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Supply chain coordination contracts with inventory level and retail price dependent demand

S. Saha [a,*], S.K. Goyal [b]

[a] Department of Mathematics, Institute of Engineering & Management, Salt Lake Electronic Complex, Kolkata 700091, West Bengal, India
[b] John Molson School of Business, Department of Decision Sciences and MIS, Concordia University, Canada H3G1M8

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ABSTRACT

In this paper three unlike coordinating contracts namely (i) joint rebate contract (ii) wholesale price discount contract and (iii) cost sharing contract are proposed for two echelon supply chain coordination perspective under stock and price induced demand. It is found analytically that the manufacturer's and the retailer's preferences among three contractual forms are not always aligned. By applying bargaining theory, it is established that stock elasticity plays an important role to select coordination contract and a threshold value stock elasticity is also determined, below which cost sharing contract is not feasible. It is also found that the retailer with higher bargaining power always prefers wholesale price discount contract among considered three contracts. Results are illustrated analytically as well as numerically.

1. Introduction

Demand of goods, especially in retail industry, is largely influenced by the product on display. According to Levin et al. (1972) "at times, the presence of inventory has a motivational effect on people around it. It is a common belief that a large pile of goods displayed in a departmental store leads the customers to buy more." In practice, retail stores, like Costco, Spencer, Wall-Mart stock large piles of goods on their shelf to magnetize customers. Marketing literature supports the belief that consumer demand may indeed vary with the inventory on display. For example, an investigation by Desmet and Renaudin (1998) has supported the hypothesis that direct shelf-space elasticity is significantly non-zero for many product categories. Chang et al. (2006) have also mentioned that an increase in shelf space for an item always induces more customers to buy it. To explore this, in the last three decades variability of inventory level dependent demand rate on the analysis of inventory system is described by researchers, see Silver and Meal (1979), Ritchie and Tsado (1985), Urban (1992), Padmanabhan and Vrat (1995), Abbott and Palekar (2008), Panda et al. (2008, 2009), Goyal and Chang (2009), Chang et al. (2010), Teng et al. (2011), Soni (2013), Tsao et al. (2014), Wu et al. (2014), Yang (2014) and others. There is a vast literature on inventory level dependent demand and its' overview can be found in the review article by Urban (2005). Although several researchers have explored characteristics of inventory-dependent demand models, few of them have discussed coordination issues of the supply chain with inventory-level-dependent demand. An important focus of this research is to design supply chain coordination contracts. Commonly used contract mechanisms have multiple versions, including buy back (Xiao et al., 2010); mail-in- rebate (Chen et al., 2007); quantity discount (Weng, 1995; Cachon, 2003; Hsieh et al., 2010); Revenue sharing (Cachon and Lariviere, 2005); two part tariffs (Lariviere, 1999); quantity flexibility contracts (Tsay, 1999); target-level sales rebates (Taylor, 2002) to name a few. In these studies, coordination mechanisms are applied in price dependent deterministic or stochastic environment. However, it is observed that items like fashion apparel, consumer goods, FMCG products, etc. reflect shelf-space elasticity. The recognition of this problem has initiated researchers to study supply chain coordination under inventory dependent demand. Wang and Gerchak (2001) have developed models for coordinating decentralized two-stage supply chains when demand is shelf-space dependent. They have characterized retailers' Nash equilibrium and explored whether the manufacturer can use incentives to coordinate such supply chains. Zhou et al. (2008) have also considered the coordination issues in a decentralized two-echelon supply chain, where the manufacturer follows a lot-for-lot policy, and the demand is stock dependent. Parthasarathi et al. (2011) have considered the stock-dependent phenomenon and studied the role of quantity discounts and return policies in the coordination of a supply chain. Panda (2013) has discussed effect of revenue and cost sharing contract under stock-price dependent demand. Yang et al. (2014) have considered the effect of credit period and quantity discount to coordinate a two-echelon supply chain under stock dependent demand rate. But in this paper we have analyze the performance of three different coordination contracts and their implications are analyzed with respect to stock elasticity.

* Corresponding author. Tel.: +91 339333553392.
E-mail addresses: subrata.scm@gmail.com, subrata_raju@rediffmail.com (S. Saha), sgoyal@vax2.concordia.ca (S.K. Goyal).

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To consider the variability of both the stock and price, in this paper we investigate the performance of two-stage supply chain with (i) joint rebate contract (ii) wholesale price discount contract and (iii) cost sharing contract under stock and price dependent demand. A recent released 'Shopper Trends Study' by Nielsen India —which covers the top eight metros and six other cities with population over 20 lakh—reinforces what the Indian shoppers looking for: deals. The proportion of shoppers actively seeking promotions has shot up from 39% to 54% a year ago. Behavior of shoppers is nudging retailers or manufacturers towards creating 'deal-weeks' as regular events. One of the largest hypermarket chains Big Bazaar, Spencer and similar modern trade formats have transformed secular public holidays like Independence day or Republic day into giant sale occasions. The marketing and economics literature have investigated the use of various forms of rebate. Gerstner and Hess (1995) have examined how retailer and consumer rebate induce the retailer and how such promotions influence manufacturer and channel profits. Taylor (2002) have noted that the sales rebate contract is one of the contracts that coordinate the supply chain and channel rebates are widely adopted in the hardware, software and auto industries. Krishnan et al. (2004) have focused on the use of retailer rebates in the presence of retailer efforts. Bernstein and Federgruen (2005) have shown that buy-back contracts with a price-discount sharing scheme jointly coordinate a two-echelon supply chain. Wong et al. (2009) have conducted a detail analysis of sales rebate contract to achieve supply chain coordination. Aydin and Porteus (2009) have compared a per-unit retailer rebate and a per-unit customer rebate. The authors have concluded that neither the manufacturer nor the retailer always prefers one particular rebate to the other. Demirag et al. (2010) have analyzed customer rebate and retailer incentive promotions in the auto industry. Yang et al. (2010) have shown that rebate promotions, combined with manufacturer's suggested retail pricing, can dampen price-setting retailers' possible adverse response to the promotion. Saha (2013) have analyzed various rebate induced contract to coordinate a two-echelon supply chain under linear and iso-elastic demand. To the best of our knowledge, there is no research investigating the interaction between rebate and stock-price dependent demand in the design of supply chain contracts. Apart from the rebate induced contract, cost sharing contract can be used to reduce the burden of huge holding cost of the retailer involved in stock-price dependent demand. Several researchers have anticipated contract based on cost sharing apart from holding cost. Chao et al. (2009) have proposed two contractual agreements based on cost sharing by which product recall costs can be shared between a manufacturer and a supplier to induce quality improvement effort. Leng and Parlar (2010) use buy-back and lost-sales cost-sharing contracts between the n-suppliers and the manufacturer to coordinate the supply chain. Kunter (2012) has shown that channel coordination requires cost and revenue sharing when demand is affected by price and non-price variables. In this paper we consider the demand of the product is stock-price dependent. To maximize profit, the manufacturer insists the retailer to carry large amount of inventory. As a consequence the feasibility of holding cost sharing contract is analyzed in this paper. We have also investigated the effect of stock sensitivity on contractual behavior. Oddly, we are unaware of any published study on comparison of the performance of cost sharing, rebate induced coordination contract and wholesale price discount contract in a two level supply chain with price and stock dependent demand.

The main purpose of this paper is to study the order quantity and retail price decision in the two-stage supply chain when the demand is dependent on the displayed inventory level and selling price of the product. Our study differs from prior studies in the following major aspects. First, we study performance of three different contracts under same channel structure with stock-price dependent demand. First one is rebate induced, second one is traditional wholesale price discount contract and last one is holding cost sharing contract. Secondly, although the design of contracts has been extensively studied, but supply chain members' preferences for contractual forms have not been comprehensively examined under stock-price dependent demand. For this reason, we conduct a detailed investigation of the manufacturer's and the retailer's preferences among the three types of contract. Thirdly, under stock dependent demand, stock elasticity plays a significant role for ordering decision. The retailer with high stock elasticity always order more to generate revenue in short period. But as initial ordering quantity increases holding cost of the retailer also increases. This phenomenon insist us to study the behavior of stock elasticity on contracts analytically to identify the range of variation of preference in perspective of each channel member. The rest of this paper is organized as follows: The model is formally developed for cooperative and non-cooperative decision making in Section 2 and then coordination of the chain is analyzed. The managerial implications of analytical findings are derived in Section 3. A final discussion, in Section 4, provides some comments on the main results obtained, on the shortcomings of the model and some suggestions for future research.

2. Notations and assumptions

The following notations and assumptions are used throughout the paper. Additional notations and assumptions will be listed when needed.

2.1. Notations

c_m	the marginal production cost of the manufacturer
c_r	the marginal ordering cost of the retailer
h	the holding cost per unit per unit of time for the retailer
p	the unit selling price of the product (decision variable)
w	the unit wholesale price of the product (decision variable)
$I(t)$	the retailer's inventory level at time t
β	retail price elasticity of demand rate
δ	inventory level elasticity of demand rate
a	the scale parameter in demand
Q	the order quantity of the retailer (decision variable)
T	the length of the order cycle (decision variable)
π_c	the average channel profit
π_r	the average profit of the retailer
π_m	the average profit of the manufacturer

2.2. Assumptions

1. The market demand rate of the product is dependent on the current inventory level and selling price of the product. In this paper the functional structure of the consumer demand $D(p, I(t))$ is assumed to be in the following form: $D(p, I(t)) = f_1(p)f_2(I(t))$ (Xie and Neyret, 2009; SeyedEsfahani et al., 2011), where $f_1(p)$ reflects the impact of the retail price on the demand, and $f_2(I(t))$ reflects the impact of the current inventory level on the demand. We further assume that f_1 and f_2 are respectively linearly decreasing with respect to p (Weng, 1995) and nonlinear function of $I(t)$ (Urban, 2005), which is a well accepted functional form in the literature. Specifically, we assume the following polynomial $D(p, I(t)) = (a - \beta p)(I(t))^{\delta}$ where $a > 0$ is a scale parameter. δ $(0 < \delta < 1)$ reflects the elasticity of the demand rate with respect to the inventory level. β (> 0) is customers retail price