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great by
deeds, not by
birth"
-Chanakya

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Working Paper

IIMK/WPS/238/QM&OM/2017/22

May 2017

Power Structure & Channel Efficiency in the Supply Chain

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Abstract

Supply chain performance is often characterized by the power of decision making of the partners involved. The various decisions taken by different partners influence the overall profit of the chain and hence affect the channel efficiency. In this paper, we have considered a supply chain where the final demand depends upon the retail price and the marketing expenses borne by either the manufacturer or the retailer. We have shown that under these circumstances, a revenue sharing contract fails to coordinate the supply chain. We develop a hybrid contract that can coordinate the supply chain and discuss the implications of its adoption for the parties involved.

Keywords: Supply Chain Management, game theory, revenue sharing, marketing expenditure

Power Structure & Channel Efficiency in the Supply Chain

1. INTRODUCTION

A supply chain (SC) is composed of various firms who act independently, but are interconnected to each other through material, information and financial flows (Stadtler, 2005). Double marginalization is often observed in a decentralized SC. With both the upstream and the downstream parties jostling to improve their own profits, it often leads to a variety of conflicts. For example, Amazon is embroiled in a dispute with publishing major Hachette over the pricing of e-books (Rankin, 2014). Disney also came in conflict with Amazon over the pricing of DVDs as well as promotional expenses (Fritz and Bensinger, 2014). Similarly, Carrefour was recently involved in a dispute with its supplier of instant noodles in China (China Daily, 2010). Belgian grocer Delhaize and Unilever clashed, leading the latter to pull several of its products from the former's shelves (Pignal and Wiggins, 2009). Relative bargaining power of the parties involved plays a crucial role in these circumstances (Li et al., 2013). The decisions taken affect all the parties in the SC as well as the overall SC profit (Jeuland and Shugan, 1983; Ertek and Griffin, 2002).

Along with pricing decisions, marketing expenditure also influences buying behavior of consumers (He et al., 2009). Marketing expenditure includes expenditure in advertising, sales promotion, sales force etc. (Achrol and Kotler, 1999). There have been several studies that have considered both pricing and marketing decisions simultaneously (Sadigh et al., 2012). Higher expenditures in marketing have a positive effect in stimulating final demand which benefits the entire SC. Given the existence of differential power structure between the manufacturer and the

retailer, the SC profits get affected by both the price and promotion related decisions. Furthermore, whenever the final demand is contingent on both the aforementioned factors, '*who chooses what*' affects the channel efficiency. Channel efficiency is defined as the ratio of total profits obtained to the maximum profits that could have been obtained, if the SC is vertically integrated (Cachon, 2003). Thus, there is a need to understand the role that SC leadership plays in conjunction with pricing and marketing expenditure so as to get a better clarity on the factors that may affect the profitability of SC members.

This paper highlights the effect of 'power' of SC partners on the efficiency of a decentralized SC where 'power' in a SC can be defined as the ability to enforce one's own decision on the other (Edirisinghe et al., 2011). There have been many studies analyzing the case of vertical dominance where one party dominates the other party in a Stackelberg game like relationship (e.g. Wei and Zhao, 2014). A Stackelberg game is a non-cooperative sequential move game where the leader of the game makes the first decision. The follower acts on the leader's decision and makes its own decision (Viswanathan and Piplani, 2001). In this paper, we have analyzed the effect of the choice of promotional and pricing decisions by the partners on the overall SC profits under both manufacturer-dominance and retailer-dominance scenarios. Furthermore, we have also studied the differential impact on profits when the promotional decision is taken by the manufacturer vis-à-vis when it is taken by the retailer. We have also examined the differential impact of the different decision-makers on the channel efficiency. More importantly, we have shown that traditional revenue sharing contracts fail to coordinate the SC in such cases. We develop hybrid revenue and cost sharing contract that can successfully achieve this objective and significantly improve the SC profits.

The paper is organized as follows: the next section presents a brief review of relevant literature and highlights the research gaps. The problem statement has been provided in section 3. Section 4 covers development of various mathematical models corresponding to different scenarios in the SC. Section 4 explores the various cases of pricing and promotion under both manufacturer and retailer Stackelberg models. In section 5 we explore different contracts that can achieve SC coordination. Numerical analysis has been carried out in section 6. We discuss our results as well their implications in section 7. The last section contains the concluding remarks.

2. LITERATURE REVIEW

Our research focuses on the role of power in the SC as well as the impact of marketing expenditure related decision making. A number of researchers in the fields of marketing, supply chain and operations have analyzed the issues of power distribution between a manufacturer and a retailer, employing a variety of methodologies. While setting the final wholesale price, manufacturers often ignore downstream effects of the price setting on the SC profits (Pasternack, 1985). Some of the earlier studies like Choi (1991) and Choi (1996) have considered the manufacturer's behavior in price setting taking into consideration the best response of the downstream retailer. Power related issues have frequently been studied by adopting a game-theoretic lens. The resulting problems resemble a Stackelberg game. In general, in most of the studies, the manufacturer is assumed to behave as a Stackelberg leader in determining the wholesale price taking into account the best response function from the retailer who in turn also aims at his own profit maximization. Edirisinghe et al. (2011) show that power imbalance hurts the performance of the SC channel. Examples of some other studies include Huang and Li (2001), Li et al. (2002), Abad and Jaggi (2003), Esmaeilli et al. (2009), Lu et al. (2011). However, with the rise of 'big-box' retailers like Wal-Mart and Tesco, it is frequently observed

in practice that the retailer might be the dominant party in a SC relationship (Ertek and Griffin, 2002), leading many researchers to study this aspect as well. Further, Chen et al. (2006) have included the effect of transaction costs in their analysis of coordination.

The second stream of literature considers channels with demand based on both price as well as other non-price related factors. Studies like Huang and Li (2001), Li et al. (2002), Gupta and Di Benedetto (2007), Wang et al., (2013), Ma et al. (2013) and Wu (2010, 2013) have considered the effect of promotional and sales effort decisions while designing the contract between manufacturer-retailer supply chains. However, these studies do not provide a comprehensive treatment relating to the power structure in terms of promotional activities as to which partner and under what conditions will commit to promotional expenditures. Our work tries to analyze the effect of power of decision making in terms of pricing and promotions on the profitability of the supply chain, as well as development of a contract that can effectively coordinate the SC.

A variety of coordination mechanisms have been forwarded in literature. Revenue sharing contracts are one such mechanism, which were first analyzed in the context of the U.S. video retail industry (Cachon and Lariviere, 2005). In a revenue sharing contract, the supplier charges the retailer with a fixed price per unit purchased (usually lower than the fixed wholesale price) and the retailer gives the supplier a percentage of his revenue earned. It was shown by Cachon and Lariviere (2005) that this contract does coordinate the SC by aligning the optimal set of actions of the retailer with that of the entire supply chain. There have been several studies that study revenue sharing contracts in detail like Dana and Spier (2001), Giannoccaro and Pontrandolfo (2004), Gerchak and Wang (2004), Yao et al. (2008), Xiao et al. (2011), Ouardighi (2014), Chakraborty et al. (2015) etc. However, the revenue sharing contracts have been proved

insufficient in SC coordination whenever the final demand is dependent on promotional effort as well (Cachon and Lariviere, 2005).

Based on the preceding discussion, we can see that very few studies analyze the impact of different power regimes in a setting where the demand is related to marketing expenditure. Furthermore, in order to truly exploit the full potential of a manufacturer-retailer relationship, there is a need to develop robust and novel contracting mechanisms that can improve the efficiency of the SC. We attempt to fill this gap through our analysis, by providing one such approach through a hybrid cost and revenue sharing contract.

3. PROBLEM STATEMENT

We consider a single manufacturer – single retailer system, with price and marketing effort dependent demand. While this two-party assumption may seem restrictive, nevertheless a large number of researchers have studied similar systems (e.g. Karray and Martin-Herran, 2009; Seyed Esfahani et al., 2011) due to a variety of reasons. Increasing proliferation of differentiated products implies a reduction in competition at the manufacturer level. Additionally, exclusive distribution arrangements have also grown manifold (Kunter et al., 2012). Furthermore, as our focus is on the impact of leadership and choice of marketing expenditure decision-maker on the efficiency of the channel, the assumption is appropriate. Such models are very useful in explicating the basic interactions inherent in the system (Darwish and Odah, 2010). In addition, we also assume that the cost and demand parameters are known. The manufacturer and the retailer transact through a price-only contract.

We first develop a model for a cooperative case in which the manufacturer and the retailer take decision jointly to take care of the interests of the integrated SC. Next, as shown in Table 1, we

model four scenarios based on which party is the leader and which party is responsible for the marketing expenditure.

Table 1: Models developed in the paper

Factor		Stackelberg Leader (S)	
Marketing Expenditure (E)	<i>Decision Maker:</i>	Manufacturer (M)	Retailer (R)
	Manufacturer (M)	<i>MS-ME</i>	<i>RS-ME</i>
	Retailer (R)	<i>MS-RE</i>	<i>RS-RE</i>

We compare and contrast the channel efficiency as well as the profits made by the individual parties for all the four models mentioned above. In addition, we show that a traditional revenue sharing contract fails to coordinate the SC when the demand is dependent on both price as well as marketing expenditure. Lastly, we develop a hybrid cost and revenue sharing contract and show that it enables full coordination of the SC.

3.1. Notations

Decision Variables

- M Marketing expenditure per unit
 P Final retail price charged
 w Unit wholesale price charged by the manufacturer

Input Parameters

- c Unit manufacturing cost
 α Price elasticity of demand ($\alpha > 1$)
 β Marketing expenditure elasticity of demand ($0 < \beta < 1, \beta + 1 < \alpha$)
 k Scaling constant for demand function ($k > 0$)
 $D(P, M)$ Demand as a function of retail price and marketing expenditure

Output Variables

- Π_M Profit of the manufacturer
 Π_R Profit of the retailer
 Π_C Profit of the coordinated channel
 Π_{tot} Total profit of the channel
 ξ Channel efficiency

4. MODEL DEVELOPMENT

4.1. Demand function

The demand as a function of retail price and marketing expenditure can be written as:

$$D(P, M) = kP^{-\alpha} M^{\beta} \quad (1)$$

The factor M aggregates all non-price related marketing decisions, while k is a scaling constant that captures the effect of other factors. The flexibility offered by this model, by variation of the values of the parameters involved, is quite useful in replicating several real-life situations (Lee and Kim, 1993). Several authors have used this demand function [see for example, Esmaeili et al. (2009)].

4.2. Cooperative model

In order to serve as a benchmark case, we first develop a mathematical model for a cooperative scenario in which both the retailer and the manufacturer work together to determine the price to be charged to the final customer and the total marketing expenditure in order to maximize the total channel profits.

Under cooperative scenario, the total profit function is given as:

$$\Pi_c = P.D - c.D - M.D \text{ or, } \Pi_c = kP^{-\alpha+1} M^{\beta} - ckP^{-\alpha} M^{\beta} - kP^{-\alpha} M^{\beta+1} \quad (2)$$

Theorem 1: The profit function in (2) is concave in P and M .

Proof: [All proofs have been provided in Appendix A (available on request)].

Solving for the first order conditions by differentiating with respect to P and M and equating to zero, we get:

$$M_c^* = \frac{\beta c}{\alpha - \beta - 1} \quad (3a)$$

$$P_c^* = \frac{\alpha c}{\alpha - \beta - 1} \quad (3b)$$

Using (3a) and (3b), the optimal order quantity will be:

$$D_C = k \cdot \left(\frac{\beta c}{\alpha - \beta - 1} \right)^\beta \cdot \left(\frac{\alpha c}{\alpha - \beta - 1} \right)^{-\alpha} \quad (4)$$

Hence, the total profit for the coordinated scenario can be written as:

$$\Pi_C = k \cdot \beta^\beta \cdot \alpha^{-\alpha} \left(\frac{c}{\alpha - \beta - 1} \right)^{-(\alpha - \beta - 1)} \quad (5)$$

We now develop the four Stackelberg models listed in Table 1. Such models are generally solved through backward induction. The follower's decision problem is first solved to get the best response function corresponding to the leader's decisions. Then, the decision problem of the leader is solved assuming that the follower acts according to the best response function.

4.3. MS-ME Model

Under this scenario, the manufacturer is the Stackelberg leader, and is responsible for the marketing expenditure and the wholesale price. The retailer decides the retail price to be charged from the consumer. Then, the retailer's profit function is given as:

$$\Pi_R = P \cdot D - w \cdot D = k P^{-\alpha} M^\beta (P - w) \quad (6)$$

Theorem 2: The function in (6) is concave in P

Then, first order condition for profit maximization gives:

$$P^* = \frac{\alpha w}{\alpha - 1} \quad (7)$$

Then, the demand can be written as:

$$D(P^*, M) = k \left\{ \frac{\alpha w}{\alpha - 1} \right\}^{-\alpha} M^\beta \quad (8)$$

Manufacturer's profit function will become:

$$\Pi_M = (w - c - M) \cdot k \left\{ \frac{\alpha w}{\alpha - 1} \right\}^{-\alpha} M^\beta \quad (9)$$

Theorem 3: The profit function given in (9) is concave in M and w .

Using first order condition and solving, we can get:

$$M^* = \frac{\beta c}{\alpha - \beta - 1} \quad (10)$$

$$w^* = \frac{\alpha c}{\alpha - \beta - 1} \quad (11)$$

Using (10) and (11) in (7), we get:

$$P^* = \frac{\alpha^2 c}{(\alpha - \beta - 1)(\alpha - 1)} \quad (12)$$

Then, we can write:

$$\Pi_M = k \cdot \frac{c^{-(\alpha-\beta-1)} \beta^\beta}{(\alpha - \beta - 1)^{-(\alpha-\beta-1)}} \cdot \left\{ \frac{\alpha^2}{\alpha - 1} \right\}^{-\alpha} \quad (13)$$

and,

$$\Pi_R = k \cdot \frac{\alpha c^{-(\alpha-\beta-1)} \beta^\beta}{(\alpha - 1)(\alpha - \beta - 1)^{-(\alpha-\beta-1)}} \cdot \left\{ \frac{\alpha^2}{\alpha - 1} \right\}^{-\alpha} \quad (14)$$

Total channel profit will be:

$$\Pi_{tot} = \Pi_M + \Pi_R = k \cdot \frac{c^{-(\alpha-\beta-1)} \beta^\beta}{(\alpha - \beta - 1)^{-(\alpha-\beta-1)}} \cdot \left\{ \frac{\alpha^2}{\alpha - 1} \right\}^{-\alpha} \left(\frac{2\alpha - 1}{\alpha - 1} \right) \quad (15)$$

Comparing with the coordinated case, we get the channel efficiency of the MS-ME scenario as:

$$\xi_{MS-ME} = \frac{\Pi_{tot}}{\Pi_C} = \left\{ \frac{\alpha}{\alpha - 1} \right\}^{-\alpha} \left(\frac{2\alpha - 1}{\alpha - 1} \right) \quad (16)$$

4.4. MS-RE Model

In this case, while the manufacturer is the Stackelberg leader, the decision on the marketing expenditure is taken by the retailer. Thus, the decision variables for the manufacturer will be w , while those for the retailer would be P and M .

The profit function for the retailer will be:

$$\Pi_R = PD - wD - MD \quad (17)$$

The profit function for the manufacturer will be:

$$\Pi_M = (w - c)D \quad (18)$$

The concavity of the expressions for profits for both the manufacturer as well as the retailers can be established as before for all the other models. Furthermore, following the procedure similar to that adopted in case of the MS-ME model, we can obtain the optimal values of retail and wholesale prices, marketing expenditure, profits made by the two parties as well as the channel efficiency. These have been provided in Table 2.

4.5. RS-ME Model

When the retailer is the Stackelberg leader, we will first determine the best response function of the manufacturer. Under RS-ME scenario, the manufacturer is responsible for the wholesale price as well as the marketing expenditure, while the retailer is responsible for the retail price. Let us assume that the retailer marks up the wholesale price w by μ , i.e. $P = w + \mu$.

The profit function of the manufacturer can then be written as:

$$\begin{aligned} \Pi_M &= (w - c - M).D \\ \text{or, } \Pi_M &= (w - c - M)(w + \mu)^{-\alpha} kM^\beta \end{aligned} \quad (19)$$

Using first order conditions, we get:

$$M^* = \frac{\beta(\mu + c)}{\alpha - \beta - 1} \quad (20)$$

$$w^* = \frac{\mu(1 + \beta) + \alpha c}{\alpha - \beta - 1} \quad (21)$$

Using (20) and (21), we can write the profit function for the retailer as:

$$\Pi_R = (P - w)D = \mu k (w + \mu)^{-\alpha} M^\beta$$

$$or, \Pi_R = \mu k \left(\frac{\alpha(c + \mu)}{\alpha - \beta - 1} \right)^{-\alpha} \left(\frac{\beta(\mu + c)}{\alpha - \beta - 1} \right)^\beta \quad (22)$$

Again, using the first order optimality conditions: $\mu^* = \frac{c}{\alpha - \beta - 1}$

Using the above, we will get:

$$w^* = c \frac{1 + \beta + \alpha(\alpha - \beta - 1)}{(\alpha - \beta - 1)^2} \quad (23)$$

$$P^* = \frac{\alpha c(\alpha - \beta)}{(\alpha - \beta - 1)^2} \quad (24)$$

$$M^* = \frac{\beta c(\alpha - \beta)}{(\alpha - \beta - 1)^2} \quad (25)$$

Using the expressions derived above, we obtain the profits made by the manufacturer and the retailer as:

$$\Pi_M = k \alpha^{-\alpha} \beta^\beta \left(\frac{c(\alpha - \beta)}{(\alpha - \beta - 1)^2} \right)^{-(\alpha - \beta - 1)} \quad (26)$$

$$\Pi_R = \frac{k c \alpha^{-\alpha} \beta^\beta}{\alpha - \beta - 1} \left(\frac{c(\alpha - \beta)}{(\alpha - \beta - 1)^2} \right)^{-\alpha} \left(\frac{c(\alpha - \beta)}{(\alpha - \beta - 1)^2} \right)^\beta \quad (27)$$

Then, the channel efficiency for the RS-ME model can be written as:

$$\xi_{RS-ME} = \frac{\Pi_{tot}}{\Pi_C} = \left(\frac{\alpha - \beta}{\alpha - \beta - 1} \right)^{-(\alpha - \beta - 1)} \left[\frac{2\alpha - 2\beta - 1}{\alpha - \beta} \right] \quad (28)$$

4.6. RS-RE Model

In this model, the decision on the marketing expenditure is taken by the retailer, who is also the Stackelberg leader. Thus, the decision variables for the manufacturer will be w , while those for the retailer would be P and M .

Proceeding as in the case of the RS-ME model, we can obtain the optimal values of retail and wholesale prices, marketing expenditure, profits made by the two parties as well as the channel efficiency.

Table 2 lists the results obtained for all the four models. Based on the results obtained, we offer the following propositions:

Proposition 1: The channel efficiency in both MS-ME and RS-RE models decreases with the increase in α and is bounded below by the constant ‘ $2/e$ ’ [where ‘ e ’ is the Euler’s number given

by $\lim_{n \rightarrow \infty} \left(1 + \frac{1}{n}\right)^n$ and is numerically equivalent to 0.3679], and as α approaches 1, the channel

efficiency also approaches 1.

Proposition 2: The channel efficiency in both MS-RE and RS-ME models decreases with the increase in $\alpha\text{-}\beta$ and is bounded below by the constant ‘ $2/e$ ’, and with β fixed, channel efficiency decreases as α increases, whereas with α fixed, channel efficiency increases with increase in β .

Proposition 3: A retailer Stackelberg model produces a higher profit for the manufacturer than the retailer, irrespective of which of the partners is taking the marketing expenditure decisions. Similarly, in a manufacturer Stackelberg model, the retailer earns a higher profit as compared to the manufacturer.

Proposition 4: The channel efficiency remain unaffected by the marketing expenditure elasticity of demand (β) if the marketing expenditure decisions are taken by the Stackelberg leader whereas if the Stackelberg follower makes the marketing expenditure decisions, β is a determinant of channel efficiency.

Table 2. Summary of the results obtained

Model	Output Variables
MS-ME	$w^* = \frac{\alpha c}{\alpha - \beta - 1}; M^* = \frac{\beta c}{\alpha - \beta - 1}; P^* = \frac{\alpha^2 c}{(\alpha - \beta - 1)(\alpha - 1)}$ $\Pi_M = k \cdot \frac{c^{-(\alpha - \beta - 1)} \beta^\beta}{(\alpha - \beta - 1)^{-(\alpha - \beta - 1)}} \cdot \left\{ \frac{\alpha^2}{\alpha - 1} \right\}^{-\alpha}; \Pi_R = k \cdot \frac{\alpha c^{-(\alpha - \beta - 1)} \beta^\beta}{(\alpha - 1)(\alpha - \beta - 1)^{-(\alpha - \beta - 1)}} \cdot \left\{ \frac{\alpha^2}{\alpha - 1} \right\}^{-\alpha}$ $\xi_{MS-ME} = \frac{\Pi_{tot}}{\Pi_C} = \left\{ \frac{\alpha}{\alpha - 1} \right\}^{-\alpha} \left(\frac{2\alpha - 1}{\alpha - 1} \right)$
MS-RE	$w^* = \frac{c(\alpha - \beta)}{\alpha - \beta - 1}; M^* = \frac{\beta c(\alpha - \beta)}{(\alpha - \beta - 1)^2}; P^* = \frac{\alpha c(\alpha - \beta)}{(\alpha - \beta - 1)^2}$ $\Pi_M = k \cdot \alpha^{-\alpha} \cdot \beta^\beta \left(\frac{c(\alpha - \beta)}{(\alpha - \beta - 1)^2} \right)^{-(\alpha - \beta - 1)}; \Pi_R = \frac{kc \cdot \alpha^{-\alpha} \beta^\beta}{\alpha - \beta - 1} \cdot \left(\frac{c(\alpha - \beta)}{(\alpha - \beta - 1)^2} \right)^{-\alpha} \left(\frac{c(\alpha - \beta)}{(\alpha - \beta - 1)^2} \right)^\beta$ $\xi_{MS-RE} = \frac{\Pi_{tot}}{\Pi_C} = \left(\frac{\alpha - \beta}{\alpha - \beta - 1} \right)^{-(\alpha - \beta - 1)} \left[\frac{2\alpha - 2\beta - 1}{\alpha - \beta} \right]$
RS-ME	$w^* = c \frac{1 + \beta + \alpha(\alpha - \beta - 1)}{(\alpha - \beta - 1)^2}; M^* = \frac{\beta c(\alpha - \beta)}{(\alpha - \beta - 1)^2}; P^* = \frac{\alpha c(\alpha - \beta)}{(\alpha - \beta - 1)^2}$ $\Pi_M = k \cdot \alpha^{-\alpha} \cdot \beta^\beta \left(\frac{c(\alpha - \beta)}{(\alpha - \beta - 1)^2} \right)^{-(\alpha - \beta - 1)}; \Pi_R = \frac{kc \cdot \alpha^{-\alpha} \beta^\beta}{\alpha - \beta - 1} \cdot \left(\frac{c(\alpha - \beta)}{(\alpha - \beta - 1)^2} \right)^{-\alpha} \left(\frac{c(\alpha - \beta)}{(\alpha - \beta - 1)^2} \right)^\beta$ $\xi_{RS-ME} = \frac{\Pi_{tot}}{\Pi_C} = \left(\frac{\alpha - \beta}{\alpha - \beta - 1} \right)^{-(\alpha - \beta - 1)} \left[\frac{2\alpha - 2\beta - 1}{\alpha - \beta} \right]$
RS-RE	$w^* = \frac{1 + \beta + \alpha \cdot (\alpha - \beta - 1)}{(\alpha - 1) \cdot (\alpha - \beta - 1)} c; M^* = \frac{\beta c}{\alpha - \beta - 1}; P^* = \frac{\alpha^2 c}{(\alpha - \beta - 1)(\alpha - 1)}$ $\Pi_M = k \cdot \frac{c^{-(\alpha - \beta - 1)} \beta^\beta}{(\alpha - \beta - 1)^{-(\alpha - \beta - 1)}} \cdot \left\{ \frac{\alpha^2}{\alpha - 1} \right\}^{-\alpha}; \Pi_R = k \cdot \frac{\alpha c^{-(\alpha - \beta - 1)} \beta^\beta}{(\alpha - 1)(\alpha - \beta - 1)^{-(\alpha - \beta - 1)}} \cdot \left\{ \frac{\alpha^2}{\alpha - 1} \right\}^{-\alpha}$ $\xi_{RS-RE} = \frac{\Pi_{tot}}{\Pi_C} = \left\{ \frac{\alpha}{\alpha - 1} \right\}^{-\alpha} \left(\frac{2\alpha - 1}{\alpha - 1} \right)$

Proposition 5: In case of MS-ME and RS-RE models, the channel efficiency is identical and the total channel profits are divided in reverse ratio between the manufacturer and the retailer in these two retail structures. Similar behavior is also observed in the case of the other models viz., MS-RE and RS-ME.

Proposition 6: The final retail price in case of MS-ME and RS-RE is the same. Similarly, in case of MS-RE and RS-ME also, the final retail price is equal. Furthermore, the retail price in case MS-ME and RS-RE is less than that obtained in case of MS-RE and RS-ME.

Proposition 7: The optimal marketing expenditure in case of MS-ME and RS-RE is the same. Similarly, in case of MS-RE and RS-ME also, the optimal marketing expenditure is equal. Furthermore, the optimal marketing expenditure in case MS-ME and RS-RE is less than that obtained in case of MS-RE and RS-ME.

Proposition 8: Channel efficiency for MS-RE and RS-ME is always greater than that for MS-ME and RS-RE.

5. CONTRACT DESIGN FOR SC COORDINATION

As discussed earlier, conflicting objectives of the SC partners result in inefficiencies whenever they are involved in isolated decision making (Dudek and Stadtler, 2005). Coordination helps in resolving these inefficiencies, and a variety of contractual mechanisms have been adopted by various organizations. A revenue sharing contract is one such mechanism, which allows the manufacturer to set a wholesale price and get a share in the retailer's sales revenues (Krishnan et al., 2004). While such a contract can coordinate the SC with only price dependent demand (Cachon and Lariviere, 2005; see Appendix B), we will show that it fails to do so in case the demand is dependent on both price as well as marketing expenditure.

5.1. Revenue sharing contract

Let us assume a case in which the retailer decides both the retail price as well as the marketing expenditure. Under the traditional revenue sharing contract, the retailer is charged a fixed wholesale price ‘ w ’, and the manufacturer gets a share of the final revenue earned. If ‘ λ ’ be the proportion of the revenue retained by the retailer then we must have $w = \lambda c$ (Giannoccaro and Pontrandolfo, 2004) where $\lambda \in (0,1)$.

The profit function for the retailer can then be written as:

$$\Pi_R = (\lambda P - w - M)D(P) = (\lambda P - \lambda c - M)kP^{-\alpha}M^\beta \quad (29)$$

Using the first order conditions, we can obtain:

$$P^* = \frac{\alpha c}{\alpha - \beta - 1} \quad (30)$$

$$M^* = \frac{\lambda \beta c}{\alpha - \beta - 1} \quad (31)$$

Thus, the demand function can be rewritten as:

$$D(P, M) = k \left(\frac{\alpha c}{\alpha - \beta - 1} \right)^{-\alpha} \left(\frac{\lambda \beta c}{\alpha - \beta - 1} \right)^\beta \quad (31)$$

Retailer’s Profit is thus given as:

$$\Pi_R = \frac{\lambda c k}{\alpha - \beta - 1} \left(\frac{\alpha c}{\alpha - \beta - 1} \right)^{-\alpha} \left(\frac{\lambda \beta c}{\alpha - \beta - 1} \right)^\beta \quad (32)$$

Similarly, we can write the manufacturer’s profit as:

$$\Pi_M = [w - c + (1 - \lambda)P]D(P, M) = k \cdot \left[\frac{c(1 - \lambda)(\beta + 1)}{\alpha - \beta - 1} \right] \left(\frac{\alpha c}{\alpha - \beta - 1} \right)^{-\alpha} \left(\frac{\lambda \beta c}{\alpha - \beta - 1} \right)^\beta \quad (33)$$

From (5), (32) and (33), we can clearly see that:

$$\Pi_{tot} = \Pi_R + \Pi_M \neq \Pi_C \quad (34)$$

Thus, a revenue sharing contract fails to coordinate the SC when the demand is dependent on both the retail price as well as marketing expenditure. It can be shown that the same holds true even when the manufacturer decides the marketing expenditure.

5.2. Hybrid cost and revenue sharing contract

In this case, the retailer pays the manufacturer a fixed wholesale price and gives him a share of the total revenue earned. Further, he also charges the manufacturer with a fixed proportion of the marketing cost. Let the final marketing expenditure be divided among the retailer and the manufacturer in the proportion μ : $1 - \mu$. As a result of which, the profit expression of the retailer changes to:

$$\Pi_R = (\lambda P - \lambda c - \mu M)D(P, M) = (\lambda P - \lambda c - \mu M)kP^{-\alpha}M^\beta \quad (35)$$

As before, using first order conditions:

$$P^* = \frac{\alpha c}{\alpha - \beta - 1} \quad (36)$$

$$M^* = \frac{\lambda \beta c}{\mu(\alpha - \beta - 1)} \quad (37)$$

Then, we can write:

$$\Pi_R = k \lambda c \left(\frac{1}{\alpha - \beta - 1} \right) \left(\frac{\alpha c}{\alpha - \beta - 1} \right)^{-\alpha} \left(\frac{\lambda \beta c}{\mu(\alpha - \beta - 1)} \right)^\beta \quad (38)$$

Manufacturer's profit will be:

$$\Pi_M = [w - c + (1 - \lambda)P - (1 - \mu)M]D(P, M) \quad (39)$$

Using (36) and (37) and simplifying, we get:

$$\Pi_M = kc \left[\frac{\mu\beta + \mu - \lambda\mu - \lambda\beta}{\mu(\alpha - \beta - 1)} \right] \left(\frac{\alpha c}{\alpha - \beta - 1} \right)^{-\alpha} \left(\frac{\lambda\beta c}{\mu(\alpha - \beta - 1)} \right)^\beta \quad (40)$$

Then, total profits across the SC will be:

$$\Pi_{tot} = \Pi_M + \Pi_R = kc\alpha^{-\alpha}\beta^\beta \left(\frac{c}{\alpha - \beta - 1} \right)^{-(\alpha-\beta)} \left(\frac{\lambda}{\mu} \right)^\beta \frac{1}{\alpha - \beta - 1} \left[\frac{\mu\beta + \mu - \lambda\beta}{\mu} \right] \quad (41)$$

Comparing (41) with the profits obtained in the coordinated case in (5), we can see that the hybrid contract can coordinate the SC when:

$$\left(\frac{\lambda}{\mu} \right)^\beta \frac{1}{\alpha - \beta - 1} \left[\frac{\mu\beta + \mu - \lambda\beta}{\mu} \right] = 1 \quad (42)$$

i.e., when $\lambda = \mu$. In other words, the hybrid contract coordinates the SC if the proportion of the marketing expenditure borne by the manufacturer is actually the same as the proportion of the revenue given to the manufacturer.

6. NUMERICAL ANALYSIS

In this section, we will further illustrate and clearly establish the relevance of our results through a numerical example. Consider a single manufacturer – single retailer system with the following parameter values, $\alpha=1.7$, $\beta=0.15$, $k=3500$ and $c=1$. We will now find the various results corresponding to all the retail structures studied (Table 3).

As can be seen from the table, the results obtained are in line with the propositions forwarded earlier. Thus, we find that manufacturer's profits are higher when the retailer is the Stackelberg leader, while the retailer's profit is higher when the manufacturer is the leader. Furthermore, the retail price and marketing expenditure are the same for MS-RE and RS-ME models as well MS-ME and RS-RE models. The same holds true for channel efficiency also.

Table 3. Values of decision variables for the models developed

Channel Structure	P	M	w	Π_M	Π_R	Π_{tot}	ξ
MS-ME	7.506	0.273	3.091	170.15	413.21	583.36	75.86%
MS-RE	8.711	0.769	2.818	154.34	434.95	589.28	76.63%
RS-ME	8.711	0.769	6.893	434.95	154.34	589.28	76.63%
RS-RE	7.506	0.273	5.416	413.21	170.15	583.36	75.86%
Coordinated	3.091	0.273	-	-	-	768.98	100.00%

Next, we will conduct sensitivity analysis in order to understand the behavior of the system when the system parameters change.

6.1. Change in α

The effect of change of α on different output variables is shown in Table 4. As expected, an increase in α led to a decrease in the retail price due to increased sensitivity to price changes forcing the decision maker to cut prices in order to maintain profits. It also leads to a concomitant decrease in the profits made by the manufacturer and the retailer and consequently, a decrease in channel efficiency across all the models.

Table 4. Impact of change in price elasticity of demand

α	P	M	w	Π_R	Π_M	ξ	<i>Model</i>
1.7	7.506	0.273	3.091	413.211	170.156	75.861%	MS-ME
1.8	6.231	0.231	2.769	361.109	160.493	75.501%	
1.9	5.348	0.200	2.533	319.953	151.557	75.222%	
2.0	4.706	0.176	2.353	286.680	143.340	75.000%	
2.1	4.220	0.158	2.211	259.268	135.807	74.821%	
2.2	3.841	0.143	2.095	236.326	128.905	74.674%	
1.7	8.711	0.769	2.818	434.957	154.336	76.631%	MS-RE
1.8	7.030	0.586	2.538	377.063	148.540	76.080%	
1.9	5.911	0.467	2.333	332.019	142.294	75.669%	
2.0	5.121	0.384	2.176	296.032	136.014	75.353%	
2.1	4.537	0.324	2.053	266.663	129.913	75.105%	
2.2	4.091	0.279	1.952	242.275	124.092	74.906%	
1.7	8.711	0.769	6.893	154.336	434.957	76.631%	RS-ME
1.8	7.030	0.586	5.491	148.540	377.063	76.080%	
1.9	5.911	0.467	4.578	142.294	332.019	75.669%	
2.0	5.121	0.384	3.945	136.014	296.032	75.353%	

2.1	4.537	0.324	3.485	129.913	266.663	75.105%	
2.2	4.091	0.279	3.138	124.092	242.275	74.906%	
1.7	7.506	0.273	5.416	170.156	413.211	75.861%	RS-RE
1.8	6.231	0.231	4.462	160.493	361.109	75.501%	
1.9	5.348	0.200	3.815	151.557	319.953	75.222%	
2.0	4.706	0.176	3.353	143.340	286.680	75.000%	
2.1	4.220	0.158	3.010	135.807	259.268	74.821%	
2.2	3.841	0.143	2.746	128.905	236.326	74.674%	

6.2. Change in β

The effect of change of β on different output variables is shown in Table 5. An increase in marketing expenditure elasticity of demand led to an increase in the marketing expenditure. However, the wholesale price charged by the manufacturer also increases, necessitating an increase in the retail price by the retailer in order to maintain profit level. Profits made by the manufacturer and the retailer decreased and consequently there is a decrease in channel efficiency.

Table 5. Impact of change in promotional expenditure elasticity of demand

β	P	M	w	Π_R	Π_M	ξ	<i>Model</i>
0.15	7.506	0.273	3.091	413.212	170.146	75.861%	MS-ME
0.16	7.646	0.296	3.148	408.048	168.020	75.861%	
0.17	7.790	0.321	3.208	403.275	166.055	75.861%	
0.18	7.940	0.346	3.269	398.869	164.240	75.861%	
0.19	8.095	0.373	3.333	394.806	162.567	75.861%	
0.20	8.257	0.400	3.400	391.066	161.027	75.861%	
0.15	8.711	0.769	2.818	434.946	154.336	76.631%	MS-RE
0.16	8.978	0.845	2.852	431.209	151.203	76.696%	
0.17	9.260	0.926	2.887	427.885	148.222	76.764%	
0.18	9.556	1.012	2.923	424.951	145.378	76.833%	
0.19	9.869	1.103	2.961	422.388	142.661	76.905%	
0.20	10.200	1.200	3.000	420.180	140.060	76.980%	
0.15	8.711	0.769	6.893	154.336	434.946	76.631%	RS-ME
0.16	8.978	0.845	7.126	151.203	431.209	76.696%	
0.17	9.260	0.926	7.373	148.222	427.885	76.764%	
0.18	9.556	1.012	7.633	145.378	424.951	76.833%	
0.19	9.869	1.103	7.908	142.661	422.388	76.905%	
0.20	10.200	1.200	8.200	140.060	420.180	76.980%	

0.15	7.506	0.273	5.416	170.146	413.212	75.861%	
0.16	7.646	0.296	5.497	168.020	408.048	75.861%	
0.17	7.790	0.321	5.582	166.055	403.275	75.861%	
0.18	7.940	0.346	5.670	164.240	398.869	75.861%	RS-RE
0.19	8.095	0.373	5.762	162.567	394.806	75.861%	
0.20	8.257	0.400	5.857	161.027	391.066	75.861%	

7. DISCUSSION AND MANAGERIAL IMPLICATIONS

The analysis in the preceding sections provides several pointers for academic researchers and practicing managers. The four Stackelberg models lead to different outcomes for the individual members of the SC. Interestingly, in all the four cases, the leader was worse-off as compared to the follower. In this sense, our results align with those obtained by Bichescu and Fry (2009). Furthermore, while SC efficiency was found to be the same for MS-RE and RS-ME models (and for MS-ME and RS-RE models), the individual share of the manufacturer and the retailer is reversed. Another important finding from our analysis is that channel efficiency increases when the decision on marketing expenditure is made by the Stackelberg follower. However, a follower experiences a decline in profit when he has to make the decision, even though there is a net gain for the system. From a practical viewpoint, it becomes problematic for either party to assume the mantle of leadership as it will lead to a reduction in profit. Reluctance on part of both the parties may end up jeopardizing the relationship, resulting in no transaction taking place. Nevertheless, given that entering into a relationship leads to net economic gain, it is in the interest of both to arrive at a negotiated settlement (Dudek and Stadtler, 2005). This realization has perhaps led to an increase in partnership agreements between organizations in recent times.

Revenue and cost sharing mechanisms also play an important role in creating strategic buy-in and deterring opportunistic behavior. While a pure revenue sharing arrangement fails to coordinate the SC, the hybrid contract ensures the same. However, operationalization of the hybrid contract calls for information sharing and that can only be achieved in the presence of a

certain degree of trust and goal alignment. Thus, other factors not considered in the models may play an important role in the choice of entering into a relationship (Chatterjee et al., 2014). This calls for a comprehensive evaluation of the entire set of available transactional mechanisms by both the parties (Gulati et al., 2012). Only then can the sub-optimal outcomes for the individual members as well as the entire chain be avoided.

8. CONCLUDING REMARKS

This paper has studied the decision making behavior in a single manufacturer – single retailer supply chain with price and marketing expenditure dependent demand. Alternate leadership structures and choice of decision-maker arrangements have been investigated and their impact on the profitability of the manufacturer and the retailer as well as the SC has been analyzed. In order to facilitate full coordination, a cost and revenue sharing contract has been proposed.

This work can be extended along several dimensions. Competition at both the manufacturer and the retailer level can be incorporated to mimic more real-life situations. In addition, impact of demand variability may also be investigated. Capacity constraints at both the ends may also be explored. Lastly, empirical validation of the analytical results may also provide further insights into organizational decision making and performance.

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