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Trade Credits and Bank Credits in International Trade: Substitutes or Complements?

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Abstract

Trade credits are an important financing tool for internationally active firms. This is surprising, as trade credits are generally more expensive than bank credits and thus a costly substitute for bank financing. In this paper, we investigate the relation between trade credits and bank credits for exporting firms. We develop a theoretical model and show that trade credits convey a quality signal which reduces the risk of the transaction and may thus facilitate obtaining additional bank credits. Thus, for exporters who are not able to obtain bank credits in the first place, trade credits and bank credits are complements. Using panel data on German manufacturing firms, we provide supportive evidence for our theoretical predictions. For financially unconstrained firms, trade credits and bank credits are substitutes. For financially constrained exporters, instead, trade credits have a significantly positive effect on the availability of bank credits.

Keywords: Trade Credits, Bank Credits, International Trade, Financial Constraints

JEL: F10, G30

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1. Introduction

The financing of international transactions is a very important determinant of international trade, as the recent financial crisis has forcefully shown. According to WTO Trade Statistics, world merchandise exports declined by 12% in 2009, whereas world GDP declined by only 2.5%. A lack of finance during 2009 has been blamed as one of the reasons for this pronounced decrease in global trade (Amiti and Weinstein, Forthcoming).

Apart from internal finance, firms have two options for financing their international transactions. They can ask for a bank credit or they can make use of supplier credits. In the latter case, they delay paying their supplier, usually between 30 to 60 days. Supplier credits are typically more expensive than bank credits, with a real interest rate of 40 percent per year (Petersen and Rajan, 1997). Prima facie this suggests that supplier credits are expensive substitutes, only attractive for those firms that cannot obtain bank credit. Interestingly, however, supplier credits are used more intensively by internationally active firms than purely domestic firms. About 40 percent of international transactions are financed via supplier credits (IMF, 2009). Internationally active firms are also larger and more productive than domestic ones, as firm-level studies confirm (see e.g. Bernard et al., 2007, for a survey). This raises the question why internationally active firms rely to such a large extent on supplier credits and how this relates to their use of bank credits. In this paper we address this question both theoretically and empirically.

We start from the observation that firms active in international trade have higher financing needs than purely domestic firms. They generally have higher outlays (establishment of a distribution network abroad, etc.) and there is generally a longer delay between the production of the goods and the payment. Moreover, cross-border transactions are considered to be more risky (e.g. due to exchange rate risk, different legal systems, and less knowledge about the foreign market and the foreign trading partner). Thus, internationally active firms and banks financing these firms face a high uncertainty. These information asymmetries may hinder internationally active firms from obtaining bank credits. Most models of international trade consider a world without financial friction so that these facts are insufficiently taken into account. In our paper we will show that supplier credits can alleviate financial constraints as they can reduce the information asymmetries via a quality signal. Therefore,

supplier credits and bank credits are complements for financially constrained firms.

For this purpose we develop a model of a potential exporter who needs external finance for the production of export goods. In a world without asymmetric information, bank credits are cheaper than supplier credits because banks are more efficient in providing credits. With asymmetric information, however, bank credits get more expensive, even prohibitively so. If this is the case a supplier credit can provide a signal about the quality of the supplier which may lead to an additional provision of bank credit. The uncertainty the bank faces is reduced, so the bank charges a lower interest rate for any complementary bank credit. Thus, the use of supplier credits can facilitate the provision of additional bank credits due to a reduction in uncertainty.⁴

To test our signaling hypothesis we analyze whether supplier credits and bank credits are complements or substitutes. For this purpose, we use the Business Expectations Panel of the ifo Institute for Economic Research. This is a panel data set for the years 1994 to 2009 which has merged balance sheet data and data of the ifo Business Tendency survey for 3974 German companies. The data includes information on trade accounts payable and receivable and on bank debt from the balance sheet data. Additionally, it contains variables indicating a firm's export status and whether a firm is financially constrained or not. Thus, we have a direct measure of financial constraints and can avoid the problems arising from indirect measures such as balance sheet information.⁵

We estimate the relation between supplier credits and bank credits with the two-step GMM estimator for panel data proposed by Arellano and Bond (1991). As both bank credit influences supplier credit and vice versa, we face a reverse causality problem. Therefore, we assume sequential exogeneity and instrument supplier credit with its second lag. This is admissible because the second lag of supplier credit influences bank credit today, but bank credit today does not influence supplier credit two periods ago. The results indicate that bank credit and supplier credit are substitutes for financially unconstrained firms. For

⁴In a companion paper, we explicitly look at the overall effect of trade credit on the extensive and intensive margins of exporters and importers (Eck et al., 2011).

⁵See Fazzari et al. (1988) and Kaplan and Zingales (1997) for an extensive discussion.

financially constrained firms, however, we find evidence that the two forms of credit tend to be complements. As our theory suggests, we find this effect to be even stronger for financially constrained exporters. Thus our results confirm our theoretical predictions of the quality signal conveyed by supplier credit.

Our paper is related to three strands of the literature. First, it is related to the theoretical and empirical literature on trade credits. There are several theoretical articles which explain the existence and use of trade credits (see Fisman and Love, 2003, for a review). Closest to our approach is the warranty for product quality theory (Lee and Stowe, 1993). The authors argue that some industries may require trade credits as a guarantee for product quality, because the choice of trade credit terms offered by the supplier can serve as a signal of product quality. Klapper et al. (2011) find empirical evidence on the warranty for product quality hypothesis. This paper contributes to the literature by explaining the intensive use of supplier credits by internationally active firms. In international trade, quality uncertainty is even higher. Therefore we incorporate the warranty for product quality as a motivation for the extension of trade credit into our model of international trade. We show that supplier credits are an important financing tool for financially constrained exporters.

Second, we build on the literature on the relation between bank credit and trade credit. Up to now, papers which have dealt with the relation between bank credits and trade credits have focused only on national transactions. Biais and Gollier (1997) develop a model where the firm that extends the trade credit signals its belief in the credit worthiness of the firm it provides with trade credit. This in turn helps the firm receiving the trade credit obtain additional bank credits. Their argument requires that the trade partner has an information advantage relative to the bank. This seems to be at odds with the empirical evidence (Giannetti et al., 2011) which finds that suppliers have no persistent informational advantage. In contrast to Biais and Gollier (1997), in our model we assume that the firm extending trade credit signals its own quality, which seems to be the more natural and realistic assumption.

Empirically, Gama and Mateus (2010) find that in general, bank credits and supplier credits are substitutes. For smaller and younger firms, the substitution and complementary hypothesis are not mutually exclusive, however. Their interpretation of this result is that supplier credits signal the creditworthiness of the small firm to the bank, which can increase

the bank credit supply. Additionally, Giannetti et al. (2011) find that trade credits help firms secure financing from relatively uninformed banks or get better deals from their banks. Thus, they also confirm the complementary relation of supplier credits and bank credits. We go beyond their analysis by focusing on exporters for whom we expect the information problem for banks to be even larger. In contrast to previous findings we show that the complementary relationship between supplier credits and bank credits holds also for large firms. Most noteworthy, our results show that it is not size that determines the relation between supplier credits and bank credits, but whether a firm is financially constrained and whether it is internationally active.

The third strand of literature we build on are the papers on financial constraints in international trade. Manova (2010) shows that firms that have a high enough productivity level to become exporters may not be able to become internationally active if they are financially constrained. Bellone et al. (2010) and Feenstra et al. (2011) provide empirical evidence for the importance of financial constraints in international trade. While these studies have focused only on bank credit as a source of external finance, other recent papers add also supplier credits to the analysis (Ahn, 2010; Antràs and Foley, 2011; Schmidt-Eisenlohr, 2011). These studies focus on the optimal choice of financing modes in international trade considering supplier credits. Our paper extends this literature by showing that supplier credits and bank credits are not necessarily substitutes among which exporters have to choose but can also be complements.

The remainder of the paper proceeds as follows: In Section 2 we present the basic model and compare different forms of financing. Furthermore, we derive empirical hypotheses from the model. Section 3 presents the data and gives summary statistics. In Section 4 we explain the estimation strategy used and provide empirical results. Finally, Section 5 draws a conclusion.

2. Theoretical Framework

2.1. Basic setup

Consider a firm that decides whether or not to export depending on its productivity level.⁶ This productivity level may differ across firms. The firm needs to buy inputs to produce its final good that it can sell on the foreign market for an exogenously given market price p .⁷

The firm has the following Cobb-Douglas production function

$$f(q_1, \bar{q}_2) = x = [(1 + \beta)q_1]^{\frac{1}{2}} \bar{q}_2^{\frac{1}{2}} \quad (1)$$

where x is the quantity produced and q_1 and \bar{q}_2 are the input factors. \bar{q}_2 is a fixed input requirement. It can be interpreted as machines the quantity of which cannot be adjusted in the short run. $(1 + \beta)$ is the productivity level, where $\beta > 0$. Thus, an increase in the productivity level leads to a larger output using the same quantity of inputs.

The firm has to buy the inputs q_1 from a supplier at price p_1 . Minimizing costs for a given x leads to variable costs of production $k(x) = p_1 \frac{x^2}{(1+\beta)\bar{q}_2}$. The variable costs are marginally increasing in the quantity produced and are decreasing in the firm's productivity level and the fixed input requirement. Furthermore, the firm faces fixed costs. These fixed costs consist of the fixed input costs ($F = p_2\bar{q}_2$) on the one hand and fixed costs of exporting (F_{EX}) on the other hand. These fixed costs of exporting can stem from the establishment of a distribution network or the acquirement of knowledge about the foreign market, for example.

The input good is subject to a quality risk.⁸ With probability σ the supplier produces a product which is of good quality at marginal production costs of \bar{c} . With probability $1 - \sigma$ she produces low quality, at marginal costs \underline{c} , where $\bar{c} > \underline{c}$. The final good of the exporter can be sold only if the input used in the production process is of good quality, which is in

⁶We do not take into account the firm's domestic activities.

⁷We assume that the effect of the firm's production decision on the market price is negligible.

⁸For simplicity we will not consider quality uncertainty with respect to the exporter.

line with the O-Ring Theory (Kremer, 1993). The supplier knows her own quality, but the exporter does not.

The price to be paid for the input good, p_1 , is determined in a bargaining procedure between the exporter and the input supplier. In the following we assume that the exporter has all the bargaining power, i.e., can choose the input price p_1 and the supplier only has to choose whether or not to supply the input. If we allow the supplier to have some market power this changes our results only quantitatively, not qualitatively.

Production takes place in period $t = 0$. This is when the potential exporter has to incur the variable and the fixed costs. The revenues of the international transaction are generated in period $t = 1$. We assume that the potential exporter has no internal funds, thus external finance is needed to bridge this time lag. Our assumption about the distribution of bargaining power implies that the financing need of the exporter is minimized. It is straightforward to extend our analysis to cases when this assumption is relaxed. In the following, we will analyze different financing scenarios and derive the minimum productivity level necessary for successful exporting under these different financing scenarios.

2.2. Pure bank credit financing

Consider first the case where the firm asks the bank for a credit to cover the production costs. Like the exporter, the bank cannot judge the quality of the supplier. There is perfect competition in the banking sector. Thus, if the quality of the input good is unknown, it is necessary that

$$\sigma D(1 + r_B) = (1 + \bar{r}_B)D \quad (2)$$

for the bank to break even. σ represents the probability that the input is of good quality such that the exporter generates positive revenues and repays his credit. D stands for the amount of credit demanded, $(1 + r_B)$ is the gross interest rate charged by the bank and \bar{r}_B are the refinancing costs incurred by the bank. Therefore the gross interest rate charged by the bank amounts to

$$(1 + r_B) = \frac{(1 + \bar{r}_B)}{\sigma} \quad (3)$$

It is increasing with the refinancing costs and the quality risk (decrease of σ).

The exporter's profit function is now

$$\pi_{EX}^{BC} = \sigma px - \sigma \frac{(1 + \bar{r}_B)}{\sigma} \left[p_1 \frac{x^2}{(1 + \beta)\bar{q}_2} + F + F_{EX} \right] \quad (4)$$

The firm has expected revenues of σpx . The total costs will be financed via bank credit which is repaid with probability σ .

The exporter chooses the input price p_1 such that the profits are maximized. This implies choosing the smallest possible price p_1 that satisfies the incentive constraint of the high quality input supplier so that the input good is delivered.

$$p_1 q_1 - \bar{c} q_1 \geq 0 \quad (5)$$

Thus, the exporter will pay the supplier $p_1 = \bar{c}$.

Maximizing the firm's profits with respect to the quantity and plugging in p_1 yields

$$x = \frac{\sigma p (1 + \beta) \bar{q}_2}{2\bar{c}(1 + \bar{r}_B)}. \quad (6)$$

Plugging this into the profit function and setting it equal to zero gives the minimum productivity level necessary for successful exporting with bank credit financing

$$(1 + \beta)^{BC} \equiv \frac{4(1 + \bar{r}_B)^2 (F + F_{EX}) \bar{c}}{(\sigma p)^2 \bar{q}_2}. \quad (7)$$

Firms with a productivity level $1 + \beta \geq (1 + \beta)^{BC}$ will be able to export as they make at least zero profits. Firms with a productivity level smaller than the threshold level will not be able to start exporting.

Doing simple comparative statics, we find that the higher the costs, the higher the productivity a firm has to have in order to break even. In contrast, the higher the market price, the higher the revenues, so that the productivity threshold is lower. Moreover, the higher the quality uncertainty the firm faces, the lower are the expected revenues and the higher the productivity level has to be in order to export successfully. In case of no information asymmetries, $\sigma = 1$, firms need to be less productive to enter the foreign market.

2.3. Full supplier credit and bank credit financing

Firms with a productivity level below the minimum threshold necessary to afford bank credit financing may turn to supplier credits instead. The supplier delivers the input, but the potential exporter can pay it later. Usually, the payment can be made up to 30 to 60 days after delivery. By definition, the maximum amount of supplier credit extended are the costs of the input good (p_1q_1). The rest has to be financed via bank credit. To capture the idea that banks are inherently more efficient in supplying credits, we assume that the refinancing costs of suppliers, $(1 + \bar{r}_{SC})$, are higher, i.e., $(1 + \bar{r}_{SC}) > (1 + \bar{r}_B)$. Note that these refinancing costs, $(1 + \bar{r}_{SC})$ can also be interpreted as a measure of the financial constraint of the supplier.

Consider first the case where the supplier credit covers the total input good costs, p_1q_1 . In this case the exporter will condition the payment of the input on the success of resale. Only if the final goods can be sold on the foreign market successfully, will the exporter pay the supplier. Note that our assumption that the exporter has no internal funds to finance production precludes paying the supplier if there are no revenues from selling the good on the export market. Consequently, only good suppliers have an incentive to participate in the transaction. For the good supplier to be willing to do so, it is necessary that

$$p_1q_1 - \bar{c}q_1(1 + \bar{r}_{SC}) \geq 0 \quad (8)$$

Thus, the exporter will pay the supplier $p_1 = \bar{c}(1 + \bar{r}_{SC})$ if the export goods are successfully sold.

As only the good supplier will participate in the transaction, the quality uncertainty is eliminated. The bank therefore sets $\sigma = 1$ and is willing to finance the fixed costs at the interest rate $(1 + \bar{r}_B)$.

The exporter's profit function then looks as follows

$$\pi_{EX}^{SC} = px - \bar{c}(1 + \bar{r}_{SC}) \frac{x^2}{(1 + \beta)\bar{q}_2} - (1 + \bar{r}_B)(F + F_{EX}) \quad (9)$$

Applying the same procedure as before, we can derive the minimum productivity level necessary for successful exporting with supplier credit financing for the variable costs and bank

credit financing for the fixed costs

$$(1 + \beta)^{SC} \equiv \frac{4(1 + \bar{r}_B)(F + F_{EX})\bar{c}(1 + \bar{r}_{SC})}{p^2\bar{q}_2}. \quad (10)$$

Comparing (10) with (7) yields that firms who cannot afford bank credit financing are able to obtain supplier credit financing for the full variable costs and bank credit only for the fixed costs if and only if

$$(1 + \beta)^{SC} \leq (1 + \beta) < (1 + \beta)^{BC}.$$

Note that there exist parameter cases for which the supplier credit threshold is below the bank credit threshold if and only if

$$(1 + \bar{r}_{SC}) < \frac{(1 + \bar{r}_B)}{\sigma^2}. \quad (11)$$

This is summarized in the following Proposition.

Proposition 1. *The higher the quality uncertainty (lower σ), the more attractive is supplier credit financing relative to pure bank financing. Furthermore, the higher the refinancing costs of the supplier, the more expensive supplier credit financing gets.*

2.4. Partial supplier credit

Consider now the case where the exporter uses a supplier credit only for a fraction of the input costs, to save on high interest rates. In the following we will determine the minimum amount of supplier credit necessary to still solve the adverse selection problem. The rest of the production cost has to be covered by a bank credit.

The timing of the game is as follows:

1. Nature determines the supplier's type, ($T = \{G, B\}$), the good type ($T = G$) with probability σ and the bad type ($T = B$) with probability $1 - \sigma$. The supplier learns her type.
2. The exporter chooses the amount of supplier credit as a fraction $\alpha(T)$ of the costs of the input good $\left(p_1 \frac{x^2}{(1+\beta)\bar{q}_2}\right)$ and chooses the price he will pay for the input (p_1).

3. The bank observes the amount of supplier credit extended to the exporter by the supplier (but not the supplier's quality) and makes an offer to the exporter about an additional bank credit, choosing either a high $(\frac{1+\bar{r}_B}{\sigma})$ or low $(1 + \bar{r}_B)$ interest rate or no credit offer at all.
4. Depending on the decisions by the bank and the supplier, the firm decides whether to export or not in period $t = 0$.
5. In period $t = 1$ payoffs are realized.

Note that we assume that a fraction of the input costs can be paid later. Generally, however, the supplier credit equals the whole amount of an invoice, but the terms of payment vary, i.e., whether the invoice amount can be paid 30 or 60 days after delivery. It is straightforward to reinterpret the fraction α as a temporal instead of a quantitative fraction.

The profit function of the supplier is

$$\pi_{SU}(T) = \begin{cases} \alpha p_1 q_1 - (\bar{c}q_1 - (1 - \alpha)p_1 q_1)(1 + \bar{r}_{SC}) & \text{if } T = G \\ [(1 - \alpha)p_1 q_1 - \underline{c}q_1](1 + \bar{r}_{SC}) & \text{if } T = B \end{cases}$$

The good supplier gets paid the fraction α ($0 \leq \alpha \leq 1$) of the input costs in period $t = 1$. This reflects the repayment of the supplier credit. The rest of the input costs are paid at delivery in $t = 0$. The difference between the production costs of the input and the amount paid at delivery, $(\bar{c}q_1 - (1 - \alpha)p_1 q_1)$, has to be financed at the interest rate $(1 + \bar{r}_{SC})$.

The profit function of the bad supplier differs in that she never gets the rest of the purchasing price which is supposed to be paid later because the exporter generates no revenues. If the bad supplier extends a supplier credit, she delivers the good and receives only the amount which has to be paid immediately at delivery in $t = 0$.

We consider two types of equilibria, separating equilibria and pooling equilibria. In a separating equilibrium, the exporter will choose the amount of supplier credit and the input price such that he effectively screens the suppliers and only the good type will participate in the transaction. In a pooling equilibrium, the amount of supplier credit and the input price are chosen such that both types participate in the transaction and so the type of the supplier is not revealed.

2.4.1. Separating equilibrium

When does the supplier credit provide a credible signal that the input is of good quality? The signal is credible if the amount of supplier credit extended is large enough so that the supplier yields positive profits if she is of the good type and her profits equal zero if she is of the bad type. This guarantees that the bad type has no incentive to mimic the good type by granting a supplier credit. The amount of supplier credit necessary for a credible signal is given by

$$(1 - \alpha)p_1 \leq \underline{c} \quad \Rightarrow \quad \alpha^{sep} \geq 1 - \frac{\underline{c}}{p_1} \quad (12)$$

Furthermore, the participation constraint of the good supplier has to be fulfilled.

$$\alpha p_1 q_1 - (\bar{c} q_1 - (1 - \alpha)p_1 q_1)(1 + \bar{r}_{SC}) \geq 0 \quad (13)$$

From this we can derive

$$p_1 = \underline{c} + (\bar{c} - \underline{c})(1 + \bar{r}_{SC}) \quad (14)$$

$$\alpha^{sep} = \frac{(\bar{c} - \underline{c})(1 + \bar{r}_{SC})}{\underline{c} + (\bar{c} - \underline{c})(1 + \bar{r}_{SC})} \quad (15)$$

Consider the following belief structure of the bank. The bank believes that a supplier which extends a level of supplier credit of $\alpha \geq \alpha^{sep}$ is of the good type $Pr(G|\alpha \geq \alpha^{sep}) = 1$ and a supplier which extends a level of supplier credit of $0 \leq \alpha < \alpha^{sep}$ is of the bad type $Pr(G|0 \leq \alpha < \alpha^{sep}) = 0$. If the bank believes that the supplier is a good one, it will set $\sigma = 1$. If instead the bank believes that the supplier is of the bad type, it will not extend a bank credit at all. Using this belief structure of the bank we can check whether there exists a separating equilibrium in which the good supplier extends a fraction $\alpha(G) = \alpha^{sep}$ of supplier credit and the bad supplier chooses not to extend a supplier credit at all, $\alpha(B) = 0$.

The profit function of an exporter who finances the costs via supplier credits ($\alpha(G) = \alpha^{sep}$) and bank credits has the following form

$$\pi_{EX}^{SC/BC} = px - [(1 - \alpha^{sep})p_1(1 + \bar{r}_B) + \alpha^{sep}p_1] \frac{x^2}{(1 + \beta)\bar{q}_2} - (1 + \bar{r}_B)(F + F_{EX}) \quad (16)$$

The exporter has higher expected revenues compared to a situation with pure bank financing because he knows that the supplier is of good quality. Additionally, the bank charges a lower interest rate as it believes that the supplier is of good quality and sets $\sigma = 1$.

Again, the exporter maximizes profits with respect to the quantity. Plugging the optimal quantity into the exporter's profits and setting it equal to zero we get the minimum productivity level necessary to export successfully with a combination of supplier credit and bank credit financing:

$$(1 + \beta)^{SC/BC} \equiv \frac{4(1 + \bar{r}_B)(F + F_{EX}) [\underline{c}(\bar{r}_B - \bar{r}_{SC}) + \bar{c}(1 + \bar{r}_{SC})]}{p^2 \bar{q}_2}. \quad (17)$$

Proposition 2. *For firms with $(1 + \beta) \geq (1 + \beta)^{SC/BC}$ there exists a separating perfect Bayesian equilibrium, in which only the good suppliers extend supplier credits and the bank charges the low interest rate as it believes in the quality signal. The strategies and beliefs of this separating equilibrium are given by*

$[(\alpha(G) = \alpha^{sep}, \alpha(B) = 0)$, (gives bank credit at interest rate $1 + \bar{r}_B$, gives no bank credit), $Pr(G|\alpha \geq \alpha^{sep}) = 1$ and $Pr(G|0 \leq \alpha < \alpha^{sep}) = 0$].

Proof. See the Appendix. □

For firms with a productivity level $(1 + \beta) < (1 + \beta)^{BC}$, i.e., who cannot afford bank credit, supplier credit helps them to overcome their financial constraints and realize the international transaction if and only if

$$(1 + \beta)^{SC/BC} \leq (1 + \beta) < (1 + \beta)^{BC}.$$

Using (7) and (17), it is straightforward to see that there exist parameter cases for which the supplier credit threshold is below the bank credit threshold if the following condition holds

$$\underline{c}(\bar{r}_B - \bar{r}_{SC}) + \bar{c}(1 + \bar{r}_{SC}) < \frac{(1 + \bar{r}_B)\bar{c}}{\sigma^2}. \quad (18)$$

This is summarized in the following Proposition.

Proposition 3. *Consider firms with $(1 + \beta) < (1 + \beta)^{BC}$. Depending on the quality un-*

certainty σ , the difference in production costs of the suppliers $\bar{c} - \underline{c}$, the refinancing costs of the supplier \bar{r}_{SC} , and the refinancing costs of the bank \bar{r}_B , it is the more likely that the combination of supplier credit and bank credit yields a positive payoff for exporters who would not be able to receive pure bank financing

(1) the lower the refinancing costs of the supplier (\bar{r}_{SC}),

(2) the higher the refinancing costs of the bank (\bar{r}_B),

(3a) if $(1 + \bar{r}_{SC})\sigma^2 > (1 + \bar{r}_B)$: the lower the difference in production costs of the suppliers,

(3b) if $(1 + \bar{r}_{SC})\sigma^2 < (1 + \bar{r}_B)$: the higher the difference in production costs of the suppliers,

(4) the higher the quality uncertainty (lower σ) and hence importance of the signal.⁹ For $\sigma = 1$ pure bank credit financing is cheaper than supplier credit.

We have shown that a supplier credit can ease financial constraints due to two mechanisms. First, there is the direct channel. Supplier credits provide the firm with liquidity. Consequently, the amount of credit which has to be financed by the bank is reduced. Additionally, there is the indirect channel of supplier credit. The supplier can signal her quality via the extension of supplier credit. The supplier delivers the good, but the firm need only pay for it later. This means that in fact the exporter can condition the payment of the input good on the quality delivered. Accordingly, the risk of the transaction is reduced. Hence, the higher the risk of the transaction, the more attractive supplier credits become. As we have argued before, in our model suppliers can be national or international. However, supplier credits will be of higher importance for international suppliers as the uncertainty faced by the exporter and the bank will be higher than with a national supplier.

⁹This signaling effect is also of importance for domestically active firms, which we do not consider in our model. But as the uncertainty in international transactions is higher (e.g. foreign supplier), supplier credits play a more important role in international transactions.

2.4.2. Pooling equilibrium

Consider next the possibility of a pooling equilibrium where both suppliers give the same amount of supplier credit, $\alpha(G) = \alpha(B)$, with $0 \leq \alpha(T) < \alpha^{sep}$. In such a pooling equilibrium, the bank does not learn anything about the supplier's type. Hence, the same credit rate applies as in the case without supplier credit.

The exporter's profit function in a pooling equilibrium equals

$$\pi_{EX}^{pool} = \sigma p x - [(1 - \alpha)p_1(1 + \bar{r}_B) + \sigma \alpha p_1] \frac{x^2}{(1 + \beta)\bar{q}_2} - (1 + \bar{r}_B)(F + F_{EX}) \quad (19)$$

where the fraction of the input costs extended in form of supplier credit is $0 \leq \alpha \leq \alpha^{sep}$.

From the participation constraint of the good supplier we can derive that for a given α , the exporter sets the price p_1 in a pooling situation such that

$$\alpha p_1 q_1 \geq (\bar{c} - \underline{c})(1 + \bar{r}_{SC}) \quad (20)$$

Furthermore, for both suppliers to extend the same amount of supplier credit it has to hold that

$$(1 - \alpha)p_1 \geq \underline{c}$$

We can again derive the minimum productivity level necessary for successful exporting:

$$(1 + \beta)^{Pool} \equiv \frac{4(1 + \bar{r}_B)(F + F_{EX}) [\sigma(\bar{c} - \underline{c})(1 + \bar{r}_{SC}) + \underline{c}(1 + \bar{r}_B)]}{(\sigma p)^2 \bar{q}_2}. \quad (21)$$

Proposition 4. *For firms with $(1 + \beta) \geq (1 + \beta)^{Pool}$ there exists a pooling equilibrium with the following strategies*

[($\alpha(G) = \alpha(B)$), where $0 \leq \alpha(T) < \alpha^{sep}$], (gives bank credit at interest rate $(1 + \bar{r}_B)/\sigma$, gives bank credit at interest rate $(1 + \bar{r}_B)/\sigma$), $Pr(G|\alpha \geq \alpha^{sep}) = 1$, $Pr(G|0 \leq \alpha < \alpha^{sep}) = 0$ and $Pr(G|\alpha(G) = \alpha(B)) = \sigma$].

Proof. See the Appendix. □

For firms with a productivity level $(1 + \beta) < (1 + \beta)^{BC}$, i.e., who cannot afford bank credit, supplier credit in a pooling equilibrium helps them to realize the international transaction if

and only if

$$(1 + \beta)^{Pool} \leq (1 + \beta) < (1 + \beta)^{BC}.$$

Using (7) and (21) we can show that there exist parameter cases for which the supplier credit threshold is below the bank credit threshold if and only if

$$\sigma(1 + \bar{r}_{SC}) < (1 + \bar{r}_B). \quad (22)$$

If this condition holds, firms are enabled to export using supplier credit even though it provides an uninformative signal. The uninformative signal does not reduce the uncertainty, however. Comparing the separating cutoff with the pooling cutoff yields that the parameter range for which there exists a separating equilibrium is larger than the parameter range for the pooling equilibrium. Comparing the expected profits of the exporter, supplier, and bank, we can derive that firms prefer playing the separating rather than the pooling equilibrium.

Proposition 5. *The pooling equilibrium is Pareto-dominated by the separating equilibrium.*

Proof. See the Appendix. □

Thus, in our empirical predictions we restrict attention to the separating equilibrium.

2.5. Empirical hypotheses

Our theoretical model illustrates the ambivalent nature of supplier credits. On the one hand, bank credit financing can be substituted for by supplier credits for some or all of the variable costs. Thus, bank credits and supplier credits are substitutes. On the other hand, due to the reduction in risk, supplier credits can make the extension of a bank credit possible for firms that are financially constrained, i.e., that otherwise could not afford pure bank credit financing. For these firms, supplier credits and bank credits can be complements.

In the empirical part of this paper, we want to focus on the indirect channel portrayed in our theoretical model by looking at the relation between supplier credit and bank credit. We test whether a supplier credit alleviates financial constraints by helping firms get additional bank credit.

We cannot test directly whether supplier credits provide a quality signal to the bank. However, we can test whether supplier credits lead to more bank credits for financially constrained firms. In our model, firms with a high enough productivity level can afford bank credit to finance their international transaction. Therefore, they are not financially constrained. For them, supplier credit and bank credit are substitutes, as they have the option to finance the variable costs via supplier credit or bank credit. Firms with a lower productivity level, not high enough to afford a bank credit, are financially constrained. The availability of supplier credit helps these firms get additional bank credits in order to export. Therefore, we want to test empirically the following hypotheses:

Hypothesis 1: In general, bank credit and supplier credit are substitutes.

Hypothesis 2: For financially constrained firms, supplier credit and bank credit are complements.

Hypothesis 3: This complementary effect is stronger for internationally active firms.

3. Data

The dataset we use is the Business Expectations Panel of the ifo Institute for Economic Research provided by the Economic and Business Data Center (EBDC). It contains balance sheet data and data of the ifo Business Tendency Survey for 3974 German companies from the manufacturing sector for the years 1994 to 2009. The balance sheet data is taken from Amadeus and Hoppenstedt on a yearly basis. The ifo Business Tendency Survey is conducted on a monthly basis and contains mainly questions on the firms' business situation, expectations, and demand situation.¹⁰ It is an unbalanced panel.

The balance sheet data includes information on trade accounts payable and receivable and on bank debt. Additionally, the ifo Business Tendency Survey contains variables indicating whether a firm exports or not and whether a firm is financially constrained or not.

¹⁰For an overview of the collected variables, see Becker and Wohlrabe (2008) and for the methodological background of the survey, see Goldrian (2007).

Supplier Credit

We measure supplier credit taken by a firm by trade accounts payable scaled by total assets from the balance sheet data. We scale it as the supplier credit volume is directly linked to the size and the sales volume of a firm.¹¹ We take the logarithm as trade accounts payable divided by total assets is a highly skewed variable. The disadvantage of trade accounts payable is that they include not only voluntarily granted supplier credits but also delayed payments not agreed to by the supplier ex ante. One could argue that involuntarily extended supplier credits do not provide a quality signal. However, trade accounts payable are frequently used as a proxy for supplier credits (see for example Fisman and Love, 2003) and it is the best measure available to us.¹²

Bank Credit

The amount of bank credit a firm has is measured by the variable bank debt, also scaled by total assets from the balance sheet data. As bank debt divided by total assets is also highly skewed, we again take the logarithm.

Export Status

In the ifo Business Tendency Survey, firms are asked about their export status. From this we construct a dummy variable. As the firms are asked each month and we conduct our analysis on a firm-year basis, we collapse the data. We classify a firm as internationally active if it exported its product at least 20% of the time of a year.

¹¹By scaling the variable, we can use the nominal values, as the price effects cancel out.

¹²Another idea might be to take supplier credit use as a dummy variable as the extension of supplier credit provides the signal and one might argue that there is no linear effect, such as the more supplier credit the firm uses the more bank credit it gets. But the volume of trade accounts payable consists of several supplier credits from different suppliers, which all signal their quality. Consequently, there may be a linear effect. Furthermore, we do not have any zeros in our data. All firms have trade accounts payable in their balance sheet.

Financial constraints

The Ifo Business Tendency Survey contains also two questions concerning the financial situation of a firm. In one question the firms are asked whether they are constrained in their production due to financial constraints (yes/no). The second question asks how the firms judge the willingness of banks to give credits to firms (cooperative/normal/restrictive). The latter question is general in nature. However, we argue that firms will answer this question based on their own experience and thus, the answer reflects their financial situation.¹³ We take these two measures together and classify a firm as financially constrained if it answered at least once a year that it was hindered in production due to financial constraints or that it judges the willingness of banks to extend credits as restrictive or both. This variable thus provides us with a direct measure of financial constraints. Hence, we can overcome the problems raised by the discussion between Fazzari et al. (1988) and Kaplan and Zingales (1997) concerning the use of indirect measures of financial constraints such as investment–cash flow sensitivities.

Other control variables

We control for the productivity of a company which we measure as the logarithm of sales over the number of employees (Helpman et al., 2004). Additionally, we take into account the firm’s tangible assets. Again we divide the firm’s tangible assets by its total assets and take the logarithm (Gama and Mateus, 2010). Furthermore, we control for the growth of the firm’s sales to capture firm-specific growth prospects.

Table A.2 Panel A provides summary statistics for the variables we use in our analysis.¹⁴ The average number of employees of the firms in the dataset is 2489. The fraction of firms that are exporting is 93%. This high fraction can be explained by the fact that mainly large firms are included in the dataset. The Ifo Business Tendency Survey mainly addresses large

¹³These questions are not asked every month. The question on whether the firm was constrained in production due to financial constraints is asked in January, April, July and October. The question on the willingness of banks to extend credits is asked in March and August.

¹⁴These summary statistics are pooled over all the years for the regression sample.

firms. For large firms in Germany a fraction of exporters of about 80%–90% is reasonable (Burg et al., 2009). 15% of the firms report that they are financially constrained. The share of trade accounts payable relative to total assets is 8%. In comparison, the share of bank credit relative to total assets is 17%. Thus, we see that firms use a larger share of bank credits to finance their costs. However, the share of trade accounts payable is also quite high compared to the bank credit share. Hence, supplier credit is a significant source of financing.¹⁵

Comparing exporters to non-exporters in Table A.2 Panel B, we find that exporters are significantly larger than non-exporters. This is the usual result stated by a lot of researchers (see Bernard et al., 2007, for a survey) and the basis for the selection into exporting theory modeled by Melitz (2003). We also see that slightly fewer exporters are financially constrained than non-exporters. 15% of the exporters report being financially constrained compared to 20% of the non-exporters. However, there is no difference in the use of trade accounts payable relative to total assets between exporters and non-exporters. But when we compare financially constrained exporters to non financially-constrained exporters in Table A.2 Panel C, we find that financially constrained exporters use a significantly higher share of trade accounts payable than non financially-constrained exporters at the 1% significance level. This finding supports the theoretical results of our model. Those firms which do not get bank credit in the first place and are thus financially constrained, will use supplier credit. Furthermore, supplier credit financing is even more important for internationally active firms. This explains the difference in the use of supplier credit between financially constrained exporters and non financially-constrained exporters.

We have a missing data problem both in the survey data as well as in the balance sheet data. As mostly large firms answer the ifo Business Tendency Survey and have balance sheet data available our empirical analysis focuses on large firms. Therefore, we do not claim to have a representative sample of German manufacturing firms overall, but of large German manufacturing firms.

¹⁵Fisman and Love (2003) find a similar result for the share of trade accounts payable used for the US.

4. Estimation Strategy and Results

4.1. The effect of supplier credit on bank credit for financially constrained and unconstrained firms

To test the hypotheses derived above, we analyze the effect of trade credit on bank credit. The first hypothesis considers the general relation between bank credit and trade credit and the second hypothesis focuses on the effect of supplier credit on bank credit for financially constrained firms. To analyze the relation for both financially constrained and unconstrained firms the corresponding estimation equation is

$$BC_{it} = \beta_0 + \beta_1 SC_{it} + \gamma_1 SC_{it} * CON_{it} + \delta_1 \mathbf{x}_{it} + \eta_i + \lambda_t + \epsilon_{it} \quad (23)$$

Our dependent variable is the bank credit of firm i in period t (BC_{it}). Supplier credit is the explanatory variable of interest (SC_{it}). We also include an interaction term of supplier credit taken and a dummy indicating whether a firm is financially constrained or not. The variable \mathbf{x}_{it} includes a vector of control variables. These control variables are firm productivity, growth of sales, a dummy indicating whether the firm feels financially constrained, a dummy for whether the firm is exporting, and tangible assets. Furthermore, we include firm fixed effects (η_i) and time fixed effects (λ_t).

As both bank credit influences supplier credit and vice versa, we have a reverse causality problem. Facing its total financing needs, the firm decides simultaneously on how much to finance via bank credit and how much to finance via supplier credit. If the firm does not get enough or any bank credit, it will approach its supplier and ask for a supplier credit instead. In the other direction too, if the firm gets supplier credit, this might enable it to get an additional bank credit. We estimate this equation with the two-step generalized method of moments (GMM) estimator for panel data proposed by Arellano and Bond (1991). We use the finite sample correction of the asymptotic variance estimates derived by Windmeijer (2005). Generally, the two-step GMM estimator uses heteroskedasticity-robust standard errors, but in small samples the estimated standard errors tend to be too small. This is due to the presence of estimated parameters in the weight matrix.

We assume sequential exogeneity and instrument supplier credit with its second lag only

(this is the Anderson and Hsiao (1982) estimator) and its second- and third-lag (which is the Arellano and Bond (1991) estimator, exploiting more of the available moment conditions). This is admissible because the second lag of supplier credit (SC_{it-2}) influences bank credit in period t (BC_{it}), but bank credit in period t does not influence supplier credit two periods ago. Like this, instrumenting SC_{it} with SC_{it-2} and SC_{it-3} solves our simultaneity problem. SC_{it-2} is strongly correlated with SC_{it} (correlation coefficient of 0.82), thus it is relevant. Furthermore, SC_{it-2} has an influence on BC_{it} only via SC_{it} . Additionally, we use all the right-hand-side variables as instruments, except for the financial constraints dummy. As we would argue that the amount of bank credit the firm receives depends on whether the firm feels financially constrained but the reverse is also plausible, we instrument the financial constraints dummy also by its second and third lag, as well as the interaction term of supplier credit and the financial constraints dummy. The Anderson and Hsiao (1982) and the Arellano and Bond (1991) estimators use first-differences. Thus, we account for the fact that the relation between bank credit and supplier credit might be a spurious relationship attributed to unobservable specific heterogeneity among firms. The two-step GMM estimator is only consistent if there is no second-order serial correlation of the errors. We provide a direct test of the second-order residual serial correlation coefficient proposed by Arellano and Bond (1991). Furthermore, we also use the Hansen test of over-identifying restrictions to test the validity of our instruments. The Hansen test can be weakened by instrument proliferation. Therefore, instead of using one instrument for each time period, variable and lag distance, we use one instrument for each variable and lag distance. The idea is that the moment conditions are summed over the years for each lag distance. Another study which uses this technique is among others Beck and Levine (2004).

The fact that we have an unbalanced panel does not prevent the use of the two-step GMM estimator. Arellano and Bond (1991) argue in their paper that no fundamental changes occur provided that a minimal number of continuous time periods is available on each firm. This is the case in our dataset. The average number of years over which the firms, used in our regressions, are in the dataset is four. The maximal number of years is 13. However, to avoid losing observations we use the orthogonal deviations transform instead of first-differencing proposed by Arellano and Bover (1995). Instead of subtracting the previous observation, the

orthogonal deviations transform subtracts the average of all available future observations. Like differencing this removes fixed effects. But using orthogonal deviations preserves the sample size in panels with gaps.

In (23) we would suppose supplier credit as such to have a negative effect on bank credit and the interaction term of supplier credit and the financial constraints dummy to have a positive effect. In this estimation, we cannot separately identify the different motives for the use of supplier credit and their effects on the use of bank credit. Certainly, there is the positive effect on bank credit included in the volume of supplier credit due to the signal, but this effect probably does not compensate for the general substitution effect.

In Table A.3 column 1, the results of the two-step GMM estimator are shown using Windmeijer finite sample corrected standard errors where we used the second- and the third-lag as instruments for the endogenous variables. As explained above, we collapsed the instruments and used orthogonal deviations. This gives us a sample of 1720 observations for 410 companies and we use 23 instruments. We find that for financially unconstrained firms the fraction of supplier credits used has a negative influence on the fraction of bank credits used which is significant at the 10% level. As both measures are in logs the coefficient indicates that 1% more supplier credit leads to 4% less bank credit. The coefficient of the interaction term of the share of supplier credit used and the financial constraints dummy is positive. It is marginally significant with a p -value of 0.126. This indicates that although bank credit and supplier credit are substitutes for unconstrained firms, supplier credit has a positive impact on bank credit for financially constrained firms. The coefficient of the variable tangible assets is positive as one would expect, though insignificant. Tangible assets can serve as collateral and hence should enable firms to get more bank credit. Salesgrowth is negative but its effect is zero. The dummy indicating whether a firm feels financially constrained has a large positive coefficient, which is significant at the 10% level. This is surprising as one would expect that firms that feel financially constrained should get less bank credit. The export dummy has a negative coefficient which is insignificant. Being an exporter reduces the amount of bank credit you have. This might reflect the higher risk due to international transactions which reduces the willingness of banks to extend credit. Additionally, although internationally active firms usually need to finance more investments

and transactions, they also generally have higher profits and might use them to build up internal funds. The coefficient of productivity is positive, which implies that more productive firms can get more bank credit as they are supposed to be more reliable creditors.

In Table A.3 column 2 we conducted the same estimation with only the second lag as instrument for the endogenous variables. The coefficients change slightly in size but the signs remain the same. Now, the coefficient of supplier credit is significantly negative at the 5% significance level. The coefficient of tangible assets also becomes significant at the 10% significance level. The financial constraints dummy remains significantly positive at the 10% level. The coefficient of supplier credit for financially constrained firms remains positive and marginally significant with a p -value of 0.133. Furthermore, the coefficient of labor productivity becomes significant at the 10% level.

The test for serial correlation in both specifications shows that we have first-order serial correlation of the errors but no second-order or third-order serial correlation. Hence, the Arellano-Bond (1991) estimator is consistent. This does support our sequential exogeneity assumption. The Hansen test of overidentifying restrictions for the specification in the first column is fulfilled for this set of instruments. The Null that the instruments as a group are exogenous cannot be rejected. We also test whether subsets of instruments are exogenous by using difference-in-Hansen statistics. We find that all subsets of instruments are exogenous. In column 2 we do not report the Hansen test of overidentifying restrictions as the system is just identified. Thus, we can conclude that we have an indication for the signaling effect of supplier credit in our data. Although supplier credits and bank credits are substitutes for unconstrained firms, they are complements for financially constrained firms.

4.2. The importance of supplier credit for internationally active firms

Bellone et al. (2010) and Feenstra et al. (2011) show that financial constraints play an important role in international trade. This is the case because the costs and the risks faced by firms are higher in international transactions. Therefore, supplier credits, as an additional source of finance, are especially vital in international trade. We now want to test whether the complementarity between supplier credit and bank credit for financially constrained firms is

more important for internationally active firms. We use the following estimation equation

$$\begin{aligned}
 BC_{it} = & \beta_0 + \beta_1 SC_{it} + \varphi_1 SC_{it} * CON_{it} * EXP_{it} \\
 & + \boldsymbol{\delta}_1 \mathbf{x}_{it} + \eta_i + \lambda_t + \epsilon_{it}
 \end{aligned}
 \tag{24}$$

This equation now only differs from (23) in the triple interaction term we add instead of the interaction term of supplier credit with the financial constraints dummy. We interact supplier credit used with the dummy for whether a firm is financially constrained and a dummy indicating export status. Thus, φ_1 displays the effect of supplier credit on bank credit for financially constrained exporters. β_1 is the effect of supplier credit on bank credit for non financially-constrained firms, both exporters and non-exporters and financially constrained non-exporters. We could also include the interaction term of supplier credit and the financial constraints dummy. This would then explicitly capture the group of financially constrained non-exporters. However, due to the high share of exporters and the small fraction of financially constrained firms in our data this group is so small such that it does not make sense to include it separately. Furthermore, we are interested in comparing the group of financially constrained exporters to all other firms. Following our model, we also do not add an interaction term for supplier credits for unconstrained exporters as unconstrained exporters are able to obtain bank credit in the first place without relying on the signal extended by supplier credit. Again, we also use the interaction terms lagged twice or three times as instruments.

In Table A.3 column 3 the share of supplier credit used again has a significantly negative effect on the share of bank credit used (5% significance level). The coefficient of supplier credit for financially constrained exporters is significantly positive at the 5% significance level. Thus, the signaling effect of supplier credit seems to be significant for financially constrained exporters. This is in line with our theory as we argue that for exporters the uncertainty is higher and thus the signaling effect is more important. For those exporters with a very high productivity level that nevertheless get bank credit financing, the signal provided by supplier credits is of no great importance. For those exporters with a lower productivity level whose bank credit financing is constrained, however, the signaling effect of supplier credit plays a significant role. The coefficient of tangible assets has a significantly

positive effect on bank credit also at the 5% significance level. The financial constraints dummy remains significantly positive at the 10% significance level and labor productivity remains significantly positive at the 10% significance level.

The results using only the second-lag as instruments shown in column 4 are similar. The coefficient of supplier credit is significantly negative at the 10% significance level. Furthermore, the effect of supplier credit for financially constrained exporters remains significantly positive at the 10% significance level. The tests for serial correlation and the Hansen test for overidentification again yield that the estimator is consistent and the instruments are valid.

4.3. Robustness check

Using sales over employees is the best productivity measure we can use. Alternatively, we rerun the estimations using the logarithm of sales of a firm as a proxy for its size (?). In Table A.4 the results are shown. The signs remain the same for all coefficients. Only the sizes of the coefficients differ slightly. In column 1 and 2 one sees that the effect of supplier credit as such remains significantly negative. The effect of supplier credit for financially constrained firms is positive, but insignificant. However, the estimation results in column 3 also support our results obtained using our productivity measure. Again, supplier credit for financially constrained exporters has a positively significant effect at the 5% significance level. In column 4 this effect is also positive but insignificant, with a p -value of 0.159. The tests for serial correlation and the Hansen test for overidentification are again satisfied.

In a second robustness check we scale trade accounts payable and bank debt by total liabilities instead of total assets. Hence, we then consider the effect of the importance of supplier credits considering the whole amount of external finance on the importance of bank credits in the financing portfolio. As bank credits and supplier credits are not the only forms of external finance this effect can again be positive or negative. In Table A.5 columns 1 and 2 the generally substitutive relation between supplier credits and bank credit can be confirmed. The coefficient of supplier credit for financially constrained firms is positive but insignificant. In columns 3 and 4 there is again supportive evidence for the positive effect of supplier credits for financially constrained exporters.

Summing up all the estimation results, we have seen that the share of supplier credit

used has a negative effect on the share of bank credit used for financially unconstrained firms (Hypothesis 1). However, if we only look at financially constrained firms the share of supplier credit used affects the share of bank credit used positively (Hypothesis 2). This positive effect seems to play a more significant role, though, for financially constrained exporters. The relation is positively significant. (Hypothesis 3). The empirical results therefore provide supporting evidence for our theoretical model.

5. Conclusion

Supplier credits are an important financing tool especially for internationally active firms. This is surprising, as supplier credits are generally a lot more expensive than bank credits, with a real interest rate of 40% or more per year. We have shown that supplier credits reduce the uncertainty due to a quality signal, which is of special importance for internationally active and financially constrained firms.

In a companion paper we also look at the overall effect of trade credits on both exporters and importers (Eck et al., 2011). There we show that the availability of supplier credits and cash-in-advance can help more firms to become internationally active and also to export and import more. Hence, papers dealing with financial constraints in international trade should also take into account trade credits. As we have shown, trade credits are better than their reputation. They are not only a more expensive substitute to bank credits but an efficient financing tool, especially in risky international transactions.

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Appendix A.

Proof of Proposition 2:

Given the belief of the bank, $Pr(G|\alpha \geq \alpha^{sep}) = 1$ and $Pr(G|0 \leq \alpha < \alpha^{sep}) = 0$, both suppliers have no incentive to deviate. The exporter sets the α , p_1 and q_1 . Given p_1 and q_1 , the good supplier could choose a higher α , but he has no incentive to do so, since $\frac{\partial \pi_{SU}(G)}{\partial \alpha} < 0$.

$$\frac{\partial \pi_{SU}}{\partial \alpha} = [\underline{c} + (\bar{c} - \underline{c})(1 + \bar{r}_{SC})] q_1 - [\underline{c} + (\bar{c} - \underline{c})(1 + \bar{r}_{SC})] q_1(1 + \bar{r}_{SC}) < 0$$

Likewise, the good type has no incentive to lower α , as the exporter would not obtain a bank credit then and the export transaction does not take place which means that the supplier would make losses.

The bad type does not have an incentive to choose $0 < \alpha(B) \leq \alpha^{sep}$, because the transaction does not take place as the bank does not give a bank credit and hence she makes losses. For $\alpha(B) = \alpha^{sep}$, the supplier still makes zero profits and thus has no incentive to deviate to α^{sep} .

The bank updates its belief according to the Bayes rule and sets $\sigma = 1$ when $\alpha = \alpha^{sep}$. If $\alpha = 0$, the bank updates its belief according to the Bayes rule and sets $\sigma = 0$ and hence denies a credit. Thus, $[(\alpha(G) = \alpha^{sep}, \alpha(B) = 0), (\text{gives bank credit at interest rate } \frac{1+\bar{r}_B}{\lambda}, \text{ gives no bank credit}), Pr(G|\alpha \geq \alpha^{sep}) = 1 \text{ and } Pr(G|0 \leq \alpha < \alpha^{sep}) = 0]$ is a perfect Bayesian equilibrium.

Note that condition (18) requires the suppliers' refinancing costs not to be too high

$$\bar{r}_{SC} < \frac{(1 - \sigma^2)\bar{c} + \bar{r}_B(\bar{c} - \sigma^2\underline{c})}{\sigma^2(\bar{c} - \underline{c})}$$

and the adverse selection problem to be severe

$$\sigma^2 < \frac{(1 + \bar{r}_B)\bar{c}}{\underline{c}(\bar{r}_B - \bar{r}_{SC}) + \bar{c}(1 + \bar{r}_{SC})}.$$

In Figure A.1, the shaded area gives all the parameter combinations satisfying (18). This shows by example that the parameter set for which $(1 + \beta)^{SC/BC} < (1 + \beta)^{BC}$ is non-empty. In fact, for reasonable parameter constellations the productivity threshold for supplier credit

```
In[6]:= RegionPlot [1.08 * 2 / σ^2 > 2 * (1 + RSU) - 1 (RSU - 0.08), {σ, 0.1, 0.9}, {RSU, 0.5, 6}, FrameLabel -> {σ, RSU}]
```

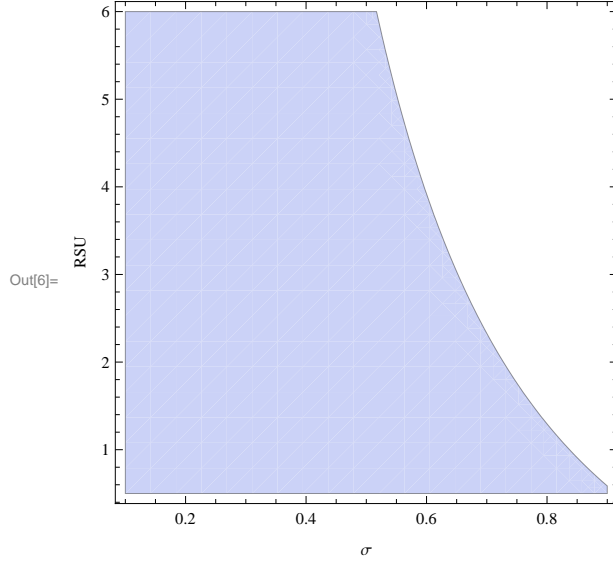


Figure A.1: Parameter combinations showing when Proposition 3 holds.

and bank credit financing is almost always below the one for pure bank credit financing.

Proof of Proposition 4

Given the belief of the bank $Pr(G|\alpha \geq \alpha^{sep}) = 1$, $Pr(G|0 \leq \alpha < \alpha^{sep}) = 0$ and $Pr(G|\alpha(G) = \alpha(B)) = \sigma$ both suppliers have no incentive to deviate. They will not deviate to a higher α as their profits decrease in α (see above). Furthermore, they will not unilaterally decrease α as they will not get any bank credit then. Thus, in this case the bank does not learn anything and hence does not update its belief.

Proof of Proposition 5

Comparing (17) with (21) we can derive that the minimum productivity level in the separating equilibrium lies below the one in the pooling equilibrium:

$$\frac{4(1 + \bar{r}_B)(F + F_{EX}) [\underline{c}(\bar{r}_B - \bar{r}_{SC}) + \bar{c}(1 + \bar{r}_{SC})]}{p^2 \bar{q}_2} < \frac{4(1 + \bar{r}_B)F [\sigma(\bar{c} - \underline{c})(1 + \bar{r}_{SC}) + \underline{c}(1 + \bar{r}_B)]}{(\sigma p)^2 \bar{q}_2}$$

$$\sigma^2(\bar{c} - \underline{c})(1 + \bar{r}_{SC}) + \sigma^2 \underline{c}(1 + \bar{r}_B) < \sigma(\bar{c} - \underline{c})(1 + \bar{r}_{SC}) + \underline{c}(1 + \bar{r}_B)$$

Firms with a productivity level $(1 + \beta) \in [(1 + \beta)^{pool}, (1 + \beta)^{BC}]$ if $(1 + \beta)^{pool} < (1 + \beta)^{BC}$,

can play both the separating or the pooling equilibrium. To say which equilibrium they prefer playing, we have to compare the expected profits of both equilibria. In the separating equilibrium only the good suppliers participate. Therefore, we have to multiply the profits of the separating equilibrium with the probability that the supplier is good (σ). Only if the supplier is good are the costs incurred and the revenues realized. In the pooling equilibrium, both types of suppliers participate. The pooling equilibrium will never be played by the exporter if

$$\begin{aligned} \sigma \pi_{EX}^{sep} &> \pi_{EX}^{pool} \\ (1 - \sigma)(1 + \bar{r}_B)(F + F_{EX}) &> \frac{1}{2}p\sigma [x^{pool} - x^{sep}] \end{aligned}$$

This is always fulfilled, as the quantity produced by the exporter is always smaller in the pooling equilibrium than in the separating equilibrium. Thus, the separating equilibrium Pareto-dominates the pooling equilibrium. Playing the pooling equilibrium only has disadvantages. The exporter incurs the fixed costs and pays part of the variable costs to the supplier but does not get any revenues from selling its products if the supplier is of bad quality. It can still be better than using only bank credit financing as the exporter only pays a part of the variable costs and not the whole variable costs to the supplier.

Every pooling equilibrium where $0 \leq \alpha(T) \leq \alpha^{sep}$ is Pareto-dominated by the separating equilibrium independent of beliefs. Furthermore, there does not exist any other pooling equilibrium with $\alpha > \alpha^{sep}$ as the bad supplier will always make negative profits.

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Table A.1: Description of Variables

Variable	Definition
SC	Logarithm of trade accounts payable divided by total assets
BC	Logarithm of bank debt divided by total assets
tangibles	Logarithm of tangible assets divided by total assets
salesgrowth	Sales of period t divided by sales of period $t - 1$ minus 1, $((sales_t/sales_{t-1}) - 1)$
constrain	0/1 dummy indicating whether firms feel financially constrained or not This is the case if either the question whether the firm is constrained in its production due to financial constraints is answered with yes or if the question how the firm judges the willingness of banks to give credits to firms is answered with restrictive.
exp	0/1 dummy indicating whether firms export or not A firm is classified as exporter if it exported its product at least 20 % of the time of a year.
labprod	productivity of a firm measured as $\ln(sales/employees)$
sales	Logarithm of sales
SCLIab	Logarithm of trade accounts payable divided by total liabilities
BCLIab	Logarithm of bank debt divided by total liabilities

Table A.2: Descriptive Statistics

Panel A: Summary statistics of firm characteristics

	Mean	SD
no. of employees	2489	10,999
trade accounts payable (1000 Euros)	26,800	122,000
bank credit (1000 Euros)	53,300	400,000
tangible assets (1000 Euros)	74,100	185,000
trade accounts payable/total assets	8	6
bank debt/total assets	17	15
tangible assets/total assets	27	18
salesgrowth (%)	28	630
sales/no. employees	267792	475664
fraction of exporters (%)	93	-
fraction of financially constrained firms (%)	15	-

Panel B: Exporters vs. Non-Exporters

	Exporters	Non-Exporters	Difference
no. of employees	2583	1293	1290***
trade accounts payable/total assets (%)	8	8	0
bank credit/total assets (%)	17	15	2
tangible assets/total assets (%)	26	42	-16***
salesgrowth (%)	30	4	26
fraction of financially constrained firms (%)	15	20	-5

Panel C: Constrained vs. Unconstrained Exporters

	Constrained Exporters	Unconstrained Exporters	Difference
no. of employees	1928	2697	-769*
trade accounts payable/total assets (%)	9	7	2***
bank credit/total assets (%)	23	16	7***
tangible assets/total assets (%)	25	26	-1
salesgrowth (%)	8	34	-26

Panel A provides average firm characteristics pooled over all years for the regression sample. The number of observations is 1626. Panels B and C provide mean comparison tests for various firm characteristics between exporters and non-exporters and financially-constrained exporters and non financially-constrained exporters, respectively. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.3: Estimation Results

VARIABLES	(1)	(2)	(3)	(4)
	BC	BC	BC	BC
SC	-3.981*	-4.626**	-3.849**	-4.101*
	(2.311)	(2.331)	(1.682)	(2.215)
tangibles	1.215	1.457*	1.216**	1.291
	(0.788)	(0.856)	(0.603)	(0.797)
salesgrowth	-0.020	-.0215	-0.0181	-0.0191
	(0.0199)	(0.0193)	(0.0141)	(0.0151)
constrain	7.689*	7.359*	6.684*	6.252
	(4.321)	(3.964)	(3.507)	(3.822)
constrain*SC	2.118	1.9763		
	(1.385)	(1.315)		
constrain*SC*exp			1.854**	1.720*
			(0.9371)	(1.044)
exp	-0.454	-0.479	-0.3056	-0.3137
	(0.737)	(0.7258)	(0.6639)	(0.6877)
labprod	1.183	1.409*	1.116*	1.223
	(0.804)	(0.832)	(0.569)	(0.767)
year dummies	yes	yes	yes	yes
Observations	1720	1720	1720	1720
No. of companies	410	410	410	410
No. of instruments	23	20	25	21
Lags used	2+3	2	2+3	2
AR(1)	0.005	0.007	0.002	0.005
AR(2)	0.290	0.288	0.199	0.248
AR(3)	0.989	0.774	0.824	0.909
Hansen	0.851	.	0.953	0.383

BC stands for bank credit, which is our dependent variable. The variable bank credit is divided by total assets and the logarithm is taken. *SC* stands for supplier credit. Supplier credit is measured by trade accounts payable divided by total assets and the logarithm is taken. *labprod* is measured by the logarithm of sales over the number of employees. *TANG* stands for the share of tangible assets a firm has relative to total assets. Again the logarithm is taken and stands for the labor productivity of the firm. *salesgrowth* is calculated as sales of period t divided by sales of period $t - 1$ minus 1 ($(sales_t/sales_{t-1}) - 1$). *SC*constrain* is an interaction term of the fraction of supplier credit used and a dummy variable indicating whether a firm feels financially constrained. *SC*constrain*EXP* is a triple interaction term of supplier credit used, the financial constraints dummy and a dummy variable indicating whether a firm is an exporter. In (1) and (3) we use the two-step GMM estimator with Windmeijer finite sample corrected standard errors using the second and the third lag as instruments for the endogenous variables. In (2) and (4) we only use the second lag as instrument.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.4: Estimation Results

VARIABLES	(1) BC	(2) BC	(3) BC	(4) BC
SC	-3.431*	-4.145**	-3.572**	-3.896**
	(1.889)	(2.024)	(1.417)	(1.871)
tangibles	0.946	1.184*	1.003**	1.101*
	(0.615)	(0.698)	(0.491)	(0.641)
salesgrowth	-0.027	-0.0307*	-0.0277*	-0.0293*
	(0.0184)	(0.0185)	(0.0147)	(0.016)
constrain	7.212*	6.651*	6.336**	5.724
	(4.218)	(3.953)	(3.131)	(3.567)
constrain*SC	1.876	1.611		
	(1.332)	(1.307)		
constrain*SC*exp			1.6548**	1.424
			(0.8354)	(1.0100)
exp	-0.495	-0.548	-0.3792	-0.4058
	(0.738)	(0.734)	(0.6883)	(0.708)
sales	1.321	1.635*	1.383**	1.538*
	(0.815)	(0.908)	(0.609)	(0.817)
year dummies	yes	yes	yes	yes
Observations	1720	1720	1720	1720
No. of companies	410	410	410	410
No. of instruments	23	20	25	21
Lags used	2+3	2	2+3	2
AR(1)	0.003	0.007	0.001	0.004
AR(2)	0.327	0.327	0.233	0.263
AR(3)	0.812	0.912	0.706	0.829
Hansen	0.832	.	0.970	0.476

BC stands for bank credit, which is our dependent variable. The variable bank credit is divided by total assets and the logarithm is taken. *SC* stands for supplier credit. Supplier credit is measured by trade accounts payable divided by total assets and the logarithm is taken. *sales* stands for the logarithm of sales. *TANG* stands for the share of tangible assets a firm has relative to total assets. Again the logarithm is taken and stands for the labor productivity of the firm. *salesgrowth* is calculated as sales of period t divided by sales of period $t - 1$ minus 1 ($(sales_t/sales_{t-1}) - 1$). *SC*constrain* is an interaction term of the fraction of supplier credit used and a dummy variable indicating whether a firm feels financially constrained. *SC*constrain*EXP* is a triple interaction term of supplier credit used, the financial constraints dummy and a dummy variable indicating whether a firm is an exporter. In (1) and (3) we use the two-step GMM estimator with Windmeijer finite sample corrected standard errors using the second and the third lag as instruments for the endogenous variables. In (2) and (4) we only use the second lag as instrument.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.5: Estimation Results

VARIABLES	(1)	(2)	(3)	(4)
	BCliab	BCliab	BCliab	BCliab
SCliab	-3.549** (1.720)	-3.657** (1.633)	-3.102** (1.291)	-3.881** (1.532)
tangibles	1.153* (0.634)	1.195* (0.856)	1.008** (0.498)	1.270** (0.609)
salesgrowth	-0.020 (0.013)	-0.020 (0.012)	-0.017 (0.012)	-0.019 (0.013)
constrain	3.395 (4.009)	4.093 (3.214)	4.458* (2.663)	3.479 (2.764)
constrain*SCliab	1.121 (1.350)	1.186 (1.091)		
constrain*SCliab*exp			1.356* (0.813)	0.993 (0.905)
exp	0.309 (0.335)	0.332 (0.338)	0.271 (0.321)	0.352 (0.344)
labprod	1.037* (0.609)	1.063* (0.589)	0.839 (0.442)	1.124** (0.552)
year dummies	yes	yes	yes	yes
Observations	1720	1720	1720	1720
No. of companies	410	410	410	410
No. of instruments	23	20	25	21
Lags used	2+3	2	2+3	2
AR(1)	0.005	0.005	0.002	0.003
AR(2)	0.330	0.340	0.305	0.292
AR(3)	0.998	0.869	0.754	0.785
Hansen	0.666	.	0.656	.

BCliab stands for bank credit, which is our dependent variable. The variable bank credit is divided by total liabilities and the logarithm is taken. *SCliab* stands for supplier credit. Supplier credit is measured by trade accounts payable divided by total liabilities and the logarithm is taken. *labprod* is measured by the logarithm of sales over the number of employees. *TANG* stands for the share of tangible assets a firm has relative to total assets. Again the logarithm is taken and stands for the labor productivity of the firm. *salesgrowth* is calculated as sales of period t divided by sales of period $t - 1$ minus 1 ($(sales_t/sales_{t-1}) - 1$). *SCliab*constrain* is an interaction term of the fraction of supplier credit used and a dummy variable indicating whether a firm feels financially constrained. *SCliab*constrain*EXP* is a triple interaction term of supplier credit used, the financial constraints dummy and a dummy variable indicating whether a firm is an exporter. In (1) and (3) we use the two-step GMM estimator with Windmeijer finite sample corrected standard errors using the second and the third lag as instruments for the endogenous variables. In (2) and (4) we only use the second lag as instrument.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.