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Alleviating supplier's capital restriction by two-order arrangement

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ABSTRACT

Consider a manufacturer that offers an advance payment to pre-order a quantity that must be satisfied by the production of a supplier before actual demand arises, and can order more after demand arises. We study the effectiveness of such two-order arrangement in alleviating the supplier's capital restriction on channel performance.

1. Introduction

In recent decades, globalization has offered companies great opportunities to lower cost by sourcing from external suppliers, by capitalizing on the differentials in labor and material costs among regions and countries. However, external suppliers, though having access to inexpensive resources, frequently encounter problems to secure capitals to afford production. For instance, Sharp Corp, Apple's key supplier for screens, scrambled to raise fund to afford its high production cost and partially took the blame for Apple's struggling to meet demand in 2012. On the other hand, as a CNet report reveals, major manufacturers are hoarding cash instead of investing in fixed assets. This makes it feasible for them to financially assist their capital-drained suppliers. But, under what circumstance, in what manner, and to what extent should manufacturers assist their suppliers?

To address these issues, we explicate a model in which a manufacturer sources from a capital constrained supplier and sells products in an uncertain market. The manufacturer offers an advance payment to pre-order from the supplier who has to satisfy at least its order commitment. All this occurs before demand reveals. After knowing the actual demand, the manufacturer can order more than its pre-order quantity, but its "excess" at-once order is subject to availability. The pre-order price differs from the regular price for the at-once order. Such two-order arrangement has been widely adopted in the electronics and automobile industries, and is permeating industries that have had long lead times. For instance, Crocs, Inc, in the footwear industry, pre-orders from suppliers who usually add 20–50% more to schedule production. With its responsive production model brought from Flextronics and optimized for molded shoes, Crocs can place an extra real-time order for components and assemble them into final products after knowing the realized worldwide demand.

We find that the two-order arrangement can insulate the system from the capital restriction at the supplier, either when the regular price is low or the pre-order discount is large enough so that the manufacturer can commit to a large quantity to take over inventory control, or when the capital shortage at the supplier is not too deep so that the manufacturer can finance it to afford the desired production. A lower pre-order price will benefit the manufacturer, and can earn the supplier a higher profit as well under certain circumstance. As the supplier's capital status improves, the manufacturer will always be better off, but the supplier itself may suffer a profit loss. We also show that, when both pre-order and regular prices are endogenously chosen, the effectiveness of the two-order arrangement to restore system inventory heavily depends on which party makes the wholesale pricing decisions.

Literature review

This paper contributes to the stream of literature in which the downstream firm can commit to inventory early (pre-order or advance order) before the upstream firm produces, and late (regular or at-once order) after actual demand reveals. [10] shows that the supply chain can achieve Pareto improvement if an early order opportunity is added into a push system. [11] shows that the upstream firm can use advance purchase as a strategic commitment to trigger the downstream firm to reveal private information. [3] demonstrates that an advance purchase discount can achieve channel coordination and allow arbitrary profit allocation. [5] explores the implication of two order chances on inventory

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ownership and decision right allocation. [4] analyzes a newsvendor that faces a capital constraint and can borrow from a bank to finance a larger quantity. [6] studies a supplier selling to a capital constrained retailer that borrows from a bank.

To study joint operational and financial decisions in a supply chain, [2] includes asset-based financing into production decisions, and studies its impacts on inventory management; [7] analyzes various contracting regimes from the supplier's perspective; [8] shows that adding a trade credit term in the traditional contract can attain channel coordination; [9] shows that coordination on stocking level and review period in a supply chain inventory system can be achieved by negotiation on credit term; [1] studies joint optimization of capacity investment and financial subsidy for the manufacturer to alleviate the suppliers' capital burden.

2. Model preliminaries

Consider a supplier providing a component to a manufacturer who produces and sells final products. Market demand Ξ is uncertain on a support of $[0, \infty)$, has CDF $F(\cdot)$, and PDF $f(\cdot)$. Assume $F(\cdot)$ satisfies the increasing failure rate (IFR) property, i.e., $h(\varepsilon) \equiv \frac{f(\varepsilon)}{1-F(\varepsilon)}$ increases in ε. The supplier has a capital position of B, produces at a marginal cost of c, and wholesales the components to the manufacturer at a price of w. We refer to w as the regular price. The final product is sold at a price of p, with $c \le w \le p$. The cost incurred by the manufacturer in processing and selling final products is scaled to zero. Holding and penalty costs are also assumed away to ease expressions. We follow the literature to assume that the manufacturer is aware of the supplier's financial status. This assumption is reasonable as firms typically exercise caution and enforce strict audit for financial matters. For instance, by GM's new contract, a supplier must provide, upon request, its latest income statement, balance sheet, cash-flow statement, etc. "*The new clause would help GM to monitor suppliers that might have trouble delivering parts because of a financial crisis*" (*Automotive News*, August 5, 2013).

The manufacturer engages in a two-order arrangement with the supplier. It offers an advance payment of D to pre-order a quantity of $\frac{D(1+r)}{w}$, where $\frac{w}{1+r}$ be the pre-order price and $r \in [0, \frac{w-c}{c}]$ is the discount factor. The supplier produces Q to at least satisfy its committed quantity ($Q \ge \frac{D(1+r)}{w}$), and can produce up to $\frac{D+B}{c}$ before demand uncertainty is resolved. After actual demand ε arises, the manufacturer orders $\mathrm{Min}\{\varepsilon, Q\}$ and pays $w\left(\mathrm{Min}\{\varepsilon, Q\} - \frac{D(1+r)}{w}\right)^+$ for its at-once order.

In the benchmark setting, the supplier has no capital concern, and the manufacturer orders only after knowing the actual demand. The expected profit of the supplier by producing Q is $\pi_S(Q) = -cQ + wS(Q)$, where $S(Q) = Q - \int_0^Q F(\varepsilon)\,d\varepsilon$ is the expected sales. It can be shown that the optimal production is $Q^0 = \bar{F}^{-1}\left(\frac{c}{w}\right)$, which we refer to as the *benchmark quantity*.

3. Two-order arrangement

Under the two-order arrangement, given an advance payment of D and a pre-order of $\frac{D(1+r)}{w}$ by the manufacturer, the supplier produces Q to maximize its expected profit of:

$$\pi_S(Q) = E\left\{D + w\left(\mathrm{Min}(\Xi, Q) - \frac{D(1+r)}{w}\right)^+ - cQ\right\}$$
$$= (w-c)Q - \int_{\frac{D(1+r)}{w}}^{Q} wF(\varepsilon)d\varepsilon - Dr,$$

subject to $\frac{D(1+r)}{w} \le Q \le \frac{D+B}{c}$. The optimal production can be expressed as:

$$Q^*(D) = \begin{cases} \dfrac{D(1+r)}{w} & D > \dfrac{w}{1+r}Q^0 \\ Q^0 & \left(cQ^0 - B\right)^+ \le D \le \dfrac{w}{1+r}Q^0 \\ \dfrac{D+B}{c} & 0 \le D < \left(cQ^0 - B\right)^+ \end{cases}, \quad (1)$$

at which the expected profit of the manufacturer is:

$$\pi_M(D) = pE\mathrm{Min}\left\{\Xi, Q^*(D)\right\} - wE\left[\mathrm{Min}\left\{\Xi, Q^*(D)\right\} - \frac{(1+r)D}{w}\right]^+ - D$$
$$= \begin{cases} \pi_M^{(1)}(D) \triangleq pS\left(\dfrac{D(1+r)}{w}\right) - D, \\ \quad D \ge \dfrac{w}{1+r}Q^0 \\ \pi_M^{(2)}(D) \triangleq (p-w)S(Q^0) - \displaystyle\int_0^{\frac{D(1+r)}{w}} wF(\varepsilon)\,d\varepsilon + Dr, \\ \quad \left(cQ^0 - B\right)^+ \le D < \dfrac{w}{1+r}Q^0 \\ \pi_M^{(3)}(D) \triangleq (p-w)S\left(\dfrac{D+B}{c}\right) - \displaystyle\int_0^{\frac{D(1+r)}{w}} wF(\varepsilon)\,d\varepsilon + Dr, \\ \quad 0 \le D < \left(cQ^0 - B\right)^+. \end{cases} \quad (2)$$

Note from (2) that the supplier's capital position, if sufficient to afford benchmark quantity ($B \ge cQ^0$), will enforce no restriction on decision making and hence system performance. In this situation, with a large advance payment of $D \ge \frac{w}{1+r}Q^0$, the supplier will produce to exactly match the pre-order quantity. The manufacturer thus takes over inventory control and earns a profit of $\pi_M^{(1)}(D)$, which decreases in D if $0 \le r < \frac{w^2}{pc} - 1$, but is maximized at $\frac{w}{1+r}Q^{(1)}(r)$, where $Q^{(1)}(r) \triangleq \bar{F}^{-1}\left(\frac{w}{p(1+r)}\right) \ge Q^0$ if $\frac{w^2}{pc} - 1 \le r \le \frac{w}{c} - 1$. With a low advance payment of $0 \le D < \frac{w}{1+r}Q^0$, the supplier will maintain benchmark production, and the manufacturer will earn a profit of $\pi_M^{(2)}(D)$, which is maximized at $\frac{w}{1+r}Q^{(2)}(r)$, where $Q^{(2)}(r) \triangleq \bar{F}^{-1}\left(\frac{1}{1+r}\right) \le Q^0$.

Proposition 1. *Suppose the supplier's capital position satisfies $B \ge cQ^0$.*
Let $w_0 \in (c, \sqrt{pc})$ satisfy that $pS\left(\bar{F}^{-1}\left(\frac{w_0}{p}\right)\right) - w_0\bar{F}^{-1}\left(\frac{w_0}{p}\right) - (p-w_0)S\left(Q^0\right) = 0$. Then:

(1) *When $c \le w \le w_0$, the optimal two-order arrangement is:*

Discount factor r	*Optimal advance payment D^**	*Supplier's production Q^**
$0 \le r \le \frac{w-c}{c}$	$\frac{wQ^{(1)}(r)}{1+r}$	$Q^{(1)}(r)$

(2) *When $w_0 < w \le p$, let $r_H(w) \in \left(0, \frac{w}{c} - 1\right)$ satisfy that:*

$$(p-w)S\left(Q^0\right) + \frac{w}{1+r_H}\left(r_H Q^{(2)}(r_H) + Q^{(1)}(r_H)\right) - w\int_0^{Q^{(2)}(r_H)} F(\varepsilon)d\varepsilon - pS\left(Q^{(1)}(r_H)\right) = 0.$$