Chapter 2

Exploring the effect of corporate social responsibility in supply chains

Most models in supply chain literature are developed by assuming supply chain members are profit maximizers. Deviating from it the chapter examines whether non-profit maximizing motives of the supply chain members lead to any profit benefits or not. That is, is it true that a profit maximizing firm always earns maximum profit? To discuss this, the present chapter considers three different structures of supply chain to examine the effect of corporate social responsibility (CSR). In modelling the chapter only considers the effect of CSR in the form of consumer surplus in the channel members profit rather than the CSR activities, which they perform. Unlike the natural intension of maximizing the channel members profits, it uses the concept of the classic principle of Vickers [143]. The principle indicates that non-profit maximizing firm may earn higher profit than would profit-maximizers. Here the objectives of the channel members are to engage in CSR and to find the effects that CSR tends to bring about. The outcome of the chapter supports Vickers principle that when the channel members concentrate more on CSR than profit, their profits are always higher than their respective pure profits. The chapter mainly analyzes the effect of CSR on pricing policies and channel coordinated policies in different types of supply chain structures in three different sections. It is divided into three sections which are respectively two-level supply chain, three-level supply chain and distribution channel.

Section-2.1 considers a manufacturer-retailer chain that besides pure profit swells stakeholder’s welfare by exhibiting CSR. The manufacturer and the retailer share the channel CSR in a proportion. In manufacturer-Stackelberg game setting the section applies the concept of the subgame perfect equilibrium and extended alternating offer bargaining that uses the idea of random proposer, breakdown probability and outside option ([134], [15]) to resolve channel conflict and to divide the surplus between the channel members. The purpose of this section is to find some reasonable directions about the following queries. First, how the transfer pricing
policy that the channel members use is influenced by their social responsibilities. Second, how the pure profits of the channel members are affected by their CSR intensities. Third, how do the channel members balance the shareholder’s value and stakeholder’s value? Fourth, is there any compromise solution that effectively divides the channel’s socially responsibility between the channel members?

Section-2.2 intends to merge two research areas, CSR and channel coordination in a three-echelon supply chain that consists of a manufacturer, a distributor, and a retailer. Beside pure profit motive the manufacturer has the intent to swell stakeholder’s welfare by exhibiting CSR. In manufacturer-Stackelberg game setting the model developed here proposes a contract-bargaining process to resolve channel conflict and to distribute surplus profit among the channel members. In the contract-bargaining process the manufacturer first provides wholesale price discount to the distributor and bargain with the distributor for profit share. Based on the intermediate profit, the distributor provides wholesale price discount and bargains with the retailer for profit share.

The purpose of the section-2.3 is to incorporate CSR in a three-level distribution channel that consists of a manufacturer, multiple distributors, and multiple retailers under each distributor. Besides pure profit, the manufacturer, as the leader of the channel, considers stakeholders’ welfare through CSR and influences the downstream channel members to behave socially. In manufacturer-Stackelberg game setting apart from discussing the effects CSR in decentralized and centralized decision making, the section applies a new revenue sharing (RS) mechanism to resolve channel conflict and to find win-win profits of the channel members. In particular, the objective is to explore the effects of CSR on the channel members coordinated profits. Also, the section examines how the parameters of the RS contract are affected by the CSR attribute of the channel.

2.1 Coordination and profit division in a two-echelon socially responsible supply chain

This section\(^1\) considers a two-echelon supply chain consisting of a manufacturer and a retailer. The channel besides pure profit swells stakeholder’s welfare by exhibiting CSR. The manufacturer and the retailer share the channel CSR in a proportion. In modelling the study only considers the effect of CSR in the form of consumer surplus in the channel members profit rather than the CSR activities, which they perform. In manufacturer-Stackelberg game setting it applies the concept of the subgame perfect equilibrium to resolve channel conflict and to divide the surplus between the channel members.

The present study differs from the prior work as follows. First, although substantial research has been done on channel coordination by applying various contracts, mechanisms addressing to divide surplus profit among the channel members remain unexplored. Nagarajan and

\(^1\)This section is based on the paper entitled “Exploring the effects of social responsibility on coordination and profit division in a supply chain”, which is communicated to Journal of Cleaner Production.
Sosic [103] have pointed out “though transfer pricing policies are used extensively for channel coordination, ex-post to coordination, the question of how the shares are determined is left unaddressed.” This study uses the idea of subgame perfect equilibrium and strategic bargaining, which are fewer in supply chain literature, for channel coordination and profit division. 

Second, previous researches have explored CSR, effects of CSR on supply chain and channel coordination discretely. In contrast the present study examines the double marginalization issues in a socially responsible supply chain. Although Hsueh and Chang [64] have used exogenous monetary transfer to coordinate a socially responsible supply chain network, this study uses an endogenous procedure not only to coordinate the channel but also to divide the surplus profit among the channel members. Third, in Ni et al. [109] the supplier performs CSR and the downstream firm shares the CSR cost through wholesale price contract though channel coordination is not examined. Assuming each channel member has CSR cost Ni and Kevin [108] have found win-win profits through strategic interaction. The section assumes that both the channel members are socially responsible and presents a procedure that finds best channel profit through coordination. Also, it discusses about the channel members’ social responsibility performance in terms of pure profits and total profits.

2.1.1 Model formulation and basic analysis

Consider a manufacturer-retailer supply chain, where the manufacturer produces the product in a single lot at a cost $c$ and supplies it to the retailer in a single lot at a wholesale price $w^{m}$. The retailer sales the product to the customers at a retail price $p^{r}$. The demand at the retailer’s end is linear in retail price and is of the form $D(p^{r}) = a - bp^{r}$, where $a$, is the market potential and $b$ is the price sensitivity factor of demand. $p^{r} \in (0, a/b)$ ensures that under any circumstance the demand at the retailer’s end is non-negative.

Many leading brands face intense pressure for socially responsible supply chain management [7]. A commonly noted response to this pressure is the primary firm introduces code of conduct to its partners business practice to the socially responsible [117]. As a result other members of the channel involve in CSR practice. Thus, assume that the retailer and the manufacturer jointly exhibit social responsibility to the stakeholders in the proportions $k$ and $(1 - k)$, $0 \leq k \leq 1$. It is well established that a firm’s social responsibility is accounted through the consumer surplus that is accrued from its stakeholders ([88], [55], [56], [85], [109], [108]). Consumer surplus is the difference between the maximum price that the consumers are willing to pay for a product and the market price that they actually pay for the product. Thus, in the present modelling the consumer surplus can be found as

$$\int_{p^{r}_{\text{mkt}}}^{p^{r}_{\text{max}}} Q dp = \int_{(a-Q)/b}^{a/b} (a - bp^{r}) dp^{r} = \frac{Q^{2}}{2b} \quad (2.1)$$

If $\alpha \in [0, 1]$ is the fraction of CSR that is the socially responsible supply chains concerned then the retailer and the manufacturer incorporate $k\alpha Q^{2}/2b$ and $(1 - k)\alpha Q^{2}/2b$ consumer surpluses in their profit functions respectively. $\alpha = 0$ indicates that the supply chain is simply pure profit maximizing and $\alpha = 1$ represents that the supply chain is the perfect welfare maximizing. On
the other hand, if (i) \( \alpha \neq 0 \) and \( k = 0 \) then the manufacturer is socially responsible, and (ii) \( \alpha \neq 0 \) and \( k = 1 \) then the retailer is socially responsible. Since the channel members perform CSR in a proportion, the individual profit function of a channel member is the sum of pure profit and a fraction of consumer surplus that it accrues from the stakeholders. Under this assumption following subsection presents the decentralized and centralized decisions of the model.

### 2.1.2 Centralized and decentralized policy

When the channel members cooperate and find the decision that maximizes the supply chain performance, it is essentially the centralized decision making process. It may be assumed that there is a single decision maker, who produces and sales the product to the customers. The total profit of the channel is the sum of pure profit \( (\pi_c) \) and the consumer surplus \( (CS_c) \) that the channel accrues from the stakeholders. The profit function of the channel is

\[
v_c = \pi_c + CS_c
\]

Where \( \pi_c = (p^r - c)(a - bp^r) \) and \( CS_c = \alpha(a - bp^r)^2 / 2b \). The necessary condition, \( dv_c / dp^r = 0 \), for the existence of the optimal solution yields the optimal value of \( p^r \). Using it, the optimal order quantity, optimal pure profit, consumer surplus and total profit can be found and are presented in Table-2.1. Moreover, \( d^2v_c / dp^r^2 = -b(2 - \alpha) < 0 \), i.e., the optimal wholesale price provides global maximum to (2.2).

In decentralized decision making the channel members operate independently and maximize their individual profit functions. The study considers the manufacturer-stackelberg game, where the manufacturer is the leader of the channel and the retailer is its follower. In Stackelberg game, leader makes first move and follower then reacts by playing the best move consistent with available information. Objective of leader is to design own move in such a way to maximize own revenue after considering all rational moves follower can devise \[12\]. The manufacturer initiates the first move and enforces its own strategy on the retailer. Based on the manufacturers strategy the retailer finds its move that maximizes it’s profit. The pure profits of the retailer and the manufacturer are respectively as

\[
\pi_r = (p^r - w^m)(a - bp^r)
\]

\[
\pi_m = (w^m - c)(a - bp^r)
\]

Since, the channel members exhibit CSR in a proportion, their total profits are the sum of pure profits and the parts of consumer surplus that they accrue from the stakeholders. Using (2.1), the total profits of the retailer and the manufacturer are respectively found as

\[
v_r = \pi_r + k \left[ \frac{\alpha}{2b} (a - bp^r)^2 \right]
\]

\[
v_m = \pi_m + (1 - k) \left[ \frac{\alpha}{2b} (a - bp^r)^2 \right]
\]

Using backward induction, the Stackelberg equilibrium solution in the decentralized decision
making process can be found and are presented in table-2.1.

<table>
<thead>
<tr>
<th>Optimal</th>
<th>Decentralized channel</th>
<th>Centralized channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>(a(2 - \alpha)(2 + k)bc) (b(4 - \alpha - k))</td>
<td>(a - bc) ((4 - \alpha - k))</td>
</tr>
<tr>
<td>Order quantity</td>
<td>(\frac{a - bc}{(4 - \alpha - k)})</td>
<td>(\frac{a - bc}{(4 - \alpha - k)})</td>
</tr>
<tr>
<td>Pure profit((\pi))</td>
<td>(\frac{(2 - \alpha)T}{4(4 - \alpha - k)})</td>
<td>(\frac{(1 - \alpha)T}{4(4 - \alpha - k)})</td>
</tr>
<tr>
<td>Consumer surplus((CS))</td>
<td>(\frac{\alpha(1 - k)T}{2(4 - \alpha - k)})</td>
<td>(\frac{\alphaT}{2(4 - \alpha - k)})</td>
</tr>
<tr>
<td>Total profit ((PP+CS))</td>
<td>(\frac{T}{2(4 - \alpha - k)})</td>
<td>(\frac{(2 - \alpha)T}{2(4 - \alpha - k)})</td>
</tr>
</tbody>
</table>

Table 2.1: Optimal values in centralized and decentralized decision making.

In table-2.1, for abbreviation \(T = (a - bc)^2 / b\) is used. Now, the effects of CSR on the centralized and decentralized optimal decisions are examined through the following subsection.

### 2.1.3 Effects of CSR on centralized and decentralized decisions

Observe that, \(dv_{\alpha}/d\alpha = T/[2(2 - \alpha)^2] > 0, d\pi_{\alpha}/d\alpha = -\alpha T/(2 - \alpha)^3 < 0, dCS_{\alpha}/d\alpha = (2 + \alpha)T/2(2 - \alpha)^3 > 0\), i.e., in the centralized channel, the optimal total profit and consumer surplus increase but the pure profit decreases with increasing CSR of the channel. Also, \(dCS_{\alpha}/d\alpha - |\pi_{\alpha}/d\alpha| = T/[2(2 - \alpha)^2] > 0\), i.e., the increment of consumer surplus is higher than the decrement of pure profit. As a result total profit of the centralized channel increases with increasing CSR. Further, \(dp_{\alpha}/d\alpha = (a - bc)/b(2 - \alpha)^2 < 0\) and \(dQ_{\alpha}/d\alpha = (a - bc)/(2 - \alpha)^2 > 0\), i.e., the retail price of the channel decreases with increasing CSR. Since, the order quantity is inversely related to the retail price, it increases with increasing CSR. When the channel acts as the perfect welfare maximizer, \(p_{\alpha}|_{\alpha=1} = c\), the optimal retail price of the channel is equal to the marginal production cost. In such case \(v_{\alpha} = T/2, \pi_{\alpha} = 0\) and \(CS_{\alpha} = T/2\), i.e., the pure profit of the centralized channel is zero and the channel earns profit only through the consumer surplus from its stakeholders. On the contrary, when \(\alpha = 0\), i.e., in the traditional profit maximizing channel, \(p_{\alpha} = (a + bc)/2b, Q_{\alpha} = (a - bc)/2, v_{\alpha} = T/4, \pi_{\alpha} = T/4\) and \(CS_{\alpha} = 0\). Obviously \(v_{\alpha}|_{\alpha=1} > v_{\alpha}|_{\alpha=0}\), i.e., total profit of the perfect welfare maximizing centralized channel is higher than that of the traditional pure profit maximizing centralized channel. Also, total profit is an increasing function of the CSR. Thus, the socially responsible supply chain acts more competitively than a pure profit maximizing supply chain. It encourages the customers to buy more quantity by reducing the retail price. By doing so it earns more consumer surplus, that effectively nullifies the loss of pure profit and generates higher total profit.

Note that \(dv_{\alpha}/d\alpha = (4 - \alpha k - \alpha k^2)T/2(4 - \alpha - \alpha k)^3 > 0\), for any \(k \in [0, 1]\). Also \(dv_{m}/d\alpha = (1 + k)T/2(4 - \alpha - \alpha k)^3 > 0\), i.e., the total profit of the manufacturer and the retailer increase with increasing CSR. Also \(dp_{\alpha}/d\alpha = -(2 - \alpha k)(4 - \alpha - \alpha k)((2 + 5k - 2ak(1 + k))a + kbc) - 2(1 + 3k - ka - k^2)\((6 - (2 + 5k)a + b(1 + k)(2 - ka)bc)) / b(2 - \alpha k)^2(4 - \alpha - \alpha k)^2 < 0\),
\[ \frac{dQ}{d\alpha} = \frac{(a - bc)(1 + k)/(4 - \alpha - \alpha k)^2 > 0 \text{ and } \frac{dw}{d\alpha} = -2(1 - k)(a - bc)/b(4 - \alpha - \alpha k) \leq 0 \text{ for any } k \in [0, 1]. \]

In decentralized decision making, to perform more competitively by exhibiting CSR, the manufacturer and the retailer act as follows. When they decide to increase CSR, the manufacturer reduces the wholesale price. In response, the retailer also reduces the retail price to encourage the customers to buy more. As a result, the order quantity increases. Obviously, the channel members lose some pure profits, which are compensated by the increment of consumer surplus. However, in decentralized decision making process the pure profits of the channel members behave quite differently from those of a pure profit maximizing supply chain. The profit functions satisfies the following properties.

**Proposition 2.1** In decentralized decision making for any \( k \in (0, 1) \) (a) the pure profit (i) of the retailer is increasing for any \( \alpha \in (0, f(k)) \), \( f(k) \leq 1 \) and decreasing for any \( \alpha \in (f(k), 1) \), \( f(k) \leq 1 \) (ii) of the manufacturer is increasing for any \( \alpha \in (0, g(k)) \), \( g(k) \leq 1 \) and decreasing for any \( \alpha \in (g(k), 1) \), \( g(k) \leq 1 \). (b) the pure profits of the manufacturer and the retailer (i) are increasing for \( \alpha \in (0, \min\{f(k), g(k)\}) \), \( f(k) \leq 1 \), \( g(k) \leq 1 \) and (ii) behave inversely for \( \alpha \in (\min\{f(k), g(k)\}, \max\{f(k), g(k)\}) \).

**Proof** See appendix A-2.1.

![Graphical representation of the Proposition-2.1](image)

(a) Nature of \( f(k) \) and \( g(k) \)

(b) Nature of the decentralized pure profit

**Figure 2.1:** Graphical representation of the Proposition-2.1

Proposition-2.1 indicates the behaviour of the decentralized profit functions of a socially responsible two-tire supply chain. It demonstrates that increment or decrement of the channel members’ pure profits are heavily influenced by the intensity of CSR and the channel members must concentrate on the share of CSR in order to receive reasonable pure profits. In the present model setting, if the channel members choose any \( \alpha \in (g(k), f(k)) \) and the retailer shares CSR in \([0.33, 0.561]\) leaving the rest for the manufacturer then both members’ pure profits would increase with increasing \( \alpha \) (see fig-2.1).
When $0 \leq \alpha \leq g(k)$ and the retailer takes the responsibility of CSR in $[0, 0.33]$, its pure profit increases but the manufacturer's pure profit decreases with increasing $\alpha$. Finally, for any $\alpha \in (f(k), 1)$ and for any $k \in [0.56, 1]$, the manufacturer's pure profit increases but the retailer's pure profit decreases with increasing $\alpha$. Thus, in decentralized decision making besides the channel CSR, the share of channel CSR is the key parameter that actually determines the pure profit division between the channel members. On the other hand, this result does not hold when any one channel member is socially responsible. For socially responsible manufacturer and socially responsible retailer the optimal values of the decision variables and optimal profits of the channel are depicted in table-2.2.

<table>
<thead>
<tr>
<th>$k$</th>
<th>CSR member</th>
<th>Optimal</th>
<th>Decentralized channel</th>
<th>Centralized channel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Price</td>
<td>Manufacturer</td>
<td>Retailer</td>
</tr>
<tr>
<td>0</td>
<td>Manufacturer</td>
<td>$a(2-\alpha)+bc/(4-\alpha)$</td>
<td>$2(3-\alpha)a+bc/(2(4-\alpha))$</td>
<td>$(1-\alpha)a+bc/6(2-\alpha)$</td>
</tr>
<tr>
<td></td>
<td>Order quantity</td>
<td>$a-bc/(4-\alpha)$</td>
<td>$a-bc/(4-\alpha)$</td>
<td>$a-bc/(2-\alpha)$</td>
</tr>
<tr>
<td></td>
<td>Pure profit</td>
<td>$(2-\alpha)/2(4-\alpha)$</td>
<td>$(1-\alpha)/2(4-\alpha)$</td>
<td>$(1-\alpha)/2(4-\alpha)$</td>
</tr>
<tr>
<td></td>
<td>Consumer surplus</td>
<td>$aT/2(4-\alpha)$</td>
<td>$T/(4-\alpha)$</td>
<td>$T/(4-\alpha)$</td>
</tr>
<tr>
<td></td>
<td>Total profit</td>
<td>$2(4-\alpha)$</td>
<td>$T/(4-\alpha)$</td>
<td>$T/(4-\alpha)$</td>
</tr>
<tr>
<td>1</td>
<td>Retailer</td>
<td>Price</td>
<td>$a+bc/2b$</td>
<td>$(3-2\alpha)a+bc/2b(2-\alpha)$</td>
</tr>
<tr>
<td></td>
<td>Order quantity</td>
<td>$a-bc/(2-\alpha)$</td>
<td>$a-bc/(2-\alpha)$</td>
<td>$a-bc/(2-\alpha)$</td>
</tr>
<tr>
<td></td>
<td>Pure profit</td>
<td>$(1-\alpha)/2(4-\alpha)$</td>
<td>$(1-\alpha)/2(4-\alpha)$</td>
<td>$(1-\alpha)/2(4-\alpha)$</td>
</tr>
<tr>
<td></td>
<td>Consumer surplus(CS)</td>
<td>$0$</td>
<td>$aT/8(2-\alpha)$</td>
<td>$0$</td>
</tr>
<tr>
<td></td>
<td>Total profit (PP+CS)</td>
<td>$T/4(2-\alpha)$</td>
<td>$(2-\alpha)/8(2-\alpha)$</td>
<td>$T/4$</td>
</tr>
</tbody>
</table>

Table 2.2: Optimal values in limiting cases of the share of CSR.

Note that $d(\pi^r)_{k=0}/d\alpha = 2T/(4-\alpha)^3 > 0$, i.e., when the manufacturer is socially responsible, the retailer’s profit increases with increasing CSR. Also $d(\pi^m)_{k=1}/d\alpha = T/(2-\alpha)^2 > 0$, i.e., the manufacturer’s profit increases with increasing CSR of the socially responsible retailer.

Notice that $v_r + v_m = (6 - \alpha - 2\alpha k)T/2(4 - \alpha - \alpha k)^2 < v_r$ for all $\alpha \in [0, 1]$ and $k \in [0, 1]$, i.e., the channel conflict is not resolved. Also, $d(\pi_c - (v_r + v_m))/d\alpha = (T/2)(2/(4-\alpha)^3 - ((8 - \alpha - 3\alpha k) + 2k(2 - \alpha k))/(4 - \alpha - \alpha k)^3) > 0$ for all $k \in [0, 1]$ and $\alpha \in [0, 1]$, i.e., the difference of the centralized channel profit and decentralized total profit increases with increasing CSR of the channel. This result is different from a pure profit maximizing supply chain. In pure profit maximizing supply chain the channel conflict decreases when the retailer reduces the retail price and the channel is coordinated when the retailer set the centralized retail price.

However, in a socially responsible supply chain double marginalization increases though the retail price of the channel decreases with increasing CSR. Now $\pi_c - (\pi^r + \pi^m) = [(1-\alpha)(4-\alpha - \alpha k)^2 - (2-\alpha)^2(3-\alpha - \alpha k)]T/(2-\alpha)^2(4-\alpha - \alpha k)^2 > 0$ if $(1-\alpha)(4-\alpha - \alpha k)^2 - (2-\alpha)^2(3-\alpha - \alpha k) > 0$ i.e. if $\alpha < h(k)$, say, and $k \in (0,1)$, where $h(k)$ is the real root of the equation $k(k+1)\alpha^3 - (2+6k+k^2)\alpha^2 + 4(k+2)\alpha - 4 = 0$. Thus, the pure profit of the
centralized channel is higher than the sum of the pure profits in the decentralized channels for $\alpha \in (0, h(k))$ and $k \in (0, 1)$ (see fig-2.2). Also, note that when the manufacturer is only socially responsible, i.e., $k = 0$ and is the perfect welfare maximizer, i.e., $\alpha = 1$, $v_r = T/9$, $v_m = T/6$ and $v_r + v_m = 5T/18$, i.e., the channel conflict is not resolved. So, in a socially responsible supply chain, the manufacturer’s perfect welfare maximizing motive does not resolve channel conflict. Further, when the retailer is only socially responsible, i.e., $k = 1$, and is the perfect welfare maximizer, i.e., $\alpha = 1$, $v_r = T/8$, $v_m = T/4$ and $\pi^r = 0$. In the stackelberg game setting, when the retailer is socially responsible, the effect of CSR is its own and it would not be included in the centralized channel. As such, $\pi^r|_{\alpha=1} + v_m|_{\alpha=1} = T/4 = \pi_c|_{\alpha=0}$, i.e., the channel is coordinated. Thus the analysis concludes following proposition.

**Proposition 2.2** In a socially responsible supply chain (i) the channel conflict increases with increasing CSR of the channel, (ii) the pure profit of the centralized channel is lower for $\alpha \in (0, h(k))$ when compared with the decentralized total pure profit and (iii) the retailer’s perfect welfare maximizing motive resolves channel conflict though the manufacturer’s perfect welfare maximizing motive does not.

### 2.1.4 Channel coordination and profit division

As a socially responsible channel member, the manufacturer’s goal is to receive larger lot from the retailer to act more competitively through CSR practice. Although as a CSR channel member, the retailer wants to increase its decentralized order quantity, it’s pure profit will be suboptimal in that case. To cope with this situation, transfer pricing policies may be used as coordination contracts, which effectively reduce conflicting objectives of the channel members and lead to the channel best decision. Interestingly, a coordination contract helps to provide the channel best solution but it does not provide any idea about the division of surplus that is generated through coordination. Most of the papers in such case assume the channel surplus created through coordination is split arbitrarily [103]. This procedure has two problems. First,
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if the channel members have some outside options then why do they accept the agreement that resolves only the channel conflict? Second, instead of considering division of channel surplus, the channel members may continue negotiation hoping that they may gain larger share of profit surplus. Wu [147] has indicated there are three reasons, which impel to apply strategic bargaining as an alternative to supply chain interaction. First, contract negotiation is generalized to a bilateral bargaining over the expected channel surplus. Second, instead of considering the contract would be accepted in one offer, an alternating offer bargaining process takes place before a final agreement is reached. Third, instead of the pre-determined contract, the channel members bargaining powers settle the division of the channel surplus. Thus, instead of using any transfer pricing policy, the study considered a game theoretic approach for channel coordination and profit division between the channel members. Study first shows that in the present model setting the subgame perfect equilibrium resolves channel conflict then extended alternative offer bargaining is used to divide the surplus between the channel members. Although the study assumes the manufacturer-Stackelberg game setting, in a supply chain it is always possible for any one of the channel members to offer a wholesale price-retail price pair to the other member of the channel. Since, the channel has two members, either the retailer or the manufacturer may propose the price pair. The following proposition shows that the subgame perfect equilibrium can resolve the channel conflict.

**Proposition-2.3** Irrespective of the proposer in the channel, the subgame perfect equilibrium retail price \((1 - \alpha)a + bc/b(2 - \alpha)\) resolves the channel conflict.

**Proof** See appendix A-2.2.

Notice that \(p^*_r = p^*_m = p^*_c\), i.e., whoever is the offering party, the subgame perfect equilibrium price is the best retail price and it is equal to the centralized retail price of the channel. Also, the total profit corresponding to the subgame perfect equilibrium is same as the centralized profit. So, it resolves channel conflict. Since, any channel member can offer the pricing policy, each iteration is a subgame of same structure. Thus, the profit equilibrium strategies of the players are same in each subgame. In subgame perfect equilibrium the wholesale price, when the retailer proposes is different from that when the manufacturer proposes. In both the cases the optimal retail price and channel profit remain same. The wholesale price does not affect the equilibrium price and the channel profit because it is simply the transfer of revenue from the retailer to the manufacturer in the channel.

Irrespective of the proposer as the subgame perfect equilibrium price coordinates the channel, based on it strategic bargaining is applied to divide the channel surplus between the members. The intuition behind considering the subgame perfect equilibrium as the basis of the strategic bargaining is straightforward. The subgame perfect equilibrium strategy allows predicting the result of bargaining and the bargaining game will finish in one iteration when the players use the subgame perfect equilibrium strategy. In the line of Sutton [134], Binmore et al. [15] the study considers the extended alternating offer bargaining game, where three additional criterions are included. First, to make the iterations of the bargaining process independent assume that both players are equally likely to make an offer at any iteration of the game. Second, to depict the stability of the bargaining process, assume the negotiation may breakdown with a
certain probability. Third, the players have the outside options. Wu [147] has mentioned the bargaining process is influenced by the outside options because a player’s negotiation power depicts its ability to influence the breakdown probability. The study also considers two essential properties, which are satisfied by the unique subgame perfect equilibrium strategy of alternating offer bargaining game. No delay, i.e., a player’s equilibrium offer will be always accepted by the other player and stationarity, i.e., a player will make the same offer in the equilibrium (see Shaked and Sutton [128] and Sutton [134] for detail description). The sequence of events in the bargaining game is as follows. With equal probability \( \frac{x}{2} \), \( 0 \leq x \leq 1 \) a player proposes an offer that splits the channel profit into certain amounts. \( \rightarrow \) The other player either accept the offer (the negotiation end) or reject the offer and wait for the next round. \( \rightarrow \) With probability \( (1 - x) \) the negotiation breaks down and the players take their corresponding outside options. \( \rightarrow \) If the negotiation continues, the game restarts from the beginning. It is obvious to assume that for an effective bargaining process the sum of the players outside options are less than or equal to the maximum total surplus of the trade, i.e., \( \pi_s \geq O_r + O_m \). Under the above game setting, the extended alternating offer bargaining game provides the following result.

**Proposition-2.4** In subgame perfect equilibrium, if the retailer (manufacturer) proposes the offer first then it asks a share \( R \) (\( M \)) of the channel surplus and leaves the remaining for the manufacturer (retailer), where \( R \) and \( M \) are \( \pi_s - O_m - x^2(\pi_s - O_m - O_r)/2(2 - x) \) and \( \pi_s - O_r - x^2(\pi_s - O_m - O_r)/2(2 - x) \) respectively.

**Proof** See appendix A-2.3.

It turns out that the bargaining game will end in one iteration when a player offers subgame perfect equilibrium strategy and the offer is better than the other players outside option. Also, the stationarity and no delay assumptions ensure that a player’s offer remains same at each iteration and a player’s offer will always be accepted by the other player. Thus, when the retailer is the offering party, total profit of the retailer and the manufacturer are \( v^b_r = v_r + R \) and \( v^b_m = v_m + (\pi_s - R) \) respectively. However, as pointed out by Osborne and Rubinstein [111], there is a first mover’s advantage but the advantage diminishes as the probability of breakdown approaches to zero. Also, when the channel members have no outside options, i.e., \( O_r = O_m = 0 \), the probability for opting outside option is zero. In that case, the manufacturer and the retailer share the channel surplus equitably.

As the subgame perfect equilibrium strategy is the channel optimal, determination of the wholesale price is equivalent to divide the channel surplus \( \pi_s \) through bargaining. Therefore, when the retailer offers \( (p^c, w^{mb}) \) for the share \( R \) of the channel surplus, the following relation can be realized.

\[
(p^c - w^{mb})Q_c + k\frac{\alpha}{2b}(Q_c)^2 = \pi^b_r
\]  

(2.7)

Simplifying (2.7) and solving, \( w^{mb} \) can be found as

\[
w^{mb} = c + \frac{\pi_c}{Q_c} + \frac{k\alpha Q_c}{2b} - \frac{v_r + R}{Q_c}
\]  

(2.8)

Consequently the channel optimal pure profits and total profits of the manufacturer and the
CHAPTER 2. EXPLORING EFFECT OF CSR IN SUPPLY CHAIN

2.1.5 Effects of CSR on the channel optimal decision

In a CSR supply chain when the channel members share the channel CSR in a proportion it is possible to get the channel optimal wholesale price by using stationary strategic bargaining. Also, it is possible to divide the surplus profit between the channel members. In order to examine the effect of CSR on the channel members’ decisions, when there are no outside options, substituting $O_r = O_m = 0$ in (2.8) the wholesale price can be found as

$$w^m_c = c + \left(\frac{a - bc}{2b}\right) \left[\frac{2 - 2\alpha + \alpha k}{2 - \alpha} - \frac{(2 - \alpha k)(6 - 2\alpha - \alpha k)}{2(4 - \alpha - \alpha k)^2}\right]$$  \hspace{1cm} (2.9)

Now, the impact of the CSR on the manufacturer’s wholesale price can be summarized by the following proposition.

Proposition-2.5 In a socially responsible supply chain, where the manufacturer and the retailer share the CSR, $\alpha$ in the proportion $(1-k)$ and $k$, $0 \leq k \leq 1$, the channel optimal wholesale price of the manufacturer is (i) inversely proportional to the channel’s CSR practice, (ii) less than its marginal production cost for $\alpha \in (\phi(k), 1)$ and $k \in (0, 0.425)$ and (iii) negative for $\alpha \in (\psi(k), 1)$.

Proof See appendix A-2.4.

In equilibrium the socially responsible channel behaves more competitively than a pure profit maximizing channel. As the leader of the channel the manufacturer reduces its wholesale price to exhibit more channel CSR. As such its wholesale price may be less than its marginal pro-
duction cost. Even it may be negative for heavy CSR practice, i.e., the manufacturer pays the retailer to sell products extra to the retailer’s decentralized order quantity. In fact the objective of the manufacturer is not to find the channel best pure profit rather by doing so it encourages the retailer to sell more units by reducing the selling price.

In response, the CSR retailer also sells the product below its decentralized selling price. Since, the channel members display CSR jointly, the fraction of CSR that the manufacturer shares has great impact on its own wholesale price. With increasing CSR if the manufacturer considers higher share of social responsibility then the rate of decrement of its bargaining wholesale price is higher. Thus, the wholesale price of the manufacturer is highly influenced by the CSR and CSR sharing fraction. This result is quite different from a pure profit maximizing supply chain. In a pure profit maximizing supply chain, when a transfer pricing is used for channel coordination, the channel optimal wholesale price is equal to or less than the marginal production cost and it is never negative. This result does not hold in a socially responsible supply chain. In the present model setting, the manufacturer’s wholesale price is less than its marginal production cost for the channel’s heavy CSR practice ($\alpha \in (0.73, 1)$) and it is negative for any channel CSR in $(\psi(k), 1)$. In that case, how much share of CSR, the manufacturer bears that depends on the system parameters (See fig 2.3).

**Proposition-2.6** In a socially responsible supply chain, where the manufacturer and the retailer shares the CSR, $\alpha$ in a proportion $(1-k)$ and $k \leq 1$, (i) the equilibrium pure profit of the manufacturer increases and the equilibrium pure profit of the retailer decreases in the region where $\alpha \in (0, \min\{\beta(k), 1\})$, $k \in (0.445, 1)$, (ii) the equilibrium pure profit of the manufacturer decreases and the equilibrium pure profit of the retailer increases in the region where $\alpha \in (0, \min\{\eta(k), 1\})$, $k \in (0, 0.445)$, (iii) the equilibrium pure profits of the manufacturer and the retailer decrease for $\alpha \in ((\min\{\beta(k), 1\}, 1) \cup (\min\{\eta(k), 1\}, 1))$, $k \in (0.17, 0.811)$, (iv) the equilibrium pure profit of the manufacturer is negative for $\alpha \in (\phi(k), 1)$ and $k \in (0, 0.425)$ (v) the equilibrium pure profit of the retailer is negative for $\alpha \in (\xi(k), 1)$ and $k \in (0.425, 1)$.

**Proof** See appendix A-2.5.

Proposition 2.6 indicates the behaviour of channel optimal bargaining pure profits of the channel members with respect to the channel CSR and CSR sharing fraction. The socially responsible

<table>
<thead>
<tr>
<th>CSR member</th>
<th>Wholesale price</th>
<th>Range of $\alpha$</th>
<th>Wholesale price $&lt; \alpha$</th>
<th>Wholesale price $&lt; 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>$c + \frac{\pi_n}{Q_c} + \frac{knQ_r}{2b} - \frac{v_r + R}{Q_r}$</td>
<td>$k \in (0, 0.445)$</td>
<td>$(\phi(k), 1)$</td>
<td>$(\psi(k), 1)$</td>
</tr>
<tr>
<td>Retailer</td>
<td>$\frac{(1-\alpha)[a+bc]}{b(2-\alpha)} - \frac{(3-\alpha)[a-bc]}{b(4-\alpha)^2}$</td>
<td>$k \in (0.17, 0.811)$</td>
<td>$(0.73, 1)$</td>
<td>$(\alpha_1, 1)$</td>
</tr>
<tr>
<td>Retailer</td>
<td>$c + \frac{(5-4a+\alpha^2)[a-bc]}{4b(2-\alpha)^2}$</td>
<td>$k \in (0, 0.425)$</td>
<td>Never</td>
<td>Never</td>
</tr>
</tbody>
</table>

Table 2.3: Equilibrium wholesale price and its properties for different CSR member
CHAPTER 2. EXPLORING EFFECT OF CSR IN SUPPLY CHAIN

channel members’ profits are quite different from those of a pure profit maximizing supply chain. When the channel CSR increases, the pure profits of the channel members may increase or decrease. Since, both the channel members practice CSR, the CSR sharing fraction is the determining factor for the channel member’s increment or decrement of the pure profit.

However, total pure profit of the channel is inversely proportional to the channel’s CSR practice. Thus, once the intensity of the channel CSR is determined and the retailer shares the CSR heavily then it’s pure profit decreases but the manufacturer’s pure profit increases (see fig 2.4). Reverse trend may be observed if the manufacturer displays CSR heavily. Interestingly, as the wholesale price of the manufacturer is inversely proportional to the channel’s CSR practice, it may be less than it’s marginal production cost.

Thus, the manufacturer’s pure profit may be negative for the CSR sharing fraction below a threshold. Similarly, for exhibiting CSR as the retailer reduces the decentralized retail price, it’s pure profit may be negative for CSR sharing fraction above a threshold (see fig 2.5). This result is similar to “it pays good but not too good” [98]. On the other hand, though the pure profit of the channel decreases as the channel CSR increases the total profit of the channel increases (see table-2.4). The intuitive reason is straightforward. The pure profit that the channel loses for CSR is over compensated by the consumer surplus which the channel earns for practicing CSR. Thus, it is important for the channel members to decide up to what extent the channel shows CSR and how much CSR they share such that (i) the channel conflict is resolved and (ii) they balance the pure profits and total profits of the channel members.

An abbreviation, \( T_{11} = 20 - 12\alpha - 8\alpha k + 2\alpha^2 + 2\alpha^2k + \alpha^2k^2 \) is used in table-2.4.

2.1.6 Special cases

The previous section explores the impacts of CSR on the channel members’ profits when the manufacturer and the retailer jointly swell stakeholders welfare by exhibiting CSR in a proportion.
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(a) Nature of $\xi(k)$

(b) Nature of $\beta(k)$ and $\eta(k)$

Figure 2.5: Graphical representation of $\xi(k)$, $\beta(k)$ and $\eta(k)$

TABLE 2.4: Equilibrium profits of the manufacturer and the retailer for different CSR member

<table>
<thead>
<tr>
<th>CSR member</th>
<th>Manufacturer</th>
<th>Retailer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pure profit</td>
<td>Total profit</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>$\frac{T_{11}}{2(4-a-ak)^2} \pi_c^*$</td>
<td>$\frac{T_{11}}{2(4-a-ak)^2} \pi_c^*$</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>$\frac{2(10-19a+8a^2-a^3)}{(2-a)(4-a)^2} \pi_c^*$</td>
<td>$\frac{2(10-6a+a^3)}{(4-a)^2} \pi_c^*$</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>$\frac{(5-8a+a^3)}{2(2-a)^2} \pi_c^*$</td>
<td>$\frac{(5-4a+a^3)}{2(2-a)^2} \pi_c^*$</td>
</tr>
<tr>
<td>Retailer</td>
<td>$\frac{(1-a)b(4-a)^2}{b} \pi_c^*$</td>
<td>$\frac{(3-a)(1-a)\pi_c^*}{2(2-a)^2}</td>
</tr>
</tbody>
</table>

When the manufacture exhibits CSR, it’s equilibrium wholesale price can be found by substituting $k = 0$ in (2.9) as

$$w_{m/e/m}^* = \frac{(1-a)ab}{b(4-a)^2} - \frac{(3-a)(a-bc)}{b(4-a)^2}$$  \hspace{1cm} (2.10)

Consequently, the pure profits and total profits of the channel members can be found and are presented in table-2.4. Note that $dw_{m/e/m}^*/d\alpha = -[(a-bc)/b][(1/(2-\alpha)^2)+((2-\alpha)/(4-\alpha)^3)] < 0$, i.e., the equilibrium wholesale price of the manufacturer decreases with its increasing CSR. Now, $w_{m/e/m}^* < c$ if $10 - 19a + 8a^2 - \alpha^3 < 0$, i.e., if $\alpha > 0.73$ then the wholesale price is less than its marginal production cost. Otherwise, for any $\alpha \in (0,0.73)$ the wholesale price of the manufacturer is higher than the marginal production cost. Furthermore, $w_{m/e/m}^* < 0$ if $\alpha \in (\alpha_1,1)$, where $\alpha_1$ is the real root of the equation $a\alpha^3 - 2(4a + bc)\alpha^2 + (19a + 13bc)\alpha - 2(5a + 11bc) = 0$ and is given by

$$\alpha_1 = M_1 \frac{3a}{3a} - \frac{21/3(-M_1^2 + 3aN)}{3aS_1} + \frac{S_1}{21/3a}$$  \hspace{1cm} (2.11)
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Where, \( M_1 = (8a + 2bc) \), \( N_1 = (19a + 13bc) \), \( T_1 = 10a + 22bc \) and
\[
S = \left[27a^2T_1 + 2M_1^3 - 9aM_1N_1 + \sqrt{4(-M_1^2 + 3aN_1)^3 + (27a^2T_1 + 2M_1^3 - 9aN_1N_1)^2}\right]^{1/3}
\]

Thus it concludes the following proposition.

**Proposition-2.7** The equilibrium wholesale price of the CSR manufacturer is (i) inversely proportional to it’s CSR practice, (ii) less than it’s marginal production cost for any \( \alpha \in (0, 73, 1) \) and (ii) negative for any \( \alpha \in (\alpha_1, 1) \).

The CSR manufacturer acts quite differently when compared with a pure profit maximizing manufacturer. For CSR it reduces wholesale price to encourage the retailer to sell additional units by reducing it’s selling price. Thus, the manufacturer may supply the product below it’s marginal production cost. Even it’s wholesale price may be negative for heavy CSR practice, i.e., the CSR manufacturer pays the retailer to sell products additional to the decentralized order quantity.

On the other hand, when the manufacturer’s CSR increases, it’s pure profit decreases but the consumer surplus that it accrues from the stakeholders increases. This is quite reasonable because the equilibrium wholesale price of the manufacturer is inversely proportional to it’s CSR. When the manufacturer performs CSR heavily, it’s wholesale price is below the marginal production cost or negative. So, the manufacturer’s pure profit is negative though the consumer surplus that it receives from the stakeholders compensates the loss of pure profit and leads to increment of total profit when compared with decentralized total profit. Thus, the manufacturer should be careful while choosing the intensity of CSR such that it’s pure profit and CSR activity are suitably balanced.

2.1.6.2 The CSR retailer

When the retailer is only socially concerned, the CSR is it’s own. As indicated, the centralized profit function is independent of consumer surplus. The centralized profit function is \( \pi_{c/r} = (p^* - c)(a - bp^*) \). Consequently, optimal selling price, order quantity and profit are respectively as \( p_{c/r} = (a + bc)/2b \), \( Q_{c/r} = (a - bc)/2b \) and \( \pi_{c/r} = (a - bc)^2/4b \). The coordinated total profit of the channel is same as the centralized channel profit. Thus, the channel surplus after coordination can be found by subtracting the sum of decentralized pure profits of the manufacturer and the retailer (for \( k = 0 \)) from \( \pi_{c/r} \) and is given by

\[
\pi_{s/r} = \left(\frac{1 - \alpha}{2 - \alpha}\right)^2 \pi_{c/r}
\]

Since, in equilibrium the channel surplus is divided equitably between the retailer and the manufacturer, the manufacturer’s profit in equilibrium \( T/[4(2 - \alpha)] + \pi_{s/r}/2 \) is equal to \( (w_{e/r} - c)Q_{c/r} \). On simplification, the wholesale price of the manufacturer is found as

\[
w_{e/r} = c + \frac{(5 - 4\alpha + \alpha^2)(a - bc)}{4b(2 - \alpha)^2}
\]
Consequently, the pure profits and total profits of the retailer and the manufacturer can be found and are presented in table-2.4.

Note that \( \frac{d w_{e/r}}{d \alpha} = \frac{2}{(2 - \alpha)^3} \) for any \( \alpha \in (0, 1) \), i.e., when the retailer increases it’s CSR, the manufacturer increases it’s wholesale price. Further, \( w_{e/r} - c > 0 \) for any \( \alpha \in (0, 1) \), i.e., the equilibrium wholesale price of the manufacturer is always higher than it’s marginal production cost. The CSR retailer acts more competitively than a pure profit maximizing retailer. When it puts more weight on CSR, it increases the number of units that it orders to the manufacturer. As a result, the manufacturer increases it’s wholesale price. The intuition is straightforward. When the retailer’s CSR increases, it’s pure profit decreases but it’s total profit increases because of consumer surplus that it accrues from the stakeholders. On the other hand, in order to acquire the retailer’s loss of pure profit due to CSR, the manufacturer increases it’s wholesale price. As a whole in this case total profit of the retailer and the manufacturer are win-win when compared with the decentralized profits.

2.1.6.3 A comparison

As indicated, in a socially responsible supply chain either any one channel member or both the channel members practice CSR. Now, study examines which policy is acceptable to the channel members in the decision making context. For simplicity of analysis assume that when the channel members jointly exhibit CSR, they practice it equitably, i.e., \( k = 0.5 \). Then, from (2.9) the equilibrium wholesale price can be found as

\[
\left. w_{e/m} \right|_{k=0.5} = c + \left( \frac{a - bc}{4b} \right) \left[ \frac{4 - 3\alpha}{2 - \alpha} - \frac{(4 - \alpha)(12 - 5\alpha)}{(8 - 3\alpha)^2} \right]
\]  

(2.14)

Now, as far as acceptability of the policies are concerned, the following proposition can be stated.

**Proposition-2.8** For pure profit, a channel member always prefers the other’s CSR and equitable share of CSR may be the compromise solution.

**Proof** See appendix A-2.6.

Fig-2.6 depict a comparison of the wholesale prices and pure profits of the channel members in these cases. Proposition-2.8 is reasonable. For CSR practice a channel member loses its pure profit though it is compensated by consumer surplus that it accrues from the stakeholders because of CSR practice. But this is not acceptable to some extent because besides to look after the stakeholders welfare an organization always has the responsibility to its shareholders (pure profit). Thus, apart from exhibiting CSR a channel member always wants to maximize its pure profit. In this direction equitable share of CSR intensity is the best possible compromise solution because it allows accruing the consumer surplus that the channel receives from the stakeholders equitably. Obviously, it enables the channel members to balance the stakeholders value and loss of pure profit due to the social responsibility.
CHAPTER 2. EXPLORING EFFECT OF CSR IN SUPPLY CHAIN

This section explains channel coordination and surplus profit division in a two-echelon supply chain, where the channel members display CSR in a proportion. While framing the model the effect of CSR in the form of consumer surplus is incorporated in the channel member’s profit function. The section uses subgame perfect equilibrium and extended strategic bargaining for channel coordination and profit division between the channel members. Also, it discusses the scenarios when any one channel member practices CSR. The result traced have some practical importance not only because these are different from a pure profit maximizing supply chain but also because of the current global business practice as pointed out earlier.

2.2 Coordination and profit division in a three-echelon social responsible supply chain

This section demonstrates coordination of a socially responsible manufacturer-distributor-retailer supply chain, where the manufacturer exhibits corporate social responsibility (CSR). The CSR goal is the manufacturer’s own. Through a code of conduct the manufacturer induces other members of the channel to involve in CSR practice. In manufacturer-Stackelberg game setting, it proposes a contract-bargaining process to resolve channel conflict and to distribute surplus profit among the channel members. The contract-bargaining process is the combination of two wholesale price discounts and two Nash bargaining products. The section intends to merge two research areas, CSR and channel coordination in a three-echelon supply chain.

The objectives of the model differs significantly from the previous works as follows. First, previous researches have explored CSR, effects of CSR on supply chain and channel coordination discretely. In contrast the present work examines the double marginalization issues in a socially responsible supply chain. Although Hsueh and Chang [64] have used exogenous mon-

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3This section is based on the paper “Channel coordination and profit distribution in a social responsible three-layer supply chain” published in International Journal of Production Economics.
etary transfer to coordinate a socially responsible supply chain network. This model uses an endogenous procedure not only to coordinate the channel but also to distribute the surplus profit among the channel members. Second, in Ni et al. [109] the supplier performs CSR and the downstream firm shares the CSR cost through wholesale price contract though channel coordination is not examined. Assuming each channel member has CSR cost Ni and kevin [108] have found win-win profits through strategic interaction. The present study assumes that the upstream channel member has CSR cost and presents a procedure that find optimal channel profit through coordination. Third, the contract that is used for channel coordination and profit distribution is very close to current business practice for a multi-echelon supply chain. In the contract-bargaining process a channel member interacts for cooperation in one-to-one basis rather than simultaneous interaction among the channel members. As a result starting from the leader of the channel, the surplus profit due to channel coordination flows downward in a proportion that is acceptable to all channel members.

2.2.1 Model formulation and basic analysis

Consider a three-layer supply chain that consists of a manufacturer, a distributor and a retailer. The manufacturer produces products at a unit cost $c$ and supplies it to the distributor at a wholesale price $w^m$ in a single lot. The distributor supplies the product to the retailer at a wholesale price $w^d$. Finally, the retailer satisfies the customer’s demand by selling the product at a retail price $p^r$. Assume that the demand at the retailer’s end is linear in retail price and is of the form $D(p^r) = a - bp^r$, where $a > 0$ is the market potential and $b > 0$ is the customers price sensitivity. This demand function is fairly common in the literature. Shortages are not allowed at any stage of the channel. The lead time between the manufacturer and the distributor, and between the distributor and the retailer are zero because the demand is deterministic. The manufacturer follows lot-for-lot production policy. This simple channel structure allows us to analyze the effect of CSR on the channel members profits. Also, assume that the manufacturer is the leader of the channel and takes decision independently. Other channel members make decision based on the decision of the manufacturer. Proceeding in similar manner of section 2.1, the consumer surplus can be calculated as

$$
\int_{p^r_{\text{min}}}^{p^r_{\text{max}}} Qdp^r = \int_{(a-bp^r)/b}^{a/b} (a-bp^r)dp^r = \frac{Q^2}{2b} \quad (2.15)
$$

Under this setting the study first derive the centralized and decentralized decisions of the channel members.

2.2.2 Centralized policy

The profit function of the centralized channel is

$$
\pi_c = (p^c - c)(a - bp^c) + \frac{\alpha}{2b}(a - bp^c)^2 \quad (2.16)
$$

---

4 As in equation 2.1
CHAPTER 2. EXPLORING EFFECT OF CSR IN SUPPLY CHAIN

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Using the necessary condition, \( d\pi_c/dp^c = 0 \), for the existence of the optimal solution, optimal value of \( p^c \) can be found and is depicted in table-2.5. Also, the optimal order quantity, pure profit, consumer surplus and total profit in the centralized channel are presented in table-2.5. Moreover, \( d^2\pi_c/dp^c = -b(2 - \alpha) < 0 \), i.e., \( p^{c*} \) provides global optimum to (2.16). Note that \( d\pi^*_c/d\alpha = k/(2 - \alpha)^2 > 0 \), i.e., optimal total profit increases when the manufacturer puts more weight on CSR. \( dP^*_c/d\alpha = -2k\alpha/(2 - \alpha)^3 < 0 \) and \( dCS^*_c/d\alpha = (2 + \alpha)/(2 - \alpha)^3 > 0 \), i.e., pure profit of the centralized channel decreases and consumer surplus increases when CSR increases. The increment of consumer surplus overcompensates the decrement of pure profit. As a result, total profit of the centralized channel increases with increasing CSR. The

\[ \frac{d\pi^*_c}{d\alpha} = \frac{k}{(2 - \alpha)^2} > 0, \text{i.e., optimal total profit increases when the manufacturer puts more weight on CSR.} \]

Consider the manufacturer-stackelberg game, where the distributor is the manufacturer’s immediate follower and the retailer follows the distributor. It is a sequential move game, where the manufacturer enforces its own strategy on the distributor. Based on it the distributor finds its own strategy and enforces it on the retailer. Finally, depending on the optimal strategy of the distributor, the retailer identifies its own strategy. In fact the entire decision making process consists of two stackelberg games. One between the manufacturer and the distributor and the other is between the distributor and the retailer. The study uses backward induction to find the sub-game perfect solution of the game. The profit functions of the channel members are

\[ \pi^m = (w^m - c)(a - bp^r) \] (2.17)

\[ \pi^d = (w^d - w^m)(a - bp^r) \] (2.18)

\[ \pi^r = (p^r - w_d)(a - bp^r) \] (2.19)

Total profit of the manufacturer is

\[ \psi_m = \pi^m + \frac{\alpha}{2b}(a - bp)^2 \] (2.20)

Using backward induction the optimal solution can be found and are presented in table-2.5 where \( k = (a - bc)^2/2b \).

Observe that \( d\pi^*_r/d\alpha = 4k/(8 - \alpha)^3 > 0, d\pi^*_d/d\alpha = 8k/(8 - \alpha)^3 > 0, d\psi^*_m/d\alpha = k/(8 - \alpha)^2 > 0 \), but \( d\psi^*_m/d\alpha = -2ak/(8 - \alpha)^3 < 0 \), i.e., the manufacturer’s total profit, the distributor’s
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<table>
<thead>
<tr>
<th>Optimal</th>
<th>Decentralized channel</th>
<th>Centralized channel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price</strong></td>
<td>( \frac{(4-\alpha)a+4bc}{(8-\alpha)b} )</td>
<td>( \frac{(6-\alpha)a+2bc}{(8-\alpha)b} )</td>
</tr>
<tr>
<td><strong>Order quantity</strong></td>
<td>( \frac{a-6c}{(8-\alpha)} )</td>
<td>( \frac{a-6c}{(8-\alpha)} )</td>
</tr>
<tr>
<td><strong>Pure profit (PP)</strong></td>
<td>( \frac{2(4-\alpha)k}{(8-\alpha)^2} )</td>
<td>( \frac{4k}{(8-\alpha)^2} )</td>
</tr>
<tr>
<td><strong>Consumer surplus (CS)</strong></td>
<td>( \frac{k}{(8-\alpha)} )</td>
<td>( \frac{4k}{(8-\alpha)^7} )</td>
</tr>
<tr>
<td><strong>Total profit (PP+CS)</strong></td>
<td>( \frac{2(4-\alpha)k}{(8-\alpha)^2} )</td>
<td>( \frac{4k}{(8-\alpha)^2} )</td>
</tr>
</tbody>
</table>

Table 2.5: Optimal values in centralized and decentralized decision making

profit and the retailers profit increase but the manufacturer’s pure profit decreases with increasing CSR. Also, \( dp^*/d\alpha = -(a - bc)/(8 - \alpha)^2 < 0 \), \( dQ^*/d\alpha = (a - bc)/(8 - \alpha)^2 > 0 \), \( dw^*/d\alpha = -2(a - bc) + bc)/(8 - \alpha)^2 < 0 \), \( du^*/d\alpha = -4(a - bc)]/b(8 - \alpha)^2 < 0 \). When the manufacturer puts more weight on CSR, it reduces its wholesale price. In response, the distributor also reduces its wholesale price. Finally, the retailer reacts to the upstream channel members’ activities by reducing retail price. Since, the retail price of the channel is reduced, customers are encouraged to buy more. As a result, the order quantity of the retailer increases. Thus the CSR attribute of the manufacturer influences all the downstream members of the channel. Through CSR the manufacturer acts more competitively than a pure profit maximizing manufacturer. Although it loses some pure profit, it acquires some consumer surplus, which is more than the loss of pure profit. So, its total profit increases. The pure profit that the manufacturer loses due to CSR is accumulated at the distributor’s and the retailer’s sides in some proportion. Thus, the profits of the distributor and the retailer increase as the manufacturer’s CSR intensity increases.

Figure 2.7: Behaviour of profits in centralized and decentralized channel with respect to CSR

Note that \( \pi^* + \pi^{ds} + \nu^*_m = (14 - \alpha)k/(8 - \alpha)^2 < \pi^*_c \), i.e., the channel conflict is not resolved. \( d[\pi^*_c - (\pi^* + \pi^{ds} + \nu^*_m)]/d\alpha = 16(28 - 17k)/(2 - \alpha)^2(8 - \alpha)^3 > 0 \), i.e., the difference of centralized total profit and decentralized total profit increases with increasing CSR. This result is quite different from form a pure profit maximizing supply chain. In a pure profit maximizing supply chain the double marginalization of the channel decreases when the retailer reduces its unit selling price. When the selling price is equal to the centralized selling price, the channel is
coordinated. But in a socially responsible supply chain though the retail price decreases with the manufacturer’s increasing CSR, the double marginalization of the channel increases. Also, $(\pi^r + \pi^d + v_m)|_{\alpha=0} = 7k/32 \neq k/2 = \pi^*_c|_{\alpha=0}$ and $(\pi^r + \pi^d + v_m)|_{\alpha=1} = 13k/49 \neq k = \pi^*_c|_{\alpha=1}$. Thus, pure profit maximizing channel is not coordinated and the perfect welfare maximizing motive of the manufacturer does not resolve channel conflict.

The pure profit of the centralized channel is $PP_c = 2(1-\alpha)k/(2-\alpha)^2$ and the pure profit of the decentralized channel is $PP_{ds} = \pi^r* + \pi^d* + \pi^m* = 2(7-\alpha)k/(8-\alpha)^2$. Now $PP_c - PP_{ds} > 0$ if $\alpha^2 - 8\alpha + 6 < 0$, i.e., $\alpha < 4-\sqrt{10}$. Thus, the pure profit of the centralized channel is higher when compared with decentralized pure profit if $\alpha \in (0, 4-\sqrt{10})$, otherwise the decentralized pure profit is higher.

**Proposition 2.9:** In a socially responsible supply chain (i) the manufacturer’s perfect welfare maximizing motive does not resolve channel conflict, (iii) double marginalization increases when the retailer’s unit selling price decreases and (iii) the pure profit of the decentralized channel is higher for $\alpha \in (4-\sqrt{10}, 1)$ when compared with centralized pure profit.

It turns out that, when the channel members do not cooperate the manufacturer should limit its CSR in $(4-\sqrt{10}, 1)$. In such case, the retailer’s profit and the distributer’s profit are higher but the manufacturer’s pure profit is lower compared to centralized profits. But the consumer surplus that the manufacturer accrues from it’s stakeholders compensates its loss of pure profit. Otherwise, when the channel members cooperate, the best channel performance can be found through a transfer pricing policy.

### 2.2.4 Channel coordination, ranges of win-win opportunities and surplus pure profit distribution.

As a socially responsible channel member, the manufacturer always wants to receive order of larger lot size from the retailer because in that case it can operate more competitively through CSR practice. But the retailer and the distributer has no reason to order larger lot than the optimal decentralized EOQ because of their suboptimal profits. Assume that as incentive the manufacturer provides a wholesale price discount to the distributer, who is its immediate downstream channel member. In response, by providing a wholesale price discount the distributer impels the retailer to increase the order quantity. The channel members provide and accept the wholesale price discounts under two restrictions. First, the retailer must order channel optimal order quantity. Second, under any form of wholesale price discount the channel members must get at least their decentralized profits.

Generally a channel member in a multi-echelon supply chain interacts with other members of the channel in one-to-one basis, where it assumes that there is no other member in the channel. The manufacturer can provide wholesale price discount to the distributer until its decentralized total profit is reserved. The retailer accepts the distributer’s wholesale price discount and orders centralized quantity as long as its loss of profit is subsidized through the wholesale price discount. In the entire transfer pricing policy, the distributer plays the central role because as an intermediator it maintains the incentive streaming from the manufacturer to the retailer.
By doing so it also receives some profit additional to its decentralized profit. Thus, when the wholesale price discount policy is applied aiming at resolving channel conflict the distributor decides (i) the manufacturer’s minimum wholesale price discount and (ii) maximum wholesale price discount that it can provide to the retailer. These two are interrelated and one definitely gets different limits when approaches from the manufacturer to the retailer and from the retailer to the manufacturer. In the former case, the manufacturer and the distributor jointly decide the minimum and maximum discounts on the manufacturer’s wholesale price for channel coordination. Within this range they decide a particular discount that effectively divides the surplus profit between them. Based on the decentralized profit and the surplus profit share, the distributor and the retailer find win-win wholesale price discount range and bargain for benefit share. In the later case, first the distributor deals with the retailer and settles benefit share. Based on decentralized profit and benefit share, it deals with the manufacturer. Since the surplus profits at the manufacturer’s end and at the retailer’s end are different, the results are different in these two cases. However, the study considers the approach from the manufacturer to the retailer through the distributor because the manufacturer is the leader of the channel. Also it is quite common in marketing practice that any discount flows from the manufacturer to the customers through different echelons and the move is initiated at the manufacturer’s side. Since, two coordination contracts and two types of bargaining are involved in the entire process the study terms it as contract-bargaining process. In this process the channel members operate in the following sequence.

Step 1 The manufacturer and the distributor find the wholesale price discount range for win-win profits subject to the condition that the distributor has to compensate the retailer’s loss due to changed order quantity.

Step 2 Within this discount range the manufacturer bargains with the distributor for a particular profit share. The decentralized profit plus the surplus profit is the manufacturer’s optimal profit. The decentralized profit plus surplus profit is the distributor’s intermediate profit.

Step 3 Depending on the intermediate profit, the distributor and the retailer determines the win-win range of wholesale price discount.

Step 4 The distributor and the retailer determine surplus profit share through bargaining. Decentralized profit plus surplus profit share is the retailer’s optimal profit. Intermediate profit plus surplus profit is the distributor’s optimal profit.

Suppose the manufacturer provides \( \tau w^m \), \( (\tau > 0) \) discount on wholesale price to the distributor, where it assumes that the distributor will compensate the retailer’s loss due to changed order quantity. The manufacturer’s total profit under the wholesale price discount is

\[
v^w_m = (w^m - c)(a - bp^c) + \frac{\alpha}{2b} Q_c^2 - \tau w^m Q^*_c \tag{2.21}
\]

The manufacturer can provide the discount on the wholesale price as long its decentralized total profit is reserved, i.e., \( v^w_m \geq v^*_m \). If \( \tau \) is the maximum discount on wholesale price then simplifying the inequality \( \tau \) can be found as

\[
\tau = 1 - \left[ \frac{c}{w^m} + \frac{(2 - 6\alpha + \alpha^2)(a - bc)}{bw^m(2 - \alpha)(8 - \alpha)} \right] \tag{2.22}
\]
Therefore, the minimum wholesale price that the manufacturer can offer to the distributer is
\[
w^m = (1 - \tau)w^m = c + \frac{(2 - 6\alpha + \alpha^2)(a - bc)}{b(2 - \alpha)(8 - \alpha)}
\] (2.23)

Similarly, the distributer can consider the manufacturer’s wholesale price discount until its decentralized profit and minimum compensation to the retailer are reserved. If the distributer demands \(\tau w^m\) minimum discount from the manufacturer then
\[
(w^d - w^*_m)Q^*_c + \tau w^m Q^*_c = \pi^d + \left[\pi^r - (p^c - w^*_d)Q^*_c\right]
\]
Simplifying the above expression, \(\tau\) can be found as
\[
\tau = \frac{24(1 + \alpha)k}{(2 - \alpha)^2(8 - \alpha)^2 w^m Q^*_c}
\] (2.24)

Consequently the manufacturer can demand maximum wholesale as
\[
\overline{w^m} = (1 - \tau)w^m = c + \frac{(4 - \alpha)(a - bc)}{b(8 - \alpha)} - \frac{12(1 + \alpha)(a - bc)}{b(2 - \alpha)(8 - \alpha)^2}
\] (2.25)

For any \(w^m \in (\overline{w^m}, \overline{w^m})\) the manufacturer’s profit is win-win and after providing minimum compensation to the retailer, the distributer’s profit is also win-win. Within this range the manufacturer bargains with the distributer for a particular wholesale price that effectively divides the surplus profit between them. The bargaining outcome is based on the symmetric Nash bargaining product. The Nash bargaining model that has been used in various contexts, is an axiomatic derivation of bargaining solution. The axiomatic derivation leaves out the actual process of negotiations while focusing on the expected outcome based on prespecified solution procedures. Also the axioms does not reflect the rationale of the agents or the process in which the agreement is reached. One of the important characteristics of the Nash solution concept is that the outcome is random because it depends on the participating players negotiation powers. In Nash bargaining model the objective function is the product of the players benefit from cooperation and it must be maximized. Each players benefit is the difference between the negotiated profit and profit under decentralized decision making. The Nash bargaining product of the manufacturer and the distributer is
\[
\max_{\tau \leq \tau \leq \overline{\tau}} \left[\left(w^m - \tau w^m - c\right)Q^*_c + \frac{\alpha}{2b}Q^*_c - v^*_m\right]\left(w^d - w^m + \tau w^m\right)Q^*_c - \left(\pi^d + \left(\pi^r - (p^c - w^*_d)Q^*_c\right)\right)
\] (2.26)

From (2.26) optimal value of \(\tau\) can be found as
\[
\tau^B = \frac{6(10 + \alpha)k}{(2 - \alpha)^2(8 - \alpha)^2 w^m Q^*_c}
\] (2.27)

Therefore, the bargaining wholesale price of the manufacturer is
\[
w^B_m = (1 - \tau^B)w^m = c + \frac{(4 - \alpha)(a - bc)}{b(8 - \alpha)} - \frac{3(10 + \alpha)(a - bc)}{b(2 - \alpha)(8 - \alpha)^2}
\] (2.28)
CHAPTER 2. EXPLORING EFFECT OF CSR IN SUPPLY CHAIN

After first round of bargaining the distributor’s intermediate profit is

\[ \pi_{ib}^d = \pi_d^* + \frac{18(6 - \alpha)k}{(2 - \alpha)^2(8 - \alpha)^2} \]  \hspace{1cm} (2.29)

Based on the intermediate profit, the distributor and the retailer determine the range of wholesale price discount. If \( \bar{p}w^{d^*} \) is the maximum discount on wholesale price that the distributor can provide to the retailer then

\[ \pi_{ib}^d - \bar{p}w^{d^*}Q_c^* = \pi^{d^*} \]

i.e.,

\[ \bar{p} = \frac{1}{w^{d^*}} \left[ \frac{9(6 - \alpha)(a - bc)}{b(2 - \alpha)(8 - \alpha)^2} \right] \]  \hspace{1cm} (2.30)

Consequently the minimum wholesale price of the distributor under the wholesale price discount policy is

\[ \underline{w}^d = (1 - \bar{p})w^{d^*} = c + \frac{(6 - \alpha)(a - bc)}{b(8 - \alpha)} - \frac{9(6 - \alpha)(a - bc)}{b(2 - \alpha)(8 - \alpha)^2} \]  \hspace{1cm} (2.31)

If the distributor provides minimum \( \rho w^{d^*} \), \( \rho > 0 \) discounts on wholesale price then the retailer’s profit is

\[ \pi_r^{wd} = (p_r^c - \bar{w}_d^*)Q_c^* + \rho w^{d^*}Q_c^* \]

From the inequality \( \pi_r^{wd} \geq \pi_r^* \), \( \rho \) can be found as

\[ \rho = \frac{36(a - bc)}{b(2 - \alpha)(8 - \alpha)^2w^{d^*}} \]  \hspace{1cm} (2.32)

Thus the maximum wholesale price that the distributor can demand from the retailer is

\[ \overline{w}^d = (1 - \rho)w^{d^*} = c + \frac{(6 - \alpha)(a - bc)}{b(8 - \alpha)} - \frac{36(a - bc)}{b(2 - \alpha)(8 - \alpha)^2} \]  \hspace{1cm} (2.33)

For any \( \underline{w}^d \in (\underline{w}^d, \overline{w}^d) \) the distributor’s profit and the retailer’s profit under wholesale price discount contract are win-win. Within the range the distributor and the retailer bargain for particular wholesale price, which effectively divides the surplus profit between them. The Nash bargaining product is

\[ \max_{\underline{p} \leq \tau \leq \overline{p}} [\pi_{ib}^d - \rho w^{d^*}Q_c^* - \pi_r^*] [(\rho_{c^*}^{d^*} - \bar{w}_d^*)Q_c^* + \rho w^{d^*}Q_c^* - \pi_r^*] \]  \hspace{1cm} (2.34)

The optimal value of \( \rho \) is

\[ \rho^B = \frac{9(10 - \alpha)(a - bc)}{2b(2 - \alpha)(8 - \alpha)^2} \]  \hspace{1cm} (2.35)

Consequently the distributor’s optimal wholesale price in contract bargaining process is

\[ \underline{w}^d_B = (1 - \rho^B)w^{d^*} = c + \frac{(6 - \alpha)(a - bc)}{b(8 - \alpha)} - \frac{9(10 - \alpha)(a - bc)}{2b(2 - \alpha)(8 - \alpha)^2} \]  \hspace{1cm} (2.36)
Thus, in the contract-bargaining process the optimal profits of the channel members are

\[ v_m^b = v_m^* + \frac{18k}{(2 - \alpha)(8 - \alpha)^2} \]  
\[ \pi_d^b = \pi_d^{d*} + \frac{9k}{(2 - \alpha)(8 - \alpha)^2} \]  
\[ \pi_r^b = \pi_r^{r*} + \frac{9k}{(2 - \alpha)(8 - \alpha)^2} \]  
\[ \pi_m^b = \frac{(34 - 59\alpha + 14\alpha^2 - \alpha^3)(a - bc)^2}{b(2 - \alpha)^2(8 - \alpha)^2} \]

Note that \( \pi_d^b + \pi_r^b + v_m^b = k/(2 - \alpha) = \pi_m^*, \) i.e., the channel conflict is resolved. All the channel members’ profits are win-win. The manufacturer takes away half of the surplus profit \( 36k/[(2 - \alpha)(8 - \alpha)^2] \) and the remaining is divided between the distributor and the retailer equitably. Thus, the proposition follows.

**Proposition 2.10:** The contract-bargaining process resolves channel conflict and distributes surplus profit among the channel members.

### 2.2.5 Effects of CSR

Using the contract bargaining process it is possible to find win-win total profit for the manufacturer and win-win pure profits for the distributor and the retailer for any \( w^m \in (w^m, \bar{w}^m) \) and for any \( w^d \in (w^d, \bar{w}^d) \). Note that \( dw^m/da = -[(a - bc)(4\alpha^2 - 28\alpha + 76)/b(2 - \alpha)^2(8 - \alpha)^2] < 0 \) and \( dw^m/da = -[4(a - bc)(116 - 93\alpha + 6\alpha^2 - \alpha^3)/b(2 - \alpha)^2(8 - \alpha)^2] < 0 \) for any \( \alpha \in (0, 1) \), i.e., the discounted wholesale price of the manufacturer, when contract bargaining process is used, decreases with increasing CSR. Further, \( \bar{w}^m - c = (2 - 6\alpha + \alpha^2)(a - bc)/b(2 - \alpha)(8 - \alpha) > 0 \) if \( 2 - 6\alpha + \alpha^2 > 0 \), i.e. if \( \alpha < 0.3542 \). Also, \( \bar{w}^m - c = (4 - \alpha)(a - bc)/b(8 - \alpha) - 12(1 + \alpha)(a - bc)/b(2 - \alpha)(8 - \alpha)^2 > 0 \) if \( (2 - \alpha)(4 - \alpha)(8 - \alpha) > 12(1 + \alpha) \) i.e. if \( 52 - 68\alpha + 14\alpha^2 - \alpha^3 > 0 \), i.e for any \( \alpha > 0.93144 \).

Therefore, the discounted wholesale price of the manufacturer is always larger than its marginal production cost for any \( \alpha < 0.3542 \) and always less than its marginal production cost for any \( \alpha > 0.93144 \). The discounted wholesale price may be larger or less than it’s production cost for \( \alpha \in (0.3542, 0.93144) \). Also, \( w^m \geq 0 \) if \( a\alpha^2 - 2(3a + 2bc)\alpha + 2(a + 7bc) \geq 0 \) i.e, if \( \alpha \leq [3a + 2bc - \sqrt{7a^2 - 2abc + 4b^2c^2}]/a \) and \( \bar{w}^m \geq 0 \) if \( \alpha > \alpha_1 \), say, where \( \alpha_1 \) is the real root of the equation \( a\alpha^2 - (14a - 4bc)\alpha^2 + 4(17a - 13bc)\alpha - 52(a - bc) = 0 \). So, the discounted wholesale price of the manufacturer is non-negative for \( \alpha \in (0, 3a + 2bc - \sqrt{7a^2 - 2abc + 4b^2c^2}]/a \) and always negative if it performs CSR above the threshold \( \alpha = \alpha_1 \) (see fig-2.8). Thus Hence the proposition follows.

**Proposition 2.11:** In the contract bargaining process the CSR manufacturer’s wholesale price is always (i) less than its marginal production cost for \( \alpha \in (0.93144, 1) \), (ii) greater than its marginal production cost for \( \alpha \in (0, 0.3542) \), (iii) positive for \( \alpha < [3a + 2bc - \sqrt{7a^2 - 2abc + 4b^2c^2}]/a \) and (iv) negative for \( \alpha > \alpha_1 \).
The CSR manufacturer acts quite differently from a pure profit maximizing manufacturer. When it puts more weight on CSR, it reduces its wholesale price to encourage the distributor to supply more units to the retailer by decreasing wholesale price. The objective of the manufacturer is not to coordinate the channel. Actually, as the leader of the channel and for CSR practice, it encourages all the channel members to sell more units by reducing the selling price. As such, for exhibiting CSR, the manufacturer may supply the product to the distributor below its marginal production cost even its wholesale price may be negative for heavy CSR practice. The CSR manufacturer, in such case pays the distributor to sell products additional to the decentralized order quantity.

Interestingly, when the manufacturer’s CSR increases, its shareholder’s value decreases but its stakeholder’s value increases. The intuitive reason is straightforward. The wholesale price of the manufacturer in the contract-bargaining process is inversely proportional to its CSR practice. So, when the manufacturer performs CSR heavily, its wholesale price may be below the marginal production cost or negative. As a result the manufacturer’s pure profit (shareholder’s value) is negative though it’s stakeholder’s value compensates the loss of pure profit and leads to win-win total profit. This finding is quite consistent with “it pays to be good but not too good” [98]. Thus, it is very important for the manufacturer to decide up to what level the CSR activity should be extended such that (i) the channel conflict is resolved and (ii) it can balance the shareholder’s value and stakeholder’s value while practicing CSR.

The range of optimal wholesale price of the distributor for channel coordination is determined after first round of contract bargaining process between the manufacturer and the retailer. Observe that \( \frac{dw}{d\alpha} = -(a-bc)[2(8-\alpha)(2-\alpha)^2 + 9(2-\alpha)(4-\alpha) + 9(6-\alpha)(8-\alpha)]/b(8-\alpha)^3(2-\alpha)^2 < 0 \) and \( \frac{dw}{d\alpha} = -2(a-bc)[(2-\alpha)^2 + 72(4-\alpha)]/b(8-\alpha)^3(2-\alpha)^2 < 0 \) i.e, the discounted
wholesale price of the distributor is sensitive to the manufacturer’s CSR. In fact, the distributor provides more discount on wholesale price when the manufacturer’s CSR increases. Further, 

\[ w^d - c = [(6 - \alpha)(a - bc)/b(8 - \alpha)] - [9(6 - \alpha)(a - bc)/b(2 - \alpha)(8 - \alpha)^2] > 0 \text{ if } \alpha^2 - 10\alpha + 7 > 0, \]

i.e. if \( \alpha < 0.75936 \). Also, 

\[ w^d - c = [(6 - \alpha)(a - bc)/b(8 - \alpha)] - [6(6 - \alpha)(a - bc)/b(2 - \alpha)(8 - \alpha)^2] > 0 \text{ if } (2 - \alpha)(6 - \alpha)(8 - \alpha) \geq 36, \]

i.e. if \( 60 - 76\alpha + 16\alpha^2 - \alpha^3 \geq 0 \) i.e. if \( \alpha < 0.97885 \). Thus the wholesale price of the distributor in the contract bargaining process is greater than the manufacturer’s marginal production cost for \( \alpha < 0.75936 \) and less than the manufacturer’s marginal cost if \( \alpha > 0.97885 \).

![Figure 2.9: Effect of CSR on distributors wholesale price (Minimum, Maximum and Bargaining solution)](image)

Also, note that \( w^d < 0 \) if \( \alpha > \alpha_3 \), say, where \( \alpha_3 \) is the real root of the equation 

\[ 42a + 86bc - (67a + 29bc)\alpha - 2(8a + bc)\alpha^2 - aa^3 = 0 \]

and \( w^d < 0 \) if \( \alpha > \alpha_4 \), say, where \( \alpha_4 \) is the real root of the equation 

\[ 60a + 68bc - 4(19a + 5bc)\alpha + 2(8a + bc)\alpha^2 - aa^3 = 0. \]

Thus, the proposition follows.

**Proposition 2.12** In the contract bargaining process, the pure profit maximizing distributor’s discounted wholesale price is always (i) greater than the manufacturer’s marginal production cost for any \( \alpha > 0.75736 \), (ii) less than the manufacturer’s production cost for any \( \alpha > 0.97885 \), (iii) positive for \( \alpha < \alpha_3 \) and (iv) negative for \( \alpha > \alpha_4 \).

It is a common practice, in a socially responsible supply chain that the leader of the channel is mainly responsible for CSR and it introduces code of conduct such that all the other channel members business practices are socially responsible. As such in response to the manufacturer’s reduced wholesale price, the distributor also reduces its wholesale price to encourage the retailer to sell more units by reducing its retail price. The distributor’s wholesale price is inversely proportional to the manufacturer’s CSR intensity. Thus, when the manufacturer’s CSR intensity increases, the distributor’s wholesale price may be less than the manufacturer’s marginal production cost \( (\alpha > 0.75736) \) and it may be negative for the manufacturer’s heavy CSR practice \( (\alpha > \alpha_4) \). That is, the distributor pays the retailer to sell units additional to decentralized order quantity. In such case, the distributor’s business practice is socially responsible and its pure profit objective is not only reserved but also pure profit is win-win. The intuitive reason is straightforward. First, the positive wholesale price of the distributor is always larger than that
of the manufacturer and both the wholesale prices lie in their corresponding win-win ranges of
the contract-bargaining process. As a result the distributor’s profit is always win-win. Second,
in the contract bargaining for CSR, the manufacturer pays the distributor to sell additional
units when $\alpha > \alpha_2$ and the distributor pays the retailer when $\alpha > \alpha_5$. Note that $\alpha_5 > \alpha_2$ i.e,
before paying the retailer, the distributor receives some revenues from the manufacturer, which
is larger than the subsidy that the distributor provides to the retailer for selling inventories
additional to the decentralized order quantity.

In response to other channel members socially responsible activities, the retailer also performs
socially because it reduces the retail price to sell additional units. Since, the objective of the
channel is to perform in coordinated way, the retailer fixes its retail price same as the central-
ized channel. In that case, the retailer’s profit is also win-win because the distributor supplies
inventories by reducing it’s wholesale price or pays the retailer. The discount on the wholesale
price that the distributor provides not only nullifies the retailer’s loss due to deviation from the
decentralized order quantity but also provides some extra profit.

\[ \theta \]

\[ w_m \]

\[ w_d \]

Figure 2.10: Nature of the optimal wholesale prices

The optimal wholesale price of the manufacturer in the contract bargaining process decreases
with increasing CSR and it is less than marginal production cost if $\alpha^3 - 14\alpha^2 + 59\alpha - 34 \leq 0$
i.e. if $\alpha > 0.6809$. The optimal wholesale price of the manufacturer in the contract bargaining
process is negative if $\alpha \in (\alpha_2, 1)$, where $\alpha_2$ is the real root of the equation $34a + 94bc - (59a +
37bc)\alpha + (14a + 4bc)\alpha^2 - a\alpha^3 = 0$ (see fig-2.10). Since, the optimal wholesale price of the contract
bargaining process lies in $(w_m, w_d)$, the limit of CSR intensity of non negative wholesale price
is lower than over all non-negative CSR intensity, i.e, $\alpha_2$ is always less than $\alpha_1$. Similarly,
the optimal bargaining wholesale price of the distributor is less than the manufacturer’s marginal
production cost if $102 - 143\alpha + 32\alpha^2 - 2\alpha^3 \geq 0$ i.e $\alpha > 0.87538$. Also the optimal discounted
wholesale price of the distributor is negative if $\alpha > \alpha_5$, say, where $\alpha_5$ is the real root of the
equation $102a + 154bc - (143a + 49bc)\alpha + (32a + 4bc)\alpha^2 - 2a\alpha^3 = 0$ (see fig-2.10). Hence the
proposition follows.
Proposition 2.13: (a) The optimal bargaining wholesale price of the manufacturer is less than its marginal production cost if \( \alpha > 0.6809 \) and negative for \( \alpha > \alpha_5 \) and (b) the optimal bargaining wholesale price of the distributor is less than the manufacturer’s marginal production cost if \( \alpha > 0.87538 \) and (ii) negative for \( \alpha > \alpha_5 \).

Figure 2.11: Nature of the optimal profit after bargaining

Note that \( d\pi^b_g / d\alpha = (140 - 59\alpha + 8\alpha^2)/(2 - \alpha)^2(8 - \alpha)^3 > 0 \) and \( d\pi^b_r / d\alpha = (124 - 43\alpha + 4\alpha^2)/(2 - \alpha)^2(8 - \alpha)^3 > 0 \), i.e., the optimal bargaining profits of the distributor and the retailer increase with increasing CSR practice of the manufacturer. Also, \( d\pi^b_m / d\alpha = -(164 + 278\alpha - 129\alpha^2 + 18\alpha^3 - \alpha^4)/(2 - \alpha)^3(8 - \alpha)^3 < 0 \) and \( dw^b_m / d\alpha = (250 - 90\alpha + 12\alpha^2 - \alpha^3)/(2 - \alpha)^2(8 - \alpha)^3 > 0 \), i.e., optimal bargaining pure profit of the manufacturer decreases but optimal total profit increases with increasing CSR (see fig-2.11). The pure profit is maximum at \( \alpha = 0 \) and the total profit is maximum when the manufacturer is the perfect profit maximizer. The manufacturer’s pure profit is non-negative for \( \alpha \in (0, 0.6809) \) because in this range it’s wholesale price is larger than the marginal production cost. Also, in this range the manufacturer’s total profit is win-win. So, CSR is purely a costly endeavour to the manufacturer. Obviously for any \( \alpha > 0.6809 \) the manufacturer’s bargaining pure profit is negative. Thus, instead of selling the right of the product to the distributer, the manufacturer encourages the distributer to to sell more units by subsidizing the sell units. Even it pays the distributer \( w^b_m < 0 \) to sell additional units.

2.3 Coordinating a socially responsible distribution channel with revenue sharing contract

This chapter\(^5\) deals with channel coordination in a socially responsible distribution channel that consists of a manufacturer, multiple distributers and multiple retailers under each distributer. The manufacturer intends to swell stakeholders welfare by exhibiting corporate social responsibility (CSR). Demand at the retailers’ end is linear in price and is influenced by the manufacturer’s suggested retail price. In manufacturer-Stackelberg game setting a new revenue

\(^5\)This section is based on the paper entitled “Coordinating a socially responsible distribution channel with manufacturer suggested retail price”, which is communicated to International Journal of Applied and Computational Mathematics.
sharing (RS) contract is used to resolve channel conflict and win-win wholesale price-RS fraction ranges are identified in closed forms. The purpose of the research is to incorporate CSR in a three-level distribution channel. Besides pure profit, the manufacturer, as the leader of the channel, considers stakeholders’ welfare through CSR and influences the downstream channel members to behave socially. In manufacturer-Stackelberg game setting apart from discussing the effects CSR in decentralized and centralized decision making, a new revenue sharing (RS) mechanism is applied to resolve channel conflict and to find win-win profits of the channel members. In particular, the objective is to explore the effects of CSR on the channel members coordinated profits. Also, the section examines how the parameters of the RS contract are affected by the CSR attribute of the channel.

The present study differs from the prior works as follows. First, it considers a conventional three-echelon distribution channel that is close to realistic structure of a supply chain and analyzes channel members decisions for the socially responsible manufacturer’s CSR practice. Second, previous researches have explored CSR, effects of CSR on two-level supply chain and channel coordination discretely. In contrast the present study examines the channel coordination issues in a socially responsible distribution channel.

2.3.1 Model formulation and basic analysis

Consider a three-tire conventional distribution channel that consists of a manufacturer, multiple distributors and multiple retailers associated with each distributor. The channel structure is displayed in fig-2.12. The manufacturer produces and supplies a product in a single lots to \( n \) distributors. The \( j \)-th, \( j = 1, 2, ..., n \), distributor supplies the product to its \( n_{ij} \), \( i = 1, 2, ..., n_{j} \), number of retailers. Finally, the retailers sell the product to the customers. It is customary to assume that shortages are not allowed at any level of the channel and lead time is zero. That is, the product flows from the upstream to the downstream channel members without any delay when demand occurs. Assume that a particular retailer is associated with a particular distributor, i.e., for each retailer there is only one available distributor and it is quite common in current business practice.

The marginal production cost of the manufacturer is \( c \) and it sales the product to the distributer at a wholesale price \( w^m \). The \( j \)-th, \( j = 1, 2, ..., n \), distributor sales the product to its associated \( n_{ij}, i = 1, 2, ..., n_{j}; j = 1, 2, ..., n \), retailers at the wholesale price \( w^d_{ij} \) and the \( ij \)-th retailer sales the product at the retail price \( w^r_{ij} \). For analytical simplicity assume that the system running cost of each of the channel member is normalized to zero because in such case the qualitative results will not be altered.

Assume that the \( ij \)-th retailer can choose the retail price \( p^r_{ij} \) and the manufacturer suggests the retail price \( P \). Also, assume that the demand is linear in retail price and the customers demand at the \( ij \)-th retailer’s end is given by

\[
D^r_{ij} = a_{ij} - b_{ij}^r + \zeta(P - p^r_{ij}), i = 1, 2, ..., n_{j}; j = 1, 2, ..., n
\]

\( a_{ij} \) is the market potential for the \( ij \)-th retailer. \( b \) is the customers price sensitivity for the product. \( \zeta(P - p^r_{ij}) \) represents the customers reference price effect on demand. If \( P > p^r_{ij} \) then
the customers enjoy the utility gain and it has positive effect on demand. When \( P < p_{ij}^r \), the customers suffer utility loss and the demand is negatively affected in such case. \( 0 < \zeta < 1 \) is the coefficient of reference price effect. Yang et al. [150] have mentioned that \( \zeta \) is influenced by price, promotion, past purchase experience etc. The jth, \( j = 1, 2, ..., n \) distributor has \( n_j \) retailers and its demand is

\[
D_j^r = \sum_{i=1}^{n_j} D_{ij}^r = a_j - (b + \zeta) \sum_{i=1}^{n_j} p_{ij}^r + n_j \zeta P, j = 1, 2, ..., n
\] (2.42)

Where \( a_j = \sum_{i=1}^{n_j} a_{ij} \). The manufacturer has \( n \) distributors and the cumulative demand of the channel is

\[
D_m^r = \sum_{j=1}^{n} D_{ij}^r = a - (b + \zeta) \sum_{i=1}^{n} \sum_{j=1}^{n_j} p_{ij}^r + n^r \zeta P
\] (2.43)

Where \( a = \sum_{i=1}^{n_j} \sum_{j=1}^{n} a_{ij} \) is the total market potential.

Assume that an upstream channel member has different reservation prices for different downstream channel members. This assumption is quite reasonable because of standard practice in marketing. Generally, a channel member sets its price for a downstream member based on the facility that it receives from that member. Since, it receives different facilities from different downstream channel members, obviously the prices would be different.

Suppose the manufacturer, which is the leader of the channel, exhibits CSR to the stakeholders of the channel. Under the present model setting the consumer surplus can be found as

\[
\sum_{i=1}^{n_j} \sum_{j=1}^{n} \int_{p_{min}}^{p_{max}} D_{ij}^r dp_{ij}^r = \sum_{i=1}^{n_j} \sum_{j=1}^{n} \int_{p_{min}}^{p_{max}} \left( \frac{(a_{ij} + \zeta P)}{b + \zeta} \right) dp_{ij}^r = \sum_{i=1}^{n_j} \sum_{j=1}^{n} \frac{[D_{ij}^r]^2}{2(b + \zeta)}
\] (2.44)
CHAPTER 2. EXPLORING EFFECT OF CSR IN SUPPLY CHAIN

If $\alpha \in (0, 1)$ is the fraction of CSR that is socially responsible manufacturers concerned then the manufacturer accounts $\sum_{i=1}^{n} \sum_{j=1}^{n} [D_{ij}]^2/[2(b + \zeta)]$ as consumer surplus in its profit.

2.3.2 Decentralized policy

The CSR goal is the manufacturer’s own and it is aligned with the channel through a code of conduct. We consider the manufacturer-Stackelberg game, where the distributors are the manufacturer’s immediate followers and the retailers follow their respective distributors. The entire decision making process consists of two Stackelberg games. One is between the manufacturer and the distributors and the other is between the distributors and their corresponding retailers. We use backward induction to find the sub-game perfect solution of the games. The profit function of the manufacturer, the distributors and the retailers are respectively as

$$\pi^m = (w^m - c)(a - (b + \zeta)\sum_{i=1}^{n} \sum_{j=1}^{n} \rho_{ij} + n^r \zeta P)$$ (2.45)

$$\pi_j^d = (w^d - w^m)(a_j - (b + \zeta)\sum_{i=1}^{n} \rho_{ij} + n_j \zeta P), j = 1, 2, ..., n$$ (2.46)

$$\pi_{ij}^r = (p_{ij}^r - w^d)(a_{ij} - b_j \rho_{ij} + \zeta(P - p_{ij}^r)), i = 1, 2, ..., n_j; j = 1, 2, ..., n$$ (2.47)

Total profit of the manufacturer is the sum of pure profit and the consumer surplus that it accrues from the stakeholders and is given by

$$v_m = \pi^m + \alpha \sum_{i=1}^{n} \sum_{j=1}^{n} [D_{ij}]^2/2(b + \zeta)$$ (2.48)

Using backward induction the optimal solutions can be found and are presented in table-2.6. Moreover, $d^2 \pi_{ij}^r / dw^{r^2}_j = -2(b + \zeta) < 0$, $d^2 \pi^d / dw^d_j = -n_j(b + \zeta) < 0$ and $d^2 v_m / dw^m_n = -n^r(b + \zeta)(8 - \alpha)/16 < 0$, i.e., the profit functions of the channel members are concave. Using optimal wholesale prices of the manufacturer and the distributors and retail prices of the retailers, order quantities of the retailers and the distributors and the profits can be determined and are presented in table-2.6. Also, using these values, pure profit and consumer surplus hence total profit of the manufacturer are determined and are depicted in table-2.6 where $S = (4 - \alpha)(a + n^r \zeta P + 4(b + \zeta)n^r c)/(8 - \alpha)n^r$ and $T_{ij} = [a_{ij} + \zeta P - (b + \zeta)c]$.

Notice from table-2.6 that $dp_{ij}^r / da = -(a + n^r \zeta P + (b + \zeta)n^r c)/(b + \zeta)n^r(8 - \alpha)^2 < 0$, $dw^d_j / da = -2(a + n^r \zeta P + (b + \zeta)n^r c)/(b + \zeta)n^r(8 - \alpha)^2 < 0$ and $dw^m_m / da = -4(a + n^r \zeta P + (b + \zeta)n^r c)/(b + \zeta)n^r(8 - \alpha)^2 < 0$. Moreover, $dD_{ij}^r / da = (a + n^r \zeta P + (b + \zeta)n^r c)/n^r(8 - \alpha)^2 > 0$. To perform more competitively through CSR practice the manufacturer reduces its wholesale price. In response the distributors and the retailers reduce their wholesale prices and retail prices respectively, which encourage the customers to buy more. As a result, the demand in decentralized system increases. Also, observe that $dv_m^a / da = \sum_{i=1}^{n} \sum_{j=1}^{n} [D_{ij}]^2/2(b + \zeta) > 0$, $d\pi^m / da = -\alpha T/(8 - \alpha)^3 < 0$, where $T = [a + \zeta n^r P - (b + \zeta)n^r c]/(b + \zeta)n^r$. But, $d\pi_{ij}^r / da = [2a_{ij} - a_j/n_j + \zeta P - [(4 - \alpha)(a + n^r \zeta P + 4(b + \zeta)n^r c)/(8 - \alpha)n^r][(a + n^r \zeta P + (b + \zeta)n^r c)/(2(b + \zeta)n^r(8 - \alpha)^2] > 0$ and...
Optimal | Decentralized channel | jth Distributer | ijth Retailer | Centralized channel
--- | --- | --- | --- | ---
Price | $\frac{4S}{b+ζ}$ | $a_j + n_j P + 4n_j S$ | $\frac{2n_j a_{ij} + a_j + 3n_j P + 4n_j S}{4n_j(b+ζ)}$ | $(1-\alpha)(a_{ij} + ζP) + (b+ζ)c$ | $\frac{a_{ij} - (b+ζ)c + ζP}{2-\alpha}$
Order quantity | - | - | $\frac{2a_{ij} + ζP}{4} - a_j + 4n_j S$ | - | $(1-\alpha)\left(\sum_{i=1}^{n_j} \sum_{j=1}^{n} T_{ij}^2\right)$ | $\frac{(b+ζ)(2-\alpha)}{2}$
Pure profit (PP) | $(4-\alpha)(a + ζn^P - (b+ζ)n^S)^2$ | $\frac{n_j}{8(b+ζ)} \left[ a_j + ζn_j P - 4n_j S \right]^2$ | $\frac{1}{16(b+ζ)} \left[ n_j (2a_{ij} + ζP - 4S) - a_j \right]^2$ | $(1-\alpha)\left(\sum_{i=1}^{n_j} \sum_{j=1}^{n} T_{ij}^2\right)$ | $\frac{αζ^2P^2n^r}{16(b+ζ)}$ | $\frac{αn_r S^2}{2(b+ζ)}$ | $\frac{32(b+ζ)}{32}$ | $\frac{α(α + ζP)n^rS}{4(b+ζ)}$ | $\frac{αn_r S^2}{2(b+ζ)}$ | $\frac{αn_r S^2}{2(b+ζ)}$
Consumer surplus (CS) | $\frac{α}{2(b+ζ)} \left[ \sum_{i=1}^{n_j} \sum_{j=1}^{n} \left( \frac{a_{ij}}{2} \right)^2 \right]$ | $\frac{n_j}{8(b+ζ)} \left[ a_j + ζn_j P - 4n_j S \right]^2$ | $\frac{1}{16(b+ζ)} \left[ n_j (2a_{ij} + ζP - 4S) - a_j \right]^2$ | $(1-\alpha)\left(\sum_{i=1}^{n_j} \sum_{j=1}^{n} T_{ij}^2\right)$ | $\frac{αζ^2P^2n^r}{16(b+ζ)}$ | $\frac{αn_r S^2}{2(b+ζ)}$ | $\frac{32(b+ζ)}{32}$ | $\frac{α(α + ζP)n^rS}{4(b+ζ)}$ | $\frac{αn_r S^2}{2(b+ζ)}$ | $\frac{αn_r S^2}{2(b+ζ)}$
Total profit (PP+CS) | $(4-\alpha)(a + ζn^P - (b+ζ)n^S)^2$ | $\frac{n_j}{8(b+ζ)} \left[ a_j + ζn_j P - 4n_j S \right]^2$ | $\frac{1}{16(b+ζ)} \left[ n_j (2a_{ij} + ζP - 4S) - a_j \right]^2$ | $(1-\alpha)\left(\sum_{i=1}^{n_j} \sum_{j=1}^{n} T_{ij}^2\right)$ | $\frac{αζ^2P^2n^r}{16(b+ζ)}$ | $\frac{αn_r S^2}{2(b+ζ)}$ | $\frac{32(b+ζ)}{32}$ | $\frac{α(α + ζP)n^rS}{4(b+ζ)}$ | $\frac{αn_r S^2}{2(b+ζ)}$ | $\frac{αn_r S^2}{2(b+ζ)}$

Table 2.6: Optimal values in centralized and decentralized decision making
optimal value of \( p_d C S_0 \), The necessary condition, \( dv \)

Proposition-2.14 (i) The manufacturer’s and the distributors’ wholesale prices as well as the retail price of the product decrease with increasing CSR but the demand of the product behave inversely. (ii) Total profit of the manufacturer, profit of the distributors and the retailers increase but pure profit the manufacturer decreases with increasing CSR.

2.3.3 Centralized policy

In centralized decision there is a single decision maker who produces a product in a single lot and sales it to the customers. The channel members cooperate and find the decision that maximizes the supply chain performance. The total profit of the channel is the sum of pure profit and the consumer surplus that the channel accrues from the stakeholders and it is given by

\[
v_c = \sum_{i=1}^{n} \sum_{j=1}^{\aleph} [(a_{ij} + \zeta_i P)/n_j - [(4 - \alpha)(a + n' \zeta_i P) + 4(b + \zeta_i) c]/(8 - \alpha)] [(a + n' \zeta_i P + (b + \zeta_i) n' c)/(b + \zeta_i) n'(8 - \alpha)^2] > 0\].

The necessary condition, \( dv_c / dp^{rc}_{ij} = 0 \), for the existence of the optimal solution yields the optimal value of \( p^{rc}_{ij} \) as follows.

\[
p^{rc*}_{ij} = (1 - \alpha)(a_{ij} + \zeta_i P) + (b + \zeta_i) c/(2 - \alpha)(b + \zeta_i), \quad i = 1, 2, ..., \aleph; j = 1, 2, ..., n \] (2.50)

Moreover, \( d^2 v_c / dp^{rc}_{ij}^2 = -(b + \zeta_i)(2 - \alpha) < 0 \), i.e., the optimal selling price provides global maximum for the centralized channel. Using optimal selling price the other values are found and depicted in table-2.6.

Observe that, \( dp^{rc*}_{ij} / d\alpha = -[(a_{ij} + \zeta_i P) - (b + \zeta_i) c]/(2 - \alpha)(2 - \alpha) > 0 \) and \( dD^{rc*}_{ij} / d\alpha = [(a_{ij} + \zeta_i P) - (b + \zeta_i) c]/(2 - \alpha)^2 > 0 \). The manufacturer’s social responsibility influences the retail price of the centralized channel. When the manufacturer puts more weight on CSR, the channel price decreases. Since, the order quantity inversely related to the retail price, the order quantity increases with the manufacturer’s increasing CSR. Moreover, \( dv_c / d\alpha = (a_{ij} + \zeta_i P - (b + \zeta_i) c^2)/(b + \zeta_i)(2 - \alpha) > 0, \quad d^2 v_c / d\alpha = -\alpha(a_{ij} + \zeta_i P - (b + \zeta_i) c^2)/(2(b + \zeta_i)(2 - \alpha)^3 < 0, \quad dCS_c / d\alpha = (2 + \alpha)(a_{ij} + \zeta_i P - (b + \zeta_i) c^2)/(2(b + \zeta_i)(2 - \alpha)^3 > 0, \) i.e., pure profit
of the channel decreases but total profit of the channel increases with increasing CSR of the manufacturer because the consumer surplus that the channel accrues from the stakeholders increases. Also, the increment of consumer surplus is higher than the decrement of pure profit. The socially responsible centralized channel is more efficient than a pure profit maximizing channel. The channel increases its sales quantity by reducing the retail price. As a result the channel compensates the loss of pure profit by accruing consumer surplus even provides some extra profit to the channel. This observation can further be justified from (2.50) as follows. 

\[ p_{ij}^{rc} \big|_{\alpha=1} = c, \text{ i.e., when the manufacturer is the pure profit maximizer, the channel retail price is same as the marginal cost of the channel.} \]

Then, from table-2.6 it follows that the channel’s pure profit is zero and the channel accrues only the consumer surplus through CSR practice. Thus, the proposition follows.

**Proposition-2.15** In centralized channel, i) retail price of the product decreases with increasing CSR of the manufacturer and (ii) total profit increase but pure profit of the channel decreases with increasing CSR.

Notice that, 
\[ v^*_{c} > v^*_{m} + \sum_{j=1}^{n} \pi_{j}^{ds} + \sum_{i=1}^{n} \sum_{j=1}^{n} \pi_{ij}^{rs}, \text{ i.e., double marginalization exists in the channel and transfer pricing policy must be applied to obtain the best channel performance.} \]

### 2.3.4 Channel coordination using revenue sharing contract

When centralized decisions are implemented for the channel best performance, the manufacturer and the distributors are benefited though the retailers’ profits are less compared compared to decentralized profits. Thus, the retailers have no reason to accept the centralized decision unless they receive some incentives that ensure at least their decentralized profits. As such, assume that the channel members jointly apply RS contract to resolve conflict among them. RS contract is a coordination mechanism offered by the upstream member to the downstream member, which modifies the downstream members profit (and also the upstream members one) so as to incentivize it to make decisions coherent with the supply chain’s total optimization. Assume that the manufacturer proposes the RS contract \((w_{j}^{m/rs}, \mu_{ij})\) \(0 < \mu_{ij} < 1\), to each \(j=1,2,...,n\) to the \(j\)th distributer. That is, the manufacturer supplies the product to the \(j\)th distributer at a wholesale price \(w_{j}^{m/rs}\), instead receives a fraction of revenue \(\mu_{ij}\) from the distributer that it creates. To encourage each of its retailers, the \(j\)th distributer supplies the product to its \(i\)th retailer, \(i=1,2,...,n_{j}\) at a wholesale price \(w_{ij}^{d/rs}\) and claims \(\phi_{ij}, 0 < \phi_{ij} < 1\) percentage of revenue from the retailer that it generates. In response to the upstream channel members cooperative initiatives, the \(i\)th retailer, \(i=1,2,...,n_{j}; j=1,2,...,n\), sets the retail price \(p_{ij}^{r/rs}\). Notice that in the proposed nested revenue sharing setting every upstream channel member sets different wholesale price and claims different revenue share from different downstream channel members. In a multi-member, multi-level distribution channel the general practice is that and upstream channel member analyzes the situation of its downstream members in one-to-one basis and takes decision. It is very common in marketing channel that an upstream channel member provides more facilities to some of its downstream members than the others because it receives more from those members. Obviously, how much incentive an upstream member can provide to a downstream member that depends on how much it receives from that member. Undoubtedly this assumption makes the model realistic and it is common in marketing practice. Under
RS contract profits of the $ij$th retailer, the $j$th distributor, pure profit and total profit of the manufacturer are respectively as

$$
\pi_{ij}^{r/rs} = (\phi_{ij} p_{ij}^{r/rs} - w_{ij}^{d/rs}) D_{ij}^{r/rs} \quad i = 1, 2, ..., n; j = 1, 2, ..., n
$$

(2.51)

$$
\pi_{j}^{d/rs} = \sum_{i=1}^{n_{j}} \left[ \mu_{ij} ((1 - \phi_{ij}) p_{ij}^{r/rs} + w_{ij}^{d/rs}) - w_{ij}^{m/rs} \right] D_{ij}^{r/rs} \quad j = 1, 2, ..., n
$$

(2.52)

$$
\pi_{m/rs}^{m/rs} = \sum_{j=1}^{n} \sum_{i=1}^{n_{j}} \left[ (1 - \mu_{ij}) [(1 - \phi_{ij}) p_{ij}^{r/rs} + w_{ij}^{d/rs}] + (w_{ij}^{m/rs} - c) \right] D_{ij}^{r/rs}
$$

(2.53)

$$
v_{m/rs}^{m/rs} = \pi_{m/rs}^{m/rs} + \alpha \sum_{j=1}^{n} \sum_{i=1}^{n_{j}} [D_{ij}^{r/rs}]^2 / (2(b + \zeta))
$$

(2.54)

The $ij$th retailer will selfishly maximize its profit function, $\pi_{ij}^{r/rs}$ and necessary condition to obtain optimal solution, $d\pi_{ij}^{r/rs} / dp_{ij}^{r/rs} = 0$ yields

$$
p_{ij}^{r/rs} = \frac{\phi_{ij} (a_{ij} + \zeta P) + (b + \zeta) w_{ij}^{d}}{2(b + \zeta) \phi_{ij}} \quad i = 1, 2, ..., n; j = 1, 2, ..., n
$$

(2.55)

The revenue sharing contract will align the $ij$th retailer and the $j$th distributor’s decisions only when $p_{ij}^{r/rs} = p_{ij}^{d/rs}$. Simplifying, the $j$th distributor’s optimal wholesale price for the $ij$th retailer can be found as

$$
w_{ij}^{d/rs} = \phi_{ij} \left[ \frac{2(1 + \phi_{ij})(b + \zeta) - (\alpha + 2 \phi_{ij})(a_{ij} + \zeta P)}{(2 - \alpha)(b + \zeta)} \right] w_{ij}^{m/rs}
$$

(2.56)

Thus, when the $j$th distributor, $j = 1, 2, ..., n$, sells the product to its $ij$th, $i = 1, 2, ..., n; j = 1, 2, ..., n$ retailer at the wholesale price $w_{ij}^{d/rs}$, the $ij$th retailer sets the centralized retail price. Like the retailer the distributor will also selfishly maximize its wholesale price in the RS contract. From (2.52) the necessary condition for the maximization of the $j$th distributor’s profit function yields the wholesale price as

$$
w_{ij}^{d*} = \frac{\phi_{ij} (a_{ij} + \zeta P) + (b + \zeta) w_{ij}^{d}}{2(b + \zeta) \phi_{ij}}
$$

(2.57)

The channel will be coordinated only when $w_{ij}^{d*} = w_{ij}^{d/rs}$. Simplifying the expression, the manufacturer’s wholesale price for the $ij$th retailer can be found as

$$
w_{ij}^{m/rs} = \mu_{ij} \left[ \frac{2(1 + \phi_{ij})(b + \zeta)(c - \alpha + 2 \phi_{ij})(a_{ij} + \zeta P)}{2 - \alpha(b + \zeta)} \right] i = 1, 2, ..., n; j = 1, 2, ..., n
$$

(2.58)

But, in the decision making context it is not possible as well as feasible for the manufacturer to set different wholesale price for different retailers under a single distributor. Thus, the manufacturer sets the wholesale price of the $j$th distributor as the weighted mean of the wholesale prices of its corresponding retailers. As such, the wholesale price of the manufacturer for the
jth distributor is
\[ w_{j}^{m/rs} = \sum_{i=1}^{n_j} \left[ D_{ij}^{r/rs} \cdot w_{ij}^{m/rs} \right] \cdot \frac{1}{\sum_{i=1}^{n_j} [D_{ij}^{r/rs}]} , j = 1, 2, ..., n, \] (2.59)

Therefore, as long as \( 0 < \phi_{ij} < 1 \), \( 0 < \mu_{ij} < 1 \), \( i=1, 2, ..., n; j=1, 2, ..., n \), the manufacturer sets wholesale price \( w_{j}^{m/rs} \) for the jth distributor. In response the jth distributor sets the wholesale price \( v_{ij}^{d/rs} \) for the ijth retailer and the ijth retailer sets the centralized retail price. Furthermore, in pure profit maximizing distribution channel as long as \( 0 < \phi_{ij} < 1 \), \( 0 < \mu_{ij} < 1 \), \( i=1, 2, ..., n; j=1, 2, ..., n \), lower wholesale prices of the channel members in comparison to the marginal cost of the manufacturer ensures channel coordination. Here also in the socially responsible distribution channel
\[ w_{ij}^{d/rs} - c = -\frac{\alpha \phi_{ij} [a_{ij} + \zeta P - (b + \zeta) c]}{(2 - \alpha)(b + \zeta)} - (1 - \phi_{ij}) c < 0, \quad \forall \ \phi_{ij} \in (0, 1) \]
\[ w_{ij}^{m/rs} - c = -\mu_{ij} (\alpha + 2 \phi_{ij}) [a_{ij} + \zeta P - (b + \zeta) c] \]
\[ (2 - \alpha)(b + \zeta) - (1 - \mu_{ij}) c < 0, \quad \forall \ \phi_{ij} \in (0, 1), \mu_{ij} \in (0, 1) \]

From (2.59) notice that \( w_{ij}^{m/rs} \) is the convex combination of \( w_{ij}^{m/rs} \), Each \( w_{ij}^{m/rs} < c \) ensures \( w_{ij}^{m/rs} < c \). That is, the optimal wholesale prices of the manufacturer and the jth distributor \( (j=1, 2,..n) \) corresponding to the ijth retailer \( (i=1, 2, ..., n; j=1, 2, ..., n) \) are always less than its marginal production cost.

Using the optimal wholesale prices in (2.51), (2.52), (2.53) and (2.54), optimal profits of the channel members under RS contract are found as follows
\[ \pi_{ij}^{r/rs} = \frac{\phi_{ij} [a_{ij} + \zeta P - (b + \zeta) c]}{(b + \zeta)(2 - \alpha)^2}, \quad i = 1, 2, ..., n; \quad j = 1, 2, ..., n \] (2.60)
\[ \pi_{j}^{d/rs} = \sum_{i=1}^{n_j} \mu_{ij} (\phi_{ij} + 1) [a_{ij} + \zeta P - (b + \zeta) c]^2 \]
\[ (b + \zeta)(2 - \alpha)^2, \quad j = 1, 2, ..., n \] (2.61)
\[ \pi^{m/rs} = \sum_{j=1}^{n} \sum_{i=1}^{n_j} \frac{(1 - \alpha - \phi_{ij} - \mu_{ij} - \phi_{ij} \mu_{ij}) [a_{ij} + \zeta P - (b + \zeta) c]^2}{(b + \zeta)(2 - \alpha)^2} \] (2.62)
\[ v^{m/rs} = \sum_{j=1}^{n} \sum_{i=1}^{n_j} \frac{(2 - \alpha - 2 \phi_{ij} - 2 \mu_{ij} - 2 \phi_{ij} \mu_{ij}) [a_{ij} + \zeta P - (b + \zeta) c]^2}{2(b + \zeta)(2 - \alpha)^2} \] (2.63)

Notice that \( \sum_{j=1}^{n} \sum_{i=1}^{n_j} \pi_{ij}^{r/rs} + \sum_{j=1}^{n} \pi_{j}^{d/rs} + v^{m/rs} = v^{c} \), i.e., the channel conflict is resolved by using the RS contract and the proposition follows.

**Proposition 2.16** The sets of RS parameters \( (w_{ij}^{m/rs}, \mu_{ij} \) and \( (w_{ij}^{d/rs}, \phi_{ij} \), \( 0 < \phi_{ij} < 1 \), \( 0 < \mu_{ij} < 1 \), \( i=1, 2, ..., n; j=1, 2, ..., n \) coordinates the socially responsible distribution channel.

Although the proposed RS contract resolves the channel conflict, it is acceptable to the channel members only when they receive win-win outcomes. Cachon and Lariviere [22] have mentioned
that in a pure profit maximizing supply chain, surplus profit due to channel coordination is arbitrarily distributed among the channel members and it depends on the revenue sharing fraction \( \phi_{ij} \) and \( \mu_j \), \( i = 1, 2, ..., n; j = 1, 2, ..., n \). The win-win outcomes of the channel members are ensured if they receive at least equal to their respective decentralized profits. As such, the proposition follows.

**Proposition 2.17** In a distribution channel with CSR manufacturer, the RS contract cuts out channel conflict and leads to win-win outcomes for the channel members for \( w_{d/rs}^{d} \in (w_{d/rs}^{d}, w_{d/rs}^{d}) \), \( w_{m/rs}^{d} \in (w_{m/rs}^{d}, w_{m/rs}^{d}) \), \( \phi_{ij} \in (\phi_{ij}, \phi_{ij}) \), \( \mu_j \in (\mu_j, \mu_j) \), \( k \in (k, k) \), \( k \) are given in table-2.7

**Proof**: See appendix A-2.7.

Using the win-win ranges of the RS contract’s parameters the profit ranges of the channel members can be determined and are presented in table-2.7.

### 2.3.5 Effects of CSR on the channel coordinated decision

In a socially responsible distribution channel the proposed RS contract resolves channel conflict and finds win-win pure profits for the channel members and win-win total profit for the manufacturer. Notice that \( w_{m/j}^{m} > 0 \) and \( w_{m/j}^{m} > 0 \) for any \( \alpha \in (0, 1) \) and \( j = 1, 2, ..., n \), i.e., win-win wholesale price range of the manufacturer for the jth distributor decreases with its increasing CSR practice. Eventually, \( w_{m/j}^{m} < 0 \) if \( \alpha > \alpha_{m}^{m} \), where \( \alpha_{m}^{m} \) is the real root of the equation \( \sum_{i=1}^{n} (D_{r/i}^{f} - w_{m/j}^{m}) = 0 \) and \( w_{m/j}^{m} > 0 \) if \( \alpha > \alpha_{m}^{m} \), where \( \alpha_{m}^{m} \) is the real root of the equation \( \sum_{i=1}^{n} (D_{r/i}^{f} - w_{m/j}^{m}) = 0 \). Therefore, the wholesale price of the manufacturer for the jth distributor is negative for \( \alpha_{m}^{m} < \alpha < 1 \). Also from table-2.7 observe that \( w_{m/j}^{m} < 0 \) if \( \alpha > \alpha_{1}^{m} \), where \( \alpha_{1}^{m} \) is the real root of the equation \( \sum_{j=1}^{n} \sum_{i=1}^{n} ((1 - \alpha)T_{i}^{2} - (\pi_{i}^{m} + \pi_{j}^{m})(b + \zeta)(2 - \alpha)^{2}) = 0 \) and \( w_{m/j}^{m} < 0 \) if \( \alpha > \alpha_{1}^{m} \), where \( \alpha_{1}^{m} \) is the real root of the equation \( \sum_{j=1}^{n} \sum_{i=1}^{n} [2(b + \zeta)(2m - a_{ij}^{m}T_{ij}^{2})] = 0 \). Furthermore, \( d\pi_{m/j}^{m}/d\alpha < 0 \) and \( d\pi_{m/j}^{m}/d\alpha < 0 \) for any \( \alpha \in (0, 1) \), i.e., the manufacturer’s pure profit range under RS contract decreases with increasing CSR practice. Therefore, the manufacturer’s pure profit will be negative for any \( \alpha > \alpha_{1}^{m} \). Thus, the proposition follows.

**Proposition 2.18** In a socially responsible distribution channel, under RS contract, the manufacturer’s (a) wholesale price for the jth distributor, \( j = 1, 2, ..., n \) (i) decreases with increasing CSR, (ii) is negative for any \( \alpha > \alpha_{j}^{m} \), and (b) pure profit (i) decreases with increasing CSR and (ii) is negative for any \( \alpha > \alpha_{1}^{m} \).

The wholesale price of the manufacturer in the RS contract in a socially responsible distribution channel is quite different from that of a pure profit maximizing distribution channel. In a
<table>
<thead>
<tr>
<th></th>
<th>Manufacturer</th>
<th>jth Distributor</th>
<th>i jth Retailer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholesale Price</td>
<td>( \min )</td>
<td>( \frac{\sum_{i=1}^{n_j} [D_{ij}^{f}/w_{ij}^{m}/c]}{\sum_{i=1}^{n_j} [D_{ij}^{f}/w_{ij}^{m}/c]} )</td>
<td>( \frac{1}{T_0^2} \left[ \frac{(b+\zeta)(2-\alpha)}{b+\zeta} \right] ) ( c_2 - \frac{\alpha(a_i+\zeta P)}{b+\zeta} ) ( \pi_{ij}^* )</td>
</tr>
<tr>
<td>RS fraction</td>
<td>( \min )</td>
<td>( \frac{\sum_{i=1}^{n_j} [D_{ij}^{f}/w_{ij}^{m}/c]}{\sum_{i=1}^{n_j} [D_{ij}^{f}/w_{ij}^{m}/c]} )</td>
<td>( \frac{\sum_{i=1}^{n_j} [D_{ij}^{f}/w_{ij}^{m}/c]}{\sum_{i=1}^{n_j} [D_{ij}^{f}/w_{ij}^{m}/c]} )</td>
</tr>
<tr>
<td>Pure Profit</td>
<td>( \min )</td>
<td>( \sum_{j=1}^{n} \sum_{i=1}^{n_j} \left[ v_{ij}^{m*} - \frac{\alpha{T_{ij}^2}}{2(b+\zeta)(2-\alpha)^2} \right] )</td>
<td>( \left( \pi_{ij}^d + \pi_{ij}^r \right) )</td>
</tr>
<tr>
<td>max</td>
<td>( \sum_{j=1}^{n} \sum_{i=1}^{n_j} \left[ \frac{(1-\alpha){T_{ij}^2}}{2(b+\zeta)(2-\alpha)^2} - \left( \pi_{ij}^d + \pi_{ij}^r \right) \right] )</td>
<td>( \sum_{i=1}^{n_j} \left[ \frac{T_{ij}^2}{2(b+\zeta)(2-\alpha)} - \left( \pi_{ij}^d + \pi_{ij}^r \right) \right] )</td>
<td>( \sum_{i=1}^{n_j} \left[ \frac{T_{ij}^2}{2(b+\zeta)(2-\alpha)} - \left( \pi_{ij}^d + \pi_{ij}^r \right) \right] )</td>
</tr>
<tr>
<td>Total Profit</td>
<td>( \min )</td>
<td>( v_{ij}^{m*} )</td>
<td>( \frac{n_j}{8(b+\zeta)} \left[ a_i + \zeta n_j P - 4n_j S \right] )</td>
</tr>
<tr>
<td>max</td>
<td>( \sum_{j=1}^{n} \sum_{i=1}^{n_j} \left[ \frac{T_{ij}^2}{2(b+\zeta)(2-\alpha)} - \left( \pi_{ij}^d + \pi_{ij}^r \right) \right] )</td>
<td>( \sum_{i=1}^{n_j} \left[ \frac{T_{ij}^2}{2(b+\zeta)(2-\alpha)} - \left( \pi_{ij}^d + \pi_{ij}^r \right) \right] )</td>
<td>( \sum_{i=1}^{n_j} \left[ \frac{T_{ij}^2}{2(b+\zeta)(2-\alpha)} - \left( \pi_{ij}^d + \pi_{ij}^r \right) \right] )</td>
</tr>
</tbody>
</table>

Table 2.7: Ranges under revenue sharing contract.
pure profit maximizing distribution channel, the wholesale price of the RS contract is always non-negative. But this result does not hold in a socially responsible distribution channel. Furthermore, when the manufacturer puts more weight on CSR, it also reduces the wholesale price to encourage the retailer to sell more units by decreasing the retail price. The intention of the manufacturer is not to coordinate the channel but rather to encourage the retailer to sell more units through a lower selling price. The manufacturer implements this by selling the product to the retailer below the marginal production cost. So the wholesale price may be negative because it is inversely related to the manufacturer’s CSR, i.e. a corporately socially responsible manufacturer pays the retailer to sell units additional to the decentralized order quantity. So, CSR is purely a costly endeavor to the manufacturer.

**An example** Consider a distribution channel consisting of a manufacturer (M), two distributors \((D_1, D_2)\) and five retailers \((R_{11}, R_{21}\) under distributor \(D_1\) and \(R_{12}, R_{22}, R_{32}\) under distributor \(D_2\)). The parameter values are taken as \(a_{11} = 160, a_{21} = 155, a_{12} = 156, a_{22} = 150, a_{32} = 152, P = 200, b = 0.4, \zeta = 5, c = 50\). For these parameter values the optimal non-negative wholesale price ranges of the manufacturer for the distributors \(D_1\) and \(D_2\) are respectively as \((0.3406, 0.9075)\) and \((0.3468, 0.912)\). Therefore, for any \(\alpha > 0.9075\) and \(\alpha > 0.912\) the manufacturer for the distributors \(D_1\) and \(D_2\) are negative.

![Figure 2.13](image-url)

(a) Nature of the wholesale prices of the manufacturer (b) Nature of the pure and total profit of the manufacturer

Figure 2.13: Nature of the manufacturer’s wholesale price and profit

Fig-2.13(a) justifies this result. Also, it depicts that the wholesale prices of the manufacturer for the distributors decrease with increasing CSR. From fig-2.13(b) note that the pure profit range of the manufacturer decreases, whereas total profit range of the manufacturer increases with increasing CSR. Also, \(\alpha_1 = 0.3542\) and \(\bar{\pi}_1 = 0.8432\). Thus, for any \(\alpha > 0.8432\), the pure profit of the manufacturer is negative.

Observe from table-2.7 that \(\frac{dU_{ij}}{d\alpha} < 0\) and \(\frac{dW_{ij}}{d\alpha} < 0\) for any \(\alpha \in (0, 1)\). Moreover, \(\frac{dU_{ij}}{d\alpha}\) and \(\frac{dW_{ij}}{d\alpha}\) are negative for any \(\alpha > \frac{2\zeta(b+c)}{a_{ij}+\zeta P} = \alpha_2 = \alpha_{ij}^*\). Also notice from table-2.7 that \(\frac{d\pi_j^{RS}}{d\alpha} > 0\) and \(\frac{d\pi_j^{RS}}{d\alpha} > 0\) for any \(\alpha \in (0, 1)\). For the example described above
\[ \alpha_{11}^d = 0.912, \alpha_{21}^d = 0.935, \alpha_{12}^d = 0.9342, \alpha_{22}^d = 0.9391 \text{ and } \alpha_{32}^d = 0.9375. \]

(a) Nature of the wholesale prices of the distributor

(b) Nature of the pure and total profit of the distributor

Figure 2.14: Nature of the distributor’s wholesale price and profit

Fig-2.14(a) describes that the wholesale prices of the distributors for their retailers decrease and become negative with the manufacturer’s increasing CSR. Also fig-2.14(b) shows that the distributors’ profits are inversely propositional to the manufacturer’s CSR. Thus, the proposition follows.

Proposition 2.19 Under RS contract, (a) the wholesale prices of the distributors (i) decrease with increasing \( \alpha \), (ii) are negative for \( \alpha_{ij}^d < \alpha < 1 \), \( i = 1,2,\ldots,n \); \( j = 1,2,\ldots,n \) and (b) profits of the distributors are inversely proportional to the manufacturer’s CSR.

Observe from fig-2.15 that \( \phi_{ij} \) and \( \mu_j \) decrease with increasing CSR of the manufacturer. The intuitive reason is straightforward. When the manufacturer increases it’s CSR, the downward
wholesale prices are reduced as a result upward revenue flows are increased. That is, the up-
stream channel members reduces their wholesale prices and claim more revenues from their
downstream channel members.

It is a common practice, in a socially responsible supply chain that the leader of the channel is
mainly responsible for CSR and it introduces code of conduct such that all the other channel
members business practices are socially responsible. As such, in response to the manufacturers
reduced wholesale price, the distributors also reduce wholesale prices to encourage the retailers
to sell more units by reducing retail prices. The distributors’ wholesale prices are inversely
proportional to the manufacturers CSR intensity. Thus, when the manufacturers CSR inten-
sity increases, the distributors’ wholesale prices may be less than the manufacturers marginal
production cost and may be negative for the manufacturers heavy CSR practice. That is, the
distributor pays the retailer to sell units additional to decentralized order quantity. Finally, to
exhibit CSR the retailers’ sell the products at centralized prices. In such case, the distributors
and the retailers’ business practices are socially responsible. As the retailers sale the product at
the centralized prices, their sales volumes increases and they earn more profits. To compensate
the loss of revenues due to reduced wholesale prices the retailers’ transfer fractions of revenues
to their respective distributors. In turn the distributors also transfer some revenues to the
manufacturer. Since, for the higher emphasis on CSR, the reduction on wholesale prices are
higher, the downstream channel members revenue transfers in reverse order are higher due to
higher profit gains.

2.4 Managerial implications and concluding remarks

This chapter discusses channel coordination for three types of socially responsible supply chain.
Besides addressing coordination issues, it also analyzes effect of corporate social responsibility
on supply chain. Models only incorporate the effect of CSR in the form of consumer surplus
in the socially responsible firms profit function rather than the activities, which the channel
perform. Unlike the natural intension of the channel members’ profit maximization, the chapter
uses the concept of the classic principle of Vickers [143]. The principle indicates that non-profit
maximizing firm may earn higher profits than would profit-maximizers. Here the objectives of
the channel members are to engage in CSR and to find the effects that CSR tends to bring
about. The chapter yields following insights.

The model demonstrated in section 2.1, yields the following insights. Firstly, it depicts an
alternative avenue for profit making in a supply chain, where the interdependent channel mem-
ers are profit-maximizers. Deviating from the profit-maximizing channel, which the supply
chain literature assumes, the model follows the classic principle of Vickers [143] that non-profit
maximization objective through heavy CSR practice may generate higher profit margin than
would the profit maximization motive. Outcomes of the paper justify Vickers [143]. Thus, a
supply chain may strategically involve in heavy CSR practice rather than engaging in applying
profit maximizing strategies for higher profit benefit. That is, a firm has the option to use CSR
as a profit making tool. Obviously, this raises a question on the validity of ‘natural selection’
of Friedman [48]. Thus, extensive research is essential in this regard. Secondly, in decentralized
CHAPTER 2. EXPLORING EFFECT OF CSR IN SUPPLY CHAIN

decision making always there is a possibility for simultaneous increment of the pure profits of
the channel members with increasing CSR. But it depends on the suitable choice of CSR and
how the channel members share the social responsibility. On the other hand, the CSR retailer’s
perfect welfare maximizing motive resolves channel conflict though the CSR manufacturers
perfect welfare maximizing motive does not. Thirdly, unlike the pure profit maximizing supply
chain, the double marginalization in a socially responsible supply chain increases with decreas-
ing retail price of the channel. Also, the retail price is equal to the marginal production cost
when the channel is the perfect welfare maximizer though the channel is not coordinated. Thus,
CSR is cost enhancing by inducing a higher output and lower price and the socially responsible
channel behaves more competitively than a pure profit maximizing channel because it accepts
less profit to act socially. Fourthly, the equilibrium wholesale price of the manufacturer that
cuts out channel conflict and divides surplus profit between the channel members is different
from a pure profit maximizing supply chain. The wholesale price is inversely proportional to the
channel’s CSR practice. The wholesale price of the manufacturer is less than its marginal pro-
duction cost above a threshold of CSR and it is negative for the channel’s heavy CSR practice.
In such case in which proportion the channel members share the CSR is the determining factor
for the channel member’s pure profits. Proposition-2.6 suggests the behavior of the channel
member’s pure profits for CSR and CSR sharing fraction. The pure profit of the retailer may be
negative, i.e., it pays the customers to sell units added to decentralized order quantity when the
CSR and the CSR sharing fraction are above some thresholds. Same property may be observed
for the manufacturer also. On the other hand, when the retailer is only socially responsible, the
wholesale price of the manufacturer is always higher than its marginal production cost. The
manufacturer picks up the retailer’s pure profit that it loses for exhibiting CSR by increasing
its wholesale price. When the manufacturer is only socially responsible, its wholesale price may
be below its marginal production cost or negative for heavy CSR practice. As a result the man-
ufacturer’s pure profit is negative. Thus, while managing a socially responsible supply chain,
managers should carefully choose the intensity of CSR and CSR sharing fraction. Otherwise,
the shareholders value may be diminished or completely destroyed. Fifthly, as far as applica-
ibility of the models is concerned, a channel member always prefers the others CSR practice
because in that case its shareholders value will increase significantly. But in cooperative envi-
ronment it is not possible because every organization wants to reserve at least it’s shareholder’s
value. Thus, in equilibrium a compromise solution as showed in proposition-2.8 may be applied.

The model demonstrated in section 2.2, yields the following insights. First, in decentralized
decision making the socially responsible channel member’s perfect welfare maximizing motive
is not enough for channel coordination. Unlike the pure profit maximizing channel, the dou-
ble marginalization of the socially responsible channel increases with decreasing retail price
of the channel. Moreover, in the centralized channel the retail price is equal to the marginal
production cost for the perfect welfare maximizing motive of the socially responsible channel
member. So, CSR is cost enhancing by inducing a higher output and lower price and the so-
cially responsible channel behaves more competitively than a pure profit maximizing channel
because it accepts less profit to act socially. Second, the contract-bargaining resolves channel
conflict and distributes surplus profit among the channel members. The wholesale prices of
the contract-bargaining process are different when compared with the wholesale prices of a
traditional supply chain. The wholesale price of the manufacturer is less than its marginal pro-
duction cost above a threshold of CSR practice. Even it is negative for the manufacturer’s
heavy CSR activity. As a result the manufacturer’s pure profit may be negative, i.e., it pays
the distributor to sell additional units that it produces for exhibiting CSR. The behaviour of
the distributor’s wholesale price is same as that of the manufacturer but for the manufacturer’s
higher threshold of CSR. As a consequence, the distributor’s profit and the retailer’s profit
are win-win. Third, the manufacturer’s pure profit and it’s CSR are inversely proportional.
Thus, the manufacturer can not maximize the shareholder’s value and the stakeholder’s value
simultaneously. In the contract bargaining process, if the manufacturer’s CSR is above 0.6809
then it’s shareholder’s value destroys completely. Although the consumer surplus, which the
manufacturer accrues, compensates the loss of pure profit, still the manufacturer should identify
of CSR that balances shareholder’s value and stakeholder’s value.

The third model yields following insights. First, it is found that in a decentralized three-echelon
distribution channel all the channel members earn more profit when the manufacturer is more
socially responsible. Moreover, consumers are also benefited for increasing CSR of the manu-
facturer because selling price of the product decrease when the manufacturer increase its CSR.
Second, it is found that the RS contract coordinates the channel. It is also showed that, the
RS contract cuts out channel conflict and leads to win-win outcomes for the channel members.
Third, The wholesale prices under the RS are different when compared with the wholesale prices
of a traditional supply chain. The wholesale price of the manufacturer is less than zero above a
threshold of CSR practice , i.e., it pays the distributor to sell additional units that it produces
for exhibiting CSR. Even the manufacturer’s pure profit become negative for its heavy CSR
activity. The consumer surplus, which the manufacturer accrues, compensates the loss of pure
profit.

The chapter demonstrates the concept of alternating offer bargaining to coordinate the two-level
supply chain. It also incorporates a new methodology namely, sequential bargaining processes
to coordinate and to distribute surplus profit among the members in a three-level supply chain.
Although the proposed chapter provides some idea about how a socially responsible supply
chain can be managed in the sense of pure profit maximization, still it has some limits. Firstly,
for simplicity of analysis the demand is assumed as deterministic linear in price. Models may
be developed by considering some well established deterministic demands or stochastic price
dependent demand. Secondly, the CSR and CSR sharing fraction have great impact on the
channel members’ pure profits. Although in the present model setting we find the ranges
of CSR and CSR sharing fraction for non-negative pure profits of the channel members, still
extensive investigation is required to find more characteristics about this range. Also, how these
two parameters’ impacts can be incorporated through good behavioral practice by introducing
a model code of conduct may be an interesting research topic. However, the outcomes of
the chapter should have the potentialities to initiate new research directions, such as profit
maximization using non-profit maximizing objective in supply chains, how to find threshold of
CSR for an acceptable shareholders’ value, and should have an impressive impact on a firms
basic working principle that a manager follows.