

# Simulation Study of Collaborative Inventory Management for Seasonal Products by Incorporating Newsvendor and Buyback Contract

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**Abstract.** As supply chains become leaner, supply chain (SC) managers are often subjected to decrease inventory. Determining the appropriate inventory level for seasonal products without compromising the level of service provided to customers is crucial. This poses a challenge for supply chain managers to find the best trade-off between having excess or less inventory. A well-known model to determine such trade-offs is the newsvendor model. This model is focused on a decentralized business strategy. This research seeks to evaluate the contributions of collaborative inventory management for seasonal products with demand uncertainties having a single order in a cycle through newsvendor and buyback contract for a two-tier SC for both decentralized and centralized business strategies. To explore the effects of these uncertainties on seasonal products such as newspaper, apparels, perishable foods and major holiday products, a Monte Carlo simulation model was used to optimize the decision variable (the maximum order quantity,  $Q^*$ ) to improve the financial performance of the SC. The results indicate that wholesale price discount and buyback contract are efficient in collaborative inventory management. Buyback contract is less attractive when costs associated with returns are high. High return costs reduce the profitability of the SC significantly.

## Introduction

In today's competitive business environment, supply chain should efficiently and effectively integrate suppliers, manufacturers, warehouses, and stores so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time [1]. Therefore, businesses co-operate in the supply chain (SC) looking for a more efficient flow of materials, faster deliveries, and reduction of stock levels, for quick response to customer changing demands. However, even though supply chain management (SCM) plays a significant role in improving the management of inventory and the entire SC, uncertainties are always considered to be inherent part of every SC. These uncertainties are due to changes in the forces of the market, rapid technological innovations, forecasting, consumer perception and disasters. These drivers of uncertainties make the market demand to be stochastic both in quantity and quality. Supply chain collaboration (SCC) has been considered as an effective tool to minimise these uncertainties and improve the performance of the entire SC. According to Wee et al [2] supply chain collaboration (SCC) is defined as, "Two or more autonomous partners working jointly to plan and execute a supply chain to achieve common goals through predetermined negotiations based on rules and structures to govern their mutual relationship." It enhances synergy to develop among players in the SC and supports joint planning and real-time information sharing in a bid to improve the performance of the entire SC [1, 3–5].

Seasonal products are very essential in our everyday life. However, retailers selling them often face the challenge in aligning their inventory levels with the uncertainty of market demand. Therefore, how to make the ordering and pricing decisions could help to increasing the profitability of the SC. Collaborative inventory management would potentially reduce inventory, lower costs, shortened lead times, increases the quality and level of production, increases service level, better customer satisfaction, enhances flexibility and improves the performance of the SC [6]. The stochastic single period inventory model (SPIM) also known as the classical newsboy problem (CNP) is a well-known

stochastic problem in inventory control theory. According to Adhikary et al [7], this model is particularly known to find the optimal order quantity in an attempt to minimize the expected cost and/or maximize the expected profit. Buyback contract is one of the business strategies the players in the upstream of the SC use to encourage the downstream players to increase their order quantity. The motivation for considering a buyback contract is that it is one of the popular contracts in practice, well understood in contracts literature, and coordinates the supply chain under the supposition of information visibility [8].

As a result of the keen competition that comes with the tendency of having control over market share, there are many challenges faced by retailers today in the retail supply chain [9]. This research *is aimed at investigating how collaborative inventory management improves the performance of a two-tier SC of seasonal products with high demand variability* [10]. Also, how to optimise inventory retention in situations where demand is uncertain for the SC players to strike a balance between the costs associated with under and over stocking [11].

This research proposed a model extended from the (CNP) by considering collaborative and buyback contract scenarios on inventory management for seasonal products limited to *apparels, newspapers, groceries and major holiday products*. This research is different in the following ways: the model is analysed by using a Monte Carlo simulation and made a comparison on the following scenarios: when there is no collaboration; when there is collaboration but no buyback contract and when there is collaboration with buyback contract. These scenarios are limited to managing inventory for a single order per cycle with one decision variable: order quantity. It will showcase the fact that even though the market can be highly volatile, yet with proper inventory management combined with collaboration, businesses would potentially increase their financial performance. It would also add to the existing literature for further research.

## Literature Review

Supply chain collaboration has been defined by many authors depending on their orientation. For example, Simatupang & Sridharan [12] defined SCC as “Two or more chain members working together to create a competitive advantage through sharing information, making joint decisions, and sharing benefits which result from greater profitability of satisfying end-customer needs than acting alone.” According to Ha & Nam [13], it is “Joint work that generates better performance through joint planning and execution of supply chain operations by two or more independent participants.” Simatupang & Sridharan [14] postulated SCC as, “A network consisting of key players, such as a retailer and a supplier who partner with each other to improve the value of the entire system.” From these definitions, it is apparent that whatever the orientation from which SCC is been defined, the goal is to satisfy the end-user and increase the performance of the SC by the shared responsibility of the key players involved in the chain.

Supply chain academics have put forward a classification for the identification of different product characteristics in the retail chain. Retail merchandisers are therefore classified into two different categories: functional and innovation products depending on their sales history [15]. Functional products also known as staple products are those that are purchased daily. They are classified according to their inventory cycles [16]. Here, cycle inventory refers to those items held by the store to fulfil the demand between orders. They could also mean those items purchased and stored in anticipation for future demand [17]. The amount of cycle inventory to be held is a factor in the relationship between production and transportation or batch sizes. Economically, companies should purchase in large lots to benefit from economies of scale in transportation, production or administrative costs. But in the real world, things seem to happen a bit differently. The cost of carrying inventory plays a major role in the frequency-of-buy decisions in most companies. This is one of the very strategic challenges retail supply chain managers are faced with. They are often charged with finding the trade-off between the cost of holding inventory and the frequency of transportation of goods in terms of cost benefits. Supply chain design based on operational efficiency is most suited for functional products [18]. Innovative products on the other hand, are more difficult to forecast,

but they provide huge profit margins to manufacturers or distributors. They are also characterized by short sales period, which usually includes new product introduction and seasonal products [15]. They have a better profit margin and higher mark-up percentages than staple products. More differentially, they have multiple retail paths to customers. Supply chain design based on operational responsiveness is mostly suited for innovative products.

Collaboration is defined as two or more companies sharing the responsibility of exchanging common planning, management, execution, and performance measurement [5]. Collaboration gives suppliers a better understanding and ability to cope with demand variability. This is an important feature when trying to counter the costly bullwhip effect. For this reason, retailers and suppliers have become partners in meeting the challenges of fluctuating demand. The impact of the bullwhip effect, where suppliers receive a disproportionate amount of variability based on retailer consumer demand variability, has helped facilitate collaborative efforts to better respond to demand fluctuations [19]. These initiatives are aimed at reducing costs for both the retailer and supplier.

Another supplier and retailer partnership initiative is collaborative planning, forecasting, and replenishment (CPFR). Collaborative Planning, Forecasting and Replenishment (CPFR) is the latest strategy in the evolution of supply chain collaboration. It is an all-inclusive collaboration strategy that provides an outstanding opportunity for both the customer and the supplier to collaborate and jointly develop demand forecast and replenishment planning activities. It combines the intelligence of multiple partners in the planning and fulfilment of customer demand with the assumption that the parties involved have synchronized their data and established standards for exchanging information [20].

Vendor managed inventory (VMI) or consignment inventory (CI) is another form of retailer-supplier collaboration. In a traditional supply chain (TSC), the task of the supplier is to execute orders as precisely as possible with the challenge to ensuring an efficient and reliable supply in order to meet customers' demand. As a result of this, inventories are held to avoid stockouts while at the same time organisations seek to keep inventory levels low to avoid over stocking related costs. A solution for this problem is Vendor Managed Inventory (VMI), which in contrast to TSC strategies, increases the service level for the customers and at the same time allows a reduction of inventory levels and hence inventory costs [21]. Information sharing practices such as VMI give supply chain players access to more accurate demand information [22]. With VMI, the vendor can coordinate long-term plans and control the day-to-day flow of products and materials [23]. Determining the appropriate inventory level is crucial since inventory ties up money and affects performance. It becomes clear that management attention should be focused on keeping inventory level somewhere in between, striving for increased customer satisfaction and minimum stock outs while keeping inventory costs as low as possible [24].

The objective of a vendor is to provide the customers a reasonable customer service level (CSL). The CSL is the expected probability of not hitting a stock-out during the next replenishment cycle or the probability of being able to service the customers' demand without facing backorder or lost sales [25]. A stock-out does not only instantly cause a profit loss on cancelling the order, but also affects the long term profitability of the business since it has the potentiality of reducing the likelihood of receiving new orders from those customers whose demand could not be met [26]. For non-perishables, overstocking is acceptable as unsold products can be sold at a later point. But for perishable or seasonal products, they might perish before they are sold even at discounted value, resulting to a lot of waste. The notion of CSL is more relevant in scenarios where the future demand is uncertain as being investigated by this research. However, CSL should not be confused with fill rate (FR) which represents the fraction of demand that is served without delays or lost sales. In today's aggressive business world, business minded entrepreneurs often try to regulate and monitor the percentage of total volume ordered that is readily available to satisfy customer demand, not the percentage of cycles without a stock out. This quantity is called fill rate and is often considered to be a better measure of inventory performance. CSL indicates the frequency of stock-outs, not taking cognisance of the total amount whereas, (FR) measures the inventory performance based on volume. CSL reflects the frequency of stockouts. FR on the other hand, reflects the amount stocked out, that is the percentage of demand that is not met.

$$CSL = \frac{C_{us}}{C_{us} + C_{os}}. \quad (1)$$

$C_{us}$  is the cost per unit of under stocking and  $C_{os}$  is the cost per unit of over stocking.

$$FR = 1 - \frac{E(bo)}{E(d)/\text{period}}. \quad (2)$$

$E(bo)$  is the expected back order and  $E(d)/\text{period}$  is the expected demand per period.

$$E(bo) = \sigma \times L(z). \quad (3)$$

$L(z)$  is the loss function with the standard normal distribution.

The concept of SC contracts is discussed extensively in the existing literature. This is so because of the effect of double marginalization where, the wholesale price-only contracts often lead to some deficiency in the efficiency of the SCs facing market demand uncertainties [27]. In order to mitigate this loss of efficiency, numerous other contracting models have been developed in supply chain management. Typical among them is the buyback model [28]. In this type of contract, a retailer pays a wholesale price for each unit ordered but can return at the end of the selling season all or a fraction of the unsold items to the manufacturer with a predetermined full or partial refund per unit. In this research, we consider a buyback contract where any leftover inventory with the retailer can be returned to the manufacturer at some pre-specified terms of the buyback contract. Buyback contract because it is aligned with the proposed model. SC models with market demand uncertainties, buyback provisions are beneficial simultaneously for the manufacturer, the retailer, and the supply chain system, while this is not the case in the other demand settings [29]. Buyback contracts have been exploited extensively in various retail sectors such as publishing, fashion apparels, computers, groceries and cosmetics.

The Newsboy problem is probably the simplest model of all stochastic inventory management problems, involving a single order decision and a stochastic sales outcome [30]. From the extant literature Jian et al [31], Wang et al [32], Groenendaal et al [33], Ren et al [34] and Wang et al [35], it is evidenced that this model has been improved on by many researchers over the years. Pando et al [36] argued that the newsboy model is probably the most studied stochastic inventory model in inventory control theory and with most extensions in recent years. It is predominantly important for items with significant demand uncertainty and large over-stocking and under-stocking costs. The reasons for the possible extension of (CNP) are: the probable use of overstocked products at the end of the sales period and the possible existence of an emergency order to fill an understock during the selling season. For instance, the first approach was considered by Roy et al [37] using rebates to sell the surplus or overstocked inventory below the normal selling price. Panda et al [36] carried out a research on the second approach.

## Conceptual Model and Framework

The proposed model is divided into two parts as shown below. Fig.1 considers the costs flow. It considers a decentralised (I) and centralized (II & III) two-echelon supply chain with a manufacturer and a retailer in a single ordering period setting. The manufacturer produces a perishable product at a unit cost of  $C_m$  and sells the product to the retailer at a price  $P_m$ . The retailer buys from the manufacturer at  $C_r$  and sells to the end-users at  $P_r$ . Fig. 2 shows the materials flow from the manufacturer to the end-users through the retailer. The retailer faces a stochastic market demand ( $MD$ ) per cycle and must determine his ordering quantities ( $Q$ ), which he orders from the manufacturer at the beginning of the selling period. The ordering quantity is being driven by the average demand ( $\mu$ ) and the average standard deviation ( $\sigma$ ). When placing the order, the retailer does not know the exact market demand pattern but knows that the demand follows a normal distribution. From (I & II), if the ordered amount is more than the market demand so that the surplus products cannot be sold at the end of the period, the retailer would salvage any leftover inventory to the market at a price value of  $S$ . This indicates there is no buyback contract collaboration between the retailer

and the manufacturer. In this scenario, the burden of risk is solely with the retailer. In the other scenario (III), if  $Q > D$  so that the surplus products cannot be sold at the end of the period, the retailer would salvage any leftover inventory to the manufacturer at a price value of  $B$  because there exists an established buyback contract collaboration between them. If the  $Q < D$ , the retailer loses  $C_{us}$  of not meeting to the market demand, but if  $Q > D$ , he loses  $C_{os}$ .

This model unlike the traditional newsboy model, investigate how collaborative buyback contract will affect the performance of the SC. However, this research is limited to perishable inventories like newspaper, apparel, groceries and major holidays products. These are perishable products that would likely constitute salvage or buyback value.

$Q^*$  is the decision variable where as  $\pi_r$  and  $\pi_m$  are the response variables for the retailer and manufacturer respectively. All the other variables are inputs. For example,  $C_{os}$  is the profit decrease that results from ordering an item that cannot be sold at its normal price while  $C_{us}$  is the profit decrease that results from failing to order an item that could have been sold at its normal price. To determine  $Q^*$  for  $\pi_r$  and  $\pi_m$  to be maximised, the following steps were considered:

First, a unit cost of understocking ( $C_{us}$ ) and a unit cost of overstocking ( $C_{os}$ ) must be identified.

$$C_{os} = C_r - S. \tag{4}$$

$$C_{us} = P_r - C_r. \tag{5}$$

The CSL provided by an order quantity of  $Q$  items given that demand follows a normal distribution is defined as the probability that a stock-out will not occur when  $Q$  items are ordered. Thus, the optimal CSL is calculated using Eq. 1. To achieve this service level,  $Q^*$  must be determined. The NORM.INV function from spreadsheet was used to calculate that value.

$$Q^* = \text{NORMINV}(\text{CSL}, \mu, \sigma). \tag{6}$$

The profit function of the retailer ( $\pi_r$ ) for scenarios I and II is calculated thus:

$$\pi_r = (P_r \times \text{Min}(Q^*, D) + \text{IF}(D < Q^*, S \times (Q^* - D) - (C_r \times Q^*), 0)). \tag{7}$$

The profit function for the manufacturer ( $\pi_m$ ) for scenarios I and II can be estimated as the product of the optimal quantity ordered and the profit margin. That is:

$$\pi_m = Q^* \times (P_m - C_m). \tag{8}$$

For the III scenario where there is buyback contract, the profit function of the retailer remains the same as Eq.7 with  $S = B$ , but that of the manufacturer needs to be updated. The probability factor like that of the retailer must be taken into consideration. Therefore, the new profit function of the manufacturer becomes:

$$\pi_m = Q^* \times P_m - (Q^* - C_m) + \text{IF}(Q^* > D, (B - S_m) \times (Q^* - D), 0). \tag{9}$$

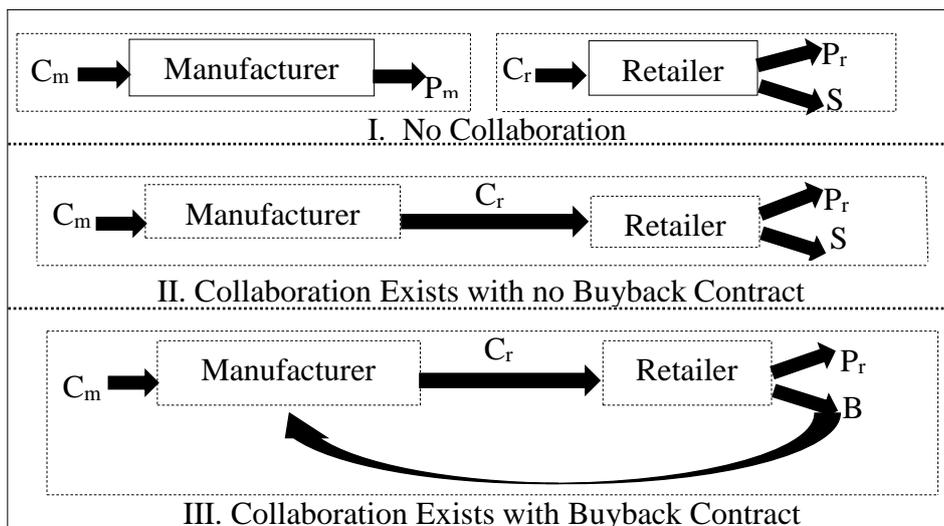


Figure 1: The Costs Flow of Proposed Model

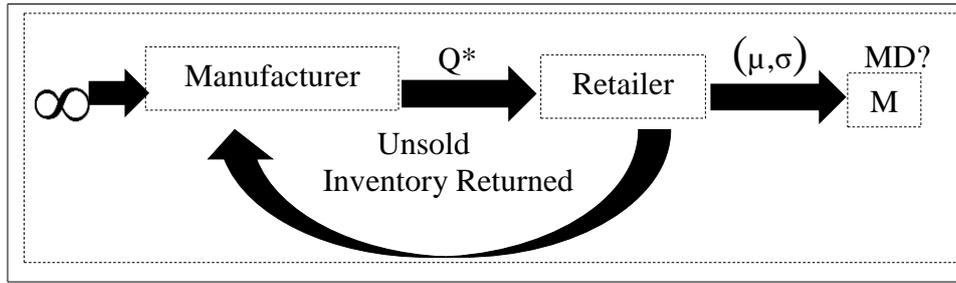


Figure 2: Materials Flow of Proposed Model

In carrying out the experiment using a Monte Carlo simulation, data were drawn from [38] and [39]. The first dataset investigates the number of skis to purchase for the winter season from a sporting goods store while the second dataset considers a retailer who sells a perishable product. Both datasets assumed that the demand uncertainty ( $\xi$ ) follows a normal distribution.

The variables/parameters used in the model are stated and described as thus:

$C_m$  = cost price of the manufacturer per unit

$C_r$  = cost price of the retailer per unit

$P_r$  = selling price of the retailer per unit

$P_m$  = selling price of the manufacturer per unit

$S$  = salvage value per unit

$B$  = buyback value per unit

$S_m$  = Salvage value of the manufacturer

$C_{os}$  = cost of overstocking per unit

$C_{us}$  = Cost of understocking per unit

$D$  = weekly demand

$CSL^*$  = optimal cycle service level with the probability that  $D$  follows a normal distribution

$\mu$  = weekly mean demand

$\sigma$  = weekly standard deviation

$Q^*$  = corresponding optimal order quantity

$\pi_r$  = total weekly probability profit of the retailer

$M$  = market/consumer

$MD$  = market demand

$\pi_m$  = total weekly probability profit of the manufacturer

$z$  = number of standard deviations corresponding to the service level probability

## Results and Discussions

The simulation process was carried out using spreadsheet. Five hundred replications were done on each dataset. The summaries are represented in Tables 4-1 and 4-2 below.

Table 4-1: The average profit of skis with Buyback Contract

Wholesale (\$)	CSL (%)	Buyback (\$)	Order Quantity $Q^*$ (Units)	Retailer's Profit (\$)	Manufacturer's Profit (\$)	Supply Chain Profit (\$)
100	0.6	0	375	42,355	30,000	72,355
100	0.882	80	469	48,404	41,393	89,797
100	0.898	83	477	48,766	42,662	91,428
100	0.909	85	484	49,017	43,723	92,739
100	0.92	87	491	49,278	44,812	94,090
Total			<b>2,296</b>	<b>237,820</b>	<b>202,590</b>	<b>440,410</b>

For an effective comparison, there should be a baseline to compare with other scenarios in the same context. To that end, the output average profits of the retailer, manufacturer and SC in this scenario where there is no collaboration represented as zero in Tables 4-1 and 4-2 are used as the baseline to compare with the other scenarios: average profits of the retailer, manufacturer and SC with collaboration but no buyback and with both collaboration and buyback contract. When the manufacturer collaborates with the retailer to sell the product to the retailer slightly lower than the nominal cost, holding all other variables constant is called wholesale price discount contract [27]. It is evidenced from the outputs in Tables 4-1 and 4-2 that if the manufacturer sets a wholesale price that is slightly lower than its nominal wholesale price, the retailer will order more products because it increases the retailer's profit margin and reduces the cost of overstocking. Conversely, lowering the wholesale price will increase the manufacturer's expected profit due to the increase in the ordering quantity. For example, in Table 4.2, for a discount of 0.07 on the wholesale price, the CSL increases from 0.882 to 0.924 which is 4.76% increment. This increase also accounts for the profits of the players and the SC. The profit of the retailer increases by 6.72% while that of the manufacturer and SC increases by 5.12% and 6% respectively. These results explain that collaboration with discounts would arguably increase the profitability of the retailer more than the manufacturer. One of the possible reasons is because the profit margin of the manufacturer is reduced in order to attract the retailer to increase the ordering quantity.

From Table 4-1, increasing the buyback value to \$7, the CSL increases by 38.8%. This increase in the CSL corresponds to a 20% increase in the optimal quantity ordered by the retailer. From the results, buyback contracts seem to increase the profit of the manufacturer more than the retailer. With the 20% increase in the order quantity, the profit of the retailer increases by 13% whereas that of the manufacturer increases by 31%. For a buyback value of \$7, the SC profit is about 22% of the entire SC profit. Overall, the SC profitability increases by 20%. It was also observed that the order quantity at \$7 is approximately 22% of the total quantity ordered.

Table 4-2: The average profit of Skis with Discount

Wholesale (\$)	CSL (%)	Discount Factor	Order Quantity Q* (Units)	Retailer's Profit (\$)	Manufacturer's Profit (\$)	Supply Chain Profit (\$)
100	0.882	0	469	48,404	37,520	85924.36
100	0.888	0.01	472	48,859	37,760	86619.2
100	0.90	0.03	478	49,783	38,240	88023.14
100	0.912	0.05	485	50,718	38,800	89517.78
100	0.924	0.07	493	51,661	39,440	91100.96
<b>Total</b>			<b>2,397</b>	<b>249,425</b>	<b>191,760</b>	<b>441,185.4</b>

## Conclusion and Future Research

From the results it can be supported that the model can be used as a tool to manage inventory for seasonal products through newsvendor and buyback contract. Also, it is seen from the results of the experiment that collaboration in the form of whole sale price discount and buyback contract between the manufacturer and the retailer increases the performance of inventory management in a two-tier SC model depicted by the model. If the retailer is operating in a monopolistic market and that the demand is deterministic, then supply chain without collaboration is arguably the best option. However, considering the ever-growing dynamics of the business environment, it is likely that any business operates without some degree of collaboration. From the inventory perspective, collaboration in the form of wholesale price discount is most preferable. It does not only support the manufacturer to increase production, but also reduces the cost of overstocking inventory from the side of the retailer. In terms of profitability, the wholesale price discount and buyback contract tend to increase the profits of both players and the SC. However, from the analyses, collaboration with

buyback contract is more attractive for the manufacturer than the retailer. For a demand distribution with high price sensitivity, wholesale price discount seems to be more attractive than buyback contract.

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