Trade credit, bank lending and monetary policy transmission

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Abstract

This paper investigates the role of trade credit in the transmission of monetary policy. Most models of the transmission mechanism allow firms to access only financial markets or bank lending according to some net worth criterion. In our model we consider external finance from trade credit as an additional source of funding for firms that cannot obtain credit from banks. We predict that when monetary policy tightens there will be a reduction in bank lending relative to trade credit. This is confirmed with an empirical investigation of 16,000 UK manufacturing firms.

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1. Introduction

Recent research has ensured that market imperfections have a central place in the transmission of monetary policy through the credit channel. When there is imperfect information, alternative types of credit cannot be regarded as perfect substitutes and hence the choice of external finance on the part of firms, and the availability and
Price of external funds offered by financial intermediaries will depend on factors related to the strength of firms’ balance sheets. This approach to the monetary policy transmission is known as the broad credit channel view, extensively surveyed in Gertler (1988), Hubbard (1995) and Kashyap and Stein (1994). Some firms with characteristics that prevent effective access to alternative markets for funds such as corporate paper or bond markets may be particularly dependent on bank finance and this gives rise to the bank lending channel.

It has been a characteristic of this literature to think of market finance and bank finance as the two available external finance options. For example theoretical research has been developed to allow bank lending and a capital market to co-exist even though the former is more expensive (see Diamond, 1991; Besanko and Kanatas, 1993; Hoshi et al., 1993; Holstrom and Tirole, 1997; Bolton and Freixas, 2000; Repullo and Suarez, 2000). In these papers, capital market imperfections mean that access is denied to the capital market for firms with a weak financial position. These models predict that periods of monetary tightening will mostly affect financially weak firms (usually small firms) by restricting their access to bank loans and will cause a proportionate decline in aggregate investment, which has been corroborated using disaggregated data in Gertler and Gilchrist (1994) and Oliner and Rudebush (1996).

In this paper, we consider another important source of external finance for firms, namely trade credit. According to a Federal Reserve Board Study by Elliehausen and Wolken (1993) trade credit represents about 20% of non-bank non-farm businesses’ liabilities, and up to 35% of total assets. A later study by Rajan and Zingales (1995) calculated that trade credit represented 17.8% of total assets for all American firms in 1991. In many other countries, such as Germany, France and Italy, trade credit represents more than a quarter of total corporate assets. And in the United Kingdom 70% of total short-term debt (credit extended) and 55% of total credit received by firms comprised trade credit (Kohler et al., 2000). Eighty per cent of all firms use trade credit according to a review by Atanasova and Wilson (2002), and the scale of trade credit usage is much increased during periods of monetary contractions.

Meltzer (1960) was the first to suggest that a trade credit channel might be a substitute for the bank lending channel, but from a theoretical point of view the implications of trade credit for the broad credit channel view have not yet been explored. Existing theoretical works are mostly concerned with explaining the use of trade credit. For example, Ferris (1981) and Schwartz (1974) have suggested that trade credit provides transactions services to firms, and Cunat (2003) demonstrates that, in the context of limited enforceability of debts, firms may use both trade credit and bank credit when the supplier and the buyer engage in specific production processes. Other papers have explained why trade credit is extended at all. Jain (2001) argues that non-financial firms extend credit to their customers as intermediaries between banks and the ultimate buyers. This supports the conjecture of Biais and Gollier (1997) that the seller’s provision of trade credit can provide a valuable signal to the banker that the buyer is worthy of credit, thus mitigating credit rationing. However, these papers do not explain what the consequences might be for corporate finance and monetary policy making if firms take up trade credit when
other funds are inaccessible and this puts them at odds with the small empirical literature that attempts to address this question (cf. Nilsen, 2002; Kohler et al., 2000).

In this paper, we tie in a theoretical model with the existing empirical evidence. In our theoretical model we incorporate trade credit and bank loans into a framework that has some similarities with Repullo and Suarez (2000). The existence of imperfections in the credit market means that firms have access to different sources of external funding according to their initial wealth level (although firm size and project size are allowed to differ). We begin by allowing firms to access bank finance only, and find that wealthier firms borrow from banks while lower wealth firms fail to obtain any funding for their projects. When we introduce trade credit, firms with intermediate wealth can find funding for their projects by accepting trade credit. Thus instead of a monetary contraction resulting in some firms being refused credit altogether as in the simple version of our model and in that of Repullo and Suarez (2000), we find monetary tightening brings about a reduction in bank loans but trade credit allows some firms to pursue their projects. As a result trade credit can smooth out the impact of tightening monetary policy. In the final section of the paper we test the predictions of our model against data from a panel of 16,000 UK manufacturing firms finding results that are consistent with the theoretical model.

The rest of the paper is organized as follows. Section 2 presents the general theoretical model without trade credit. Section 3 brings in trade credit and describes the new distribution of firms over the two credit sources. Section 4 analyzes the impact of a monetary policy tightening in both settings. Section 5 considers the impact of firm size on credit access, while Section 6 allows for variable project size. Sections 7 and 8 present the predictions of the model and provide some empirical evidence that supports the theoretical predictions of the paper. Finally, Section 9 concludes.

2. The model without trade credit

Consider a two-sector economy with two dates \( t = 0, 1 \). The first sector is competitive and produces an intermediate input. Firms in this sector are not financially constrained. In the second sector firms produce a final good using the intermediate input.\(^1\) More specifically, final good producers are endowed with the following risky technology. For each unit of the intermediate input invested in the risky technology at \( t = 0 \), the technology, at \( t = 1 \), will yield either \( H \) units of the final good with probability \( z \) or 0 units with probability \( 1 - z \). The market for the intermediate good is competitive and all producers charge a price of \( P \) units of the final good for each unit of the intermediate good. Firms in the final goods sector

\(^1\)We are going to refer to final good producers as ‘firms’ and to intermediate input producers as ‘sellers’.
also differ in size measured by their capacity to invest. We assume that a firm of size $S$ has the capacity to invest up to $S$ units of the intermediate input in the risky technology.\footnote{In this section, we restrict all firms to invest at full capacity. In Section 6, we allow firms to choose the level of their investments.}

We assume that $zH - PR > 0$. The inequality states that the risky technology is socially efficient. We further assume that all agents in this economy are risk-neutral and only consume at $t = 1$. Each final goods producer is endowed with a level of initial wealth $W$ that differs across firms. Let $g$ denote the density function of the wealth distribution, $G$. All firms with $W < PS$ need to borrow funds in order to invest in their risky technologies. In this section, we assume that they can only borrow from banks. Firms can also invest their initial endowment in a risk-free asset and earn the riskless gross interest rate $R (> 1)$. Lastly, in this and the following section we assume that all firms have the same size $S = 1$; in words they require one unit of the intermediary input.\footnote{We relax this assumption in Section 5.}

2.1. Banks

The banking sector is competitive. We assume that it is costly for banks to verify the projects’ realized returns. The ‘costly state verification’ problem was originally studied by Townsend (1979) who demonstrated that in this type of environment, under the additional assumption that lenders can commit, the optimal contract is the standard debt contract.\footnote{The role of banks as monitors when it is costly to verify returns has been studied by Boyd and Prescott (1986), Diamond (1984) and Williamson (1986).}

Let $M$ denote the loan repayment that banks demand from a borrower when the return of the project is equal to $H$, let $R_B$ denote the corresponding gross interest rate and let $L$ denote the size of the loan. Then the loan interest rate and the repayment must satisfy the condition $R_B L = x M$. According to the optimal contract at $t = 1$ a borrower repays $M$ to the bank when the return of the project is equal to $H$ and the bank verifies when the return is equal to 0. Let $V$ denote the total verification costs. We assume that these costs increase with the size of the loan: $V = mL^\gamma$, where $m$ is a constant and $\gamma > 1$.

Competition in the banking sector implies that banks make zero profits:

$$\pi_B = R_B L - (1 - x)mL^\gamma - RL = 0,$$

where $RL$ denotes the opportunity cost of funds.

From the expression of the banks’ profits we can derive the gross interest rate charged on loans:

$$R_B = R + (1 - x)mL^{\gamma - 1}.$$  

Eq. (2) shows that different firms pay different interest rates. The smaller the loan size the lower the interest rate charged. Thus, if the amount of funds needed is sufficiently high then the verifying costs will become so high that the firm might not be willing to borrow at the corresponding interest rate.
2.2. Firms

At $t = 0$, firms decide whether to run their projects or to place their wealth in the risk-free asset earning the interest rate $R$. In order to run their projects they borrow from banks $L = (P - W)$ and pay an interest rate $R_B$ on their loan. Their profit function is given by

$$\pi_f = \pi(H - M) = \pi H - R_B(P - W).$$ (3)

Firms will choose to run the project if profits are higher than the amount they would get from investing their wealth in the risk-free asset. This condition can be formalized as follows:

$$\pi H - R_B(P - W) \geq WR.$$ (4)

We can state now the main result of this section.

Proposition 1. There exists a cut-off value $W_B$, such that firms with wealth levels less than $W_B$ prefer not to run their projects and invest their wealth in the risk-free asset.

Proof. Substituting the expression of $R_B$ given by (2) into condition (4) we get

$$\pi H - PR - (1 - \pi)m(P - W) \geq 0.$$ (5)

Denote by $W_B$ the value of $W$ for which the inequality binds. Simple algebraic calculations give the solution

$$W_B = P - \left[\frac{\pi H - PR}{(1 - \pi)m}\right]^{1/\gamma}.$$ (6)

Notice that for sufficiently high values of either $m$ or $\gamma$, $W_B$ will be positive. Proposition 1 shows that the initial level of wealth is critical. Firms with high levels of wealth ($W > W_B$) take bank loans, whilst firms with low levels of wealth ($W < W_B$) do not invest in their projects.

3. The model with trade credit

In addition to borrowing from banks, firms may obtain loans from their suppliers. Trade credit represents an important source of external finance for firms. Despite its unattractiveness in terms of costs, firms do request this kind of credit, expressing their willingness to pay high interest rates for the use of short-term financing. Moreover, it seems that firms use more trade credit when monetary policy is tight.

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5This is another way to say that at the end of the period firms pay back nothing in the bad state and $M$ in the good state.

6An indicator of the high cost of trade credit is the lost earnings of firms that do not use the early payment discounts.
3.1. Sellers

There exists a sufficiently large number of wealthy firms in the competitive sector that produce the intermediate input. The per unit cost of the intermediate input, measured in final good units, is equal to $C$. At $t = 0$, firms approach the sellers and ask for one unit of the intermediate input; the sellers invest $C$ and produce the good instantly. We assume that $C < P$ so that sellers earn a profit of $(P - C)$ per unit sold.

Our approach to modelling trade credit is in accord with the informal model in Stiglitz and Greenwald (2003). Sellers can observe the realized returns of their customers’ projects without incurring any cost. They have better information about their customers than banks do. This advantage arises from the fact that sellers and buyers are mostly engaged in the same non-financial transactions. Sellers might be willing to offer trade credit to firms in order to earn financial profits but also in order to keep as customers those firms that were refused bank loans. Non-discrimination among buyers requires that sellers will charge the same interest rate to all their customers taking trade credit.\footnote{Empirical studies by Ng et al. (1999) and Nilsen (2002) have investigated how credit terms vary across industries. They have found wide variations in terms across industries but rather similar credit terms within industries.}

Let $R_T$ denote the interest rate charged by trade creditors. Note that because sellers can observe their customers’ payoffs the form of the financial contract is indeterminate. Then, without any loss of generality, we assume that the contract is the standard debt contract.\footnote{This allows comparisons between the terms of bank loans and those of trade credit contracts.} If state $H$ occurs, the seller demands a repayment $M_T$ that satisfies the following condition:

\begin{equation}
R_T(P - W) = \alpha M_T.
\end{equation}

Then, at $t = 0$, sellers offer trade credit. They will receive $W$ and offer one unit of the intermediate good. Therefore, the size of the loan will be $(P - W)$. The interest rate that the seller charges, $R_T$, defines a cut-off level of wealth, $W_2$ such that all firms with $W > W_2$, prefer to approach the banks. Those firms with initial wealth equal to $W_2$ are indifferent between taking a bank loan or trade credit. Therefore,

\begin{equation}
R_T = R_B(W_2) = R + (1 - \alpha)m(P - W_2)^{\gamma - 1},
\end{equation}

where $R_B(W_2)$ denotes the interest rate that the bank would charge to a borrower with initial wealth $W_2$. Solving for $W_2$ we get

\begin{equation}
W_2 = P - \left(\frac{R_T - R}{(1 - \alpha)m}\right)^{1/(\gamma - 1)}.
\end{equation}

Evidently $W_2$ has to be higher than $W_B$. Suppose that the seller chooses the critical level of initial wealth to be $W_B$ by setting $R_T = R_B(W_B)$. The only firms that could afford trade credit are those firms with initial wealth $W_B$, in other words firms that are indifferent between bank loans and trade credit. Wealthier firms are offered better terms by banks while lower wealth firms do not find bank loans attractive. As
a consequence, the seller will be able to sell the intermediate input to other firms with wealth levels lower than $W_B$ only if the trade credit interest rate is lower than $R_B(W_B)$.

From (7) we find that as the seller moves the cut-off level, $W_2$, further away from $W_B$ (by offering a lower interest rate, $R_T$) the demand for trade credit increases. In fact, the demand increases for two reasons. Some of the firms that are eligible for loans from banks prefer trade credit and some of the firms that could not obtain loans from banks at all can now afford trade credit. Then, the interest rate $R_T$ defines another cut-off value, $W_1$, such that all firms with initial wealth levels in the range $(W_1, W_2)$ receive trade credit. The cut-off value $W_1$ must satisfy the following condition:

$$zH - R_T(P - W) = W_1R.$$  \(8\)

In words, those firms with initial wealth levels equal to $W_1$ are indifferent between receiving trade credit to invest in their risky technologies and investing their initial wealth in the risk-free asset. Using (8) we find that

$$W_1 = P - \frac{zH - PR}{R_T - R}.$$  \(9\)

The following proposition summarizes the results so far:

**Proposition 2.** *In the presence of trade credit, there exist two cut-off values $W_1$ and $W_2$, where $W_1 < W_2$. These differentiate among firms with respect to their source of external funding. Firms with high levels of wealth $W > W_2$ borrow from banks, while firms with medium levels of wealth $W_1 < W < W_2$ take trade credit, and firms with low levels of wealth $W < W_1$ do not run their projects at all but invest their initial level of wealth in the risk-free asset.*

Therefore, the seller maximizes profits on the interval $[W_1, W_2]$. In choosing the two cut-off levels (by choosing $R_T$), the seller considers the extra profits earned from offering trade credit. These extra profits are given by

$$(R_T - R)(P - W)$$

for firms with \(W_B < W < W_2\),

$$(R_T - R)(P - W) + (P - C)R$$

for firms with \(W_1 < W < W_B\).

Note that the opportunity cost is different between the two intervals. The first group of firms can borrow from banks and buy the intermediate good even in the absence of trade credit. Therefore, the seller by offering trade credit makes only an additional financial profit. For the second group of firms, the seller earns even higher profits. Without trade credit these firms cannot purchase the good. By offering trade credit the seller manages to sell the intermediate good to more firms. Therefore, the lower the interest rate the sellers charge the higher the demand for the intermediate input.

Up to this point we have only considered the financial advantages the seller has over banks. We must now consider the factors that constrain credit policies. As in Emery (1984), we limit the amount of funds committed to accounts receivable. Then the seller chooses the interest rate $R_T$ so that the
following condition is satisfied:

\[
\int_{W_1}^{W_2} (P - W)g(W) \, dW = T,
\]

where \( T \) is a constant. Notice that if sellers did not face such constraints then the only form of short-term credit offered in equilibrium would be trade credit. But while trade creditors have an informational advantage over banks they do not have an unlimited supply of funds.

4. Monetary policy

In this section, we consider the monetary policy implications of introducing trade credit in our model. We examine the effects of an increase in the rate of interest (tighter monetary policy) on the taxonomy of firms according to their financial source.

4.1. No trade credit

We start the analysis by considering the simple model with only bank finance. Allowing for a monetary policy tightening, we observe the effects of an increase in the riskless interest rate \( R \).

**Proposition 3.** In an economy without trade credit, an increase in the market interest rate \( R \) increases the threshold wealth level above which firms take bank loans. As a result bank lending decreases when monetary policy tightens.

**Proof.** An increase in \( R \) will lead to

\[
\frac{\partial W_B}{\partial R} = \frac{P}{\gamma} \frac{P - W_B}{\gamma H - PR} > 0.
\]

Total bank lending is decreasing because fewer firms borrow in order to run their projects. \( \Box \)

Our model predicts that a monetary tightening reduces bank lending. Similar results are obtained by Repullo and Suarez (2000).

4.2. Trade credit

We now do the same kind of exercise including trade credit among the sources of external finance. A monetary tightening will change the taxonomy of firms according to their sources of external finance. We can prove the following proposition:

**Proposition 4.** Sellers will increase the interest rate that they charge by less than the increase in the riskless interest rate.
**Proof.** Notice that condition (2) implies that the interest rates that banks charge will increase by the same amount in percentage points as the corresponding increase in the riskless rate. Suppose that sellers did not change $R_T$. Then $W_1$ would remain unchanged but $W_2$ would increase as some firms that previously obtained funding from banks would now prefer to receive trade credit. Therefore, at the old interest rate there would be an excess demand for trade credit. Next, suppose that sellers increase $R_T$ by the same amount of percentage points as the corresponding increase in the riskless rate. In this case $W_1$ would increase as some firms that previously received trade credit would now prefer to invest their initial endowments in the riskless asset. In contrast, $W_2$ would remain the same because firms that were previously indifferent between obtaining bank loans and trade credit remain indifferent after the increase in the riskless rate. Therefore, if sellers were to increase $R_T$ by the same amount in percentage points as the corresponding increase in the riskless rate there would be an excess supply of trade credit. The above arguments complete the proof of the proposition.

Proposition 4 states that sellers will increase the interest rate they charge their customers in the event of a monetary tightening but by less than the increase in the riskless interest rate. This result is similar to Wilner (2000). The following proposition follows from Proposition 4:

**Proposition 5.** An increase in the riskless interest rate $R$ will increase both the threshold wealth level above which bank lending is available and the threshold wealth level above which firms take trade credit. As a result, bank lending diminishes relative to trade credit since firms that cannot obtain bank finance will resort to trade credit.

**Proof.** Using Proposition 4 and Eq. (9),

$$\frac{\partial W_1}{\partial R} = \frac{1}{R_T - R} \left[ P - (P - W_1) \left( 1 - \frac{\partial R_T}{\partial R} \right) \right] > 0.$$  

Similarly, from (7),

$$\frac{\partial W_2}{\partial R} = \frac{1}{\gamma - 1} \frac{P - W_2}{R_T - R} \left( 1 - \frac{\partial R_T}{\partial R} \right) > 0.$$  

Total bank lending is decreasing relative to trade credit because fewer firms borrow from banks while borrowing in the form of trade credit remains constant.

The cut-off values are defined as functions of the cost of funds in the corresponding markets. Thus, the threshold wealth level above which firms take bank loans increases. This is consistent with the credit channel view: an increase in the costs of external finance produces a flight to quality, i.e. there is a ranking of firms according to quality (captured in our model by the extent of self-finance) that ensures that the best customers obtain bank credit, the middle ranked customers obtain trade credit and the lowest quality customers do not obtain any funding.
5. Size

In this section, we relax the assumption that all firms in the second sector have the same size $S = 1$ but we retain the assumption that firms produce at full capacity. Therefore if a firm of size $S$ decides to invest in the risky technology then it will purchase $S$ units of the intermediate input.

Let $G_S$ denote the wealth distribution of firms of size $S$. We assume that $G_S(SW) = k$ (constant) for every $S$ (i.e. the distribution function is homogeneous of degree 0). This assumption implies that we can create the wealth distribution of firms of size $S$ by multiplying the initial wealth level of firms of size 1 times $S$. Put differently, we assume that on average larger firms are wealthier. Now let $W_B(S)$, $W_1(S)$ and $W_2(S)$ denote the three threshold wealth levels for firms of size $S$. Then by following exactly the same steps as above we can prove the following:

**Example 1.** Let the verification cost function take the form $V = mL^2/S$. Then $W_B(S) = SW_B$, $W_1(S) = SW_1$ and $W_2(S) = SW_2$.

The example implies that the proportion of firms obtaining bank loans (either in the case without trade credit or in the case with trade credit), the proportion of firms receiving trade credit and the proportion of firms that do not have access to external finance are not affected by changes in size. Thus in this particular case scale effects are absent. However, the literature on the ‘credit channel’ strongly suggests that on average larger firms find it easier to get access to external finance. In what follows, we are going to alter the verification cost function so that in the absence of trade credit larger firms have greater access to bank loans than smaller ones. Then we are going to examine how that change affects our results when we introduce trade credit.

**Example 2.** Suppose that the verification cost function takes the form $V = m(S) L^2 / S$, where $m'(S) < 0$, $m''(S) > 0$ and $m(S) \to 0$ as $S \to \infty$. Then $W_B(S) < SW_B$, $W_1(S) = SW_1$ and $W_2(S) < SW_2$.

The above example follows directly from the values of the three threshold levels given by (5), (7) and (9). The first inequality implies that, in the absence of trade credit, the proportion of large firms with access to bank loans is higher than the corresponding proportion of small firms. The second and third inequalities imply that, when we introduce trade credit, the proportion of large firms with access to bank loans is higher than the corresponding proportion of small firms and the proportion of large firms that obtain trade credit is smaller than the corresponding proportion of small firms that obtain trade credit. 

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10 Notice that for the derivation of the new thresholds we need to multiply $H$ and $P$ times $S$.

11 For example, this could be the case because larger firms on average survive for longer periods and can take advantage of ‘reputation effects’.

12 We get similar results with the verification cost function $V = mL^2/S$ if $1 < \gamma < 2$. 
proportion of small firms. Therefore, trade credit is more important as a source of external finance for small firms.

5.1. Monetary policy

How does size affect the impact of monetary policy on the choice of external finance? Suppose that we use the same verification cost function as that used in Example 2. Then from (7) it is clear that for any monetary stance (i.e. level of $R$) there exists a threshold level of size, $\hat{S}(R)$, such that all firms larger than that threshold obtain bank finance irrespective of their level of wealth. It is clear that $d(\hat{S})/dR > 0$.

Then after an increase in the interest rates there are some firms, in particular those of small size, that while before the increase in interest rates were financing their investments with bank loans, after the change seek trade credit. Firms that are sufficiently large will not be affected (i.e. they will keep financing their investments with bank loans). For most of the small firms trade credit will increase because of the increase in interest payments. Lastly, because of the increase in $W_1$ there will also be some small firms that can no longer afford trade credit.

6. Variable investments

Up to this point we have assumed that firms operate at full capacity. Given the structure of our model if we relax this assumption then all firms will be able to get some form of external finance. For example, firms with very low levels of wealth will be able to invest in small size projects that they self-finance. Thus, while an attractive feature of our model is that some firms are unable to get any external finance, it does not allow firms to choose the size of their projects. In this section, we are going to consider a simple extension that allows for both of these possibilities. To simplify the analysis we are going to restrict our attention to the case where $S = 1$. Let $Z (0 \leq Z \leq 1)$ denote the number of units of the intermediate input invested in the risky technology.

In addition, to the variable cost $P$, a firm faces a fixed cost $F$. Firms in the final goods sector have an initial endowment of wealth that is greater or equal to $F$. Thus, we assume that their wealth is sufficiently high to cover their fixed cost. Let $w$ denote their wealth level after we subtract the fixed cost. Once more we assume that the project is socially efficient, i.e. $zH - (P + F)R > 0$.

13To see this set (7) equal to zero and totally differentiate to get

$$\frac{d(\hat{S})}{dR} = \left(\frac{dR_T/dR - 1}{P(1 - z)w'(\hat{S})}\right).$$

Notice that Proposition 4 implies that the numerator is negative.

14Once more, we are interested in the choice between bank loans and trade credit and we assume that only purchases of the intermediate input can be financed with trade credit.
6.1. No trade credit

In this section, we consider the case where the only source of external finance is bank loans. A firm with wealth equal to \( w + F \) will choose \( Z \) to maximize

\[
\pi_f = \alpha Z H - R_b(PZ - w) = \alpha Z H - (R + (1 - \alpha)m(PZ - w)^{\gamma - 1})(PZ - w)
\]

subject to the constraints

\[
\pi_f \geq (w + F)R \quad \text{(11)}
\]

and

\[
0 \leq Z \leq 1. \quad \text{(12)}
\]

The f.o.c. is given by

\[
\alpha H - P(R + \gamma(1 - \alpha)m(PZ - w)^{\gamma - 1}) = 0.
\]

The following proposition describes the complete solution.

**Proposition 6.** There exist two threshold levels \( w_{B1} \) and \( w_{B2} \) \((w_{B1} < w_{B2})\) such that all firms with wealth levels less than \( w_{B1} + F \) do not invest in their projects, all firms with wealth levels in the interval \([w_{B1} + F, w_{B2} + F] \) partially invest in their projects and all firms with wealth levels above \( w_{B2} + F \) use the full capacity of their projects.

**Proof.** Let \( Z^* \) denote the optimal investment level and \( \hat{Z} \) the value of \( Z \) that solves the f.o.c. (unconstrained case). Then, if \( \hat{Z} \geq 1 \) then \( Z^* = 1 \). This will be the solution for relatively wealthy firms. The threshold \( w_{B2} + F \) denotes the wealth level of those firms for which \( \hat{Z} = 1 \). For those firms with \( \hat{Z} > 1 \) constraint (12) is binding. For those firms with wealth levels less than \( w_{B1} + F \) constraint (11) is binding. Those firms with wealth levels equal to \( w_{B1} + F \) are indifferent between partially investing in their projects and investing their wealth in the risk-free asset. \( \square \)

Therefore, those firms with wealth levels above \( w_{B2} + F \) would like to invest more than one unit of the intermediate input but they are restrained by their capacity while those firms with wealth levels less than \( w_{B1} + F \) invest their wealth in the risk free asset. The f.o.c. also implies that all firms that underinvest borrow exactly the same amount and face exactly the same interest rate on their bank loans that is equal to the interest rate that firms with wealth levels equal to \( w_{B2} + F \) have to pay. Let \( \bar{R}_B \) denote this interest rate.

6.2. Trade credit

As long as the trade credit interest rate, \( R_T \), is less than \( \bar{R}_B \) some firms will use trade credit to finance their investments. In fact, we can show the following:

**Proposition 7.** There exist two threshold levels \( w_{T1} \) and \( w_{T2} \) \((w_{T1} < w_{T2})\) such that all firms with wealth levels less than \( w_{T1} + F \) do not invest in their projects, all firms with wealth levels in the interval \([w_{T1} + F, w_{T2} + F] \) fully invest in their projects and finance...
their investments with trade credit and all firms with wealth levels above \( w_{T2} + F \) use the full capacity of their projects and borrow from banks.

**Proof.** The profits of firms with wealth levels equal to \( w_{B1} + F \) are higher when they finance their investments with trade credit than when they finance them with bank loans. But the definition of \( w_{B1} \) implies that their profits when they use trade credit are positive. Therefore, there exists a threshold level of wealth \( w_{T1} + F \) which is less than \( w_{B1} + F \) such that firms with wealth level equal to that threshold are indifferent between fully investing in their projects and investing their wealth in the risk-free asset. Furthermore, the profits of those firms with wealth levels equal to \( w_{B2} + F \) are higher when they finance their investments with trade credit than when they finance them with bank loans. Therefore, there exists a threshold level of wealth \( w_{T2} + F \) which is higher than \( w_{B2} + F \) such that firms with wealth level equal to that threshold are indifferent between trade credit and bank loans. \( \square \)

Notice that because the trade credit interest rate is not a function of the size of the loan, all firms use the full capacity of their projects. Therefore, when we introduce trade credit the model with variable investments behaves in exactly the same way as when the size of the projects is fixed.

### 7. Predictions

Our model predicts that when there is no trade credit, a monetary contraction will diminish bank lending and some firms will not be able to run their projects. When there is trade credit, our model predicts that as bank lending is withdrawn from certain firms with low wealth, trade credit will take its place. Hence, in contrast to the model of Repullo and Suarez (2000), we take into account the fact that some firms that used to obtain bank funding before the monetary tightening may continue to obtain funding through trade credit.

The implications of introducing trade credit are:

1. that the magnitudes of trade credit relative to total liabilities should increase while bank loans relative to total liabilities should decline in periods of tight monetary policy relative to looser periods;
2. that trade credit relative to bank loans should increase.

If the firms that face financial constraints are predominantly small firms (because small firms have insufficient wealth to reach the threshold for bank finance) then we should also observe:

3. that smaller firms are affected more dramatically than large firms by a monetary tightening. That is during periods when monetary policy tightens, small firms’ access to bank loans as opposed to trade credit should decline and therefore the ratios of trade credit to total liabilities or bank loans should increase. These effects should not be observed for firms that are larger (and financially more...
healthy) because they should be able to meet the required thresholds even during tight monetary policy periods.

The next section examines the evidence from a panel of 16,000 manufacturing firms in the United Kingdom over the period 1990–1999.

8. Empirical evidence

In this section, we report empirical results that support the theoretical predictions of our model. To test the implications of the model we use a sub-sample of the FAME database that allows us to analyze some aspects of the monetary transmission mechanism and to emphasize the role played by firms’ financial position.15

8.1. Data definitions and methodology

The sample includes data from active British companies that satisfy the following criteria:

- their main activity is in the manufacturing sector, according to 1992 UK SIC Code;
- they were established prior to 1989 and have information up to 1999.

In addition we separate our panel into two periods: 1990–1992 when monetary policy was tight, and data for the period 1993–1999, when it was loose.16

The dependent variables are the supply of bank loans provided by financial intermediaries (banks), and trade credit, which is credit in the form of a delay in the payment for inputs provided by suppliers. These are formed into ratios to eliminate potential demand effects, scaled by total liabilities to ensure that large firms do not have disproportionate influence on the results.17

Our explanatory variables are indicators of monetary policy conditions and firm-specific characteristics. The indicator of monetary stance (MS) is measured by the level of the rate of interest set by the Bank of England (often referred to as the ‘base rate’), which is comparable to the Fed Funds rate used in US studies as the preferred

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15The FAME dataset is provided by Bureau van Dijk Electronic Publishing and is available at (http://www.bvdep.com).

16The choice of the sample period was to some degree arbitrary and was determined by the availability of a sufficient number of firms. 1990 was the year that the government of the United Kingdom entered the European Exchange Rate Mechanism. The period 1990–1992 was a period when the level of the interest rate was high in comparison to subsequent years. In September 1992 United Kingdom left the Exchange Rate Mechanism and the Bank of England was established as an inflation targeting central bank. The period 1993–1999 was a period of low inflation and low interest rates.

17The choice of scaling variable does not alter the properties of the statistics—we calculated, but do not report, trade credit and bank loans scaled by total assets.
indicator of monetary conditions (see for example Bernanke and Blinder, 1988, 1992; Kashyap et al., 1993; Gertler and Gilchrist, 1994; Oliner and Rudebush, 1996). It is expected that the composition of the credit obtained by firms will alter with the monetary policy stance (interest rate), and the sensitivity to the interest rate may alter according to whether monetary policy is ‘tight’ or ‘loose’. Accordingly we interact all our variables with a vector of dummy variables $D$, with elements that take the value one when the data refers to the sub-period 1993–1999, i.e. when the monetary policy was loose, and zero for the tight monetary period 1990–1992. This allows us to examine whether firms face different conditions as monetary stance changes from a tight to a loose regime.

The firm specific characteristics include solvency, which is an indicator of the liquid assets of the firm. Our measure of risk is the Quiscore measure produced by Qui Credit Assessment Ltd., which assesses the likelihood of company failure in the 12 months following the date of calculation.\footnote{Based on a statistical analysis of a random selection of companies to ensure that the model is not distorted, three categories are screened out from the initial selection: major public companies, companies that have insignificant amounts of unsecured trade credit, and liquidated companies that have a surplus of assets over liabilities.} The score is calculated as a number in the range 0–100, which to facilitate interpretation is separated into five distinct bands. The bands are: Secure (81–100) where failure is very unusual and normally occurs only as a result of exceptional changes within the company or its market. Stable (61–80), where company failure is a rare occurrence and will only come about if there are major company or marketplace changes. Normal (41–60) containing many companies that do not fail, but some that do. Unstable (21–40) where a significant risk of company failure exists. High Risk (0–20), where most companies are unlikely to be able to continue trading unless significant remedial action is undertaken. This definition of perceived financial health is wider than the commonly used bond rating, used by Whited (1992) and Kashyap et al. (1994), which only applies to a small fraction of rated firms. Age is the time elapsed since the year of incorporation. This allows us to gauge the extent to which the firm is ‘young’ and therefore to some extent a higher risk, or ‘old’ with the advantages of having time to build up a track record and a relationship with creditors. The variable sales is the logarithm of total sales and this is an indicator of the importance of the size of the firm. Each of these variables was interacted with the vector of dummy variables $D$, to indicate the response to firm-specific characteristics when the monetary policy was loose.

We estimate the relationship between the financial choices of firms and their specific characteristics using a standard panel model written as follows:\footnote{Trade credit, the main variable in our study, is a source of external finance for short periods of time. It is typically extended and paid back several times during a single year. Thus, there is very little dependence year-on-year between trade credit received or granted. For this reason static estimation is preferred to dynamic estimation.}

$$y_{it} = \mathbf{a}_i + \mathbf{X}_{it}\beta + \mathbf{e}_{it},$$

where $i = 1, 2, \ldots, N$ refers to a cross section unit (firms in this study), $t = 1, 2, \ldots, T$ refers to time period. $y_{it}$ and $\mathbf{X}_{it}$ are the dependent variable and the vector of...
non-stochastic explanatory variables for firm $i$ and year $t$, respectively. $e_{it}$ is the error term, $x_i$ captures firm-specific effects. We reject the hypothesis of no systematic difference between coefficients obtained from the random effects and fixed effects models by using both the Hausman and the Breusch Pagan Lagrange Multiplier test. Therefore, the within groups model is justified. Since we divide the sample into two different time periods corresponding to ‘tight’ and ‘loose’ monetary policy periods using a dummy variable, we interact the dummy vector with all variables and run a nested panel regression

$$ y_{it} = x_i + X_{it} \beta + x_i D + X_{it} \beta D + \xi_{it}. $$

Estimation results are interpreted as follows: the coefficients referring to the tight monetary policy period are given by the non-interacted variables. The impact on the dependent variable when monetary policy is loose is given by the sum of the coefficients associated with a given variable and with the variable interacted with the period dummy.

For all our reported results we split the firms into size categories. In determining the size of the firm it seems reasonable to follow the criteria used by the Companies Act (1985) used in data disclosure. Firms are classified as small or medium if they satisfy two out of the three criteria given in Table 1. We also use a different classification method to ensure our results are robust using size categories determined by taking into account their total assets.

8.2. Descriptive statistics

We report the descriptive statistics for real trade credit, real bank lending and real trade debit in Tables 2 and 3. The first of these tables reports figures in millions of pounds per annum, i.e. unweighted year averages for tight and loose monetary episodes. The second reports the unweighted average figures in millions of pounds per firm, and firm-weighted averages per firm where the figures in million of pounds are weighted according to the share of each firms’ assets in the total assets for each year. Taking year averages helps to remove the distortions that arise from the arbitrary allocation of contracts between adjacent financial years, while unweighted and firm-weighted averages across firms illustrates the extent to which firms of different sizes take up (or offer) trade credit, and bank lending.

These data indicate that the absolute level of real trade credit taken up by manufacturing firms on average per year was higher during periods of tight

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Size categories of firms—DTI definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
</tr>
<tr>
<td>Turnover</td>
<td>Max £2.8 mn</td>
</tr>
<tr>
<td>Balance sheet</td>
<td>Max £1.4 mn</td>
</tr>
<tr>
<td>Employees</td>
<td>Max 50</td>
</tr>
</tbody>
</table>

*Source: DTI.*
monetary policy, while the average level of bank loans in each period shows the opposite (standard errors are in brackets). Trade credit in the tight period is greater than trade credit in the loose period therefore the ratio in row 3 is greater than unity, but bank loans were higher in the looser monetary period and lower in the tighter period so the ratio is less than one. Trade debit (delayed payment terms offered to downstream firms that purchase inputs, in contrast to trade credit which is delayed payment terms received from upstream firms, i.e. suppliers) was marginally greater in the tighter monetary period than subsequently. A comparison between trade credit and trade debit (which is net trade credit reported in the final column) suggests that manufacturing firms were offering more credit (not necessarily to other manufacturing firms) than they were receiving during the loose monetary policy period.

The ratio between trade credit and bank loans almost halves when we compare the average per annum ratio for 1993–99 with 1990–92 in the second panel of Table 2.
This shows trade credit relative to bank loans was 1.79 times higher during the tight period of monetary policy. Comparing the extent of trade credit to the sum of trade credit and bank loans we find a similar effect, although the magnitude is lower. The final two columns report the ratio of trade credit to total liabilities and the ratio of bank loans to total liabilities. In both cases the ratios behave as predicted since trade credit to total liabilities is much higher in the tight money period than subsequently, while for bank loans to total liabilities the ratio is lower. This is consistent with our first and second prediction.

Table 3 shows the unweighted and firm-weighted averages of trade credit relative to bank lending. The first two rows illustrate the average amount of trade credit, bank loans, trade debit and net trade credit (trade credit minus trade debit) for each firm calculated for tight and loose periods of monetary policy. The ratio of trade credit to bank loans on average per firm was greater in the tight period than the loose period. The data show that on average firms have more trade credit relative to bank loans when policy was tight, but there is a large dispersion around the mean values since the uptake of different types of credit varies with scale (as indicated by the standard errors in brackets). The figures in the lower panel correct for the scale effects, and report weighted average values where the scale is accounted for by total assets. The ratios of trade credit to bank loans continue to be larger for tight periods of monetary policy.

8.3. Estimation results

The empirical results that evaluate the response of trade credit during tight and loose periods of monetary policy are reported in Tables 4–7. We define the sizes of firms in the first three columns using the official definition of size given by the UK government’s Department of Trade and Industry (DTI), while the next three columns report the results for firms classified according to their asset size. The results are remarkably similar. In the first two rows of each table we report the marginal response to monetary policy stance (the level of interest rates); the first coefficient indicates the response of the dependent variable under the tight, while the second coefficient indicates the change in the response (relative to the tight period) during the loose period of monetary policy—therefore, the net response in the loose period is evaluated by summing the two coefficients. The following rows in each table report the marginal responses to the control variables that measure the variation in the dependent variable with respect to solvency (shareholder’s funds/total assets), quiscore (the risk assessment by QuiScore Ltd.), age (years since incorporation), and sales (the logarithm of the total final sales of the firm). In each case the dummy variable for the loose period of monetary policy is interacted with the control variable to gauge the change in the response relative to the tight period and the net response under loose period of policy is found by summing the coefficients. Since the period of tight policy coincided with a recessionary environment, which was regarded as a harsh environment for existing and new corporate borrowers, while the latter period of loose policy was also an expansionary phase, the response of the dependent variables to the controls might reasonably be expected to vary due to
non-monetary causes. The intercept captures the changes in both monetary and non-monetary conditions in each period.

In Table 4, we find that, for all firm types, the ratio of trade credit to the sum of trade credit and bank loans increases with an increase in the base rate during periods of tight monetary policy, and it decreases with an increase in the base rate when monetary policy is loose. The coefficients are significant for both periods. The scale

Table 4
Trade credit/(trade credit + bank loans) × 100 (response of trade credit ratio to tight monetary policy (1990–1992) versus loose monetary policy (1993–1999))

<table>
<thead>
<tr>
<th></th>
<th>DTI definition</th>
<th>Total assets definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
</tr>
<tr>
<td>MS</td>
<td>2.405***</td>
<td>0.967***</td>
</tr>
<tr>
<td></td>
<td>(0.159)</td>
<td>(0.086)</td>
</tr>
<tr>
<td>MSD</td>
<td>−2.530***</td>
<td>−1.342***</td>
</tr>
<tr>
<td></td>
<td>(0.305)</td>
<td>(0.186)</td>
</tr>
<tr>
<td>Solvency</td>
<td>−0.177***</td>
<td>−0.188***</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>SolvencyD</td>
<td>0.193***</td>
<td>0.141***</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>Quiscore</td>
<td>0.656***</td>
<td>0.712***</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>QuiscoreD</td>
<td>−0.182***</td>
<td>−0.097***</td>
</tr>
<tr>
<td></td>
<td>(0.028)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Age</td>
<td>−0.646***</td>
<td>−0.676***</td>
</tr>
<tr>
<td></td>
<td>(0.097)</td>
<td>(0.059)</td>
</tr>
<tr>
<td>AgeD</td>
<td>0.042*</td>
<td>0.018*</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>Sales</td>
<td>4.054***</td>
<td>−2.395***</td>
</tr>
<tr>
<td></td>
<td>(0.711)</td>
<td>(0.560)</td>
</tr>
<tr>
<td>SalesD</td>
<td>−0.956</td>
<td>3.927***</td>
</tr>
<tr>
<td></td>
<td>(0.641)</td>
<td>(0.510)</td>
</tr>
<tr>
<td>Constant</td>
<td>−14.000**</td>
<td>54.477***</td>
</tr>
<tr>
<td></td>
<td>(5.473)</td>
<td>(4.962)</td>
</tr>
<tr>
<td>D</td>
<td>35.469***</td>
<td>−21.945***</td>
</tr>
<tr>
<td></td>
<td>(5.284)</td>
<td>(4.640)</td>
</tr>
</tbody>
</table>

Observations 19,960 36,665 36,018 17,295 35,107 43,354
No. of id 4889 7446 5375 4133 7436 6461
$R^2$ 0.13 0.18 0.23 0.15 0.17 0.21

Notes: Monetary stance (MS) represents the level of base rates. $D$ represents a dummy variable for the loose monetary period. The coefficients referring to the tight monetary period are given by the non-interacted variables. The impact on the dependent variable when monetary policy is loose is given by the sum of the coefficients associated with a given variable and with the variable interacted with the period dummy. Standard errors in parentheses.

*Indicates significance at 10%
**Indicates significance at 5%
***Indicates significance at 1%.
of the response is two and a half times greater for small firms than for medium firms and over four times greater for small firms relative to large firms in the tight period. Similar results are obtained when firms are classified using the total assets definitions, although the scale diminishes a little. The controls show that greater trade credit is obtained by firms with fewer shareholder funds (lower solvency), better risk assessment scores (quiscore) and higher sales. Older firms tend to take up less trade credit, possibly because they have time to forge relationships with banks. During loose periods of monetary policy, the impact of all of the variables diminishes since the summed coefficients are smaller in absolute terms than during the tight period of policy. We observe that for small firms, while trade credit increases in tight periods the position is subsequently reversed in loose periods. One interpretation of this finding is that trade credit is determined by financing decisions only in tight periods, and when policy is loose it picks up the slack in internal funds. Therefore trade credit is indeed part of the optimal financial choice when the firm is financially constrained.

In Table 5, a similar pattern emerges for trade credit scaled by total liabilities: trade credit increases significantly with monetary policy during tight periods, but this effect is almost entirely reversed in loose periods of policy. The scale differences between small and medium/large firms are not so great in this table as they were in Table 4. The main difference here is that all firms increase the ratio of trade credit to total liabilities when solvency improves, but this is likely to be because greater funds can be used to reduce liabilities.

In Table 6, bank loans relative to total liabilities decline for small firms with an increase in the base rate when monetary policy is tight, there is a more moderate decline for medium sized firms and, by contrast, there is an increase in bank loans to large firms with an increase in the base rate when credit conditions are tight. This could be explained by the fact that large firms, which are usually borrowers on the capital market, find that tight monetary policy produces a flight-to-quality effect on all credit markets such that some of these former capital market borrowers need to resort to bank finance. When monetary policy is relaxed bank lending increases relative to total liabilities, and thus the effect of the monetary stance is more than reversed for small firms compared to the tight monetary policy period. This provides compelling evidence for a bank lending channel that differentially and adversely affects small firms. For medium and large firms the positive responses in the loose period of policy are virtually indistinguishable. The distinctive response of small firms is consistent with our predictions.

These results support our third prediction and confirm that UK manufacturing firms, especially small firms with few assets, resort to trade credit when monetary policy tightens. The prediction of our model is upheld after we have conditioned for other factors that might explain the response to a change in monetary conditions, such as solvency, age, credit rating, and sales. Our findings that trade credit is taken up during tight periods of monetary policy and bank loans are reduced may indicate substitution of one type of finance for another. To confirm this view we follow Atanasova and Wilson (2004) in exploring the relationship between bank loans and trade credit. Their paper takes the bank loans–total asset ratio as the dependent
variable and evaluates the impact of the trade credit–total asset ratio in a disequilibrium model for a panel of UK firms over an almost identical sample period. Since we are interested in the uptake of trade credit, we refer to trade credit as the dependent variable and scale this by total liabilities. Our results in Table 7 show a significant and negative sign on the bank lending–total liabilities ratio which is greater during the tight policy period, when more firms might be expected to be

Table 5
Trade credit/total liabilities × 100 (response of trade credit ratio to tight monetary policy (1990–1992) versus loose monetary policy (1993–1999))

<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS</td>
<td>1.647*** (0.111)</td>
<td>1.413*** (0.059)</td>
<td>1.399*** (0.048)</td>
<td>1.652*** (0.122)</td>
<td>1.415*** (0.063)</td>
<td>1.413*** (0.045)</td>
</tr>
<tr>
<td>MSD</td>
<td>−1.631*** (0.211)</td>
<td>−1.587*** (0.126)</td>
<td>−1.300*** (0.104)</td>
<td>−1.711*** (0.228)</td>
<td>−1.571*** (0.134)</td>
<td>−1.360*** (0.097)</td>
</tr>
<tr>
<td>Solvency</td>
<td>0.083*** (0.017)</td>
<td>0.238*** (0.012)</td>
<td>0.344*** (0.009)</td>
<td>0.042*** (0.019)</td>
<td>0.226*** (0.013)</td>
<td>0.317*** (0.008)</td>
</tr>
<tr>
<td>SolvencyD</td>
<td>0.136*** (0.018)</td>
<td>0.020*** (0.012)</td>
<td>−0.074*** (0.009)</td>
<td>0.156*** (0.020)</td>
<td>0.039*** (0.013)</td>
<td>−0.059*** (0.008)</td>
</tr>
<tr>
<td>Quiscore</td>
<td>0.106*** (0.018)</td>
<td>0.067*** (0.012)</td>
<td>−0.001*** (0.009)</td>
<td>0.139*** (0.021)</td>
<td>0.064*** (0.012)</td>
<td>0.017*** (0.008)</td>
</tr>
<tr>
<td>QuiscoreD</td>
<td>−0.151*** (0.020)</td>
<td>−0.092*** (0.013)</td>
<td>−0.020*** (0.010)</td>
<td>−0.176*** −0.101***</td>
<td>−0.034*** (0.023)</td>
<td>−0.009*** (0.014)</td>
</tr>
<tr>
<td>Age</td>
<td>−0.415*** (0.066)</td>
<td>−0.495*** (0.040)</td>
<td>−0.505*** (0.032)</td>
<td>−0.307*** −0.459***</td>
<td>−0.545*** (0.073)</td>
<td>−0.452*** (0.042)</td>
</tr>
<tr>
<td>AgeD</td>
<td>0.030*** (0.015)</td>
<td>0.009*** (0.007)</td>
<td>0.006*** (0.005)</td>
<td>0.011*** 0.018***</td>
<td>0.007*** (0.017)</td>
<td>0.008*** (0.008)</td>
</tr>
<tr>
<td>Sales</td>
<td>3.532*** (0.489)</td>
<td>0.730*** (0.380)</td>
<td>2.775*** (0.204)</td>
<td>3.516*** 4.045***</td>
<td>4.184*** (0.520)</td>
<td>3.277*** (0.327)</td>
</tr>
<tr>
<td>SalesD</td>
<td>−0.417*** (0.438)</td>
<td>1.957*** (0.345)</td>
<td>−0.804*** (0.114)</td>
<td>−0.087*** 0.379***</td>
<td>−0.923*** (0.446)</td>
<td>0.397*** (0.294)</td>
</tr>
<tr>
<td>Constant</td>
<td>−12.082*** (3.781)</td>
<td>13.008*** (3.363)</td>
<td>−8.621*** (2.347)</td>
<td>−12.532*** −15.565***</td>
<td>−22.689*** (4.005)</td>
<td>(2.988) (1.855)</td>
</tr>
</tbody>
</table>

Observations 20,516 37,120 36,353 17,799 35,692 43,811
No. of id 4960 7483 5388 4210 7500 6486
R² 0.05 0.11 0.21 0.04 0.10 0.20

Notes: Monetary stance (MS) represents the level of base rates. D represents a dummy variable for the loose monetary period. The coefficients referring to the tight monetary period are given by the non-interacted variables. The impact on the dependent variable when monetary policy is loose is given by the sum of the coefficients associated with a given variable and with the variable interacted with the period dummy. Standard errors in parentheses.

*Indicates significance at 10%
**Indicates significance at 5%
***Indicates significance at 1%.
financially constrained, than during the loose period. Table 7 shows direct evidence of substitution (through the negative coefficient), and is entirely consistent with the reported result in Atanasova and Wilson (2004) where there was also a significant negative relationship between bank lending and trade credit.

By evaluating the responses of trade credit and bank loans when interest rates take their mean values during tight and loose periods of monetary policy it is possible to determine the effect at the mean of the monetary policy stance. We report the figures

Table 6

<table>
<thead>
<tr>
<th></th>
<th>DTI definition</th>
<th>Total assets definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
</tr>
<tr>
<td>MS</td>
<td>−1.516***</td>
<td>−0.037</td>
</tr>
<tr>
<td></td>
<td>(0.117)</td>
<td>(0.065)</td>
</tr>
<tr>
<td>MSD</td>
<td>1.758***</td>
<td>0.342**</td>
</tr>
<tr>
<td></td>
<td>(0.222)</td>
<td>(0.141)</td>
</tr>
<tr>
<td>Solvency</td>
<td>0.238***</td>
<td>0.306**</td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>SolvencyD</td>
<td>−0.101***</td>
<td>−0.069***</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>Quiscore</td>
<td>−0.656***</td>
<td>−0.720***</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>QuiscoreD</td>
<td>0.073***</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.014)</td>
</tr>
<tr>
<td>Age</td>
<td>0.548***</td>
<td>0.536***</td>
</tr>
<tr>
<td></td>
<td>(0.070)</td>
<td>(0.045)</td>
</tr>
<tr>
<td>AgeD</td>
<td>−0.030***</td>
<td>−0.020**</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Sales</td>
<td>−1.209**</td>
<td>3.450***</td>
</tr>
<tr>
<td></td>
<td>(0.514)</td>
<td>(0.424)</td>
</tr>
<tr>
<td>SalesD</td>
<td>0.565</td>
<td>−3.116***</td>
</tr>
<tr>
<td></td>
<td>(0.460)</td>
<td>(0.386)</td>
</tr>
<tr>
<td>Constant</td>
<td>66.302***</td>
<td>11.392***</td>
</tr>
<tr>
<td></td>
<td>(3.975)</td>
<td>(3.758)</td>
</tr>
<tr>
<td>D</td>
<td>−21.293***</td>
<td>25.422***</td>
</tr>
<tr>
<td></td>
<td>(3.813)</td>
<td>(3.515)</td>
</tr>
</tbody>
</table>

Notes: Monetary stance (MS) represents the level of base rates. D represents a dummy variable for the loose monetary period. The coefficients referring to the tight monetary period are given by the non-interacted variables. The impact on the dependent variable when monetary policy is loose is given by the sum of the coefficients associated with a given variable and with the variable interacted with the period dummy. Standard errors in parentheses.

*Indicates significance at 10%
**indicates significance at 5%
***indicates significance at 1%.
in Table 8 calculated from coefficients on the MS and MSD variables reported in Tables 5 and 6, which indicate the response to monetary stance after we have conditioned for other controls. Our table of figures gives the magnitude of the change in the trade credit–total liabilities ratio and the bank loans–total liabilities ratio when interest rates take their average values for tight and loose periods, respectively (reported in rows 1 and 2 for Table 5 and rows 3 and 4 for Table 6). We evaluate the response to interest rates for small, medium and large firms and report

<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank</td>
<td>−0.431***</td>
<td>−0.373***</td>
<td>−0.243***</td>
</tr>
<tr>
<td>(0.011)</td>
<td>(0.007)</td>
<td>(0.006)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>BankD</td>
<td>0.120***</td>
<td>0.109***</td>
<td>0.070***</td>
</tr>
<tr>
<td>(0.012)</td>
<td>(0.008)</td>
<td>(0.006)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>Solvency</td>
<td>0.204***</td>
<td>0.334***</td>
<td>0.405***</td>
</tr>
<tr>
<td>(0.017)</td>
<td>(0.011)</td>
<td>(0.009)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>SolvencyD</td>
<td>0.065***</td>
<td>−0.010</td>
<td>−0.085***</td>
</tr>
<tr>
<td>(0.017)</td>
<td>(0.011)</td>
<td>(0.009)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Quiscore</td>
<td>−0.197***</td>
<td>−0.186***</td>
<td>−0.169***</td>
</tr>
<tr>
<td>(0.019)</td>
<td>(0.012)</td>
<td>(0.010)</td>
<td>(0.022)</td>
</tr>
<tr>
<td>QuiscoreD</td>
<td>−0.036**</td>
<td>−0.030**</td>
<td>0.020**</td>
</tr>
<tr>
<td>(0.020)</td>
<td>(0.013)</td>
<td>(0.011)</td>
<td>(0.023)</td>
</tr>
<tr>
<td>Age</td>
<td>−0.357***</td>
<td>−0.593***</td>
<td>−0.616***</td>
</tr>
<tr>
<td>(0.060)</td>
<td>(0.037)</td>
<td>(0.030)</td>
<td>(0.067)</td>
</tr>
<tr>
<td>AgeD</td>
<td>0.010</td>
<td>0.001</td>
<td>−0.001</td>
</tr>
<tr>
<td>(0.014)</td>
<td>(0.007)</td>
<td>(0.005)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>Sales</td>
<td>3.454***</td>
<td>2.505***</td>
<td>2.832***</td>
</tr>
<tr>
<td>(0.457)</td>
<td>(0.361)</td>
<td>(0.200)</td>
<td>(0.488)</td>
</tr>
<tr>
<td>SalesD</td>
<td>−0.171</td>
<td>0.851***</td>
<td>−0.771***</td>
</tr>
<tr>
<td>(0.410)</td>
<td>(0.329)</td>
<td>(0.112)</td>
<td>(0.420)</td>
</tr>
<tr>
<td>Constant</td>
<td>28.203***</td>
<td>36.955***</td>
<td>25.001***</td>
</tr>
<tr>
<td>(3.358)</td>
<td>(3.112)</td>
<td>(2.214)</td>
<td>(3.567)</td>
</tr>
<tr>
<td>D</td>
<td>−2.363</td>
<td>−10.917***</td>
<td>4.376***</td>
</tr>
<tr>
<td>(3.139)</td>
<td>(2.844)</td>
<td>(1.302)</td>
<td>(3.285)</td>
</tr>
</tbody>
</table>

**Notes:** Monetary stance (MS) represents the level of base rates. D represents a dummy variable for the loose monetary period. The coefficients referring to the tight monetary period are given by the non-interacted variables. The impact on the dependent variable when monetary policy is loose is given by the sum of the coefficients associated with a given variable and with the variable interacted with the period dummy. Standard errors in parentheses.

*Indicates significance at 10%
**indicates significance at 5%
***indicates significance at 1%.
the findings for DTI and total asset based definitions of size. Row 1 shows that all types of firms increase their trade credit–total liabilities ratio in tight periods of policy and the magnitudes of the responses are not greatly different; this contrasts with the loose period when the response in row 2 is negligible. Contrasting these results with the responses in rows 3 and 4 shows that small firms reduce their bank loans–total liabilities ratio in tight periods, while large firms continue to see the ratio increase, but in loose periods all firms increase their bank loan–total liability ratio. Inspection of the magnitudes implies that small firms increase their trade credit–total liability ratio by almost exactly the same amount as their bank loan–total liability ratio falls in tight periods. This offers further evidence that these firms substitute one form of finance for the other.

In our model we cannot define exactly what the cut-off values for the critical wealth levels might be when we attempt to determine the access to sources of finance for different types. The significant difference in the responses of small firms compared to medium and large firms to a tightening of monetary policy suggests that the cut-off for bank loans occurs somewhere between the size of small firms (less than £1.4m) and medium-sized firms (less than £5.6m). Small firms experience far less bank loans and more trade credit in tight periods of monetary policy than medium and large firms. This confirms that the composition of corporate finance changes significantly between tight and loose periods of monetary policy and that the responses are significantly different for small firms compared to medium and large firms.

9. Conclusions

The paper analyzes the channel of monetary policy transmission when trade credit is included among the sources of external finance. Due to imperfections in the credit
market, banks observe firms’ returns at a cost and, therefore, charge their clients higher interest rates proportional to the amount that they lend. Since sellers have an information advantage over banks, they may have incentives to ameliorate credit conditions for borrowers and at the same time increase their profits. The credit market equilibrium in our model is characterized by high wealth firms borrowing from banks, intermediate wealth level firms taking trade credit, and low wealth level firms not running their projects. In this framework, we examine the consequences of a monetary policy change. We predict that a monetary tightening causes two main results: (a) a decrease in bank loans relative to trade credit if the outflows of firms seeking funds at the lower end of the wealth spectrum exceeds the inflows from the upper end; (b) a flight-to-quality effect for bank borrowers. The results are consistent with the existing empirical literature that has identified a wider use of trade credit over periods of monetary tightening.

When we examine the evidence using panel data from 16,000 manufacturing firms in the UK we find that all our predictions are upheld. Bank loans decline in absolute and relative terms and trade credit increases. When we separate small firms from medium and large firms, and compare the responses over tight and loose monetary policy we find that it is the small (financially weaker firms) that are excluded from bank loans and these firms resort to trade credit. This is the case even when we take into account the effects of solvency, age, credit rating, sales and demand side effects. The magnitudes of the responses of small firms are many multiples of the responses of medium and large firms, which show practically identical responses. This suggests that the cut-off for bank loans (when asset levels are used to proxy firm size) occurs somewhere between the small and medium firm size.

The model suggests that financially constrained firms that are excluded from bank loans can still receive credit from other firms. This implies that the influence of a given increase in interest rates should have a more muted effect than if there is no alternative to bank finance. The existence of trade credit weakens the influence of the credit channel to some degree, although it is more expensive than bank loans and is typically only held for the short term.

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