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Contracts Choice in Retailer-led Supply Chain

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Abstract

This paper considers a two-stage supply chain with one manufacturer and one retailer for short life-cycle products in a risk-neutral setting. Retailer's demand depends on the product's price and initial stock levels displayed at the store. The manufacturer's capacity limits the order quantity. An unbiased player determines the optimal price and quantity for the centralized supply chain. Then, a retailer-led Stackelberg game is employed with four decentralized settings, namely wholesale-price, markdown, revenue-sharing, and buyback contracts. Numerical results for different contract forms show that the markdown policy yields the highest expected profit for the retailer, over the range of stock and price sensitivity levels. Sensitivity analysis shows that the markdown policy and revenue-sharing contracts favor the retailer's profits. In contrast, the buyback and wholesale-price contracts favor the manufacturer. Also, the revenue-sharing contract results in the highest selling price and the buyback contract with the lowest selling price.

Key words: game theory; supply chain contract; markdown; revenue-sharing; buyback.

JEL classification: C61; C65; C71; C72; C73.

1. Introduction

Interest in supply chain models for short life-cycle products (SLPs) is being renewed with the customer's preference for more personalized products (Goldman, 1982; Ye and Li, 2011). Manufacturers meet these demands with fast fashion SLPs with a short selling season, after which their demand reduces drastically (Buzzo and Abreu, 2019). Demand for SLPs can change each season and may never return in the following season (Partha Sarathi et al., 2014). Clothing may also be a one-time purchase, like a sports team jersey, which are purposefully redesigned every year to make more sales. Companies like Zara replace their collections on offer every month. Demand, in this case, is uncertain for which the retailer has to decide the order quantity a priori.

Contract mechanisms have been developed to minimize the risk of under/over-

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stocking and reduce retailer's costs (Tsay et al., 1999). For example, Zhang et al. (2014) study the buyback contract (BB) under variable demand. Cachon and Lariviere (2005) determine the coordination criteria for the revenue-sharing contract (RS). Quantity flexibility contracts in the context of disintermediation risk have been addressed (Bicer and Hagspiel, 2016). Markdown policy (MD) as a part of the contract was incorporated by Nair and Closs (2006).

Supply chain contracts have theoretical underpinnings in game theory. Game theory as a concept had its beginnings in studying economic behavior (Von Neumann et al., 2007) from which its application has progressed in a multitude of fields, including supply chain contracts (Cachon and Netessine, 2006). A supply chain game can be classified into a cooperative and non-cooperative game. In a cooperative supply chain, the players collude or cooperate in an unbiased manner to maximize the overall profit of the supply chain. In a non-cooperative game, there can be players who are more powerful than the others and decide the terms of the contract in their favor by making the first move in the game.

We consider a single period, a two-stage supply chain with one manufacturer and one retailer. The retailer, as a Stackelberg leader, decides the optimal price and order quantity to meet uncertain market demand, which maximizes its expected profit. In this context, we develop various contract models. First, we develop a centralized setting model where an unbiased player is a decision-maker, and then decentralized models are designed with RS, BB, MD contracts. The retailer can choose the best contract form that maximizes its expected profit as well as the overall supply chains' profit. Numerical analysis shows the effect of different contracts on the expected profit of the players. Sensitivity analysis illustrates the impact of demand's dependency on the displayed quantity of stock and the product price on the decision parameters and player's profits.

The remainder of this paper is organized as follows. Section 2 gives a brief literature review. Section 3 describes the problem with the notations used and the assumptions made. Section 4 formulates the contract models and comparative static analysis. Section 5 illustrates the models through numerical examples and sensitivity analysis. The last section gives the conclusion, managerial insights, and future research directions.

2. Literature Review

Many studies have been conducted on price-sensitive demand in the supply chain under a risk-neutral scenario (Cai et al., 2009; Venegas and Ventura, 2018). Different supply chain contracts under these conditions can be employed to maximize member profits (Tsay et al., 1999). In this section, we briefly review three streams of literature: (1) RS contract, (2) BB contract, and (3) MD policy as follows.

RS contracts have traditionally been studied with the manufacturer as a Stackelberg leader, where the retailers do not have sufficient funds to purchase before the sales period (Cachon and Lariviere, 2005). The manufacturer sells at a reduced wholesale price and, in return, takes a share of the revenue earned by the retailer. In a retailer-led supply chain scenario, a manufacturer gets the share of revenue to invest in producing more products. Many authors have studied revenue-sharing contracts in different contexts (Qin and Yang, 2008; Zhang et al., 2019).

In BB contracts, the manufacturer promises to repurchase unsold goods from the retailer and can reprocess it to make new goods. Many manufacturers offer the choice of BB contract to avoid the possibility of stock-out and promote retailers to stock more inventory in the hope of increased sales (Wang et al., 2015). The manufacturer places a limit on either the number of products or cost up to which it will buy. The retailer bears the cost of any unsold goods beyond this limit. BB contracts can be designed to favor the retailer to make higher net sales (Govindan and Malomfalean, 2019). One major limitation of buyback contracts is the cost and effort of operations involved in shipping unsold goods back to the manufacturer. However, due to established supply chains, logistics operations can incorporate these return shipping with minimal costs. The following policy can be used to avoid the added cost of return shipping.

In an MD policy, the retailer sells leftover inventory at discounted prices to ensure freeing up of inventory space for better selling products. The manufacturer can choose to transfer a fraction of lost money to the retailer to make up for the loss to coordinate the supply chain. However, in a retailer-led supply chain, they do not get any reimbursement from the manufacturer. Instead, this MD policy gives a choice to the retailer to recover some costs, even if they do not break-even on that batch of goods (Nair and Closs, 2006).

Coordination of supply contracts has been extensively studied with the manufacturer as the Stackelberg leader (Li et al., 2002; Abad and Jaggi, 2003). Few studies attempt the problem with the retailer as the Stackelberg leader (Yue et al., 2006). Wan and Chen (2015) analyze the effect of Option contracts on the decisions and performance of both the supplier and the retailer using the principles of game theory. Table 1 gives a list of articles using game theory in supply chain contracts.

Table 1. Literature Review – Supply Chain Contracts Using Game Theory

Author (Year)	Contract	Game	Leader	Author (Year)	Contract	Game	Leader
Zeng & Hou (2019)	QD	C, NC	S	Yang et al. (2015)	RS	NC	B
Zhang et al. (2019)	RS	NC	M	Xu et al. (2015)	BB	NC	S
Zhai et al. (2019)	CS	NC	B	Giri & Bardhan (2014)	BB	NC	S
Govindan & Malomfalean (2019)	BB, RS	NC	B	Partha Sarathi et al. (2014)	RS	NC	S
Huang et al. (2018)	RS	C, NC	B	Cao (2014)	RS	C, NC	S
Cao & Yu (2018)	BB, RS	C, NC	S	Lee et al. (2013)	BB, RS	NC	S
Chen et al. (2018)	QD	NC	S	Xiao & Jin (2011)	MD	NC	S
Bai et al. (2018)	RS	C, NC	S	Leng & Parlar (2010)	BB	NC	S
Chen et al. (2017)	RS	NC	S, B	Qin & Yang (2008)	RS	NC	S, B
Giri et al. (2016)	BB	NC	S	This Paper	BB, RS, MD	NC	B

Legend: RS-Revenue Sharing, BB-Buy Back, MD-Mark Down, QD-Quantity Discount, CS-Cost Sharing, C-Cooperative, NC-Non-cooperative, S-Supplier, B-Buyer, M-Mediator

With the advent of large, dominant retailers like Walmart, Amazon, Alibaba, etc. retailer-led supply chains are becoming more common in the industry. This paper attempts to address the problem of choosing the better among the available contract mechanisms in coordinating the supply chain.

3. Problem Description

We consider a two-stage supply chain with a risk-neutral retailer and manufacturer in a single-period setting. The manufacturer has a maximum production capacity of K units to fulfill the retailer's order quantity, Q. The manufacturer delivers to the retailer a quantity that is minimum of either Q or K. The retailer sells to its customers and, by the end of the period, realizes a demand D. If $D > Q$, the retailer incurs a shortage cost, like loss of goodwill. However, if $D < Q$, the retailer can salvage the goods in the wholesale price (WS) and RS contract or sell the products back to the manufacturer in the BB contract or sell to its customers at a discounted price in the MD policy, until stocks are cleared. The retailer has to choose the best contract form, which maximizes its expected profit as well as the supply chain's profit. The notations and assumptions used in the model are given below.

3.1 Notations

Table 2 shows the notations used in the proposed models.

Table 2. Notations and Their Description

Notation	Description	Notation	Description
x	Subscript x represents:	y	Subscript y represents:
M	Manufacturer	ws	Wholesale price contract
R	Retailer	rs	Revenue-sharing contract
T	Total system	bb	Buyback contract
		md	Markdown policy
u	Base demand	$\Pi_{\xi\psi}$	Expected profit of x under contract y
v	Price-sensitivity coefficient	Q_y	Order quantity under contract y
w	Stock-sensitivity coefficient	D	Item demand
p_y	Selling price /unit for contract y	K	Manufacturer's production capacity
ω_ψ	Wholesale price /unit for contract y	Q_b	Buy-back quantity limit
a_y	Transformation variable for stocking decision under contract y	r	Fraction of revenue kept by retailer under revenue-sharing contract
d	Marked-down price /unit for markdown policy	n	Fraction of Q that the manufacturer will buyback from the retailer
s_l	Salvage price /unit	ε	Demand uncertainty
s_h	Shortage price /unit	μ	Mean Demand
m	Production cost /unit	$f(.)$	Probability density function
b	Buyback price /unit under buyback	$F(.)$	Cumulative distribution function

3.2 Assumptions

The following assumptions were made when developing the models:

- Market information is common knowledge.
- The manufacturer has limited capacity.
- Zero lead time between product order, production, delivery, retail, etc.
- Uncertain demand for end items is price-sensitive and stock-sensitive.
- For a bounded problem, the following parameter limiting assumptions were made:

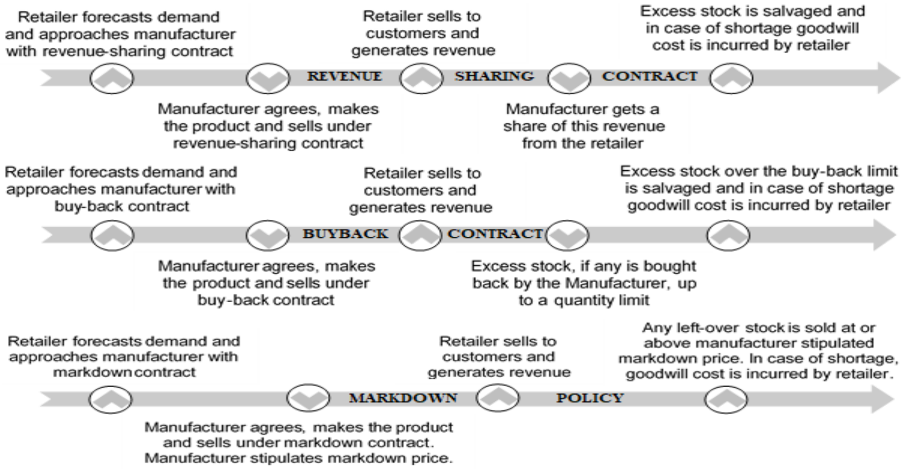
$$p_y \geq \omega_{ws} \geq \{\omega_{rs},\omega_{bb},\omega_{md}\} \geq \{d,b\} \geq m > \{s_h,,s_l\} \geq 0 \; ; \; 0 \leq \{r,n\} \leq 1 \; ; \; \{Q_b,Q_y\} \leq K$$

4. The Models

In two-player supply contract negotiation, either player can be more powerful, i.e., the market leader or socio-politically superior than the other. In these cases, a Stackelberg leadership model can be used to study the optimal decisions of each firm. The leader will initiate the process and attempt to maximize its profit. This paper studies the scenario with the retailer (buyer) as the market leader. To better understand the process, different contract models are illustrated with examples in the subsequent sections. The centralized setting is developed first where the retailer and manufacturer make decisions as one entity, followed by the decentralized WS setting, which is used as the benchmark model. Further decentralized models like RS, BB, and MD are designed.

In the WS setting, the retailer purchases from the manufacturer at a fixed wholesale price and sells to its customers. In the RS contract, the retailer buys goods from the manufacturer at a reduced wholesale price. In return, the retailer shares a part of its revenue with the manufacturer based on pre-determined criteria. The sequence of events for the RS, BB, and MD contracts are shown in Figure 1. In the BB contract, the retailer is incentivized to purchase as much inventory as possible. The manufacturer buys a fraction of the unsold stock back from the retailer, up to a maximum quantity Q_b. Leftover goods at the retailer are salvaged, bringing in marginal revenue. The manufacturer can reprocess these goods to make new products. In MD policy, the retailer purchases goods from the manufacturer and sells it to customers. When demand is lower than the order quantity, the retailer has approval from the manufacturer to sell unsold products to the same market up to a lower limit price, until the stocks clear. This discounted price is higher than the salvage price and helps the retailer gain some marginal revenue, which would otherwise have been lost. There are lower costs as goods are not returned to the manufacturer. In the following sub-sections, the demand equation, optimal decisions, and expected profit equations for the centralized setting are given, followed by the same for the four decentralized settings.

Figure 1. The Sequence of Events in the RS, BB, and MD Contracts



4.1 Modeling Demand

The price-sensitive, stock-dependent, and uncertain component of demand are modeled as a linear function of the order quantity and the price of the product, given as, $D = u - vp + wQ + \varepsilon$. Here u is the extent to which the product will be accepted in the market, v is the responsiveness of demand to the selling price, w is the sensitivity of the demand to stock displayed as a function of the order quantity and ε introduces the random component of the demand. Henceforth, all expected profit values are dependent on the realization of demand where $E(i)^+$ denotes the expected value of *i* or 0, whichever is higher.

4.2 Centralized Setting

The supply chain's total expected profit is the expected revenue plus the salvage revenue less any shortage cost less production cost, as shown in equation (1).

$$\Pi_T = p\,E(min(D,\min(Q,K)))^+ + s_l\,E(min(Q,K) - D - Q_b)^+ - s_h\,E(D - min(Q,K))^+ - mE(min(Q,K))^+ \tag{1}$$

In the centralized setting, the optimal value of the price p^* is obtained by taking the first-order conditions of equation (1) w.r.t respect to *p* to get:

$$p^* = \frac{1}{2v}\{u + vm + aw + (1-w)(\mu - f(a))\} \tag{2}$$

To get the optimal expression for order quantity Q^*, we must use a transformation variable a, which acts as an alternate stocking decision. The transformational variable a is given by, $a = Q - (u - vp + wQ)$ which can be rewritten to get, *Q* as in equation (3).

$$Q = \frac{u - vp + a}{1 - w} \tag{3}$$

Substituting (3) in (1) gives the transformed profit equation. Now we take the first-order condition of transformed equation (1) w.r.t *a* and get, optimal a^*

$$a^* = F^{-1}\left(\frac{p - m + s_l\,(1-w)}{(p - s_l + s_h)(1-w)}\right) \tag{4}$$

From the definition of the transformation, the optimal order quantity is derived by substituting equations (2) and (4) in (3) to get (5).

1. $$Q^* = \frac{u - vp^* + a^*}{1 - w} \tag{5}$$

Here, Q^* is dependent on the base demand level, price sensitivity coefficient and the stock sensitivity coefficient, apart from p^* and a^*. The total profit in the centralized setting is computed by substituting these optimal decisions in equation (2). A centralized supply chain generates the best possible profits than the decentralized counterpart setting (Cachon and Netessine, 2006). However, centralization involves complete information sharing between the retailer and manufacturer, which may not be feasible nor desirable in many cases. Thus, we study the following decentralized contracting models.

4.2.1 Decentralized WS Price Contract

In the WS price contract, the retailer's expected profit (6) is the expected revenue plus salvage revenue minus wholesale purchase cost less shortage cost. The manufacturer's expected profit (7), is the expected wholesale revenue, less production cost.

$$\Pi_{Rws} = p\,E(min(D,\min(Q,K)))^+ - w_{ws}\,E(min(Q,K))^+ + s_l\,E(min(Q,K) - D - Q_b)^+ - s_h\,E(D - min(Q,K))^+ \tag{6}$$

$$\Pi_{Mws} = w_{ws}\, E(min(Q,K))^{+} - mE(min(Q,K))^{+} \tag{7}$$

The optimal price and order decisions are determined by taking the first-order conditions of equation (6), w.r.t p and a, as given below.

$$p^{*}_{ws} = \frac{1}{2v}\left\{u + v\omega_{ws} + aw + (1-w)\big(\mu - f(a)\big)\right\} \tag{8}$$

$$a^{*}_{ws} = F^{-1}\left(\frac{p-\omega_{ws}+s_l\,(1-w)}{(p-s_l+s_h)(1-w)}\right) \tag{9}$$

Similar to (5), optimal Q^{*}_{ws} is obtained by substituting equations (8) and (9) in (3). The optimal expected profit of the retailer, manufacturer, and the total supply chain is obtained by substituting these optimal decisions in equation (6), (7), and (10), respectively.

$$\Pi_{Tws} = pE(min(D, min(Q,K)))^{+} + s_l E(min(Q,K) - D - Q_b)^{+} - s_h E(D - min(Q,K))^{+} - mE(min(Q,K))^{+} \tag{10}$$

4.2.2 Decentralized RS, BB, and MD Contracts

Similar to the benchmark WS price contract, the expected profit equations for the retailer and the manufacturer are determined in other decentralized settings. Then the optimal values of price and stocking decision are computed. Then we calculate the optimal order quantity for each contract. Finally, the individual and total supply chain profit are calculated by substituting these optimal decisions in the expected profit equation. The remaining decentralized setting results are given in Table 3.

In the RS contract, the retailer's expected profit (11) is the sum of the retailer's share of expected sales revenue and salvage revenue less than the wholesale cost and shortage cost. The manufacturer's expected profit (12) is the expected wholesale revenue plus its share of the retailer's revenue, less production cost. The expected retailer's profit (16) in the BB contract is the sum of total revenue, buyback revenue, and salvage revenue, less purchase cost, and shortage cost. The expected manufacturer's profit (17), is the wholesale revenue minus the production cost and buyback cost. The expected profit of the retailer (21) in MD policy is the sum of total revenue and marked down revenue less cost of purchase and shortage cost. The expected profit of the manufacturer (22) is the wholesale revenue minus the production cost.

Table 3. Expected Profits and Optimal Decisions under Decentralized Settings

Revenue Sharing Contract	
$\Pi_{Rrs} = rpE(min(D, \min(Q,K)))^{+} - w_{rs}E(min(Q,K))^{+} + s_l E(min(Q,K) - D - Q_b)^{+} - s_h E(D - min(Q,K))^{+}$	(11)
$\Pi_{Mrs} = w_{rs}E(min(Q,K))^{+} - mE(min(Q,K))^{+} + (1-r)p\, E(min(D, \min(Q,K)))^{+}$	(12)
$p^{*}_{rs} = \frac{1}{2vr}\left\{ur + v\omega_{rs} + aw + r(1-w)\big(\mu - f(a)\big)\right\}$	(13)
$a^{*}_{rs} = F^{-1}\left(\frac{p-\omega_{rs}+s_l\,(1-w)}{(rp-s_l+s_h)(1-w)}\right)$	(14)
$\Pi_{Trs} = p\, E(min(D, \min(Q,K)))^{+} - w_{rs}\, E(\min(Q,K))^{+} - s_h\, E(D - min(Q,K))^{+} + s_l\, E(min(Q,K) - D - Q_b)^{+} - mE(min(Q,K))^{+}$	(15)
Buyback Contract:	
$\Pi_{Rbb} = p\, E(min(D, \min(Q,K)))^{+} - w_{bb}E(min(Q,K))^{+} + b\, E(min(Q-D, Q_b))^{+} + s_l E(min(Q,K) - D - Q_b)^{+} - s_h\, E(D - min(Q,K))^{+}$	(16)
$\Pi_{Mbb} = w_{bb}\, E(min(Q,K))^{+} - mE(min(Q,K))^{+} - b\, E(min(Q-D, Q_b))^{+}$	(17)
$p^{*}_{bb} = \frac{1}{2v}\left\{u + v\left(\omega_{bb} - \frac{b}{n}\right) + aw + (1-w)\big(\mu - f(a)\big)\right\}$	(18)
$a^{*}_{bb} = F^{-1}\left(\frac{p-\omega_{bb}+s_l\,(1-w)+\frac{b}{n}}{(p-s_l+s_h)(1-w)}\right)$	(19)
$\Pi_{Tbb} = p\, E(min(D, \min(Q,K)))^{+} - mE(min(Q,K))^{+} + s_l\, E(min(Q,K) - D - Q_b)^{+} - s_h\, E(D - min(Q,K))^{+}$	(20)
Markdown Policy:	

$$\Pi_{Rmd} = p\, E(min(D, \min(Q,K)))^{+} - w_{md}\, E(min(Q,K))^{+} + \ d\, E(min(Q,K) - D)^{+} \ - \ s_h\, E(D - min(Q,K))^{+} \tag{21}$$

$$\Pi_{Mmd} = \ w_{md}\, E(min(Q,K))^{+} - \ mE(min(Q,K))^{+} \tag{22}$$

$$p^{*}{}_{md} \ = \frac{1}{2v}\left\{u + v\omega_{md} + aw + (1 - w)\big(\mu - f(a)\big)\right\} \tag{23}$$

$$a^{*}{}_{md} \ = F^{-1}\left(\frac{p - \omega_{md} + d\,(1 - w)}{(p - d + s_h)(1 - w)}\right) \tag{24}$$

$$\Pi_{Tmd} \ = p\, E(min(D, \min(Q,K)))^{+} - \ mE(min(Q,K))^{+} + \ d\, E(min(Q,K) - D)^{+} \ - \ s_h\, E(D - min(Q,K))^{+} \tag{25}$$

4.3 Comparative Static Analysis

Comparative static analysis (Cachon and Netessine, 2006) is performed to determine the effect of exogenous parameters w, on the decision variables, optimal price p^{*} and stocking decision a^{*}. Table 4 gives the first order condition of optimal decisions w.r.t w for each contract model. A unit change in w will change the value of p^{*} by a factor of $(a - (\mu - f(a))/2v)$ in the WS price contract, BB contract, and MD policy, and by $(a/r - (\mu - f(a))/2v)$ in the RS contract. The change in optimal price is dependent on the price-sensitivity coefficient, transformation variable, and the mean demand in all contracts and additionally the share of the retailer's revenue in the RS contract. Change in optimal stocking decision w.r.t w depends on the price, salvage price, shortage price, wholesale price, and other contract-specific parameters.

Similarly, to determine the impact of w on $Q^{*}{}_{y}$, we take the first-order condition of $Q^{*}{}_{y}$ with respect to exogenous w, as in equation (32). Substituting the values of the optimal decisions and their partial derivatives in (32), we can get the expression for $\frac{\partial Q^{*}{}_{y}}{\partial w}$. It is interesting to note that $\frac{\partial Q^{*}{}_{y}}{\partial w}$ is exponentially increasing with w.

Table 4. Comparative Static Analysis Results

Decision	**First-order condition**		**First-order condition**	
Price	$\frac{\partial p^{*}{}_{y}}{\partial w} = \frac{a-(\mu-f(a))}{2v}$: $y \in ws, bb, md$	(26)	$\frac{\partial p^{*}{}_{rs}}{\partial w} = \frac{a/r-(\mu-f(a))}{2v}$	(27)
Stocking Decision	$\frac{\partial a^{*}{}_{ws}}{\partial w} = \frac{(p-s_l+s_h)F(a)+s_l}{(p-s_l+s_h)(1-p+\omega_{ws})f(a)}$	(28)	$\frac{\partial a^{*}{}_{rs}}{\partial w} = \frac{(rp-s_l+s_h)F(a)+s_l}{(rp-s_l+s_h)(1-p+\omega_{rs})f(a)}$	(29)
	$\frac{\partial a^{*}{}_{bb}}{\partial w} = \frac{(p-s_l+s_h)F(a)+s_l}{(p-s_l+s_h)(1-p+\omega_{bb}+b/n)f(a)}$	(30)	$\frac{\partial a^{*}{}_{md}}{\partial w} = \frac{(p-d+s_h)F(a)+d}{(p-d+s_h)(1-p+\omega_{md})f(a)}$	(31)
Order Quantity	$\frac{\partial Q^{*}{}_{y}}{\partial w} = \frac{a^{*}{}_{y}-vp^{*}{}_{y}-u}{(1-w)^{2}} + \frac{\frac{\partial a^{*}{}_{y}}{\partial w}-v\frac{\partial p^{*}{}_{y}}{\partial w}}{(1-w)}$: $y \in ws, rs, bb, md$			(32)

5. Numerical Illustration

The above-formulated contract models are illustrated through numerical examples. The demand equation is given by, $D = 200 - 25p + 0.1Q + \varepsilon$. The value of other parameters are as follows: $\omega_{ws} = 3.25$, $\omega_{rs} = \omega_{bb} = \omega_{md} = 2.5$, $m = 1$, $s_l = 0.25$, $s_h = 0.25$, $r = 0.65$, $K = 200$, $b = 2$, $d = 2$, $n = 0.5$, $Q_b = 0.1^{*}Q$. The problem is solved using Matlab 2018b.

5.1 Results

First, we determine the optimal decisions in centralized and decentralized WS price settings to compute the coordination benefit due to centralization. Next, we determine the optimal selling price and order quantity in the other decentralized settings, viz., MD, BB, and RS contracts. All results are presented in Table 5. From the table, we observe that the centralized setting results in the highest total profits. However, in scenarios where the retailer and manufacturer do not make a centralized decision to price and manufacture their products, the dominant retailer will push for the contract, which maximizes its profits and simultaneously the total supply chain profit.

Table 5. Expected Profit in Centralized and Decentralized Setting

Variable / Expected Profits	Centralized Setting	Decentralized Setting			
		WS	RS	BB	MD
Optimal Selling Price, p^*	4.608	5.71	6.045	3.331	5.352
Optimal Order Quantity, Q^*	104.49	69.55	66.14	148.42	89.51
Expected Retailer's Profit	121.15	162.92	198.72	162.49	199.47
Expected Manufacturer's Profit	235.11	156.49	99.21	132.60	134.26
Expected Total Profit	356.26	319.41	297.92	295.09	333.73

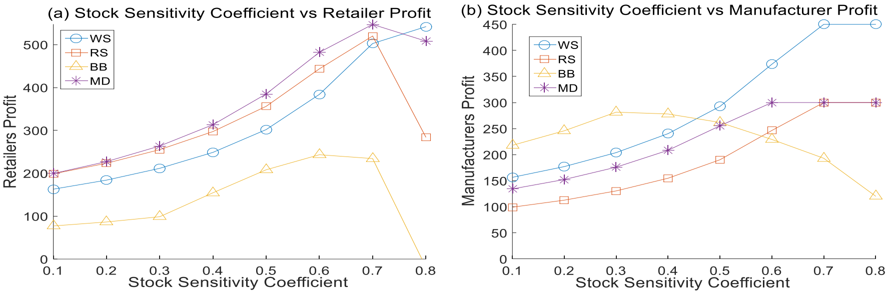
In the decentralized settings, the MD contract gives the best total profit, followed by the WS price contract for the given parameters. The MD contract also gives the best profit for the retailer and is its preferred choice. The retailer gets a larger share of expected profits in the RS contract because he can sell more products with a lower capital requirement, but the manufacturer will not prefer this contract due to meager profits. In the BB contract, both the retailer and the manufacturer get a proportionate share of the profits but generate the lowest total supply chain profit. If the BB contract is chosen, the manufacturer can use the returned product as work-in-progress for other products, as seen in the fashion industry.

It is also observed that the BB contract has the largest order quantity with the lowest price. Although the total profit is lowest, a retailer can use this contract to capture the market share by flooding the market with lower-priced goods while still being somewhat profitable. Then, as a part of the long-term strategy, the retailer can switch to MD policy, generating higher profits, with a larger market share. Better insights are obtained from the sensitivity analysis in the next section, which demonstrates the impact of price and stock sensitivity coefficients on the player decisions and individual profits.

5.2 Sensitivity Analysis

Sensitivity analysis is performed to investigate the impact of input parameters on the individual player's decisions and expected profits. First, we analyze the effect of price and stock sensitivities on the retailer's and manufacturer's expected profit for all decentralized contracts. Figure 2 shows the impact of stock sensitivity on player's profits.

Figure 2. Impact of Stock Sensitivity Coefficient on Retailer's and Manufacturer's Profit


(a) Stock Sensitivity Coefficient vs Retailer Profit

(b) Stock Sensitivity Coefficient vs Manufacturer Profit

We observe that the retailer's profit is higher in the MD policy up to a value of 0.75

of stock sensitivity while BB performs worst. For the manufacturer, the BB contract gives higher profit up to a stock-sensitivity level of 0.45, and then WS is better. It may be because, at lower stock sensitivity levels of demand, the BB contract can clear the retailer's inventory. However, with highly stock sensitive products, excessive inventory levels can result in the manufacturer purchasing it all back from the retailer, reducing profitability.

Figure 3. Impact of Price Sensitivity Coefficient on Retailer's and Manufacturer's Profit

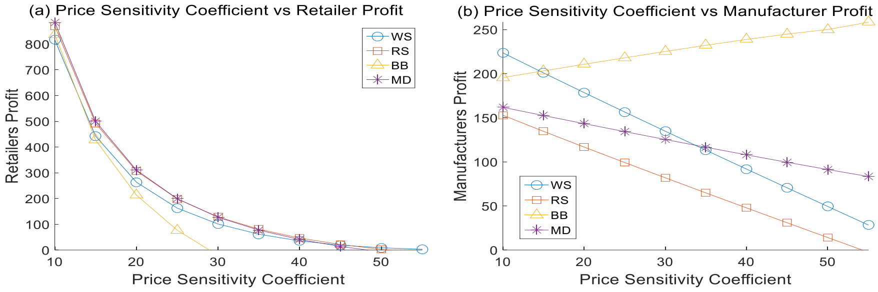
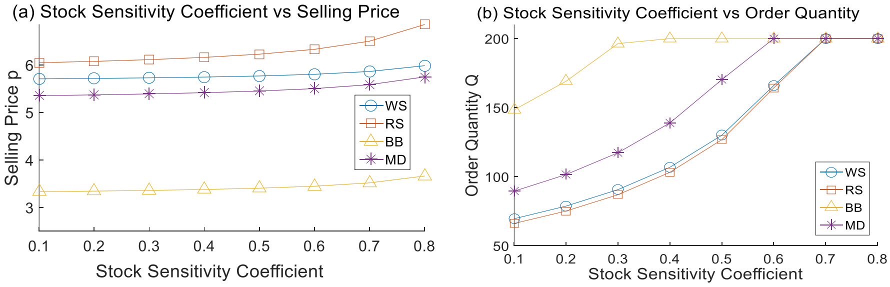


Figure 3 shows the impact of price sensitivity on the retailer's and manufacturer's expected profits. Increasing demand's price sensitivity reduces the retailer's profit for all contracts. The MD and RS contracts generate the highest retailer profit while BB is unsustainable beyond a price sensitivity level of 28. The BB contract gives the best manufacturer's profit beyond the price sensitivity level of 15. The manufacturer's profit in WS, RS, and MD policy decrease, with an increase in price sensitivity. We also see that the MD contract gives the manufacturer higher profits than the WS price contract and the RS contract beyond a level of 35, but then the retailer's profits reduce to very low values. It may be because there is a loss in sales volume if the product is very price-sensitive, and customers are waiting for the price to drop before purchasing. The MD contract enables selling the product at a reduced price to the market and thereby recovering some revenue, and thus is the preferred choice for the retailer.

Figure 4. Impact of Stock Sensitivity Coefficient on Selling Price and Order Quantity



Next, in Figure 4, we study the impact of price and stock sensitivity on the decision variables, viz., the selling price, and the order quantity under the different supply chain contracts. We observe that for each contract, the selling price is mostly independent of the stock sensitivity factor at low to moderate levels up to 0.6, and beyond that, the selling price increase with stock sensitivity factor. In the BB contract, the order quantity reaches the maximum capacity level quickly at a stock sensitivity level of 0.3. In contrast, in the MD policy, the order quantity reaches capacity at 0.6, and in the other two contracts at 0.7. From the results, it is evident that the BB contract has the highest optimal order quantity for a specific stock sensitivity parameter. It can help the decision-makers to decide how much capacity to build for a type of product with a particular stock sensitivity level.

Figure 5. Impact of Price Sensitivity Coefficient on Selling Price and Order Quantity

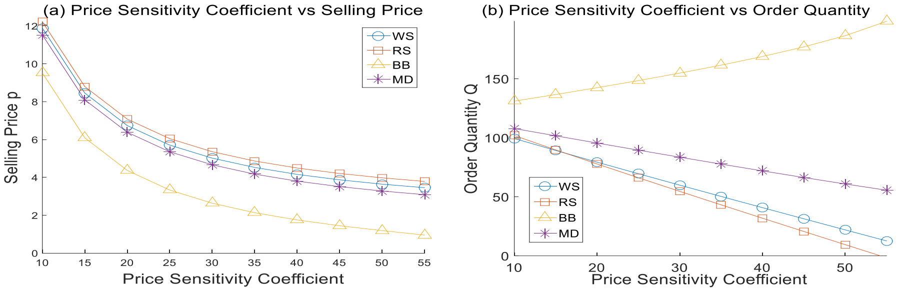


Figure 5 gives the impact of price sensitivity on the selling price and order quantity. We observe that the selling price decreases with an increase in the price sensitivity for all contracts with a more significant drop for the BB contract. The decrease is because, as the price sensitivity of a product increases, the customer's purchase behavior will increasingly depend on the price, and higher profits can be generated only with lower-priced products. The order quantity also decreases with an increase in price sensitivity for the WS, RS, and MD policy as price-sensitive customers will avoid purchasing with varying prices and cause a reduction in demand, which in turn reduces the order quantity. In the BB contract, the order quantity increases with price sensitivity as the retailer has the incentive from the manufacturer to purchase more goods, always to have stock, and be able to make the highest volume of sales. Further conclusions and managerial insights derived from the analysis are stated in the following section.

6. Conclusion

This paper investigates a two-stage supply chain with a manufacturer and a retailer, where the retailer is the Stackelberg leader. The retailer's objective is to determine the optimal price and order quantity for an SLP to meet uncertain market demand. We then develop contract models in centralized and four decentralized settings, viz., the WS, MD, RS, and BB contracts. The retailer has to choose the total and its profit-maximizing contract. We find that the MD policy gives the highest profits to the retailer when the product demand is low to moderately dependent on stock sensitivity. MD policy generates higher total supply chain profit than the other decentralized settings. Thus, the retailer, as the more dominant player, will choose the MD policy. The next profitable alternative is the RS contract, but it is detrimental to the manufacturer's profits, who may not agree to the contract. The WS price contract is the next available choice, which generates higher total profits than the RS and BB contracts but generates a lower profit than the MD policy. Thus, the MD policy is the best choice for the retailer aiming to maximize its profits while simultaneously maximizing the total supply chain profit. From the perspective of the manufacturer, the BB contract is the best choice, followed by the WS price contract.

The study generates some interesting managerial insights. Firstly, managers at the retailer may have to decide the best contract suitable for their product whose price sensitivity or stock sensitivity levels may change over time. In such dynamic scenarios, they may prefer contracts that remain viable over a broader range of sensitivities. This rules-out the BB contract due to its unstable returns. The MD policy is consistent in performance and gives the best profits over a range of sensitivity values. Second, from the perspective of strategic management, who may want to sell their products at a competitive price in the market, the BB contract is the better choice in the short term, with the lowest price. It is counter-intuitive, but a manager may prefer to increase market share using the low product price in the BB contract, rather than target absolute profits in the short term. Then, managers may switch to the MD contract in the long run when they prefer to generate higher profits with a sustainable business. Third, the BB contract requires a larger order quantity to generate similar levels of profits, while the other three contracts are relatively less dependent on large sales volumes. Depending on the type of products and how fast they can be manufactured, managers may choose a different contract type. Last, with very high stock and price-sensitive products, managers should stick with the WS price contract, which generates the highest profit while ensuring that the product is not sold to the same market at highly discounted rates. This prevents the dilution of the product brand in the consumers' minds and ensures demand in the long run.

Further extension of this work can be done by combining other contracting models for win-win situations for the manufacturer and the retailer in a multi-period setting. For example, the RS contract can be combined with another contract to give better profits in a given context. Reduced cost of procurement from unsold goods can be incorporated in the second cycle to further improve the manufacturer's profits without affecting the retailer. This paper assumes initial demand as stochastic and indeterminable, dependent on the stock levels displayed. This demand can be forecasted with a certain degree of error using analytics on real data to get a realistic starting point for demand. To implement RS and BB contracts in the application, logistics, and information technology costs, which are already a part of large retailers and manufacturers, can also be incorporated.

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