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# Financing and Cost sharing for a Supply Chain under CSR - sensitive demand

Franck MORAUX, Dinh Anh PHAN, Thi Le Hoa VO

Université de Rennes 1, CNRS, CREM UMR6211  
IGR-IAE de Rennes, 11 Rue Jean Macé, CS 70803, 35708 Rennes Cedex 7, France

**Abstract.** Downstream firms nowadays adopt either financing or cost sharing (CS) mechanisms to enhance the corporate social responsibility (CSR) performance of their suppliers. In this paper, we are interested in combining these two mechanisms in a supply chain. We consider a supply chain where the demand is CSR-dependent and where a large retailer shares the costs of CSR activities undertaken by a SME supplier. We investigate how the retailer's choice of two financing mechanisms, namely Bank Financing (BF) and Reverse Factoring (RF), can influence the various operational decisions of both parties and the performance of the supply chain. Our findings demonstrate that no matter which financing mechanism is applied (BF or RF), CS leads to higher CSR effort and higher profits for all supply chain members. Moreover, a CS contract affects the financing preferences of both the retailer and the supplier. Managerially, a CS contract combined with an appropriate financing mechanism help to improve the CSR performance and the profitability of a supply chain.

**Keywords:** Corporate social responsibility, Supply chain, Bank financing, Reverse factoring, Cost-sharing contract.

## 1 Introduction

Many companies nowadays support their suppliers in adopting CSR, by sharing costs or co-financing the CSR. For example, Hewlett-Packard Company incentivizes its main suppliers by sharing CSR investment costs [1], while Wal-Mart Stores Inc. launched in 2010 a Global Social Compliance Program that co-finances CSR investment costs with suppliers. For financing, in recent years, large retailers recourse to BF and RF to support the supplier's CSR efforts. E.g., PUMA uses BF to pay its suppliers early, if they show a high sustainability performance in terms of environment, health and safety, and social welfare. PUMA also cooperates with the International Finance Corporation (IFC), a member of the World Bank Group, to offer a lower financing rate for suppliers with a high CSR score. Motivated by the aforementioned practices, our research explores whether and how the buying companies should use financing and cost-sharing together to promote the CSR performance of suppliers. The existing literature in supply chain management has mainly considered situations where only one of these two mechanisms is viable. Early studies (such as [2, 3, 4]) show that CS contracts can coordinate supply chains engaged in CSR efforts and improve the supply chain performance, but none of

these early investigations integrate financing issues. This contrasts a lot with the observation that most upstream suppliers are SMEs located in developing countries and need financial supports for entering such CSR practices. The literature logically introduces and explores some BF and RF solutions to mitigate the aforementioned concern. Under BF, the retailer can get some direct financing from banks to pay the suppliers early [5]. By contrast, under RF, the retailer, the supplier and a factor enter a contract that can help the supplier receive early payments from the factor [6]. Most of investigations in this stream of research focus on the influence on BF and RF on the operational and financing decisions (see respectively [5, 7] and [8, 9, 10]).

In this study we explore the joint impact of financing and cost-sharing on the CSR performance and efficiency of a supply chain. Intuitively, under BF, we can expect that a CS contract granted by the retailer, financed by cash and coupled with a bank loan to early pay the supplier, raises the financial burden of the retailer. Indeed, the cash provided by the retailer to the supplier for sharing the CSR investment directly impacts the loan amount to borrow and indirectly the loan interest rate charged by the bank. This means that, *ceteris paribus*, the retailer's final benefits decrease. By contrast, under RF, the level of cost-sharing has no impact on the financial burden for the retailer, because RF simply engages invoices. Given these potential interactive effects, understanding how to combine cost-sharing and financing so as to improve the profitability of the supply chain and the performance of the CSR effort is important for both the supplier and the retailer. Our research addresses specifically the three following questions. (1) Given a financing mechanism, is it beneficial for the buyer to offer a CSR CS contract to the supplier? (2) Does the financing affect the effectiveness of the CS contract in order to boost the supplier's CSR effort? (3) What is the effect of cost-sharing on the preferences of each supply chain member with regards to the financing?

The rest of the paper is organized as follows: Section 2 describes the model framework, assumptions and notations. Section 3 investigates the combination of CSR cost sharing with each financing mechanism BF or RF. Some numerical results and managerial observations will be presented in Section 4. Finally, we conclude the paper with some remarks and perspectives.

## 2 Model description

Consider a supply chain with one upstream supplier "S", referred as "he" and one downstream retailer "R", referred as "she". S produces and delivers a single type of finished product to R. R then sells these products to some final consumers during a single selling season at a known (unit) retail price  $p$ . R and S have some initial levels of capital denoted by  $k^R$  and  $k^S$  respectively. The CSR-dependent random demand  $\tilde{D}$  is well described by  $\tilde{D}(\theta) = \tilde{D}_0 + \beta\theta$  where  $\beta$  is the marginal effect on the demand of any additional CSR effort  $\theta$  undertaken by S, and  $\tilde{D}_0$  is the random demand in absence of any CSR effort. To encourage S to undertake CSR activities, R announces her willingness

to co-finance any CSR investment<sup>1</sup>. The CSR investment cost is variable and increases with the CSR effort nonlinearly; it is formally equal to  $d\theta^2$  where  $\theta$  stands for the level of S's CSR efforts and  $d$  is a positive parameter. The proportion of the CSR investment cost shared by R is denoted by  $\lambda$  a parameter such that  $0 \leq \lambda < 1$ . The setting of the parameter  $\lambda$  occurs after the nature of the CSR activities is revealed by S but before he announces his effort. Consequently, the parameter  $\lambda$  can influence  $\theta$  the associated level of effort chosen by S and this latter is better denoted by  $\theta(\lambda)$ . Similarly, the decisions to invest in CSR and to share CSR investment costs are taken *before* the retailer placed an order from the supplier, so that both decisions should influence the following ordering of R and the R's order quantity is better denoted by  $q(\lambda, \theta(\lambda))$ . Three important remarks deserve to be made. First of all, we assume, without loss of generality, that all unmet demand is lost and the salvage value of products is zero. Secondly, regarding the cost sharing, we investigate two different ways to set the parameter  $\lambda$ . The first approach leads to a R-led CS contract, where R determines and sovereignly proclaims the level of her contribution  $\lambda$  alone (that is on the sole basis of her profit function  $\pi_i^R$ ). The second approach leads to a negotiated CS contract where S and R bargain on the parameter  $\lambda$ . The design of this latter bargaining then follows the line exposed in [11] and the optimal sharing ratio is determined by maximizing  $\pi_i^B = \pi_i^R \times \pi_i^S$ , the product of individual profits of parties under strategy  $i$ , respectively denoted by  $\pi_i^R$  and  $\pi_i^S$ . Thirdly, regarding the decision-making process, one will assume that both S and R can internalize the steps ahead and that the objective function to consider in the different decision-making processes is designed backward. For instance, if R chooses her contribution alone, then she maximizes  $\pi_i^R(\lambda, \theta_S^*(\lambda), q_R^*(\lambda, \theta_S^*(\lambda)))$  where  $\theta_S^*(\lambda)$  results from the optimization of the CSR effort undertaken by S and where  $q_R^*(\lambda, \theta_S^*(\lambda))$  results from the optimization of the order quantity undertaken by R. In other words, the backward sequential decision-making approach allows the parties to internalize the subsequent decisions and to choose the optimal parameters. We thus employ a standard backward induction approach to derive the equilibrium strategies for players.

**Table 1. List of notations**

$\theta$	CSR effort level	$k^R$	Initial capital of R
$q$	Ordered quantity of products	$k^S$	Initial capital of S
$r^R$	Interest rates of the loan granted by the bank to R	$r^S$	Interest rates of the loan granted by the bank to S
$\gamma_R$	RF Discount	$d$	CSR investment parameter
$\lambda$	Cost sharing ratio	$\tilde{D}_0$	Random demand without CSR
$v$	Proportion of invoice financed by RF	$\beta$	Marginal effect of the CSR effort on demand
$p$	Sale price	$cs$	Credit spread
$w$	Wholesale price	$r_f$	Risk-free interest rates
$\eta$	Price discount granted by S to R	$\Delta t_p$	The production delay

<sup>1</sup> Most cost-sharing contracts mentioned in the literature take the form of a financing that is granted by the retailer and that the supplier must reimburse later. Consequently, the commonly investigated CS contract does not improve the financial situation of the supplier/that much.

### 3 Financing Mechanisms and CSR Cost-sharing

#### 3.1 The Competitive Interest Rate

We assume that to finance the buying of products, R contracts a credit to borrow an amount  $L$  at the reference credit spread  $cs$ . Then, following Kouvelis and Zhao [12], the competitive interest rate  $r^R$  must satisfy

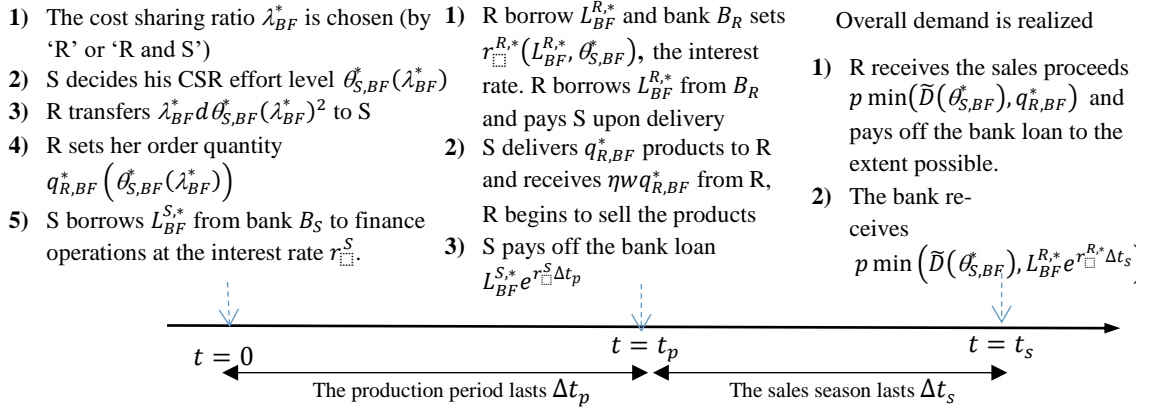
$$Le^{(r_f+cs)\Delta t_s} = E[\min(\text{rec}(\tilde{D}), Le^{r^R \Delta t_s})] \quad (1)$$

where  $\text{rec}(\tilde{D})$  is the demand-dependent recovery the lender can expect in case of default. As an example, consider a bank loan whose recovery is the retailer's revenue, the bank's competitive interest rate then is implicitly determined by Eq. (2)

$$Le^{(r_f+cs)\Delta t_s} = E[\min(p\tilde{D}, Le^{r^R \Delta t_s})] \quad (2)$$

#### 3.2 CSR Cost-sharing under Bank Financing (CS-BF)

The sequence of events and decisions in the CS-BF is illustrated in Fig. 1.



**Fig. 1.** The sequence of events and decisions in the CS-BF

The expected profit (hereafter, profit for short) of S at the end of sales season can be formulated as

$$\pi_{BF}^S = (\eta w q_{R,BF} - (c q_{R,BF} + (1 - \lambda_{BF}) d \theta_{S,BF}^2 - k^S) e^{r^S \Delta t_p}) e^{r_f \Delta t_s} - k^S e^{r_f t_s} \quad (3)$$

and the profit of R at the end of sales season is

$$\pi_{BF}^R = E \left[ \max \left( p \min(\tilde{D}, q_{R,BF}) - L_{BF}^R e^{r^R \Delta t_s}; 0 \right) \right] - k^R e^{r_f t_s} \quad (4)$$

where  $L_{BF}^R = \eta w q_{R,BF} - (k^R - \lambda_{BF} d \theta_{S,BF}^2) e^{r_f \Delta t_p}$ , and by virtue of the competitive interest rate charged by the bank, the profit of R becomes

$$\pi_{BF}^R = E \left[ p \min(\tilde{D}, q_{R,BF}) \right] - L_{BF}^R e^{(r_f+cs)\Delta t_s} - k^R e^{r_f t_s} \quad (5)$$

### 3.3 CSR Cost-sharing under Reverse Factoring (CS-RF)

The sequence of events and decisions in the CS-RF is depicted in Fig. 2. Given a credit spread  $cs$ , the proportion  $v$  of invoice financed by RF and by virtue of the Eq. (2), the RF discount  $\gamma_R$  satisfies

$$\gamma_R v w q e^{(r_f+cs)\Delta t_s} = E[\min(p\tilde{D}, wq_{R,RF})] - E[\min(p\tilde{D}, (1-v)wq_{R,RF})] \quad (6)$$

The profit functions of S and R can be formulated as

$$\pi_{RF}^S = E[\min(p\tilde{D}, (1-v)wq_{R,RF})] + (\gamma_R v w q_{R,RF} - L^S e^{r^S \Delta t_p}) e^{r_f \Delta t_s} - k^S e^{r_f t_s} \quad (7)$$

where  $L^S = cq_{R,RF} + (1 - \lambda_{RF})d\theta_{S,RF}^2 - k^S$ .

$$\pi_{RF}^R = E[p \min(\tilde{D}, q_{R,RF})] - E[\min(p\tilde{D}, wq_{R,RF})] - \lambda_{RF} d\theta_{S,RF}^2 e^{r_f t_s} \quad (8)$$

From (7), both S and the factor can understand that  $\partial \pi_{RF}^S / \partial v < 0$  and this in turn implies that (if S is free to choose  $v$ ) S will choose  $v$  to be as low as possible, namely  $v =$

$$v_{min} = \frac{L^S e^{r^S \Delta t_p}}{\gamma_R w q_{R,RF}}, \text{ and the resulting profit function of S is equal to}$$

$$\pi_{RF}^S = E[\min(p\tilde{D}, wq_{R,RF})] - L^S e^{r^S \Delta t_p} e^{(r_f+cs)\Delta t_s} - k^S e^{r_f t_s} \quad (9)$$

and no longer depends on  $v$  or  $\gamma_R$ . Consequently, when S maximizes his profit the solution will not depend directly on the RF conditions.

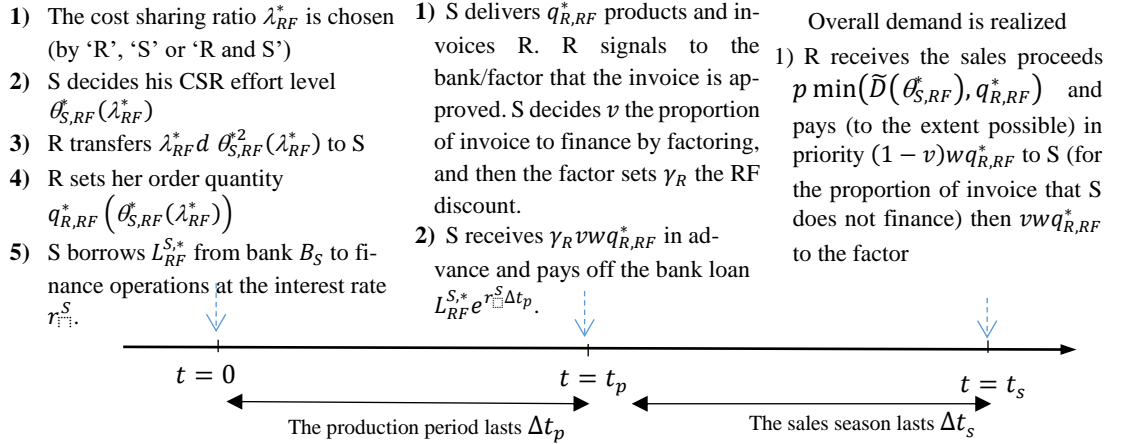


Fig. 2. The sequence of events and decisions in the CS-RF

## 4 Numerical Study and Managerial Observations

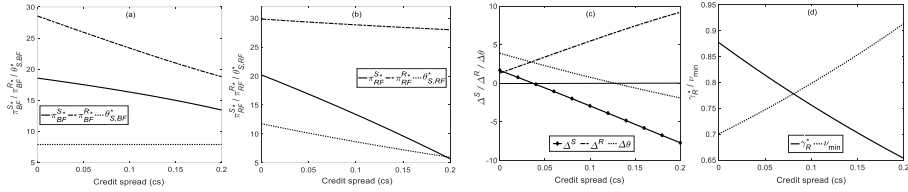
### 4.1 The parameter setting

We denote  $\pi_i^{k*}$  as the equilibrium profit of the entity  $k$  under strategy  $i$ . Here,  $k \in \{S, R\}$  represent S and R respectively, and  $i \in \{BF, RF, CS^RBF, CS^B BF, CS^R RF, CS^B RF\}$  represent for the strategies of BF, RF, BF with R-led CS contract, BF with bargaining CS contract, RF with R-led CS contract, and RF with bargaining CS contract, respectively. We explore the differences  $\Delta^k = \pi_{RF}^{k*} - \pi_{BF}^{k*}$  to quantify the value of RF to the entity  $k$  when the supply chain shifts from BF to RF. Similarly,  $\Delta\theta = \theta_{S,RF}^* - \theta_{S,BF}^*$  informs on

the difference of CSR effort between RF and BF. We consider a normal distribution, namely  $\tilde{D} \sim N(\mu, \sigma)$ , for modelling the market demand uncertainty without CSR investment due to the advantage in describing separately the mean and variance. The following base case parameters are:  $\mu = 100$ ,  $\sigma = 50$ ,  $p = 1$ ,  $w = 0.6$ ,  $c = 0.3$ ,  $\eta = 0.9$ ,  $\beta = 1$ ,  $d = 0.01$ ,  $k^S = 0$ ,  $cs = 0.05$ ,  $R_f = 2\%$  ( $r_f = 1.98\%$ ),  $\Delta t_p = 1$ ,  $\Delta t_s = 1.5$ ,  $R^S = 18\%$  ( $r^S = 16.55\%$ ) and  $k^R = 20$ .

## 4.2 The supply chain performance without a CS Contract

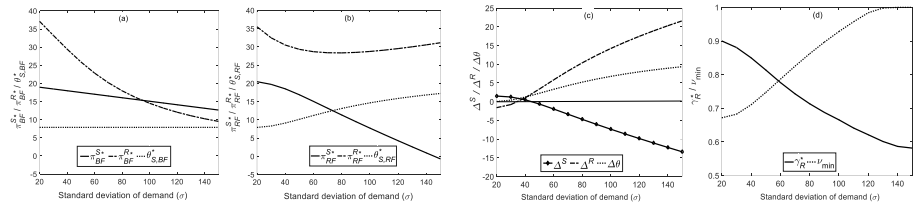
### a. Impact of Credit Spread



**Fig. 3.** Impact of the credit spread

The effects of the credit spread ( $cs$ ) on the equilibrium CSR effort and the profits of S and R are shown in Fig. 3. This figure shows that there exists a certain  $cs$  threshold (around 13% in our setting) beyond which the CSR effort under RF is lower than that under BF. Panel (c) of Fig. 3 shows that R has a clear incentive to promote RF instead of BF, especially when  $cs$  increases. We can observe that both R and S agree to adopt RF for small values of  $cs$  only. There exists a  $cs$  threshold (around 4%) beyond which S would favor BF and this of course contrasts with the opinion of R. The bottom line of this numerical illustration is that when  $cs$  is below 4%, the adoption of RF is profitable for S and R, and it enhances the CSR effort. Finally, panel (d) shows that  $cs$  impacts almost linearly both  $v_{min}$  and  $\gamma_R$  but positively for  $v_{min}$  and negatively for  $\gamma_R$ . The effect highlighted in panel (d) finally suggests a sort of compensation between both parameters (even if  $\gamma_R \times v_{min}$  is not exactly a constant). Consequently, we can conclude from this approximate compensation that S cannot (under RF) instrumentalize the proportion of invoice to mitigate the rise of  $cs$  that is the rise of the financing cost.

### b. Impact of demand variability



**Fig. 4.** Impact of the demand variability

The effects of the demand variability (measured by the variance or the standard deviation) on the equilibrium CSR effort and the profits of S and R are shown in Fig. 4. Panel(a) shows that the demand variability does not influence the CSR effort under BF. In contrast, the CSR effort under RF increases and is highly sensitive to demand



variability (see Panel(b)). This suggests that RF incites S to invest more in CSR effort when the demand variability is high. Panel (c) shows different signs for  $\Delta^S$  and  $\Delta^R$  in many instances suggesting that the preferences of parties are irreconcilable. The adoption of RF will bring relatively more benefit for R when the variation of the market demand is high and the reverse holds for S. Panel (d) shows that the RF discount  $\gamma_R$  and the proportion of invoice  $v_{min}$  vary significantly and nonlinearly with the demand variability.

### 4.3 The SC Performance with CS Contract

#### 4.3.1. The feasibility of CS contract

Table 2 shows the equilibrium under RF and BF with R-led cost sharing contract with different values of demand variance. It can be seen that the optimal cost sharing ratios under BF and RF are higher than zero, meaning that the feasibility of a cost sharing contract does not depend on the financing choice. However, we find that the optimal cost sharing under BF does not depend on the demand variance, whereas, the optimal cost sharing under RF decreases with the demand variance. Hence, a higher demand variance discourages R to grant a CS contract to S under RF.

**Table 2. Equilibrium under RF and BF with R-led cost sharing contract**

$\sigma$	BF					RF				
	$\lambda_{BF}^*$	$q_{R,BF}^*$	$\theta_{S,BF}^*$	$\pi_{BF}^{S*}$	$\pi_{BF}^{R*}$	$\lambda_{RF}^*$	$q_{R,RF}^*$	$\theta_{S,RF}^*$	$\pi_{RF}^{S*}$	$\pi_{RF}^{R*}$
20	0.64	116.57	21.62	20.27	39.24	0.64	116.57	22.62	20.27	39.24
30	0.64	114.05	21.62	19.78	35.38	0.63	116.49	22.21	19.99	34.47
40	0.64	111.52	21.62	19.30	31.59	0.59	117.29	21.19	19.99	32.00
50	0.64	109.00	21.62	18.81	28.07	0.52	120.38	20.25	18.28	30.38
60	0.64	106.48	21.62	18.33	24.97	0.45	125.22	19.52	16.35	29.40
70	0.64	103.95	21.62	17.85	22.33	0.38	131.28	18.99	14.34	28.88
80	0.64	101.43	21.62	17.36	20.10	0.31	138.18	18.61	12.34	28.67
90	0.64	98.91	21.62	16.88	18.23	0.26	145.66	18.32	10.36	28.69
100	0.64	96.38	21.62	16.40	16.66	0.20	153.57	18.13	8.44	28.87
110	0.64	93.86	21.62	15.91	15.32	0.16	161.79	17.98	6.56	29.18
120	0.64	91.34	21.62	15.43	14.19	0.12	170.23	17.87	4.72	29.57
130	0.64	88.81	21.62	14.95	13.22	0.08	178.85	17.78	2.91	30.04
140	0.64	86.29	21.62	14.46	12.39	0.05	187.61	17.71	1.13	30.57
150	0.64	83.77	21.62	13.98	11.67	0.03	196.48	17.66	-0.61	31.14

#### 4.3.2. Joint impact of bargaining and financing choice on the performance of cost sharing contract

OBSERVATION 1. The equilibrium CSR effort satisfies the following order:  $\theta_{CS^B RF}^* > \theta_{CS^R RF}^* \geq \theta_{RF}^*$ ;  $\theta_{CS^B BF}^* > \theta_{CS^R BF}^* \geq \theta_{BF}^*$ .

Observation 1 demonstrates the impact of the CS contract and the bargaining during the cost-sharing on CSR effort. It shows that under both BF and RF the CSR effort is

highest in the bargaining CS contract, followed by an R-led CS contract, and lowest for the case without cost-sharing agreement. Thus, the CS contract can effectively enhance the CSR effort. In addition, the bargaining CS contract can make the CSR effort even higher than that under an R-led CS contract. Therefore, negotiations during cost-sharing are necessary for promoting CSR investment in the chain.

**OBSERVATION 2.** The equilibrium values of profits satisfy the following relationship

$$(i) \quad \pi_{CS^{R}RF}^{R*} > \pi_{CS^{B}RF}^{R*} > \pi_{RF}^{R*}; \pi_{CS^{R}BF}^{R*} > \pi_{CS^{B}BF}^{R*} > \pi_{BF}^{R*},$$

$$(ii) \quad \pi_{CS^{B}RF}^{S*} > \pi_{CS^{R}RF}^{S*} > \pi_{RF}^{S*}; \pi_{CS^{B}BF}^{S*} > \pi_{CS^{R}BF}^{S*} > \pi_{BF}^{S*}.$$

Observation 2 (i) reveals that under both BF and RF the R profit is highest in the bargaining CS contract, followed by the R-led CS contract, and lowest for the case without a cost-sharing agreement. In Observation 2 (ii) the S profit is highest in the bargaining CS contract, followed by the R-led CS contract, while it is the lowest in the case without a cost-sharing agreement. Overall, Observation 2 shows that no matter which financing mechanism is applied, the CS contract results in higher profits for all partners in the chain and subsequently increases the overall profitability of the supply chain. Regarding the impact of bargaining on the performance of CS contracts, Observation 2 implies that R may be unwilling to negotiate a cost-sharing parameter as it results in lower profits than the case where R determines the cost-sharing parameter. In contrast, bargaining on the CS benefits S as it leads to higher profit for S.

## 5 Concluding Remarks

In this study, we consider the two financing mechanisms of BF and RF, and a CSR cost-sharing contract for a capital-constrained supply chain where a downstream retailer's sales are influenced by the upstream supplier's CSR effort. Based on the equilibrium analysis, we find that no matter which financing mechanism of RF and BF is applied, a CS contract always results in higher supplier's CSR effort and higher profits for all supply chain members when compared with the case without a CS contract. This finding corroborates with the literature [2, 3]. However, our numerical results contribute to the extant literature by revealing that the effectiveness of the CS contract does not depend on the characteristics of the supply chain such as wholesale price, capital constraint, and demand variability. Our study also suggests that the performance of the CSR effort and the profitability of all members of the supply chain really depend on the financing mechanism they choose. In most situations, a RF tailored to meet the supplier's best interests appears the best way to achieve these double goals. Combining these financing mechanisms with a (sharing) coordination between members will always ensure a higher engagement, a larger gain as well as a more sustainable support of the CSR development by the supply chain. Therefore, our findings confirm the increasing propensity of using RF to support CSR goals of many big companies like PUMA, Hewlett-Packard Company, etc. with their suppliers. Finally, our work serves as an initial step for future work in designing mechanisms to improve CSR performance and efficiency of the supply chain, based on a combination of financing and sharing mechanisms. Pursuing the efforts to integrate supply chain finance and supply chain coordination should be a fertile direction for future research

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