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Financial assistance in a capital-constrained cellphone supply chain

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Abstract. In the cellphone industry, some manufacturers may face the problem of insufficient funds in the production process and some retailers can return unsold phones to the manufacturer at a repurchase price. Hence, in this article, we aim to investigate the supply chain operation and financing strategy under a buyback policy in the product lifecycle management of the cellphone. In this supply chain, the manufacturer can obtain money from two sources, one is the downstream retailer's advance payments, the other is the loans from a third-party financial institution. Through modeling, the optimal strategy of the supply chain is determined, and the influence of the deviation between repurchase price and residual value on the optimal strategy of the supply chain is analyzed. The results show that the deviation between the repurchase price and the residual value of the unsold cellphone has an impact on the manufacturer's decisions, and the repurchase price has an impact on the financing equilibrium. Finally, the numerical analysis verifies the results.

Keywords: Supply Chain Management, Capital Constraints, Supply Chain Financing, Residual Value, Buyback Policy

1 Introduction

Many cellphone enterprises are faced with capital constraints when they make decisions such as purchasing or production and cannot make optimal decisions because of the lack of money. Therefore, they choose financing to meet the needs of business development and enhance the profitability of enterprises. Some enterprises, especially small and medium-sized enterprises (SMEs), often fail to apply for bank loans due to their mortgage assets and the lack of guarantees, which not only affects their development but also affects other enterprises in the supply chain [1, 2]. In the supply chain, if upstream manufacturers face a shortage of money, it will lead to supply disruptions or shortages for downstream enterprises. To address this problem, supply chain finance (SCF) has emerged, which uses the high-quality credit resources of the core enterprises in the supply chain to help SMEs obtain money [3]. In the past few years, SCF services have been widely adopted worldwide. How to use effective financing strategies and solve the problem of capital constraints of manufacturers is important in cellphone research.

Further, cellphone manufacturers introduce new products quickly, resulting in a short product life cycle. Due to the rapid change of client tastes and the existence of many unobservable factors, demand is random. If the retailer orders more than the actual market demand, at the end of the selling season there will be unsold stock with residual value, and the retailers can clear excess via the residual value [4]. In this article, we investigate cases where residual values are handled by the manufacturer. We consider a buyback contract, also known as a return contract, which is an agreement at the end of the sale period for the manufacturer to repurchase any unsold inventory from the retailer at a certain price. This contract is common in perishable goods supply chains, which was first proposed by Pasternack [5]. Under the return contract, the risk of uncertain market demand can be shared by the manufacturer and the retailer.

Therefore, this paper studies two kinds of financing instruments, one is an external financing instrument: return support buyer-backed purchase order financing (RSBPOF), and the other is an internal financing instrument: return support advance payment discount (RSAPD) to ease the financial constraints of the manufacturer. RSAPD is a form of cash in advance, to alleviate the financial stress before product delivery. If the retailer is willing to pay in advance, the manufacturer will offer a unit discount on the wholesale price. By paying for products in advance, the downstream enterprise can help the manufacturer produce smoothly or motivate the manufacturer to prepare more inventory to cope with the uncertain market demand in the future. On the other hand, by providing financing loans, downstream buyers can build closer partnerships with key manufacturers. RSBPOF means that a financial institution provides loans according to a reliable buyer purchase order before product delivery. There is no literature on how to solve the problem of supply chain working capital constraints through RSAPD and RSBPOF. Hence, with these two financing ways, our research objective is to investigate the optimal decisions in the cellphone supply chain under some conditions, and our main results are in three aspects: 1) the manufacturer's capacity level and expected profit are affected by the deviation between repurchase price and residual value. The smaller the gap, the higher the capacity level, and the higher the manufacturer's profit. 2) in RSAPD, with a higher deviation, the manufacturer should offer a lower discount rate to the buyer, thus reducing the financing cost and risk.

The rest of this research begins with the literature review in Section 2. Two models with RSAPD and RSBPOF are built in Section 3. Section 4 analyzes the financing equilibrium. Numerical experiments are carried out in Section 5 and Section 6 summarizes and concludes the paper.

2 Literature Review

Two literature streams are relevant to the research: SCF and the study on the buyback contract.

Firstly, the closest thing to our work is SCF research. For a long time, operating management and corporate finance research respectively in different directions. The

studies of operating management have tended to ignore the corporate usability problem, and the corporate finance research often neglects the operational problems of the enterprise. Few scholars take operations management and financing at the same time into consideration. Joint operational and financial strategies could be used to deal with the enterprise's budget constraints. Recently, there has been a growing emphasis on various financing ways. According to Petersen and Rajan [6], trade credit is the most popular short-term financing for American companies. Trade credit is also widely used in economies with underdeveloped financial markets or weak bank-enterprise relationships [7]. Cai, Chen [8] investigated the relationship between trade credit and bank financing when a retailer faces both budget constraint and demand uncertainty. Zhong, Shu [9] proposed a supply chain network design model with trade credit to optimize system-wise location, transportation, inventory, and financing costs. Yang and Birge [10] theoretically and empirically showed that even when bank and supplier financing can be jointly used, supplier financing is still preferred to bank financing. Alan and Gaur [11] explored the role of inventory in bank financing and trade credit. Tanrisever, Cetinay [12] studied how reverse factoring creates value for each party in the supply chain. Lekkakos, Serrano [13] examined how the adoptions of reverse factoring and traditional factoring affect the inventory policy in a stochastic multi-period setting. Khan, Shaikh [14] presented the impact of early-payment financing on supply decisions for perishable goods and showed the demand depended on price and inventory. Qin, Han [15] investigated the importance of advance payment financing on carbon emission problems. Most SCF studies focus on retailers' capital constraints, with little discussion of upstream enterprises' capital constraints (e.g., [16-18]).

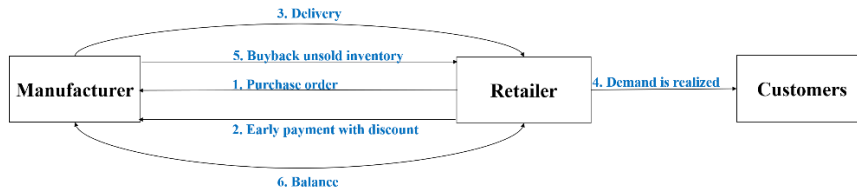
Further, a buyback contract, also known as a return contract, is an agreement at the end of the sale period for the manufacturer to repurchase any unsold product from the retailer at a certain price. The purpose of the return contract provided by the manufacturer is to stimulate the retailer to increase the order quantity and ultimately improve the revenue of himself and the supply chain. Under the return contract, the risk of uncertain market demand can be shared by the manufacturer and the retailer. This contract focuses on adjusting the return price, which is common in perishable goods supply chains, which was first proposed by Pasternack [5] to study sales pricing. The individual rational buyback contract was designed by Devangan, Amit [19] that can coordinate the supply chain when the retailer was faced with the demand related to inventory level. He and Zhao [20] found that the commonly used classic coordination contracts could not coordinate the supply chain, and showed that combining production cost subsidy, an advance-purchase discount contract, and a revenue-sharing contract can effectively coordinate the supply chain. Xue, Hu [21] studied the value of buyback contract by analyzing the supply chain of one manufacturer and two competing retailers and present the effects of uncertainty of demand, level of competition, and processing cost of the contract on the profits of the manufacturers, retailers and the supply chain. This paper is related to the studies on the return contract, however, different from the previous studies, the presence of the residual value is considered, and the effect of buyer return on the two financing ways when using return policy is studied.

3 Models

This study considers a newsvendor framework that a buyer places an order with a manufacturer before the sales period starts. The manufacturer then produces the finished product to meet the retailer's need, and the retailer receives these finished products from manufacturers, sells them to clients, and charges retail prices for each item. The buyer faces a stochastic market demand, and purchases from the manufacturer to meet the demand. The manufacturer provides a return policy for repurchasing unsold goods at the end of the sale period. This in turn stimulates the retailer to order more. In the model, the manufacturer is strapped for cash, and the retailer may run into financial difficulties in financing manufacturers. Without sufficient working capital, the retailer uses RSAPD or RSBPOF to obtain money.

Furthermore, D , $F(D)$, $f(D)$, $\bar{F}(D)$ and $h(D)$ are the uncertain demand, the cumulative distribution function, the probability density function, the complementary cumulative distribution function, and the hazard rate, respectively. Here, $\bar{F}(D) = 1 - F(D)$ and $h(D) = f(D) / \bar{F}(D)$. Let $H(D) = Dh(D)$ represents the generalized failure rate, and the generalized failure rate is shown as $h(D) = Df(D) / (1 - F(D))$. Fig. 1 shows the sequence of RSAPD and RSBPOF. The notations are presented in Table 1.

RSAPD



RSBPOF

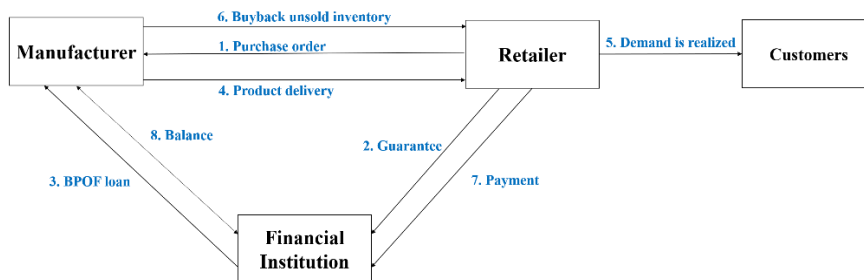


Fig. 1. The sequence of events in RSAPD and RSBPOF.

Table 1. Summary of notations.

Notation	Definition
Π_i	Expected profit
L_i	Short-term debt
A_i	Asset level
p	Selling price
α	Proportional distress cost
γ	Proportional liquidation cost
δ	A portion of financial institution's loss
c_p	Production cost
c_k	Capacity cost
i	Interest rate
s	Residual value
r	Repurchase price
q	Order quantity
K	Capacity level
w	Wholesale price
d	Discount rate
λ	A portion of purchase order value

3.1 RSAPD Model

In this case, only RSAPD is applied. It is important to notice that there exist unsold inventories, and the upstream manufacturer has the responsibility to repurchase the unsold goods at the repurchase price. In our study, the capital market is imperfect. That is, when the manufacturer fails to pay debts, the manufacturer can either be liquidated or be in an expensive restructuring process. In the case of liquidation, the cost of financial default is a proportion $1 - \gamma$ ($0 < \gamma < 1$) of firm value. In the case of reorganization, the cost of financial distress is a proportion $1 - \alpha$ ($0 < \alpha < 1$) of raised capital.

Therefore, the manufacturer's expected profit is

$$\begin{aligned} \pi_m^{bsapd} = & [w(1-d) - c_p]N^{bsapd} - c_k K - (r-s)[N^{bsapd} - D]^+ \\ & - (1-\alpha)[L_s - A_s + c_k K - w(1-d)q]^+ \end{aligned} \quad (1)$$

Here $N^{bsapd} = \min(q^{bsapd}, K^{bsapd})$. For liquidation, the optimal capacity $K^{bsapd*} = 0$. K^{bsapd*} under continuation (C), and K^{bsapd*} under reorganization (R) satisfy $[p - (p-r)F(K^{bsapd*})][1 - h(K^{bsapd*})] = [c_p + c_k + (r-s)F(K^{bsapd*})]/(1-d)$, and

$[p - (p-r)F(K^{bsapd*})][1 - h(K^{bsapd*})] = [c_p + (2-\alpha)c_k + (r-s)F(K^{bsapd*})]/(1-d)$, respectively:

Under RSAPD, the retailer's expected profit is

$$\pi_r^{bsapd} = pE \min[D, N] - w(1-d)N + r[N - D]^+$$

(2)

If RSAPD is enough to support the manufacturer's financial needs, the retailer's optimal order quantity q^{bsapd*} meets $(p-r)F(q^{bsapd*}) = p-(1-d)w$ in continuation and $(p-r)F(q^{bsapd*}) = p-(2-\alpha)(1-d)w$ in reorganization.

Proposition 1. In RSAPD financing, the deviation between r and s harms the profit of the manufacturer and the capacity level; Moreover, π_r^{bsapd} and q^{bsapd*} are increasing with the repurchase price.

Proposition 1 first proves that the manufacturer's expected profit and production capacity are affected by the deviation between the repurchase price and the residual value when the quantity transported exceeds the customer's demand. Under the return policy, the manufacturer is more inclined to pack fewer goods with high r - s to reduce losses. Besides, the retailer's expected profit and optimal order quantity are not related to the residual value of the unsold cellphones, but since the retailer returns the products and the residual value is not processed by the retailer, the retailer's expected profit and optimal order quantity are positively affected by the repurchase price.

Proposition 2. The discount rate d is decreasing with the deviation between r and s .

Proposition 2 indicates that in RSAPD, the larger the deviation between r and s , the smaller the discount rate provided by the manufacturer. In other words, the greater the deviation between the repurchase price and the residual value of the remaining cellphones, the higher the adverse degree to the manufacturer and the greater the risk that the manufacturer takes. Therefore, when return costs are high, the manufacturer should offer lower discount rates and thus lower financing costs.

3.2 RSAPD Model

In RSBPOF financing, the financial institution provides the manufacturer with a loan that is guaranteed from the downstream retailer. We can get the manufacturer's profit:

$$\begin{aligned} \pi_m^{bsbpo} &= (w-c_p)N^{bsbpo} - c_k K - (r-s)[N^{bsbpo} - D]^+ \\ &\quad - \lambda wqi - (1-\alpha)[L_s - A_s + c_k K - w(1-d)q]^+ \end{aligned}$$

(3)

Here $N^{bsbpo} = \min(q^{bsbpo}, K^{bsbpo})$. For liquidation, the manufacturer's optimal capacity $K^{bsbpo*} = 0$. Otherwise K^{bsbpo*} satisfies:

$$[p - (p-r)F(K^{bsbpo*})] = [c_p + c_k + (r-s)F(K^{bsbpo*})] / [1 - h(K^{bsbpo*})] \quad (C)$$

$$[p - (p-r)F(K^{bsbpo*})] = [c_p + (2-\alpha)c_k + (r-s)F(K^{bsbpo*})] / [1 - h(K^{bsbpo*})] \quad (R)$$

Further, the retailer's profit is:

$$\begin{aligned} \pi_r^{bsbpo} &= pE \min[D, N] - wN + r[N - D]^+ - \\ &\quad \int_{A_s}^{\frac{w}{\delta}} \left\{ \lambda wq - \gamma \left[(w-c_p)N - c_k K - (r-s)[N - D]^+ \right] \right\} \phi(A_s) dA_s \end{aligned} \quad (5)$$

The retailer's profit function is concave, and the optimal order quantity is $q^{bsbpo*} = F^{-1}\left(\frac{p-w}{p-r}\right)$.

Proposition 3. In RSAPD financing, both the profit of the manufacturer and the capacity level decrease with the deviation between the repurchase price and the residual value. The retailer's profit and order quantity are positively related to r .

Proposition 3 holds that the manufacturer's profit and capacity are affected by the repurchase price and residual value. If there is surplus inventory, a higher r -s would give the manufacturer an incentive to install less capacity, reducing expected profits. Therefore, the implementation of the return strategy will bring greater risk to the manufacturer. For the retailer, his order quantity and expected profit will be affected by the repurchase price, the higher the repurchase price will encourage the retailer to place more orders, to maximize his profit. It is worth noting that the retailer's order number and profit are not related to the residual value, but only positively related to the repurchase price because all unsold items are bought back by the manufacturer.

4 Financing Equilibrium

After analyzing the two financing methods separately, we will study the financing equilibrium problem under the single financing condition. We assume that if the retailer is unfamiliar with both types of financing, the retailer will prefer RSAPD.

Theorem 3. Under single financing, if the manufacturer's repurchase price is over a threshold μ_r such that RSBPOF is preferred. Here,

$$\mu_r @ \frac{p[EN^{bsapd*} - EN^{bsbpoF*}] + w[q^{bsbpoF*} - (1-d)q^{bsapd*}] + \int_{\Delta_s}^{\frac{\Delta_s}{\lambda}} \delta \left\{ \lambda w q^{bsbpoF*} - \gamma \left[\begin{array}{l} (w - c_p)q^{bsbpoF*} - c_k K^{bsbpoF*} \\ -(r-s)M^{bsbpoF} - \lambda w q^{bsbpoF*} i + A_s - L_s \end{array} \right] \right\} \phi(A_s) dA_s}{M^{bsbpoF} - M^{bsapd}}, \text{ where}$$

$$N^{bsbpoF} = \min(q^{bsbpoF}, K^{bsbpoF}), \quad N^{bsapd} = \min(q^{bsapd}, K^{bsapd}), \quad M^{bsbpoF} = (q^{bsbpoF*} - D)^+,$$

$$M^{bsapd} = (q^{bsapd*} - D)^+. \quad \text{Otherwise, RSAPD is preferred}$$

when $r \leq \mu_r$ since $\pi_r^{bsapd*} \geq \pi_r^{bsbpoF*}$.

Theorem 3 reveals that whether the manufacturer's repurchase price exceeds a certain threshold can determine the retailer's financing decision. The retailer is more likely to use RSBPOF than RSAPD when the manufacturer's repurchase price is extremely high and there is no financial difficulty. This is because high repurchase prices reduce the losses of the retailer and release the financing risks. Therefore, when the unique threshold is lower, the retailer has more incentive to fund the manufacturer with its money (RSAPD financing).

5 Numerical Analysis

In this section, the deviation between the repurchase price and the residual value is investigated on the decisions of the cellphone manufacturer through a numerical study. The benchmark parameter values include $p = \$600$, $\alpha = 0.85$, and $ck = cp = \$100$.

Demand is normally distributed, $N(1000,100)$. We allow $r-s$ to vary between 0 and 150.

We first investigate how the deviation between the repurchase price and the residual value affects the manufacturer's capacity level and discount rate under RSAPD and RSBPOF conditions. We show these effects in Fig.2 and Fig.3. Fig.2 first shows that the manufacturer's capability level is affected by $r-s$. Under the return policy, the manufacturer is more inclined to pack fewer goods with high $r-s$ to reduce losses. When $r-s$ is relatively small, the manufacturer's capacity level is larger. With the increase of $r-s$, the manufacturer's capacity level in RSBPOF decreases, which also makes the manufacturer's profit at a lower level. We can also see from Fig.2 that the deviation between the repurchase price and the residual value has a greater impact on RSBPOF, and the decline is more obvious, because the wholesale price of RSAPD is lower, and the manufacturer tends to prepare less capacity before shipment. Therefore, to maximize profits, the manufacturer prefers to borrow money by adopting RSBPOF.

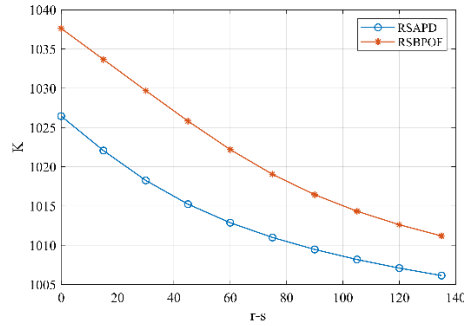


Fig. 2. Impact of $r-s$ on manufacturer's capacity level.

Fig. 3 shows that in RSAPD, the discount rate provided by the manufacturer decreases with the increase of the deviation between the repurchase price and the residual value. When $r-s$ is relatively small, the discount rate offered is high. And when $r-s$ goes up, the discount rate goes down. The higher the price deviation between r and s is, the more unfavorable it will be to the manufacturer. Therefore, in the face of higher return costs, the manufacturer should offer a lower discount rate.

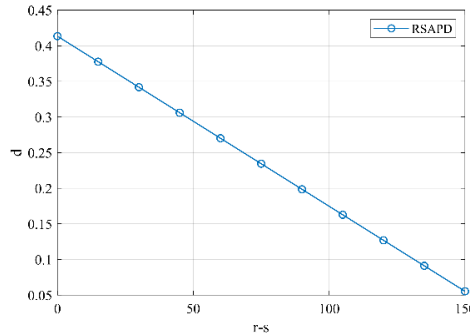


Fig. 3. Impact of $r-s$ on the discount rate.

6 Conclusion and Future Research

This study considers a capital-constrained supply chain with a cash-strapped manufacturer selling to an established retailer considering the existence of the residual value under the return policy. To address the financial distress in the product lifecycle management of the cellphone, the manufacturer can use financial institution loans (RSBPOF) and/or the retailer's early payment (RSAPD). In the study, the following research questions can be addressed: In the presence of the residual value, whether the deviation between the repurchase price and the residual value affect the participants' decisions in the supply chain? What is the financing equilibrium of RSAPD and RSBPOF? It is shown that the deviation between the repurchase price and residual value of unsold cellphones affects the manufacturer's capacity level under both RSAPD and RSBPOF and the discount rate under RSAPD. Furthermore, when the repurchase price is above a certain threshold, the only financing equilibrium is RSBPOF. Otherwise, RSAPD should be selected.

In the future, the research work can be divided into two parts, that is investigating other post-shipment financing instruments and exploring a variable residual value on the financing equilibrium in the supply chain.

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