Analyzing the Impact of Coordinated Decisions within a Three-Echelon Supply Chain

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ABSTRACT

Supply chain performance is highly influenced by the coordination level between its members, which needs information sharing. In this article we consider a three-echelon direct sell supply chain model and focus on the problem of coordinated decision-making between its members. Our contribution is a first approach that measures the impact of the degree of coordination between the members. Demand behavior is modeled using a geometric Brownian process. Simulation models are run in order to analyze various cooperation scenarios. Our results show a direct relation between the degree of coordination within the supply chain and the total system cost. Although this result is intuitive, our simulations allowed us to quantify such a relation and in which measure these costs are whether or not associated to imperfect coordination. [Article copies are available for purchase from InfoSci-on-Demand.com]

Keywords: Cooperation; Decision-Making; Simulation; Three-Echelon Supply Chain

INTRODUCTION AND PROBLEM STATEMENT

In today’s globalized context, enterprise management becomes more and more difficult to master. Market evolution has driven the enterprises to create strategic alliances with both their suppliers and their clients. Today, enterprise networks or logistic/supply chains or even value chains, market competition is not anymore between the enterprises themselves, but between the supply chain(s) they belong (Lee and Billington, 1995). The study of logistic chains may be done from two points of view (Huang et al., 2003). The first one corresponds to the study of supply, manufacturing and distribution activities within one on the members of the supply chain. The second analysis point of view corresponds to the study of coordination mechanism of product, information and economic flows between the members of the supply chain. Models and analysis in this article are given from the second point of view. Although the first approach may be considered as a part of the second, seminal works in the
literature related to the first approach have not very often considered the interaction between the members of the supply chain.

Since several years ago, demand uncertainty is one of the most important characteristics of any market (Cleaves and Masche, 1996; Fisher, 1997). At the production planning level, market evolutions have added great challenges to enterprises concerning data management and maintenance. Coordination within the supply chain has become one of the strategies considered by enterprises in order to achieve their performance objective and to survive within today’s highly competitive market. One of the mechanisms to establish and to maintain coordination within the supply chain is information between the members of the chain. One of the negative consequences of non information sharing is the well-known bullwhip effect: forward order variability augmentation in the supply chain. Supply chain performance is thus highly influenced by the coordination level between its members. According to Sepulveda and Frein (2004a), the notion of coordination between the members of the chain needs some information sharing. Simatupang and Sridharan (2001) claim that positive outputs can be obtained when information is shared: contracts between the members of the supply chain are clear and understandable, it is possible to quickly respond to market variability, coordination between members of the supply chain is easier and opportunistic behavior are reduced. From the quantitative standpoint, these authors showed also gains on storage costs.

The classical buyer-vendor coordination problem introduced by Goyal (1976). Since then, several authors have studied this problem focusing on inventory control, production planning and scheduling, product distribution or even contracts, and considering a variety of performance measures. See for example the works of Toptal et al. (2003) and Toptal and Cetinkaya (2008). The review of models presented here is based on the most recent works as possible. Chen (2001) stated that centralized information about demand may decrease orders’ variability though the logistic chain. Chen et al. (2002) tried to find a quantitative measure of this variability (known as the bullwhip effect) for each member of the supply chain. They proved that the increase of demand variability within the supply chain is an additive function of lead time for each member when shared information is centralized and a multiplicative function otherwise. Cachon and Zipkin (1999) and Sepulveda and Frein (2004b) compared various inventory policies with and without information sharing within a two-echelon supply chain. Zijm and Timmer (2008) considered the problem of coordination of inventory control three-echelon serial and distribution system under decentralized control. Saab and Correa (2005) investigated the general applicability of specific solutions suggested by selected authors in the literature, aiming at controlling the bullwhip effect and consequently reducing inventory and stock-outs, and increasing stock turnover in supply chain managements. Lee et al. (2000) also measured the gains of information sharing, showing that information sharing in the supply chain is positive when both demand correlation and its variance are high and lead times are long. The work presented by Sepulveda and Frein (2004a) implemented a simulation model to analyze coordination scenarios between the members of a dyadic supply chain and information sharing. They used simulation to measure the impact of information sharing on the performance of production scheduling policies. This scheduling problem was also studied by Montoya-Torres (2003) who theoretically proved the gain obtained using information sharing within a two-echelon logistic chain. Kreipl and Dickersbach (2008) present an information background review about production planning and scheduling functionality in commercial supply chain planning software. These authors present three scheduling coordination problems in supply chain planning, namely the integration of production planning and production scheduling, the integration of sales order confirmation and production scheduling, and the integration of vendor managed inventory planning and production scheduling. Yan and Ghose (2008) investigated the
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