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Cooperation between multiple news-vendors with transshipments

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Abstract

We study a situation with n retailers, each of them facing a news-vendor problem, i.e., selling to customers over a finite period of time (product with a short life cycle, such as fashion). Groups of retailers might improve their expected joint profit by coordinating their orders, followed by transshipments after demand realization is known. We analyze these situations by defining a cooperative game, called a general news-vendor game, for such a situation with n retailers. We concentrate on whether it makes sense to cooperate by studying properties of general news-vendor games. Our main result states that general news-vendor games have non-empty cores.

Keywords: Supply chain management; Game theory; News-vendor; Transshipments; Balancedness

1. Introduction

Consider a group of retailers who buy from the same supplier and who have to place their purchase orders well in advance of receiving customer orders. For example, imagine a supplier located in Asia and retailers located in Europe who have to place orders for a seasonal product. They have to place their orders in advance of knowing actual demand to cover the manufacturing and transportation lead time. After all orders have been received, the supplier has to make a release decision on how much to produce in total (i.e., for all retailers). The retailers might improve their joint expected profit, for example when it is possible to postpone the allocation decision (i.e., which portion of the quantity manufactured to allocate to each of the retailers). This raises the question of whether in such a setting it is always beneficial for companies to cooperate and to order jointly. In this paper we use cooperative game theory to analyze this question. We look at the benefits for the total supply chain and at benefits for the

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individual companies, assuming that under cooperation demand information is shared and orders are based on combined demand.

Companies may benefit even more from cooperation by not sharing all information. For example, they may have private information about actual demand as it materializes after placing the order and they may use this information to their own benefit. In case of shortages, they order more than they really need while expecting to actually receive what they anticipate to need (shortage gaming, see Lee et al. (1997)). See, for example, Cachon and Lariviere (1999) for a model in a news-vendor setting where retailers have private information about demand and retailers can influence their allocation through their orders. Cachon and Lariviere (1999) investigate allocation rules that maximize expected total profit and are attractive for the individual companies. They show that supply chains may not benefit from allocation rules that lead retailers to tell the truth (i.e., order exactly their needs). We refer to Cachon (1999) for a review and analysis of non-cooperative game theory in supply chain settings. Further, single period supply chain ordering (usually referred to as contracts), possibly consisting of two consecutive decisions (initial order-reallocation) is reviewed by Tsay et al. (1999). Yet, strategic behavior with non-cooperative gaming is outside the scope of this paper.

This paper contributes to the literature that applies cooperative game theory to Operations Research problems. Borm et al. (2001) provide a recent survey of cooperative games associated with operations research games, in which five types of underlying OR-problems are distinguished, one of them being 'inventory'.

We consider a general news-vendor situation in a supply chain consisting of a single supplier (wholesaler) and n retailers. The retailers order the same product from a single supplier and resell the product to consumers. Each retailer i orders a quantity q_i at the supplier, who in its turn orders a quantity q at the manufacturer of the goods. Every retailer experiences stochastic demand and realization of demand is not known at the moment of ordering. News-vendor models are single period models, which means that inventory is not carried over to another period. Furthermore, any remaining products at the end of the period can be disposed of at a certain expense, or can be sold at a lower price than the market price. Initially, this type of modeling was applied to products with very high perishability, such as newspapers. Later, especially in the fashion industry, news-vendor models were proven to be of use for short life cycle production (see Fisher and Raman (1996) who study the single period setting in the fashion industry), and following the decrease of product life cycles in the high-tech industry, such as personal computers and mobile phones, news-vendor models are now well-accepted to model ordering decisions in these environments (see, e.g., Tayur et al. (1999), for a series of papers using this setting). This means that the news-vendor setting studied in this paper has been widely accepted as one of practical relevance.

In the news-vendor situation discussed above, retailers can increase total expected profits (the sum of expected profits of all parties in the supply chain) by combining their orders. Besides price effects, this is because if some companies have ordered more and others have ordered less than they can sell, products are transferred between these companies. This builds on the traditional news-vendor problems (see, e.g., Silver et al. (1998) and many other textbooks; see also Khouja (1999) for a review). Although ordering jointly is collectively rational, the feasibility of such an arrangement depends on whether the expected profits of individual companies increase as a result of cooperation. It has been investigated in several studies whether it makes sense for companies to cooperate. Gerchak and Gupta (1991) compare four simple allocation rules in a continuous review single period inventory model with complete backordering. They show that individual stores may be unhappy. Robinson (1993) reexamines their results in terms of the core and subsequently studies the Shapley value (cf. Shapley, 1953) for these games and an alternative allocation rule for games with a large number of retailers. Hartman and Dror (1996) formulate three criteria for allocation rules in this setting: non-emptiness of the core, computational ease, and justifiability. This last criterion demands the existence of an appealing dual