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## Short-term financing in a cash-constrained supply chain

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### Abstract

In this paper we consider a two-level supply chain with a single retailer and a manufacturer, where both the firms are facing financial constraints and can not produce/order their optimal quantity. Our work shows that a lender who finances the manufacturer has a motivation to finance the retailer as well. Motivated by this, we investigate lender's problem of financing both the firms by making a joint decision on the loan amount and comparing it with the case when lender makes independent decision on loan amount for both the firms. Our numerical study indicates that if one of the firms in the supply chain has sufficiently low cash, joint decision (we refer to it as supply chain financing) may be better not only for the lender but for the retailer and manufacturer as well.

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### Introduction

Firms operating under cash constraints may not be able to order or produce optimally. Especially for fast-growing firms, money acts as a catalyst if potential demand is high but financial constraints leave them no choice but to order less. In this setting, implications for supply chain can be detrimental where lack of financial resources at one level can plague the performance of the whole supply chain, at least temporarily until restored.

While financing a firm, although a lender tries to perceive its exposure to default risk by looking into borrower's accounts, due to lack of proper information, the buying or selling capacities of preceding or following stakeholders, as in manufacturer and its retailer of supply chain remain unknown. Lender's analysis is then based on certain assumptions. This lack of information is a reality, especially for small firms that are not publicly listed.

To understand the gravity of cash-constraints for small-firms, readers are encouraged to refer to Archibald et al. (2002) who show that start-up firms find themselves in a predicament if they can't borrow, and a small amount of cash can give a steep rise to survival probabilities. In another study, during their survey in 23

judicial districts of United States, Sullivan et al. (1998) found that 28% of all business bankruptcies were due to financing reasons. These insights reflect the importance of proper financing schemes not only for the borrower but the lender as well. Under the bankruptcy of a firm, her lenders, customers and suppliers may have to bear significant losses.

This paper looks into supply chain financing from the lender's point of view. We try to investigate how the lender's profit is related to the cash position in the next level of the supply chain of the borrowers, is there any motivation for lender to finance in successive levels of the supply chain, and how important is it for the lender to know that two of her customers (borrowers) are linked in a supply chain?

We consider a simple two-stage supply chain consisting of a single manufacturer ( $M$ ) and a retailer ( $R$ ) under a single-period setting.  $M$  produces goods at a constant rate and ships it to  $R$  with zero lead time. Retailer ( $R$ ) is of the classical newsvendor type.  $R$  returns the defective quantity to  $M$  who is liable to compensate for it at the end of the period. For simplicity we assume that both the firms have no other assets but the cash available with them, before they commence their respective activities.

There is a single lender ( $L$ ) who is approached for a short-term loan by both the firms. Long term loans are not available as in Buzacott and Zhang (2004). In our setting borrowers  $M$  and  $R$  are small firms with no bargaining power. Our objective is to solve  $L$ 's problem to maximize her profit under certain meaningful constraints. We assume that all the three participants have an outside option of investing in a constant risk-free rate  $\alpha'$  per unit dollar per unit time. The sequence of events during the period is as follows:

1. At time zero  $M$  has an initial cash of  $x_m$ , a loan of  $w_m$  borrowed from  $L$  and no other assets or liabilities. He predicts  $R$ 's order quantity and commences the production of  $q_m$  units of product with a rate of  $1/k$  unit per unit of time. The cost is incurred at  $C_m$  per unit at the beginning of the period.
2. At time  $kq_m$ , the retailer ( $R$ ) with initial cash of  $x_r$  and no other assets or liabilities, receives a loan of  $w_r$  from  $L$ , places her order of  $q_r$  units with  $M$  and receives a quantity  $\min\{q_m, q_r\}$  upon immediate payment at a unit price of  $P_m$ . At this point of time only the probability distribution  $F(u) = \Pr(\xi \leq u)$  of future demand  $\xi$  is known,  $\overline{F}(u) = 1 - F(u)$  and  $f(u) = F'(u)$ . This distribution is common knowledge.  $M$  salvages unsold inventory at a price  $C'_m$  per unit in an external market where  $C'_m < C_m$ .  $M$  then repays the loan and interest (assumed to be simple interest) with a rate of  $\alpha_m$  per unit dollar per unit time to  $L$ . After the payment of loan,  $M$ 's cash is  $X_m(q_r, q_m)$ .
3. Over the period  $(kq_m, kq_m + T)$ ,  $R$  receives a demand of  $\xi$ . At the end of the period  $R$  earns cash with sale at a unit price of  $P_r$  and disposes the unsold inventory at a unit salvage price of  $C'_r$ , where  $C'_r < P_m$ . For simplicity, we assume that the defective quantity of product received by  $R$  is a linear function of  $q_r$  and is equal to  $q_r \lambda$ ,  $\lambda < 1$ . At the end of the period,  $M$  is liable to buy-back this defective quantity at a unit value of  $P_m$ . Then  $R$  repays the loan and interest (assumed to be simple interest) with interest rate  $\alpha_r$  per unit dollar per unit time to  $L$ . After payment of loan  $R$ 's cash is  $X_r(q_r, \xi)$ .

The organization of the paper is as follows. The next section reviews the related literature. Section 3 discusses lender's independent decisions on the amount of loans to manufacturer and retailer. Section 4 shows the lender's analysis for joint decision and total profits from independent and joint decision cases. Section 5 presents a numerical study. The last section is reserved for conclusions.

## Literature review

Some authors have considered financial issues in production. Lederer and Singhal (1994) study the capacity investment problem using an optimal mix of equity and debt in a multi-period setting. Li et al. (1997) model the production and financial decisions under demand uncertainty. Xu and Birge (2004) analyze the effect of taxes and financial distress costs on the firm's joint financing and operating decisions. Babich and Sobel (2004) consider capacity expansion and financial decisions to...

## Independent decision case

This section shows how lender ( $L$ ) can make the decision to finance manufacturer ( $M$ ) in an independent fashion. We show that  $L$  has a motivation to finance retailer ( $R$ ). Then we discuss  $L$ 's independent decision to finance  $R$ ...

## Joint decision and total expected profit

When  $L$  knows that  $M$  and  $R$  are linked in a supply chain she faces a joint decision problem which is discussed in this section. We assume that before financing any of these firms,  $L$  is approached by both the firms and that  $L$  knows  $R$ 's starting cash  $x_r$  by monitoring  $R$ 's accounts....

## Numerical study

Table 1 illustrates how joint decision profit and independent decision profit vary as initial cash positions  $x_r$  and  $x_m$  vary. For this example, the market demand distribution is exponential with mean 50,  $C_m = 1$ ,  $P_m = 1.5$ ,  $C'_m = 0.5$ ,  $\alpha_m = \alpha_r = 0.1$ ,  $\alpha' = 0.06$ ,  $P_r = 1.8$ ,  $C'_r = 0.9$ ,  $T = 1$ ,  $\lambda = 0.05$  and  $k = 0.1$ . As intuition would suggest, joint decision is better than independent decision when initial cash positions  $x_r$  and  $x_m$  of  $R$  and  $M$  respectively are low but when this is so difference in  $\Pi^I$  and  $\Pi^J$  is striking. Notice...

## Conclusions

In this paper we considered a cash-constrained supply chain of a manufacturer and a retailer. We showed that a lender who finances the manufacturer has a motivation to finance retailer as well. We characterized lender's decision problem in two ways, one where she makes an independent decision on the loan amounts to the two firms and the other where a joint decision is made. We performed a numerical study to understand the effects of joint decision on lender's profit by changing various...

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