In–Kind Finance

Mike Burkart*   Tore Ellingsen**

August 6, 2002

Abstract

It is typically less profitable for an opportunistic borrower to divert inputs than to divert cash. Therefore, suppliers may lend more liberally than banks. This simple argument is at the core of our contract theoretic model of trade credit in competitive markets. The model implies that trade credit and bank credit can be either complements or substitutes depending on, amongst other things, the borrower's wealth. The model also explains why firms both take and give costly trade credit even when the borrowing rate exceeds the lending rate. Finally, the model suggests reasons for why trade credit is more prevalent in less developed credit markets and for why accounts payable of large unrated firms are more countercyclical than those of small firms.

JEL classification: G32.
Keywords: Credit rationing, trade credit, input monitoring.

---

*Address: Department of Finance and SITE, Stockholm School of Economics, Box 6501, SE—113 83 Stockholm, Sweden. Email: mike.burkart@hhs.se.

**Address: Department of Economics, Stockholm School of Economics, Box 6501, SE—113 83 Stockholm, Sweden. Email: tore.ellingsen@hhs.se.

This paper is produced as part of a CEPR project on Understanding Financial Architecture: Legal Framework, Political Environment and Economic Efficiency, funded by the European Commision under the Human Potential – Research Training Network program (Contract no HPRN-CT-2000-00064). Financial support from Riksbankens Jubileumsfond is gratefully acknowledged. We are grateful to Denis Gromb, Bengt Holmström, Raghuram Rajan, Andrei Shleifer, Javier Suarez, Jean Tirole and seminar participants at Bank of Norway, Bank of Sweden, CentER (Tilburg), the CEPR workshop on Banking and Financial Markets (Barcelona, 1999), ESSFM 2001, Norwegian School of Management, SITE (Stockholm), and University of Basel for helpful comments on this paper and its precursor. All remaining errors are our own.

1 Introduction

A remarkably stable feature of short term commercial lending is the central role played by input suppliers.[1] Suppliers not only sell goods and services, but extend large amounts of credit as well. While trade credit is less important nowadays than a century or two ago, it shows no signs of vanishing. Examining the balance sheets of publicly listed non–financial firms in the G7 countries, Rajan and Zingales (1995) find that accounts receivable vary from 13 percent of assets in Canada and 18 percent in the US to 29 percent in France and Italy. Accounts payable display less variation, ranging from 11.5 percent of assets in Germany to 17 percent in France. For non–listed European firms numbers are even larger (Giannetti, 2002).[2] Generally, the volume of trade credit by far exceeds the volume of short–term commercial bank credit. Understanding the mechanics of trade credit is therefore important not only to corporate finance specialists, but also to macroeconomists who want to investigate the credit channel of monetary policy.

In the presence of specialized financial institutions, it is puzzling that the exchange of goods is bundled with a credit transaction. It is particularly hard to understand why banks are unwilling to lend when suppliers, with inferior access to funds, are willing to do so (Petersen and Rajan, 1997). After all, a sizable fraction of firms end up regularly borrowing from their suppliers at annual interest rates above 40 percent (Petersen and Rajan, 1995). Why do not banks make these seemingly very profitable loans instead?

A common explanation for trade credit is that suppliers have a monitoring advantage over banks.[3] In the course of business, suppliers obtain information about the buyer which other lenders can only obtain at a cost, as argued by Schwartz and Whitcomb (1978,1979), Emery (1987), Freixas (1993), Biais and Gollier (1997), Jain (2001), among others. While the monitoring advantage theory is intuitively appealing, we think it suffers from two shortcomings. First, the literature has so far failed to give a convincing argument for why a bank, being specialized in the evaluation of borrowers' creditworthiness, would

[1]For an historical account, see for example Cameron (1967).

[2]Mian and Smith (1992) and Petersen and Rajan (1997) provide a closer examination of the US data.

[3]Of course, this is not the *only* explanation for the existence of trade credit. Other explanations are based on buyers' private information about their own willingness or ability to pay (Smith, 1987, and Brennan et al. 1988); on suppliers' private information about product quality (Smith, 1987, Long, Malitz and Ravid, 1993, and Lee and Stowe, 1993); on suppliers' advantage in liquidating collateral (Frank and Maksimovic, 1998); on tax effects (Brick and Fung, 1984); on long–term buyer/seller relationships (Wilner, 2000); and on the transaction costs of paying bills (Ferris, 1981).

frequently have less information than suppliers. Second, if many suppliers have information that banks do not have, why is their lending so closely tied to the value of the input transaction? That is, the theory has not explained why suppliers regularly lend inputs, but only very rarely lend cash.

In the present paper we propose a new theory of in–kind finance, based on a fundamental monitoring advantage that input suppliers have over other external creditors.[4] We argue that the source of the suppliers' informational advantage is the input transaction itself. Unlike other creditors, an input supplier automatically knows that an input transaction has been completed. Other creditors can only obtain this information by incurring monitoring costs. The value of input monitoring stems in turn from the fundamental difference between inputs and cash. Cash is easily diverted, in particular if diversion is interpreted broadly as any use of resources which does not maximize the lenders' expected return. In contrast, inputs are less easily diverted and hence less subject to moral hazard. Hence, input illiquidity facilitates trade credit. Another salient result of our model is that the availability of trade credit, by mitigating the moral hazard problem, also boosts the supply of bank credit.

Our theory can explain why firms are willing to extend trade credit despite having to take trade credit at a higher interest rate. In fact, the decision to extend trade credit is often trivial. If all accounts receivable can be sold (to a factoring company) or securitized, the own cost of capital is irrelevant to the decision to extend trade credit: the operation is self–financing. This argument also explains why the nominal trade credit interest rate is zero in many industries. Essentially, suppliers are able to extend trade credit at the bank interest rate. At the bank rate, buyers have no incentive to turn down the loan. Hence, the interest rate might as well be included in the standard price – i.e., the suppliers could offer net terms exclusively. Only when receivables are (partly) illiquid, and the suppliers as a group are sufficiently poor, does a supplier have to trade off real investment against investment in receivables. This mechanism might explain why profitable firms on average are more reluctant to supply trade credit, as noted by Petersen and Rajan (1997). If profitable firms on average have a high marginal return on real investment, and if trade credit extension is not entirely self–financing, this is what our theory would predict.[5]

---

[4]This is not to say that we provide a foundation for existing formal models. As will become clear, our notion of monitoring is different from the notion captured by, for example, Biais and Gollier (1997).

[5]Of course, if our theory is correct, profitability should not matter to trade credit supply by firms that are unconstrained in the bank credit market. Similarly, profitability should not matter less in industries where suppliers offer net terms. These are two of the predictions

Variation across countries and across time can also be understood within our model. With perfect legal protection of creditors, trade credit loses its edge, because it becomes as difficult to divert cash as to divert inputs. More generally, the importance of trade credit compared to bank credit should be greater when creditor protection is weaker, and when firms are undercapitalized due to entrepreneurs' lack of wealth. This may explain why trade credit is a considerably more important source of funding in Italy and France than in the US and Canada. As for variation over the business cycle, Meltzer (1960) famously argued that trade credit provides a cushion through which wealthy firms insure poorer firms against the consequences of tight money. Our model explains why the cushion is provided by most suppliers, not just the wealthy ones, and suggests that the cushion against tight money is most valuable for entrepreneurs with "intermediate" amounts of wealth. Very wealthy entrepreneurs don't need the cushion, and very poor entrepreneurs should see their trade credit limits move in tandem with their bank credit limits in a credit slump. This mechanism may explain Nilsen's (2002) finding that trade credit is more countercyclical for large firms (except among firms with a bond rating, as these firms never need to take costly trade credit).

At the core of our model is the conventional idea that moral hazard at the investment stage gives rise to credit rationing of poor entrepreneurs. When bank credit is the only source of funds, our competitive credit market model behaves like virtually any other model in the vast literature on credit rationing.[6] The debt capacity increases in the borrowers wealth, in the quality of the investment project, and in the level of creditor protection. Arguably, the basic model's only remarkable feature is the ease with which overdraft facilities emerge endogenously as equilibrium credit contracts. To this generic model we add a competitive input market and our two crucial assumptions: (i) inputs are less easily diverted than cash is, and (ii) input transactions are more easily observed by suppliers (who take part in them) than by banks.

The general idea that illiquid assets facilitate borrowing has earlier been explored by Myers and Rajan (1998). They argue that banks are able to attract depositors precisely because their loan portfolios are relatively illiquid. Our model is quite different, as it relies on lender asymmetries: Suppliers lend goods and services whereas banks lend cash. In the model of Myers and Rajan, bank deposits are all cash, so there is no corresponding asymmetry between lenders. In comparison with earlier theoretical work on trade credit, the most

---

that we hope to test in future work.

[6] As Holmström and Tirole (1997) point out, generic moral hazard models of credit rationing are useful because they give rise to a rich set of insights while maintaining a high degree of tractability.

closely related paper is Biais and Gollier (1997). Like us, they highlight the relationship between trade credit and bank finance. However, we think that their work is best seen as a general model of multiple lenders. Biais and Gollier's key assumption is that the bank and the supplier have different signals about the buyer's creditworthiness; heterogeneous signals apart, there is no difference between bank credit and trade credit.[7]

The paper is organized as follows. Section 2 presents the basic model. Section 3 studies the entrepreneurs' borrowing and investment decision when bank credit is the sole source of external funding. Section 4 introduces trade credit and contains all the main results. Section 5 concludes. Mathematical proofs are in the Appendix.

2 Model

We consider a risk-neutral entrepreneur who has observable wealth, $\omega \geq 0$, and has the opportunity to invest in a project. To begin with, we shall assume that the wealth consists entirely of cash, but we modify this assumption later. The entrepreneur's objective is to maximize his return to ω.[8]

The entrepreneur has access to a project that transforms an input into an output. (Multiple inputs would not affect the basic insights, but require tiresome additional notation.) Let q denote the amount of purchased input. This quantity is observable to the input supplier, but not to outside parties (the bank). We refer to the input quantity that is put into the project, I, as the *investment*. The project transforms input into output according to the production function $Q(I)$ that is deterministic, increasing and concave. The investment I is not verifiable to outsiders. The entrepreneur is a price taker in both the input and the output markets; the input price is normalized to 1, and the output price is denoted by p. The revenues pQ are assumed to be verifiable. In order to rule out trivial solutions, we assume that $Q(0) = 0$ (it is impossible to produce any output without input), and that $pQ'(0) > 1$ (neglecting interest rates, it is always profitable to produce a strictly positive quantity).

In the absence of wealth constraints, the optimal investment is given by the solution to the first–order condition $pQ'(I) - 1 = 0$. More generally, in a

[7]Another distinction between our work and that of Biais and Gollier is that they focus on the problem of borrower screening whereas we are concerned with borrower moral hazard. In screening models there is no obvious distinction between lending cash and lending inputs.

[8]The model can also be given other interpretations. E.g., the entrepreneur could be thought of a manager acting in the interest of existing shareholders, who have provided the equity capital ω.

perfect credit market with an interest rate r_B, the entrepreneur would ideally want to implement the first–best investment level, $I^*(r_B)$, where

$$pQ'(I^*) = 1 + r_B. \tag{1}$$

We assume that the entrepreneur is wealth constrained and cannot fund first-best investment internally, i.e., $\omega < I^*(r_B)$. Apart from his wealth, the entrepreneur has two potential sources of funding, bank credit and trade credit. The total supply of external funds is also going to be limited, because the entrepreneur cannot commit to invest all available resources into the project. More precisely, the entrepreneur may use (part of) the available resources to generate non–verifiable private benefits. We refer to such activities as *diversion.*

While both output and sales revenues are verifiable and can therefore be pledged to outside investors, neither the input purchase nor the investment decision are contractible. Thus, the entrepreneur enjoys project returns only after honoring all repayment obligations. Diverted resources, on the other hand, can be enjoyed in full and are only repaid to the extent that project returns are available. If all resources are diverted, nothing is repaid. The assumption that diverted resources yield zero return to outside investors is for simplicity only.[9]

Crucial to the model is that the two sources of external funding differ in their exposure to moral hazard. Each unit of diverted cash yields $\phi < 1$ units of private benefit, while each unit of diverted input yields $\beta\phi$ units of private benefit, where $\beta \in [0, 1)$.[10] We interpret ϕ as the level of *creditor vulnerability* (creditors are better protected if ϕ is small), whereas β is a measure of *input liquidity.* When β is large, the input can be transformed into private benefits almost as easily as cash. If β is small, the input cannot easily be diverted. An input can have low liquidity for several (related) reasons: It may have a very specific application (like special purpose machinery), it may be easy for creditors to monitor use and resale transactions, or the input may have a low second–hand value.

If $\phi = 0$ there is no diversion opportunity. If legal protection of creditors were perfect in this sense, it would always be possible to fund first–best investment even for a penniless entrepreneur. In order to make our problem

[9]While looting of companies by insiders is a relevant problem even in the United States, as documented by Akerlof and Romer (1993), empire building and other milder forms of opportunistic behavior are probably more important.

[10]The linearity of the "diversion technology" could be relaxed with no change in the results. What we need for some of our results is that diversion is never socially desirable.

interesting, we thus make the assumption that

$$\phi > \underline{\phi} = \frac{pQ(I^*(r_B)) - I^*(1+r_B)}{I^*(r_B)}. \tag{2}$$

In other words, diversion yields a private benefit in excess of the average rate of return to first–best investment.

As already indicated, both banks and suppliers are competitive. Banks offer contracts $\{(L_B, D_B(pQ, L_B))\}$, where L_B is an amount of cash (the principal) that the bank is willing to lend to the entrepreneur and D_B is the associated repayment obligation. In principle, the repayment can be made conditional on the size of the loan, L_B, and on the verifiable return from investment, $pQ(I)$. Thus, we do not rule out, for instance, external equity finance. What we do rule out is a contract that depends directly on the investment I or the input purchase q. In reality, banks may try to contract on input purchases, but it is costly to monitor that the clause is being adhered to. The practice of using *sight bills*, quite common a century ago, illustrates that bank monitoring is possible but costly. Suppliers would ship inputs to some port, with the bank as recipient. The bank would inspect the goods, making sure that quality and quantity were in accordance with the contract, and if so agree to pay for them. The buyer would then obtain the goods in return for taking a loan from the bank. The rate of interest would reflect the bank's substantial administrative costs. Of course, this procedure could also entail unfortunate delays for the buyer. To highlight the distinction between trade credit and bank credit we here assume that these monitoring costs are prohibitive. For simplicity, we also assume that lending is exclusive, in the sense that the entrepreneur may not borrow from multiple banks or multiple suppliers at the same time.[11] A particular kind of contract is the *overdraft facility* $\{(L, (1+r_B)L)\}_{L \leq \bar{L}}$, which specifies a credit line $\bar{L}$ and a constant interest rate r_B. We shall start out by assuming that all banks offer overdraft facilities, but this is without any loss of generality. As we show below, no other contract can upset an equilibrium in overdraft facilities.

Similarly, suppliers offer contracts of the form $\{(L_S, D_S(pQ, L_S, q), q)\}$, where L_S is an amount of trade credit and D_S is the repayment obligation. Again, the contract is exclusive and does not specify I. It is, however, obviously possible to condition the contract on the input purchase, since the supplier costlessly obtains this information. This is the crucial difference between trade finance and bank finance.

[11]Without this restriction, the same equilibrium payoffs could be sustained through a variety of constellations of lenders, each providing a certain part of the external finance.

Observe that contracts cannot be conditioned on each other. For example, a loan offer by a bank cannot be conditioned on the amount of trade credit accepted by the entrepreneur. One justification for this assumption is that it is costly to verify contracts with third parties. (Even if the legitimacy of a voluntarily disclosed contract can be verified, it is much harder to verify the absence of additional contracts which undo the effects of the disclosed contract.) Moreover, the assumption buys simplicity and does not drive our main results.

The sequence of events is as follows.

1. Banks and suppliers simultaneously make their contract offers.

2. The entrepreneur chooses among the contract offers.

3. The entrepreneur chooses L_B, L_S and q.

4. The entrepreneur makes the investment/diversion decision.

5. The payoff realizes and repayments are made.

We characterize the subgame perfect equilibrium outcomes of this game.

3 Pure bank finance

In order to highlight the various features of the model, it is useful to first consider the case in which trade credit is unavailable. Showing that the model generates conventional credit rationing due to moral hazard in this setting is helpful for evaluating the additional results that are generated once trade credit is introduced.

Suppose for simplicity that banks have access to unlimited funds at constant marginal cost ρ. Competition among banks then drives their equilibrium profits to zero. Nonetheless, banks do not lend unlimited funds, because a sufficiently large loan tempts the entrepreneur to divert all the resources—in which case the bank would make a loss.

To make this insight precise, suppose for a moment that banks are constrained to offer overdraft facilities. Define

$$L^u = \min\{I^*(r_B) - \omega, \bar{L}\}. \tag{3}$$

If the entrepreneur abstains from diversion, the overdraft facility is utilized up to the point L^u. That is, a non–diverting entrepreneur either borrows enough to make the first–best investment or fully exhausts the credit line. Borrowing more (less) means that the marginal return on the investment is smaller (greater) than the marginal cost of funds. However, the entrepreneur is assumed to be opportunistic, so investment cannot be taken for granted. Once the entrepreneur gains access to the overdraft facility, he chooses I, q, and L to maximize utility,

$$U = \max\{0, pQ(I) - (1 + r_B)L\} + \phi[\beta(q - I) + (\omega + L - q)], \tag{4}$$

subject to the constraints

$$\begin{aligned} q &\leq \omega + L, \\ I &\leq q, \\ L &\leq \bar{L}. \end{aligned}$$

The first term is the residual return from investment, taking into account the entrepreneur's limited liability. The second term is the private benefit associated with diversion of inputs and cash respectively. Inspection of the problem reveals that the entrepreneur never finds it optimal to divert only a fraction of inputs, i.e., to choose $q > I > 0$. This option is dominated either by $I = q$ or by $I = 0$. Another dominated option is to divert only a fraction of available cash, i.e., to have $\omega + L_B > I > 0$. Once the entrepreneur plans to repay the loan in full, the marginal benefit from investment is at least $1 + r_B$, which is larger than the marginal benefit from diversion ϕ. If, on the other hand, the entrepreneur were to invest too little to repay the loan in full, there is no point in investing any resources at all, since any additional return would be claimed by the bank. Thus, diversion is essentially an all or nothing choice, the entrepreneur behaving prudently if and only if his residual return from investing exceeds the payoff from diverting all funds. That is, the credit line $\bar{L}$ has to satisfy the "global incentive constraint"

$$pQ(\omega + L^u) - (1 + r_B)L^u \geq (\omega + \bar{L})\phi. \tag{5}$$

Since diversion and hence default do not occur in equilibrium, the equilibrium interest rate must be $r_B = \rho$, as this is the only interest rate that yields zero profit for the banks. It remains to determine the equilibrium credit limit and consequent investment.

Proposition 1 *For any pair of parameters (ϕ, p) satisfying our assumptions, there exists a critical wealth level $\hat{\omega}(\phi, p) > 0$ such that entrepreneurs with less wealth than $\hat{\omega}$ are credit constrained and invest strictly less than $I^*(r_B)$. Entrepreneurs with more wealth than $\hat{\omega}$ borrow less than their credit limit and invest $I^*(r_B)$.*

To finance first–best investment, a poor entrepreneur with $\omega < \hat{\omega}$ would need to borrow substantially. The resulting large repayment obligation would leave him with a residual return below the payoff from diverting all available funds. Consequently, his credit limit constrains investment and is given by the binding incentive constraint

$$pQ(\omega + \bar{L}) - (1 + r_B)\bar{L} = (\omega + \bar{L})\phi. \tag{6}$$

(Lemma A1 in the Appendix shows that this constraint is binding for all wealth levels close enough to zero.) The credit limit cannot be lower in equilibrium. Otherwise, there would exist a contract with a higher limit and a higher interest rate that would be preferred by the bank as well as the constrained entrepreneur. By contrast, wealthy entrepreneurs need to borrow less money in order to fund first–best investment. With a small repayment obligation the residual return from investment exceeds the diversion payoff, and hence the entrepreneur's investment is unconstrained.

If the credit limit does not constrain investment, there is some ambiguity as to what the equilibrium credit limit would be. There is an interval of possible credit lines that yield the same utility for the entrepreneur. We resolve this issue by focussing on the equilibrium in which the banks offer the *maximum* credit line, as given by the solution to the incentive constraint under first–best investment,

$$pQ(I^*(\rho)) - (1 + \rho)(I^* - \omega) = (\omega + \bar{L})\phi. \tag{7}$$

Our main results do not depend on this tie–breaking choice. Notably, the equilibrium payoffs are unique. The assumption merely relieves us of the need to distinguish binding credit lines from non–binding ones when describing trade credit supply.

The equilibrium credit line has the following properties.

Proposition 2 *The equilibrium credit line $\bar{L}$ is increasing in wealth (ω) and in the output price (p), and is decreasing in creditor vulnerability (ϕ) and in the interest rate ρ.*

An increase in wealth lowers the entrepreneur's borrowing requirement and hence increases his residual return for a given investment level. It also increases his residual return for a given loan size, making larger repayment incentive compatible. As a result, the supply of credit (the credit line) increases in wealth. Both higher profitability and better lender protection increase the opportunity costs of diversion. Hence, larger repayment obligations and thus higher credit limits become incentive compatible. Finally, a higher bank interest rate lowers the entrepreneur's residual return for a given loan size. Thus, the credit line must be reduced in order to maintain incentive compatibility.

Actual lending varies in a more complicated way than does the credit line. Although a wealth shock affects the credit line of all entrepreneurs in the same manner, its impact on credit varies across poor and wealthy entrepreneurs. If all entrepreneurs become wealthier, those entrepreneurs that are credit constrained can and do borrow more, whereas unconstrained entrepreneurs borrow less.

These parameter changes also affect which entrepreneurs are credit constrained, i.e., the threshold $\hat{\omega}$. The effect is ambiguous for those parameters that move both the equilibrium credit line and the first–best level of investment. For example, an increase in the interest rate tightens the credit line and lowers the first–best investment level. Hence, the threshold $\hat{\omega}$ may go either up or down (See Lemma A2 in the Appendix).

The restriction to credit line contracts is immaterial for all the above results.

Proposition 3 *The equilibrium overdraft facility is an optimal contract.*

Another contract would only outperform the overdraft facility if it were to enable an entrepreneur with wealth below $\hat{\omega}$ to invest more. A larger investment is feasible only with a larger principal, which in turn requires a larger repayment (otherwise the bank incurs a loss). However, such a larger repayment obligation violates the entrepreneur's incentive compatibility constraint. To prove this, consider an optimal general contract $\{L, D(pQ, L)\}$. In order for there to be any investment at all, the contract must satisfy the global incentive constraint $pQ(\omega + L) - D(pQ, L) \geq \phi(\omega + L)$. The crucial term is the total repayment D. Given that banks do not accept to lose money, total repayment cannot be lower than $(1 + \rho)L$. But this is exactly the repayment implied by the overdraft facility. Since the global incentive constraint is the only binding constraint in the case of an overdraft facility, the latter is indeed an optimal contract.[12]

4 Bank finance and trade credit

When suppliers can extend credit, a new trade–off emerges. On the one hand, the use of trade credit improves the investment incentive because the supplier

[12] An optimal contract also has to guard against partial diversion, i.e., have the property that $pQ'(I)[1 - D_1'(pQ, L)] \geq \phi$. This constraint never binds in equilibrium under a debt contract, since (by definition) $D_1' = 0$ and rational investment implies $pQ'(I) \geq 1 + r_B \geq \phi$. Partial diversion can be a problem under other contracts, such as an equity contract, where repayment is an increasing function of returns ($D_1' > 0$). (Typically, when entrepreneur moral hazard is the problem, equity can outperform debt only if the return from investment is uncertain.)

lends inputs, which are less easily diverted than cash. Unlike the bank, the supplier can also condition the supply of trade credit on the total purchase volume. On the other hand, the entrepreneur has more diversion opportunities. As before, the entrepreneur may divert cash. In addition (or alternatively), the entrepreneur may now divert inputs. This option was dominated above, because all inputs had to be paid in cash. With trade credit, it becomes possible to cheat the supplier as well.

To facilitate the analysis, let us now normalize ρ, the bank's cost of capital, to zero. Also, let us assume for simplicity that the suppliers' marginal cost of funds is constant at some rate $r > 0$.[13] Since trade credit will ease the bank credit constraint, we also need to strengthen our earlier parameter restriction. We now assume that

$$\phi > \underline{\phi}(\beta) = \frac{pQ(I^*(r)) - [1 + (1-\beta)r]I^*(r)}{\beta I^*(r)}. \tag{8}$$

Otherwise, even a penniless entrepreneur could fund first–best investment.

By the same reasoning as above (Proposition 2), we may without loss of generality confine attention to credit lines $\bar{L}_B$ and $\bar{L}_S(q)$. Since competition drives the profits of banks and suppliers to zero, we know that equilibrium interest rates are 0 and r respectively. We shall say that the bank credit limit is binding if $I^*(0) > \bar{L}_B$ and that the trade credit limit is binding if $I^*(r) > \bar{L}_B + \bar{L}_S(I^*(r))$.

Because $r > 0$, the entrepreneur only utilizes trade credit in equilibrium if he is sufficiently tightly rationed in the bank credit market. More precisely, trade credit is desired at an interest rate r if and only if $\bar{L}_B + \omega < I^*(r)$. Suppose that $\bar{L}_B$ is such that this inequality holds. If the entrepreneur abstains from diversion, he purchases inputs $q = \omega + L_B + L_S$ and utilizes trade credit

$$L_S^u = \min\{I^*(r) - \bar{L}_B - \omega, \bar{L}_S\}. \tag{9}$$

That is, a prudent entrepreneur takes just enough trade credit to sustain the first–best investment level given the marginal cost of funds, r. If first–best investment is beyond reach, the prudent entrepreneur invests as much as the credit lines allow.

As noted above, investment cannot be taken for granted. The entrepreneur's problem after having accepted the contract offers of one bank and one supplier

[13] If the suppliers were to have lower costs of funds than the banks, there would be no bank credit in our model. Of course, any supplier who faces a binding bank credit constraint indeed has a higher opportunity cost of funds.

is to choose q, I, L_B, and L_S to maximize his utility

$$U = \max\{0, pQ(I) - L_B - (1+r)L_S\} + \phi[\beta(q-I) + (L_B + L_S + \omega - q)] \quad (10)$$

subject to the constraints

$$\begin{aligned} q &\leq \omega + L_B + L_S, \\ I &\leq q, \\ L_B &\leq \bar{L}_B, \\ L_S &\leq \bar{L}_S(q). \end{aligned}$$

As in the case of bank credit only, the entrepreneur never finds it optimal to divert a fraction of inputs or cash. Consequently, there are only two relevant temptations facing the entrepreneur. First, he may exhaust the available trade credit only to divert all inputs and any remaining cash. This temptation is only resisted (in favor of investing in the project) if

$$pQ(\bar{L}_B + L_S^u + \omega) - \bar{L}_B - (1+r)L_S^u \geq \phi[\beta q + (\bar{L}_B + \bar{L}_S + \omega - q)].$$

The left hand side of the inequality is the entrepreneur's maximum return from investment; the right hand side is the entrepreneur's return from borrowing a maximum amount and then diverting all resources.[14]

A noteworthy property of this expression is that any transformation of cash into input reduces the value on the right hand side. Hence, the maximum incentive compatible trade credit limit is increasing in q and reaches its maximum when all funds are used to buy inputs. We refer to this maximum trade credit limit as $\bar{L}_S$, which is defined as the solution to the equation

$$pQ(\bar{L}_B + L_S^u + \omega) - \bar{L}_B - (1+r)L_S^u = \phi\beta(\bar{L}_B + \bar{L}_S + \omega). \quad (11)$$

The second relevant temptation is not to purchase any inputs at all (in which case the supplier does not offer any trade credit, so $L_S = 0$) and to divert the cash $\omega + \bar{L}_B$. The entrepreneur abstains from diverting all cash only if

$$pQ(\bar{L}_B + L_S^u + \omega) - \bar{L}_B - (1+r)L_S^u \geq \phi(\bar{L}_B + \omega). \quad (12)$$

Hence, the equilibrium credit limits are determined by the incentive constraints (11) and (12).

[14] Since revenues are verifiable, the bank can claim project returns even if all the bank's money has been diverted. Thus, diverting all resources dominates diverting some (or all) of the bank loan and investing some (or all) trade credit.

As we have already noted, sufficiently wealthy entrepreneurs do not utilize trade credit. As wealth decreases, some trade credit is used, and the investment level is determined by the first–order condition

$$pQ'(I) - (1 + r) = 0.$$

Eventually, for the poorest entrepreneurs, both bank credit and trade credit are fully exhausted.

Proposition 4 *For given parameters (β, ϕ, p) there exist critical wealth levels $\tilde{\omega}_1 > 0$ and $\tilde{\omega}_2 > \tilde{\omega}_1$ such that: (i) entrepreneurs with wealth above $\tilde{\omega}_2$ take no trade credit and invest $I \in [I^*(r), I^*(0)]$; (ii) entrepreneurs with wealth inbetween $\tilde{\omega}_1$ and $\tilde{\omega}_2$ take trade credit and invest $I^*(r)$; (iii) entrepreneurs with wealth below $\tilde{\omega}_1$ exhaust both bank and trade credit limits and invest less than $I^*(r)$.*

The investment of entrepreneurs with wealth above $\tilde{\omega}_2$ is unaffected by the availability of trade credit, because they can already invest $I^*(r)$ or more. However, all entrepreneurs with less wealth than $\tilde{\omega}_2$ would have invested less than $I^*(r)$ if trade credit was unavailable. In general, these entrepreneurs invest more when trade credit is available than if bank credit is the sole source of funds. Compared to the pure bank lending regime, the introduction of trade credit therefore increases efficiency.

Regarding the supply of bank credit, as given by the bank credit limit $\bar{L}_B$, the comparative statics are qualitatively the same as under the pure bank lending regime. Higher wealth and output price increase bank credit supply, and higher creditor vulnerability decreases it. As one might suspect, the impact of these parameters on the trade credit limit is analogous. Thus, our model is comfortingly consistent with the evidence of Petersen and Rajan (1997) that the supply of trade credit is positively related to various measures of overall creditworthiness. The positive co–movement between the two credit limits is in fact completely general, because both limits are also decreasing in input liquidity and in the trade credit interest rate.

Proposition 5 *(i) For an entrepreneur with wealth smaller than $\tilde{\omega}_1$ the equilibrium credit lines $\bar{L}_B$ and $\bar{L}_S$ are increasing in the output price (p) and in the entrepreneur's wealth (ω) and are decreasing in the creditor vulnerability (ϕ), in the input liquidity (β), and in the trade credit interest rate (r). (ii) For $\omega \in [\tilde{\omega}_1, \tilde{\omega}_2)$, the same results hold, except that $\bar{L}_B$ is independent of β.*

Perhaps the most surprising result is that the supply of bank credit is decreasing in input liquidity and in the trade credit interest rate. After all, neither of these parameters enter the incentive constraint (12) directly. Bank credit is nonetheless sensitive to input liquidity and to the trade credit interest rate, because the availability of additional trade credit makes investment more valuable compared to diversion. Additional trade credit increases the investment size, and thereby the entrepreneur's residual return. (Technically, the left hand side of (12) is increasing in L_S^u.) By implication, any entrepreneur who is rationed in the bank is offered more bank credit when trade credit is available than when it is unavailable. The supply of bank credit and trade credit are complements.

The complementarity between bank credit and trade credit does not imply that the proportion between the two is fixed. When β is close to 1, $\bar{L}_S$ is close to zero, so a reduction of β obviously leads to an increase in $\bar{L}_S/\bar{L}_B$. However, this relationship need not be monotonic. While it is difficult to sign the impact of β on the ratio of trade credit to bank credit, the ratio of trade credit to investment is unambiguous.

Proposition 6 *The ratio $\bar{L}_S/I$ is decreasing in β.*

The proof is easy. Divide equation (11) by (12) to get

$$L_S = (\omega + L_B)(1-\beta)/\beta.$$

It follows immediately that the ratio of trade credit to investment is

$$\frac{L_S}{\omega + L_B + L_S} = 1 - \beta. \tag{13}$$

The intuition is also straightforward. Input illiquidity increases both credit limits, but not the entrepreneur's wealth. This result, that users of illiquid inputs utilize relatively more trade credit than users of liquid inputs, is a unique prediction of our model that would be interesting to test.

Proposition 6 also suggests a trade–off between the financing capacity of a project and its technologically efficient input–mix. Suppose a project requires several inputs of differing liquidity, and that trade credit is available. Unless the technology requires inputs in fixed proportions, a financially constrained firm can gain by deviating from the technologically efficient input mix and rely more on relatively illiquid inputs. The additional credit generated by a reduction of liquidity compensates for lower productive efficiency. Such technology distortion should be particularly pronounced in countries with poor legal protection of creditors, since this is where credit limits are more likely to bind. We are not aware of any study that directly addresses this issue. However, Claessens and Laeven (2001) document that firms in countries with poor property rights protection apply technologies that are more intensive in tangible capital. This occurs even when the legal structure is such that it gives little collateral value to the fixed assets. Since workers in poor countries (workers are the most common suppliers of intangible assets) are often not in a position to extend any credit at all, firms may need substantial bank credit to fund investment in intangible assets that also tend to deliver slow returns.[15] Given that banks are reluctant to lend, it may be better to operate on a larger scale using a technology that delivers faster returns and uses tangible inputs that are funded by trade credit.[16]

So far we have only been concerned with trade credit supply. When supply is not a binding constraint, we can characterize trade credit demand, i.e., the use of trade credit by entrepreneurs who are rationed only in the bank credit market.

Proposition 7 *For entrepreneurs with wealth $\omega \in (\tilde{\omega}_1, \tilde{\omega}_2)$ trade credit utilization L_S is decreasing in the entrepreneur's wealth (ω) and increasing in creditor vulnerability (ϕ). The effects on L_S of an increase in the output price (p) or in the trade credit interest rate (r) are indeterminate.*

These entrepreneurs borrow up to the bank credit limit and invest $I^*(r)$, which is independent of both wealth and of creditor vulnerability. Following a change in either ω or ϕ, the entrepreneurs continue to invest $I^*(r)$ and compensate the reduction (increase) in $\bar{L}_B$ fully by an increase (reduction) in L_S. In other words, there is only a *credit substitution* effect. This reasoning does not apply to variations in the output price or in the trade credit interest rate, because these parameters affect $I^*(r)$. Therefore there is a *credit volume* effect as well. For example, an increase in r leads to a decrease in $I^*(r)$ as well as in L_B. The total effect on trade credit depends on which reduction is larger. Notably, trade credit can easily be a "Giffen good", in the sense that trade credit demand is an increasing function of r over some range. This only requires that I^* is relatively insensitive to r, in which case the credit substitution effect dominates.

Our theory predicts a sharp difference in trade credit dynamics depending on whether the borrower is rationed in the trade credit market or not. For those that are constrained, bank credit volumes and trade credit volumes move in the same direction. For those who are not constrained by their trade credit limits, bank credit and trade credit should often (though not always) move in opposite directions. When there is a general credit crunch due to a drop in corporate

[15]If workers can extend credit, our theory says that this should be utilized by capital constrained firms. Perhaps it is no coincidence that wage payment is delayed more as workers get richer. The convention in Western countries has moved from payment daily and weekly, to fortnightly and monthly pay.

[16]Denis Gromb has pointed out that our model implies that consultancy firms and law firms should extend substantial trade credit, since these services are highly illiquid.

wealth, unconstrained firms that already take some trade credit take more of it. However, constrained firms have to reduce their use of trade credit in tandem with the tighter bank credit limits. This finding sheds light on the "puzzle" recently reported by Nilsen (2002) that large US firms without a bond rating increase their use of trade credit during monetary contractions more than unrated small firms do. This finding has been considered puzzling because large firms are considered to be financially sounder and hence supposedly less dependent on trade credit than small firms are. We think that this is indeed true. The crux is that those (often small) firms that are most dependent on trade credit *cannot* increase their trade credit borrowing in recessions because they already exhaust their trade credit limit. To put it bluntly: The only thing worse than having to increase trade credit borrowing is to be unable to do so. Conventional wisdom therefore holds only for the comparison between rated versus unrated firms. Firms with bond rating do not need to utilize costly trade credit even in a recession, so their trade credit volumes should be cyclical, tracking the change in input purchases.

If unconstrained firms dominate among those that take trade credit, our model produces countercyclical swings in trade credit, as has been observed in US data by Ramey (1992).[17] In less developed economies, it is likely that constrained firms dominate, in which case trade credit should be pro–cyclical with respect to wealth shocks. When the cycle is caused by swings in demand (p) rather than changes in wealth, the predictions are more ambiguous for any country, because unconstrained firms may take either more or less trade credit as demand changes.

As for cross–section variation in trade credit volumes, the model gives clear implications with respect to entrepreneurs' wealth and creditor protection.

Proposition 8 *The ratio of trade credit to investment is non–increasing in wealth (ω) and non–decreasing in creditor vulnerability (ϕ).*

For firms that are constrained in both markets, we know from (13) that the ratio L_S/I depends only on β. For firms that are only constrained in the bank credit market, bank and trade credit are substitutes with respect to changes in ω and ϕ (Proposition 7). Hence, the ratio of trade credit to investment is decreasing in ω and increasing in ϕ. Proposition 8 is broadly confirmed by the balance sheet data of Rajan and Zingales (1995) and Giannetti (2002), which indicates that trade credit is more important in countries with worse creditor protection.[18] In Giannetti's sample of (predominantly) unlisted firms in eight

[17] Ramey's finding is sensitive to data set and method. For example, Oliner and Rudebusch (1996) do not find a countercyclical movement in trade credit.

[18] Recent empirical work by Fisman and Love (2001) indicates that the difference in firms'

European countries, accounts payable constitute on average 29 percent in Italy, 30 percent in France, and 36 percent in Portugal, while being only 11 percent in Netherlands and 15 percent in the UK.

So far, we have considered an entrepreneur who starts up a new venture, endowed with cash only. Such an entrepreneur cannot offer trade credit, because there is no output to sell. In order to investigate more closely the supply of trade credit, let us now consider instead an entrepreneur with a going concern.

For simplicity, suppose that a stock of output with market value ω is the only asset being left over from last period, once all outstanding debts have been repaid. If the entrepreneur sells all the output for cash, the situation is again exactly as depicted above. Suppose now that the entrepreneur can sell his output ω on credit at an interest rate s. As we have shown, it is typically not desirable to sell all the output on credit, because some cash payment is needed to keep customers from diverting. Suppose that a fraction κ of the output is sold on credit. After the sales transaction the entrepreneur obtains a cash balance of $(1-\kappa)\omega$ and trade credit claims with a face value of $\kappa\omega(1+s)$. Would the entrepreneur be willing to do this, considering the need for investment funds? Clearly, the answer depends on whether it is possible to borrow against the trade credit claims or not. Suppose transactions costs are zero, and that the trade credit claim is safe and verifiable. Then the entrepreneur can go to the bank and borrow $\kappa\omega(1+s)/(1+\rho)$ against it. If $s > \rho$, it is optimal to extend trade credit, because this financial investment does not in any way interfere with the real investment. On the contrary, the extension of trade credit leaves the entrepreneur with liquid wealth of more than ω, which in turn increases any credit limits he himself faces. As the entrepreneur's own cost of funds is irrelevant for this calculation, the model readily explains why some firms both take and give trade credit despite the fact that the borrowing rate r is sometimes higher than the lending rate s. If the market for trade bills is frictionless in the sense described above, the supplier is thus willing to extend any incentive compatible amount of trade credit as long as the trade credit interest rate is not below the bank rate.

Proposition 9 *If trade bills can be funded frictionlessly, suppliers' wealth does not affect the supply of trade credit, and the equilibrium trade credit interest rate equals the bank interest rate.*

---

performance across countries is smaller in industries that rely heavily on trade credit, as measured by trade credit use in the US. A possible interpretation of their finding is that US firms' funding advantage on average is smaller in these industries than in other industries; i.e., ϕ_{US} and ω_{US} are relatively low. Alternatively, these industries rely on sufficiently illiquid input everywhere, and so do not face binding credit constraints.

In this frictionless world, the *nominal* trade credit interest rate could actually be below the bank rate. If the effective trade credit interest rate equals the bank rate, no buyer has an incentive to borrow in the bank in order to buy inputs. Thus, instead of offering a small cash discount that no buyer takes, the supplier might as well offer net terms only, i.e., including the bank interest rate in the price to be paid in, say, 30 days. Here, then, is a straightforward rationale for the widespread use of "net" terms.

An objection to the above argument is that banks are rarely willing to lend up to the full value of trade credit claims; as a rule of thumb, banks typically offer only 80 percent (or less) as accounts receivable secured debt (Mian and Smith, 1992). Within our model, this policy can be explained as a response to the problem of reckless trade credit extension. If suppliers could lend fully against receivables, they might be tempted to lift their customers' trade credit limit beyond the incentive compatible level. Even if there is recourse, so the supplier is liable for bad bills, reckless lending is a problem, because the supplier himself may divert resources in anticipation of the customers' non–payment. This temptation is reduced if the bank caps lending against receivables.[19] Thus, the extension of trade credit could be limited by the ability to collateralize receivables. A credit constrained entrepreneur might thus prefer to invest scarce resources in the business rather than in receivables. This potentially explains why unprofitable firms extend more trade credit (as documented by Petersen and Rajan, 1997).[20]

In a competitive market, equilibrium trade credit interest rates are not driven by the financial status of a single supplier. The trade credit interest rate increase above the bank rate only if the suppliers *collectively* are credit rationed. This is our explanation for why trade credit terms are so similar within industries, and so heterogeneous across industries and countries (Ng et al., 1999; Marotta, 2001).

---

[19]Even if the supplier sets recklessly high trade credit limits, not all customers will take all the credit and default. By diverting resources despite the borrowing cap of 80 percent the supplier forgoes 20 percent of the revenue from the sound trade credit claims. Hence, the cap improves the supplier's incentive to lend prudently.

[20]A factor offers a potential circumvention of the trade–off between supplying trade credit and making business investments. Factoring offers instant payments against the trade bills, and heavily constrained entrepreneurs therefore prefer factoring to receivable secured debt. Of course, as our model suggests, factoring requires that the entrepreneur gives up some control of the credit granting and the credit enforcement process. (Otherwise, the incentive to engage in reckless lending is too strong.) The associated monitoring by the factor is costly, so in this case the supplier also faces a trade–off between trade credit extension and real investment. We refer to Mian and Smith (1992) and Sopranzetti (1998) for closer discussions of factoring.

In conclusion, then, trade credit should be provided independently of suppliers' characteristics as long as reckless lending can be controlled at a low cost. Only when reckless lending (or strategic default by buyers more generally) is a sufficiently large problem at the industry level should these characteristics start to matter, with financially strong and relatively unprofitable firms extending more trade credit.[21]

5 Final remarks

Suppliers lend goods and banks lend cash. This simple observation has been shown to provide a coherent explanation for the existence of costly trade credit in competitive credit and product markets. Confronting the theory with broad-brush evidence from previous studies, we think it stands up well. In future work we hope to investigate empirically the additional predictions that the theory generates.

There theory itself might also be extended in several directions. An obvious extension is to admit multiple periods. Such a model has the potential to explain, among other things, why bank credit is routinely rolled over, whereas trade credit is not. The reason is that the illiquidity of inputs is temporary. Once the input is transformed into output and sold for cash, the funding advantage of the supplier disappears. Hence, the duration of trade credit should be no longer than the time it takes to produce and sell. An overdraft facility, on the other hand, may be in principle be rolled over, because cash is equally liquid at any point in time. We are hopeful that our distinction between liquid and illiquid lending is fundamental enough to have implications for bankruptcy priority rules, but this extension requires the introduction of uncertain project outcomes, so that bankruptcy becomes an equilibrium phenomenon. Another topic for future research is the relationship between input liquidity and the boundaries of firms.

[21]If reckless lending is an extremely severe problem and suppliers are poor, we do not expect trade credit. Other forms of input–related bank lending, such as *sight bills* (mentioned in Section 2) could then emerge instead.

Appendix

Proof of Proposition 1

Proposition 1 is proved in the main text, with the exception of the existence and uniqueness of $\hat{\omega}(\phi, p)$.

Lemma A1: *There exists a unique threshold* $\omega = \hat{\omega}(\phi, p) > 0$ *such that* $\bar{L} + \hat{\omega} = I^*(r_B)$ *and* $pQ(\bar{L} + \omega) - (1 + r_B + \phi)\bar{L} - \phi\omega = 0$.

Proof: Recall that the credit line $\bar{L}$ is given by the binding incentive constraint

$$pQ(\bar{L} + \omega) - (1 + r_B)\bar{L} - \phi(\bar{L} + \omega) = 0.$$

Observe that the constraint is only binding if $pQ'(\bar{L} + \omega) - (1 + r_B + \phi) < 0$. (Otherwise L could be increased without violating the incentive constraint.) In order to show that there is a unique value of ω such that $\omega + \bar{L}(\omega) = I^*(r_B)$, it suffices to show (i) that $0 + \bar{L}(0) < I^*(r_B)$ and (ii) that $\bar{L}$ is (continuously) increasing in ω. Part (i) follows immediately from our assumption that $\phi > \underline{\phi}$ (equation 2). Part (ii) is established by differentiating the incentive constraint, to get

$$[pQ'(I) - (1 + r_B + \phi)]\, d\bar{L} + [pQ'(I) - \phi]\, d\omega = 0,$$

or equivalently,

$$\frac{d\bar{L}}{d\omega} = -\frac{[pQ'(I) - \phi]}{[pQ'(I) - (1 + r_B + \phi)]}.$$

The numerator is positive, because $pQ'(I) \geq (1 + r_B)$ by the first–order condition, and $\phi < 1$. As shown above, the denominator is negative whenever the incentive constraint binds. $\square$

Proof of Proposition 2

Proposition 2: *The equilibrium credit line* $\bar{L}$ *is increasing in wealth* (ω) *and in the output price* (p) *and decreasing in the ease of diversion* (ϕ) *and the interest rate* ρ.

Proof: The proof that $d\bar{L}/d\omega > 0$ is provided in (the proof of) Lemma A1. Totally differentiating the bank credit limit with respect to $\bar{L}$ and p yields

$$\frac{d\bar{L}}{dp} = -\frac{Q(\bar{L} + \omega)}{\left[pQ'(\bar{L} + \omega) - (1 + r_B + \phi)\right]}.$$

From the proof of Lemma A1 we know that the denominator is negative, and hence $d\bar{L}/dp > 0$. Totally differentiating the bank credit limit with respect to $\bar{L}$ and ϕ yields

$$\frac{d\bar{L}}{d\phi} = \frac{(\bar{L}+\omega)}{\left[pQ'(\bar{L}+\omega)-(1+r_B+\phi)\right]} < 0.$$

Finally, totally differentiating the bank credit limit with respect to $\bar{L}$ and ρ, recalling that $\rho = r_B$, yields

$$\frac{d\bar{L}}{d\rho} = \frac{\bar{L}}{\left[pQ'(\bar{L}+\omega)-(1+r_B+\phi)\right]} < 0.$$

□

In the pure bank lending regime, the threshold level of wealth has the folloing properties.

Lemma A2: *The critical threshold $\hat{\omega}(\phi, p)$ increases with the ease of diversion (ϕ), while a change in either the output prices (p) or in the interest rate (r_B) has an indeterminate effect on $\hat{\omega}(\phi, p)$.*

Proof: Substituting $\bar{L} = I^*(r_B) - \hat{\omega}$ into the binding incentive constraint that defines $\hat{\omega}$, we obtain $pQ(I^*(r_B)) - (1+r_B)\bar{L} = \phi(\bar{L}+\omega)$, which can be rearranged as $pQ(I^*(r_B)) - (1+r_B+\phi)I^*(r_B) + (1+r_B)\hat{\omega} = 0$. Totally differentiating with respect to $\hat{\omega}$ and ϕ yields

$$\frac{d\hat{\omega}(\phi,p)}{d\phi} = \frac{I^*(r_B)}{(1+r_B)} > 0.$$

Totally differentiating $pQ(I^*(r_B)) - (1+r_B+\phi)I^*(r_B) + (1+r_B)\hat{\omega} = 0$ with respect to $\hat{\omega}$ and r_B yields

$$\frac{d\hat{\omega}(\phi,p)}{dr_B} = \frac{[(1+r_B+\phi)-pQ'(I)]\frac{dI^*(r_B)}{dr_B} + (I^*(r_B)-\omega)}{1+r_B}.$$

From the proof of Lemma A1 we know that $[(1+r_B+\phi)-pQ'(I)] > 0$ and hence that the first term is negative. As the second term is positive, the overall sign is indeterminate. Similarly, totally differentiating with respect to $\hat{\omega}$ and p yields

$$\frac{d\hat{\omega}(\phi,p)}{dp} = \frac{[(1+r_B+\phi)-pQ'(I)]\frac{dI^*(r_B)}{dp} - Q(I^*(r_B))}{(1+r_B)},$$

which is also indeterminate. □

Proof of Proposition 4

Proposition 4 is proved in the main text, except for the existence and uniqueness of $\tilde{\omega}_1(\beta, \phi, p)$ and $\tilde{\omega}_2(\beta, \phi, p)$. Also we need to show that $\tilde{\omega}_2(\beta, \phi, p) > \tilde{\omega}_1(\beta, \phi, p)$. To prove these properties (and subsequent comparative-static results), it is helpful to define the function

$$h(I) = pQ'(I) - [1 + r + \beta(\phi - r)].$$

The following result is will be used repeatedly.

Lemma A3: *For all* $I < I^*(r), h(I) < 0$.

Proof: When both credit limits bind, (11) and (12) become

$$pQ(\bar{L}_B + \bar{L}_S + \omega) - \bar{L}_B - (1 + r)\bar{L}_S = \phi\beta(\bar{L}_B + \bar{L}_S + \omega) \tag{14}$$

and

$$pQ(\bar{L}_B + \bar{L}_S + \omega) - \bar{L}_B - (1 + r)\bar{L}_S \geq \phi(\bar{L}_B + \omega). \tag{15}$$

It follows that

$$\bar{L}_S = \frac{1 - \beta}{\beta}[\bar{L}_B + \omega].$$

Thus, $\bar{L}_B + \bar{L}_S + \omega = I = (\bar{L}_B + \omega)/\beta$. Substituting into (15) and rearranging, we have the following expression for the maximum incentive compatible investment level:

$$pQ(I) - [(1 + r)(1 - \beta) - \beta(1 + \phi)]I + \omega = 0. \tag{16}$$

By virtue of being maximal, the expression must have a negative derivative, i.e.,

$$pQ'(I) - [(1 + r)(1 - \beta) - \beta(1 + \phi)] < 0.$$

Slight rearrangement yields the desired result. □

We now complete the proof of Proposition 4 by establishing the existence and uniqueness of $\tilde{\omega}_1(\beta, \phi, p)$ and of $\tilde{\omega}_2(\beta, \phi, p)$ and $\tilde{\omega}_2(\beta, \phi, p) > \tilde{\omega}_1(\beta, \phi, p)$.

Lemma A4: *For any* $\phi > r$ *there exists a pair of threshold values* $\tilde{\omega}_1(\beta, \phi, p)$, $\tilde{\omega}_2(\beta, \phi, p)$ *such that*

i) $pQ(\bar{L}_B + \omega) - \bar{L}_B - \phi[\bar{L}_B + \omega] = 0$ *for* $\omega = \tilde{\omega}_2(\beta, \phi, p)$,

ii) $pQ(\bar{L}_B + \bar{L}_S + \omega) - \bar{L}_B - (1 + r)\bar{L}_S - \phi[\bar{L}_B + \omega] = 0$ *and* $pQ(\bar{L}_B + \bar{L}_S + \omega) - \bar{L}_B - (1 + r)\bar{L}_S - \phi\beta[\bar{L}_B + \bar{L}_S + \omega] = 0$ *for* $\omega = \tilde{\omega}_1(\beta, \phi, p)$,

iii) $\tilde{\omega}_2(\beta, \phi, p) > \tilde{\omega}_1(\beta, \phi, p) > 0$.

Proof: Part i): The threshold $\tilde{\omega}_2(\beta, \phi, p)$ is the smallest wealth such that the entrepreneur can fund $I^*(r)$ using bank credit alone. The proof of existence and uniqueness of this threshold is analogous to the proof of Lemma A1 and hence omitted.

Part ii): The threshold level $\tilde{\omega}_1(\beta, \phi, p)$ is the smallest wealth that admits investing $I = I^*(r)$ using both bank and trade credit. Since (16) gives the maximum investment level for a given level of wealth, the threshold level of wealth must satisfy

$$\tilde{\omega}_1(\beta, \phi, p) = [\beta(1+\phi) + (1-\beta)(1+r)]I^*(r) - pQ(I^*(r)). \tag{17}$$

The threshold exists and is unique if both $\bar{L}_B$ and $\bar{L}_S$ are increasing in ω. Totally differentiating (14) and (15) and solving yields

$$\frac{d\bar{L}_B}{d\omega} = -\frac{pQ'(I) - [(1-\beta)(1+r) + \beta\phi]}{h(I)} > 0$$

and

$$\frac{d\bar{L}_S}{d\omega} = -\frac{1-\beta}{h(I)} > 0,$$

where the inequalities follow directly from Lemma A3. Thus, both credit limits are increasing in ω.

Part iii) It follows from $\phi > r$ that $[\beta(1+\phi) + (1-\beta)(1+r)] < (1+\phi)$ and hence $\tilde{\omega}_2(\beta, \phi, p) > \tilde{\omega}_1(\beta, \phi, p)$. Finally, $\tilde{\omega}_1(\beta, \phi, p) > 0$ follows from the assumption that $\phi > \underline{\phi}(\beta)$.□

The threshold levels have the following properties.

Lemma A5: *The critical threshold $\tilde{\omega}_1(\beta, \phi, p)$ increases with the ease of diversion (ϕ) and the input liquidity (β), while a change in either the output prices (p) or in the interest rate (r) has an indeterminate effect on $\tilde{\omega}_1(\beta, \phi, p)$.*

Proof: Differentiation of (17) yields

$$\frac{d\tilde{\omega}_1(\beta, \phi, p)}{d\phi} = \beta I^*(r) > 0,$$

$$\frac{d\tilde{\omega}_1(\beta, \phi, p)}{d\beta} = (\phi - r)I^*(r) > 0,$$

$$\frac{d\tilde{\omega}_1(\beta, \phi, p)}{dr} = [\beta(1+\phi) + (1-\beta)(1+r) - pQ'(I)]\frac{dI^*(r)}{dr} + (1-\beta)I^*(r),$$

and

$$\frac{d\tilde{\omega}_1(\beta,\phi,p)}{dp} = [\beta(1+\phi) + (1-\beta)(1+r) - pQ'(I)]\frac{dI^*}{dp} - Q(I^*(r)).$$

From Lemma A3 we know that $[\beta(1+\phi) + (1-\beta)(1+r) - pQ'(I)] > 0$ and hence that the first term of $d\tilde{\omega}/dr$ is negative. As the second term is positive, the overall sign is indeterminate. Similarly, the sign of $d\tilde{\omega}/dp$ is indeterminate. □

Lemma A6: *The threshold $\tilde{\omega}_2(\beta,\phi,p)$ increases with the ease of diversion (ϕ) and decreases with the interest rate (r), while a change in the output prices (p) has a indeterminate effect on $\tilde{\omega}_2(\beta,\phi,p)$.*

Proof: The threshold $\tilde{\omega}_2$ is given by

$$pQ(I^*(r)) - (1+\phi)I^*(r) + \tilde{\omega}_2(\beta,\phi,p) = 0,$$

and since the investment is maximal, we have that $pQ'(I^*(r)) - (1+\phi) < 0$. Differentiation yields

$$\frac{d\tilde{\omega}_2(\beta,\phi,p)}{d\phi} = I^*(r) > 0,$$

$$\frac{d\tilde{\omega}_2(\beta,\phi,p)}{dr} = [(1+\phi) - pQ'(I)]\frac{dI^*(r)}{dr} < 0,$$

and

$$\frac{d\tilde{\omega}_2(\beta,\phi,p)}{dp} = [(1+\phi) - pQ'(I)]\frac{dI^*}{dp} - Q(I^*(r)).$$

As for $d\tilde{\omega}_2/dp$, the sign is indeterminate, because the first term is positive and the second term is negative. □

Proof of Proposition 5

Proposition 5: *(i) For an entrepreneur with wealth smaller than $\tilde{\omega}_1$ the equilibrium credit lines $\bar{L}_B$ and $\bar{L}_S$ are increasing in the output price (p) and in the entrepreneur's wealth (ω) and are decreasing in the creditor vulnerability (ϕ), in the input liquidity (β), and in the trade credit interest rate (r). (ii) For $\omega \in [\tilde{\omega}_1, \tilde{\omega}_2)$, the same results hold, except that $\bar{L}_B$ is independent of β.*

Proof: We start by proving part (i). For entrepreneurs with $\omega < \tilde{\omega}_1(\beta,\phi,p)$ the bank and trade credit limits are given by (14) and (15). Differentiating these two equations with respect to $\bar{L}_B$, $\bar{L}_S$, and p yields (after some manipulation)

$$\frac{d\bar{L}_B}{dp} = \frac{-\beta Q(I)}{h(I)}$$

and

$$\frac{d\bar{L}_S}{dp} = \frac{-(1-\beta)Q(I)}{h(I)},$$

which are both positive (the denominators are negative by Lemma 3).

The proof that $d\bar{L}_B/d\omega > 0$ and that $d\bar{L}_S/d\omega > 0$ is already provided in Lemma A4.

Differentiating the (14) and (15) with respect to $\bar{L}_B$, $\bar{L}_S$, and ϕ yields

$$\frac{d\bar{L}_B}{d\phi} = \frac{(\bar{L}_B + \omega)\beta}{h(I)}$$

and

$$\frac{d\bar{L}_S}{d\phi} = \frac{(\bar{L}_B + \omega)(1-\beta)}{h(I)},$$

which are both negative by Lemma A3.

Differentiating (14) and (15) with respect to $\bar{L}_B$, $\bar{L}_S$, and β yields

$$\frac{d\bar{L}_S}{d\beta} = -\frac{[\bar{L}_B + \bar{L}_S + \omega]\,[pQ'(I) - (1+\phi)]}{h(I)}$$

and

$$\frac{d\bar{L}_B}{d\beta} = \frac{[\bar{L}_B + \bar{L}_S + \omega]\,[pQ'(I) - (1+r)]}{h(I)}.$$

By Lemma A3, the denominator $h(I)$ is negative, and so is the numerator of $d\bar{L}_S/d\beta$. The numerator of $d\bar{L}_B/d\beta$ is positive, because $pQ'(I) > 1 + r$ at $I < I^*$.

Differentiating (14) and (15) with respect to $\bar{L}_B$, $\bar{L}_S$, and r yields

$$\frac{d\bar{L}_B}{dr} = \frac{\beta\bar{L}_S}{h(I)}$$

and

$$\frac{d\bar{L}_S}{dr} = \frac{(1-\beta)\bar{L}_S}{h(I)},$$

which are both negative by Lemma A3.

Part (ii) of Proposition 5 is proved in similar fashion. For entrepreneurs with $\omega \in [\omega_1(\beta,\phi,p), \hat{\omega}_2(\beta,\phi,p,))$ bank and trade credits are given by

$$pQ(\bar{L}_B + L_S + \omega) - \bar{L}_B - (1+r)L_S - \phi[\bar{L}_B + \omega] = 0$$

and

$$pQ'(\bar{L}_B + L_S + \omega) - (1+r) = 0.$$

The comparative static results are established by totally differentiating these two equations. We omit the details, except noting that β no longer appears in any of the expressions. $\square$

5.1 Proof of Proposition 7

Proposition 7: *For entrepreneurs with wealth $\omega \in (\tilde{\omega}_1, \tilde{\omega}_2)$ trade credit utilization L_S is decreasing in the entrepreneur's wealth (ω) and increasing in creditor vulnerability ϕ. The effects on L_S of an increase in the output price (p) or in the trade credit interest rate (r) are indeterminate.*

For changes in ϕ and ω we prove an even more precise result.

Lemma A7: *Following an increase in the ease of diversion (ϕ) entrepreneurs with $\omega \in (\tilde{\omega}_1, \tilde{\omega}_2)$ fully substitute the reduction in bank credit (supply) with trade credit, i.e.,*

$$\frac{d\bar{L}_B}{d\phi} = \left|\frac{dL_S}{d\phi}\right|.$$

Proof: For entrepreneurs with $\omega \in (\tilde{\omega}_1, \tilde{\omega}_2)$ bank and trade credit demand are independent of β and given by

$$pQ(\bar{L}_B + L_S + \omega) - \bar{L}_B - (1+r)L_S - \phi[\bar{L}_B + \omega] = 0 \quad (18)$$

and

$$pQ'(\bar{L}_B + L_S + \omega) - (1+r) = 0. \quad (19)$$

Differentiating (18) and (19) with respect to $\bar{L}_B$, L_S, and ϕ yields

$$[pQ'(I) - (1+\phi)]\, d\bar{L}_B + [pQ'(I) - (1+r)]\, dL_S - [\bar{L}_B + \omega]d\phi = 0$$

and

$$pQ''(I)d\bar{L}_B + pQ''(I)dL_S = 0.$$

Solving yields

$$\frac{d\bar{L}_B}{d\phi} = -\frac{[\bar{L}_B + \omega]}{(\phi - r)} < 0.$$

□

Lemma A8: *Following an increase in wealth, entrepreneurs with $\omega \in (\tilde{\omega}_1, \tilde{\omega}_2)$ fully substitute trade credit with bank credit.*

Proof: Differentiating (18) and (19) with respect to $\bar{L}_B$, L_S, and ω yields

$$\frac{d\bar{L}_B}{d\omega} = -\frac{[pQ'(I) - (1+r)]}{[pQ'(I) - (1+\phi)]}\frac{dL_S}{d\omega} - \frac{[pQ'(I) - \phi]}{[pQ'(I) - (1+\phi)]}$$

and

$$\frac{dL_S}{d\omega} = -\left[1 + \frac{d\bar{L}_B}{d\omega}\right].$$

Solving yields

$$\frac{d\bar{L}_B}{d\omega} = \frac{1}{(\phi - r)} - 1 > 0,$$

and

$$\frac{dL_S}{d\omega} = -\frac{1}{(\phi - r)} < 0.$$

□

Finally, we show that the effect of changes in p and r are indeterminate.

Lemma A9: *Following an increase in the trade credit interest rate r, entrepreneurs with $\omega \in (\tilde{\omega}_1, \tilde{\omega}_2)$ may demand more or less trade credit.*

Proof: Differentiating (18) and (19) with respect to $\bar{L}_B$, L_S, and r (and solving) yields

$$\frac{d\bar{L}_B}{dr} = \frac{[pQ'(I) - (1+r)]\,/pQ''(I) - L_S}{(\phi - r)} < 0$$

and

$$\frac{dL_S}{dr} = \frac{L_S}{(\phi - r)} - \frac{[pQ'(I) - (1+\phi)]}{pQ''(I)(\phi - r)} \gtrless 0.$$

□

Lemma A10: *Following an increase in the output price (p), entrepreneurs with $\omega \in (\tilde{\omega}_1, \tilde{\omega}_2)$ may demand more or less trade credit.*

Proof: Totally differentiating bank and trade credit demands with respect to $\bar{L}_B$, L_S, and p (and solving) yields

$$\frac{d\bar{L}_B}{dp} = \frac{Q(I)}{(\phi - r)} - \frac{[pQ'(I) - (1+r)]}{(\phi - r)}\frac{Q'(I)}{pQ''(I)} > 0$$

and

$$\frac{dL_S}{dp} = -\frac{Q(I)}{(\phi - r)} + \frac{[pQ'(I) - (1+\phi)]}{(\phi - r)} \frac{Q'(I)}{pQ''(I)} \lesseqgtr 0.$$

□

References

Akerlof, George and Paul M. Romer (1993): Looting: The Economic Underworld of Bankruptcy *Brookings Papers on Economic Activity* v. 0, iss. 2, 1–60.

Biais, Bruno and Christian Gollier (1997): Trade Credit and Credit Rationing, *Review of Financial Studies* 10, 903–937.

Brick, I E. and K H. Fung (1984): Taxes and the Theory of Trade Debt, *Journal of Finance* 39, 1169–1176.

Brennan, Michael J., Vojislav Maksimovic and Josef Zechner (1988): Vendor Financing, *Journal of Finance* 43, 1127–1141.

Cameron, Rondo (1967): *Banking in the Early Stages of Industrialization,* New York: Oxford University Press.

Claessens, Stijn and Luc Laeven (2001): Financial Development, Property Rights, and Growth, mimeo., University of Amsterdam.

Emery, Gary (1987): An Optimal Financial Response to Variable Demand, *Journal of Financial and Quantitative Analysis* 22, 209–225.

Ferris, J. Stephen (1981): A Transactions Theory of Trade Credit Use, *Quarterly Journal of Economics* 94, 243–270.

Fisman, Raymond and Inessa Love (2001): Trade Credit, Financial Intermediary Development and Industry Growth, mimeo, Columbia University.

Frank, Murray and Vojislav Maksimovic (1998): Trade Credit, Collateral, and Adverse Selection, mimeo.

Freixas, Xavier (1993): Short–Term Credit versus Accounts Receivable Financing, Universitat Pompeu Fabra, Economics Working Paper 27.

Giannetti, Mariassunta (2002): Do Better Institutions Mitigate Agency Problems? Evidence from Corporate Finance Choices, mimeo., Stockholm School of Economics.

Jain, Neelam (2001): Monitoring Costs and Trade Credit, *Quarterly Review of Economics and Finance* 41, 89–110.

Holmström, Bengt and Jean Tirole (1997): Financial Intermediation, Loanable Funds, and the Real Sector, *Quarterly Journal of Economics* 112, 663–691.

Lee, Yul W. and John D. Stowe (1993): Product Risk, Asymmetric Information, and Trade Credit, *Journal of Financial and Quantitative Analysis* 28, 285–300.

Long, Michael S., Ileen B. Malitz and S. Abraham Ravid (1993): Trade Credit, Quality Guarantees, and Product Marketability, *Financial Management* 22, 117–127.

Marotta, Guiseppe (2001): Is Trade Credit More Expensive than Bank Loans? Evidence from Italian Firm–Level Data, mimeo, Universita di Modena e Reggio Emilia.

Meltzer, Allan H. (1960): Mercantile Credit, Monetary Policy, and Size of Firms, *Review of Economics and Statistics* 42, 429–437.

Mian, Shezad L. and Clifford W. Smith (1992): Accounts Receivables Management Policy: Theory and Evidence, *Journal of Finance* 47, 169–200.

Myers, Stewart C. and Raghuram Rajan (1998): The Paradox of Liquidity, *Quarterly Journal of Economics* 113, 733–771.

Ng, Chee K., Janet Kiholm Smith and Richard L. Smith (1999): Evidence on the Determinants of Credit Terms in Interfirm Trade, *Journal of Finance* 54, 1109–1129.

Nilsen, Jeffrey H. (2002): Trade Credit and the Bank Lending Channel *Journal of Money, Credit and Banking* 34, 226–253.

Oliner, Stephen and Glenn Rudebusch (1996): Monetary Policy and Credit Constraints: Evidence from the Composition of External Finance: Comment, *American Economic Review* 86, 300–309.

Petersen, Mitchell A. and Raghuram Rajan (1995): The Effect of Credit Market Competition on Lending Relationships *Quarterly Journal of Economics* 60, 407–444.

Petersen, Mitchell A. and Raghuram Rajan (1997): Trade Credit: Theory and Evidence, *Review of Financial Studies* 10, 661–691.

Rajan Raghuram G. and Luigi Zingales (1995): What Do We Know about Capital Structure? Some Evidence from International Data, *Journal of Finance* 50, 1421–1460.

Ramey, Valerie A. (1992): The Source of Fluctuations in Money, *Journal of Monetary Economics* 30, 171–193.

Schwartz, Robert A. and David Whitcomb (1978): Implicit Transfers in the Extension of Trade Credit, in K.E Boulding amd T.F. Wilson (eds.) *The Channels of Redistribution through the Financial System,* New York: Praeger.

Schwartz, Robert A. and David Whitcomb (1979): The Trade Credit Decision, in J.L. Bicksler (ed.) *Handbook of Financial Economics,* Amsterdam: North–Holland.

Smith, Janet (1987): Trade Credit and Informational Asymmetry, *Journal of Finance* 42, 863–869.

Sopranzetti, Ben J. (1998): The Economics of Factoring Accounts Receivable, *Journal of Economics and Business* 50, 339–359.

Wilner, Benjamin S. (2000): The Exploitation of Relationships in Financial Distress: The Case of Trade Credit, *Journal of Finance* 55, 153–178.