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Finance sourcing in a supply chain

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ABSTRACT

We examine the relative merits of bank versus trade credit in a supply chain consisting of a manufacturer and a capital constrained retailer. We show that trade credit is more effective than bank credit in mitigating double marginalization when production costs are relatively low, and that bank credit becomes more effective otherwise. Under bank financing, with limited liability the retailer carries the same inventory as if it faces no capital constraint. Under trade financing, the manufacturer shares the risk of low demand with the retailer, prompting the latter to stock a higher inventory than under bank financing. This higher inventory level mitigates (aggravates) double marginalization when the production costs are relatively low (high). This article thus provides a new explanation for trade credit, and also guides the manufacturer's decision as to when to offer such credit.

1. Introduction

Trade credit, the credit that a seller extends to its buyer for the purchase of goods, is common in both developed economies such as the US and the other G7 countries (e.g., Petersen and Rajan [11], Rajan and Zingales [12]) and economies with less developed financial markets or weak bank–firm relationships (Biais and Gollier [1], Booth et al. [2]). In the current article, we provide a new explanation of the use of trade credit that suggests it may alleviate double marginalization in a supply chain more effectively than bank credit does.

Much attention has been paid to why the seller may extend trade credit even in the presence of specialized financial institutions such as banks. When buyers have private information about their heterogeneous payoff distribution, a lender wishes to be able to price discriminate among them, and Brennan et al. [3] and Smith [14] show that trade credit is a more effective screening device than bank credit. The information advantage theory argues that while the manufacturer gathers useful information about the buyer in the normal course of business, financial institutions must overcome additional barriers to obtain such information (e.g., Biais and Gollier [1], Burkart and Ellingsen [4], Emery [5], and Schwartz and Whitcomb [13]). If a buyer defaults, the manufacturer may have an advantage in salvaging the collateral (Mian and Smith [10]). When the manufacturer has private information about the quality of its product, trade credit may be used to signal product quality (Lee and Stowe [8], Long et al. [9]). Ferris [7] proposes that trade credit may help control the transaction costs between trading partners. In addition, Wilner [16] offers a relationship lending theory of trade credit. Petersen and Rajan [11] provide a more detailed discussion of some of these perspectives.

We develop a model of a supply chain consisting of one manufacturer and one retailer. The manufacturer has sufficient capital, but the retailer has zero working capital. Demand for the product in the end market is stochastic and is not realized until the end of the selling season. We assume that the product is a commodity and that its prior demand distribution is common knowledge. There also exists a market of specialized financial intermediaries such as banks. All players (the manufacturer, retailer, and banks) are risk neutral, and none of them receives further signals about demand prior to its realization. We thus examine a scenario in which no player possesses any informational advantage. Following the convention in the literature, we assume the bank market to be competitive so that a lending bank makes zero expected profits. The retailer can always borrow from a bank to finance its operations. In addition, the manufacturer may find it optimal to offer trade credit to the retailer. When trade credit is available, the retailer chooses between bank and trade credit to fund its inventory purchase.

At the beginning of the selling season, the manufacturer announces a wholesale price and acceptable payment schemes. Specifically, the manufacturer declares whether payment must be in cash or can be postponed until the end of the season. If the manufacturer allows payment to be postponed, it is essentially extending trade credit to the retailer. If the manufacturer accepts only up-front cash payment, then the retailer decides on an inventory level and borrows from a bank to finance the purchase. If delayed payment is allowed, then the retailer decides on an inventory level and chooses between bank or trade credit to finance the purchase. We assume that the product is a perishable so that at the end of the season any leftover units have zero salvage value. This means that unsold inventory

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cannot serve as collateral on a loan application. Clearly, the retailer's revenue is always stochastic, regardless of its source of financing. The manufacturer's revenue is also stochastic when it extends trade credit. At the end of the season, the retailer realizes its revenue and repays its creditor the smaller of its revenue or the loan (including interest). Note that by focusing on a supply chain with a single retailer, our model naturally excludes any price discrimination effect of trade credit.

In a supply chain context such as ours, it is well known that the total profits of the manufacturer and the retailer are below those in a centralized supply chain, where the same firm produces and sells directly to its end customers. Such a phenomenon is commonly referred to as double marginalization (Spengler [15]). Our central result is that both bank and trade credits have their comparative merits in ameliorating double marginalization in the supply chain. When the marginal production cost is sufficiently low (relative to market demand parameters), trade credit yields higher total profits in the supply chain than bank credit. In this case, trade credit helps mitigate double marginalization and then allows the manufacturer to make more profits. When the marginal production cost is relatively high, bank financing yields higher total profits in the supply chain than trade financing. In this case, bank credit better alleviates double marginalization and leads to higher profits for the manufacturer. The manufacturer thus will not issue trade credit.

The rationale behind our result is as follows. When the retailer finances with bank credit, it is the lending bank that bears the retailer's default risk if demand is low. Because the lending bank makes zero expected profits due to Bertrand competition, the capital-constrained retailer financing via bank credit behaves just like a self sufficient retailer facing no capital constraint. In particular, the capital constrained retailer will stock the same inventory as a retailer endowed with sufficient capital. In this sense, the retailer's limited liability does not play any active role under bank credit. In contrast, when the retailer finances with trade credit, the manufacturer bears the retailer's default risk. Because the manufacturer shares the risk of low demand, its limited liability prompts the retailer to stock a higher inventory than it does under bank credit. When the marginal production cost is low enough, this higher inventory level mitigates double marginalization, making the manufacturer strictly better off and the retailer equally well off relative to bank financing. Trade credit is thus the unique financing equilibrium. On the other hand, when the marginal production cost is sufficiently high, the higher inventory under trade credit aggravates double marginalization, and bank credit becomes the unique financing equilibrium.

Our paper is related to the work of Federgruen and Wang [6]. In an infinite horizon, they examine a supply chain consisting of a manufacturer and a capital constrained retailer and compare the performance of the supply chain under three alternative financing arrangements: inventory subsidy, trade credit, and independent financing (i.e., bank credit). They employ a more general demand distribution and solve the constrained game with a fixed wholesale price, but they do not solve the full game where the manufacturer chooses both wholesale price and the retailer's capital cost. They show that at any fixed wholesale price, both supply chain members are better off under trade credit than bank credit. In contrast, our model is more parsimonious: We consider a single period setting with a much simpler demand specification. We derive the supply chain equilibria with endogenous wholesale price under bank and trade credits. Our finding is that either form of credit may prevail in equilibrium under certain conditions.

The remainder of the article is organized as follows. Section 2 develops a model of a supply chain with a discrete demand distribution. Section 3 presents the centralized supply chain as a benchmark, derives the market equilibrium under bank and trade credit, respectively, and then characterizes the financing equilibrium in the supply chain. As Section 4 shows, the basic insight from the discrete model carries over to a model of continuous demand. Section 5 concludes.

2. Model

We examine a product market comprising one manufacturer and one retailer. The manufacturer does not sell directly to the end consumers. Instead, the good is sold by the retailer. Such a manufacturer–retailer relationship is commonly known as a supply chain. While the manufacturer has sufficient working capital, the retailer faces capital constraints. The retailer's capital endowment is normalized to zero without loss of generality. There also exists a market of financial intermediaries (banks, say). Clearly, for the product market to be viable the retailer must obtain either bank or trade credit. Following the convention in the trade credit literature (e.g., Brennan et al. [3], Burkart and Ellingsen [4]), we assume that the bank market is competitive and that banks have access to unlimited funds at a risk free interest rate r_f, which is normalized to zero (without loss of generality). A zero risk-free interest rate also confers the advantage of allowing us to ignore discounting. In many markets, there are multiple banks offering similar services. The assumption of a competitive bank market keeps the retailer's costs of using bank credit at a minimum. In our model, the supply of trade credit is monopolistic by nature. We wish to show that even with a competitive bank market, trade credit may have an advantage under certain conditions. All players in the model (i.e., the retailer, the manufacturer, and the banks) are risk neutral and maximize their respective expected profits.

Product demand in the retail market, D, is stochastic and not realized until the end of the selling season. To ease exposition, the prior demand distribution is assumed to be binary: $D=H$, with probability α ($0<\alpha<1$), and $D=L$ (where $0<L<H$), with the remaining probability, $1-\alpha$. The assumption of a binary demand distribution is relaxed in Section 4. The retail price is assumed to be fixed at 1. Neither member of the chain has fixed operating costs. The marginal production cost is constant at c, with $0<c<1$. Without loss of generality, we assume that the retailer incurs no other variable costs besides the wholesale price. The product is perishable, so any unsold units have zero salvage value by the end of the season. The retailer therefore cannot use leftover inventory as collateral for its loan.

The retailer has limited liability. If its revenue exceeds its loan, the retailer repays its loan fully. Otherwise, it repays its entire revenue and defaults on the remainder. We assume that borrowing is exclusive, in that the retailer may borrow from only one creditor.

The sequence of events is as follows. At the start of the season, the manufacturer announces a per unit wholesale price w and specifies whether full payment must be made upon purchase or can be made at the end of the season. Observing the wholesale price and the permitted payment options, the retailer chooses a financing scheme and a corresponding inventory level. If the manufacturer does not extend trade credit and accepts only cash payment, the retailer has to borrow from a bank to finance its inventory purchase. If the manufacturer accepts both cash payment and delayed payment, then the retailer chooses between bank and trade credit.

Let Q denote the retailer's inventory level and r the bank's interest rate to the retailer. If the retailer chooses bank credit, it borrows wQ dollars from a bank and pays this amount to the manufacturer to buy inventory. At the end of the season, it repays the lending bank the smaller of its revenue ($\min\{D,Q\}$) or the principal and interest ($w(1+r)Q$) of its loan. If the retailer chooses trade credit, it receives Q units of product at the start of the season and pays the manufacturer the smaller of its revenue ($\min\{D,Q\}$) or wQ at the end of the season. Clearly, the retailer will choose inventory Q such that $L\le Q\le H$ provided $w(1+r)\le 1$ under bank credit or $w\le 1$ under trade credit.

Finally, we make the following tie breaking rules. If the retailer is indifferent between two inventory levels, we assume that it chooses the higher inventory. If trade credit is available and the retailer is indifferent between bank and trade credit, we assume that it uses trade credit.