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Coordination of competing supply chains with news-vendor and buyback contract

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ABSTRACT

Under the competing supply chain framework, we examine the impact of buyback policy on retail price, order quantity and wholesale price in a duopoly of two manufacturer–retailer supply chains. Demand is assumed to follow a general distribution similar to a newsvendor case. We consider two channel policies for both competing supply chains: Vertical Integration (VI) and Manufacturer's Stackelberg (MS). We show that buyback strategy can lead to a higher profit than non-buyback in both VI and MS in competing supply chains, which is consistent with existing result in a single supply chain. We also show that the profits obtained by the supply chain individuals and the entire supply chain profit increase as the chain competition increases.

1. Introduction

Supply chain coordination has attracted a great deal of attentions from both practitioners and researchers in the past decade. Existing work has shown that in a single chain with perfect competing retailers a vertically integrated supply chain maximizes the chain profit (see for example, Jeuland and Shugan, 1983; Cachon, 2003; Ru and Wang, 2010; Li et al., 2009). However, in competing supply chains this result may never hold. In a recent work, Baron et al. (2008) and Wu et al. (2009) suggest that the supply chain coordination mechanisms that focus on inducing supply chains to act as if they are vertically integrated should be treated with caution.

Both Baron et al. (2008) and Wu et al. (2009) adopt the framework of McGuire and Staelin (1983) and focus on two supply chains operations in the same market. Wu et al. (2009) suggest that such a framework can be used to model lots of practical situations including the cellular phone industry, Internet and telephony services, the Canadian coffee shop market, fast food, car manufacturing and retailing, and crude oil and gasoline industries. Baron et al. (2008) focus on bargaining contract in a certain demand case and Wu et al. (2009) extend the work of Baron et al. (2008) to include uncertain demand with only two states: a high-demand and low-demand state. Wu (in press) develops bargaining models in supply chain with price and promotional effort dependent demand. In the current study we extend the work of Baron et al. (2008), Wu et al. (2009) and Wu (in press) to include newsvendor models and buyback contracts.

We examine the impact of buyback policy on retail price, order quantity and wholesale price in a duopoly of two manufacturer–retailer supply chains using newsvendor model. In the competing supply chains, the manufacturer maximizes its profit under its own optimal choice of a wholesale price. Given the wholesale price, the retailer makes the procurement determination and obtain the purchasing items from the manufacturer and resells them at the retail level with a self-determined price. We check both non-buyback policy and buyback policy for two competing supply chains in VI and MS. We note that in the VI case with buyback policy the manufacturer and retailer act as the same agent to set up a return policy and decide on ordering quantity and retail price.

The rest of this paper is organized as follows: the next section presents a literature review. Section 3 presents the models and analysis. Section 4 reports computational experiments that illustrate our results and findings. Section 5 discusses conclusions and future research.

2. Literature review

There are two streams of the literature relevant to this paper: (i) supply chain coordination using buyback contracts and (ii) supply chain coordination models with uncertainty and competition.

The first stream of the literature discuss supply chain coordination and the design of contract confronting stochastic demand. Various supply chain contracts have been discussed in the literature,

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which involves, but not limited to, buy back contracts revenue sharing contracts quantity flexibility contracts (Tsay et al., 1999), quantity discount contracts and others Pasternack (1985) and Lariviere and Porteus (2001) discuss a return policy in a single manufacturer and retailer channel using the newsvendor-type demand. Results show that the unrestricted return quantity policy is independent of the demand distribution. Lariviere and Porteus (2001) discuss a return policy in a single manufacturer and retailer channel using the newsvendor-type demand. Results show that the unrestricted return quantity policy is independent of the demand distribution. He does not consider supply chain coordination in his model. Tsay et al. (1999) assumes the retailer receives an imperfect demand signal before submitting his final order and production is done without learning any demand information in advance, which resemble a newsvendor problem. Wang (2004) develops a generalized newsvendor model to analyze the coordinated quantity decisions between the manufacturer and the buyer. Wang and Gerchak (2001, 2002) and Cachon (2003) provide good recent reviews of the first stream of the literature.

The above literature ignore competition between different supply chains. Padmanabhan and Png (2004) show that a manufacturer can use a buy back contract to manipulate price competition between retailers and increase its profitability in the presence of demand uncertainty. This conclusion is based on Padmanabhan and Png's (1997) simplification of demand uncertainty applied to the monopoly market. Note that the simplification of demand uncertainty in the duopoly market has never been discussed, thus the methods in Padmanabhan and Png (2004) are problematic if demand uncertainty in the duopoly market cannot be simplified using the technique applied to the monopoly market. Moreover, Padmanabhan and Png's (1997) results hold only if the demand uncertainty can be resolved before retail price is determined and a constraint is imposed on the demand uncertainty. In practice, the assumption needs to be relaxed.

The second stream of the literature considers competition and cooperation for supply chain individuals. Deneckere et al. (1997) examine a market with a continuum of identical retailers offering completely homogenous products. Cachon and Zipkin (1999) and Cachon (2001) develop game-theoretic models for both continuous review and periodic review cases. Lariviere and Porteus (2001) examine the case where a wholesaler acts as a Stackelberg leader by setting a wholesale price and a newsvendor applies its best response of order quantity. Chen et al. (2001) extends this model by considering multiple competing retailers, each facing a random demand volume. However, competition between competing supply chains has never been addressed in above-mentioned literature.

In the marketing science field, various competition schemes in different channels have been addressed. Choi (1991) considers two manufacturers selling their products through a common retailer. Lee and Staelin (1997) and Trivedi (1998) generalize the above work to a competitive environment with two manufacturers and two common retailers. To the best of our knowledge, this paper is the first to address competition between different supply chains using newsvendor model. Moreover, we address the coordination of newsvendor model using four game models: (i) VI non-buyback, (ii) VI buyback, (iii) MS non-buyback and (IV) MS buyback.

3. Analysis

3.1. Decision structure

We consider two competing supply chains consisting of two manufacturers and two retailers. The decision sequence is depicted in Fig. 1. In the ith supply chain, the manufacturer maximizes its profit by choosing a wholesale price w_i. Similar to a newsvendor problem, the retailer chooses her desired order quantity q_i before the start of a single selling season that has stochastic demand. Finally the retailer determines her retail price p_i to maximize her expected profit.

Using both non-buyback policy and buyback policy, we consider two channel policies for both competing supply chains: VI and MS. Buyback contracts provides mechanisms for the retailer and the manufacturer to share the risks embedded. In a buyback contract, a wholesale price w_i^B and a buy back price B_i for each unsold unit are specified by the manufacturer in the ith SC. The decision structures in these four game cases are depicted in Fig. 2. In the MS case, we have three decision variables: wholesale price w_i, retailer price p_i and ordering levels q_i, while in the VI case we only need to decide p_i and q_i.

In VI, the manufacturer and the retailer are controlled by a centralized decision maker and thus both the manufacturer and the retailer face the same market. After the centralized decision maker i announces a production policy, the centralized decision maker determines the retailer price. In VI non-buyback case, the manufacturer i determines the production quantity q_i while in VI buyback case, the manufacturer i chooses both the production quantity q_i and the return policy reflected in the buyback price B_i.

In MS, the manufacturer i announces a policy and the retailer i then choose the retailer price and ordering levels. The manufacturer i has market power to impose his individual optimal policy on the retailer then no incentive exists for either the manufacturer or the retailer to deviate from their individual optimal policy. The weaker player, i.e., the retailer, must deviate from his individual optimal policy and adapt to the manufacturer's policy. In MS non-buyback case, the manufacturer i determines the production quantity q_i while in MS buyback case, the manufacturer i chooses both the production quantity q_i and the return policy reflected in the buyback price B_i. This MS structure is common in literatures (Padmanabhan and Png, 1997, 2004; Wang, 2004), where return policies are carefully studied with application to the video rental industry.

3.2. Notations and general models

Notations in this study are defined as follows:

p_i	the ith retailer price, $i=1,2$
q_i	the ith retailer's order quantity
v_i	per unit salvage value in the ith supply chain
w_i	wholesale price by the ith manufacturer in the non-buyback case
$D_i(p,\beta_i)$	uncertain demand function determined by related price p and some randomness β_i
$f_i(\bullet),F_i(\bullet)$	pdf and cdf of the distribution of $D_i(p,\beta_i)$
$d_i(p_i,p_j)$	expected demand function

In a buyback contract, a wholesale price w_i^B and a buy back price B_i for each unsold unit are specified by the manufacturer in the ith SC

w_i^B	wholesale price by the ith manufacturer in the buyback case

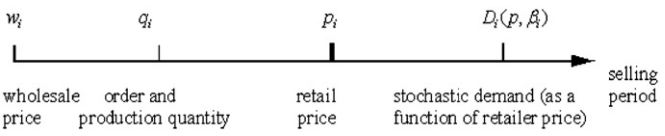

Fig. 1. Decision sequence.