horizon and lost-sales and checked out a two person nonzero-sum stochastic game under the discounted payoff criterion.

In another early work on single period models, Nti (1987) investigated an inventory procurement model with n competitive organizations (countries). In random demand, Nti showed that a unique Nash equilibrium exists. Lippman and McCardle (1997) examined a competitive news boy problem in both oligopoly and duopoly environments. They started the duopoly case with two facets of demand allocation: the initial allocation and the reallocation. With the initial allocation, they determined various rules to split demands to different firms. The reallocation is the same. Mahajanand van Ryzin (2001)analyzed a more general model with n-firm inventory competition with dynamic choice behavior of heterogeneous consumers and its effects on firms' inventory and profit. Anupindi, et al. (2001) developed a general outline to study a two stage decentralized distribution system where N retailers confront