



# An integrated revenue sharing and quantity discounts contract for coordinating a supply chain dealing with short life-cycle products



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## ABSTRACT

This paper develops a combined contract model for coordinating a two stage supply chain where the demand at the retailer's end is price sensitive and stock dependent. It has been shown that proposed coordination mechanism achieves perfect coordination and win-win situation for both the members of the supply chain. Further, an extensive sensitivity analysis is performed to examine the impact of various parameters on supply chain performance. It has been found that stock dependency factor has positive impact on order quantity and subsequently on supply chain performance. The paper has also made a comparative statics analysis to see the impact of certain parameters on the pricing and replenishment policies of the retailer.

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## 1. Introduction

Short life cycle products are characterized by a short selling season after which their value reduce drastically. Fashion apparel, electronic goods, personal computers, toys etc. are some of the examples of short life cycle product. The short selling season with uncertain nature of demand poses many challenges to the members of supply chain (SC) dealing with such type of products. For example, the Korean manufacturers of cellular phones introduce more than 50 new models each year, and the average life-cycle of cellular phones in Korea is less than 10 months [1]. The short life-cycle products on one hand, invite the risks of overstocking and understocking while on the other hand, it provides greater opportunities for higher margins [2]. These attractive characteristics of this category of products have prompted the researchers to work in the area of managing supply chains of short life-cycle products. In addition to it, since the selling season of such product is small, it is necessary to ensure the availability of stock in the shelf of the retailer and display of it plays an important role in stimulating the demand. Stock dependent demand has been studied in the inventory literatures for quite some times now (Urban, [3]) but only few studies have explored the effect of stock dependency on the performance of the SC and it has motivated us to take up the study on price sensitive stock dependent demand of short life cycle product in the context of SC.

The uncertain nature of demand, faulty planning and poor purchasing practices are some of the reasons that increase the risk of under stoking and over stoking of short life cycle products among the members of the SC. To minimize these risks, various contracts such as buy back (BB), quantity discount (QD), revenue sharing (RS) and quantity flexibility (QF) contract etc. have been cited as coordination mechanism in the SC literature. For example, Agrawal and Seshadri [4] developed risk

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free contract for a risk averse retailer under news vendor framework to coordinate the SC. In SC contract literature, BB contracts have been widely studied, but in reality, BB contract has certain limitations. First, the physical handling of returns may be impractical in certain situations [5]. Second, the retailer may not have enough cash to go for one time procurement of the optimum stock [6]. Under such situations it is necessary to explore other contract mechanisms to coordinate the SC. RS is one such mechanism that has gained a lot of attention from both academia and industry [7,1]. Under RS contract, the retailer pays the supplier a wholesale price for each unit purchased and a certain percentage of revenue the retailer generates [8]. This type of contract is attractive to the retailer and can replace BB contract particularly when the items are expensive [6]. There are certain advantages with RS contract over BB contract. First, the physical handling of returns is not required. Second, the retailer obtains goods at a lesser wholesale price and need not have to invest huge capital in procuring the items. It is found that RS contract is widely employed in video rental industries and e-commerce businesses.

In this paper, using newsvendor framework, a combined RS and QD contract model is developed for single manufacturer and single retailer SC dealing with a short life-cycle product considering demand to be price-sensitive and stock dependent. This paper extends the work of Yao et al. [9]. They have studied RS contract using price-setting newsvendor framework. Our work differs from Yao et al. [9] in two respects. First, it captures stock dependency of demand in addition to price-sensitivity. Second, it integrates RS and QD contract.

In Section 2, we briefly review the literature relevant to our work. In Section 3, we present the mathematical model developed for coordinating the SC. In Section 4, we illustrate the model through a numerical example. We also provide the results of sensitivity analysis on this section. Section 5 concludes the paper with a brief summary and directions for further research work.

## 2. Literature review

In this section, we have provided a brief review of literature related to our work. Excellent review on SC contract models have been provided by Tsay et al. [10] and Cachon [11] and readers can read those articles to get idea about different types of coordination models. Earlier, many authors have studied SC coordination considering demand as deterministic or constant. But in real practice, it is not true and demand is found to be stochastic in nature. Stochastic model under news vendor framework can be classified as fixed price and price setting. In fixed price case, the market price is considered to be fixed and determines only the optimal order quantity (see [12,13]); whereas in case of price setting, optimal price and order quantity are determined simultaneously (see [9,14–17]). Wei and Choi [18] under mean variance framework, SC coordination is explored through wholesale price and profit sharing scheme. Chiu et al. [19] have studied target sales rebate as a coordination mechanism for a manufacturer and a risk averse retailer under mean variance framework. Tsay [20] analyzed how sensitivity to risk affects the behaviors and outcomes on both sides of a manufacturer-retailer supply relationship, and how these dynamics are altered by a manufacturer return policy.

Modeling of demand is an important component to correctly depict the reality. It is well known that price influences demand and vice versa. To capture this reality, some researchers have introduced a new concept from the principles of thermodynamics to model demand and price relationship. When demand is price sensitive, they consider price to be analogous to temperature. In such models, demand is considered as the potential or the driving force that creates the difference in monetary value or price and for details of such model, one can refer Jaber et al. [21,22]. In recent times, some authors have developed models considering sales effort of the retailer, lead time and stock level at the retailer's end as a means for enhancing the demand [23–25].

Further, it has been well recognized in the literature that demand of many items at the retailer level is proportional to the amount of inventory displayed [26]. The real-life examples include short life-cycle products such as, sugar, spices, clothes, gift cards etc. [27]. Specifically, the supermarkets, where the products are displayed on the aisles, require inventory control models that take stock level into consideration. To model this situation, mainly two approaches have been adopted in the literature. Demand is expressed as a function of initial stock level or is considered as time dependent stock level [3]. Though in the inventory literature, the importance of stock level has been recognized for quite a long time, yet it has not received adequate attention from SC management researchers. A coordination model considering a two stage SC with an initial stock level dependent demand was developed by Wang and Gerchak [28]. A coordination model considering stock dependent demand is also developed recently by Zhou et al. [29].

To coordinate a SC, in recent times, combined contract models, i.e., contracts with two or more coordination mechanisms have been proposed in the literature [30,31]. Under fixed price newsvendor framework, Shi and Su [13] developed a combined BB and QD contract model and have shown that contract is self-enforcing. Burnetas et al. [30] have pointed out that QD contract combined with other mechanisms such as BB offers tremendous scope for future research. Recently, Güler and Bilgiç [32] have used a mixed BB and RS contract to coordinate an assembly system. The manufacturer shares its sales revenue with the suppliers. Aydin and Porteous [33] considered two types of rebate for coordinating a two stage SC, one directly to the consumer and another to the retailer and have shown that no members of the SC always favor only one kind of rebate. Demirag et al. [34] also studied two different types of promotion, retailer incentive scheme and customer rebate policy in a two stage SC setting. They have shown that under market uncertainty condition, combined policy performs better and improves the sales and increase the profit of the manufacturer. Considering demand as a function of sales effort of the retailer, Taylor [24] has shown that SC coordination can be achieved through a properly designed target rebate and return contract.

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