

Industry Structure and the Strategic Provision of Trade Credit by Upstream Firms

Alfred Lehar
University of Calgary*

Yang Song
University of Calgary

Lasheng Yuan
University of Calgary

February 2012

*Corresponding author, Haskayne School of Business, University of Calgary, 2500 University Drive NW, Calgary, Alberta, Canada T2N 1N4. e-mail: alfred.lehar@haskayne.ucalgary.ca, Tel: (403) 220 4567.

Industry Structure and the Strategic Provision of Trade Credit by Upstream Firms

Abstract

We explain trade credit financing as a strategic tool for a supplier to influence her retailer behavior in a product market, provide a new rationale for the existence as well as the contract structure of trade credit financing, and show why financially unconstrained firms occasionally finance their inventory with expensive trade credit. In our model competing supply chains deliver a homogeneous good to a market with imperfect competition where retailers have to make inventory decisions before demand is realized. When demand is weak trade credit financing makes the retailer more aggressive as he avoids having to finance unsold inventory at the high trade credit interest rate. The ex-ante expected cost of having to finance excess inventory at the high trade credit rate when demand is weak reduces retailers' optimal ex-ante inventory levels. When demand is high sales are constrained by inventory and competition is less intense. The modified product market behavior induced by trade credit financing increases the producer surplus at the expense of consumers in oligopoly markets, while we find no benefit for producers in either monopoly or perfect competition. We empirically confirm an inverse U-shape relationship of trade credit use and competition for a sample of U.S. firms.

Keywords: Trade Credit, Vendor Financing, Product Market Competition, Price Discrimination, Supply Chains

JEL-Classification Numbers: G31, G32, L11, L13

1 Introduction

Trade credit financing is one of the largest and most important short-term financing options in the United States and other countries. Cunat (2007) shows that trade credit accounts for 25 percent of total assets and 47 percent of total short term debt for a US representative firm.¹ Trade credit financing is also structured differently from straight debt as retailers borrow goods from their suppliers free of charge for a certain period of time. When consumer demand is high and all goods get sold, the retailer gets free inventory financing. Once the free financing period has expired, however, trade credit becomes a very expensive source of financing as suppliers charge very high effective interest rates.² In this paper, we complement the existing literature by offering a novel explanation why trade credit contracts are optimally structured with a very high interest rate following a period of free financing, why financially unconstrained firms occasionally finance their inventory with expensive trade credit, and why only suppliers but not banks can effectively offer trade credit financing.

We model an infinitely repeated game where, in each period, retailers in a downstream market, who sell homogeneous goods to consumers, face demand uncertainty when making their inventory decisions. When consumer demand is low retailers will not sell all of their inventory and finance any unsold goods for sale in the next period. Under trade credit financing retailers have to finance the excess inventory at the high penalty rate. By selling one more good the retailer can save on paying the high financing costs for the good, which effectively lowers the marginal cost of selling another unit, thus making the retailer sell goods more aggressively when demand is low.

The possibility of having to finance excess inventory at a high rate when demand is low also influences a retailer's ex-ante inventory decision. The retailer using trade credit financing will optimally adopt smaller inventory to save on expected financing costs relative to a retailer using straight debt. When demand is high, this reduced inventory in hand cannot meet the consumers'

¹Trade credit accounts for 17 percent of total assets and 50 percent of short debt for a representative UK firm.

²For example, the commonly found scheme of 2/10 net 30 means that the retailer has to pay 2% more if he pays within 30 days rather the first 10 days, which is equivalent to an annual interest rate of around 46%—a huge penalty for the delayed payment. See also Smith (1987) and Petersen and Rajan (1997). Ng, Smith, and Smith (1999) report that most firms in their survey claim to demand payment within 30 days. Examining actual trade credit contracts Klapper, Laeven, and Rajan (2011) document that payment terms are often much longer and that for 30% of the contracts in their sample the discount period ends exactly one day before the payment is due indicating that the discount is an incentive to pay on time.

demand and the retailers' sales are constrained by inventory. The shortage of supply makes the retailer less competitive and softens the competition in a good state.³

The distortions trade credit financing creates in the product market competition allow suppliers and retailers to extract rents from consumers. Trade credit financing serves as a collusion mechanism that increases total producer surplus and reduces welfare. We show that the increase in total producer surplus from trade credit financing relative to bank financing is highest in oligopoly markets and there is no benefit of trade credit financing under monopoly or perfect competition. Our model thus implies an inverse U-shaped relationship between the benefit of extending trade credit and the degree of competition.

Previous studies as well as our own empirical analysis confirm this inverse U-shaped relation between competition and trade credit use. Analyzing trade credit policy of Indonesian companies, Hyndman and Serio (2010) find an inverse U-shaped pattern exactly as predicted by our model with a very sharp increase in trade credit when moving from monopoly to duopoly. Our predicted positive relationship of trade credit use and competition in highly concentrated markets is consistent with the findings of Fisman and Raturi (2004), who examine supply chain relationships in five African countries and find that monopoly power is negatively associated with credit provision. Our predicted negative relationship of trade credit use and competition in more competitive markets is consistent with McMillan and Woodruff (1999), who find trade credit to decrease as competition intensifies for a sample of Vietnamese firms, and Giannetti, Burkart, and Ellingsen (2011), who find that sellers of differentiated goods, which are subject to less competition, carry higher receivables than producers of homogeneous goods.

In our own short empirical analysis, we confirm the inverse U-shaped pattern between competition and receivables for a sample of U.S. firms from Compustat. We measure competition as either the Herfindahl-Hirschman Index (HHI) based on each firm's share of total sales in Compustat or as the HHI reported by the U.S. Economic Census of Manufacturing. Using two alternative specifications, we empirically confirm the novel prediction of our model.

We contribute to the existing literature in three ways: first, we document a new channel through which alternative types of debt financing, trade credit and bank loans, influence retailers' behavior in a product market and how trade credit effectively allows suppliers to price discrim-

³This prediction of our model is consistent with the findings of Zettelmeyer, Morton, and Solva-Risso (2007) who find that car dealers earn scarcity rents when demand for cars is high.

inate to their retailers over different demand states by charging state contingent financing costs. Second, we offer a new explanation for the existence of trade credit under symmetric information, and in the absence of financial constraints, inability to access bank financing, default, or agency problems. The only friction we need is that retailers have to make their inventory decision before knowing consumer demand. Our model also provides an explanation on why the trade credit contract optimally differs from traditional debt, with a free financing period followed by a high interest rate, and why firms optimally pay the higher trade credit interest rate even though they would have access to cheaper sources of financing. Finally we show that trade credit use can benefit suppliers and retailers at the expense of consumers and thus yields to an inefficient outcome.⁴

Our paper builds on the literature that examines trade credit as a strategic tool for price discrimination following Brennan, Maksimovic, and Zechner (1988). In their model, a producer price-discriminates between consumer types. Low type consumers finance goods with expensive trade credit but default with a high probability on their debt, effectively making a low expected payment to the vendor. High type customers never default and prefer to pay cash to avoid the high interest rate, and thus pay an ex-ante higher price for the good. In our model, suppliers price discriminate under symmetric information over demand states. The price discrimination mechanism of trade credit in our model also requires no default.

Our paper is also tied into the literature on the interaction of financial structure and product market competition that builds on Brander and Lewis (1986). They show that debt financing makes firms with limited liability more aggressive in Cournot competition. While most of the work in this field examines how levels of debt change firms' behavior in imperfect competition, our paper analyzes how different types of debt affect firms' behavior in a strategic setting. Our approach also differs because we do not utilize default or conflicts between shareholders and

⁴Our paper adds to a large body of literature that explains the existence of trade credit in the presence of competitive banking system (see Petersen and Rajan (1997) for a survey). Previous studies point out that suppliers have a comparative advantage to control their retailers (suppliers can stop supplying goods to retailers, see Cunat (2007); it is easier for suppliers to re-possess collateral than banks, see Frank and Maksimovic (2005); it is costly for a retailer to find a new supplier, see Boyer and Gobert (2009), suppliers also have an informational advantage relative to outside financiers since it is less costly for suppliers monitor retailers' financial status (Jain (2001)). In addition, trade credit can mitigate a moral hazard problem on the side of retailers (Cunat (2007) and Burkart and Ellingsen (2004)), trade credit might also serve as a quality-guarantee mechanism for intermediate goods (Lee and Stowe (1993)), relaxes budget constraint due to the possibility of a postponed debt payment (Ferris (1981)), and help retailers overcome credit rationing problems if asymmetric information makes banks unwilling to lend to retailers (Biais and Gollier (1997)).

bondholders in our model.⁵

The rest of the paper is organized as follows: Section 2 sets up the model; Section 3 discusses how bank and trade credit financing affect a retailer's behavior in imperfect competition; Section 4 analyzes how the incentive of a supplier to offer trade credit varies with industry structure, Section 5 provides empirical evidence, and Section 6 concludes the paper. All proofs are in the Appendix.

2 The Model

We consider a three-stage infinite horizon game in which n supply chains, each consisting of one supplier selling to one retailer, that produce and sell a homogeneous, non depreciable good to consumers. Consumer demand is either high (good state) with probability q or low (bad state) with probability $1 - q$. The price in the product market is given by $P = A_s - Q$, where the intercept is state dependent and Q denotes aggregate quantity.

In stage 1, at the beginning of each period, each upstream supplier, given the financing scheme (bank financing or trade credit financing), sets a price P for the good as well as the trade credit interest rate r_s , if applicable. Suppliers can produce unlimited quantities of the good at zero marginal cost. In stage 2, each retailer orders goods from his own upstream supplier to fill his inventory, taking the price (and trade credit interest rate if applicable) as given.⁶ In stage 3, at the end of each period, consumer demand is realized and retailers sell their goods to the product market, competing in quantity.

The only friction we assume is that a retailer cannot acquire inventory from his supplier instantly (e.g. goods take time to build or require transportation); each retailer's sales are therefore bound by his inventory. However, retailers can store any unsold inventory for the next period at no cost, except financing costs. The retailers have no fixed costs but always need external financing for their inventory at the beginning of each period because profits are assumed to be

⁵Our paper is also related to the huge literature on contracting and competition in vertical relationships based on Hart and Tirole (1990) and to papers identifying other mechanisms for price discrimination such as resale price maintenance (e.g. Chen (1999)), or slotting allowances (e.g. Shaffer (1991)).

⁶The contract between a supplier and a retailer is exclusive: each retailer can only purchase inventory from their own supplier not the other one and vice versa.

distributed to shareholders at the end of each period to simplify the exposition of the paper.⁷

There are two available external financing choices for the retailers—straight debt provided by a competitive banking sector (or a bond market) and trade credit financing offered by their own suppliers. Under bank financing, the retailer pays the supplier at the time of the order and finances the inventory with a bank. Under trade credit financing, the retailer gets free financing from the vendor for the goods that are sold at the end of the period, while he has to pay the trade credit interest rate r_s , which is optimally chosen by the supplier, to finance any unsold inventory that is rolled over to the next period. Since retailers have no fixed costs and are on average profitable, they will never default. Under bank financing retailers can thus borrow at the risk free rate. In this infinite horizon game, the end of current period equals the beginning of the next period. We assume that all agents are risk-neutral.

2.1 Solution

Our model is a dynamic game with demand uncertainty and the solution could be path dependent as current orders depend on last period sales and inventory levels. Because of the infinite horizon we can rearrange and reinterpret the cash flows and inventory valuation in such a way that each period is identical and solve the game as a time independent static game, which is much more tractable. We will explain in more detail our approach in the following subsections. We solve for the subgame perfect Nash equilibrium by backward induction starting with the retailers' decision problem.

The retailer's end of period problem —ex-post competition At the end of the period, each retailer i maximizes its profit ω_i by competing in quantity Q_s^f given the demand state s , the chosen form of financing f , and the amount of inventory I obtained before the state of the

⁷This assumption can be relaxed without changing the findings of the model. All we need for model is that the marginal good sold in the bad state is financed externally. Allowing the firm to finance a part of the inventory with equity does not change our main result but complicates the exposition of the paper substantially. To simplify the exposition we assume that all profits are paid out to shareholders at the end of each period.

demand is realized.⁸ The retailer's problem is

$$\max_{Q_s^f} \omega_s^f = (A_s - Q_s^f - Q_s^{-i,f})Q_s^f - C_s^f, \quad f \in \{B, T\}; s \in \{b, g\} \quad (1)$$

$$\text{s.t. } Q_s^f \leq I \quad (2)$$

where $Q_s^{-i,f}$ is the aggregate quantity offered by the other retailers except i and C_s^f is the retailer's total cost measured in the end of period values.

Holding inventory is costly under both forms of financing and therefore the retailer will never optimally hold more inventory than what he can sell in the good state.⁹ In the good state, the constraint (2) is therefore binding and $Q_g^f = I$. In the bad state, the sales in equilibrium should be below the sales in a good state or the inventory. Thus, the constraint should not be binding, i. e., $I > Q_b^f$. We solve the third stage game assuming the inventory constraint to be binding in good states and not binding in bad states and later verify that this assumption is indeed true.

We start by analyzing the bank financing case first. The lower part of Panel A in Table 1 provides an overview of the end of period cash flows and inventory levels under bank financing. At the end of each period the retailer has an inventory of Q_g^B which is fully financed with bank debt having a face value of $P^B Q_g^B$. The retailers total cost C_s^B consists of the interest paid to the bank for financing the inventory and the repayment of the principal of the loan for the sold units. Since the inventory is always fully financed with bank debt the financing costs of the inventory are the product of the interest rate and the cost of the inventory, $rP^B Q_g^B$, where r is the bank interest rate and P^B is the price charged by the supplier under bank financing. If a good state occurs, the retailer sells his whole inventory Q_g^B and re-pays the full face value of the outstanding loan, $P^B Q_g^B$, to the bank. His total cost in the good state is $C_g^B = rP^B Q_g^B + P^B Q_g^B$. If a bad state occurs the retailer sells only Q_b^B goods to consumers and still keeps $Q_g^B - Q_b^B$ unsold goods in hand for sale in the next period. He then repays the loan for the sold Q_b^B goods and thus reduces the face value by $P^B Q_b^B$. Thus, his total cost is $C_b^B = rP^B Q_g^B + P^B Q_b^B$.¹⁰

⁸Superscript $f \in \{B, T\}$ indicates a retailer's financing choices, either bank financing (B) or trade credit financing (T); subscript $s \in \{b, g\}$ denotes the demand states, either a good state (g) or a bad state (b). In a bad state, the choke price is A_b ; in a good state, the choke price is A_g , where $A_g > A_b$. To avoid a degenerate solution with zero sales in the bad state we assume that the choke price in the bad state is sufficiently high, $A_b > (A_g - A_b)q$.

⁹Under bank financing excess inventory would have to be financed at the bank rate r , and under trade credit financing excess unsold inventory is financed at the trade credit interest rate r_s .

¹⁰Our model would also work if the retailer used a part of his profit to reduce his debt by more than $P^B Q_b^B$ to

Table 1. State dependent cashflows for the retailer under bank financing (panel A) and trade credit financing (panel B). By allocating cashflows and valuing inventory as presented in the tables we make the total wealth at the beginning of the period independent of the state in the previous period as shown in the upper part of Panels A and B. The total wealth at the end of the period only depends on the demand state that is realized in that period. We can therefore see each period as identical. Q_g and Q_b denote the quantity sold in the good state and the bad state, P denotes the price charged by the supplier, P_m is the price achieved in the retail market, and ω_g and ω_b are the retailer's profit in the good and bad state, respectively. All superscripts, which are used to indicate bank financing or trade credit financing throughout the text are omitted for simplicity.

Panel A: Bank financing						
Beginning of each period						
	Previously good state			Previously bad state		
	Goods	Cash Flow	Loan balance	Goods	Cash Flow	Loan Balance
Starting value	0		0	$Q_g - Q_b$		$-(Q_g - Q_b)P$
Order	Q_g	$-Q_gP$		Q_b	$-Q_bP$	
Draw loan		$+Q_gP$	$-Q_gP$		$+Q_bP$	$-Q_bP$
Total wealth	Q_g	0	$-Q_gP$	Q_g	0	$-Q_gP$
End of each period						
	Good state			Bad state		
	Goods	Cash Flow	Loan balance	Goods	Cash Flow	Loan Balance
Starting value	Q_g		$-Q_gP$	Q_g		$-Q_gP$
Sale	$-Q_g$	Q_gP_m		$-Q_b$	Q_bP_m	
Interest		$-rQ_gP$	$-Q_gP$		$-rQ_bP$	
Repay Loan		$-Q_gP$	$+Q_gP$		$-Q_bP$	$+Q_bP$
Total wealth	0	ω_g	0	$Q_g - Q_b$	ω_b	$-(Q_g - Q_b)P$
Panel B: Trade credit financing						
Beginning of each period						
	Previously good state			Previously bad state		
	Goods	Cash Flow	payables	Goods	Cash Flow	payables
Starting value	0	0	0	$Q_g - Q_b$		$-(Q_g - Q_b)P$
Order	Q_g	0	$-Q_gP$	Q_b		$-Q_bP$
Total wealth	Q_g	0	$-Q_gP$	Q_g	0	$-Q_gP$
End of each period						
	Good state			Bad state		
	Goods	Cash Flow	payables	Goods	Cash Flow	payables
Starting value	Q_g		$-Q_gP$	Q_g		$-Q_gP$
Sale	$-Q_g$	Q_gP_m		$-Q_b$	Q_bP_m	
Interest		0	0		$-\frac{r_s}{1+r}(Q_g - Q_b)P$	
Pay supplier		$-Q_gP$	$+Q_gP$		$-Q_bP$	$+Q_bP$
Total wealth	0	ω_g	0	$Q_g - Q_b$	ω_b	$-(Q_g - Q_b)P$

Now we turn to analyze the trade credit financing case as shown in the lower part of Panel B in Table 1. If a good state occurs, the retailer clears out his inventory, pays the supplier for all goods, and total cost is $C_g^T = P^T Q_g^T$, where P^T is the price charged by each supplier under trade credit financing. There is no financing cost because the retailer borrowed Q_g^T goods from his supplier at the beginning of the period, sells all of the inventory to consumers, and then obtains free-financing when paying all of the debt within this period. However, if a bad state occurs, the retailer only sells Q_b^T goods, cannot repay the supplier in full, and has to finance the unsold inventory at the trade credit interest rate r_s . Specifically the retailer will pay an amount of $P^T Q_b^T$ to the supplier and will finance the unsold inventory with face value $P^T(Q_g^T - Q_b^T)$ at the trade credit interest rate r_s until the end of the next period when product markets open again. Since interest payments are made in arrears we discount the trade credit interest payment for one period at the risk free rate r . The retailer's total cost is then given by $C_b^T = P^T Q_b^T + P^T r_s (Q_g^T - Q_b^T) / (1 + r)$.

As noted above in a good state the constraint (2) is binding and the sales are constrained by the inventory I which is determined in stage 2. In a bad state, however, the constraint is not binding and the first order condition to solve Q_b^f is

$$\frac{\partial}{\partial Q_b^f} \left[(A_b - Q_b^f - Q_b^{-i,f}) Q_b^f - C_b^f \right] = 0, \quad f \in \{B, T\}. \quad (3)$$

The retailer's start of period problem —ex-ante inventory decision Given the price of the good, P^f , (and trade credit interest rate, r_s , if applicable) charged by each supplier, each retailer makes an ex-ante inventory decision to maximize their expected total profits. As illustrated in the upper parts of Panels A and B in Table 1, no cash flows occur for the retailer at the beginning of the period because inventory is externally financed either through straight debt or through trade credit financing. At the beginning of the period each retailer stocks up his inventory to the optimal level Q_g^f and thus ends up with the same inventory level and payment obligations, either to the bank or to the supplier. Because – independent of the demand state in the previous

save on future financing costs as long as the marginal unit sold in the bad state is still financed with debt. Our debt repayment policy is consistent with industry practice. For example the U.S. Small Business Administration defines floor plan financing as "Floor plan financing is a revolving line of credit that allows the borrower to obtain financing for retail goods. These loans are made against a specific piece of collateral (i.e. an auto, RV, manufactured home, etc.). When each piece of collateral is sold by the dealer, the loan advance against that piece of collateral is repaid." (see *U.S. Small Business Administration, Special Purpose Loans Program*, <http://www.sba.gov/content/what-floor-plan-financing>)

period – after ordering their inventory retailers have the same inventory level, the same payment obligations, and no cash flows, we can transform the potentially complex dynamic optimization problem to a state-independent static optimization problem in which all periods are ex-ante identical. One strategy to maximize overall profits in this infinitely repeated game, and the one we will focus on in this paper, is to maximize profit in each period, ω^f .

The first order condition that determines the inventory and thus the sales quantity in the good state maximizes the expected payoff, which is the probability weighted average of the retailers profit in the good state, ω_g^f , and in the bad state, ω_b^f , respectively,

$$\frac{\partial}{\partial Q_g^f} \left[(1 - q)\omega_b^f + q\omega_g^f \right] = 0 \quad f \in \{B, T\}, \quad (4)$$

where we substitute the solution from Equation (3) for Q_b^f , which occurs in ω_b^f .

The supplier's problem Given the product market strategy of the retailer, and thus the state contingent quantities they will order, the supplier sets the price (and the trade credit interest rate, if applicable) to maximize her profits. We again structure cash flows such that each period is identical and examine the strategy to maximize each period's profit, π^f as one way to maximize overall profits.

Under bank financing, each supplier only has price as a choice variable to maximize their expected profits

$$\max_{P^B} \pi^B = (1 + r)P^B Q_g^B - (1 - q)P^B(Q_g^B - Q_b^B) \quad (5)$$

When selling Q_g^B goods to their retailer, the supplier immediately obtains the cash payment, which will be worth $(1 + r)P^B Q_g^B$ at the end of the period. However, with probability $1 - q$ a bad state will occur and the retailer will buy fewer goods in the next period as he keeps $Q_g - Q_b$ goods in hand. Thus, the supplier will indirectly lose the profit for the amount of $(1 - q)P^B(Q_g^B - Q_b^B)$.

Under trade credit financing, each supplier maximizes the expected profit through simultaneous choice on price P^T and trade credit interest rate r_s .

$$\max_{P^T, r_s} \pi^T = qP^T Q_g^T + (1 - q) \left(P^T Q_b^T + \frac{r_s P^T (Q_g^T - Q_b^T)}{1 + r} \right) \quad (6)$$

With probability q , a good state occurs and each supplier obtains a cash payment of $P^T Q_g^T$ at the end of the period for all the goods she has lent to the retailer. With probability $1 - q$, a bad state occurs and each supplier gets paid for the sold goods $P^T Q_b^T$ in the current period and can collect the penalty payment in the next period, which has a present value of $r_s P^T (Q_g^T - Q_b^T)/(1 + r)$.

The first order condition to solve for the price P under bank financing is then

$$\frac{\partial}{\partial P^B} [(1 + r)P^B Q_g^B - (1 - q)P^B (Q_g^B - Q_b^B)] = 0 \quad (7)$$

and under trade credit financing we solve

$$\frac{\partial}{\partial P^T} \left[qP^T Q_g^T + (1 - q) \left(P^T Q_b^T + \frac{r_s P^T (Q_g^T - Q_b^T)}{1 + r} \right) \right] = 0 \quad (8)$$

$$\frac{\partial}{\partial r_s} \left[qP^T Q_g^T + (1 - q) \left(P^T Q_b^T + \frac{r_s P^T (Q_g^T - Q_b^T)}{1 + r} \right) \right] = 0 \quad (9)$$

where we substitute the solutions from Equations (3) and (4) for Q_g and Q_b , respectively.

Solving the first order conditions (3), (4), and (7) in the case of bank financing or (8) and (9) in the case of trade credit financing, respectively, and assuming firms are symmetric, i.e. $Q_s^{-i,f} = (n - 1)Q_s^f$, we solve for the equilibrium strategy of retailers and suppliers. To simplify the exposition of the paper, we present from now on the results for the limit case when the risk free rate goes to zero.¹¹ The following propositions summarize the game solutions for bank financing and trade credit financing, respectively.

Proposition 1 *There exists a subgame perfect Nash equilibrium under bank financing such that each supplier charges $P^B = \frac{2(qA_g + (1-q)A_b)}{3+n}$, each retailer orders an inventory $Q_g^B = \frac{(3+n-2q)A_g - 2(1-q)A_b}{(n+3)(n+1)}$, and sells exactly Q_g^B in a good state and $Q_b^B = \frac{2qA_g + (1+n+2q)A_b}{(n+3)(n+1)}$ in a bad state, respectively.*

Proposition 2 *There exists a subgame perfect Nash equilibrium under trade credit financing*

¹¹Our results also hold for a positive risk free rate but the expressions are significantly more complex without providing any major insights. Some results require that the risk free rate is below a well defined upper bound, which will be mentioned in the text. A Mathematica workbook with the solutions for the general case is available from the authors upon request.

such that each supplier charges $P^T = \frac{2(qA_g + (1-q)A_b)}{3+n}$ and sets the trade credit interest rate at $r_s = \frac{q(A_g - A_b)}{qA_g + (1-q)A_b}$, each retailer orders an inventory $Q_g^T = \frac{A_g}{n+3}$, and sells exactly Q_g^T in a good state and $Q_b^T = \frac{A_b}{n+3}$ in a bad state, respectively.

We can immediately see that the form of financing has an effect on the quantities firms offer and will thus influence the overall profitability of the firms in the supply chain.¹² It is also noteworthy that the trade credit interest rate is always positive as $A_g > A_b$ by assumption. We will explore the intuition for the firms' optimal product market strategy and its empirical implications in the following sections.

3 Financing choice and product market behavior

In this section, we first illustrate how financing choices affect a retailer's behavior in imperfect competition, how this affects profits, and why both suppliers and retailers prefer trade credit over bank financing.

The retailer's behavior in a bad state

We start with a retailer's ex-post behavior in a bad state. As stated in Equation (3) at the optimal quantity, the marginal revenue (MR_b) from selling one more unit must equal the total marginal cost (MC), which we can write as the sum of the marginal purchasing (MPC) and marginal financing costs (MFC),

$$MR_b = MC_b = MPC + MFC_b^f. \quad (10)$$

Under both forms of financing marginal revenue and marginal purchase costs are given by $MR_s = A_s - 2Q_s^f - Q_s^{-i,f}$, and $MPC = P^f$, respectively. Under bank financing the marginal financing cost is zero in a bad state, because the financing cost depends only on the inventory level and is independent the retailers' bad-state sales. Under trade credit financing, however, the value of any unsold inventory has to be financed at the trade credit interest rate r_s . Selling an additional good saves the trade credit interest payment which is due at the end of next period.

¹²The price the supplier charges is identical under both forms of financing, but this holds only when the risk free rate goes to zero.

Since $r_s > 0$, the marginal financing cost is negative, $MFC^T = -P^T r_s / (1 + r)$. Trade credit financing therefore effectively lowers the total marginal cost for the retailer in bad states and makes him more aggressive in sales. The higher the trade credit penalty rate is, the lower the retailer's total marginal cost in bad states is and the more severe the competition is. By changing the trade credit interest rate, the supplier can strategically influence the retailer's aggressiveness in a bad state.

The retailer's inventory decision and behavior in a good state

The trade credit penalty also affects the retailer's behavior in a good state through the ex-ante inventory decision. We will show that sales are always bound by inventory in good states and that constraint (2) is binding. Thus, the retailer's quantity choice in good states is actually made when he chooses inventories before the state of demand is realized.

We can rewrite the first order condition in Equation (4) for the retailer's optimal level of inventory as

$$qMR_g = qMC_g^f = q(MPC + MFC_g^f) + (1 - q)MFC_b^f. \quad (11)$$

The retailer obtains a marginal revenue from an increased unit of inventory only in the good state because not all of the inventory is sold in a bad state. Increasing inventory incurs two ex-ante marginal costs: the marginal cost of purchasing and financing the additional good when it gets sold in the good state and the marginal cost of financing the additional good in the bad state when it stays in inventory. Similar to the analysis of the bad state, the marginal revenue and purchase costs are $MR_s = A_s - 2Q_s^f - Q_s^{-i,f}$, and $MPC = P^f$. Under bank financing, the ex-ante marginal financing cost equals to the interest paid for the value of the additional good in both bad and good states, $MFC_g^B = MFC_b^B = rP^B$. Substituting into Equation (11) we get

$$qMC_g^B = q(P^B + rP^B) + (1 - q)rP^B.$$

The total marginal cost is then $MC_g^B = P^B(1 + \frac{1}{q})$. Under trade credit financing, the retailer gets free financing for the good state in which all goods are sold but has to finance the unsold goods at the trade credit interest rate in the bad state: $MFC_g^T = 0$, $MFC_b^T = P^T r_s / (1 + r)$ and $MC_g^T = P^T(1 + \frac{r_s}{1+r} \frac{1-q}{q})$.

In good states, if we were to ignore the inventory constraints, the retailer's optimal level of

sales should be given by $MR_g = MPC + MFC_g^f$. Comparing to the inventory decision problem, the retailer would choose to sell more than the inventory under both, bank financing and trade credit financing. The shadow price of the inventory is $r\frac{1}{q}P^B$ and $\frac{r_s}{(1+r)}\frac{1-q}{q}P^T$, respectively, for bank financing and trade credit financing. The retail competition in good states therefore is softened under both financing schemes. However, there are two differences between bank financing and trade credit financing. First, under trade credit financing, r_s explicitly reduces the marginal cost in bad states and increases the marginal cost in good states, while r does not have an explicit effect on the marginal cost in the bad state under bank financing. More importantly, r_s is a choice variable while r is exogenously given. As a result, the trade credit financing scheme enables the supplier to strategically influence her retailer's aggressiveness in both demand states: how much to intensify the competition in a bad state and how much to soften the competition in a good state. We summarize the above results in the following proposition.

Proposition 3 *Under trade credit financing, the retailers' marginal cost is lower (higher) in the bad (good) state, competition is intensified (softened), and aggregate supply increases (decreases) relative to bank financing.*

The trade credit interest rate

From Proposition 2, we know that the trade credit interest rate is $r_s = \frac{q(A_g - A_b)}{qA_g + (1-q)A_b}$ as r goes to zero, which has several noteworthy properties: First, r_s is always positive, i.e., the solution is consistent with the empirical facts that the retailers have to pay a penalty rate if they cannot repay their suppliers on time. Second, r_s increases when a good state becomes more significant (q or $A_g - A_b$ is high) or a bad state is less significant (A_b or $1 - q$ is low). As the relative importance of the good state increases, protecting the good state profit (softening the competition) becomes more important, which requires a rise in r_s .

Corollary 1 *Under trade credit financing, the penalty rate r_s increases with the probability of a good state and the gap of choke prices in both states.*

Trade credit financing as a supplier's price discrimination scheme against her retailer

There are potentially two stages of price discrimination. First, retailers price discriminate against consumers in different states of demand. Second, the suppliers price discriminate

against their retailers. Trade credit financing implicitly allows the supplier to charge the retailer state contingent marginal costs and thus price discriminate between demand states. On appearance, the supplier seems to charge the retailer a low price (free financing) in good states and a high price (due to a higher trade credit interest rate) in bad states, which seems to contradict the typical pricing pattern in price discrimination theory (a high(low) price is charged when a demand is high(low)). The misconception arises from the incorrect use of the average price instead of unit price or marginal price. To find the correct state contingent prices rewrite the supplier's profit function

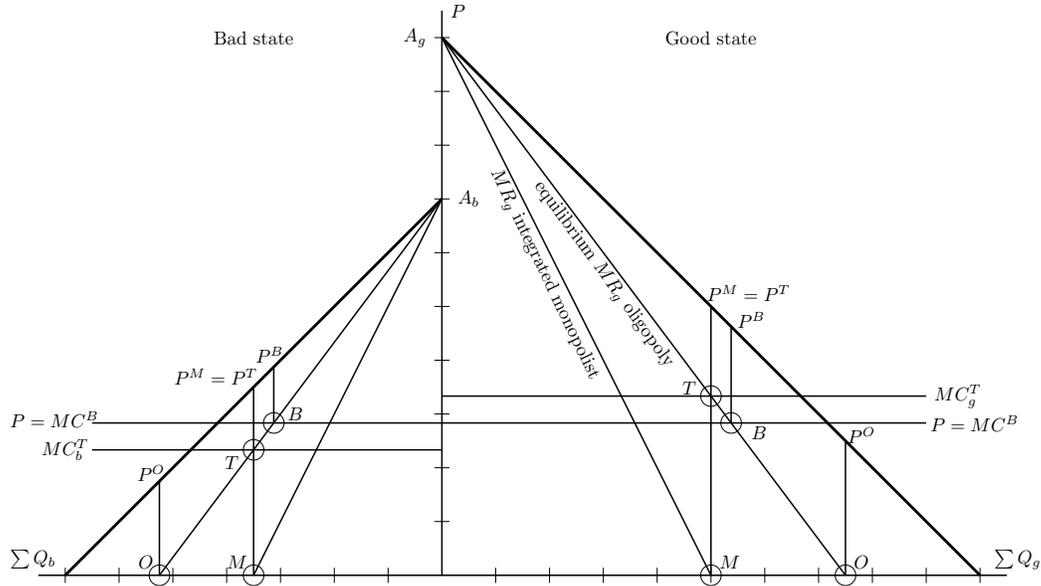
$$\begin{aligned}
\pi^T &= qP^T Q_g^T + (1-q) \left(P^T Q_b^T + \frac{r_s P^T (Q_g^T - Q_b^T)}{1+r} \right) \\
&= \left(qP^T Q_g^T + (1-q) \frac{r_s P^T Q_g^T}{1+r} \right) + \left((1-q) \left(P^T Q_b^T - \frac{r_s P^T Q_b^T}{1+r} \right) \right) \\
&= q \left(P^T + \frac{1-q}{q} \frac{r_s P^T}{1+r} \right) Q_g^T + (1-q) \left(P^T - \frac{r_s P^T}{1+r} \right) Q_b^T \\
&= qP_g^T Q_g^T + (1-q)P_b^T Q_b^T
\end{aligned}$$

where $P_g^T = P^T \left(1 + \frac{1-q}{q} \frac{r_s}{1+r} \right)$ and $P_b^T = P^T \left(1 - \frac{r_s}{1+r} \right)$ are the supplier's effective prices in good and bad states, respectively. The price charged by the supplier in the good state is clearly higher than that in the bad state. Notice that P_g^T and P_b^T are exactly the retailer's total marginal costs for the equilibrium sales in good and bad states, respectively.

The incentive for a supplier to provide trade credit is hence to price-discriminate to her retailer between strong and weak demand states. In our model the rationale for a supplier to set state contingent prices is to change the marginal cost for the retailer to influence his behavior in the final market. The supplier's price discrimination in our analysis is a double price discrimination, or a price discrimination to influence the retailer's price discrimination against the consumers. We summarize our findings in the following proposition:

Proposition 4 *Under trade credit financing, the supplier optimally price discriminates the retailer between the states of demand: charging a high effective price $P_g^T = P^T \left(1 + \frac{1-q}{q} \frac{r_s}{1+r} \right)$ in*

Figure 1. Product market equilibria, marginal revenues and costs under alternative financing arrangements. The graph shows the inverse demand curve (bold line), the marginal revenue of the integrated monopolist, and the equilibrium marginal revenue line for an oligopoly, for which each point corresponds to an equilibrium in an oligopoly game and represents the marginal revenue and aggregate supply in that equilibrium. The point M , O , B , and T denote the equilibrium points where marginal revenue equals marginal cost of the integrated monopolist, the integrated oligopolist, the n supply chains under bank financing, and the n supply chains under trade credit financing, respectively. The parameters for the graph are: $A_g = 10, A_b = 7, q = 1/2, r = 0, n = 3$.



good states and a low effective price $P_b^T = P^T(1 - \frac{r_s}{1+r})$ in bad states. As a result, compared to bank financing, the profits of the supplier are higher under trade credit financing.

4 Financing choice and industry structure

We now look into the incentive of a supplier to offer trade credit financing, the effect of industry structure, and the producer surplus.

Figure 1 illustrates the basic mechanics of our model by means of an example. The graph shows the marginal cost curves under trade credit and bank financing (horizontal lines), the in-

verse demand curve (bold line), and the marginal revenue for the integrated monopolist. Each point in the line labeled "equilibrium marginal revenue oligopoly" corresponds to an equilibrium in a Cournot oligopoly game and shows the marginal revenue (along the vertical axis) and aggregate output (along the horizontal axis) in that equilibrium. To derive this line we solve a simple Cournot game for marginal costs ranging from zero to the choke price. We then plot for each equilibrium a point defined by marginal revenue and the aggregate output.

Start as a reference case with a single, vertically integrated monopolist. Since production cost of the good is assumed to be zero, the optimal quantity that the vertically integrated monopolist offers can be found where the marginal revenue line hits the x-axis (point M) and the corresponding price in the consumer product market is given by P^M . When more firms enter the industry, competition flattens the equilibrium marginal revenue curve under oligopoly and firms offer more in aggregate (point O) which decreases their equilibrium revenue as products in the consumer market are sold for P_O .

The retailers of an oligopoly supply chain face the same marginal revenue function but their marginal costs increase because they have to purchase the intermediate goods at price P from the supplier. When r goes to zero, as in the example of the graph, the retailers using bank financing pay no financing costs and thus their marginal cost equals the price set by the supplier, P , and the overall equilibrium in the product market is at point B . The aggregate output of the supply chain comes closer to the quantity that is offered by the vertically integrated monopolist, however under bank financing we see that the output is too high in the good state and too low in the bad state, respectively. This is exactly the problem that trade credit can overcome. By optimally choosing the trade credit interest rate the supplier can increase her retailer's marginal cost in the good state to MC_g^T and lower the marginal cost in the bad state to MC_b^T . In some cases it is possible – as in this specific example – to achieve exactly the output of a vertically integrated monopolist. In general trade credit financing, with its ability to charge state dependent marginal costs, can make the retailer choose an output closer to the output of the integrated monopolist than bank financing.

Trade credit financing allows producers to price discriminate across demand states, moves industry output closer to the integrated monopolist's optimal choice and thereby increases producer surplus at the expense of consumers. Price discrimination results in a less efficient outcome and under trade credit financing consumer surplus as well as welfare decrease relative to

bank financing. This intuition is summarized in the following proposition.

Proposition 5 *In imperfect competition expected consumer surplus and total welfare are lower under trade credit financing than under bank financing. With at least two supply chains the expected producer surplus per supply chain is higher under trade credit financing.*

For producers the relative advantage of trade credit financing over bank financing depends on industry concentration. In the case of a monopoly supply chain, under bank financing, we have a typical double marginalization problem. The retailer will then set prices higher than the integrated monopoly prices and the aggregate profits fall. Under trade credit financing, the supplier and the retailer still face the double marginalization problems. In addition, to strategically price discriminate against the retailer, the supplier artificially makes the marginal cost different for the retailer and thus introduce a further distortion to the market. As a result aggregate profits are further reduced.

With two or more competing supply chains competition lowers prices. When the number of supply chains increases initially, the competition mitigates the effects of double marginalization, brings the equilibrium prices closer to the monopoly price, and the aggregate profits grow. As the number of the supply chains increases further, competition dominates and the prices and aggregate profits fall. In perfect competition, we can see from Propositions 1 and 2 that the suppliers' price P is zero and thus the form of financing becomes irrelevant. We summarize our intuition in the following proposition:

Proposition 6 *The difference in expected producer surplus per supply chain between trade credit financing and bank financing is an inverse U-shaped function in the number of supply chains.*

4.1 Stability

Trade credit is a collusion mechanism that allows producers to extract rents from consumers. Like for most other collusion mechanisms there exists an incentive for firms to deviate from the collusive equilibrium for short term gain. One way to deviate in our equilibrium is that a whole supply chain might move from trade credit financing to bank financing. However, we believe

that trade credit is a very robust collusion mechanism because firms can observe at the beginning of each period, before the product market opens, whether other firms offer vendor financing or not. In practice companies also create an institutional framework for vendor financing which can be seen as a commitment device to the trade credit equilibrium. For example, almost all car companies have financing arms, separate corporations, that offer favorable financing for car dealers' inventory (floor plan financing). Set up costs of these finance companies and long term financing contracts with dealers make it very costly for car manufacturers to deviate from the trade credit equilibrium for short term gain. We also find that for a wide range of parameter values the benefit of short term deviation is far smaller than the present value of future gains obtained under the trade credit equilibrium.

Proposition 7 *There exists an upper bound $\bar{r} > 0$ such that for all $r < \bar{r}$ the one time benefit in producer surplus from deviating to bank financing is smaller than the present value of future gains from trade credit financing.*

Another possible deviation from equilibrium can occur ex-post in the bad state. In our model the retailer is financially unconstrained and has always access to debt markets. Instead of financing any unsold inventory at the high trade credit interest rate, the retailer could borrow from the bank at a much lower rate and repay the supplier in full. However, while such a strategy would be rewarding in the short term, in the long term the supply chain as a whole would be worse off when all firms revert back to bank financing. As long as the producer surplus under trade credit is larger than under bank financing the supplier can make the retailer always indifferent with respect to the financing scheme with transfer payments. For example car producers make ex-post transfer payments called "holdbacks" to their retailers on a monthly or quarterly basis which are based on past sales volume.¹³ Suppliers can then refuse to pay holdbacks when retailers deviate to bank financing. Another potential transfer mechanisms is advertising which is often paid by the supplier and benefits the retailers' sales.

¹³The IRS describes holdbacks in the following way: 'When dealers acquire their new car inventory from manufacturers, usually the invoice includes a separately coded charge for "holdbacks." Dealer holdbacks generally average 2-3 percent of the Manufacturer's Suggested Retail Price (MSRP) excluding destination and delivery charges. These amounts are returned to the dealer at a later date. The purpose of the "holdbacks" is to assure the dealer of a marginal profit.', see *New Vehicle Dealership Audit Technique Guide 2004 - Chapter 14 - Other Auto Dealership Issues (12-2004)*, Internal Revenue Service.

Another issue to consider is why banks cannot offer a contract that replicates the trade credit contract. By offering a trade credit contract with free initial financing and a payment of r_s in the bad state banks would earn a positive profit. Since we assume free entry in the banking sector banks would compete that profit away and such a contract would not be sustainable.¹⁴

5 Empirical Evidence

As derived in Proposition 6 the benefit of trade credit is inversely u-shaped in industry concentration. Given other costs and benefits of trade credit that are outside of our model we should see that the use of trade credit is proportional to its benefit and therefore also inversely u-shaped in industry concentration. Empirical literature exploring the link between trade credit use and industry concentration is scarce. Hyndman and Serio (2010) analyze a panel of small companies in Indonesia and find a pattern that is almost exactly as predicted by our model with a discrete jump in trade credit use between monopoly and duopoly. Similar to the results obtained under our model for many parameterizations, they find that credit provision peaks in markets with 4 competitors in their sample and from this point onwards slowly decreases in competition. In line with the predictions of Proposition 5, Fisman and Raturi (2004) examine supply chain relationships in five African countries and find that monopoly power is negatively associated with credit provision. Our findings are also consistent with McMillan and Woodruff (1999) who examine trade credit use in competitive markets and find trade credit to decrease as competition intensifies for a sample of Vietnamese firms.

For our empirical analysis we collect data on all US firms between 1980 and 2010 from Compustat excluding financial companies. We define trade credit usage as the logarithm of accounts receivables over total sales and compute the HHI based on each firms share of total sales, where industry is defined based on 4 digit SIC codes. As pointed out by Ali, Klasa, and Yeung (2009), Compustat excludes private companies which might lead to mis-measurement of industry concentration. To check for robustness we follow their approach and download the HHI

¹⁴Banks could in theory offer a step-function contract with a negative interest rate for one period and a positive rate for any unsold goods such that the expected profit of the contract is zero. However, we believe that such a contract would be hard to sustain in equilibrium. Unless demand states are contractable the retailer could claim that a high demand state has occurred and refinance the inventory with another bank. Since banks and retailers have no long term relationship there are no negative consequences for the retailer. The same criticism would not apply for trade credit for the reasons mentioned above.

of the largest 50 companies from the U.S. Economic Census for manufacturing companies.¹⁵ We use control variables commonly used in the literature. *Firm size* is the logarithm of sales, *book leverage* is total book value of total liabilities over total assets, *Cash/TA* is the amount of cash over total assets, *market/book* is the ratio of market value over book value of equity, return on assets (*ROA*) is net income over total assets, *tangibility* is net property plant and equipment over total assets, *profit margin* is sales minus costs of goods sold over sales, Free cash flow over total assets is defined as EBIT after taxes plus depreciation minus capital expenditures over total assets, *acquisition* is a dummy equal to one if the company conducted an *acquisition*, and *dividend paying* is a dummy indicating that the firm paid dividends. We trim our data and exclude the 5% tails of each variable.

Table 2 presents summary statistics of the two samples: the U.S. Census is conducted for manufacturing firms only resulting in a smaller sample compared (Panel B) to the one which measures industry concentration based on all Compustat firms (Panel A). The Compustat sample shows a wider variation in industry concentration, which could partly be explained by missing private firms. The US census only includes manufacturing firms, which probably explains why firms in this sample use more trade credit and show less variation in trade credit use.

Figure 2 shows trade credit use, defined as receivables over total sales, for deciles of industry concentration measured in the Compustat sample.¹⁶ In line with our theoretical predictions and with Hyndman and Serio (2010), we find an inverse U-shape both in mean as well as median trade credit use over industry concentration.

For our analysis we run two regression specifications: first we regress trade credit use on the HHI and on the squared HHI to capture the curvature. Second we regress trade credit use on the HHI and allow for a change in slope at the 85% quantile by multiplying a dummy that equals one of the HHI is in the 85% tail with the change in the HHI beyond the 85% quantile.

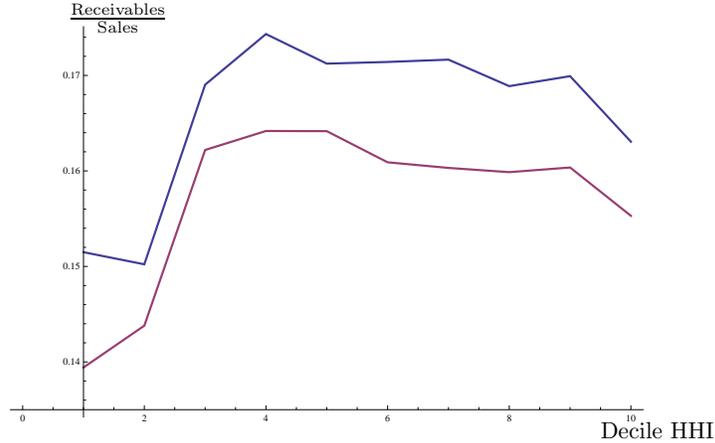
¹⁵Census concentration data is classified based on four digit SIC codes for the years 1982, 1987, and 1992, and uses the NAICS classification for the 1997, 2002, and 2007 censuses. We merge our datasets based on the respective industry classifications. Industry concentration in years between censuses is set to the closest available census data point.

¹⁶While our model assumes that one supplier only contracts with one retailer, in practice one supplier might deliver goods to several retailers that serve different (potentially overlapping) markets, e.g. Ford and GM sell cars to several dealerships that serve local markets. The benefit of trade credit in our model is mainly driven by competition between suppliers, e.g. car producers. Therefore we use receivables of suppliers as measure of trade credit use. Trade credit use of retailers might vary due to local competition in their markets.

Table 2. Summary statistics of firm and industry data: Trade credit use is defined as logarithm of receivables over total sales. HHI is the Herfindahl-Hirschman Index based on sales, based on either Compustat data (Panel A), or on the U.S. Economic Census of Manufacturing (Panel B), respectively. Firm size is the logarithm of sales, book leverage is total book value of total liabilities over total assets, Cash/TA is the amount of cash over total assets, market/book is the ratio of market value over book value of equity, return on assets (ROA) is net income over total assets, tangibility is net property plant and equipment over total assets, profit margin is sales minus costs of goods sold over sales, Free cash flow over total assets is defined as EBIT after taxes plus depreciation minus capital expenditures over total assets, acquisition is a dummy equal to one if the company conducted an acquisition, and dividend paying is a dummy indicating that the firm paid dividends.

Panel A: HHI based on Compustat data (78,454 Obs.)					
	Mean	Std.Dev.	Median	Min.	Max.
Trade credit	-2.042	0.732	-1.899	-11.292	-0.663
HHI	0.253	0.185	0.203	0.013	1.000
Firm Size	5.452	2.168	5.348	-4.423	13.035
Book Leverage	0.495	0.197	0.514	0.000	0.900
Cash/TA	0.080	0.105	0.037	0.000	0.647
Market/Book	2.088	1.739	1.601	0.300	15.995
ROA	0.029	0.066	0.038	-0.300	0.147
Tangible assets/TA	0.303	0.221	0.249	0.000	0.920
Profit Margin	0.332	0.150	0.319	0.000	0.681
FCF/TA	0.037	0.047	0.040	-0.079	0.142
Acquisition	0.382	0.486	0.000	0.000	1.000
Dividend paying	0.475	0.499	0.000	0.000	1.000
Panel B: HHI based on U.S. Census data (29,716 Obs.)					
	Mean	Std.Dev.	Median	Min.	Max.
Trade credit	-1.900	0.498	-1.847	-9.592	-0.666
HHI	0.066	0.057	0.048	0.000	0.300
Firm Size	5.485	2.195	5.360	-3.863	13.035
Book Leverage	0.463	0.198	0.476	0.003	0.900
Cash/TA	0.091	0.109	0.047	0.000	0.646
Market/Book	2.079	1.687	1.622	0.300	15.970
ROA	0.030	0.070	0.041	-0.299	0.147
Tangible assets/TA	0.256	0.163	0.226	0.000	0.918
Profit Margin	0.352	0.146	0.340	0.000	0.681
FCF/TA	0.042	0.047	0.046	-0.079	0.142
Acquisition	0.373	0.484	0.000	0.000	1.000
Dividend paying	0.462	0.499	0.000	0.000	1.000

Figure 2. Trade Credit use and industry concentration: The graph shows the mean (upper blue line) as well as the median (lower purple line) of receivables over total sales for deciles of industry concentration as measured by the Herfindahl-Hirschman Index of sales based on Compustat data.



Formally, let $q85$ be the 85% quantile of the HHI distribution we estimate the following model

$$TC = a \text{ HHI} + b \mathbf{1}_{\text{HHI} > q85} (\text{HHI} - q85) + \text{controls} \quad (12)$$

where $\mathbf{1}_{\text{HHI} > q85}$ is an indicator function equal to one if HHI is in the 85% tail of the distribution. In all our regressions we control for time fixed effects to control for time variation in credit demand through the business cycle and report robust standard errors.¹⁷

Our regression results are presented in Table 3. In line with previous empirical studies for other markets we confirm our prediction of an inverse U-shaped use of trade credit over industry concentration for our sample of U.S. firms. Models (1) and (3) confirm a concave, quadratic relationship between trade credit and industry concentration. The coefficient of HHI^2 differs because of the different range in HHI for the two samples but confirms an inverse U-shape over

¹⁷We do not include firm or industry fixed effects as they would pick up the variation in trade credit use across industries that we seek to identify. A firm fixed effects model would essentially relate inter-temporal changes in trade credit use to inter-temporal changes in industry concentration. We refrained from using such a specification because, first, we are not too sure how fast trade credit use will respond to changes in industry concentration and, second, in many industries concentration does not change by much relative to possible measurement errors in HHIs. Due to the low frequency for Censuses we can only observe five changes in HHIs with the largest changes occurring when industry classification changed from SIC to NAICS. For the Compustat sample we are concerned that most year-to-year changes in measured industry concentration are of a similar magnitude than the ones resulting from new firms getting listed or other firms going private and thus entering or leaving the Compustat database.

Table 3. Regression results of trade credit use on market concentration. Dependent variable is trade credit use is defined as logarithm of receivables over total sales, HHI is the HerfindahlHirschman Index based on either Compustat data (models (1) and (2)), or on the U.S. Economic Census of Manufacturing (models (3) and (4)), q_{85} is the 85% quantile of the HHI distribution, and $1_{HHI > q_{85}}$ is a dummy variable equal to one if the HHI is in the 85% tail. The control variables are defined as in Table 2. All regressions include time fixed effects and robust standard errors. One, two, and three stars indicate significance at the 10%, 5%, and 1% level, respectively.

Model	(1)	(2)	(3)	(4)
Number of Observations	78,454	78,454	32,865	29,716
HHI ²	-0.38***		-1.90***	
HHI	0.40***	0.25***	0.43***	0.16*
$(HHI \geq q_{85}) \times (HHI - q_{85})$		-0.38***		-0.36*
Firm Size	-0.03***	-0.03***	0.00	0.00
Book Leverage	-0.08***	-0.08***	0.07***	0.07***
Cash/TA	-0.58***	-0.58***	-0.57***	-0.57***
Market/Book	0.01***	0.00***	-0.01***	-0.01***
ROA	-0.11**	-0.11**	0.23***	0.22***
Tangible assets/TA	-0.92***	-0.92***	-1.02***	-1.02***
Profit Margin	0.81***	0.81***	0.69***	0.69***
FCF/TA	-0.41***	-0.41***	-1.15***	-1.15***
Acquisition	0.13***	0.14***	-0.03***	-0.03***
Dividend paying	0.05***	0.05***	0.06***	0.06***
HHI	Compustat	Compustat	Census	Census
R^2	0.1358	0.1359	0.1588	0.1532

the range of observed HHIs. From Models (2) and (4) we can see that trade credit first increases in industry concentration and then sharply drops once industry concentration is high. This latter observation is in line with Fisman and Raturi (2004) who observe a discrete drop in trade credit provision for monopoly suppliers in Africa. Most control variables are of similar magnitude as in Dass, Kale, and Nanda (2011), who use a similar sample.

6 Conclusion

We investigate how different kinds of debt issues affect output market equilibrium by comparing bank and trade credit financing, and offer a novel explanation that why trade credit exists even though it is often viewed an expensive financing option. We argue that trade credit fi-

nancing modifies a retailer's ex ante inventory policy and ex post optimal sales, respectively, in an uncertain demand environment. As the retailer in a low demand state tries to sell more to avoid financing the unsold inventory at the high trade credit rate, trade credit interest rate hence lowers the ex-post marginal cost, and being charged a low price, the retailer becomes more aggressive. However, since the retailer faces the expected high marginal cost, which is also induced by the trade credit penalty on the unsold goods before demand uncertainty is resolved, he would choose less inventory which then restricts the sales in a high demand state, and therefore the retailer being implicitly charged a high price behaves less competitively. As a result, trade credit financing serves as a strategic tool for a supplier to price-discriminate to her retailer between demand states in an imperfectly competitive market in which competition is intensified when demand is weak but mitigated when demand is strong. The mechanism of trade credit in our paper works in such a way that zero interest rate in the first period plus a high interest rate in the second period effectively change the retailer's ex ante and ex post marginal costs, which in turn affect the retailer's optimal behavior in an uncertain demand environment. This argument might give another possible explanation on the trade credit contract we usually observe and provides a new rationale that how suppliers affect their retailers' behavior by using financing tools (e.g. trade credit) in vertical relationship literature.

In addition, compared to bank financing, a less efficient outcome in oligopolistic market arises from trade credit financing under which consumer and total surplus decrease but total producer surplus (the sum of a retailer's and supplier's profits) increases. Trade credit financing is thus beneficial to producers in oligopoly; however, we find it is not beneficial to producers either in monopoly or perfect competition. Therefore, the strategic use of trade credit might only apply in oligopoly competition, and then there exists an inversed-U-shape curve between the use of trade credit and the industry concentration. Such inversed-U-shape curve is empirically verified from a sample of U.S. firms.

References

- Ali, Ashiq, Sandy Klasa, and Eric Yeung, 2009, The Limitations of Industry Concentration Measures Constructed with Compustat Data: Implications for Finance Research, *Review of Financial Studies* 22, 3839–3871.
- Biais, Bruno, and Christian Gollier, 1997, Trade Credit and Credit Rationing, *Review of Financial Studies* 10, 903–937.
- Boyer, Martin, and Karine Gobert, 2009, The impact of switching costs on vendor financing, *Finance Research Letters* 6, 236–241.
- Brander, James, and Tracy Lewis, 1986, Oligopoly and Financial Structure: The Limited Liability Effect, *American Economic Review* 76, 956–970.
- Brennan, Michael, Vojislav Maksimovic, and Josef Zechner, 1988, Vendor Financing, *Journal of Finance* 43, 1127–1141.
- Burkart, Mike, and Tore Ellingsen, 2004, In-Kind Finance: A Theory of Trade Credit, *American Economic Review* 94, 569–590.
- Chen, Yongmin, 1999, Price Discrimination and Resale Price Maintenance, *The Rand Journal of Economics* 30, 441–455.
- Cunat, Vicente, 2007, Trade Credit: Suppliers as Debt Collectors and Insurance Providers, *Review of Financial Studies* 20, 491–527.
- Dass, Nishant, Jayant Kale, and Vikram Nanda, 2011, Trade Credit, Relationship-specific Investment, and Product-market Power, working paper.
- Ferris, Stephen, 1981, A Transactions Theory of Trade Credit Use, *Quarterly Journal of Economics* 94, 243–270.
- Fisman, Raymond, and Mayank Raturi, 2004, Does Competition Encourage Credit Provision? Evidence from African Trade Credit Relationships, *The Review of Economics and Statistics* 86, 345–352.
- Frank, Murray, and Vojislav Maksimovic, 2005, Trade Credit, Collateral, and Adverse Selection, working paper, University of Maryland.
- Giannetti, Mariassunta, Mike Burkart, and Tore Ellingsen, 2011, What You Sell Is What You Lend? Explaining Trade Credit Contracts, *Review of Financial Studies* 24, 1261–1298.
- Hart, Oliver, and Jean Tirole, 1990, Vertical Integration and Market Foreclosure, *Brookings Papers on Economic Activity*.

- Hyndman, Kyle, and Giovanni Serio, 2010, Competition and inter-firm credit: Theory and evidence from firm-level data in Indonesia, *Journal of Development Economics* 93, 88–108.
- Jain, Neelam, 2001, Monitoring Costs and Trade Credit, *Quarterly Review of Economics and Finance* 41, 89–110.
- Klapper, Leora F., Luc Laeven, and Raghuram G. Rajan, 2011, Trade Credit Contracts, working paper, World Bank.
- Lee, Yul W., and John D. Stowe, 1993, Product Risk, Asymmetric Information, and Trade Credit, *Journal of Financial and Quantitative Analysis* 28, 285–300.
- McMillan, John, and Christopher Woodruff, 1999, Interfirm Relationships and Informal Credit in Vietnam, *Quarterly Journal of Economics* 114, 1285–1320.
- Ng, Chee K., Janet Kiholm Smith, and Richard L. Smith, 1999, Evidence on the Determinants of Credit Terms Used in Interfirm Trade, *Journal of Finance* 54, 1109–1129.
- Petersen, Mitchell, and Raghuram Rajan, 1997, Trade Credit: Theory and Evidence, *Review of Financial Studies* 10, 661–691.
- Shaffer, Greg, 1991, Slotting Allowances and Resale Price Maintenance: A Comparison of Facilitating Practices, *The Rand Journal of Economics* 22, 120–135.
- Smith, Janet, 1987, Trade Credit and Informational Asymmetry, *Journal of Finance* 42, 863–869.
- Zettelmeyer, Florian, Fiona Scott Morton, and Jorge Solva-Risso, 2007, Scarcity Rents in Car Retailing: Evidence from Inventory Fluctuations at Dealerships, NBER working paper.

A Proofs.

Proof of Proposition 1:

There exists a subgame perfect Nash equilibrium under bank financing such that each supplier charges $P^B = \frac{2(qA_g + (1-q)A_b)}{3+n}$, each retailer orders an inventory $Q_g^B = \frac{(3+n-2q)A_g - 2(1-q)A_b}{(n+3)(n+1)}$, and sells exactly Q_g^B in a good state and $Q_b^B = \frac{2qA_g + (1+n+2q)A_b}{(n+3)(n+1)}$ in a bad state, respectively.

Proof. Solving the partial derivative and substituting the cost C_b^B , Equation (3) becomes

$$A_b - 2Q_b^B - Q_b^{-i,B} + P^B = 0 \quad (13)$$

which yields the best response function

$$Q_b^B = \frac{A_b - Q_b^{-i,B} + P^B}{2} \quad (14)$$

Assuming that all firms are symmetric we set $Q_b^{-i,B} = (n-1)Q_b^B$ and solve for the optimal quantity that the retailer offers in the bad state which is

$$Q_b^B = \frac{A_b - P^B}{n+1} \quad (15)$$

By substituting the cost C_g^B and the optimal quantity that the retailer offers in the bad state, Q_b^B , and solving the partial derivative, Equation (4) becomes

$$A_g - 2Q_g^B - Q_g^{-i,B} + P^B = 0 \quad (16)$$

which yields the best response function

$$Q_g^B = \frac{A_g - Q_g^{-i,B} + P^B}{2} \quad (17)$$

Assuming that all firms are symmetric, we set $Q_g^{-i,B} = (n-1)Q_g^B$ and solve for the optimal quantity that the retailer offers in the good state which is

$$Q_g^B = \frac{A_g - P^B}{n+1} \quad (18)$$

By substituting the optimal quantities, Q_b^B , Q_g^B , that the retailer offers in a bad state and a

good state, respectively, and solving the partial derivative, Equation (7) becomes

$$\frac{A_g q + A_b(1 - q) - 2P^B}{n + 1} = 0 \quad (19)$$

which yields the price charged by a supplier under bank financing,

$$P^B = \frac{2}{n + 3} [A_g q + A_b(1 - q)] \quad (20)$$

By substituting the equilibrium price into the Equation (15) and Equation (17), the quantities sold in the good state and the bad state are $\frac{(3+n-2q)A_g - 2(1-q)A_b}{(n+3)(n+1)}$ and $\frac{2qA_g + (1+n+2q)A_b}{(n+3)(n+1)}$, respectively.

This completes the proof. ■

Proof of Proposition 2

There exists a subgame perfect Nash equilibrium under bank financing such that each supplier charges $P^T = \frac{2(qA_g + (1-q)A_b)}{3+n}$ and sets the trade credit interest rate at $r_s = \frac{q(A_g - A_b)}{qA_g + (1-q)A_b}$, each retailer orders an inventory $Q_g^T = \frac{A_g}{n+3}$, and sells exactly Q_g^B in a good state and $Q_b^T = \frac{A_b}{n+3}$ in a bad state, respectively

Proof. Solving the partial derivative and substituting the cost C_b^T , Equation (3) becomes

$$A_b - 2Q_b^T - Q_b^{-i,T} + P^T(1 - r_s) = 0 \quad (21)$$

which yields the best response function

$$Q_b^T = \frac{A_b - Q_b^{-i,T} + P^T(1 - r_s)}{2} \quad (22)$$

Assuming that all firms are symmetric we set $Q_b^{-i,T} = (n - 1)Q_b^T$ and solve for the optimal quantity that the retailer offers in the bad state which is

$$Q_b^T = \frac{A_b - P^T(1 - r_s)}{n + 1} \quad (23)$$

By substituting the cost C_g^T and the optimal quantity that the retailer offers in the bad state, Q_b^T , and solving the partial derivative, Equation (4) becomes

$$q(A_g - 2Q_g^T - Q_g^{-i,T} - P^T) - (1 - q)P^T r_s = 0 \quad (24)$$

which yields the best response function

$$Q_g^T = \frac{q(A_g + P^T) - (1 - q)P^T r_s - Q_b^{-i,T}}{2} \quad (25)$$

Assuming again that all firms are symmetric, we set $Q_g^{-i,T} = (n - 1)Q_g^T$ and solve for the optimal quantity that the retailer offers in the good state which is

$$Q_g^T = \frac{(A_g - P^T)q - (1 - q)P^T r_s}{n + 1} \quad (26)$$

By substituting the optimal quantities, Q_b^T , Q_g^T , that the retailer offers in a bad state and a good state, respectively and solving the partial derivative, Equations (8) and (9) become

$$\frac{A_b(1 - q)q(1 - r_s) + A_g q(q + r_s - q r_s) - 2P^T(q + (1 - q)r_s^2)}{n + 1} = 0 \quad (27)$$

$$\frac{P^T(1 - q)[(A_g - A_b)(1 - q) + 2P^T r_s]}{(n + 1)q} = 0 \quad (28)$$

Simultaneously solving Equations (27) and (28) yields the price and trade credit interest rate charged by a supplier under trade credit financing,

$$P^T = \frac{2(qA_g + (1 - q)A_b)}{3 + n} \quad (29)$$

$$r_s = \frac{q(A_g - A_b)}{qA_g + (1 - q)A_b} \quad (30)$$

By substituting the equilibrium price and trade credit interest rate into the Equation (23) and Equation (26), the quantities sold in the good state and the bad state are $\frac{A_g}{n+3}$ and $\frac{A_b}{n+3}$, respectively.

This completes the proof. ■

Proof of Proposition 3

Under trade credit financing, the retailers' marginal cost is lower (higher) in the bad (good) state, competition is intensified (softened), and aggregate supply increases (decreases) relative to bank financing.

Proof. The marginal cost in the bad state

Under bank financing, Equation (10) becomes

$$MC_b^B = P^B + MFC_b^B \quad (31)$$

The marginal financing cost is zero in the bad state, thus, the marginal cost is equal to P^B .

Under trade credit financing, Equation (10) becomes

$$MC_b^T = P^T + MFC_b^T \quad (32)$$

The marginal financing cost is $-\frac{P^T r_s}{(1+r)}$ in the bad state, thus, the marginal cost is equal to $P^T - \frac{P^T r_s}{(1+r)}$, since $P^B = P^T$ at the equilibrium, the marginal cost under trade credit is lower in the bad state.

The marginal cost in the good state

Rearrange Equation (11), it becomes

$$MC_g = MPC + MFC_g^f + \frac{(1-q)}{q} MFC_b^f. \quad (33)$$

under bank financing, the marginal cost is equal to P^B since the marginal financing costs in both states are zero by assuming $r = 0$.

Under trade credit financing, the marginal product cost is P^T , the marginal financing cost in the good state is 0; and the marginal financing cost in the bad state is $\frac{(1-q)}{q} \frac{P^T r_s}{(1+r)}$, thus the marginal cost in a good state is $P^T (1 + \frac{(1-q)}{q} \frac{r_s}{(1+r)})$. Again, as $P^B = P^T$ at the equilibrium, the marginal cost under trade credit is higher in a good state.

This completes the proof. ■

Proof of Corollary 1

Under trade credit financing, the penalty rate r_s increases with the probability of a good state and the gap of choke prices in both states.

Proof. As $r_s = \frac{q(A_g - A_b)}{qA_g + (1-q)A_b}$, thus the partial derivative with respect to q is given by

$$\frac{\partial r_s}{\partial q} = \frac{A_b(A_g - A_b)}{(qA_g + (1-q)A_b)^2} > 0 \quad (34)$$

and the partial derivative with respect to $(A_g - A_b)$ is given by

$$\frac{\partial r_s}{\partial(A_g - A_b)} = \frac{q}{qA_g + (1-q)A_b} > 0 \quad (35)$$

This completes the proof. ■

Proof of Proposition 4 Under trade credit financing, the supplier optimally price discriminates the retailer between the states of demand: charging a high effective price $P_g^T = P^T(1 + \frac{1-q}{q} \frac{r_s}{1+r})$ in good states and a low effective price $P_b^T = P^T(1 - \frac{r_s}{1+r})$ in bad states. As a result, compared to bank financing, the profits of the supplier are higher under trade credit financing.

Proof. see the main text.

This completes the proof. ■

Proof of Proposition 5

In imperfect competition of at least two supply chains, the expected total producer surplus is higher, and the expected consumer surplus and total welfare are lower under trade credit financing than under bank financing.

Proof. By using the solutions obtained from Proposition 1 and Proposition 2, we have the explicit solutions of supplier and retailer's profits as well as consumer surplus for both bank financing and trade credit financing cases. Under bank financing, by substituting the equilibrium price, quantities sold by the retailer in both good and bad states into Equation 4 and 6, the profits obtained by the retailer and the supplier as well as the total producer surplus are shown as:

$$\omega^B = \frac{1}{(1+n)^2(3+n)^2} [A_g^2(9+n^2+n(6-4q)-8q)q - 8A_gA_b(2+n)(1-q)q + A_b^2(1-q)(1+n^2+8q+n(2+4q))] \quad (36)$$

$$\pi^B = \frac{2(A_b(1-q) + A_gq)^2}{(3+n)^2} \quad (37)$$

$$\omega^B + \pi^B = \frac{1}{(1+n)^2(3+n)^2} [A_g^2(9+6n-6q+n^2(1+2q)) + 4A_gA_b(n^2-3)(1-q) + A_b^2(1-q)(3+6n+6q+n^2(3-2q))] \quad (38)$$

Similarly, under trade credit financing, by substituting the equilibrium price, trade credit interest rate and quantities sold by the retailer in both good and bad states into Equation 4 and 7, the profits obtained by the retailer and the supplier as well as the total producer surplus are shown as:

$$\omega^T = \frac{A_b^2(1-q) + A_g^2q}{(3+n)^2} \quad (39)$$

$$\pi^T = \frac{2(A_b^2(1-q) + A_g^2q)}{(3+n)^2} \quad (40)$$

$$\omega^T + \pi^T = \frac{3(A_b^2(1-q) + A_g^2q)}{(3+n)^2} \quad (41)$$

Thus, the difference of producer surplus between trade credit financing and bank financing is

$$(\omega^T + \pi^T) - (\omega^B + \pi^B) = \frac{2(A_g - A_b)^2(n^2 - 3)(1-q)q}{(3 + 4n + n^2)^2} \quad (42)$$

From the above equation, we can find that when $n = 1$ (one supply chain or monopoly industry), the total producer surplus is smaller under trade credit financing than bank financing; however, if $n \geq 2$ (at least two supply chains or duopoly industry), the total producer surplus is greater under trade credit financing than bank financing.

This completes the proof. ■

Proof of Proposition 6

The difference in aggregate profits between trade credit financing and bank financing is an inverse U-shaped function in the number of supply chains.

Proof. For Equation (42), we take the partial derivative with respect to n , and then the first order condition is shown as:

$$\frac{\partial[(\omega^T + \pi^T) - (\omega^B + \pi^B)]}{\partial n} = \frac{4(A_g - A_b)^2(12 + 9n - n^3)(1-q)q}{(3 + 4n + n^2)^3} \quad (43)$$

then, when $n = 1$, we have $\frac{\partial[(\omega^T + \pi^T) - (\omega^B + \pi^B)]}{\partial n} = \frac{88(A_g - A_b)^2(1-q)q}{3375} > 0$ and when $n = \infty$, then $\frac{\partial[(\omega^T + \pi^T) - (\omega^B + \pi^B)]}{\partial n} = 0$. From this finding, we can see that the partial derivative is rising initially when n is very small but declines when n becomes very large, therefore, there exists an inverse U-shaped relationship between the advantage of trade credit financing and the number of supply chains.

This completes the proof. ■

Proof of Proposition 7

There exists an upper bound \bar{r} such that for all $r < \bar{r}$ the one time benefit of deviating to bank financing is smaller than the present value of future gains from trade credit financing.

Proof. To be completed ■