Inter-Firm Credit and Industrial Links

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Abstract

This thesis addresses two fundamental puzzles about trade credit: why does it appear to be so expensive? and why do input suppliers engage in the business of lending money? Both questions are answered analysing the interaction between the financial and the industrial aspects of the supplier-customer relationship.

In the first part of the thesis we present a model where, in a context of limited enforceability of contracts, suppliers have a comparative advantage over banks in lending to their customers because they hold the extra threat of stopping the supply of intermediate goods. Suppliers also act as lenders of last resort, providing insurance against liquidity shocks that may endanger the survival of their customers. The relatively high implicit interest rates of trade credit result from the existence of default and insurance premiums. The two necessary elements for these two roles of suppliers are the existence of some relationship surplus that is split between suppliers and customers, and an environment where debt repayment is difficult to enforce.

Then we extend the analysis to suppliers who are themselves financially constrained. Under certain assumptions, the optimal financial contract that arises is similar to a standard factoring contract. The interest rates paid by suppliers and customers in this contract depend on their own creditworthiness, but also on the characteristics of their commercial relationship.

Finally the implications of the basic model are examined empirically using both parametric and non-parametric techniques on a panel of UK firms. The results show some regularities that had not been identified in previous literature and that support the role of suppliers as debt collectors and insurance providers of the basic model. In particular these results are consistent with the idea of trade credit being related to the existence of either some degree of technological specificity or a relationship surplus that takes time to build. Evidence is also found of the support of suppliers to their customers experiencing some form of liquidity shock.

1 Introduction

Trade credit arises when a supplier allows a customer to delay the payment of goods already delivered. It is generally associated with the purchase of intermediate goods. Empirical evidence shows that the implicit interest rate in a trade credit agreement is generally very high compared to the rates of bank credit. In spite of this high interest rate, trade credit is widely used and represents an important proportion of firms' finance. It is therefore surprising that such high interest rates survive in the presence of a competitive banking sector since banks could take over this potentially profitable business, offering more credit lines to finance commercial transactions.

This thesis addresses and answers two main questions that lie at the heart of the trade credit puzzle: i) Why does trade credit appear to be so expensive? and ii) Why do input suppliers engage in the business of lending money? Chapter 3 presents a model of trade credit, where the answer to these two questions is that a financial relationship between a supplier and a customer emerges as a natural consequence of their commercial interaction, despite the existence of a competitive banking sector. This is based on two basic elements. On the one hand, suppliers are able to enforce debt repayment better than banks, as they hold the threat of stopping the supply of intermediate goods to their customers which is not easy to replace. On the other hand suppliers may act as liquidity providers, giving financial help to their customers whenever they experience temporary liquidity shocks. The necessary condition for these elements to exist is the existence of a surplus that will be split between suppliers and customers if they stay together. In other words, there must be a commercial link between the supplier and the customer that makes it costly for the customer to find alternative suppliers and makes it costly for the supplier to find alternative customers. As a result, the high interest rate of trade credit, is justified by the existence of a default premium and an insurance premium. The default premium accounts for the fact that, in our model, suppliers use their commercial link to make a risky loan to their customers when banks are not willing to lend. Suppliers use their commercial link to the customers to lend on the basis of returns that are not backed by tangible collateral. This makes trade credit more risky than collateralised bank debt. The insurance premium is related to the fact that suppliers foresee the future needs of liquidity of their customers. As they know that they may have to provide financial help to customers in need of extra liquidity, they will charge them a premium for providing insurance against potential liquidity shocks. This insurance premium is similar to the upfront fee for a loan commitment to the customer at a favourable interest rate.

The reason why trade credit appears to be an expensive form of finance lies within the structure of a standard trade credit contract. A typical deal normally involves three elements: a discount on the price agreed if the buyer pays early; the number of days that qualify for early payment; and the maximum number of days for payment. For example, a common contract called "2-10 net 30" means that if customers pay within ten days of delivery they qualify for a 2% discount. Otherwise they can pay up to 30 days after delivery. The discount for early payment implies an interest rate that the customer pays for the credit received. In the case of the "2-10 net 30" contract, the customer is effectively receiving credit at a 2% rate for 20 days. Thus the equivalent one year interest rate of this deal is about 44%. This is an extremely high rate compared with the market rate that a bank would charge for a similar type of loan. Other common deals also have very high interest rates.[1] Despite this high cost, trade credit still constitutes a considerable share of firms' finance. For example, trade credit accounts for nearly one fifth of the total

[1] Ng *et al* (1999) find that "2-10 net 30" is the most common deal in a sample of US firms. Other common deals such as "8-30 net 50" imply even higher implicit interest rates. In this case the annual implied interest rate is 358%

assets of a representative firm and about one half of the short-term debt in two different samples of medium-sized UK firms and small-sized US firms, as shown in Table 1.[2]

Table 1: Relative size of trade credit
(average over firms)

Country	Dataset	Trade Credit/Assets	Trade Credit/Debt	Trade Credit/ST Debt
UK	FAME	17%	43%	52%
US	NSSBF	18%	34%	58%

Furthermore, these levels are higher in periods when buyers face temporary liquidity shocks. Suppliers seem to lend to their customers experiencing financial trouble, even when banks are not willing to lend. In many circumstances, this extra lending occurs via late payment of already extended debts. For example, in the NSSBF sample 59% of the firms declared that they had made some payments after the due date during the last year. These late payments do not usually carry a penalty for the customers.

The role of suppliers as debt collectors is in line with the fact that trade credit tends to be higher in small, young and high growth firms that are the ones with higher difficulties in accessing other forms of finance.[3] However, in the empirical part of this thesis, we find that the relationship between the age of a firm and the levels of trade credit used is non-linear. New-born firms start with low levels of trade credit but it builds up very quickly in the early years of a firm's life. This supports our hypothesis that trade credit is related to the existence of a link

[2]FAME (Financial Analysis Made Easy) is a database of medium-sized UK firms with information from 1993 until 1999 (see Section 5.1), while NSSBF (National Survey of Small Busines Finance) is a 1993 cross-section sample of 3000 small US firms.

[3]See Nilsen (1994) (1999), Elliehausen and Wolken (1993), Berger and Udell (1998).

between suppliers and customers. If this link takes time to build up, trade credit should also grow as the relationship evolves.

In developing our formal model, we first justify the existence of trade credit on the basis of suppliers being able to enforce debt repayment better than banks. This extra enforceability power comes from the existence of a link that makes both suppliers and customers costly to substitute. In the model this link takes the form of intermediate goods being specific to the buyer, although this specificity need not be only technological, but also due to other factors such as legal contracts or informational advantages. The existence of this link also justifies the fact that suppliers will help customers in trouble because they are costly to substitute. This help is not just restricted to renegotiation in case of default, but is more of an insurance against liquidity shocks that the customer may face. We model this as explicit extra finance in the form of extra funds or extra goods delivered on credit, but it can also be seen as extra flexibility in the terms of payment. In particular, the opportunity to incur in late payment without any penalty should be seen as part of the support that suppliers are offering to their customers in trouble. In our model, all firms use both trade credit and bank credit in equilibrium, even if we assume that banks are relatively more competitive lenders than suppliers. Suppliers can provide trade credit when their customers have already borrowed from banks up to the point where banks are not willing to lend any more funds.[4] The results of the model are consistent with the existing stylised facts, in particular with the high implicit interest rates and the extensive use of trade credit. Our explanation

[4]So far, only Biais and Gollier (1997) and Frank and Maksimovic (1999) had an equilibrium result where bank and trade credit were mixed optimally. According to Biais and Gollier, customers choose the right proportion of trade credit vs bank credit to commit credibly to avoid collusion with their suppliers. In Frank and Maksimovic low quality buyers get only trade credit while high quality buyers get mixed finance. Both models rely on the existence of a single monopolistic financier. Our model proposes an alternative explanation for this mix, based on the verifiability of the returns of the customer. The results of Section 5.5 support our hypothesis, showing a high sensitivity of this mix with respect to the levels of collateral of the firm.

of trade credit is in any case compatible and to a large extent complementary to the existing literature on trade credit. Chapter 2 reviews some of the theoretical and empirical literature that is relevant to the topic of trade credit.

In Chapter 4 we extend the analysis of Chapter 3 to financially constrained suppliers. This is a natural extension of the model, first of all because it is realistic to assume that suppliers have more difficulties in raising funds than banks (banks after all are the specialist financial intermediaries). Secondly, because in practice, most suppliers use factoring deals with banks or specialist factoring firms to raise money to finance their accounts receivable. The structure of a standard factoring deal is also consistent with our explanation of trade credit use. In a factoring deal the supplier sells some goods on trade credit and then borrows from a bank the amount of trade credit issued minus a discount, using as collateral the receivables of trade credit. Then the supplier repays to the bank when customers pay their trade credit. Some deals even specify that the customer should pay directly to the bank. In case of default of the customer the bank can either claim repayment from the supplier or the customer. Two characteristics of the typical factoring contract support our hypothesis of suppliers having a greater enforceability power over their customers. First, the fact that banks are lending to the supplier even when they are not willing to lend directly to the customer. Second, that the interest rates suppliers pay in the factoring deal are in general quite low, much lower than in an equivalent short-term credit line. Part of the reason for this low interest rate is the joint liability of suppliers and customers in the factoring contract but also the fact that the bank can effectively block the relationship between the supplier and the customer, therefore having a strong threat against both in case of default. In Chapter 4 we explore the effects of this joint liability and the supplier financial constraints on the trade credit-factoring contract. The fact that suppliers are constrained has also some implications on the insurance provided to their customers. As the insurance contract implies that suppliers collect premiums in advance and then pay for any potential shock, the extra need of funds on the suppliers side may make them better insurers as the collection of these premiums relaxes the suppliers financial constraints. We also extend the analysis of liquidity shocks to positive ones: Seen as unexpected investment opportunities that arrive in a moment when the customer is liquidity constrained and need extra funds to be undertaken.

Furthermore, in Chapter 5 we test some of the empirical implications of the model. We use the FAME-BVD database, which contains balance sheet data and cash flow statements of UK firms. The main predictions of the model that we would like to test are ,first of all, whether higher levels of specificity imply higher use of trade credit. Secondly, that suppliers should support customers that experience temporary liquidity shocks. Finally we test the influence of collateral and free collateral on the use of trade credit.

To test the first implication we would like to have an unambiguous measure of supplier specificity that measured the relationship surplus between suppliers and customers. However the nature of the links between suppliers and customers may be very diverse. It may be based on technological product specificity, but also on informational advantages or even on contractual agreements such as long-term exclusive supply contracts. It is difficult to find proxy variables that encompass all these possibilities. Instead we take two alternative approaches. Namely we use the age of the firm and the level of expenditures in Research and Development as measures of this specificity. As some of the links between suppliers and customers take time to build, one alternative is to use the length of a commercial relationship as a proxy for specificity. Unfortunately we do not have such information in our dataset. However, there is a good amount of new firms in the sample. For recently created firms, the age of the firm is a good approximation to the length of the relationship with its suppliers and therefore may be a good measure of how tight is the commercial link between them. If we follow new born firms in their first years of activity we can see how the use of trade credit taken evolves as the links with their suppliers get tighter. We run non-parametric regressions that relate the level of trade credit over total assets as a function of the age of firms. The results show a hump shaped relationship between trade credit taken and age. Firms that are just starting their activity tend to have relatively low levels of trade credit over assets (of about 14%). Later on, in the first 3 to 5 years of the life of a firm, trade credit use grows dramatically up to levels of 24%. After this date we observe a gradual substitution of trade credit by retained earnings or cheaper forms of finance. These results are robust to different specifications and survive even if we control for other relevant variables such as size, collateral or level of activity. Thus this hump shaped relationship supports the idea of trade credit being related to the links between suppliers and customers that take some time to build up. In addition, we test whether other type of links that do not necessarily build up with age and may be in place at the moment of creation of the firm, affect the use of trade credit. In particular we investigate whether higher levels of technological intensity imply a higher trade credit use. To do so we regress the levels of trade credit taken and given on measures of research and development intensity at a sector level. The results show a positive correlation between R&D intensity and trade credit. Both trade credit taken and trade credit given seem to be higher in sectors with high R&D intensity. This shows how a higher technological specificity may induce stronger links between suppliers and customers that allow for higher levels of trade credit.

The second implication of the theoretical model that is tested in Chapter 5 is the support that suppliers give to customers experiencing temporary liquidity shocks. To analyse this, we run non-parametric regressions that relate the use of trade credit to different measures of firm performance. We also run standard panel data regressions that relate trade credit use to the holdings of liquid assets of customers. The non-parametric regression shows a "U" shaped relationship between trade credit and different measures of firm performance. In essence the best firms and the ones experiencing small temporary problems are the ones that use trade credit more extensively. Firms in an expansion tend to be in need of a lot of new finance, thus they use all the possible financial instruments including trade credit. Suppliers internalize part of the future expected present value of the surplus generated by their customers, so they are willing to extend extra finance to firms in an expansion. On the contrary, firms that have low or moderate growth rates are not constrained and therefore use those financial instruments that are cheaper such as bank credit before using trade credit. Moreover, firms experiencing temporary problems also use more trade credit. These firms may have problems in finding alternative financial sources and use more trade credit, mainly through late payment, to face this temporary shock. We also find that firms experiencing serious financial problems (i.e. assets shrinking by more than 20% or sales reduced by 30%) are not actually supported by their suppliers. This is consistent with our model as it predicts that suppliers will not support customers that experience liquidity shocks if the cost of facing the shock is bigger than the value of the relationship for the supplier.

We also run standard panel data regressions that relate the levels of trade credit to measures of liquid assets. The idea behind this is to see if firms that have a shortage of liquidity tend to use more trade credit. We find a strong negative correlation between the ratio of trade credit to assets and our measure of liquid assets that points in this direction. However, we also find a positive correlation between the ratio of trade credit to total debt and the level of liquid assets. Two effects may be playing a role in this correlation. First of all, firms that are experiencing high growth rates and expansions of their demand need both more trade credit and more liquid assets. Second, firms that experience temporary liquidity shocks not only use more trade credit, but also they may use other alternative short-term borrowing facilities such as lines of credit. To avoid these two effects we re-run the regressions but concentrating on a subsample of firms that are small (thus having less access to financial markets) and also experiencing losses. The positive correlation becomes not significant in this reduced sample.

Finally we check how the availability of collateral does affect trade credit use. The empirical results show that trade credit use is smaller whenever firms have collateral. This reinforces the results in our model where bank credit is mainly collateralised, while trade credit is based on the ability of suppliers to enforce debt repayment.

2 Related Literature

The literature on trade credit is relatively new and scarce when compared with the work done regarding other types of financial sources such as bank credit or market debt. However there is already a good basis of theoretical and empirical work that explores the fundamental issues regarding trade credit. Here we show a quite comprehensive review of the different theoretical and empirical contributions to the trade credit literature. For other extensive reviews of this literature see Mian and Smith (1992), Crawford (1992), Petersen and Rajan (1997) and Smith (1995).

2.1 Theoretical Approaches to Trade Credit

Ferris (1981) justifies the existence of trade credit as a means of payment to reduce transaction costs when the timing of the arrival of new supplies is uncertain. Ferris' paper concentrates on one particular type of uncertainty associated with the purchase of intermediate goods (time uncertainty), but it can be easily extended to other types of uncertainty such as the size of the delivery or the quality of the goods delivered. If there is a cost of transforming into cash iliquid assets and any of these uncertainties are present, customers would have to keep some cash in advance to face potential and uncertain payments to their suppliers. These cash holdings have the cost of a foregone interest rate. Trade credit can therefore be seen as a monetary device that allows the transformation of an uncertain stream of payments into a more predictable and stable one.

Smith (1987), Lee and Stowe (1993) and Long, Malitz and Ravid (1994) show that trade credit can also be used as a way for customers to check the quality of goods delivered before final payment. Of course, customers could pay cash and afterwards return imperfect goods back to suppliers in exchange for a refund or credit for further purchases. The underlying assumption of these models is that returning these goods is not feasible or at least costly to do; for example if the relationship with the supplier may end after the current deal.

In a more general framework we can think that the timing of the payment for a particular delivery will depend on which agent has a potential hold up on the other. Prepayment, cash payments and trade credit will be associated with different types of goods. As seen, trade credit (or post-payment in general) may be the optimal contract when the quality of goods is uncertain, while prepayment might be the case whenever goods that take time to build and are buyer specific are produced. If the customer cannot commit, not to renegotiate the price after the goods have been produced, the suppliers will ask for some prepayment to avoid renegotiation.[5]

The use of trade credit as a means of payment and as a way to check the quality of goods before final payment, is consistent with the existence of a free delayed payment period like the first 10 days in the 2-10 net 30 deal of the example. However these explanations alone do not explain why trade credit appears to be so expensive and why firms are willing to pay such costs. The fact that we observe positive levels of trade credit in most firms, independently of their financial needs, stresses the importance of the role of trade credit as a means of payment. However, trade credit also finances an important proportion of firms' assets and firms are frequently willing to use the costly part of the trade credit contracts. For example, in the National Survey of Small Business Finance (NSSBF) sample, 46.4% of the firms forego the discount for early payment in at least half of their purchases. This justifies the need for theoretical explanations that consider trade credit as a financial instrument and justifies its existence given that banks and not suppliers

[5] See Kiyotaki and Moore (1997) and (1997b) for models in which some pre-payment is necessary to complete the sale between a supplier and a customer.

are the specialists in the business of lending money.

One possible explanation for the existence of trade credit in the presence of a competitive banking sector, is the fact that suppliers could have superior information with respect to the creditworthiness of their customers. This superior information could come from a more detailed knowledge of the sector, but also from the continuous monitoring of the levels of activity of their customers, given that suppliers have up to date information of the demand of intermediate goods of their customers. Biais and Gollier (1997) follow this line, and assume that suppliers and banks have different signals about a customer's probability of default. The assumption does not necessarily imply that suppliers have superior information, but just a different signal than banks about the customer creditworthiness. The crucial assumption of the model is that only when both signals are positive, is the expected net present value of lending to the customer positive. Under these conditions banks will only lend when suppliers are willing to and vice versa. This justifies the coexistence of trade credit and bank credit in the same firm even if suppliers are relatively inefficient lenders. Their paper also determines the optimal mix between trade credit and bank credit. If side payments between suppliers and customers are possible they could collude in order to get cheap credit from the bank, even if the signal that suppliers receive is negative. The mix of trade credit and bank credit is optimally chosen in equilibrium to avoid collusion between suppliers and customers.

One possible critique to the model in Biais and Gollier (1997) is that there is no explicit justification for the different signal received by suppliers and banks. To a large extent, the model can be seen as the interaction between two financiers (maybe just two banks) that receive a different signal about the creditworthiness of a single entrepreneur. It seems quite reasonable though, that suppliers may have a very different (although not necessarily superior) signal about the creditworthiness of their customers than a bank; while two different banks may have very similar signals about it. An attempt to endogenize this signal is done in Burkhart and Ellingsen (1999). They propose a role of trade credit as a way for customers to commit not to divert funds from profitable projects towards perks or unprofitable ones. The key assumption of the model is that while bank credit can be used either for investment or to divert funds, trade credit is associated with the purchase of intermediate goods that may be very iliquid and therefore difficult to sell and re-direct to alternative uses. The comparison between the maturity of trade credit and the average period of stay of non-processed goods in the firm becomes crucial to assess the relevance of this theory, as customers could divert funds just after selling the transformed intermediate goods. The model is built in a way that makes the customers decide between either fully invest all the funds in the productive project and repay all debts or instead fully divert all funds and default. If partial diversion were an equilibrium result, the role of trade credit as a commitment device would be reduced, as the customer could always divert the loans received from the bank while investing the goods received from the supplier.

Emery (1984) and Schwartz (1974) are examples of articles in which suppliers have superior access to financial markets. Trade credit is therefore seen as a way for buyers with little access to bank credit and financial markets to get finance indirectly through their suppliers. Suppliers borrow money from banks at the market rates and then lend it to their customers at the high rates associated with trade credit. To sustain this role of suppliers as intermediaries there must be some kind of friction that precludes banks from taking over this profitable business and lending directly to the customers. Schwartz (1974) just assumes that suppliers face a lower market interest rate than customers. Emery (1984) enumerates possible explanations for this differential based on the suppliers either having an informational advantage over banks in screening and monitoring their customers or being able to save on some transaction costs by bundling their commercial business with their activity as financiers. A similar route is taken in Jain (2001). Here, suppliers have an explicit informational advantage in order to assess the creditworthiness of their customers as they costlessly observe the customer's revenue. Banks can also gather this information through costly monitoring. Suppliers are cash constrained and lend to their customers only after borrowing from banks themselves. In equilibrium there may be either trade credit only or both trade credit and direct bank credit. The result mainly depends on the specific function assumed for monitoring costs and the relative proportion of creditworthy vs not creditworthy firms. As the monitoring costs may vary across industries the use and terms of trade credit should vary too.

The role of suppliers as intermediaries can also be sustained as in Cuñat (2000) if suppliers have a superior enforcing technology to banks, that comes from current suppliers being difficult to substitute with alternative ones. In practice, we observe suppliers being intermediaries between financial markets and customers. Suppliers either finance themselves through long-term debt (see Calomiris, Himmelberg and Wachtel, 1995) or they raise funds through factoring. The way in which the factoring business is typically structured indeed points in the direction of the suppliers having some kind of superior enforcing technology, as banks are not usually willing to lend directly to the customers, but only through their suppliers.[6] Suppliers get the difference between the market rates offered by banks and the high rates of trade credit, but they also face the risk of late payment and default, so it is not clear that suppliers make abnormal profits out of their ability of reclaiming debts more efficiently than banks.

The aggregate implications of this intermediation done by suppliers are also

[6]There seems to be a lack of recent literature regarding the factoring industry, see Zinner (1947) for a review of the factoring industry in the US and its historical evolution. Also see Smith and Schnucker (1994).

important when analysing the credit channel of monetary policy: if suppliers are able to effectively relax the financing constraints of firms with little access to financial markets the effectiveness of monetary policy through the credit channel will be lower.

Brick and Fung (1984) point out the possibilities trade credit has for reducing the tax bill of the firms involved. Because of the way in which interest rates are paid and accounted for tax purposes (in a one-off discount for early payment instead of a more continuous flow), trade credit can be used to transfer profits across periods and firms. If the supplier and the seller face different marginal tax rates, trade credit can therefore be used to avoid the payment of some taxes and these savings can be split between the buyer and the seller. This surplus share may be done through some side payments, but it is quite likely it can also be done using the terms of trade credit itself.

Brennan, Maksimovic and Zechner (1988) highlight the possibilities that trade credit offers for price discrimination. If suppliers cannot discriminate against their customers by charging them different prices but the customers with a higher price elasticity are also the ones that face tighter credit constraints, the supplier can effectively price discriminate between buyers by offering them trade credit at rates below the market ones. This seems to point in the direction of trade credit being a relatively cheap form of finance, but the argument can be generalised to the case of constrained customers having lower price elasticities to also justify high interest rates associated with trade credit.

The idea of price discrimination through trade credit stresses the fact that from an economist's point of view it is sometimes impossible to differentiate between prices paid for intermediate goods and interest rates. The nature of a seller-buyer relationship is both financial and commercial and these two aspects can not be easily disentangled. For example in some industries there is no discount for early payment and therefore most customers take trade credit on their purchases.[7] One could think that this is a case where trade credit is a free form of credit but we could also argue that if credit is always taken the interest rate paid is included in the price of the goods, (although we cannot differentiate what part of the price paid corresponds to the actual price of the goods and what part to the interest rate paid). The interest rate paid by these firms is unobservable rather than inexistent.

Brennan, Maksimovic and Zechner (1988) and also Smith (1987) link the asymmetric information and the price discrimination literature, showing that suppliers can use credit terms to screen their customers in the presence of asymmetric information. In these papers the terms of the trade credit contract can be optimally set to screen good-creditworthy buyers from the buyers to which it is unprofitable to lend. In Smith (1987) suppliers offer cash only contracts to the least profitable customers. It is assumed that suppliers can identify through monitoring these less creditworthy buyers. Suppliers then offer a menu of cash versus credit to the rest of the buyers, and those buyers select themselves to either use trade credit or to finance themselves through banks to pay cash. An interesting implication of seeing trade credit as a device to screen buyers is that it justifies the stylised fact of trade credit terms being relatively uniform within an industry.

A new stream of literature tries to explain the characteristics of trade credit as a result of its liquidation value in case of default and renegotiation. In particular, two papers reach similar conclusions starting from apparently opposite assumptions. In Frank and Maksimovic (1999) the existence of trade credit is a result of suppliers having an advantage in liquidating intermediate goods in case of default by their buyers. This advantage comes from the fact that suppliers have

[7] For example in the NSSBF data approximately half of the customers declare that a discount for early payment was offered in half, or more than half, of their transactions with their suppliers. It is also revealing that among the firms that declared to make some type of late payment, the amount of trade credit deals with no early payment discount goes down to 23% thus supporting the idea of high interest rates of trade credit being related to the possibility of late payment.

the distribution channels to re-sell these intermediate goods, if they are not too buyer specific. In principle some legal systems allow trade creditors the possibility to claim back supplied intermediate goods in case of default if these goods have not been transformed or sold.[8] As in Burkhart and Ellingsen (1999), this ability to repossess these commodities will be more or less important depending on the average length of stay of non processed goods in the customer's firm compared with the maturity of trade credit. The ability to reclaim unsold goods also depends on the legal interpretation of whether a good has been transformed or not. For example in the UK if goods from different suppliers are mixed up in a way that does not allow identification of the origin of each good, these goods cannot be reclaimed by the suppliers in case of liquidation. This makes the argument in Frank and Maksimovic, most relevant for goods that are seller specific, non perishable, easy to identify and not transformed at the customer's firm such as new cars or books, that are in many cases sold on deposit. Wilner (2000) assumes that suppliers incur in sunk costs that are specific to their buyers. If suppliers have a limit on the amount of customers that they can supply to (i.e. one) then the cost of finding a new customer can be seen as the cost of losing an existing one. As a result, in case of renegotiation of debts, suppliers give more concessions to customers than banks. Although the model in Wilner (2000) and the one in Frank and Maksimovic (1999) start from points of view that seem to be quite contradictory, they reach basically the same result. Suppliers will specialize in financing buyers with low creditworthiness, for whom liquidation is more likely to occur, and banks will finance creditworthy firms. High interest rates associated with trade credit reflect the fact that low quality firms are self-selected towards being financed by their suppliers.

[8] Note that while our model predicts higher levels of trade credit when inputs are *buyer* specific, Frank and Maksimovic (1999) predict high levels of trade credit when products are *seller* specific.

Our theoretical explanation of trade credit justifies its existence on the basis of the extra ability of suppliers to enforce debt repayment better than banks. To some extent, part of this idea has already been explored in the paper by Bolton and Scharfstein (1990). In their paper, a monopolistic financier (bank) can lend to an entrepreneur in an environment where debt is difficult to enforce because the project needs sequential financing at different stages, and the threat of not refinancing the entrepreneur is what allows debtors to effectively claim back debts. However, the main drawback in the Bolton and Scharfstein paper is the assumption of a single monopolistic financier. While it is true that banks may not be perfect substitutes to each other, it seems more natural to assume that the degree of substitutability of banks is relatively high, while the degree of substitutability of a supplier may be very low. In our model the threat of not supplying further intermediate goods is what allows suppliers to enforce debt repayment. Here, the supplier is not necessarily a monopoly in the supply of such goods, but simply costly to substitute it by an alternative supplier. The link between the supplier and the customer that justifying the existence of trade credit may take various different forms; technological, informational, legal etc. Moreover, the existence of this link justifies the role of suppliers as lenders of last resort, that will help their customers whenever their customers experience negative liquidity shocks that affect their survival or growth. This is an idea has not yet been considered in previous literature and it explains two important features of trade credit use: i) The high interest rates of trade credit and ii) The widespread phenomenon of late payment. Late payment can be seen as one of the manifestations of the support offered by suppliers to their customers in financial trouble. The fact that late payment does not carry a penalty justifies the existence of an upfront premium that compensates the supplier in advance for any future late payment or other form of financial support to customers. In the empirical part of this thesis we check some of the implications of our model, showing some regularities that had not been identified in previous literature and that support the role of suppliers as debt collectors and insurance providers. We find a hump shaped relationship between the level of trade credit taken and the age of the firm that is consistent with the idea that trade credit is related to the existence of either some degree of technological specificity or a relationship that takes time to build. Evidence is also found regarding the support given by suppliers to their customers experiencing some form of liquidity shock.

2.2 Empirical Literature on Trade Credit

One of the problems that the empirical literature on trade credit faces is that trade credit is most relevant in the financing of small and relatively opaque firms. The marginal nature of trade credit, typically used after other forms of credit have been exhausted, makes it more frequent in firms on which the market has little information. That means that the amount of data available for these types of firms is also relatively small in terms of quantity, quality and detail. Datasets like the NSSBF provide detailed information about trade credit and other sources of finance for small firms, however it has the major drawback of being a cross-sectional dataset. For the US, most of the datasets that constitute a panel of firms are mainly composed of quoted firms, typically too big to fully test trade credit theories. Within Europe, most countries ask for compulsory filing of yearly accounts of non-quoted firms. This allows for the construction of panel datasets that contain relatively small and new-born firms. However, the detail of the accounts is normally not very high.

We classify different empirical papers that study trade credit use in four main categories. Studies that use aggregate or sector data, studies that use micro data, papers that investigate the relationship of trade credit with the business cycle and monetary policy and finally articles that study the business of small business finance in general and have some relevant results regarding trade credit. We realise that these categories are not mutually exclusive, but they seem the relevant ones to differentiate the different streams of literature.

2.2.1 Aggregate-Sector Data

Nadiri (1969) uses quarterly aggregate data of US manufacturing sectors to assess the observed behaviour of trade credit when seen as an advertisement expenditure. The underlying idea is that trade credit may be a necessary component of selling goods, like publicity, salesmen etc. This can be especially important when selling to new customers. The results show that the time series evolution of trade credit is consistent with this view and trade credit behaves like any other sales cost in a neoclassical way in the sense that the levels of accounts payable and receivable seem to react to changes in their user cost.

Ng, Smith and Smith (1999) use survey data from firms included in the Compustat files to examine the variation in trade credit terms (early payment discount, early payment period, maturity, implicit interest rate) across industries using two and three digit SIC classifications. The paper finds evidence of some degree of flexibility in trade credit terms depending on customers, so even though the trade credit contract is normally standard and stable for a given industry, renegotiation and flexibility about late payment and giving price discounts that have not been strictly earned gives suppliers a possibility to discriminate among their customers. Evidence is also found supporting the interpretation of the initial free credit period as a way to smooth transactions and also as a period when the quality of the deliveries can be checked before final payment. In general the paper finds support for theories based on the different informational asymmetries regarding the supply of intermediate goods (goods quality, customers creditworthiness and willingness to repay). On the contrary, little evidence is found to support price discrimination theories and it seems that the credit terms (at least the ones in the contract without taking into account late payment and renegotiation) are not sensitive to the liquidity needs of the customers.

2.2.2 Micro Data

Elliehausen and Wolken (1993) run a cross-section analysis of the characteristics of trade credit as a source of finance for small firms, using the 1989 National Survey of Small Business Finance (NSSBF). They estimate a partial equilibrium model in which trade credit is motivated both by transaction costs and financial needs. Three aspects of the use of trade credit are explored: in the first place, whether firms decide to use trade credit or not, finding that transaction related variables are very significant when determining the use of trade credit. Financial variables are also significant, but to a lower extent. Secondly, they try to explain the determinants of the amount of trade credit used, finding again a significant influence of both transaction and finance motives. Finally, the decision to make late payments or not is explored. The results are that only financing variables seem to be explaining the probability of late payments, being younger firms with higher leverage and low liquidity, the ones that are more prone to do some kind of late payment. The variables that approximate the needs of trade credit for pure transaction costs do not seem to be related with the decision of making some late payments.

Mian and Smith (1992) use cross-sectional data of the American Institute of Certified Public Accountants (AICPA) to find the determinants of the use of factoring, accounts receivable, captive finance subsidiaries and general corporate credit. The idea is to find which firm characteristics determine that a firm manages receivables internally or uses third parties such as banks and factors to manage them. While the paper is successful in identifying the determinants of inter-firm credit between subsidiary firms, it finds little evidence of the determinants of accounts receivable being used as collateral for other credits; it does not find significant results regarding the determinants of the use of factoring either.

Petersen and Rajan (1997) use the National Survey of Small Business Finance (NSSBF) to test what explanations for trade credit use are more relevant for small businesses in the US. They run cross-sectional regressions of the accounts payable and accounts receivable of the firms in the sample as a function of variables that reflect credit quality, links with banks and suppliers, financial needs and finance availability.[9] The results show that suppliers are more willing to lend to higher quality firms. However if these firms have also access to alternative finance such as bank credit, they typically use this source first. Suppliers appear to have a special advantage in lending to firms that currently are experiencing some problems and have low creditworthiness, but also have a lot of potential for future growth.[10] The paper also finds some support for theories of trade credit a means for price discrimination.

Deloof and Jegers (1999) use a sample of Belgian firms to study the interaction of trade credit use and other forms of finance, and also whether having a single industrial group that involves both the supplier and the customer influences trade credit use. They find that the use of trade credit is positively correlated to cash holdings, negatively correlated with cash flow and also negatively related to alternative financial sources such as bank debt. However they find no significant evidence of industrial groups playing a major role in trade credit use.

[9] See Cox, Elliehausen and Wolken (1989) for a detailed description of the (1989) cohort of the NSSBF

[10] An interesting result of Petersen and Rajan (1997) is that firms that experience temporary problems are also forced to extend more trade credit. This is an added cost of financial distress that has not yet been approached by the theoretical literature on trade credit.

2.2.3 Trade Credit, Monetary Policy and the Business Cycle

The imperfections in financial markets may play an important role in the transmission of shocks and changes in monetary policy, in particular, given that small firms lack the access to financial markets and some types of securities. This makes them particularly exposed to reductions in the levels of lending of banks, that are affected by the decisions of the monetary authority.[11] Part of this reduction in bank lending may be compensated for if suppliers are able to lend more trade credit to their customers. It remains an open question whether this transmission mechanism is important in practice or not, and to what extent small firms are able to offset this shortage of bank loans by increasing their levels of borrowing with their suppliers via trade credit.

Nilsen (1999) uses Quarterly Financial Reports (QFR) data for US firms to see how the use of the trade credit of different groups of firms reacts differently with the phases of the business cycle. The paper contains VAR and standard time series regressions with subsamples of big firms with bond ratings, big firms without bond ratings and small firms. The results show how small firms borrow more trade credit during monetary contractions. The increase of trade credit is mostly used to substitute bank loans. This is normally a forced substitution as typically banks reduce their loans to small firms during downturns and monetary contractions. This is consistent with a pecking order of bank credit vs trade credit in which trade credit is used only when bank credit has been exhausted. The main financiers of this trade credit in monetary contractions are big firms that have access to commercial paper. This coincides with the results of Calomiris, Himmelberg and Wachtel (1995), showing that big firms issue commercial paper to finance their customers through trade credit. A novel result of the paper is that big firms without access to commercial paper tend to behave more like small firms,

[11]See Bernanke (1993) and Kasyap and Stein (1994) for an overview of the topic.

increasing the amount of trade credit and reducing their levels of bank credit. The overall picture of Nilsen's paper is that the results support the existence of a bank lending channel for monetary policy, as banks effectively reduce their levels of credit during monetary contractions but the effect is partly offset by big firms issuing more commercial paper and distributing funds to their customers. Marotta (1997) concentrates on the lending and borrowing behaviour of Italian firms stratified by different sizes, the results also point in the direction of small firms using more trade credit in monetary contractions. However, this growth of trade credit absorbs only partially the effect of the lending channel of monetary policy, so there is also evidence of small firms acting as financially constrained and not being completely shielded against monetary contractions.

One of the problems of previous papers that wanted to identify the existence of financing constraints of small firms by concentrating only on the reduction of bank credit, was to identify whether that reduction came from a lower demand for credits or from banks rationing the loans or their customers. The rise in trade credit present in both Marotta (1997) and Nilsen (1999) when the monetary policy tightens shows that the reduction in bank credit is not due to a smaller demand of credit of the firms, but to the rationing of credit done by banks.

Kohler et al (2000) also try to identify if suppliers help their customers in periods where monetary policy tightens, using aggregate data and a panel of quoted UK firms. Given that overall net trade credit in a closed economy is by definition zero, and assuming that most trade credit is domestic, one can infer the behaviour of small constrained firms by concentrating on the evolution of trade credit given and trade credit received of big quoted firms, as they should be the mirror image of the small constrained ones. The results support the idea of big firms providing extra finance to small ones in periods where there is a recession or the monetary policy tightens. Large firms tend to extend more trade credit and receive less trade credit in recessions

Hernandez de Cos and Hernando (1999) explore a sample of Spanish firms of all sizes and also find an increase in the levels of inter-firm credit going from big firms to small firms in downturns and monetary contractions.[12] They also find that the average payment period and the proportion of trade credit over total sales behaves countercyclically, this seems to be contradictory with the results of Nilsen (1999), however the results are to a large extent compatible. The overall picture seems to be that trade credit behaves procyclically in terms of overall trade credit given and trade credit as a proportion of firms assets, but trade credit behaves countercyclically when measured as a proportion of sales.

Ramey (1992) studies the aggregate co-movements of money, bank credit and trade credit. The paper views bank credit and trade credit as a production input (i.e. trade credit produces transaction services that are necessary for production). The co-movement between trade credit and money allows us to identify the nature of the shocks in the economy. Under technological shocks, both trade credit and money should behave in the same manner, thus producing a positive correlation between them. However monetary and financial shocks should make the two variables evolve in an opposite direction (depending on their own price and cross-price elasticities). The results show that at non-seasonal frequencies, money and trade credit are negatively correlated both in the short- and in the long-run. So the nature of the shocks seems to be mainly financial shocks that alter the relative costs of bank and trade credit. However at seasonal frequencies, the main type of shocks are non financial.

[12] They use the "Central de Balances" CBBE dataset from 1983 to 1985.

2.2.4 Trade Credit and the Financing of Small Business

Berger and Udell (1998) study the timing and the intensity of the use of different sources of finance for small firms such as bank credit, venture capital, market debt and trade credit. They survey the theoretical and empirical literature on the subject of small firm finance and they also provide some statistical information about the use of different instruments. Given the wide range of information necessary to investigate all the possible alternative sources of funds, they use different datasets to approach each of the questions of the paper separately.[13] With respect to trade credit, the paper already hints at the possible parallels between trade credit and the literature of relationship lending, expecting that younger and smaller firms would use more trade credit, but not just the new-born ones or the ones with low links with their suppliers. According to this paper, new-born firms would rely mainly on the use of insider finance and venture capital (maybe collateralised credit also) before building up the links with their suppliers that would allow them to use trade credit. Later on, the track record of the firms and the building up of links with banks can allow firms to have some non-secured bank credit.[14]

Garcia Cobos (1994) and (1995) finds results in the same direction. His paper studies the average interest rates paid by small new-born firms, finding that just new-born firms face relatively low interest rates. This is not due to the fact that they are considered creditworthy borrowers, but on the contrary, because most of their borrowing is done via collateralised loans. Afterwards, firms start getting more non-collateralised loans and trade credit. These are still seen as risky firms, so the interest rates of non-secured loans are quite high, thus the average interest rates paid rise from the ones of the original secured loans. In the long run, firms

[13]The main data soucces used arc NSSBF, Compustat, Survey of Terms of Banking Lending (STBL), Bank CALL rcports, Comunity Rcinvcstmcnt Act (CRA) and survey data on Venture Capital and Angel Finance.

[14]See Petersen and Rajan (1994) and (1995)

become more creditworthy, build up links with their banks and generate more public information about their quality, so average interest rates go down again.

Jayaratne J.; Wolken J.; Petersen M A (1999) use data of the NSSBF to investigate if there is any advantage in small firms borrowing from small banks. From the point of view of this thesis, the interesting feature of their approach is that they use the amount of trade credit taken, payment terms and late payment (among other variables) as measures of the liquidity constraints of the firm. However the paper does not find substantial differences of trade credit use when customers have access to small banks finance.

McMillan and Woodruff, (1999) collect a survey of firms in Vietnam where the enforcement of debt repayment is in general quite difficult and show that provision of trade credit is more likely when it is difficult for the customer to find an alternative supplier, when the supplier has information about the customer through information gathering or prior experience and finally when the supplier belongs to a network of similar firms. These results are very relevant to assess the relevance of our model exposed in Chapter 3, as the model starts with an environment of limited enforceability of debts and strong links between suppliers and customers. These conditions are quite common in the provision of informal credit in developing countries.

3 Suppliers as Debt Collectors and Insurance Providers

This chapter presents a model in which trade credit arises naturally as a result of the commercial interaction between a supplier and a customer, even in the presence of a competitive banking sector. The key elements behind the model are the existence of commercial or technological links between suppliers and customers, and a situation of imperfect enforceability of debt. The idea behind the model is that a supplier and a customer are more productive the longer they stay together. In other words, there are sunk costs, learning-by-doing processes, tailor-made products and so on that link suppliers and customers in a way that makes it costly for them to switch to another partner. The extra profits of staying together will normally be split according to the bargaining power of the agents, generating an interior division of this surplus. Because the customer gets part of this extra surplus, the supplier may be more efficient than banks in enforcing debt repayment having the additional threat of stopping the supply of intermediate goods in case of default by the customer.[15] On the other hand, given that the supplier also gets part of this extra surplus, she will act as lender of last resort if the customer experiences temporary liquidity needs.

The high interest payments associated with trade credit can then be justified by two extra premiums on top of the market interest rate. In the first place there is a premium that suppliers get for providing credit when banks are not willing to lend. We call this premium the default premium. Secondly, suppliers will also demand an insurance premium, due to the fact that they may be asked to provide

[15]In our model, like in Kiyotaki and Moore (1997) Hart and Moore (1994) (1998) and Hart (1995), debt contracts can not be enforced in themselves, so it is necessary that the lender has some external threat in order to generate some kind of lending. Bolton and Scharfstein (1990) suggest that the threat of not refinancing is what allows debtors to effectively claim back debts.

extra liquidity in the future.

The aim of the model is not only to give an explanation for the existence and high cost of trade credit, but also to provide testable implications that can support or reject our hypothesis. Some of the features of the model, like having an explicit startup stage or liquidity shocks that are correlated with the performance of the firm, bring some complexity to the model that may seem unnecessary from a purely theoretical point of view but are in place to bring the model closer to the empirical evidence of Section 5.

This explanation of the determinants of the characteristics of trade credit is, to some extent, complementary to the ones of previous articles.[16] For example, trade credit can be seen as a means of payment to reduce transaction costs when the timing of the arrival of new supplies is uncertain (Ferris, 1981). This is consistent with the existence of a free delayed payment period like the first ten days in the "2-10 net 30" deal of the above example. However, the model remains silent about why trade credit is so expensive and why firms are willing to pay such costs. For example in the NSSB sample 46.4% of the firms forego the discount for early payment in at least half of their purchases. Other literature considers trade credit as a financial instrument. Biais and Gollier (1997) provide an explanation for trade credit based on the existence of some form of asymmetric information; Brennan, Maksimovic and Zechner (1988) highlight the possibilities that trade credit offers for price discrimination;[17] and there is a new stream of literature that focuses on

[16] For an extensive review of theoretical and empirical literature on Trade Credit see Mian and Smith (1992), Petersen and Rajan (1997) and Smith (1995). There are also articles that base the existence of trade credit on tax advantages as Brick and Fung (1984). See also Emery (1987) and Schwartz (1974) for models in which suppliers have superior access to financial markets.

[17] Brennan, Maksimovic and Zechner (1988) and Smith (1987) link the asymmetric information and the price discrimination literature by showing that suppliers can use credit terms to screen their customers in the presence of asymmetric information. The idea of price discrimination through trade credit stresses the fact that from an economist's point of view it is sometimes impossible to differentiate between prices paid for intermediate goods and interest rates. (The nature of a seller-buyer relationship is both financial and commercial and these two aspects can

the role of trade credit in liquidation, default or renegotiation. Among the latter, Frank and Maksimovic (1999) explain the existence of trade credit as a result of suppliers having an advantage in liquidating intermediate goods in case of default by their buyers.[18] On the other hand Wilner (2000) assumes that suppliers incur sunk costs that are specific to their buyers, so in the case of renegotiation of debts, they give more concessions to customers than banks. Both models conclude that suppliers will specialise in financing buyers with low creditworthiness, for whom liquidation is more likely to occur. High interest rates associated with trade credit reflect the fact that low quality firms are self-selected towards being financed by their suppliers.

3.1 The Model

The model in this chapter explains the existence of trade credit as the financial consequence of the existence of commercial or technological links, in a context where debt repayment may be difficult to enforce. This section begins describing the different agents involved in the model. Throughout the exposition, and for the sake of clarity, we will refer to the supplier as "she" and the customer as "he". Secondly, we proceed to explain the production technology of the customers, with special attention given to the existence of a link between suppliers and customers. Then we describe the bargaining between the agents and the structure of cash flows implied by this bargaining. Next we conjecture a certain equilibrium structure and see that, under certain conditions, this is the only equilibrium of the model. Finally

not be easily disentangled).

[18]This advantage comes from the fact that suppliers can claim back supplied intermediate goods in case of default and have the distribution channels to re-sell them, if they are not too buyer specific. The ability to repossess these commodities will be more or less important depending on the average length of stay of non-processed goods in the customer's firm compared with the maturity of trade credit. Note that while our model predicts higher levels of trade credit when inputs are buyer specific, Frank and Maksimovic (1999) predict high levels of trade credit when inputs are seller specific.

we find the equilibrium values of the different endogenous parameters of the model.

3.1.1 Agents

The model is in discrete time with infinite periods. All agents live forever, are risk neutral and maximise future discounted profits. There are three types of agents in the model: banks, suppliers and customers. *Banks* are deep pockets, having access to unlimited funds. They discount future cash flows with a factor $\beta < 1$. This implies that banks are willing to lend or borrow at a market interest rate i such that $\beta \equiv \frac{1}{1+i}$. *Suppliers* are also deep pockets with the same discount factor β; they are therefore also willing to lend or borrow at the same rate of banks. We will relax the assumption of deep pocket suppliers to constrained suppliers in the next chapter. Suppliers also provide their customers with the necessary intermediate goods necessary for production. These goods are produced with a technology with constant returns to scale. The cost to produce each unit of intermediate goods is normalised to one. These inputs may be of two kinds: generic goods which can be provided by any supplier and serve any customer; or specific goods, which have been tailored to the needs of a single customer and can only be provided by a particular supplier. Finally, *customers* are endowed with a limited amount of wealth w; they are also relatively impatient with respect to deep pockets, having a discount factor $\delta < \beta$. Each customer can only run one business at a time. Every period, the customer buys a variable amount I of intermediate goods delivered by a single supplier. By transforming these inputs, the customer obtains some net income at the end of the period that can either be $A_h I$ or $A_l I$ where $A_h > A_l$. These returns are stochastic, and the probability of obtaining a high or a low return depends on whether the production process uses a startup technology with low expected productivity that transforms generic inputs; or a mature technology with high expected productivity that transforms specific inputs.

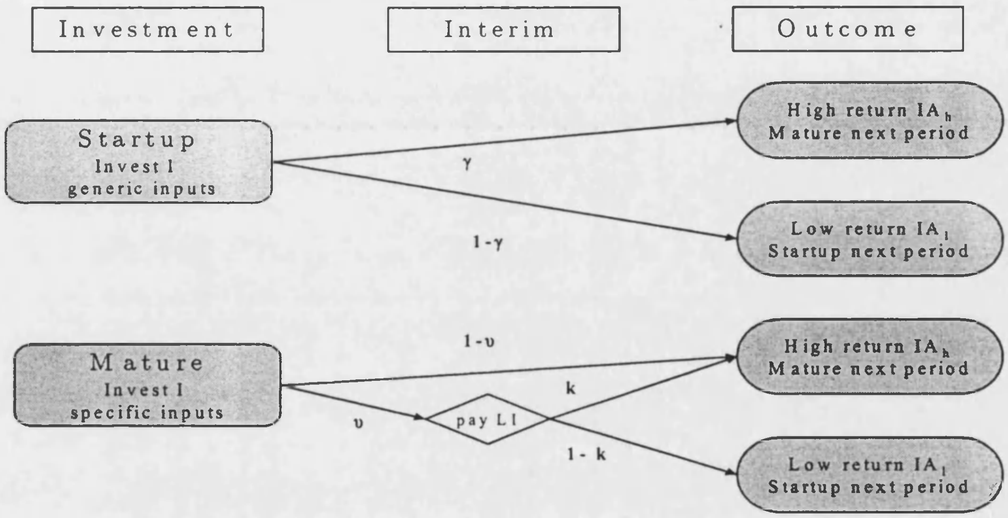
Assumption 1: Suppliers are more abundant than customers.

So in the absence of any link between suppliers and customers, customers can costlessly search for a supplier that sells them inputs at cost value.

3.1.2 Technology

The possibility of using either type of technology is determined by the process shown in Figure 1

Figure 1: Production technologies



Initially when a supplier and a customer meet for the very first time they must work with the technology that uses *generic* inputs. This represents a *startup* stage where the customer tries different ideas until finding a successful one. With a probability $(1-\gamma)$ the idea is unsuccessful, so the customer receives a return of $A_l I$ and remains in the startup stage for the next period. However with some small probability γ the idea is successful. A successful idea gives the customer returns of $A_h I$ and allows them to use a more productive technology that uses specific inputs in the next period. We call this technology *specific* or also *mature* technology. When the customer uses this mature technology there is a probability $(1-\upsilon) >$

γ that the project is successful without any further payment, so the customer gets returns of $A_h I$ and can use the mature technology again in the next period. However, with a probability υ the customer may experience a *liquidity shock.* The liquidity shock represents any kind of problem that the firm may experience that requires an additional disbursement of money to continue producing. The structure of this liquidity shock is the following: the cost of the shock is LI. If the firm invests LI in solving "the problem" then with probability k the process will be successful, and with probability $(1 - k)$ the project will be unsuccessful. However if the firm decides not to invest this sum, the project is sure to be unsuccessful. Again a successful project entails returns equal to $A_h I$ and the possibility to keep using the mature technology while an unsuccessful project means going back to the startup stage with returns equal to $A_l I$.[19]

A good example of what we mean by this liquidity shock is the existence of a breakdown in the production process that costs LI to repair. If the firm does not repair the breakdown the project is definitely unsuccessful, while if the breakdown is repaired the project is successful with probability k. This liquidity shock can also be seen as a delay in production. At the end of the period, the customer has to decide whether to get an unsuccessful return or wait some more time t to get a successful return with probability k. Thus we can see LI as the time value of delaying returns for time t. Therefore, although throughout the rest of the model, the financial support of suppliers to customers takes the form of an explicit monetary help, it can easily be generalised to otherr forms of support like the provission of more intermediate goods on credit, partial debt forgiveness, or the posibility to incur in late payment.

[19]The liquidity shock is modelled in a similar fashion to Holmströ̈m and Tirole (1998). From a theoretical point of view the shock need not be correlated with the probability of success of the project. However, as we will see, this slightly more complex model is more realistic when it comes to empirical estimation.

There is one important characteristic of the mature technology, that is crucial for the understanding of the model. When the customer has already been successful in the startup stage and is about to use the specific technology for the first time, he has to choose which supplier is going to be the one that will produce the necessary inputs. The customer faces a competitive market of suppliers willing to be the chosen one to produce these tailor-made inputs. From then onwards, at any point in time, a customer or a supplier can resolve their relationship and switch to another partner. However, given that the inputs are specific, after switching they must start using the generic technology again. The supplier owns the blueprint or the knowledge to produce the customised inputs that are necessary in the mature technology.

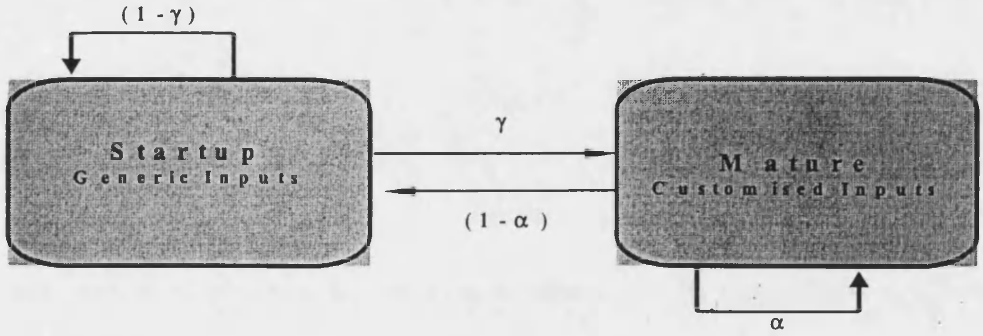
So a customer can lose the advantages of a specific inputs technology, either because there has been an unsuccessful period or by switching to a different supplier.

Assumption 2: $L < k(A_h - A_l)$

So it is always profitable for the customer to pay the liquidity shock if he has sufficient funds. It is convenient to define $\alpha = vk + (1 - v)$ as the *ex ante* success probability, conditional on always paying the liquidity shock. We are restricting ourselves to parametrisations that make it optimal to pay the liquidity shock; therefore, conditional on always paying the liquidity shock, the choice of technology can be summarised by a Markov process with transition probabilities γ and α, as shown in Figure 2.[20]

[20]The shock probability v is correlated with the success probability α, so even though the choice of the production technology is a Markov process, the whole setup is not.

Figure 2: Transition probabilities conditional on paying the liquidity shock



Assumption 3: Structure of returns.

A proportion of investment cI is consumed by the customer during the production process.[21] Also a proportion θI of the value of the firm can be used as collateral to secure debt repayment. The remainder of returns are not verifiable and can not be collateralised. By not verifiable, we mean that it is not possible to write a contract that implies some commitment of these future returns. This precludes in particular the writing of a standard debt contract. It is useful to redefine these remaining returns as follows.

$$A_h I = cI + \theta I + RI$$

$$A_l I = cI + \theta I + rI$$

Thus RI and rI represent the part of the returns of the customer that can be freely used but is genuinely non-verifiable, as the rest of the returns can either be backed by collateral, or must be consumed.

Assumption 4: $\beta(\theta + \alpha R + (1-\alpha)r - vL) < 1$

[21] The existence of cI rules out the infinite postponement of consumption and can be seen as private benefits that the entrepreneur enjoys while producing, or wages, or as a minimum level of dividends.

The expected discounted returns of the firm, excluding the ones that must be consumed, do not cover investment costs, not even when the technology is specific and we use the discount factor β. This assumption implies that infinite investment is not possible, not even if the customers could somehow commit the non-collateralisable part of their returns.[22] We do not discount the proportion of returns c that must be consumed, because it cannot be used to repay debts even if the customer wished to.

Assumption 5: $\delta(c+\theta+\gamma R+(1-\gamma)r)>1$

The project has positive net present value (NPV). Overall returns, including the part that is consumed by the customer, are bigger than the level of investment, even when the technology is generic and we discount using the customer's discount factor δ.

3.1.3 Bargaining

We assume the following simple bargaining process to determine the cash flow structure between both agents: *The supplier makes a "take it or leave it" offer to the customer at the beginning of every period; the customer can either accept it or switch to another supplier.* Obviously, if the customer is using specific inputs and switches to another supplier, he will have to use the generic technology again.

The only sub-game perfect equilibrium of this bargaining game is that the supplier will make an offer to the customer that leaves him indifferent between accepting the offer or switching to another supplier. This generates three possible different surplus distributions between the supplier and the customer, depending on whether the customer is using the startup technology, the mature technology for the first time or the mature technology after the first time.

[22] However this does not necessarily mean that firms decrease in size with time, since it does not preclude that $\theta+\alpha R+(1-\alpha)r-vL>1$.

When a customer is using the *startup technology* that uses generic inputs, suppliers are perfectly interchangeable. This means that the customer has in fact all the bargaining power in the relationship, since the customer can costlessly search until he finds the supplier that sells the intermediate goods at cost value.

When a customer is using the *mature technology* that uses specific inputs, switching to a different supplier implies that the customer would lose the advantages of the mature technology and would have to return to the startup stage again. Therefore the supplier will make a "take it or leave it" offer that extracts all the extra surplus. The customer will accept this offer as long as it is as good as the outside option of switching to another supplier. Let p denote the proportion of investment that the supplier takes as surplus share, being thus pI the total amount received by the supplier when the customer uses the mature technology, on top of the cost of the intermediate goods I.

However, there is also a special period when the customer has just been successful using the startup technology and therefore is going to use the *mature technology for the first time*. At this stage, customers have a successful idea and they have to choose which supplier is going to produce the necessary specific inputs. They still face a competitive market of suppliers that know that if they are the "chosen one" they will be locked to that customer and will be able to extract some surplus from the customer in the future. Therefore when suppliers make their offer they must "bribe" the customer with a payment that corresponds to the expected discounted value of all the future payments pI that will be received in further periods. We call d the proportion of investment paid as "bribe" to the customers; so, in this first mature period, the customer pays I in exchange for inputs, but receives dI from the supplier. Note that this cash flow look precisely like a debt contract; dI can be seen as a loan that suppliers make to their customers when they start using specific technology, while pI are the payments of interests and repayment of capital that the customer will make in future periods. Competition between suppliers ensures that dI is determined in such a way that suppliers just break even in expected terms.

3.1.4 The Customer's Investment Decision

We begin conjecturing the following equilibrium structure: the customer invests all available funds in the project, even when in the startup stage; when the liquidity shock hits in the mature stage the supplier bails out the customer by paying the cost of the shock; the customer does not keep any precautionary saving or get any insurance against the shock to force the supplier to pay for it. Through Sections 3.1.4 and 3.1.5 we will find the necessary conditions for this equilibrium to exist. In Section 3.1.6 we will derive the unique equilibrium values for the cash flows p and d, while in Section 3.3 we will see that this insurance agreement between the supplier and the customer is the optimal one.

We can now find expressions for the value functions of suppliers and customers. By value function we mean the Bellman equation that represents the overall expected discounted value of the future returns of a firm. We express these value functions per unit of wealth of the customer firm, so to get the overall value of the customer's firm, one has to multiply the relevant value function times the current endowment of the customer. We name S the per unit value function of a customer using the startup technology, N the value function of a customer using the mature technology for the first time and M the value function per unit of a customer using the mature technology after the first period.

For example, if V denotes the overall value function of a customer in the startup stage, the relevant expression will be:

$$V_t = w_t S = \delta(cI_t + \gamma \ (w_{t+1} \mid sucess) \ N + (1-\gamma) \ (w_{t+1} \mid failure) \ S)$$

Where the sub-index t qualifies the value in a particular point in time and the sub-index $t+1$ on the next period. We know that after repaying bank debt and consuming the future net wealth of the firm will be $(w_{t+1} \mid sucess) = I_t R$ in case of success and $(w_{t+1} \mid failure) = I_t r$ in case of failure. Therefore we can express the whole value function as a function of current wealth and investment $V_t = w_t S = \delta(cI_t + \gamma R I_t N + (1-\gamma) r_t I S)$. That is, the value function of the startup stage is the discounted level of consumption at the end of this period cI_t plus the discounted value of the future value of the firm. This future value will be with probability $(1-\gamma)$ the value of a firm with initial wealth $I_t r$ that still uses the startup technology, and with probability γ the value of a firm with wealth $I_t R$ that starts using the mature technology. These are the relevant sizes of the firm in the next period. If firms borrow up to their collateral limit, θI_t has to be used to repay bank debts; also cI_t must be consumed, so the initial wealth of the firm in the next period will be $I_t r$ if this period is unsuccessful and $I_t R$ if this period is successful. Taking common factor I_t and given that, as we will see later on, when a firm uses generic technology $I_t = \frac{w_t}{1-\beta\theta}$, there is an expression for S that does not depend on the level of wealth of the customer's firm: $S = \frac{1}{(1-\beta\theta)}\delta(c + \gamma RN + (1-\gamma)rS)$. Remember that S is the value function in present value per unit of wealth of using the startup technology, N the value function on the first year when supplier and customer use the mature technology, and M is the value function of the mature technology thereafter. The whole set of value functions for the customer in present value (PV) per unit of wealth is:

$$S = \frac{1}{(1-\beta\theta)}\delta(c + \gamma RN + (1-\gamma)rS) \tag{1}$$

$$N = \frac{1}{(1-d-\beta\theta)}\delta(c + \alpha RM + (1-\alpha)rS) \tag{2}$$

$$M = \frac{1}{(1+p-\beta\theta)}\delta(c + \alpha RM + (1-\alpha)rS) \quad (3)$$

The first term of each value function is the level of leverage that the firm has in every stage, or in other words, how much the customer needs to downpay per unit of investment. To understand this term we have to see what are the effective levels of investment that maximise the amount of funds committed in the project when the customer borrows as much as possible in each stage. When customers are in the *startup* stage they cannot commit to repay any funds on top of the collateral value of the firm θI_t. The discount rate of both banks and suppliers is β; to account for some competitive advantage of banks as lenders we assume that bank lending weakly dominates supplier lending, so all collateralised credit will be lent by banks. The customers will maximise the size of their firm by investing all their wealth w and the funds that they can borrow from banks $\beta\theta I$. So $I_t = w_t + \beta\theta I_t \Rightarrow I_t = \frac{w_t}{1-\beta\theta}$. When customers are using the *mature technology for the first time* they receive extra funds dI coming from their suppliers, so their leverage is higher than in the search case. The level of investment will then be $I_t = w + \beta\theta I_t + dI_t \Rightarrow I_t = \frac{w_t}{1-\beta\theta-d}$. Finally, when customers are using *mature technology* after the first time they have to share the extra surplus with their suppliers by paying them pI_t on top of the cost of the intermediate goods I_t. The level of leverage thus goes down and $I_t = w + \beta\theta I_t - pI_t \Rightarrow I_t = \frac{w_t}{1-\beta\theta+p}$.[23]

The second term of each value function is firstly the discounted value of this period's consumption, which is constant per unit of investment, and secondly the future value of the firm, which depends on the kind of technology that is being

[23] We can reinterpret the cash flows between the supplier and the customer in terms of prices. The customer is effectively paying a price 1 per unit of investment when using the start-up technology, a price $(1-d)$ when using the mature technology for the first time and $(1+p)$ when using the mature technology from then onwards.

used.[24] There is no trace in these value functions of the liquidity shock. This is because since customers are not holding any savings they will ask their supplier to pay for this liquidity shock. Section 3.1.5 shows that the supplier will agree to pay it.

Is investing all possible funds the optimal strategy? Given that customers have limited borrowing capacity, the positive net present value rule (NPV) becomes a necessary condition to invest. However it is not sufficient, since customers will choose the strategy with the maximum NPV and not just any strategy with positive NPV. Two potential strategies could yield a higher NPV than investing as much as possible in the search stage. One is to split the project into a series of infinitely small ones to maximise the probability of at least one success. This is precluded by the assumption that customers can only follow one project at a time. The other strategy is an intertemporal version of the previous one and would be to invest a small amount of money in the startup project and leave the rest in a bank account until a successful idea arrives. This strategy can be excluded if the instantaneous consumption associated with investing in the startup strategy is bigger than the option value of waiting for one period to see if the project is successful.

Proposition 1 *There is a threshold level $\delta^* \in (0, \beta)$ such that for every $\delta < \delta^*$ it is optimal for the customer to invest all available funds in the project even in the startup stage.*

Proof. See Appendix 1 ■

Assumption 6: $\delta < \delta^*$

Therefore customers have a low enough δ to commit all their available funds, even in the startup stage. In equilibrium the mature technology is going to be

[24]The value functions are well defined. The fact that d is equivalent to a discounted flow of future returns joint with Assumption 4 guarantees that $d < (1 - \beta\theta)$, so infinite investment is ruled out.

at least as profitable as the startup technology (otherwise the customer would switch to the startup technology again), so this assumption also guarantees that the customer will invest all available funds when using the mature technology.

3.1.5 The Supplier's Decision

The supplier has basically three decisions to make in the model: how much surplus to extract when supplying specific goods (determination of p); how much to offer on the first period providing specific inputs (determination of d); and finally whether to give extra funds to the customer if the liquidity shock hits and the customer has made no provisions to face it.

We use lower-case letters to indicate the equivalent value functions of the supplier, that is s is the value function of a supplier that produces intermediate goods for a supplier that uses the startup technology and so on.

The Decision to Support the Customer

Proposition 2 *Suppliers will always pay for the cost of facing the liquidity shock as long as customers have no funds to pay for it and the cost of searching for another customer exceeds the cost of paying for the shock.*

Assumption 7: $L = kR\frac{\delta(\alpha-\gamma)(R-r))}{1-\beta\theta-(\beta-\delta)\alpha R-\delta(\alpha-\gamma)r+\beta\upsilon kR}$

This is the necessary and sufficient condition that guarantees that $L < k(Rm - rs)$, so suppliers would rather pay L to save their customers from failure with probability k than losing them and searching for new ones.[25] We will see in Section 3.3 what would happen if the condition did not hold.

[25] If suppliers did not bail out their customers, they would have to search for a new one. Later on we will see that in equilibrium $s = 0$. This means that suppliers will then bail out their customers as long as $L < kRm$. In equilibrium this condition is equivalent to assumption 7.

Given that the customer invests all available funds and that suppliers will bail them out when necessary, the relevant value functions for the supplier are:

$$s = \frac{1}{(1-\beta\theta)}\beta(\gamma Rn + (1-\gamma)rs) \tag{4}$$

$$n = \frac{1}{(1-d-\beta\theta)}\{-d + \beta(\alpha Rm + (1-\alpha)rs - vL)\} \tag{5}$$

$$m = \frac{1}{(1+p-\beta\theta)}\{p + \beta(\alpha Rm + (1-\alpha)rs - vL)\} \tag{6}$$

The value functions are expressed in NPV per unit of wealth of the customer.[26] The payoffs between the supplier and the customer not only affect the level of leverage of the firm, but also represent an inflow or outflow of funds into the suppliers wealth. The term $-vL$ appears in the last two equations because if the liquidity shock hits, customers will ask for these extra funds from their suppliers and they will be willing to pay. We will also see in Section 3.3 that using the suppliers as liquidity providers is the optimal strategy for both suppliers and customers. Using this implicit insurance provided by suppliers dominates other alternatives such as precautionary saving or other types of insurance with third parties.

Initial Payment from Supplier to Customer When using specific inputs for the first time, customers have to choose which supplier will produce these specific inputs from that period onwards. Given that suppliers are relatively abundant, the fact that they can make a "take it or leave it" offer gives them no advantage since the customers will keep on searching until they find a supplier offering a deal

[26]Note that the customer's value functions are expressed in present value (PV) and supplier ones are in net present value (NPV) this is purely for notational convenience. The expression for s is written as if the same supplier would carry on with specific production in the next period. This is not necessarily true, but later on we will see that the abundance of suppliers guarantees that $n = 0$ and $s = 0$, so the specificaton for s is quite irrelevant.

that implies a zero NPV for the supplier. This means that suppliers will pay a quantity of money dI that makes $n = 0$.

Proposition 3 *d gives the customer all the discounted surplus of the relationship making $n = 0$.*

The supplier is somehow "bribing" the customer to be the chosen supplier that will be linked to that particular customer for many periods. Competition among suppliers guarantees that the customer will get the full value of all the discounted relationship surplus.[27]

Further Payments from Customer to Supplier When the customers are already using specific inputs it is costly for them to switch to another supplier because it would mean that they would have to use a generic technology again. Because of this the suppliers can use their bargaining power to extract some of the extra surplus that a specific technology produces, as compared with a generic technology.

Proposition 4 *Suppliers will extract all the extra surplus from the customer when using the mature technology after the first period, making M=S.*

Proof. See Appendix 1 ■

Suppliers have a trade-off in the determination of p. On the one hand, the higher p the higher proportion of surplus that goes to the supplier, but on the other hand, increasing p reduces the leverage and the growth rate of the customer, thus potentially reducing the future surplus for both agents. However Assumption 4 guarantees that the first effect dominates and therefore extracting as much surplus

[27] A stage in which the lender "bribes" the borrower in exchange of some future surplus extraction is a frequent feature of related lending literature, see for example Petersen and Rajan (1994) and (1995).

as possible is optimal from the supplier's point of view. So suppliers will extract all the extra surplus. That is pl will be such that customers are indifferent between staying with their current supplier or switching to a new one. In terms of the value functions, p will be such that $M = S$.

For simplicity we have assumed that the supplier makes a "take it or leave it" offer to the customer; however, any bargaining scheme that gave part (or all) of the surplus to the supplier would generate the same structure of returns, as long as this first stage of competition among suppliers to "capture" the suppliers existed. If we assumed that suppliers only got part of the future surplus in further stages, customers would get in this first specific period the discounted value of all the future surplus extraction by the supplier, and the payment would just be lower because the supplier would no longer get all the extra surplus, but just part of it.

3.1.6 Equilibrium

The equilibrium values for p and d must satisfy the participation constraints of the agents. That is, all supplier value functions (in NPV) must be bigger or equal to 0 and all customer value functions (in PV per unit committed) must be bigger than one. There are six value functions and eight endogenous parameters. The two other conditions necessary to solve for all the endogenous parameters of the model are $n = 0$ and $M = S$ that come from the only sub-game perfect equilibrium in the bargaining game.

In first place the condition $n = 0$ together with equation (4) implies that necessarily $s = 0$. This is quite intuitive since in the startup stage the supplier just covers costs, and depending on the outcome of production it will lead to a subsequent period that can be a startup period again or a first mature period with zero NPV. Equations (5) and (6) with $s = 0$ fully determine the relationship between p and d. In essence d must be equal to the expected future flow of p in the following periods, minus the expected payments of future liquidity shocks. So d can be expressed as a function of the future p and the liquidity shock.

$$d = \beta\left(\frac{\alpha R p}{(1+p-\beta\theta)-\beta\alpha R} - \frac{(1+p-\beta\theta)}{(1+p-\beta\theta)-\beta\alpha R} vL\right) \tag{7}$$

We can define $(1+g) = \frac{\alpha R}{1-\beta\theta+p}$, which is the expected rate of growth of the customer firm (and also of p) on each following period and use $\beta = \frac{1}{1+i}$ to rearrange (7) as

$$d = \frac{(1+g)p - vL}{i-g} \tag{8}$$

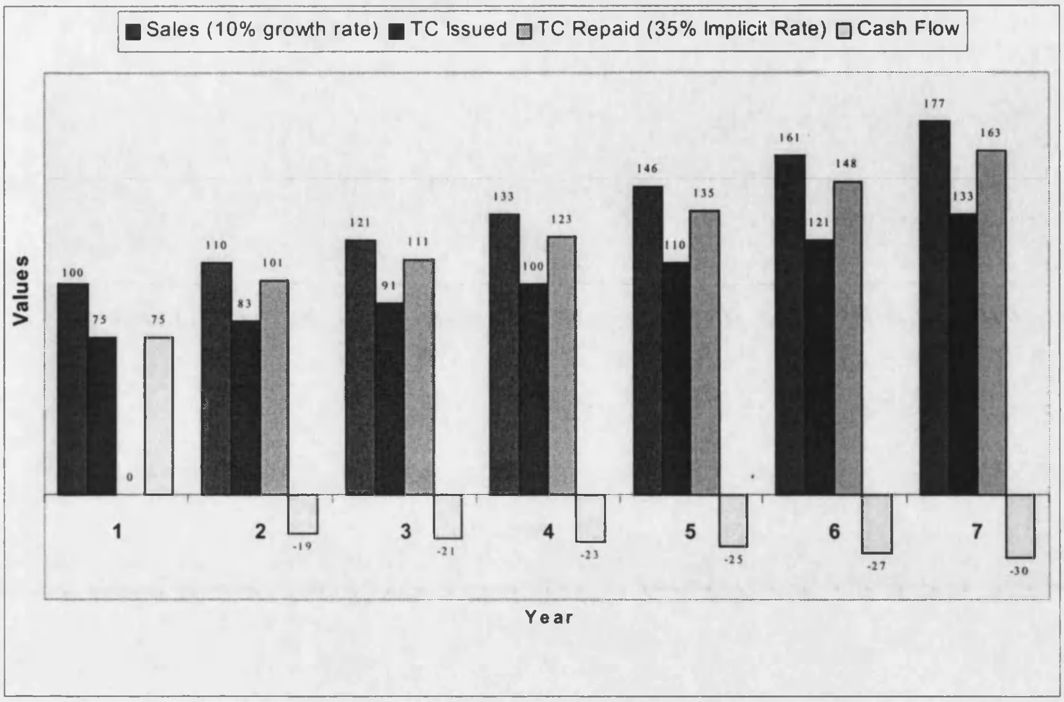
This is the formula of a growing perpetuity with an interest rate i and growth rate g. So the initial payment of the supplier d is equivalent to a perpetuity that pays $(1+g)p-vL$ in the first period and grows at a pace g. The term $(1+g)$ appears in the numerator because the first payment of p by the customer will be made at the beginning of the next period; thus the firm has already grown for one period, while the first payment of L may occur this period with probability v. This seems a quite intuitive result, by paying d in the first period using the mature technology, suppliers qualify for a future flow of payments that start with a payment $(1+g)p$ and grow at a pace $(1+g)$ per period. In fact $(1+g)$ is not the actual growth rate of a successful customer, but the expected rate of growth which accounts for the fact that customers are successful with probability α. The expression for d also takes into account the possible payments of the liquidity shock by the supplier.[28] One could think that a perpetuity is not the kind of debt structure that fits best with trade credit that is after all a short-term debt agreement. However, even though a single trade credit transaction does not look like a perpetuity, a series of purchases on trade credit actually has a structure that is very similar to a perpetuity. In the first period of receiving trade credit the customer receives goods on credit and

[28] We can also express (8) in money term multiplying the whole expression by I_t and using the fact that in expected terms $E(I_{t+1}) = (1+g)I_t$ so the expression is $dI_t = \frac{pE(I_{t+1})-vLI_t}{i-g}$

makes no payment. From then onwards the customer pays old trade credit, but gets a new amount of goods purchased on credit. The net value of paying back and receiving new goods can be seen as a coupon of a perpetuity which has as capital the initial set of goods.For example, suppose a customer firm starts with a level of input purchases of 100 units and the supplier agrees to finance 75% of those via trade credit. The firm sales and input needs grow at a 10% rate and the implicit interest rate on trade credit is 35%.[29] In the first period, the firm gets 75 units of goods from the supplier and pays nothing, so the customer is getting the value of 75 units from the supplier. In the second period, the customer has to pay 101.25 units ($75 * 1.35$) to the supplier, as capital and interests of the first delivery, but the customer also receives 82. 5 new input units to be used in this second period (corresponding to 75% of 110 units needed). In net terms the customer is effectively paying 18. 75 units to the supplier and paying cash for the new deliveries. On the third period, the customer has to repay ($82.5 * 1.35$) but receives inputs worth $82.5 * 1.1 = 91.05$ so the net cash flow is that 21 units go to the supplier. The process continues as in Figure 3; the last column of each period shows the net payments from suppliers to customers.

[29]This is equivalent in the model terms to $d = 0.75$ $\rho = 0.35$ and $(1 + g) = 1.1$

Figure 3: Trade credit of a steady growing firm



Here trade credit looks like a perpetuity with an initial payment of 75 units, and a first coupon of 18.75 that grows at a 10% rate. Moreover, if following the model lines, dI_0 is equivalent to the first capital payment and $pI_1 = I_0(1+g_1)p$ the first net payment on the next preriod (when the old trade credit is paid and new trade credit is issued).[30] Then the relationship $(1+g_1)p = d(1+\rho) - (1+g_1)d$ holds and implies that $d = \frac{(1+g)p}{i-g}$ which is precisely equation (8) in the absence of liquidity shocks. If we introduce the possibility of a liquidity shock then the expression for d becomes $d = \frac{(1+g)p - vL}{i-g}$. So the cash flows generated by pure bargaining and renegotiation in our model, actually match the ones generated in the trade credit contract that would be signed contractually in the same situation.

Equation (8) together with equations (1), (2) and (3) uniquely determine the values of all the endogenous variables.[31] In particular, d can be expressed as a

[30] Where I_o corresponds to investment on the first period using the specific technology and I_1 to the investment on the period immediately after.

[31] In fact there are two possible mathematical solutions for p, d, S, N, M, s and n, but only

function of exogenous variables only:

$$d = \beta \frac{\delta(\alpha R - vL)(\alpha - \gamma)(R - r) - (1 - \beta\theta + \delta\gamma R)vL}{1 - \beta\theta - (\beta - \delta)\alpha R - \delta(\alpha - \gamma)r} \tag{9}$$

It is useful to define $\Delta = \frac{\beta\alpha R}{1-\beta\theta-(\beta-\delta)\alpha R-\delta(\alpha-\gamma)r}$ so the expression for d becomes:

$$d = \Delta\left(\delta(R - r)(\alpha - \gamma) - \beta vL\right) - \beta vL \tag{10}$$

The initial payment d is a function of two terms that have a straightforward interpretation. The first term represents the payment that the supplier receives due to the fact that she can extract all the extra "relationship surplus". It is multiplied by Δ that is a scale factor. The term $[\delta(R - r)(\alpha - \gamma) - \beta vL]$ represents how much surplus the supplier will extract from the customer in future periods. The term $\delta(R - r)(\alpha - \gamma)$ is the excess productivity of the mature technology with respect to the startup technology from the customer point of view; or in other words how much more productive is the specific technology when compared to the generic one.[32] This term can also be seen as a measure of the degree of specificity of the specific technology. If either $R = r$ or $\alpha = \gamma$, the advantage of the mature technology would not exist. The first term $-\beta vL$ within the brackets accounts for potential future liquidity shocks. The second term $-\beta vL$ represents the fact that the supplier expects to pay the liquidity shock on this period if it happens. It can be interpreted as an insurance premium.

The equivalent expression for p is:

$$p = \Delta\frac{(i - g)}{(1 + g)}\left(\delta(R - r)(\alpha - \gamma) - \beta vL\right) + \beta vL \tag{11}$$

one has economic sense. The other one, determined by $d = 1 - \beta\theta$, implies infinite investment and negative profits for the customer in every stage of production.

[32]Investing one unit in the mature stage gives an expected value of $\beta\left(c + \theta + \gamma R + (1 - \gamma)r\right)$, while investing one unit in the startup stage gives $\beta(c + \theta + \alpha R + (1 - \alpha)r - vL)$. The difference between these two terms is in fact $\beta\left[(R - r)(\alpha - \gamma) - vL\right]$.

This has exactly the same interpretation, although the scale factor is now $\Delta\frac{(i-g)}{(1+g)}$. Again there is a first term that is positively related to the extra levels of productivity when the technology is specific, plus a term that corresponds to the payment of an insurance premium in the current period.[33]

Investment depends on the level of wealth of the firm and the attainable level of leverage. While wealth is backward looking and consists of the accumulation of past profits, leverage is forward looking, so d depends on the future profits that the supplier can extract. This situation generates an amplification mechanism. An increase of productivity of the specific technology will increase the surplus extracted by the supplier and therefore the level of leverage of the customer. This will increase the profits of the customer, thus increasing the surplus extracted by the supplier again, and so on. The scale factors Δ and $\Delta\frac{(i-g)}{(1+g)}$ summarise this amplification effect in the following way. If the mature technology became more productive by one unit (or the startup technology became less productive by one unit), d would grow by a factor of Δ and p would grow by a factor of $\Delta\frac{(i-g)}{(1+g)}$.

The whole picture of the equilibrium arrangement between the supplier and the customer is as follows: the existence of a technological link between them makes the supplier get some (in this case all) of the extra surplus of the mature technology every period. This guarantees the supplier a growing flow of income, which will only stop if the link is lost. As the customer can choose which supplier is going to get this flow of funds, the chosen supplier gives the customer in advance the expected future value of this surplus share, thus making the implicit agreement look like a debt contract. This is an equilibrium result and no actual contract needs to be written to enforce the agreement. So the fact that returns may not be verifiable does not preclude the supplier lending to the customer. The levels of

[33]Note that this expression for p is not fully exogenous, as g contains p in its denominator, the full exogenous expression for p is $p = \frac{(1-\beta\theta-\beta R\alpha)\left[(R-r)(\alpha-\gamma)-\frac{\beta}{\delta}vL\right]+\frac{1}{\Delta}R\alpha\beta vL}{\frac{1}{\Delta}R\alpha-(R-r)(\alpha-\gamma)+\frac{\beta}{\delta}vL}$.

debt depend positively on how important the link is between the supplier and the customer. In the extreme case when suppliers can be perfectly substituted, trade credit does not exist.

From an efficiency point of view this equilibrium is also the optimal arrangement for the customer. Given that the customer has a technology with positive NPV, it is optimal to bring to the present as many funds as possible and invest them all. In equilibrium, collateralisable returns are fully brought to the present through bank credit, and also some of the non-contractible returns are brought to the present via trade credit. On top of the debt-like agreement, suppliers also provide insurance against possible liquidity shocks. In Section 3.3 we also show that the insurance arrangement is also optimal.

3.2 Implicit Interest Rates

The model provides a justification for the high interest rates paid by customers for their trade credit. The interest rate paid includes two premiums that are not included in a bank credit.

The first premium is a default premium and it is related to the ability of suppliers to claim back debts, and also related to the extra risk that suppliers face. In the model, bankers are lending with a collateral claim and their loans are virtually risk free. However, suppliers are lending on the basis of their extra ability to get paid later on, thanks to the technological specificity that links them with their customers. If this specificity is lost in a bad production period, suppliers will not be able to extract any surplus from the relationship again. So from the point of view of suppliers, trade credit looks like debt with default risk, and thus they have to charge a higher interest rate to compensate for this extra risk. In reality, even though banks lend not only on collateral, it seems reasonable to think that bank credit is in general safer than most trade credit.

The second - and perhaps the most interesting - reason why trade credit should be more expensive than bank credit is that an insurance premium is charged by suppliers to compensate for the cost of providing extra liquidity to their customers in case they have temporary liquidity needs. The fact that suppliers may be asked to provide extra funds, or to extend the maturity of existing debts without charging an extra penalty is foreseen by them and they ask for a compensation in advance to cover the expected costs of these future financial help.

How can we calculate an explicit expression for the interest rates charged on trade credit in the model? One way is to consider the financial relationship that links the supplier and the customer as a perpetuity with a risk of default. We can find the interest rate ρ that makes d the fair price of a perpetuity that pays p times $\frac{R}{1-\beta\theta+p}$ on the first period and then has a growth rate of $(1+g_1) = \frac{R}{1-\beta\theta+p}$.[34]

So d can then be expressed as:

$$d = \frac{p(1+g_1)}{(1+\rho)} + \frac{p(1+g_1)^2}{(1+\rho)^2} + \frac{p(1+g_1)^3}{(1+\rho)^3} + + \frac{p(1+g_1)^4}{(1+\rho)^4} \ldots$$

Our intention is to calculate the rate ρ that makes this equation hold. We already know that d is such that suppliers break even when discounting at a rate i, so the difference between ρ and i will be the default premium and the insurance premium paid by customers. We can re-express $d = \frac{(1+g_1)p}{\rho-g_1}$ in a similar fashion to equation (8).

The expression for ρ is then:

$$\rho = \frac{(1+g_1)p}{d} + g_1 \tag{12}$$

And the difference between the market interest rate i and ρ is:

[34]Note that $(1+g_1) = \frac{R}{1-\beta\theta+p}$ is the actual growth rate of the firm if successful and should not be confused with $(1+g) = \frac{R\alpha}{1-\beta\theta+p}$ which is the expected rate of growth before knowing if the firm is going to be successful or not.

$$\rho - i = \frac{(1+g_1)p}{d} + g_1 - \frac{(1+g)p - \nu L}{d} - g \tag{13}$$

So the premium of the implicit interest rate ρ over the bank lending rate is:

$$\text{Premium} = \rho - i = (1-\alpha)g(1+\frac{p}{d}) + \frac{\nu L}{d} \tag{14}$$

The premium is composed of two terms. The first element of the premium is a default premium. Suppliers know that if the customer firm is unsuccessful they will not be able to receive any more payments from the customer. Default occurs with a probability $(1-\alpha)$ and $g(1+\frac{p}{d})$ accounts for the actual loss of future income after default. Secondly, $\frac{\nu L}{d}$ is an insurance premium that measures the foreseen payments that the supplier may have to make to support customers with liquidity problems. The term is just the expected cost of the liquidity shock over the amount lent. These two premiums explain the high cost of borrowing from suppliers. The high implicit interest rates of trade credit with respect to bank credit account for a higher risk of default of trade credit and the possibility that customers need to be bailed out or incur late payments.

3.3 Supplier Insurance Versus Other Forms of Insurance

The conjecture throughout the model was that the customer does not take any precautions against a possible liquidity shock, in order to force the supplier to pay for it. If this is the case the supplier will agree to pay it as long as the cost of the shock is sufficiently small when compared with the rents being extracted from the customer. Customers have other potential strategies to deal with the payment of the liquidity shock. In particular, they could have some precautionary saving or else they could sign an insurance contract with a third party such as a bank. This section shows that the optimal strategy for customers is to use their suppliers as insurance providers.

The first strategy that customers could use to face the liquidation shock is to have some *precautionary saving.* That is, they could save in a bank account the discounted full size of the shock βLI and use it if the shock hits. If the shock does not happen these funds are added to the initial wealth of the firm at the beginning of the next period. The other possible strategy is contracting insurance with a third party deep pocket. We call this type of insurance *bank insurance* and it consists of paying a fair insurance premium βvLI per period, to a bank who will pay the liquidity shock whenever it happens.

In pure cost terms, bank insurance and supplier insurance are equivalent. However, as we will see, supplier insurance will strictly dominate bank insurance in the presence of any contracting friction, verifiability problems or renegotiation. On the other hand, precautionary saving is more costly than the other two strategies.

3.3.1 Precautionary Saving

Precautionary saving consists in saving the full amount to be paid in case that the liquidity shock hits in a bank account. If there is a liquidity shock the customer can use these savings to face it, otherwise these finds are added to the initial cash for the next period.

Comparing the precautionary saving strategy with the bank insurance, precautionary saving is equivalent in expected returns to paying an insurance premium βvLI and saving an amount $\beta(1-v)LI$ for next period. But we know by Proposition 1 and Assumption 6 that saving is sub-optimal with respect to investing, so precautionary saving is therefore dominated by writing an insurance contract with a third party, that only involves paying the premium βvLI. So contracting insurance with a bank dominates precautionary saving. The next section shows how supplier insurance dominates bank insurance so it is also true that supplier insurance dominates precautionary saving.

Proposition 5 *Precautionary saving is strictly dominated by both bank insurance and supplier insurance.*

Proof. See Appendix 1 ■

3.3.2 Bank Insurance

Bank insurance consists in contracting with a bank an insurance contract that specifies that the bank will pay the cost of the liquidity shock LI in the event, in exchange of a premium paid in advance. As there is a competitive market for bank loans, the premium must be such that banks just break even with this transaction. The fair actuarial premium is therefore $v\beta LI$; that is the discounted size of the shock times the probability of it. In practice this is equivalent to a credit line that either charges an initial fee to be paid when it is opened or that charges some fee for the unused credit capacity. A credit line that has no fees or cost apart from the interest rate charged would not typically fall under the category of insurance, as there is no clear premium paid. One could think that there is also an implicit insurance contract in the way that relationship banks operate. In these relationships, the banks extract some extra surplus (premium) on a day- to-day basis that an arms length banker would not extract. In exchange, whenever their client suffers a liquidity shock, the bank provides the extra funds needed. In any of these cases, we are going to concentrate on situations in which the bank provides the necessary extra liquidity in exchange for some prepaid premium. Given the high cost of trade credit it is still not clear under this framework why a firm would have unused borrowing capacity from its credit lines and still use trade credit at a cost.[35]

[35] This puzzle is similar to the fact that some households systematically use credit card loans, while having unused mortgage borrowing capacity.

In the absence of any contracting friction, and being both bank and supplier deep pockets with the same discount factor, it is easy to see that the cost of supplier insurance and the cost of bank insurance should be the same. Both the supplier and the bank need to collect a premium worth $\upsilon\beta LI$ in order to cover the potential loss of future liquidity shocks. However the main advantage of supplier insurance with respect to bank insurance is that it is an equilibrium result of the interaction between both commercial partners. It is renegotiation proof, there is no need for a written contract and the supplier will always help the customer to face the shock, as long as the customer has not got any other way to handle the shock, and the continuation value for the supplier exceeds the cost of bailing out the customer. This means that there is no need for writing a contract between the supplier and the customer and also that there is no need for a court to enforce the insurance provided by the supplier. Even if the shock is sometimes non-verifiable and a written insurance contract is not always enforceable the customer can still use the supplier as lender of last resort.

Also, to some extent, supplier insurance is unavoidable. Suppliers cannot credibly commit not to give financial help to their customers if they experience a liquidity shock and they do not have any funds or alternative insurance to cover it. So there will always be an insurance premium included in the cost of trade credit. There is therefore little point in taking extra insurance with a bank and paying two premiums to cover the same risk. The only way to avoid paying the premium to the supplier is if the customer takes alternative precautions with a bank and can prove to the supplier that no extra funds will be needed. This may be a difficult task; not only does the customer have to be able to contract with the bank an insurance contract and show it to the supplier, but it has to be the case that the customer can not secretly write off the insurance contract before the liquidity shock hits, or renegotiate with the bank the terms of it. If the supplier believed that she would still have to pay for the shock anyway she will still charge the insurance premium. Thus the customer would be paying twice for the same cover. Therefore the implicit insurance contract that the supplier offers will necessarily be the dominant strategy whenever the liquidity shock is not verifiable. It will also be the dominant strategy when the shock is verifiable and an insurance contract can be written with a third party, but the customer cannot "convince" the supplier that this insurance exists. Any kind of contracting costs would also give the advantage to supplier insurance.

Proposition 6 *If customers can credibly commit to get bank insurance then bank insurance is equivalent to supplier insurance in cost terms.*

Proof. See Appendix 1 ■

So far we have followed the interpretation of LI as a monetary payment. However we could also see it as the cost of a delay in production. This interpretation may be closer to the phenomenon of late payment. If a customer production is delayed, suppliers receive the next payment of p later on. The cost of this delay can be summarised by LI. If we stick to this interpretation, supplier insurance would be even more difficult to avoid. Suppliers would face the cost of this delay and they could cover themselves with a third party if they wish to, but an insurance scheme on the customer's side would be almost unfeasible because even if customers could agree with a bank the access to a credit line if production is delayed, then it is unclear that they would actually use that line of credit instead of directly delaying payment to their suppliers.

Within the monetary interpretation of LI the only situation in which supplier insurance would not be available would be if Assumption 7 did not hold. In this case, the link between the supplier and the customer is too weak. The supplier would rather lose the customer than pay $L1$. If this was the case, bank insurance would be the optimal strategy for the customer.

3.4 Conclusions

We have shown that the existence of trade credit may be justified as a result of the interaction between a supplier and a customer that engage in specific production processes in a context of limited enforceability of debts. A certain degree of non-substitutability of suppliers, (generated by either technological, informational, legal or any other type of links) gives them an advantage in enforcing non-collateralised debts. This advantage allows them to lend beyond the maximum amount that banks are willing to lend. As a result, trade credit can exist even in the presence of a competitive banking sector. When customers are rationed in the bank credit market, trade credit may allow them to increase their leverage. The extra enforceability power of suppliers comes from the fact that they can threaten to stop supplying intermediate goods to their customers. In the presence of some kind of product specificity or a certain link between the supplier and the customer, finding a new supplier is costly, so customers will pay back their debts before switching to another supplier as long as the cost of repaying this debt does not exceed the cost of finding an alternative supplier.

However, this link works both ways. Not only are customers more willing to repay their suppliers, but suppliers will forgive debts and extend the maturity period of their credit when customers experience temporary liquidity shocks that may threaten their survival. In practice, firms in financial distress generally delay the payment of their trade credit due. This late payment rarely carries a monetary penalty, nor a cut in the flow of intermediate goods to the debtor. Their suppliers are effectively providing liquidity (as a continuous flow of intermediate goods sold on credit) as a means of increasing the survival chances of their customer. The model predicts that this type of insurance is more likely when the links between buyers and sellers are stronger, or in other words suppliers are more likely to help their customers if it is very costly for them to find a new customer.

Even though we speak about technological specificity, the ties between the supplier and the customer are not explicitly modelled. We can think of broader industrial links that are not strictly technological that would still sustain the results of this analysis. Any kind of sunk cost (legal procedures, bargaining costs, search costs, etc.) attached with starting a new commercial relationship, or production processes that benefit from learning by doing, or the build-up of reputation and trust between commercial partners would have similar effects. In fact it is quite likely that empirically these types of non-technological links are more important in determining the size of the relationship surplus of a supplier and a customer that interact for a long period of time. While this is good news for our theory (as it can be applied to a wider range of supplier-customer links) the heterogeneous nature of these commercial links will be a problem when we try to test the empirical implications of the model; as it is not easy to find a good measure of how tight the links between a supplier and a customer are.

The model is applicable outside trade credit, to a wide range of related lending situations where there are strong specificity links and enforceability is an issue. Interlinkages and lending in developing countries is an area where the model can be applied. In many countries, landowners give loans to the workers that they hire or to the ones that are renting their land. Even though enforceability of debt may be very difficult in general, the coexistence of the loan with some degree of monopsony in the labour market or the rental of the land gives the landowner a strong threat that guarantees repayment. Labour relationships are also another environment for applications of the model. Specific human capital may make employer-employee relations very specific, and there are many transactions between them (in both directions) that look like trade credit in one way or another. For example, workers work through a month but get paid at the end, they can ask for loans from the employer, and the employer may also invest in training its employees.

3.5 Appendix 1

3.5.1 Proof of Proposition 1

The customer has two basic strategies when using the startup technology: one is to invest all possible funds in the project, the other one is to invest minimum funds in the project (i.e. almost zero) and only invest all funds when using the mature technology. All other strategies are linear combinations of these two, so if we prove that investing all funds dominates investing almost zero, we will prove that it dominates all other strategies. To prove this we use the unimprovability principle that says that a strategy is optimal if we cannot find a "one-shot" deviation that improves the strategy.[36] To do so we compare the strategy of investing all possible funds with the "one-shot deviation" strategy of investing minimum funds on the first startup period and then investing all possible funds in any other period (even if the prototype strategy is used again). If this "one-shot deviation" is not an improvement, the unimprovability principle guarantees that deviating in any further period is suboptimal too. The value function of investing an infinitesimal amount for only one period is:

$$S_\epsilon = \frac{\delta}{\beta}(\gamma N + (1-\gamma)S) \tag{15}$$

We want to show that there exists a value $\delta^* \epsilon\, (0, \beta)$ such as for every $\delta < \delta^*$ it is optimal to invest all available funds even when using the prototype technology.

If $\delta = 0$ then $S = \frac{c}{(1-\theta)} > 0$ while $S_\epsilon = 0$ so $S > S_\epsilon$, so investing all funds is the optimal strategy when $\delta = 0$. However if $\delta = \beta$ then $S_\epsilon - S = \gamma(N - S) > 0$, so investing a minimum amount is the optimal strategy when $\delta = \beta$.

For any other values of δ we can evaluate $S_\epsilon - S$ using (1) and (15) $S_\epsilon - S = \frac{\delta}{\beta}(\gamma N + (1-\gamma)S) - S$ so $S_\epsilon - S < 0 \Longrightarrow \delta < \beta\frac{S}{\gamma N + (1-\gamma)S}$

[36]See Kreps (1990) for an intuitive explanation of the unimprovability principle.

Then $\delta^* = \beta\frac{S}{S+\gamma(N-S)}$. For $\delta < \delta^*$ investing as much as possible in the prototype technology is the optimal strategy. We know that $\frac{S}{S+\gamma(N-S)}\epsilon\,(0,1)$ given that $N > S$ and that both N and S are positive and increasing in δ, so we can determine that $\delta^*\epsilon\,(0,\beta)$.

Furthermore, the equilibrium function for $S_\epsilon - S = 0$ is a continuous quadratic function in δ. Expressed as a function of exogenous parameters only

$S_\epsilon - S = 0 \Longrightarrow 0 = a + b\delta + c\delta^2$

being

$a = [(R-r)(\alpha-\gamma)+R](\alpha(r-2R)+\gamma(R-r))$.

$b = [(R-r)(\alpha-\gamma)+R](\beta R(\alpha(r-2R)+\gamma(R-r))+\beta vL)$

$c = \beta^2 R[(R-r)(\alpha-\gamma)+R]\,vL$

So there are two solutions for δ^* such that $S_\epsilon - S = 0$, but given that $S_\epsilon - S > 0$ if $\delta = \beta$ and $S_\epsilon - S < 0$ if $\delta = 0$ then only one of the solutions lies between 0 and β. This means that there is a unique $\delta^*\epsilon\,(0,\beta)$ so it is also true that if $\delta > \delta^*$, investing as little as possible in the startup technology is the optimal strategy.

3.5.2 Proof of Proposition 4

As suppliers make a "take it or leave it " offer, they can choose the optimal level of p up to the point when $M = S$ where customers would opt for their outside option of going back to the startup technology. Using the unimprovability principle again we can prove that "one-shot" deviations from this strategy do not pay, by taking the continuation m as given and constant $\overline{m}$ and then taking the derivative of m with respect to p which is $m' = \frac{1-\theta-\beta\alpha R\overline{m}+vL}{(-1-p+\theta)^2}$. This derivative is positive as long as $\overline{m} < \frac{1-\theta+vL}{\beta\alpha R}$. We know that $\frac{1-\theta+vL}{\beta\alpha R} > 1$ and $\overline{m} = \frac{\delta(\alpha-\gamma)(R-r)-\beta vL}{1-\beta\theta-(\beta-\delta)\alpha R-\delta(\alpha-\gamma)r} < 1$ by Assumption 4 so one-shot deviations from setting p at maximum level do not pay.

By the unimprovability principle we can now be sure that other deviations are also suboptimal.

3.5.3 Proof of the Dominance of "Supplier Insurance" and "Bank Insurance" Over Precautionary Saving

The relevant value functions for the customer in the matched and first match stage are as follows.

$$N_p = \frac{1}{(1 - d - \beta\theta + L)}\delta[c + (\alpha R + (1 - v)L)M + (1 - \alpha)rS]$$

$$M_p = \frac{1}{(1 + p - \beta\theta + L)}\delta[c + (\alpha R + (1 - v)L)M + (1 - \alpha)rS)]$$

We use the subscript p to denote precautionary saving. The value function when searching remains the same. Using precautionary saving is equivalent to paying a premium L at the beginning of the period and getting it back with probability $(1 - v)$. This is equivalent in expected terms to paying a premium vL and saving $(1 - v)L$ for one period. Bank insurance entails paying vL and no saving. However Proposition 1 and Assumption 6 imply that saving is suboptimal even in the startup stage so it is also suboptimal in the mature stage. Thus bank insurance dominates precautionary saving.

3.5.4 Proof of Proposition 6

The expressions below (marked by the subscript b) show the value functions if the customer decides to use bank insurance.

$$N_b = \frac{1}{(1 - d_b - \beta\theta + \beta vL)}\delta(c + \alpha RM_b + (1 - \alpha)rS_b)$$

$$M_b = \frac{1}{(1 + p_b - \beta\theta + \beta vL)} \delta(c + \alpha R M_b + (1 - \alpha) r S_b)$$

The leverage factor of the customers firm has only gone down by βvL which is the expected value of the shock, instead of saving the full size of the shock as in the case of precautionary saving. Once the customer has paid this money to the bank there is no further cost or income associated with the liquidity shock for the customer. However the value functions for the supplier change, as they do not expect any more to pay LI if the shock hits. The relevant value functions for the supplier are in the case of bank insurance.

$$n_b = \frac{1}{(1 - d_b - \beta\theta + \beta vL)} \{-d_b + \beta(\alpha R m_b + (1 - \alpha) r s_b)\}$$

$$m_b = \frac{1}{(1 + p_b - \beta\theta + \beta vL)} \{p_b + \beta(\alpha R m_b + (1 - \alpha) r s_b)\}$$

The extra cost of paying LI to let the customer escape from the liquidity shock have disappeared from the value function. The key assumption for this is that the supplier actually believes that insurance has been contracted and, therefore, no further payments will be needed to save the customer. If the supplier did not believe this, for example if there was an option to cancel the contract between the banker and the customer on the back of the supplier after investment has been made, then the supplier would ask for the premium too and the customer would effectively pay double the premium.

Assuming that the customer can convince the supplier of the existence of the insurance contract, then the solutions for p and d for this case, taking into account that $M = S$, $n = 0$ and equations (4) and (1) are:

$$d_b = \Delta\left(\delta(R - r)(\alpha - \gamma) - \beta vL\right)$$

$$p_b = \Delta \frac{(i-g)}{(1+g)} \left(\delta(R-r)(\alpha-\gamma) - \beta v L\right)$$

Comparing these results with the equilibrium values for p and d in the case with supplier insurance we can see that $d_b = d + \beta v L$ and $p_b = p - \beta v L$.

That means that if the customer decides to pay $\beta v L$ at the beginning of each period to the banks to get insurance against potential liquidity shocks then the customer will get $\beta v L$ extra when using the mature technology for the first time, and will have to pay $\beta v L$ less when using the mature technology from then onwards. This makes both types of insurance perfectly equivalent in cost terms which is not surprising, as both suppliers and customers have the same discount factor and they are both asking for a fair actuarial premium to cover the customer.

4 Constrained Suppliers and Factoring

This chapter explores the possibility that suppliers themselves are cash constrained and need to borrow from banks to lend to their customers. Throughout Chapter 3 the maintained assumption was that suppliers were deep pockets, and therefore they had (or could borrow) unlimited funds at the market interest rate. This assumption reflects a situation in which the supplier has much better access to financial markets than the customer.[37] It also keeps the analysis simple allowing us to analyse the effect of the customers financial constraints without any further friction. However in practice it may be more realistic to assume that suppliers are themselves financially constrained to some extent, either because they are rationed in the maximum amount that they can borrow or because they have a higher cost of capital than banks.

When suppliers need to raise funds in order to lend to their customers they may do it by borrowing extra funds from the banking sector or issue commercial paper on the basis of their own collateral and creditworthiness.[38] However, one of the most common ways that suppliers use to overcome their own financial constraints and issue trade credit is through factoring deals with banks or specialist factoring firms. The standard structure of a factoring deal is the following: the supplier sells some goods to her customers and issues trade credit to finance the purchase. Trade credit may be formalised in different ways, (invoices, bill of exchange or credit line) Then the supplier goes to a bank or to a specialist factoring firm and receives in advance the money promised by the customer minus a discount that accounts for the interest rate charged by the bank or factor to the supplier. The

[37] See Emery (1984) and Schwartz (1974) for articles in which the supplier has a better access to financial markets than the customer and makes profit as an intermediary.

[38] See Calomiris, Himmelberg and Wachtel (1995) and Nilsen (1999) for empirical papers papers that show how suppliers with access to public debt markets issue more commercial paper to finance their customers in downturns.

supplier uses as collateral for this loan the trade credit issued to her customers. When the maturity date of trade credit arrives, the supplier collects the payment from the customer, and pays the bank immediately after. Some deals specify that the customer should pay directly to the bank.

Three facts in a common factoring contract support our hypothesis of suppliers having superior enforcing technology than customers. In the first place, banks are typically not willing to lend directly to the customers, and they only lend to them indirectly through the intermediation of suppliers. Factoring business is perceived by banks as a relatively safe form of business, and the interest rate that they charge to suppliers is quite low. Secondly, suppliers act as true intermediaries, they receive credit at low interest rates and they charge high interest rates (through discounts for early payment) to their customers, thus making an intermediation margin. This margin has to account for the cost of enforcing debt repayment and possible default; maybe also the potential cost of late payment.[39] Finally, if the customer defaults his obligations (or even incurs late payment) the supplier becomes liable for the repayment of the debt with the bank. In fact, under most legislations, the bank or factor can either claim repayment (and even induce liquidation) from either the supplier or the customer in the factoring deal. This joint liability gives the supplier an incentive to induce repayment that would not exist if the bank had simply bought the trade credit from the supplier.

Therefore, while financial instruments such as lines of credit that finance customers directly are perceived by banks as very risky, banks consider the factoring business as a low risk type of loan. The reason for this is twofold. On the one hand, banks know that both suppliers and customers are liable for a factoring loan in case the customer defaulted its obligations, so more resources (i.e. more collateral and

[39] Different factoring deals specify if the bank or the supplier has to face the cost of late payment.

returns) can be used to repay for the same loan. On the other hand banks know that suppliers have some extra enforceability power based on their tight relationship with their customers. The existence of this double guarantee (extra collateral plus extra enforceability power) can be seen in the application forms that suppliers fill in when they apply for a factoring contract. In these applications, not only the supplier is asked questions about its own creditworthiness and the creditworthiness of the final customer; but also about the nature of the customer-client relationship and the degree of substitutability of the supplier.

In this section the model of Chapter 3 is extended to the case when suppliers are financially constrained. Under certain assumptions, a "factoring like" contract arises as the optimal one for suppliers. In this optimal contract, banks are willing to factor some of the suppliers receivables, even when their customers have already exhausted their borrowing capacity. The interest rate charged to suppliers will be in equilibrium somewhere between the interest rate of loans completely secured by trade credit and the rate of trade credit. This new formulation is more realistic and allows us to understand better the phenomenon of factoring, where the joint responsibility of the supplier and the customer, and the extra enforceability power of the supplier on the factoring contract, allows banks to lend indirectly to customers through a factoring deal even when they are not willing to finance suppliers directly.

4.1 The Model

The starting point of this model are all the maintained assumptions from Chapter 3. The main departure from it will be that we are going to assume that suppliers are no longer deep pockets that can borrow or lend unlimited funds at a rate $(1 + i) = 1/\beta$. On the contrary, we assume that suppliers are cash constrained.

In particular, we will assume that suppliers have no cash at the beginning of their relationship with their customers, and that they will borrow from banks on the basis of the collateral value of their own firm and the future income that they will receive when selling to their customers. To sustain some lending based on future revenues, we have to assume that even though the returns of the customer are not verifiable, the transactions between the supplier and the customer are observable and verifiable; so they can be monitored by the banks and eventually debt repayment could be enforced in court if the supplier decided to hold the payments of the customer instead of repaying its debt with a bank.[40]

Assumption 8: The transactions between the customer and the supplier are fully verifiable.

Therefore our only non-verifiability assumption is still that the returns of the customer are non-verifiable. Suppliers can therefore borrow on the promise of repaying with the returns that they get from their customers. We are also going to assume that the production process of the intermediate goods that the supplier produces generate some level of collateral. So suppliers can also borrow from banks on the basis of their own collateral. We are going to rename the level of collateral per unit of investment of the customer $\theta = \theta_c$ to allow us to define also a level of collateral per unit sold θ_s on the supplier side.

Assumption 9: The production process of the supplier generates collateralisable assets $I\theta_s$ for every I units of intermediate input produced.

Assuming that the level of collateral of the supplier remains proportional to the level of production of goods is not strictly necessary for the validity of the

[40]Alternatively we could assume that the transactions between the supplier and the customer are not verifiable. In this alternative setup, the level of trade credit should be such that the continuation value for the supplier that repays the factoring contract is higher than the value of defaulting and losing all collateral (in terms of the notation of the rest of the chapter this would mean that $D < m + \theta_s$).

rest of the model however it simplifies the analysis of the rest of the chapter, as there is no need of an extra state variable accounting for the relative size of the suppliers collateral with respect to the size of trade credit. A way to justify a level of collateral that remains proportional to the level of inputs sold is that when a supplier is producing intermediate goods worth I, the production process includes machinery and side products worth $I\theta_s$ that remain in the supplier's firm throughout the production process and are liquidated at the end of the period. This also means that when we normalize the cost of intermediate goods to one, it means that suppliers break even after liquidating these machinery and side products at the end of the period. Therefore if the supplier pledges $I\theta_s$ as collateral for the factoring loan and further defaults on the loan, the supplier would incur a loss of precisely $I\theta_s$.

The existence of some additional borrowing capacity (i.e. collateral) on the suppliers side allows for the interest rate charged to suppliers to be lower than the rate of interest that suppliers will charge to their customers. If suppliers had no cash or collateral themselves, factoring would still be possible. However banks would face all the risk of late payment and eventually default by the customers, so they would charge the same interest rate as suppliers do in trade credit. With absolute zero collateral on the supplier's side, they would only weakly prefer to ask for debt repayment and repay themselves to just defaulting. So it is unclear what incentive suppliers would have in enforcing debt repayment from customers, as they would not have anything to gain or lose from customers honouring or defaulting their debts.[41]

Therefore these two elements: verifiability of the transactions between the supplier and the customer and the existence of some form of credible threat that the

[41]This would not be the case if the market of suppliers in the prototype-generic technology stage were not fully competitive. In that case suppliers would have an incentive to ask for full debt repayment even if they had zero collateral.

bank can make to the supplier (i.e. existence of supplier's collateral) are the necessary conditions for the factoring contract. Verifiability of the transactions between the supplier and the customer (or direct payment of the customer to the factor) guarantee that once the supplier has forced the customer to repay, the supplier will himself honour his liabilities with the bank. Some level of collateral (however small) guarantees that the supplier will ask for repayment from her customers.

The structure of factoring in this environment is related to some of the issues in Diamond and Rajan (2001). In their paper, a relationship banker (similar to our supplier) lends to a final client-entrepreneur (similar to our customer) on the basis of some superior ability to liquidate the entrepreneur's firm at a better value than an arm's length banker. The paper concentrates on the problem of how can the relationship banker sell or securitise the loans to the entrepreneur, if the value of the loan depends on the ability of the arm's length banker to liquidate the entrepreneur's firm. How the relationship banker can commit to use her liquidation or collection skills once the loan has been sold? In Diamond and Rajan, the optimal solution to this problem is for the relationship banker to finance herself through a set of small depositors that can seize the bank's assets on a first come first serve basis. This makes them behave as a whole as a single agent that will not accept a renegotiation. In a factoring contract the joint liability of supplier and the customer in case of default solves the problem of giving incentives to the supplier to act as a debt collector. The loan between the supplier and the customer is never fully securitised, and the bank has always the option to ask for repayment to the supplier directly.

In the factoring contract, the supplier becomes to some extent a "collateral translator". The relationship between the supplier and the customer is used as bilateral collateral between the supplier and the customer. This bilateral collateral guarantees that the customer has an incentive to repay its debt. How does the supplier transform this bilateral collateral into borrowing capacity? or in other words, how is this bilateral collateral transformed into multilateral collateral? It is good to see a parallel with the labour market in order to understand this "translation of collateral". In a labour relationship there may be some specific human capital that employees and employers have acquired-invested. If the employee needs to borrow from the employer the employer can use the threat of terminating the labour relationship as a way to guarantee the repayment of the loan. However, if the employer has no extra borrowing capacity, the employer would like to use this bilateral collateral to raise extra money. The optimal contract in this framework would possibly specify that if the employee does not repay its loan, the bank would terminate the labour relationship. The threat of termination would guarantee that the employee repays the loan to the employer and that the employer would pay to the bank. However this type of financial-labour contract is typically not feasible due to contracting restrictions in the labour market. On the contrary the factoring contract looks to some extent like this hypothetical contract. If the customer does not repay trade credit, the bank can effectively block any transaction between suppliers and customers, thus terminating the relationship.

This chapter explores the effects of two different types of financial constraints faced by suppliers. In the first place what happens when suppliers are rationed in their bank borrowing; that is, when their level of collateral is not enough to cover all the funds needed to finance their customers and secondly the case in which suppliers face a higher opportunity cost of capital than their customers. Each situation is going to produce different results in terms of the interest rate paid by the supplier to the bank that we are going to call i_s, and the interest rate paid by the customer to the supplier that we still call ρ. Both interest rates have to be compared to two benchmark interest rates: the market interest rate i and the trade credit interest rate of the "deep pocket suppliers" case of Chapter 3. We use $\widetilde{\rho}$ to refer to the interest rate of trade credit of the case with unconstrained suppliers.

4.2 Factoring Interest Rates and Supplier's Collateral

It is easy to see how, if the supplier has no other investment and in the absence of any further frictions, the supplier becomes a pure intermediary. The overall risk of late payment and default remains unchanged. Therefore the interest rate paid by the supplier in the factoring contract, will reflect the way in which the total risk of default and late payment is split between the supplier and the bank. Given the structure of a typical factoring contract, in which the bank can either ask for repayment to the supplier or the final customer, the part of the risk of default and late payment that the bank faces, will depend on the level of collateral of the supplier.

As limiting cases will help to understand the more general case, let's see what happens when the supplier has either no collateral at all, or when the supplier has collateral bigger than the maximum amount of trade credit demanded. Then we can explore the more general and interesting case, when collateral is positive but does not fully cover the necessary funds to finance the maximum possible trade credit level.

When the supplier has no collateral at all the bank is effectively taking over the business of the supplier. The supplier becomes a passive debt collector that faces no risk. Even though the supplier has no collateral, the fact that the transactions between the supplier and the customer are fully verifiable allows for trade credit to arise. The supplier borrows from the bank all the necessary funds to finance the customer, including the ones needed to face the existence of liquidity shocks, and then commits to repay to the bank with all the returns that she receives from the customer. It is easy to see that this situation leads to the supplier being just a passive intermediary between the bank and the customer. All the funds that the supplier gets from the bank go to the customer and all the funds (except the ones that pay for the cost of goods) that come from the customer to the supplier go to the bank. Therefore the value functions of the bank will be exactly the same as the value functions of the supplier in the case where the supplier is a deep pocket, and the interest rates will be $i < i_s = \rho = \widetilde{\rho}$. The bank faces all the risk (liquidity shock plus default) and therefore the interest rate that they charge to suppliers coincides with the one paid by customers and with the trade credit interest rate of the case with unconstrained suppliers.

The second interesting limit situation is when the supplier has a level of collateral per unit demanded bigger than $d + L$ which is the maximum amount of trade credit that a customer may get. In this case, the supplier is therefore not constrained in equilibrium and banks can issue safe debt. The supplier faces all the risk and everything looks like the "deep pocket suppliers" case of Chapter 3. The different interest rates will be $i = i_s < \rho = \widetilde{\rho}$. Where $\widetilde{\rho}$ is the solution to the case with unconstrained suppliers. This is the opposite case to the previous situation. In this case, even though suppliers are not deep pockets, their financial constraints are not really binding. If their level of collateral is bigger than the financial needs that the interaction with their customers may generate (i.e. $\theta_s > d + L$) and they have no other profitable investment opportunities, they will always have a slack of borrowing capacity to finance customers. The value functions for the supplier and the customer coincide with the ones of Chapter 3 and therefore the equilibrium also coincides with it. The supplier borrows at the riskless interest rate and lends to the customer at a rate ρ that just compensates her for the risk of default and future liquidity shocks. All the risk is faced by the supplier and none by the bank.

The more general situation is when the supplier has collateral smaller than d. In this case the supplier is constrained and can not issue safe debt, however this debt is safer than customer's debt. The supplier faces part of the risk and the bank faces part of the risk. However the total risk of default and late payment is not altered. This is an intermediate case between the situations of zero collateral and the one where collateral is bigger than $d + L$. Here, the supplier has some collateral that can be used to secure part of the debt of the factoring deal with the bank. However, this collateral is insufficient to make the deal between the bank and the supplier completely riskless. Making some inference from the results of the situation with zero supplier collateral and the one of unconstrained suppliers, it is easy to see that the interest rate that customers will pay will still be $\widetilde{\rho}$ and the level of collateral that suppliers have will determine how risk is shared between banks and suppliers so $i < i_s < \rho = \widetilde{\rho}$. Given that both the supplier and the customer have the same discount rate and that in equilibrium they will just break even, the distance between i and i_s or also between i_s and ρ can be seen as a measure of how risk (default risk and liquidity shock risk) is distributed.

To determine the face value of the loan that suppliers get from banks we start from the value function from banks assuming as in Chapter 3 that there is a competitive banking sector, so the bank just needs to break even in order to give the loan. The bank has to lend to the supplier dI_0 at the beginning of the production period. This is the amount of trade credit issued to the final customers. Furthermore if the liquidity shock hits the customer, the bank will lend extra funds vLI_0 to the supplier. Alternatively the bank may also lend vLI_0 at the beginning of the period and the supplier will keep it in a bank account to finance the customer if he experiences a liquidity shock.[42] The supplier will repay the loan from the bank with the future income received from the customer. In case of default the bank

[42]Given that both the supplier and the bank have the same discount factor, either of these alternatives is equivalent. The case where the customer holds some slack borrowing capacity is straightforward although, as seen in the previous chapter it is inefficient for the supplier to do so.

liquidates any collateral in the supplier's firm. The initial payment of the bank dI_0 has to be equal to the discounted value of the expected repayment at the end of the period. Let's define the repayment at date 1 as $(d + D)I_1$ so in case that the same bank finances again the necessary funds for next period investment, the net cash flow received at date 1 will be DI_1. Therefore the break even condition for the bank can be written as.

$$0 = -dI_0 + \beta(\alpha RI_0V + (1-\alpha)I_0\theta_s - vLI_0) \tag{16}$$

Being RI_0 the wealth of the customer in case of success and V the continuation value for the bank in case of success. The expression for V is the following:[43]

$$V\varpi_t = I_t\left[D + \beta(\alpha RV + (1-\alpha)\theta_s - vL)\right] \tag{17}$$

Given that $I_0 = \frac{\varpi_0}{1-\beta\theta_c-d}$ and conditional on success on the previous period, $I_t = \frac{\varpi_t}{1-\beta\theta_c-d}$ the value function can be written in a way that does not depend on the level of current wealth.

$$0 = \frac{1}{1-\beta\theta_c - d}\left[-d + \beta(\alpha RV + (1-\alpha)\theta_s - vL)\right] \tag{18}$$

$$V = \frac{1}{1-\beta\theta_c + p}\left[D + \beta(\alpha RV + (1-\alpha)\theta_s - vL)\right] \tag{19}$$

The first value function corresponds to the break even condition for a bank that lends d to a supplier. The continuation profits, (discounted with the discount factor β) are with probability α the ones of a supplier whose customer has grown by a factor R and with a continuation value function V. With probability $(1-\alpha)$

[43]The expression for V is written as if the same bank is going to be financing the new factoring deal. If a different bank were chosen for the new factoring deal, the relevant value function would be $V\varpi_t = I_t[D + d]$. Given that $dI_1 = \beta(\alpha RI_1V + (1-\alpha)I_1\theta_s - vLI_1)$ both expressions are equivalent.

the customer defaults and so does the supplier, so only collateral θ_s remains for the bank that lends directly to the supplier, (also θ_c goes to the bank that lent to the customer-that could be the same bank or a different one). Finally the bank faces the potential extra cost of a liquidity shock. The whole value function is multiplied by the leverage factor $\frac{1}{1-\beta\theta_c-d}$ although this is irrelevant since the left-hand side of the function is zero. The second value function are the continuation profits for a bank that lent to a supplier with a successful customer. The bank receives a payment $D < p$ and has continuation profits equal to the previous case. The leverage factor is in this case $\frac{1}{1-\beta\theta_c+p}$.

The value functions for the supplier including the condition $n = 0$ (that also implies that $s = 0$) are:

$$0 = \beta(\alpha Rm - (1-\alpha)\theta_s) \tag{20}$$

$$m = \frac{1}{(1+p-\beta\theta)}(p - D + \beta(\alpha Rm - (1-\alpha)\theta_s)) \tag{21}$$

The interpretation is similar to the value function of the banks. The first equation shows the break even condition for a supplier that has just started a relationship with a customer. As the supplier has no cash of its own, all the funds d come from a loan given by the bank and therefore there is no current net cash flow at this stage. Then $(\alpha Rm - (1-\alpha)\theta_s)$ is the continuation value, which with probability α corresponds to a successful customer and with probability $(1-\alpha)$ to default. In the second line m is the value of a supplier whose customer has just been successful, $p - D$ is the net payment on the supplier side and then comes the discounted continuation value $\beta(\alpha Rm - (1-\alpha)\theta_s)$.

To solve for D one has to take into account that putting together both value functions as if the supplier and the customer merged and simplifying the expressions, we get the following expressions:

$$0 = -d + \beta(\alpha R(V + m) - vL)) \tag{22}$$

$$(V + m) = \frac{1}{1 - \beta\theta + p}\left[p + \beta(\alpha R(V + m) - vL)\right] \tag{23}$$

Which has exactly the same structure of the equations on page 48 after taking into account that $s = 0$. Or in other words, the joint value functions of the supplier and the customer coincide with the value functions of the customer in Chapter 3. This means that, as the value functions for the customer have not changed, the solution of Chapter 3 for p and d is still valid. In particular the relationship between them will still be:

$$d = \frac{(1 + g)p - vL}{i - g} \tag{24}$$

This already shows that the interest rate that suppliers charge to their customers is going to coincide with the one in Chapter 3 of $\rho = \widetilde{\rho}$, given that the value functions of the customer have not changed, and that the previous expression that concentrates the value functions of suppliers and banks coincides with the one in Chapter 3 for the unconstrained suppliers alone. Then the final equilibrium values for p and d coincide with the ones of the unconstrained case (and therefore the interest rate will coincide too). To get the equilibrium value for D we have to use the value functions of the customer on page 48 so we have seven unknowns M, N, p, d, D, m and V and seven conditions: the two value functions of the supplier, the two value functions of the bank and the three value functions of the customer. The value functions of the bank can be combined to get a single expression for the break even condition that does not depend on V.

$$d = \alpha\beta(1 + g_1)\left[D + d\right] + \beta(1 - \alpha)\theta_s - \beta vL \tag{25}$$

Multiplying the whole expression by I_0 and using the fact that conditional on success, $(1+g_1)\, I_0 = I_1$ gives a much more intuitive expression for d that is a one period flow of funds in money terms:

$$dI_0 = \beta\left[\alpha\,(d+D)\,I_1 + (1-\alpha)\theta_s I_0 - vLI_0\right] \tag{26}$$

The interpretation of this expression is that the present value of the loan from the bank dI_0 equals the discounted value of the face value of the loan $(d+D)\,I_1$ times the probability of repayment α plus the liquidation value of the supplier $\theta_s I_0$ times the probability of default $(1-\alpha)$ minus the expected cost of financing potential liquidity shocks vLI_0.

Solving for d shows that the cost of the loan given by the bank has to be equal to the expected future flow of funds from the supplier, where every period, the bank gets D with probability α and θ_s with probability $(1-\alpha)$ minus the potential cost of any liquidity shocks. The factor $(1+g_1)$ multiplies D, as the first payment from the supplier will be made after one successful period of the customer, while the first potential liquidity shock or collateral claimed correspond to the same period where d is lent.

$$d = \frac{\alpha\,(1+g_1)\,D + (1-\alpha)\theta_s - vL}{(i-g)} \tag{27}$$

The fully endogenous expression for D can be found substituting d by expression 10 and solving.

$$D = \frac{(i-g)\Delta\,(\delta(R-r)(\alpha-\gamma) - \beta vL) - (1-\alpha)\theta_s}{(1+g)} + \beta vL \tag{28}$$

Similarly the expression for the break even condition of the supplier that does not depend on m is:

$$[p - D] = \beta(1 - \alpha)\theta_s \quad (29)$$

Which in essence says that the earnings that the supplier makes per period need to compensate for the potential loss of collateral that would happen if the customer did not repay. It also shows that $D = p - \beta(1 - \alpha)\theta_s$, so repaying D is always feasible as long as the customer is successful and pays p. Given that D is smaller than p as long as collateral is positive the interest rate between the bank and the supplier will lie between the market interest rate and the implicit interest rate of trade credit. In fact, in the absence of liquidity shocks, the factoring interest rate i_s would be a weighted average between i and ρ being the weights $\frac{\theta_s}{d}$ and $(1 - \frac{\theta_s}{d})$, the existence of liquidity shocks breaks this linearity but still i_s would be between i and ρ.[44]

Also given that D is always smaller than p for any positive level of collateral the supplier has an incentive to enforce debt repayment as she gets a profit in case that debt is repaid and makes a loss in case of default of the customer.

4.3 Supplier's Opportunity Cost of Capital

This section shows what are the effects on the trade credit contract when the supplier faces a higher opportunity cost of capital than banks. This is a situation in which the supplier has enough borrowing capacity to fully finance the customer but when there are also competing investment options on the supplier's side that make the supplier effectively rationed. The reason why this is an interesting situation is that (unlike in the previous section) the financial constraints of the supplier is going to affect the interest rate that the customer is going to pay for trade credit. In the standard factoring contract described in the previous section, the interest rate paid

[44] After a bit of algebra it is easy to see that the equation that determines the supplier interest rate in the presence of the liquidity shock is $d(1 + i_s) = \theta_s(1 + i + vL) + (d - \theta_s)(1 + \rho)$.

by the supplier to banks was higher than the market interest rate because banks were assuming part of the default and liquidity risk of the customer. However the overall risk of the trade credit contract was constant, so the interest rate paid by customers did not change, regardless of how the default risk was split between the bank and the supplier. On the contrary, in this section, a higher opportunity cost of capital for suppliers means that there will be a higher interest rate charged on trade credit as trade credit has to compete with alternative uses for the limited funds of the supplier. To introduce an opportunity cost for the supplier we will assume that the supplier has access to a liquid investment opportunity that gives return $1/\beta_s > (1+i)$ per period and has non-verifiable returns. The supplier has to distribute all her available funds between issuing trade credit and investing in this liquid technology. We will also drop Assumptions 8 and 9 of the previous section, so there is non-verifiability of the transactions between the supplier and the customer, and all the collateral that the supplier may have is generated outside the commercial relationship with its customer. Otherwise, if we kept Assumptions 8 and 9 trade credit would generate its own additional borrowing capacity.

Assumption 8b: The supplier has an outside liquid investment opportunity with a per period return equal to $1/\beta_s$ being $\beta_s > \beta$ the returns of this investment opportunity are not verifiable.

The non verifiability of the returns of the liquid technology precludes that the supplier borrows on the basis of its future returns. Otherwise the existence of this liquid technology would in fact increase the borrowing capacity of the supplier.

Assumption 9b: The supplier has outside collateral bigger than the maximum trade credit needs.

These two assumptions imply that the supplier has a limited amount of funds to devote to two competing investment options. Issuing trade credit to her customer and investing in the liquid investment technology. In the absence of any trade credit, the supplier would borrow up to its collateral limit and invest these funds in the outside investment opportunity. Does this rule out the existence of trade credit? The answer is not, only that the supplier needs to be compensated for the extra opportunity cost of funds that she is facing. So the break even condition for the supplier becomes that the expected future discounted value of trade credit should at least match the yield of the alternative investment opportunity.

Defining $\beta_s = \frac{1}{(1+i_s)}$ as the discount factor implied in the interest rate paid by suppliers. Then rewriting the value functions of the supplier using the discount factor β_s and the condition $n = 0$ to find the relationship between d and p.

$$s = \frac{1}{(1 - \beta\theta_c)}\beta_s(\gamma Rn + (1 - \gamma)rs) \tag{30}$$

$$n = \frac{1}{(1 - d - \beta\theta_c)}\{-d + \beta_s(\alpha Rm + (1 - \alpha)rs - vL)\} \tag{31}$$

$$m = \frac{1}{(1 + p - \beta\theta_c)}\{p + \beta_s(\alpha Rm + (1 - \alpha)rs - vL)\} \tag{32}$$

The interpretation of these value functions is identical to the one on page 48 . Given that the value functions for the customer are unchanged, we can follow the same steps as in Chapter 3 to find an expression for the interest rate of trade credit ρ and the premium paid by customers on top of the interest rate paid by suppliers i_s.

$$\text{Premium} = \rho - i_s = (1 - \alpha)g(1 + \frac{p}{d}) + \frac{\nu L}{d} \tag{33}$$

Being again the expected growth rate of the customer defined as $(1 + g) = \frac{\alpha R}{1-\beta\theta_s+p}$. Given the relationship between the interest rate paid by suppliers and the market interest rate in equation 33 the premium that customers pay as a function of the market interest rate is:

$$\text{Premium} = \rho - i = (1-\alpha)g(1+\frac{p}{d}) + \frac{\nu L}{d} + (i_s - i) \tag{34}$$

So the difference between the trade credit interest rate and the market interest rate is composed by three premiums: $(1-\alpha)g(1+\frac{p}{d})$ is the default premium that was already present in the basic model; $\frac{\nu L}{d}$ is the insurance premium that also existed in the case where suppliers were unconstrained; finally $(i_s - i)$ is the premium associated with the suppliers cost of capital.

Throughout this whole section we have used an outside investment opportunity to give the supplier a higher opportunity cost of capital. However the analysis would be very similar if we directly introduced a higher cost of capital for the supplier (on top of the risk sharing of the trade credit contract itself). This higher cost of capital could be modelled in several ways, for example if the liquidation of collateral by banks were inefficient with respect to its liquidation by suppliers. The influence of a higher opportunity cost of capital is the same as a higher cost of capital, the reason why we have chosen to motivate the higher cost of capital with an outside investment opportunity is because it is easier to model it in such a way that even though the cost of capital is higher for the supplier than for the bank, the differential cost between them is constant no matter how much funds they borrow.

It is important to distinguish between the situation in Section 4.2 and this section. In Section 4.2 the supplier is constrained, because the amount of funds that she can borrow at a riskless rate is limited by the amount of collateral that she has, while here is the cost of capital that is higher for the supplier. In practice, financial constraints may manifest themselves as a combination of these two case; with suppliers having a limited amount of riskless borrowing; higher cost of capital whenever borrowing over that limit; and a maximum amount of risky borrowing allowed - regardless of the interest rate paid.

4.4 Supplier vs Bank Insurance When Suppliers Are Constrained

In Section 3.3 , we explored the question of suppliers as optimal insurance providers assuming that both banks and suppliers are deep pockets with the same discount rate. Both expect to make zero profits on average in their interaction with the customers. So it is an intuitive result that the cost of getting insurance from either of the agents is the same. Now we can go back to the question of insurance when suppliers are cash constrained themselves. One assumption that would give suppliers a cost advantage over third party insurers would be if suppliers and customers were both cash constrained and had a lower discount factor than banks. For example if, as in the previous section (Section 4.3) suppliers had a limited amount of outside collateral and had access to a liquid and reversible production technology that yielded more than $\frac{1}{\beta}$ units of non-verifiable returns per period, per unit invested, where they could invest their "spare" funds or excess borrowing capacity. This would be equivalent to suppliers having a higher cost of capital so $\beta_s < \beta$.

In this case suppliers would be cheaper insurers than banks because they would discount the insurance premium at more favourable terms. As suppliers value the payment of a premium in advance more than banks. The difference in the cost of insurance is however, much bigger than the difference of the implicit discount factors of the supplier and the bank. The reason is that the supplier internalizes all the future savings that the customer is going to make in the future and the increase in the customer's growth rate in each period. As seen in Section 3.1.6 - while the wealth of the customer is backward looking, the level of leverage is forward looking, generating an expansion mechanism. The saving on the customer side would not only be equal to $(\beta - \beta_s)vLI$ but the effect would also be amplified by the multiplicator Δ (see Section 3.1.6). In particular the saving per period for the customer would be $(\beta - \beta_s)(1 + \Delta)vL$ in the first period using specific inputs, and $(\beta - \beta_s)(1 + \Delta\frac{(i-g)}{(1+g)})vL$ from then onwards. A more detailed calculation of the different premiums can be found in Appendix 2. The fact that the customer saves some insurance premium per period increases the surplus to be extracted by the supplier, therefore increasing the level of borrowing also. A higher leverage increases the expected growth rate of the customer so future surplus also grows, this again feeds back on leverage and so on. All these effects are summarised in the multiplicators Δ. and $\Delta\frac{(i-g)}{(1+g)}$.

4.5 Liquidity Shock vs Growth Opportunities

So far the liquidity shock was present in the model as a negative one in which the firm needs to pay some extra funds to avoid some negative outcome i.e. a breakdown or a bad production year. However, most of the results regarding insurance would also work if the shock is modelled as a positive one. The structure of this shock could be that the firm has the opportunity to pay LI in exchange of an investment opportunity that makes the firm have higher profits and therefore grow faster in the future. If the returns of this new project are also non-verifiable and generate no additional collateral the firm cannot finance this shock by raising extra bank finance. However, as long as LI is smaller than the incremental profits that suppliers would get from a higher growth of their customer firm they would be willing to pay if customers have no cash and have no other alternative source to finance the necessary investment. Given that the supplier extracts some relationship surplus from the customer, the supplier will internalize any changes in the relationship surplus or customer growth rates. If the customer has no liquidity to finance a growth opportunity, the supplier may finance it. In the next pages we show the conditions for the supplier willing to finance an additional unexpected investment opportunity that costs LI to finance and produces some extra surplus. We distinguish the cases where the productivity shock is temporary in the sense that surplus is higher during a single period and where the surplus grows permanently for all the future periods.

4.5.1 Temporary and Unexpected Shock

What would be the effects on trade credit of a temporary and unexpected positive productivity shock that needs some extra investment? Let's assume that a supplier and a customer are already using the mature technology for more than one period and a shock hits with the following structure: the customer can pay LI to get additional funds at the end of the period worth A_oI in case of success. The project has positive NPV so $\alpha A_oI > LI$. For simplicity, we initially assume that this is a one shot increase in productivity so we use the subindex o to denote the one-shot temporary nature of the shock. If the customer has no precautionary saving, when would the supplier be willing to finance the additional investment?

To answer this question we need to compare the value functions of the supplier under both possible situations paying vs not paying the additional investment. If the supplier does not pay the additional investment, her value function is basically

$$\frac{1}{(1+p-\beta\theta)}\beta(\alpha Rm + (1-\alpha)rs) \tag{35}$$

Which is equivalent to expression 6 but after the payment of p has been realised. If the supplier decided to pay the additional investment, the value function would be:

$$\frac{1}{(1+p-\beta\theta)}\left[-L + \beta(\alpha(R+A_o)m + (1-\alpha)rs)\right] \tag{36}$$

We can see in the expression that the supplier needs to spend extra funds L and the proceedings from this investment will go to the customer's account. However, this will mean that the customer will grow faster this period (at rates $(R + A_o)$ instead of R and therefore the future surplus that will be extracted by the supplier will also grow. Given that $s = 0$, the difference between both value functions becomes $\frac{1}{(1+p-\beta\theta)}(-L + \beta\alpha m A_o)$ which will be positive as long as $\beta\alpha m A_l > L$. This means that a positive net present value is not a sufficient condition for the suppliers to accept financing the project. Given the structure of the shock, the supplier will not be able to extract directly any of the extra surplus that the additional production generates. This is because the ability to extract surplus of the supplier is forward looking (depends on the differential future productivity) and as the shock is temporary it does not change the future productivity of the customer. However this does not mean that the supplier does not benefit at all from the positive shock. The extra returns of the customer during the period of the shock will be reinvested, and therefore the future size of the customer will be bigger, so even though the supplier will still capture a fixed proportion of the customer's investment, this proportion will mean a higher amount of funds. Therefore the returns from the extra productivity on one period will be collected by the customer, and the supplier will only benefit from them through the higher size of the customer in the future. Depending on how much surplus the supplier does get from the customer (size of m) and what is the probability to keep the customer (size of α) the supplier will be more or less interested in financing this growth opportunity.

When the shock is temporary and unexpected, the supplier only benefits from a higher growth of the customer, and not through a higher proportion of surplus extraction in future periods. Only when there is an expectation of the shock or when the shock is permanent, there is scope for a higher proportion of surplus extraction in the future.

4.5.2 Permanent and Unexpected Shock

Instead of modelling the shock as a one-off productivity shock, we can model it as an unexpected investment opportunity that generates extra cash flows in all the future periods in case of success. If this is the case, the supplier would be more willing to finance the growth opportunity as she could actually extract (directly and not through higher growth) the extra profits that the new opportunity generates. In terms of the parameters of the model a productivity shock that increases productivity of the specific technology without changing the collateral value of the customer's investment would be equivalent to an increase in R. Therefore if R increases to $R + A_p$ permanently for all the future periods, the value function for the supplier becomes.

$$\frac{1}{(1+p-\beta\theta)}\{-L+\beta(\alpha(R+A_p)m+(1-\alpha)rs)\} \tag{37}$$

Being the continuation value for a supplier after the period of the shock

$$m=\frac{1}{(1+p-\beta\theta)}\{p+\beta(\alpha R(R+A_p)+(1-\alpha)rs)\} \tag{38}$$

Note that here the continuation value for the supplier m includes also the extra profit generated by the customer. The surplus extracted by the supplier will change according to the new size of the total surplus. Equation (11) shows how the surplus extracted by the supplier p goes up by $\Delta\frac{(i-g)}{(1+g)}A_p$. The value function for the supplier m after paying L goes up by $\frac{\beta(\alpha-\gamma)}{1-\beta\theta-\beta r(\alpha-\gamma)}A_p$. So the incentive for the supplier in this case to finance the liquidity shock comes from the extra surplus extracted in all the future periods. This surplus is bigger, first because of the permanent nature of the shock, but also because the customer benefits from the extra surplus on the first period that will not be extracted by the supplier and therefore will be reinvested.

In the previous two sections we have assumed that the shock is unexpected in both cases. If the shock were expected, that is if agents believed that there is an ex-ante probability that this positive shock may occur, the analysis would be very similar. The supplier would finance the shock as long as the increased surplus extraction in the future is bigger than the cost of the investment opportunity, and the customer has no liquidity to invest in the new investment opportunity. On top of this, if the shock is expected, the expected productivity differential between the mature technology and the startup one would be affected by the expected shocks, thus increasing both p and d.

4.6 Conclusions

Throughout this chapter the analysis of trade credit was extended to financially constrained suppliers. We analysed separately two different ways in which financing constraints of the supplier may affect the factoring contract. In the first place how does the way in which risk is shared between the supplier and the bank affect the interest rate of the factoring contract and secondly the influence on these interest rates of further frictions such as a high opportunity cost of capital on the supplier side.

In a factoring contract, there is joint liability of suppliers and customers for the trade credit debt in case of default. This implies that the creditworthiness of the supplier affects the default risk that the bank is facing when factoring the supplier's receivables. Then the amount of collateral of the supplier affects how the risk of default and late payment of the customer is split between the bank and the supplier. However, regardless of the collateral of the supplier, the final interest rate paid by the customer should not be affected by how this risk is shared. A different issue is whether there are frictions that make the supplier cost of capital - or the opportunity cost of it - higher than the cost that banks face. In this case, the extra cost of funds will be passed on to customers in the trade credit contract. This is for example the case when the supplier has to distribute a limited amount of funds between different competing investment opportunities. In this case, the profit made on trade credit has to match the best alternative investment opportunity. In practice both effects can be present simultaneously as suppliers may face financing constraints, both in the form of high cost of capital and credit rationing.

The issue of supplier insurance is also affected by the existence of financing constraints on the supplier side. The structure of the implicit insurance contract (the supplier charges a premium on every trade credit contract and will pay for the cost of facing the liquidity shock whenever it hits) means that the collection of insurance premiums actually relaxes the financial constraints that suppliers face, making them cheaper insurance providers than banks. This cost advantage is magnified by a feedback effect, as suppliers also internalize the effects of this saving on future growth and surplus of the customer. On top of this cost advantage, the contracting advantages discussed in Section 3.3 still remain.

The analysis of liquidity shocks is also extended in this chapter. Unlike in Chapter 3 where the liquidity shock was seen more like a breakdown, in this chapter we also explored the possibility of the liquidity shock being modelled as investment opportunity that requires extra investment and can increase the productivity. If the customer has no funds to invest, the supplier will extend extra credit to the customer as long as the increase in the part of the relationship surplus received by the supplier is bigger than the necessary funds. If the investment opportunity permanently increases the productivity within the supplier-customer relationship, the supplier will benefit by extracting a higher share of surplus in the future. However the total discounted relationship surplus may grow, even if the shock is temporary and the supplier does not directly get any of the extra funds generated. Given that the customer will reinvest these extra funds, the supplier would benefit from a higher growth rate of the customer in the period where the shock hits.

In fact the issue of liquidity shocks and suppliers as lenders of last resort can be seen in a much broader sense. As the supplier shares part of the relationship surplus with the customer, the supplier is affected by the investment decisions and also by any shock that affects the customer. Whenever the customer cannot pay for a necessary investment of whichever nature that affects this surplus, the supplier may help or support the customer, knowing that she will internalize part of the change of this surplus.

4.7 Appendix 2

The value functions for the supplier and the customer in the event of the supplier having an external investment opportunity that yields $\frac{1}{\beta_s}$ per period and uses supplier insurance are:

$$(1-\beta\theta)S = +c + \delta(\gamma RN + (1-\gamma)rS)$$

$$(1-d-\beta\theta)N = +c + \delta(\alpha RM + (1-\alpha)rS)$$

$$(1+p-\beta\theta)M = +c + \delta(\alpha RM + (1-\alpha)rS)$$

$$(1-\beta\theta)s = \beta_s(\gamma Rn + (1-\gamma)rs)$$

$$(1-d-\beta\theta)n = -d + \beta_s(\alpha Rm + (1-\alpha)rs - vL)$$

$$(1+p-\beta\theta)m = +p + \beta_s(\alpha Rm + (1-\alpha)rs - vL)$$

Where the conditions $M = S$ and $n = 0$ still hold. Following the lines of the solution in Section 3.1.6, the final values for d and p are:

$$d = \Delta(\delta\,(\alpha-\gamma)\,(R-r) - \beta_s vL) - \beta_s vL$$

$$p = \Delta\frac{(i-g)}{(1+g)}\left[\delta(R-r)(\alpha-\gamma) - \beta_s vL\right] + \beta_s vL$$

Where $\Delta = \frac{\beta_s R\alpha}{1-\beta\theta-(\beta_s-\delta)\alpha R-\delta(\alpha-\gamma)r}$. If the customer decides to cover against potential liquidity shocks using bank insurance, then the alternative value functions are:

$$(1-\beta\theta)S = +c + \delta(\gamma RN + (1-\gamma)rS)$$

$$(1-d-\beta(\theta+vL)N = +c + \delta(\alpha RM + (1-\alpha)rS)$$

$$(1+p-\beta(\theta+vL))M = +c + \delta(\alpha RM + (1-\alpha)rS)$$

$$(1-\beta\theta)s = \beta_s(\gamma Rn + (1-\gamma)rs)$$

$$(1-d-\beta(\theta+vL))n = -d + \beta_s(\alpha Rm + (1-\alpha)rs)$$

$$(1+p-\beta(\theta+vL))m = +p + \beta_s(\alpha Rm + (1-\alpha)rs)$$

Solving for d in the same way as in Section 3.1.6 we get a final endogenous value for d of:

$$d = \Delta\left[\delta\left(\gamma-\alpha\right)\left(R-r\right)-\beta vL\right]$$

While the equivalent expression for p becomes:

$$p = \Delta\frac{(i-g)}{(1+g)}\left[\delta(R-r)(\alpha-\gamma)-\beta vL\right]$$

Given that the customer chooses to use third party insurance, he also has to pay βvL to the bank as insurance premium on top of receiving d and paying d.

The difference between bank insurance and supplier insurance is therefore $(\beta - \beta_s)(1 + \Delta)$. As the saving of $(\beta - \beta_s)$ occurs every period, suppliers are able to collect some extra surplus per period. This increases d on the first specific period and feeds back on future surpluses.

5 Empirical Analysis

The model of Chapters 3 and 4 explains some of the stylised facts regarding trade credit. In particular, the high implicit interest rates associated with using trade credit are justified by the existence of default and insurance premiums. Suppliers allow late payment without charging a penalty when their customers experience liquidity problems as part of the insurance that they are providing. The enforceability advantage on the suppliers side and their provision of insurance also explain why trade credit is so widely used in the presence of a competitive banking sector in spite of this high cost. Some customers may be rationed when borrowing from banks when banks are worried about their ability to enforce debt repayment. However, these same customers may be able to still borrow some more funds from their suppliers. Suppliers may have some extra enforceability power that banks do not have if there is some relationship surplus split between the supplier and the customer.

These properties of the model are consistent with the evidence we observe on trade credit use. Moreover, the model also has a series of testable implications that can be used to assess its relevance and compare it with other competing theories regarding trade credit. We now concentrate on three main empirical implications of the model that we are going to test throughout this chapter.

1. Trade credit should grow as the link between a customer and a supplier gets tighter: therefore we expect higher levels of trade credit whenever intermediate goods are very specific, when suppliers have private information about their customers or in general when suppliers are costly to substitute.[45]

[45]Our model does not address the idea of suppliers having superior information about their customers directly. However any kind of informational advantage that would make customers more productive with their long-term supplier than with an alternative one would fit in the model. This is not to be confused with informational asymmetries of the kind present in Biais and Gollier

A serious problem when testing this implication empirically is that it is difficult to measure the importance of this link from balance sheet data. The nature of the links between customers and their suppliers may be technological, but also informational or even contractual, so it is difficult to find a single measure that summarises all these factors. One possibility that we will explore is to use the age of the firm as a proxy for this specificity. A new born firm starts with very low links with its suppliers. Then as time goes by the relationship between the customer and its suppliers gets tighter. Therefore, according to our model, the levels of trade credit should build up with the age of a firm as the link of the firm with its suppliers grows. Once the customer has built up a relationship with his supplier the levels of trade credit should stabilise or even fall, due to substitution via bank credit and retained earnings. Thus we expect a hump shaped relationship between the levels of trade credit and the age of the firm.

This type of approach will identify the change of the relative levels of trade credit as specificity builds up, but will only capture types of specificity that actually grow with the age of the firm. Some types of specificity may already be in place when the firm is created, (i.e. very specialised inputs, patents, exclusive contracts etc). To investigate if this type of specificity also leads to high levels of trade credit we will run regressions in which we find the relationship between the levels of trade credit given and trade credit taken and the R&D intensity of the different studied sectors. In principle we expect that the expenses in R&D are going to be a good proxy for how specific the intermediate goods used by the customer firm are and therefore higher levels of R&D expenditures should be associated with higher levels of trade credit.

(1997). In their model, suppliers have an advantage in determining the creditworthiness of their customers.

2. Firms experiencing liquidity problems should use their suppliers as lenders of last resort. The ones with little access to alternative sources of finance are specially going to rely more on their suppliers.

   If we relate the levels of trade credit to a measure of firm performance such as the firm growth rate, we expect firms experiencing small temporary problems to have relatively high levels of trade credit. Additionally, we expect a negative relationship between the level of deposits of the firms and their use of trade credit, as one of the predictions of the model is that suppliers will only give extra financial support to their customers when customers have no alternative way to face their liquidity shocks. We also expect that firms that are growing at a high pace will have higher levels of trade credit for two reasons: on one hand they have high dependence on their suppliers, and on the other hand high growth firms are likely to have high needs of external finance. Given that trade credit is relatively expensive, firms will exhaust their own funds and bank lending capacities before using trade credit. So if we relate the levels of trade credit to a measure of firm performance we would expect to have a U-shaped relationship. High growth firms and the ones experiencing slight problems should be the ones that use trade credit more extensively.

   We will also check how trade credit evolves with the levels of liquidity of firms. Our prior is that when firms have little cash and liquid assets, they will use trade credit more extensively; especially when we concentrate in firms with little access to financial markets and that are experiencing some type of negative shock or financial distress.

3. Finally, the proportion of trade credit used with respect to other forms of finance should depend on the level of collateral that firms have. The higher

the level of collateralisable assets, the lower proportion of trade credit is expected. This result is almost imposed in the assumptions of the model. However we find it relevant to test our assumption, specially given that alternative theoretical models have given little or no attention at all to the determination of the "mix" between trade credit and other forms of credit.[46]

One of the problems of the theoretical model of Chapter 3 when trying to test it empirically is that as the technology used to describe the production process of the customer is of constant returns to scale with a positive NPV, firms invest until they exhaust all their possible finance sources. This emphasizes the financial constraints of the customer and also keeps the model relatively simple as all the value functions of the customer remain linear on his level of investment. However, in practice, firms do not always exhaust their finance sources and trade credit is likely to be the last option in the "pecking order" due to its high cost. When testing the implications of the model one has to be aware of this "pecking order" and interpret the results accordingly.[47]

All the regressions in this chapter relate quantities of trade credit given or taken as a function of different determinants. No investigation into the price of trade credit is made given that we do not have any information about the actual price of the goods, the discount of early payment and the effective maturity of each trade credit transaction. In particular we do not have an estimate of the different

[46] An exception is Biais and Gollier (1997). In their model suppliers and banks have different signals about a customer's probability of default and only when both signals are positive is the expected net present value of the project positive. Under these conditions, banks will only lend when suppliers are willing to and vice versa. The "mix" between bank and trade credit is chosen optimally to avoid collusion between suppliers and customers.

[47] Most empirical articles and common business practices support the "pecking order" assumption in which trade credit is used after exhausting all possible bank credit (see for example Nilsen, 1999), however some authors (Marotta, 1997) see trade credit as a cost of sales and not as a pure financial instrument. If we accept this alternative explanation this pecking order need not be true.

premiums that our model predicts. This remains an important and open question, and further research should be made to investigate this issue.[48] Our dataset of UK firms contains only data on balance sheet and cash flow statements with virtually no information on prices. Even if we had data on the actual terms of trade credit, as in the NSSBF dataset, it is not possible to calculate interest rates or premiums of trade credit without any data on the actual maturity of trade credit (including late payment) and information on prices. The information on prices is relevant, because whenever a customer is taking the maximum level of trade credit allowed by the customer, the customer can change the price of goods to charge a higher interest rate on trade credit, without actually changing the terms of the contract.

5.1 Sample Description

To test the implications of the model we use a sub-sample of the FAME-Bureau Van Dijk database. This database is collected by Jordans and Bureau Van Dijk for commercial use and it includes balance sheet data, profit and loss statements and some complementary information on all UK firms that satisfy one or more of these criteria: turnover greater than £700,000; shareholders funds greater than £700,000; or profits greater than £40,000. This accounts for about 110,000 firms. It also contains less detailed data on a sample of 100,000 firms that satisfy turnover being greater than £500,000; current assets greater than £250,000; current liabilities greater than £250,000; or pre-tax profit greater than £25,000. The advantage of this latter group of firms is that it includes relatively small firms.

The database records data from 1993 until 1999. Because the dataset is mainly aimed at consulting firms and financial analysts, many new-born firms are also included in the sampling. We restrict our analysis to manufacturing firms, retailers and wholesalers. We drop firms in sectors such as agriculture, fishing, mining, fin-

[48]See Schnucker (1993) and also Ng, Smith and Smith (1999).

ancial intermediation, other services, real estate, public administration etc, because these are sectors in which buying intermediate goods from a supplier represents a small part of the firm inputs and therefore trade credit is of little relevance. This leaves us with an incomplete panel of approximately 55,000 firms with an average of 4.5 observations per firm.

This database presents two particular characteristics that make it specially appealing for our problem. In the first place, the dataset contains both quoted and not quoted firms. Unlike in the US, where only quoted firms are required to file their quarterly or annual accounts, UK firms have to make public their accounts even if they are not present in the stock market. Given that the study of trade credit use is particularly relevant on small and new firms, this data allows us to include these firms in the analysis and also take subsamples of small firms whenever necessary. Secondly, the high number of observations is ideal to perform non-parametric estimations that are particularly important when some of the implications that we want to test are highly non linear.

The main disadvantage of this dataset are the annual frequency of the data and the limited information contained in balance sheets regarding trade credit. Ideally, we would like to have higher sampling frequency, especially when we want to test implications regarding the behaviour of firms under financial distress. This annual sampling will make it difficult to study these the short-term dynamics of trade credit. Also the data is not as rich as the National Survey of Small Business Finance (NSSBF) in terms of the amount of variables included and the information regarding commercial partners and trade credit. Ideally we would like to have some information like the number of suppliers of a certain input and the length of their relationship, unfortunately this information is not present in our UK dataset.

In Table 2 we report the composition of our sample by year, and firm size, measured both as size in assets and size in terms of number of employees.[49] We show the number of observations for the different categories. The sample contains up to 5 observations per firm.[50]

Table 2: Sample composition: Number of firms by year and size

Year	1993	1994	1995	1996	1997	1998	1999	Total
Observations	1551	8681	41593	48578	50799	51245	43941	243338
% of total sample	0.63	3.52	16.88	19.72	20.62	20.80	17.83	100

Size (Assets-£M)	<0.1	.1-.25	.25-1	1-5	5-50	50-500	>500	Total
Observations	3816	10024	54126	110717	56120	9597	1494	246388
% of total sample	1.54	4.06	21.9	44.93	22.77	3.89	0.6	100

Size (Employees)	<5	5-50	50-250	250-500	500-5k	5k-25k	>25k	Total
Observations	7797	67319	65092	11973	12168	1078	289	169472
% of total sample	4.60	39.72	38.40	7.06	7.17	0.63	0.17	100

Considering the distribution of the sample by year, most of the firms are sampled between 1995 and 1999. Data is only available at most for five years per firm. This makes the distribution to concentrate in the last five possible years. With respect to firm size we can see how relatively small firms are represented in the firm. A percentage of 27% of the firm-observations in the sample have less than £1 million assets and 44% of them have less than 50 employees. As the amount of firms represented in the sample is quite high, this leaves us with a good number of small firms. This is particularly important when dealing with empirical evidence regarding trade credit, as trade credit is likely to be more important for small firms that typically have less alternative sources of finance.[51]

[49] Assets for Table 2 are reported in £ Million.

[50] For most firms (75%) we have the last 5 observations available (eg. 1995-1999, 1994-1998 etc) others have less than 5 observations. The average observations per firm is 4.4.

[51] The proportion of big firms in our sample is much higher than the one in the country as

In Table 3 we also report the summary statistics for the different variables that we are going to use throughout our empirical analysis. We report the mean and the variance of the different variables, as well as three position measures. The sample median, the value for the 10% quantile and 90% quantile. These values can be used to evaluate the quantitative importance of the different results in our regressions.[52]

a whole. However, given that the regressions of this chapter constitute a conditional analysis, the fact that we have a stratified sample should not bias our results. The stratified nature of the sample, should only be a problem if we wanted to do a descriptive analysis of variables like: the average firm size or the average use of trade credit When reporting these statistics, one has to be aware that the fact that big firms are oversampled in our dataset makes these descriptive statistics biased, so they are not representative of the UK economy as a whole.

[52]Some of the variables used in our estimations are ratios over the level of assets of the firm. This means that we may get some extreme results when the assets of the firm are close to zero. Calculating the summary statistics of the following ratios: trade credit over assets, trade credit growth rate, trade credit over sales; we have excluded from the calculation the top (bottom) 1% of the observations, to avoid unusually high values when the denominator of these ratios is too close to zero. We also drop these observations in further estimations whenever one of these ratios appears in the regression.

Table 3: Summary statistics

Variable	mean	Std. dev.	median	10% qt.	90% qt.
Assets	22270	343074	2081	365	18683
Employees	329	2965	59	9	394
Trade credit	2500	29826	263	0	2874
Trade credit/Assets	0.18	0.18	0.13	0	0.44
Trade credit/Sales	0.10	0.12	0.08	0	0.21
Trade credit growth rate	0.13	0.71	0.02	-0.54	0.85
Trade credit/Total debt	0.43	0.32	0.41	0	0.94
Inventories	3483	37935	318	0	3618
Inventories/Assets	0.21	0.19	0.17	0	0.48
Short-term bank loans	4147	68126	200	0	3555
St banks/Total Liabilities	0.26	0.27	0.18	0	0.66
Long-term bank loans	5	2944	58111	0	0.35
Lt banks/Total Liabilities	0.10	0.17	0.005	0	0.35
Inventories/Assets	0.21	0.19	0.17	0	0.48
Liquid assets	1412	28944	44	0	1245
Liquid assets/Assets	0.9	0.15	0.2	0	0.30
Age (Years)	23	-	17	4.6	>100
Asset Growth Rates	0.05	0.28	0.06	-0.20	0.33
Collateral	6640	138308	337	7	10904
Collateral/Assets	0.23	0.21	0.18	0.007	0.54
Profits before tax	2435	42567	149	-64	1927
Return on assets	0.09	0.24	0.07	-0.03	0.24
Return on equity	0.16	11.8	0.25	-0.09	1.21
Monetary variables in thousand pounds.					

We can see in the last two tables that the size distribution of our sample is skewed towards smaller firms. Most of the variables related to the size of the firm such as assets or level of trade credit have average levels higher than the median. This is a characteristic of the population of firms in the UK rather than a special property of our sample, that contains all the big UK firms and only a subsample of the small ones. This points out that our sample is composed mainly by a big group of small and medium firms, but also that all the biggest firms of the UK are also included in the sample. More than half of the firms in our sample have less than 60 employees, while there is almost 10% of the firms in the sample with more than 300 employees.

With respect to trade credit, the average level of trade credit over assets is 18% although the variability of this ratio is quite high, as going from the 10th percentile to the 90th percentile means moving from zero trade credit to a 44% of trade credit over assets. When we measure trade credit as a proportion of sales, the average level falls to 10%, with decile values of zero and 21%. This shows that sales are normally bigger than assets on a per firm basis, but also the fact that not all the firms in our sample report a figure for sales, being the smallest firms the ones for which we have less information about their sales and their profit and loss statement. As a guide for this lack of information about sales, while we have 243338 observations for asset levels, we only have 109387 observations regarding sales. The average size of the firms that report sales in term is £36701k of assets while for the ones that do not report a sales figure, the average level of assets is £18536.

The median age of the firms in our sample is 17 years, with firms of all ages represented, including more than 10% of the sample being firms with more than 100 years of age. If we wanted to do regressions concerning the age of the firm for all firms, this would pose a problem, as a firm of more than 100 years of age may have suffered several restructurings, and therefore be "re-born" in some sense after foundation. This is not going to be a problem in our regressions that relate trade credit to firm age as we are only interested in the youngest firms of our sample. In particular, the regressions that use firm age as a dependent variable will concentrate on a subsample of firms of less than 20 years of age. This subsample of observations of firms below 20 years of age contains 34440 firms and 137907 observations.

Note that the values for the levels of collateral over assets and bank loans are very similar, being bank loans slightly higher than the level of collateral. Of course this is not true on a firm by firm basis but already hints the strong correlation between both variables that will be explored in more detail in Section 5.5.

Throughout our empirical work, we are going to abstract from business cycle considerations. The reason is not that we believe that these factors are irrelevant to the determination of the use of trade credit but because the FAME-BVD sample only covers the 1993-1999 period, that does not contain a full business cycle in it. There is already in any case some work done regarding trade credit and the business cycle (see Nilsen ,1999; Marotta ,1997 and Hernandez and Hernando ,1999 for example). To avoid that our results could be biased if we do not include variables related to the business cycle in our regressions we will include whenever possible year dummies in our estimation.

In Table 4 we can see the UK GDP growth rates in constant prices as well as two measures of profitability of the firms in our sample throughout the period: return on assets and return on equity. We also include the median values of trade credit over assets. We use median values as they provide a more stable measure.

Table 4: Trade credit and the business cycle

	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
GDP growth (1995 prices)	2.3%	4.3%	2.7%	2.5%	3.5%	2.06%	2.0%
Median return on assets	5%	6%	7%	7%	8%	8%	8%
Median return on equity	21%	22%	24%	25%	25%	27%	25%
Median trade credit/assets	17%	13%	13%	14%	14%	14%	13%
Source OECD statistical compendium and FAME-BVD							

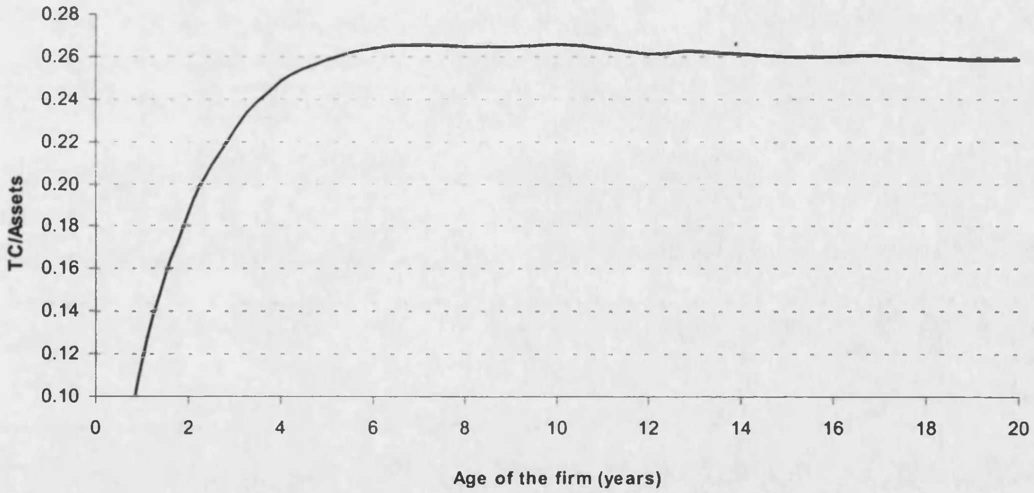
The years of our sample are relatively prosperous, with rates of GDP growth ranging from 2% to 4.3%. With the possible exception of 1998 there is no big downturn in production. Therefore it is not a very appropriate dataset to test the behaviour of trade credit in the presence of aggregate negative production shocks or monetary contractions. However on an individual basis we still have a sufficient amount of firms experiencing big expansions or contractions, so even though we will not explore the aggregate evolution of trade credit with respect to the different phases of the business cycle in Section 5.4 we will see how trade credit evolves with respect to the individual performance of each firm. The results show the differential behaviour of trade credit usage with respect to firm performance when we concentrate on healthy firms and firms that experience temporary problems. These are interesting results when trying to explain the aggregate behaviour of trade credit with respect to the business cycle and we will relate our results to the existing business cycle literature on trade credit whenever possible.

The remaining sections of the chapter are as follows. In Section 5.2 we relate the levels of trade credit taken to the age of new born firms; in Section 5.3 we relate measures of R&D intensity to both levels of trade credit taken and given; Section 5.4 explores the relationship between firm performance and trade credit taken; finally Section 5.5 investigates how trade credit relates to the levels of collateral and liquid assets available to customers.

5.2 Trade Credit and Age of the Firm

The model predicts that trade credit should grow as the links between the supplier and the customer grow. In the model this takes the form of a discrete jump that follows a stochastic process: the level of trade credit of a new born firm is zero up to a certain point in time, when the level of credit suddenly rises up to a level dI. In practice this is a process that may be gradual as the links between a supplier and a customer build up during long periods. To approximate this gradual process we use the model in Chapter 3 to simulate the levels of trade credit of a "representative" firm instead of using a single firm. We generate a sample of 5000 new-born firms that start using the startup technology and simulate their levels of trade credit according to the model. Then we take averages across firms with the same age to approximate the theoretical level of trade credit as a function of age. While for an individual firm this level will grow as a jump at certain points in time, for the representative firm this will be a gradual process. Figure 4 shows the average level of trade credit over assets of a population of firms that are all "born" at the same time. While the x axis represents the age of the firm, the y axis represents the average level of trade credit over assets.[53]

Figure 4: Simulated trade credit/assets vs age of the firm



This would correspond in practice to a link between the supplier that takes time to build. For example if the supplier and the customer get to know each other and there is a process of learning by doing that makes them gradually more productive in the first years of life of the customer's firm. Also, and closer to a

[53]The simulation is done for 5000 firms and 20 years, the parameters are $\gamma = 0.1$, $\alpha = 0.9$, $k = 0.5$, $\theta = 0.7$, $r = 0.15$, $R = 0.35$, $\beta = 0.85$, $\upsilon = 0.2$; $L = 0.05$.

strict interpretation of the model, if the product of the customer is not well defined at the beginning and the customer is trying to find the right specification for his production, while at the same time the supplier is producing intermediate goods that become more specific and closer to the final specification used in production at more mature stages.

To test empirically if this humped shape is actually present in our dataset we run a non-parametric regression which shows the non linear relationship between the level of trade credit over assets and the age of the firm. In particular we run a local linear regression since it is the non-parametric regression that has the best asymptotic properties for the studied problem. In essence the local linear smoother is a way to summarise a scatterplot graph into a non-parametric function.[54] The local linear regression substitutes each observation by a predicted one, taking n observations around each observation and solving the minimization programme:

$$\min \sum_{1}^{n} (Y_j - a - b(X_j - x))^2 K\left(\frac{x - X_j}{h_n}\right)$$

Where x is the value of the independent variable at the studied observation, Y_j X_j are the values of the dependent variable and independent variables of the observations around the studied one, and $K(\frac{x-X_j}{h_n})$ is a weight function that gives more importance to the observations that are closer to the studied one. So, in essence, each observation is substituted by the prediction of a regression that includes the n neighbouring observations. The solution to the minimisation problem is:

$$\hat{a} = \frac{\sum_1^n (w_j Y_j)}{\sum_1^n w_j}$$

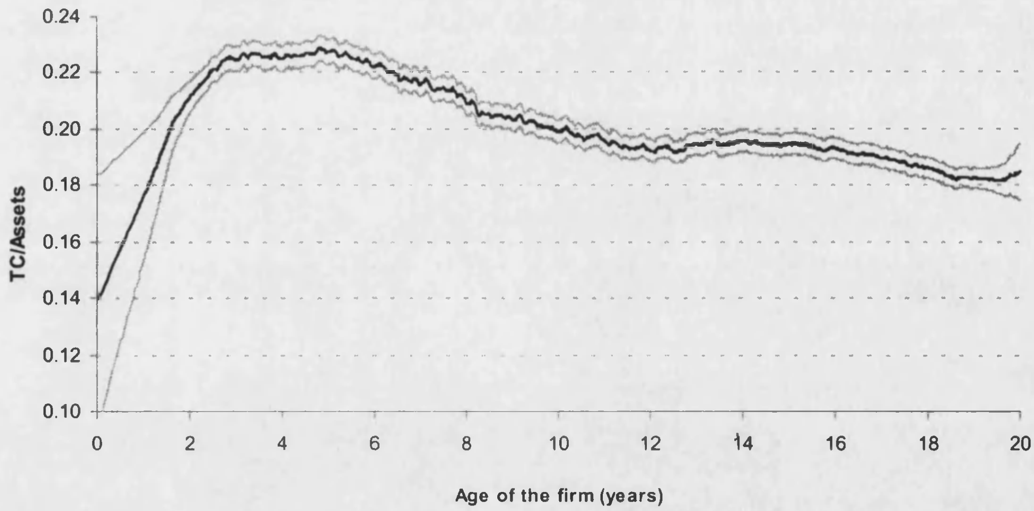
Being w_j a set of optimal weights derived from the optimization problem.

[54]See Fan (1992) for a thorough explanation of the local linear estimation.

This type of non-parametric estimation has the advantage with respect to other techniques like a Nadaraya-Watson estimator of being a consistent estimator even in the tails of the estimation and in the presence of frequency clustering among the data.[55] This is particularly important in our problem, where the results for the firms in the left tail of the estimation are particularly important. Also considering that the density of firms in different age intervals of our sample is not constant. Another advantage is that this method of estimation allows us to calculate the confidence interval for the regression that can be obtained after computing the standard deviation of the estimator.

In Figure 5 we see a local linear smoother for the whole sample, with the number of firms included in each estimation n=5000 and equal weights for each observation.[56]

Figure 5: Trade credit/assets vs age of the firm



(95% confidence interval)

[55]See Nadaraya (1964) and Watson (1964).

[56]The results of the estimation are robust to different choces of bandwith. n=5000 has a good balance betweent the flexibility of the estimator and its precision. A possible alternative would be to use the bandwith that minimises the distance of the estimator to a Cross Validation Function that is basically a kernel regression that excludes the actual datapoint estimated in each regression (see Yatchew ,1998).

As shown, the level of trade credit grows until the third year of the age of the firm, it stays at this maximum level until the fifth year, and then gradually goes down during the next periods. This is consistent with the prediction of the model. Customers do not receive much credit from their suppliers straight away, but it takes time to build up the link with their suppliers that is necessary for borrowing. So far, other empirical studies based on linear regressions found a negative relationship between trade credit and age. This corresponds in Figure 5 with the negative slope from the fifth year onwards. Our non-linear approach, allows us to also identify the initial increase of trade credit in the early years of a supplier-customer relationship.

Two features seem to make the results of Figure 5 slightly different to the one predicted by the simulation. In the first place the levels of trade credit of new-born firms are not zero. In the model, trade credit of a new-born firm is zero because trade credit is assumed to be completely unenforceable and there are no links between suppliers and customers. In reality trade credit is not completely unenforceable by law, so even if the levels of specificity of suppliers for new firms are low, there is still scope for credit. In addition, significant links between suppliers and customers may already be in place at the very beginning of their interaction; for example, if there are sunk costs or search costs associated with finding a supplier or if the customer already has a very detailed blueprint of the necessary intermediate goods, even at very early stages of the firm life. We will explore in more detail these purely technological links in Section 5.3 when we relate the levels of trade credit use to measures of technological intensity. Another reason why there is scope for positive levels of trade credit use for new-born firms is that it can be used as a transaction device. The second other main difference between our simulation and the results of the non-parametric regression is that the level of trade credit also seems to go down as the firms grow older after the fifth year. This means that trade credit is shrinking or at least that it is not growing at the same pace as the assets of the firm. By checking the evolution of other parts of the balance sheet with age we found that this decrease is mainly due to the growth in retained earnings that allows firms to substitute trade credit with cheaper sources of finance. It is also due to the fact that as firms get older their expected rate of investment goes down, so they no longer exhaust their borrowing capacity and they start reducing their most expensive loans (i.e. trade credit).

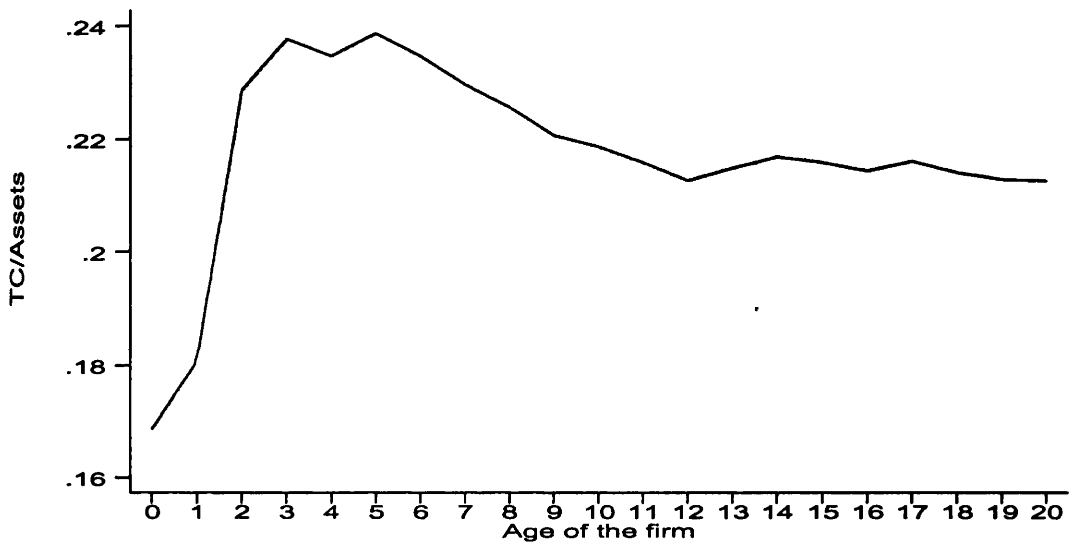
We also plot the 95% confidence interval for the estimation. The estimator is sufficiently significant to accept the hump shaped relationship between trade credit and age. The confidence interval is wider on both "tails" of the estimation. This is due to a lower number of observation used when we get closer to the tails, as there are less neighbouring observations on one side of the estimation than on the other. We can see this effect in the widening of the confidence interval on the right-hand side of the estimation.[57] The left-hand side of the figure also reflects that the density of firms at the lowest ages of the sample is lower.

The use of a local linear smoother has the advantage of a very flexible estimation of the non-linear structure of our problem. However, it has the major drawback of being a bivariant analysis that does not correct for the possible influence of other variables. The results may be due not only to the build up of a link between suppliers and customers, but may be driven by the existence of other variables such as size or the level of activity of the firm that are correlated with both age and trade credit. To make sure that this is not the case, we also show the results of spline regressions that are not as flexible as the local linear smoother, but allow us to control for other relevant variables. Spline regressions are just linear regressions in which a "spline" variable is constructed to estimate a non linear relationship

[57] While we could correct the effect on the right hand side by extending the sample and reporting only the first 20 years of age, this is not possible on the left hand side, as there are no firms with negative age.

as piecewise linear.[58] The results of this regression are shown in Figure 6. To generate it we use one spline for each year of age between zero and 20, and we control linearly for size, inventories, collateral levels, deposits and year dummies measured as in Section 5.5.

Figure 6: Trade credit/assets vs age of the firm (Spline)



The results are not qualitatively different to the ones shown in Figure 5. Again we see a rise of trade credit in the early years of life of a firm, that is now sharper in the second year than in the first one, and stabilises around the third to fifth year of age of the firm, leading to a substitution in the next years of trade credit by other sources of finance. One of the differences between the results in Figure 5 and the ones in Figure 6 is that in Figure 5 the main rise in trade credit happens in the second year of the firm life while in Figure 5 the rise is more monotonic since the first period. Part of the reason for this lies in the method of estimation itself, but some of it comes from the fact that in Figure 6 we are controlling by the size of the firm measured as the log of assets and by its level of activity measured as inventories over assets. In Figure 5 part of the big increase of the first period

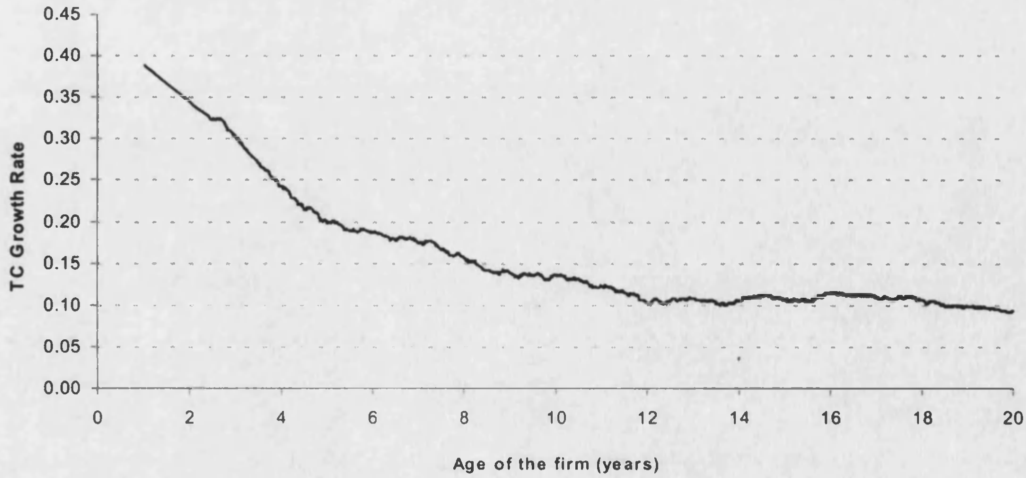
[58]See for example Suits et al (1978) for a review on spline regression and its applications in economics.

comes from the fact that firms are increasing activity and having losses on average in their first year of life, these effects are neutralized by the linear controls in the estimation of Figure 6.

Another potential source of a bad estimation of the function of trade credit as a function of firm age, would be if there were some kind of clustering of different types of firms at certain intervals of the sample, for example, if the youngest firms sampled were qualitatively different to the rest of the firms when they were founded. In principle, we do not have any a priori belief of this actually happening in our sample, however, given that each firm only appears a maximum of five consecutive years and does not cover the whole estimation interval we would like to have an estimator that corrects for any unobservable characteristics that are inherent to each firm.

The simplest way to perform this is to estimate a non-parametric regression of the change in trade credit (with respect to the level of trade credit of the previous year) vs firm age. This estimation would partly correct any additive "fixed effect" that a single firm might have, as long as it just changed the level of trade credit. Figure 7 shows the results of this estimation.

Figure 7: Trade credit growth rates vs age of the firm



As we can see the growth rate of trade credit starts at quite high rates in the first year of life of the firms in our sample, with average rates around 35-40% and then the rate of growth of trade credit falls, up to approximately the 12th year of age. This is again consistent with the formation of a relationship with the supplier of goods that takes time to build up. This early growth in trade credit is much higher than the equivalent growth of sales or assets of the firm. For example, while we estimate a change in trade credit of around 35% between the first and the second year of life of our firms, the equivalent rate of growth of assets over the same period is 3.2% and the rate of growth of sales is 24.6%.

In interpreting the results of the regression one has to pay more attention to the relative changes in the growth rate of trade credit than to the absolute values. Implicit in the estimation of the kernel regression, we are taking means of different growth rates. Given that there is a bound on how low growth rates can go, while the upside is unbounded, there is a bias towards over estimating the average growth rates of trade credit in the previous regression. Therefore, the stationary growth rate for trade credit may well be below 10%. These are growth rates for trade credit levels, and we are no longer estimating the evolution of the trade credit/assets ratio.[59]

Even though the time series interaction between trade credit and bank credit is not studied explicitly, the results of the previous regressions, and the implications of the basic model shed some light on the issue of whether trade credit and bank credit should be considered as substitutes or complementary to each other. While firms are financially constrained, extra levels of trade credit may allow firms to increase their available bank credit through higher collateral value. Similarly, higher levels

[59]Alternatively we could use a corrected Nadaraya Watson estimatior in which the bias would be avoided by taking geometric means instead of arithmetic means. Here we are running a set of OLS regressions and not taking means, so it is not obvious how to correct for this bias.

of bank credit may increase the purchases made to suppliers, increasing the size of the purchases made to customers and therefore the amount of available trade credit. Given that firms are constrained, we will see that trade credit and bank credit will behave as complementaries. However, if firms are not cash constrained typically bank and trade credit will behave as substitutes. Whenever a firm that uses both bank and trade credit has extra borrowing capacity with banks it will substitute some costly trade credit with cheaper bank credit.

Implicit in using the age of new born customer firms as a proxy for the level of specificity between them and their suppliers, we may be concentrating on types of specificity that grow slowly with time. This is particularly suitable for informational specificities (i.e. the process of getting to know your supplier and learning by doing). However there are processes, like patenting the production process for intermediate goods that may already be in place on the very first day of activity of the customer firm. To test also these kind of links we will see in the next section regressions that use R&D as a proxy for this kind of links.

5.3 Trade Credit and R&D Intensity

In the previous section, we have used the age of new born firms as a proxy for how tight the links between suppliers and customers may be. This works particularly well for links that take time to build, like knowing each other, building up a trust relationship or learning by doing. However, some technological links may already be in place when a firm is just created. For example the customer firm may need a type of input that has to be tailor made and the supplier may need to adjust its production processes to each customer. This type of situation is more likely to happen when the level of technological complexity of the goods produced is relatively high. We do not have a measure in our dataset of this technological intensity at a firm level, but there are series of research and development intensity at a sector level produced by the OECD.[60]

A priori, one should think that a higher level of R&D should be positively correlated with the level of technical specificity of the goods that a firm consumes. If the production of the firm is more complex in technological terms, the nature of its inputs should also be more complex, and therefore more likely to be very specific. Moreover, it is also the case that a firm with high levels of R&D will produce more specific inputs for its customers, so the level of specificity of their sales should also be higher.[61] Therefore in our regressions we will test if higher levels of R&D correspond with higher levels of trade credit both given and received. In Table 5 we show the results of fixed effects and random effects regressions where we regress the level of trade credit given and trade credit received over total assets as a function of three control variables and a measure of research and development intensity. The control variables are the size of the firm, measured as the logarithm of assets, the level of inventories of the firm as a proportion of assets and the level of collateral of each company as a proportion of their assets.

The measure of research and development intensity comes from the OECD statistical compendium at a sector level and is measured for all the manufacturing 2 digit SIC codes. The variable is only available from 1993 to 1995 so we restrict sample to manufacturing firms from 1993 to 1995. This leaves us with approximately 15000 observations. The OECD Research and Development Intensity Index ranges from 0.19% to 33.7%, corresponding 33.7% to the sector that has a higher intensity of research and development. The average intensity is 4.7% while the standard deviation of our R&D measure is 5.7% . The cross-sectional

[60]The index is a function of the proportion of R&D expenditure as a share of the added value of the sector.

[61]Although some firms may have very high levels of technological specificity without having high levels of research and develompment (i.e. if they buy a patent from someone else) we typically find that a higher level of R&D should be associated with productions that are technologically more intense. See Helper (1995), Sutton (1991) and (2000).

standard deviation is 7.5% and the time series standard deviation of the measure is 0.5%. We run both fixed effects and random effects regressions. The Haussman test again rejects the hypothesis of no correlation between the fixed effects and the regressors, so in theory we should concentrate on the fixed effects regressions only. However, given that most of the variation of our R&D measure comes from the cross-sectional side it is possible that the GLS estimator gives more consistent results, as it exploits both the cross-sectional and the time series variation of the sample.[62]

Table 5: Trade credit vs. research and development intensity

	Dependent Variable: Trade Credit Received/Assets		Dependent Variable: Trade Credit Given/Assets	
	Fixed Effects	GLS	Fixed Effects	GLS
Size	**0.059** (4.23)	**0.018** (12.94)	0.057 (1.61)	-0.003 (−1.51)
Inventories	**-0.36** (−4.57)	**-0.12** (−7.68)	-0.077 (−0.737)	**-0.08** (3.45)
Collateral	0.025 (0.36)	**0.103** (9.19)	-0.012 (−1.67)	**-0.20** (−11.55)
Liquid Assets	-0.0005 (−0.009)	**0.13** (7.37)	-0.071 (0.76)	**-0.25** (−8.48)
R&D	0.019 (1.32)	**0.002** (3.50)	-0.021 (−0.74)	**0.003** (2.32)

R&D intensity by sector (source OECD statistical compendium)
Number of obs = 15239   t-statistic in parenthesis
Bold number indicates significant at 95%
Hausman test rejects equality of coefficients in both regressions

[62] See Sections 5.1 and 4.2 for a more detailed explanation of how the variables are generated.

The results show how in the GLS regressions the levels of both trade credit given and trade credit received, are positively correlated with the levels of research and development of the different industries. The coefficients associated with the R&D variable are positive except for the fixed effects regression of trade credit as a proportion of total assets. The fixed effects regression gives a coefficient for the R&D variable that is not significant. This may be due, to a large extent, to lack of observations as we have a maximum of 3 year observation of the R&D variable. On the contrary the GLS coefficients are positive and statistically different to zero. Not only the coefficients are significant, but the values are quite big; moving for example from the 10th quantile (0.31% intensity) to the 90th quantile (12.16% intensity) would mean that trade credit given as a proportion of assets should grow by 3.5% and trade credit received by 2.3%. Which is a very important effect given the typical values of this variable. This shows how more technologically intensive industries tend to give and also receive higher levels of trade credit. In the lines of the theoretical model of Chapter 3 a higher level of technological intensity gives the suppliers more enforceability power over their customers, as the threat of stopping further supply of intermediate goods becomes more costly the more specific the intermediate goods supplied. Not only the enforceability power increases, but also the incentive to support customers that are experiencing temporary problems increases when intermediate goods are more specific.

There is already an important stream of literature that explores how the existence of financial constraints may restrict the possibilities for firms to do research and development.[63] Our results add a new dimension to the problem. We find a positive correlation between expenditures in research and development at a sector level and the average levels of trade credit used. On the one hand we can interpret

[63] See for example Himmelberg and Petersen (1994) for a good review of the literature on R&D and finacial constraints.

this result in the lines of our model. Higher levels of R&D mean a higher degree of specificity of the goods produced and also of the inputs demanded. So we can think that if high R&D expenditures may lead to tighter links with the firm suppliers they will therefore ease the financial constraints of the firm. On the other hand, we may just be observing the fact that firms with high R&D expenditure need a lot of funding for their long-term investments, and therefore they exhaust all their available borrowing sources, including trade credit. There is however some evidence that reinforces our interpretation of R&D being a good proxy for the level of specificity of inputs; the fact that not only trade credit taken but also trade credit given grow with R&D intensity is consistent with the interpretation of this effect as the result of higher product specificity, while it does not have a clear interpretation in the pure financial constraints literature.

Another fact that may actually be reducing the significance of our estimation is that when a supply contract in a technologically intensive industry is signed, it quite often comes attached to a finance deal in which the supplier commits to supply finance to the customer. This is actually good news for our theory, as this common strategy shows how tight technological links give rise to a financial relationship between suppliers and customers. However it poses an extra difficulty for the estimation of this effect, because some of these deals are not instrumented by using trade credit but other types of debt. For example the French telecoms manufacturer Alcatel has references on its yearly accounts of several deals that involved both supply deals and finance. For example this is a statement in the annual report of Alcatel. *"Alcatel has also implemented mechanisms to support certain customers at a financial level through flexible credit systems before the bank system takes over financing".*[64] As part of these support schemes itself offered financial support to its Brazilian partner *Intelig* in order to foster a deal that

[64] Alcatel business highlights year 2000 page 27.

made *Intelig* choose *Alcatel* as its main supplier for the system of its long distance call network. Not only we can see the correlation between strong technological links and extra finance. but the financial help of suppliers to customers in trouble can also be seen in this context. *"A subsidiary of Alcatel, the French telecoms equipment manufacturer, has offered a Dollars 25m credit facility to debt-ridden Thai provincial operator Thai Telephone"... "[Alcatel] had proposed the facility to help TT&T expand its internet services".*[65] The problem is that even though all these situations seem to support our hypotheses, they would not show up in balance sheet data as trade credit because they were instrumented using long-term debt and credit lines.

The equivalent industry wide situation gets summarised quite well in an article of the Economist on how telecommunication hardware suppliers offer significant loans to customers that decide to adopt a certain network standard of the third generation mobile phone technology. *"[Telecommunication] equipment makers such as Nokia, Ericson and Alcatel, lend money to network operators that buy their equipment. [...]some vendors are now lending as much as 200% the cost of hardware purchased, thus providing the operators with working capital that they are unable to raise from banks and public markets".*[66] Adopting a certain network standard in the telecoms industry guarantees a future flow of orders (extra purchases, maintenance, technical advice etc) to the hardware provider that is to a large extent supplier specific.

5.4 Trade Credit and Firm Performance

We have shown how tighter links between suppliers and customers lead to higher levels of trade credit between them. The main explanation for this is the extra

[65] Financial Times 23rd March 2000.
[66] Economist May 3rd 2001.

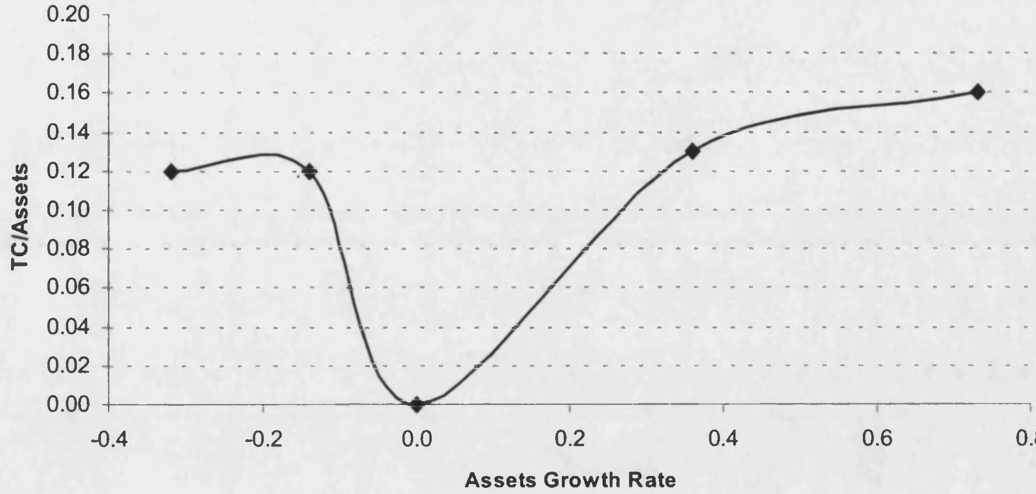
enforceability power that a supplier has if its supply of intermediate goods is costly to substitute.

Our model also predicts that when the links between suppliers and customers are strong, suppliers will have an incentive to give financial help to their customers that experience temporary liquidity shocks. This again predicts higher levels of trade credit when the relationship surplus between the buyer and the seller is big, so it is consistent with our previous result, but we can think about more detailed ways to test if this financial support is present in reality.

The high cost of trade credit induces customers to use it as a financial instrument only when other forms of finance are scarce. We expect that when firms are growing fast and undertaking new investments trade credit should grow, just because other forms of finance may not be available. We also expect that when customers experience problems they will decide to finance a higher proportion of their purchase on trade credit and also will use late payment as a way to increase the amount of finance that they receive from their suppliers. Suppliers will be willing to finance their customers in trouble as long as the value of their relationship with them is higher than the cost of bailing them out. These two effects imply that we would expect a "U" shaped distribution of the relative levels of trade credit with respect to a "performance measure". The firms that are doing best and the ones suffering slight problems should be the ones that borrow more from their suppliers.

We can show how our model predicts how the expected level of trade credit over assets should be with respect to the expected growth rate of the assets of the customer. In the model (if we position ourselves in the interim stage when the existence of the liquidity shock has already been realised) for a given set of parameters we have five possible expected growth rates and five levels of trade credit over assets. This generates a diagram like Figure 8 with five points in the trade credit/assets vs asset growth space. These points correspond from right to left to firms that use the specific technology for the first time and are not hit by the liquidity shock, firms that are using the specific technology and are not hit by the liquidity shock, firms that use generic technology, firms that are using the specific technology and are hit by the liquidity shock and finally firms that use specific technology for the first time and are hit by the liquidity shock.[67]

Figure 8: Predicted trade credit/assets vs growth rate of the firm



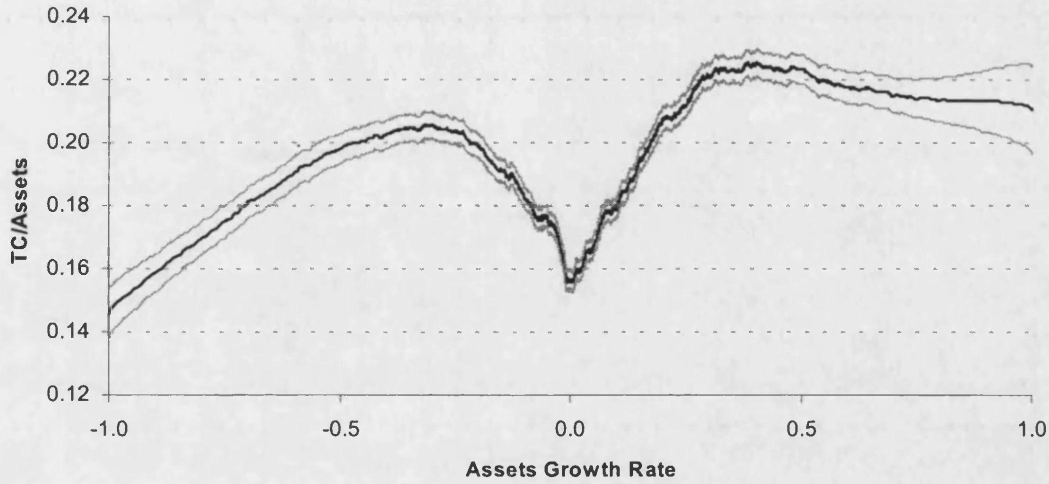
It is also possible to get a continuous set of points by simulating different populations of firms. In any case we will always find a "U" shaped relationship between trade credit and asset growth rates. Firms with the highest growth rates and firms experiencing liquidity shocks and expecting low growth rates are the ones that should use trade credit more extensively. To check if this relationship holds in reality, we run a local linear smoother on our sample of firms. We smooth

[67]Given that we are using annual data, it is difficult to distinguish between transitory liquidity shocks and permanent production shocks. However, it seems quite reasonable to assume a certain positive correlation between them. This positive correlation is implicitly assumed in the technology structure of the model and used in this section.

the level of trade credit over assets on the growth rate of the assets of the firms in the sample to see if the predicted U-shaped relationship is confirmed by the data.

Firms that have no activity have little or no trade credit (they do not purchase anything) and also have growth rates that are close to zero. For this reason we have not included in the estimation firms that declare to be dormant, firms that are pure asset holders, declare zero sales or post exactly the same balance sheet for two consecutive years. These are firms with zero (or close to zero) growth rates and very low levels of trade credit that could artificially drive the results. This estimation is shown in Figure 9, a 95% confidence interval is also plotted.

Figure 9: Trade credit/assets vs growth rate of the firm



(95% confidence interval)

The results show how trade credit is highest for the firms that grow at a higher pace. This is consistent with the fact that trade credit is relatively expensive and firms use it only when they need to use all their borrowing capacity and have exhausted other available sources of finance (i.e. when they experience high growth rates). Also, new-born firms are the ones with higher levels of growth and higher levels of trade credit, as seen in Section 5.2. The average borrowing capacity limit seems to be around 22%, while the minimum average borrowing level is around 14%. Note that these levels seem to coincide with the ones of Figure 5. This does not mean that these are the minimum and maximum levels for any individual firm but only shows what is the typical range of trade credit use as a proportion over total assets.

The most interesting feature of the results in Figure 9 is on the left-hand side, where we can see that firms that experience slight problems (small-medium negative growth rates up to -30%) seem to have relatively high levels of trade credit when compared with firms that have low growth rates. This means that suppliers still lend to these firms that are suffering problems, so trade credit grows or at least does not shrink at the same rate as assets do. This is evidence in favour of suppliers seen as lenders of last resort. The help that suppliers provide to their customers is probably not given by a monetary transfer, but most likely by accepting late payment of already extended debts and supplying more intermediate goods on credit. However, suppliers do not seem to give extra finance to firms that experience serious problems (i.e. firms that halve their assets or worse) in the far left-hand side of the figure. For these firms, trade credit decreases even more than assets, so there is a reduction of trade credit over assets for firms experiencing strong problems that comes from the supply side of it. This can be explained within our model by a liquidity shock that is too big to be paid by suppliers. Or in other words a shock that violates Assumption 7. Finally, firms in the middle range (zero growth and small positive growth rates) have relatively low levels of trade credit.[68] In the model this is justified because these are unsuccessful firms with low links with their suppliers. In practice, other complementary reasons may also be causing this slump. First, low growth firms may have lower finance needs, so they

[68] Wilner (1995) also finds a U-shaped relationship between the levels of trade credit used and different performance measures.

use cheaper ways of finance than trade credit. Second, firms that are not growing much may be buying relatively low levels of intermediate goods, thus making it more difficult for them to have high levels of trade credit.[69]

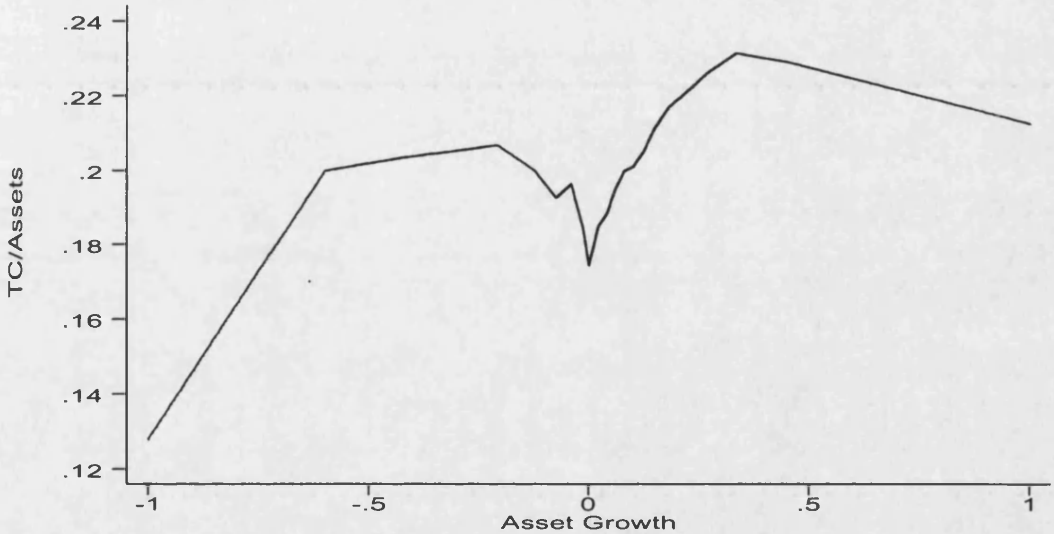
Some authors have considered that trade credit could be used as a lead indicator for the business cycle. The general result of most of the previous literature is that when we measure trade credit as a proportion of the firm's assets, it tends to be highly procyclical, with peaks that slightly lead the cycle. This is an interesting result if we want to use the evolution of trade credit levels as a predictor of business cycle changes. Moreover, by observing Figure 9, we can see that the real power of the levels of trade credit over assets ratio as a predictor, not only comes from observing the aggregate evolution of it, but also from the different use that healthy firms and the ones that experience problems make of it. In a change from and expansion period towards a downturn, most of the firms of the economy will move from the right-hand side of Figure 9 to the middle zone of it. If the economy changes from periods of low growth to an expansion, the movement of most firms will be exactly the opposite. This explains why on aggregate the trade credit over assets ratio tend to behave procyclically. But at the same time, the firms that are entering negative growth rates experience the opposite evolution. For these firms, trade credit grows in recessions and shrinks in expansions. This second group of firms may represent a minority in most economies, therefore on aggregate the effect on "healthy" firms dominates. However to extract all the possible information to predict economic activity from the use of trade credit one has to take into account not only the evolution of the total use of trade credit, but also how it changes across different groups of firms (healthy-financially distressed, constrained-

[69]It is still puzzling why suppliers normally restrict their lending to their customers to trade credit, or in other words, why can't trade credit be above the level of inputs purchased? So far only models based on liquidation rights seem to have a clear explanation for this. However there are exceptions in which suppliers top up their trade credit with additional lending to their customers.

unconstrained).[70]

Again, one could be worried about the bivariant nature of our previous estimation. We would like to know if the results of our non linear estimation also hold after controlling for other variables. To see if our results are biased because we do not control for other variables, we also show the results of spline regressions that has other linear regressors. For Figure 10 we use a spline regression on asset growth rate where each spline represents 5% of the total sample, and we control for size, inventories, collateral levels, deposits and firm dummies.[71]

Figure 10: Trade credit/assets vs asset growth rate (Spline)



The results of Figure 10 do not differ from the ones obtained in Figure 9. The firms that use trade credit more extensively seem to be the ones that are growing at a very fast pace, but also the ones that are experiencing temporary problems. This result again points in the direction of suppliers bailing out their customers

[70]The fact that trade credit also leads the cycle is consistent with the literature on working capital and inventories (see for example Caggese 2000).

[71]To allow for extra flexibility of the estimation we have split the first left hand side spline in two, so each one represents 2.5% of the sample.

in need of extra finance, especially in periods of financial distress. Note that the levels of trade credit over assets also go down in this regression for the worst firms of the sample, (i.e. the ones with negative growth rates of -30% or worse), so suppliers are able to recover their debts even faster than the rate at which assets are shrinking. As a whole the results of this regression confirm the ones in Figure 9.

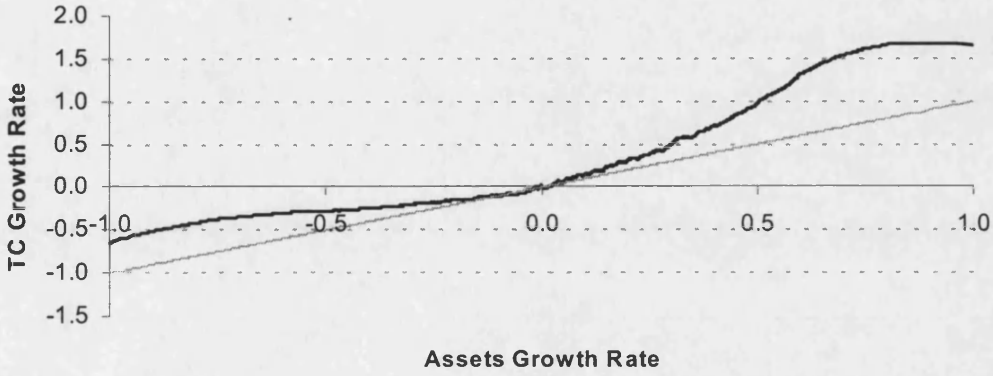
Given that each spline represents 5% of the sample, one can also infer the density of firms for each of the possible asset growth rates combination. Most of them concentrate in the middle part of the figure, with 90% of the sample within growth rates of -20% and 40%.[72]

We would also like to correct for any type of composition effects that could be present in our sample. In this case the problem of having a firm fixed effect would be less important than in the regression of trade credit vs age of the firm, because even though we may have this fixed effect, the different observations of a single firm may be distributed over the whole support of our estimation, so it is quite likely that the different fixed effects would cancel each other. In any case we run again a regression in which we regress the growth rates of trade credit (absolute growth rates of trade credit with respect to the previous year and not the growth rate of any ratio) against the asset growth rates of the firm. The results are reported in Figure 11.

If firms were trying to have a constant ratio of trade credit over assets, and the adjustment rates were sufficiently fast, then the growth rates of trade credit should coincide with the assets growth rates. A 45% line is also plotted in grey to serve as a guide to compare the growth rates of trade credit with the ones that we would find if there was a "target ratio" of trade credit over assets.

[72]Again, for this regression we did not include the firms that are dormant or inactive, or the ones with zero sales.

Figure 11: Trade credit growth rates vs asset growth rates



The results show how the trade credit growth rates are higher than the assets growth rates for firms that are growing fast, while trade credit levels seem to go down at a slower pace than assets for firms that are experiencing negative growth rates. The slow decrease of trade credit in firms with negative growth rates could be interpreted as trade credit simply not being paid back even if suppliers want to reduce it. This effect is surely present in reality. Suppliers, as any other type of lender, are sometimes not able to recover their debts from firms that show problems. However, two facts seem to indicate that this is not the only cause of the increase of trade credit for firms in financial distress. On the one hand, firms experiencing negative growth rates still have positive levels of purchases from their customers, if suppliers are selling either on credit or even on cash to these customers, they are effectively bailing them out by allowing for late payment of already issued debts and maybe issuing more debt. On the other hand we can see in Figures 9 to 11 that when firms experience even lower growth rates, trade credit actually shrinks both in relative and absolute values, so suppliers are able to foresee the high negative growth rates of their customers and reclaim their trade credit issued.

Again, one has to be aware of a certain "upward" bias to over estimate the growth rates of trade credit using a non-parametric regression. When taking arithmetic averages over growth rates the resulting average tends to be higher than the equivalent geometric average that would be closer to the "representative agent" growth rate. However it is not possible to adapt the non-parametric regression to correct for this bias.

So far throughout this section, we have used the rate of growth of assets as a measure of firm performance. We would also like to check whether this "U" shaped relationship between trade credit and firm performance also holds when we use alternative measures of firm performance such as the change in the firm sales. In Figure 12 we show the results of a local linear regression that relates the levels of trade credit over assets, as a function of the change in the firms sales. One of the reasons for using asset growth rates and not sales growth rate as our main performance measure is that in our sample, out of nearly 250000 observations reporting the level of assets of the firm, we only have 109000 that report also their level of sales. Furthermore, to calculate the change in the sales figure with respect to the previous year, we have to also lose one observation per firm and also the information of any observations that are not present on two consecutive years, leaving us with less than 60000 observations.

Figure 12: Trade credit/assets vs change in sales

(95% confidence interval)

As we can see, the U shaped relationship between trade credit and firm performance also holds when we use the change in sales from the previous year level as a measure of firm performance. In the middle part of the estimation, for sales growth rates between -0.5 and 0.5, we can see again how suppliers are financing the customers that are doing particularly well, and also bailing out those experiencing temporary problems. Firms with zero or low growth rates have levels of trade credit over assets of about 19%, while firms that have sales growing at a 30% rate have a predicted level of trade credit over assets of 22%. Also we see a very marked "financial support" effect, with firms whose sales decrease at a 50% rate having predicted levels of trade credit over assets of about 23%. Again on the far left-hand side of the picture, we see how firms experiencing serious viability problems (growth rates below -50%) have to reduce dramatically their levels of borrowing from suppliers.

However the results on the far right side of the picture seem a bit paradoxical. Namely that firms which have sales growing faster than 50% a year, do not seem to be financed that much by their suppliers. This set of firms represent a small part of the sample, as 92% of the sample lies within levels of change in sales between -50% growth and 50% growth rates. In fact only 4% of the sample had changes in sales of more than 50% growth.

To investigate more into this subset of firms we can see what type of firms typically fall in this category. Checking for example the average return of assets for the firms in our sample, we can see that the median unconditional level of return on assets is 7% for the whole sample. However, for the firms with growth in sales over 50% this median is just 5%. Moreover, the median return on assets in the previous year for this same subset of firms is just 4%. With respect to sales, the medial level of sales over assets for the whole sample is 1.97, for the firms with sales growth rates over 50% this level is 215 and these firms come from a median level of sales over assets of 0.97. We can see a summary of these results in Table 6.

Table 6: Firms with sales growth rates > 0.5

	profits / assets (median)	sales / assets (median)
Total sample	7%	197%
Firms with growth in sales > 0.5	5%	215%
Firms with growth in sales > 0.5 (previous year)	4%	97%

This shows that most of the firms that achieve increases in sales of more than 50% are actually recuperating from relatively low levels of sales, and therefore it may be that either their financial needs are not very important or that they are not perceived as sufficiently creditworthy by either banks or their suppliers.

Another interesting feature of Figure 12 when compared with our non linear regressions with the assets growth rates (see Figure 9) is that the "financial support" effect on the left-hand side of the picture seems to be much more important in the "sales" regression than in the "assets" regression, while the opposite seems to happen with the effect on the right-hand side of the figure. This is interesting when we relate it to the business cycle literature regarding trade credit. The typical results of this literature are that measures overall levels of trade credit or ratios of trade credit over assets seem to be strongly procyclical, (see for example Nilsen ,1999 or Calomiris, Himmelberg and Wachtel, 1995) however, when trade credit is measured as a proportion of firms sales, the result seems to be that it behaves in a countercyclical way (see for example Hernandez and Hernando, 1999). This apparent paradox can only be solved if firms on aggregate use more trade credit over sales in contractions and less trade credit over sales in expansions, but this effect is reversed when we measure overall trade credit or trade credit over assets because the change in sales offsets the increase-decrease in the proportion of trade credit used. This seems to be consistent with our results in Figures 9 to 12. We see that firms use more trade credit, both when they are experiencing an expansion or a contraction in demand. However, the size of both effects depends on whether we measure the performance of the firm as change in sales or change in assets.

5.5 Collateral and Liquid Assets

In this section we analyse the effects of collateral and liquid assets on trade credit, while controlling for other relevant variables. There are two main effects that we would like to explore with this analysis. On the one hand we want to know what is the relationship between the levels of collateral and the proportion of trade credit over total debt. In our model all bank credit is fully collateralised while trade credit corresponds to risky and completely unsecured debts. In practice, this absolute dichotomy need not be true; part of bank lending is not secured by collateral and trade creditors can sometimes claim the goods supplied by them in case of default. However we can check how the proportion between trade credit and other forms of debt evolves as firms have more or less collateral, to assess whether the modelling assumption is reasonable. On the other hand we want to check if the levels of trade credit rise when firms experience liquidity shocks. To do so we use the level of cash and deposits that the firm has as a way of measuring the liquidity needs of the firm. *A priori* we expect that a firm will use less trade credit the higher the level of cash and deposits. However there are deficiencies of this proxy given that we are using yearly balance sheets. Firms with low levels of deposits may be experiencing a liquidity shock, but they could also be firms that have lower needs of working capital for reasons unrelated to unexpected liquidity shocks. Ideally we would like to use higher frequency data and identify sudden drops in the levels of deposits to test the impact of liquidity shocks on trade credit levels.

We first run standard panel data regressions (fixed effects and random effects regression (GLS)) in which the dependent variable is the proportion of trade credit over total debt (including trade credit). The fixed effects estimator should control for any heterogeneity at a firm level that shifts in an additive way the use of trade credit. Trade credit terms are very stable along time within an industry and also at a firm level so we may expect a lot of inertia in trade credit use. In particular this may generate a lot of autocorrelation of our trade credit variable. So we may want to include a lagged dependent variable in our regressions to control for the existence of first order autocorrelation. To do so, we run the Arellano-Bond estimator (GMM) that allows us to estimate a fixed effect regression that also includes a lagged dependent variable. The Arellano-Bond estimator uses a instrumental variable GMM procedure to avoid the problems of endogeneity associated with using a fixed effects estimator when a lagged dependent variable is included in the estimation.[73]

[73]The Arellano-Bond estimator allows for the unbiased and consistent estimation of the coefficients of a model of the type $y_{it} = \delta y_{it-1} + \beta x_{it} + \varepsilon_{it} + \delta_i$ where ε_{it} is a standard error term and δ_i is an individual error term, by taking first differences and using lagged dependent variables (in first diffferences also) as instruments. See Arellano and Bond (1991).

The independent variables are four control variables and two variables of interest. The log of the assets of the firm (in thousand pounds) is used as a control variable to correct for the *size* of the firm. The proportion of *inventories* that the firm holds over assets reflects the level of activity of the firm. Another possibility could be to use the level of sales, unfortunately many firms in the sample do not report their level of sales, and this is particularly true for the smaller firms of the sample. The level of *inventories* over assets allows us to control for the level of activity of both big and small firms. We also include as control variables year dummies, the *age* of the firms in years and their *asset growth rate* to have a measure of firm performance. We do not report the results of these two last variables as we have already done a more detailed analysis in the last two sections. Our variables of interest are the amount of tangible assets (land, buildings, machinery, vehicles, etc.) over total assets as a measure of the level of *collateral*. We also include the proportion of cash and deposits over total assets that the firm has as a measure of the *liquid assets* of the firm, to account for the liquidity needs of the firm. We report the results of these regressions in Table 7.[74]

[74] The Haussman test rejected the equality of coefficients in both regressions, so we should consider the fixed effects regression and the Arellano-Bond estimator as the only unbiased estimation of the coefficients. However, we find it useful to show the GLS regression to see the interaction between the time series and the cross-sectional side of our data.

Table 7: Collateral and liquidity: Main specification
Panel Data Regressions

	Dependent Variable: Trade Credit/Total Debt		
	Fixed Effects	GLS	GMM
(Trade Credit/Total Debt)$_{t-1}$	-	-	**0.437** (48.85)
Size	**-0.021** (−8.82)	**-0.029** (−35.19)	**-0.103** (−3.22)
Inventories	**0.237** (26.64)	**0.166** (25.82)	**0.127** (9.55)
Collateral	**-0.116** (−14.37)	**-0.108** (−19.48)	**-0.148** (−11.46)
Liquid Assets	**0.138** (19.84)	**0.205** (34.41)	**0.087** (7.53)

+ year dummies, asset growth rates and age (not reported)
t-statistic in parenthesis (z-statistic for GMM)
Bold number indicates significant at 99%
Hausman test rejects equality of coefficients in both regressions

The results in Table 7 show that the prediction of the model with respect to the effect of the level of collateral is confirmed by the data. When firms have a higher level of collateral they use a lower proportion of trade credit and higher proportions of bank credit and other forms of finance. The coefficients associated with collateral are important also in quantitative terms; moving from the 10th percentile to the 90th percentile of the collateral over assets variable would mean a decrease of the level of trade credit over total debt of 6%. This supports our results where bank credit is highly related to collateral while trade credit corresponds to unsecured debts. In the UK the effective level of collateral attached to trade credit is very low, suppliers are very rarely able to reclaim the goods delivered in case of default and the recovery rates in case of liquidation are also very low.[75]

The coefficient of lagged trade credit over total debt on the current ratio of trade credit over total debt in the GMM regression is 0.43, showing that there is a strong autocorrelation of trade credit across periods.

Surprisingly, the level of trade credit over total debt seems to grow with the level of deposits. This seems to go against the idea of firms using more trade credit when they experience liquidity shocks.[76] A possible explanation for this correlation is related to the transactions role of trade credit. Firms with higher rotation in sales and the ones that use higher levels of intermediate goods need to use higher levels of trade credit, cash and deposits for transaction motives. This can induce a positive correlation between deposits and trade credit use. Also the annual frequency of the data is not ideal to capture temporary liquidity shocks and we are more likely to capture the cross-sectional correlation between trade credit and deposits. The fact that the coefficient is much higher and more significant in the GLS regression than in the fixed effects regression seems to point in this direction, indicating that the cross-sectional relationship is quite strong and positive so firms with higher average levels of deposits also have higher average use of trade credit. A complementary explanation of this positive correlation is that not only trade credit but also other forms of short-term lending, especially short-term bank lending in the form of overdrafts and lines of credit, grow when firms experience liquidity shocks. So it is possible that the effect of a liquidity shock on the trade credit/total debt ratio was negative even though the levels of trade credit could increase.

To avoid this possible conmovement of short-term trade credit and other debt instruments when firms experience liquidity shocks, we can use an alternative

[75]See for example Franks and Sussman (1999)

[76]Deloof and Jegers (1999) and Nilsen (1999) also find that firms with more cash use trade credit more intensively.

dependent variable. In particular we can regress the level of trade credit over assets on the same variables that we used before. Table 8 shows the results of these regressions.

Table 8: Collateral and liquidity: Main specification II
Panel Data Regressions

	Dependent Variable: Trade Credit/Assets		
	Fixed Effects	GLS	GMM
(Trade Credit/Assets)$_{t-1}$	-	-	**0.468** (31.89)
Size	**0.009** (8.39)	**-0.0013** (−29.72)	**0.024** (11.50)
Inventories	**0.201** (46.95)	**0.173** (51.81)	**0.116** (13.69)
Collateral	**-0.023** (−5.87)	**-0.052** (−18.16)	**-0.030** (−4.71)
Liquid Assets	**-0.040** (−12.01)	**-0.067** (−22.65)	**-0.026** (−4.08)

+ year dummies, asset growth rates and age (not reported)
t-statistic in parenthesis (z-statistic for GMM)
Bold number indicates significant at 99%
Hausman test rejects equality of coefficients in both regressions

Now the prediction of the model with respect to the level of deposits is confirmed. Buyers use more trade credit when they are more liquidity constrained. This seems an obvious strategy. given the high cost associated with getting credit from your suppliers. The traditional wisdom of "pay late, get paid early" does not seem to be optimal when one takes into account that the early payment discounts are in general very generous. Again higher levels of collateral are associated with a lower proportion of trade credit and higher proportions of bank credit and other forms of finance. Moving from the 10th percentile to the 90th percentile of the collateral over assets variable would mean a decrease on trade credit over assets of 2%. Note that while the model predicts that the proportion of trade credit over total debt should decrease with the proportion of collateral, the predictions of the model regarding the levels of trade credit over assets are ambiguous, since the composition effect of a lower proportion of trade credit/debt could be compensated by a higher level of leverage. However, the two regressions point in the same direction. Again the GMM estimation shows how there is a very strong autocorrelation of trade credit through different periods.

In both the fixed effects regressions and the GMM specification, the coefficient associated with the proportion of inventories is positive and highly significant (both for trade credit over total debt and trade credit over assets). In the GLS regressions the coefficient becomes smaller and in fact, in the between groups regressions (not reported) the associated coefficient was not statistically significant and even negative. This means that there is a strong positive correlation between trade credit and the level of inventories in the time series perspective of the sample, but not when we run a cross-sectional regression such as the between groups regression that is basically a means regression. This positive correlation may be related to the movement of both variables with the level of activity of the firm. Also some theories based on the relative advantage of suppliers in liquidating customers imply the existence of a positive correlation between inventories and trade credit. However, according to these theories, the correlation should be strong both in the cross section and time series while we only find a strong relationship along time.[77]

[77] Frank and Maksimovic (1999) assume that suppliers have an advantage in reselling the intermediate goods reclaimed after a liquidation procedure.

To better understand the relationship between trade credit and liquid assets we can run a regression in which we concentrate on a subsample of firms that are experiencing liquidity shocks and have little access to other alternative sources of finance. We want to isolate the fact that suppliers may help their customers in need of extra finance, when these customers have no other alternative source of finance. By concentrating on this subsample, we are eliminating two other effects that potentially could blur this "financial support" effect.

In the first place, firms that are experiencing high growth rates have higher requirements of inventories, trade credit and liquid assets from a purely transactional motive. This fact, that was identified by Nilsen (1999) for the first time can induce a positive correlation between trade credit and liquid assets that has nothing to do with the idea of supplier helping their customers in trouble. Secondly, firms that experience negative shocks may have other sources of extra finance alternative to trade credit. If firms have tight relationships with banks or access to issue commercial paper they may use these cheaper alternatives before using their suppliers as lenders of last resort.

In Table 9 we run again fixed effects and random effects regressions with the dependent variable being the level of trade credit over assets and the level of trade credit over total debt, but now we do it on a subsample of small firms that experience losses in a particular period. Small firms are defined as firms with assets below £1 million which represent roughly the lowest quartile of our sample. By restricting ourselves to the smaller firms of the sample, we are using the firms that should have more difficulties in accessing extra bank credit and financial markets. We start again showing the fixed effects, random effects and Arellano-Bond regressions where the dependent variable is trade credit divided by total debt.

Table 9: Collateral and liquidity: Small firms with negative profit
Panel Data Regressions
Robustness Check

	Dependent Variable: Trade Credit/Total Debt		
	Fixed Effects	GLS	GMM
$(\text{Trade Credit/Assets})_{t-1}$	-	-	0.124 (1.14)
Size	**0.051** (2.96)	**-0.034** (−4.40)	-0.006 (1.17)
Inventories	0.025 (0.45)	0.038 (1.49)	0.034 (0.63)
Collateral	**-0.229** (−3.92)	**-0.164** (−6.14)	-0.090 (−1.24)
Liquid Assets	0.027 (0.48)	0.075 (2.30)	0.002 (0.03)

+ year dummies, asset growth rates and age (not reported)
t-statistic in parenthesis (z-statistic for GMM)
Bold number indicates significant at 99%
Hausman test rejects equality of coefficients in both regressions

Again one might be worried about the co-movement of bank credit and trade credit when firms experience financial distress, so in Table 10 we present the same type of regressions, but using as a dependent variable the level of trade credit over total assets.

Table 10: Collateral and Liquidity: Small firms with negative profit II
Panel Data Regressions
Robustness Check

	Dependent Variable: Trade Credit/Assets		
	Fixed Effects	GLS	GMM
$(\text{Trade Credit/Assets})_{t-1}$	-	-	0.030 (0.17)
Size	0.033 (2.21)	**-0.063** (−9.79)	**-0.074** (−2.56)
Inventories	0.034 (0.690)	0.050 (2.39)	-0.028 (0.51)
Collateral	-0.126 (−2.42)	**-0.172** (−7.85)	-0.134 (1.34)
Liquid Assets	**-0.201** (−4.12)	**-0.228** (−8.36)	**-0.288** (2.80)

+ year dummies, asset growth rates and age (not reported)
t-statistic in parenthesis (z-statistic for GMM)
Bold number indicates significant at 99%
Hausman test rejects equality of coefficients in both regressions

As we can see the results confirm our prediction. When restricting ourselves to firms that are experiencing problems and have little access to financial markets, the negative effect of liquid assets on trade credit of Table 10 is emphasized, while the positive effect on trade credit over total debt of Table 9, although still positive, becomes not significant. When we use the whole sample, the effect of suppliers as insurance providers, coexists with the use of other forms of finance in periods of financial distress and also with extensive use of both trade credit and liquid assets when firms grow very fast. By restricting ourselves to firms with negative profits and low access to alternative forms of finance, we can get a clearer estimation of the role of suppliers as lenders of last resort when the levels of liquid assets are low.

In both Table 9 and 10 the GMM Arellano-Bond estimation presents coefficients that are not very significant. This is, to a large extent, due to the lack of observations. To calculate the Arellano-Bond estimator, it is necessary to have at least 3 consecutive sample observations per individual to have a valid observation to estimate. This is due to the fact that the estimation procedure starts by first taking differences of all the variables and then uses as instruments lagged dependent variables. Given that we are restricting ourselves to small firms with losses, the amount of valid observations drops below 600 with an average of "valid" periods per individual of 1.3, meaning that for most of the observations in this subsample we just have 3 consecutive observation years. The loss of valid observations is so large that not even the strong positive autocorrelation of trade credit survives in the estimation. However we still report the regressions for consistency with the rest of the chapter.

Note also that the collateral constraints seem to be higher for this subsample of firms, being that the coefficients associated to the variable collateral are higher both in the regressions of trade credit over total debt and trade credit over assets. Higher levels of collateral correspond to even lower levels of trade credit in both dimensions.

In the theoretical model of Chapter 3 firms raise funds up to their borrowing limit, thus having no free collateral and no scope to get any extra funds. However in reality, firms have a target investment level that in many cases is below their borrowing limit. We can think that a measure of the extra bank borrowing capacity could be the level of free collateral, measured as collateral minus the level of total long-term borrowing and short-term bank borrowing as these are the types of borrowing that are mostly backed with collateral. While in aggregate terms, the level of bank borrowing of firms is very close to the total level of collateral available, at a firm level the amount of free collateral is much more variable. In Table 11 we substitute the measure of collateral by a measure of free collateral. The construction of this measure is as follows. First we calculate the amount of collateral minus short-term bank loans and long-term total loans. Then we calculate the ratio of this difference over total assets. Finally we substitute by zero any observation that has a negative value on this ratio. That is, we consider that the level of free collateral over assets is zero, whenever the level of debt exceeds the total level of collateral.[78]

[78] The results are not qualitatively different if we allow for negative values of the measure.

Table 11: Free collateral and liquidity
Panel Data Regression
Robustness Check

	Dependent Variable: Trade Credit/Total Debt		
	Fixed Effects	GLS	GMM
$(\text{Trade Credit/Assets})_{t-1}$	-	-	**0.403** (46.69)
Size	**0.011** (7.28)	**-0.016** (-23.57)	0.006 (2.13)
Inventories	**0.215** (33.16)	**0.191** (40.14)	**0.187** (14.50)
Free Collateral	**0.775** (105.7)	**0.605** (106.63)	**0.883** (56.62)
Liquid Assets	**0.215** (37.33)	**0.285** (5.79)	**0.170** (15.50)

+ year dummies, asset growth rates and age (not reported)
t-statistic in parenthesis (z-statistic for GMM)
Bold number indicates significant at 99%
Hausman test rejects equality of coefficients in both regressions

The result is quite interesting, and shows a strong positive correlation between free collateral and trade credit over total debt. This is due to the fact that trade credit is never zero, not even when there is available collateral. The reason for this is that trade credit is not only used as a source of finance, but also as a monetary device to help with transactions and to reduce the need to hold cash. In practice, most firms will take the first free days of credit of a typical "two stage" contract, like the first 10 days in the 2-10 net 30 example. This means that for firms below their collateral limit, when the level of bank credit grows, the level of free collateral goes down and the level of trade credit over total debt also goes down, not because trade credit is growing, but just because the firm uses more bank credit. Only for the firms that have completely exhausted their available collateral will trade credit over total debt normally grow when they increase their borrowing. Once more, a way to see the evolution of trade credit with free collateral that does not depend directly on the co-movement of short-term bank loans is to use as a dependent variable the ratio of trade credit over total asset. The result of this regression is shown in Table 12.

Table 12: Free collateral and liquidity II
Panel Data Regressions
Robustness Check

	Dependent Variable: Trade Credit/Assets		
	Fixed Effects	GLS	GMM
$(\text{Trade Credit/Assets})_{t-1}$	-	-	**0.462** (31.59)
Size	0.033 (2.21)	**-0.004** (−10.24)	**0.023** (11.67)
Inventories	**0.132** (37.40)	**0.103** (39.02)	**0.113** (13.14)
Free Collateral	**-0.100** (−28.02)	**-0.132** (−45.13)	**-0.113** (−20.28)
Liquid Assets	**-0.259** (−8.30)	**-0.053** (−19.94)	**-0.029** (4.72)

+ year dummies, asset growth rates and age (not reported)
t-statistic in parenthesis (z-statistic for GMM)
Bold number indicates significant at 99%
Hausman test rejects equality of coefficients in both regressions

The results show how the effect on free collateral is magnified; the higher the level of free collateral, the lower the level of trade credit. Now the coefficients are even higher than in Table 8 but this may be due to the fact that free collateral is smaller than collateral itself. The significance levels of the variable associated with free collateral also grow a lot when compared with the ones of Table 8. The results are quite consistent across all three regressions.

With respect to the control variables, the results seem to be quite consistent across all the regressions on this section. The correlation of trade credit with inventories is always positive and significant. This may be due to an activity effect, when firms have higher sales they hold a higher level of inventories and they also use more trade credit both for financial and transaction purposes. It may also be related to the collateral value of inventories themselves. Regarding the size variable, there seems to be a clear pattern across all regressions. The sign of the size variable is consistently negative in the GLS regressions while it trends to be positive in both the fixed effect regressions and the Arellano-Bond regressions. This shows a positive cross-sectional negative correlation between size and trade credit (i.e. larger firms issue less trade credit in relative terms), and at the same time a positive time series correlation (i.e. firms that are growing use more trade credit). These results are consistent with the ones in Section 5.4 that related asset growth rates and trade credit use.

5.6 Conclusions

The results of this section are consistent with the implications of the model in Chapters 3 and 4. The starting point of the model is the existence of a relationship surplus split between suppliers and customers, in an environment where debt is difficult to enforce. Under these circumstances suppliers can first of all act as debt collectors, given that the threat of stopping further supply of goods gives them some extra enforceability power. On the other hand, suppliers may also act as suppliers of last resort in case the customer experienced some temporary liquidity shock that threatened its survival or future growth.

Ideally we would like to have an unambiguous measure of how tight the links between the supplier and the customer are. However it is difficult to find such a measure given that the nature of the links between suppliers and customers may be very diverse. One possible good measure could be the length of the relationship of the customer with each of its suppliers that would approximate all kind of links that take time to build. We do not have such a measure in our dataset nor the amount of trade credit given by each individual supplier. Instead, we can use a subsample of new-born firms to study this effect. For new-born firms, the age of the firm is a good proxy for the length of the relationship with their suppliers. Our findings are that customers that are just starting production seem to receive relatively low levels of trade credit. However, the level of trade credit taken rises sharply in the first three to five years of age of a new firm. After the fifth year, the level of trade credit goes down gradually due to its substitution by retained earnings and other forms of finance. The results support the idea of a link between suppliers and customers that takes time to build and gives suppliers a better enforceability technology to guarantee debt repayment.

This approach seems ideal to test the reaction of trade credit levels to the existence of a link that takes time to build. However it is not appropriate for other types of links such as exclusivity contracts, patents or specific investments, that may already be in place when a firm is just created. To see whether these effects are present in our sample we use a measure of Research and Development intensity to approximate these technological links. We relate this R&D measure to the levels of trade credit both taken and given, as our measure may capture the need of more specific inputs as well as the production of a more specific output.

The results again seem to support the idea that strong links between suppliers and customers should lead to higher levels of trade credit, with both trade credit given and taken positively related to R&D intensity.

With respect to the question of whether suppliers support customers that experience temporary liquidity shocks, we run regressions that relate the levels of trade credit taken to two different measures of firm performance change in sales and change in assets. The relationship seems to be highly non-linear. In particular we find a "U" shaped relationship between the levels of trade credit over assets and firm performance. The best firms in the sample and also the ones experiencing slight problems seem to be the ones that borrow more heavily. This is consistent with the idea that suppliers help their customers when they face a liquidity shock that threatens their survival or future growth. Also, like in Section 4.5 a new growth opportunity that needs to be financed immediately can also be seen as a liquidity shock to a large extent.

We also find evidence of suppliers not supporting the worst firms of the sample (i.e. assets shrinking more than 30% in one year). This is consistent with our model, as suppliers should only support their customers whenever the cost of "saving" the customer is smaller than the value of the relationship surplus that the supplier can extract in the future.

The results of the Arellano-Bond estimations, show a strong autocorrelation of trade credit, both when measured as a proportion of total assets or total debt. This implies that there is a lot of inertia in trade credit ratios. This contrasts with the short-term nature of each individual trade credit agreement. However it is consistent with a view of each trade credit deal being a part of a much longer trade credit agreement; also with the fact that the terms of trade credit offered are very stable at an industry level. This correlation may also be due to customer firms having long-term target ratios for trade credit.

The fact that trade credit is very high in high growth firms and its substitution by other forms of finance as firms mature shows how trade credit, being a relatively costly form of finance, trends to be marginal to other forms of finance. Firms prefer to exhaust other forms of finance before using trade credit and therefore save on foregone early payment discounts. While there is always a certain level of trade credit due to a pure transactions motive, firms only use the full capacity of trade credit when they are constrained in other forms of finance. It also sheds some light on the issue of whether trade credit and bank credit are complementaries or substitutes. The results of this chapter, as well as the model in Chapter 3 show how, while a firm is financially constrained, bank and trade credit are complementaries. An extra level of trade credit borrowing may generate some extra collateral that allows for some extra bank borrowing. On the same line, the higher the leverage of a firm the higher the size of the relationship surplus and therefore the higher the level of trade credit available.[79] On the other hand, when a firm becomes unconstrained, bank credit and trade credit become substitutes. Given that trade credit is relatively expensive, firms will substitute trade credit with bank credit if some extra borrowing capacity is available.

We also find some evidence of supplier's support to customers when we relate a measure of liquid assets to the levels of trade credit taken. We find a negative relationship between these two measures that is much more clear when we concentrate on a subsample of firms that are experiencing negative results and are likely to have low access to financial markets.

Finally we find a very strong negative correlation between the levels of trade credit taken (both as a proportion of total assets and total debt) and the level of collateral that a firm has. This shows that, to a large extent, banks lend on

[79] Informational complementarities may also generate extra complementarity between bank and trade credit as in Biais and Gollier (1997).

the basis of collateral, while suppliers lend on the basis of their enforceability power. This result is again much more intense, when we concentrate on firms that experience negative results and have little access to other forms of finance outside bank loans and trade credit.

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