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Credit channel, trade credit channel, and inventory investment: Evidence from a panel of UK firms

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Abstract

In this paper, we use a panel of 609 UK firms over the period 1980–2000 to test for the existence of a trade credit channel of transmission of monetary policy, and for whether this channel plays an offsetting effect on the traditional credit channel. We estimate error-correction inventory investment equations augmented with the coverage ratio and the trade credit to assets ratio, differentiating the effects of the latter variables across firms more or less likely to face financing constraints, and firms making a high or low use of trade credit. Our results suggest that both the credit and the trade credit channels operate in the UK, and that the latter channel tends to weaken the former.

JEL classification: D92; E22; G32

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1. Introduction

According to the credit channel, monetary policy is transmitted to the real economy through its effects on bank loans (bank lending channel) and firms' balance sheet variables

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(balance sheet channel). In the case of a tightening in monetary policy, for instance, bank loans supplies to firms are reduced. This diminishes the ability of those firms that are more bank-dependent to carry out desired investment and employment plans. Similarly, a tightening in monetary policy is associated with a rise in borrowers' debt-service burdens, a reduction in the present value of their collateralizable resources, and a reduction in their cash flow and net worth. Once again, this makes it more difficult and/or more costly for firms for which asymmetric information issues are more relevant to obtain loans, forcing them to reduce their activities (Mishkin, 1995; Bernanke and Gertler, 1995).

A number of studies have estimated regressions of firms' investment in fixed capital or inventories on their cash flow, coverage ratio,[1] stock of liquidity, or other balance sheet variables, on various sub-samples of firms. These types of regressions can be seen as indirect tests for the existence of a credit channel of transmission of monetary policy. In fact, if a firm's activity is strongly affected by financial variables, then, in periods of tight monetary policy, when all firms' financial situations become worse, this firm will have to contract its activity. Furthermore, if the credit channel were operative, one would expect financial variables to mainly affect the behavior of those firms which are relatively more constrained in credit markets (namely more bank-dependent firms, which are typically smaller, younger, and less collateralized), and this effect to be stronger in periods of recession and tight monetary policy.

The majority of the above mentioned studies have found a positive correlation between financial variables and firms' activities, generally stronger for firms facing tighter financing constraints (see for instance Fazzari et al., 1988; Kashyap et al., 1994; Carpenter et al., 1994, 1998; Guariglia, 1999, 2000, etc.). Yet, other authors, who have mainly focused on firms' investment behavior, have found that the sensitivity of investment to cash flow is in fact weaker for firms likely to face particularly strong financing constraints (Kaplan and Zingales, 1997; Cleary, 1999). The latter findings cast a cloud over the existence and the actual strength of a credit channel.[2]

One argument which could be put forward to explain why some firms exhibit a low sensitivity of investment to financial variables is that, particularly in periods when bank lending is rationed, or, more in general, when external finance becomes more difficult to obtain and/or more costly, these firms make use of another source of finance to overcome liquidity shortages, namely trade credit.

Trade credit (i.e. accounts payable) is given by short-term loans provided by suppliers to their customers upon purchase of their products. It is automatically created when the customers delay payment of their bills to the suppliers. Trade credit is typically more

[1] The coverage ratio is defined as the ratio between the firm's total profits before tax and before interest and its total interest payments. It indicates the availability of internal funds that firms can use to finance their real activities and can also be thought of as a proxy for the premium that firms have to pay for external finance (Guariglia, 1999).

[2] Another challenge to the idea that the relationship between investment and cash flow stems from financing constraints comes from Bond and Cummins (2001), Bond et al. (2004), and Oliner et al. (in press) who estimated Q-models of investment augmented with cash flow, where firms' investment opportunities are more accurately controlled for than in traditional models, and found that the coefficients associated with cash flow were poorly determined for all types of firms. They therefore concluded that cash flow attracted a positive coefficient in studies such as Fazzari et al. (1988) simply because it proxied for investment opportunities, which were not properly captured by the traditionally used measures of Q. This conclusion is challenged by Carpenter and Guariglia (2003).

expensive than bank credit, especially because customers generally do not use the early payment discount (Petersen and Rajan, 1997).[3] Yet, according to Berger and Udell (1998), in 1993, 15.78% of the total assets of small US businesses were funded by trade credit. Similarly, Rajan and Zingales (1995) document that in 1991, funds loaned to customers represented 17.8% of total assets for US firms, 22% for UK firms, and more than 25% for countries such as Italy, France, and Germany. Finally, according to Kohler et al. (2000), 55% of the total short-term credit received by UK firms during the period 1983–1995 took the form of trade credit.

It is therefore possible, that even in periods of tight monetary policy and recession, when bank loans are harder to obtain and/or more costly, financially constrained firms are not forced to reduce their real activities too much as they can finance them with trade credit (we will refer to this phenomenon as the trade credit channel hereafter). Trade credit issuance can increase in periods of tight money because the risks of issuing trade credit are always lower than those of issuing bank loans: suppliers can in fact closely monitor their clients during the normal course of business; they can threaten to cut off future supplies to enforce repayment; and can easily repossess goods in case of failed payment (Petersen and Rajan, 1997; Kohler et al., 2000). The presence of a trade credit channel could therefore weaken the relationship between firms' real activities and traditionally used financial variables, such as the coverage ratio and cash flow, and more in general, could weaken the credit channel of transmission of monetary policy.

Although the hypothesis that a trade credit channel might weaken the traditional credit channel was first suggested in 1960 by Meltzer, recent empirical tests of the hypothesis are limited. Using US data, Nilsen (2002) shows that during contractionary monetary policy episodes, small firms and those large firms lacking a bond rating or sufficient collateralizable assets increase their trade credit finance. Similarly, Choi and Kim (2003) find that both accounts payable and receivable increase with tighter monetary policy. Using UK data, Mateut et al. (in press) show that while bank lending typically declines in periods of tight monetary policy, trade credit issuance increases, smoothing out the impact of the policy. Focusing on net trade credit, Kohler et al. (2000) observe a similar pattern. Based on a disequilibrium model that allows for the possibility of transitory credit rationing, Atanasova and Wilson (2004) find that to avoid bank credit rationing, smaller UK companies increase their reliance on inter-firm credit. De Blasio (2003) uses Italian data and finds some weak evidence in favor of the hypothesis that firms substitute trade credit for bank credit during periods of monetary tightening. Finally, Valderrama (2003) shows that Austrian firms use trade credit to diminish their dependence on internal funds. Except for the latter two studies, which are based on continental European economies, the above listed studies generally focus on the determinants of trade credit and on its behavior over the business cycle, without looking at how trade credit actually relates to firms' real activities.

[3] A common form of trade credit contract is known as the "2/10 net 30" type. "2/10" means that the buyer gets a 2% discount for payment within 10 days. "Net 30" means that full payment is due 30 days after the invoice date. After that date, the customer is in default. The combination of a 2% discount for payment within 10 days and a net period ending on day 30 defines an implicit interest rate of 43.9%, which can be seen as the opportunity cost to the buyer to forgo the discount in exchange for 20 additional days of financing (Ng et al., 1999; Petersen and Rajan, 1997).

This paper contributes to the literature by providing, for the first time, rigorous tests of whether trade credit affects UK firms' activities and, more specifically, of whether the trade credit channel of transmission of monetary policy plays an offsetting effect on the traditional credit channel in the UK (this hypothesis will be referred to as the offsetting hypothesis hereafter). To perform our tests, we will make use of 609 UK manufacturing sector companies over the period 1980–2000, collected by Datastream.[4] In our econometric analysis, we will focus on the direct effect that trade credit plays on firms' inventory investment, and on the indirect effect that it has on the sensitivity of firms' inventory investment to the coverage ratio.[5] Three reasons justify our choice of inventory investment in our analysis. First, inventory investment plays a crucial role in business cycle fluctuations (Blinder and Maccini, 1991). Second, because of its high liquidity and low adjustment costs, inventory investment is likely to be more sensitive to financial variables (including trade credit) than investment in fixed capital (Carpenter et al., 1994). Third, trade credit is often related to the financing of inventories (Valderrama, 2003; Petersen and Rajan, 1997).

We will initially only focus on accounts payable as a measure of trade credit usage, considering the firms in our dataset as borrowers, and accounts payable as a form of non-bank debt (Kashyap et al., 1996). A number of studies take an approach similar to ours, focusing on accounts payable (Fisman and Love, 2003; Mateut et al., in press; Nilsen, 2002; Valderrama, 2003). Yet, other authors also consider the role played by trade credit extended (Choi and Kim, 2003; De Blasio, 2003; Kohler et al., 2000). When bank lending is constrained, firms can in fact find additional financial resources either by relying more on trade credit received or by extending less trade credit to other firms. For this reason, we also verify whether our results are robust to replacing trade credit with net trade credit, intended as the difference between accounts payable and accounts receivable.

Our results suggest that both the trade credit channel and the credit channel operate in the UK, and that there is evidence that the former channel weakens the latter. We find in fact that when trade credit is added as a regressor to an inventory investment equation which already includes the coverage ratio, it generally affects the inventory investment at both financially constrained and unconstrained firms. Yet, the coverage ratio variable remains significant for the former firms. Furthermore, we find that when the effect of the coverage ratio at financially constrained firms is further differentiated across constrained firms making a high and low use of trade credit, the coverage ratio only affects inventory investment at the latter firms. This suggests that using trade credit can help firms to offset liquidity problems. Finally, although net trade credit does not seem to directly affect inventory investment, it is still evident that the coverage ratio ceases to affect the inventory investment of those constrained firms experiencing a net increase in funding via trade credit. The finding that a strong trade credit channel, able to weaken the credit

[4] These companies are all traded on the London Stock Exchange. Datastream has been widely used to test whether financial variables affect firms' activities in the UK, and more in general to test for the presence of a credit channel of transmission of monetary policy (see for instance Blundell et al., 1992; Bond et al., 2004; Bond and Meghir, 1994; Carpenter and Guariglia, 2003; Guariglia, 1999, 2000, etc.).

[5] We include the coverage ratio in our regressions as this variable has been widely used in the literature on the effects of financing constraints on firms' activities (see Carpenter et al., 1998; Gertler and Gilchrist, 1994; Guariglia, 1999, 2000; Whited, 1992). All our results were generally robust to replacing the coverage ratio with the ratio of cash flow to the beginning-of-period replacement value of the capital stock in our regressions.

channel, operates in the UK is important as this channel is likely to dampen the effects of contractionary monetary policies, and more in general to make the recessions that generally follow these policies less severe.

The remainder of this paper is organized as follows. In Section 2, we describe our data and present some descriptive statistics. Section 3 illustrates our baseline specification, our tests of the offsetting hypothesis, and our econometric methodology. Section 4 presents our main empirical results. Section 5 discusses the results based on net trade credit, and Section 6 concludes the paper.

2. Main features of the data and summary statistics

2.1. The dataset

The data used in this paper consist of UK quoted company balance sheets collected by Datastream. We only consider the manufacturing sector. Inventory investment includes investment in finished goods, raw materials, and work-in-process.

The dataset that we use in estimation includes a total of 3283 annual observations on 609 companies for the years 1982–2000. The sample has an unbalanced structure, with the number of years of observations on each firm varying between 2 and 19. By allowing for both entry and exit, the use of an unbalanced panel partially mitigates potential selection and survivor bias. We excluded companies that changed the date of their accounting year-end by more than a few weeks, so that the data refer to 12 month accounting periods. Firms that did not have complete records on inventory investment, sales, the coverage ratio, trade credit, and total assets were also dropped.[6] Finally, to control for the potential influence of outliers, we truncated the sample by removing observations beyond the 1st and 99th percentiles for each of the regression variables. These types of sample selection rules are common in the literature and we employ them to ensure comparability with previous work.

2.2. Sample separation criteria

To test whether financial and trade credit variables have a different impact on the inventory investment of different types of firms, we initially partition firms according to whether they are more or less likely to face financing constraints. In particular, we generate a dummy variable, CONSTRAINED_{it}, which is equal to 1 if firm i is financially constrained in year t, and 0 otherwise. We then interact the financial and trade credit variables in our inventory investment equations with CONSTRAINED_{it} and $(1 - \text{CONSTRAINED}_{it})$ to gauge the extent to which the effects of the former variables on inventory investment differ for constrained and healthy firms. This procedure allows firms to transit between classes.[7]

[6] These are the variables included in our main regressions. Complete definitions of all variables can be found in Appendix.

[7] For this reason, our empirical analysis will focus on firm-years rather than simply firms. See Bond and Meghir (1994), Carpenter and Guariglia (2003), Guariglia (2000), and Kaplan and Zingales (1997), for a similar approach.

We use three criteria to determine whether a firm-year is more or less likely to face financing constraints. Our first criterion is an indicator of the firm's bank-dependence, called the "mix". It is defined as the ratio of the firm's short-term bank borrowing to its total short-term borrowing.[8] It was introduced by Kashyap et al. (1993, 1996) and Oliner and Rudebusch (1996) in their tests for the presence of a bank lending channel of transmission of monetary policy, and subsequently used by Huang (2003). The higher the mix, the more bank-dependent a firm is, and the more likely it is to be affected by a tightening in monetary policy via the bank lending and balance sheet channels. We create an interaction dummy variable associated with the mix, $BANKDEP_{it}$, equal to 1 if firm i's mix is in the highest quartile of the distribution of the mixes of all firms belonging to the same industry as firm i in year t, and 0 otherwise.[9]

Our second criterion is based on the firm's ratio of tangible assets to total assets. The higher this ratio, the more collateralized the firm i's, and the less likely it is to face financing constraints. Assets that are more tangible sustain in fact more external financing because tangibility increases the value that can be recaptured by creditors in case of borrower's default (Carpenter and Petersen, 2002; Nilsen, 2002; Almeida and Campello, 2004; Braun and Larrain, 2005). We define a dummy variable, $LOWCOLL_{it}$, equal to 1 if firm i is financially constrained in year t, following this new criterion. More specifically, $LOWCOLL_{it}$ is equal to 1 if firm i's ratio of tangible assets to total assets in year t falls in the lowest quartile of the distribution of the corresponding ratios of all the firms operating in the same industry as firm i in year t, and 0 otherwise.

Our third criterion is based on the firm's total real assets. In particular, we define a dummy variable $SMALL_{it}$, equal to 1 if firm i's total real assets in year t fall in the lowest quartiles of the distribution of the real assets of all the firms operating in the same industry as firm i in year t, and 0 otherwise. As our sample is made up of quoted, and therefore relatively large firms, this criterion is likely to be less informative than the previous two to determine whether a firm is financially constrained or not. We have decided to report it anyway in order to ensure comparability with previous studies on inventory investment and financial constraints (e.g. Carpenter et al., 1994, 1998; Benito, 2005, etc.).

In order to verify whether the effects of financial variables on inventory investment are different for firms that make a high or low use of trade credit, we construct two additional interaction dummies. The first one, $HIGHTC_{it}$, is equal to 1 if the ratio of trade credit to total beginning-of-period assets for firm i in year t is in the highest quartile of the distribution of the corresponding ratios of all the firms in that particular industry and year, and 0 otherwise. The ratio of a firm's trade credit to total assets can be interpreted as the percentage of the firm's total assets which is financed by trade credit.[10] The second interaction

[8] Total short-term borrowing includes bank overdrafts, loans, and other short-term borrowing. The current portion of long-term debt is also included.

[9] Firms are allocated to one of the following industrial sectors: metals, metal goods, other minerals, and mineral products; chemicals and man made fibres; mechanical engineering; electrical and instrument engineering; motor vehicles and parts, other transport equipment; food, drink, and tobacco; textiles, clothing, leather, footwear, and others (Blundell et al., 1992).

[10] See Fisman and Love (2003) for a discussion of why it is appropriate to deflate trade credit using the firm's total assets. Also note that out of the 3283 observations in our sample, only 22 are characterized by a value of 0 for trade credit. This suggests that almost all the firm-years in our sample make use of trade credit. All our results were robust to dropping observations with trade credit equal to 0.

dummy, HIGHTC1_{it}, is constructed in the same way but focuses on the ratio between the firm's trade credit and the sum of its short-term debt and trade credit, which indicates the percentage of the firm's total short-term finance that comes from trade credit.

2.3. Descriptive statistics

Table 1 reports descriptive statistics. Column 1 refers to the full sample; columns 2–7, to the sub-samples based on the level of financing constraints faced by firms; and columns 8–11, to the sub-samples based on their degree of trade credit usage.

Columns 2 and 3 report descriptive statistics relative to the less and more bank-dependent firm-years. We can see that the latter are smaller both in terms of number of employees and assets. Moreover, they display lower sales growth and inventory investment, a slightly lower net trade credit to assets ratio, and a slightly lower tangible assets to total assets ratio compared to their less bank-dependent counterparts.

Comparing firm-years with relatively high and low collateral (columns 4 and 5) shows that the latter display lower levels of total assets, number of employees, and the mix, but higher sales growth, inventory investment, trade credit to assets ratio, and trade debt to assets ratio than the former. There do not seem to be significant differences between the ratio of trade credit to the sum of trade credit and short-term debt between firm-years with different levels of collateral.

Columns 6 and 7 show that larger firm-years display higher sales growth and inventory investment, and a higher ratio of tangible assets to total assets compared to small firm-years. Although a higher percentage of their total short-term finance comes from trade credit, the former firm-years display a lower trade credit to assets ratio. Finally, all firm-years in our sample display a negative average net trade credit to assets ratio, indicating that they are all net extenders of trade credit.

Columns 8–11 of Table 1 focus on divisions based on trade credit usage. Columns 8 and 9 refer respectively to firm-years with a relatively low and a relatively high ratio of trade credit to total assets. By comparing the two columns, we can see that the latter firm-years are generally smaller, and display a much higher sales growth, and inventory investment. Furthermore, they tend to exhibit a higher trade credit to short-term debt plus trade credit ratio, to extend more trade credit to other firms, and to make less use of short-term and total bank debt compared to firm-years with a lower trade credit to assets ratio. When comparing firm-years according to their trade credit to short-term debt plus trade credit ratios (columns 10 and 11), we can see that the pattern is similar.

The fact that those firm-years characterized by a relatively high use of trade credit are generally smaller, and therefore more likely to face financing constraints can be seen as very preliminary evidence in favor of the offsetting hypothesis. In the sections that follow, we formally test whether the trade credit channel plays a statistically significant effect in offsetting the credit channel.

3. Baseline specification, tests of the offsetting hypothesis, and estimation methodology

3.1. Baseline specification

The baseline specification that we use is a variant of Lovell's target adjustment model (1961). Let I and S denote the logarithms of inventories and sales; and let COV denote the

Table 1
Descriptive statistics

	All firm-years (1)	Firm-years such that $BANKDEP_{it}=0$ (2)	Firm-years such that $BANKDEP_{it}=1$ (3)	Firm-years such that $LOWCOLL_{it}=0$ (4)	Firm-years such that $LOWCOLL_{it}=1$ (5)	Firm-years such that $SMALL_{it}=0$ (6)	Firm-years such that $SMALL_{it}=1$ (7)	Firm-years such that $HIGHTC_{it}=0$ (8)	Firm-years such that $HIGHTC_{it}=1$ (9)	Firm-years such that $HIGHTC1_{it}=0$ (10)	Firm-years such that $HIGHTC1_{it}=1$ (11)
Emp_{it}	4354.971	5323.069	2326.690	4690.187	3222.324	5179.720	345.022	4968.450	1885.974	4732.682	3192.165
	(8901.97)	(10405.33)	(4349.04)	(9414.08)	(6779.64)	(9567.39)	(356.76)	(9709.88)	(3340.44)	(9403.10)	(7020.43)
A_{it}	2879.730	3590.781	1406.517	2944.182	2662.053	3445.700	121.764	3345.504	1000.203	3198.461	1895.352
	(6551.37)	(7624.21)	(3141.36)	(6569.72)	(6488.66)	(7060.34)	(77.19)	(7163.55)	(2156.91)	(6962.33)	(4952.14)
ΔI_{it}	0.023	0.026	0.022	0.020	0.033	0.030	−0.012	−0.007	0.144	0.023	0.023
	(0.25)	(0.26)	(0.23)	(0.24)	(0.27)	(0.25)	(0.27)	(0.23)	(0.30)	(0.25)	(0.24)
ΔS_{it}	0.051	0.055	0.049	0.047	0.065	0.058	0.020	0.030	0.138	0.049	0.059
	(0.19)	(0.19)	(0.17)	(0.18)	(0.21)	(0.18)	(0.20)	(0.17)	(0.23)	(0.19)	(0.18)
$(I_{i(t-1)} - S_{i(t-1)})$	−1.877	−1.925	−1.767	−1.889	−1.835	−1.876	−1.882	−1.856	−1.961	−1.839	−1.994
	(0.55)	(0.58)	(0.48)	(0.54)	(0.60)	(0.553)	(0.56)	(0.56)	(0.54)	(0.540)	(0.58)
COV_{it}	18.891	16.453	17.112	18.47	20.30	19.39	16.440	18.667	19.797	10.327	45.340
	(53.60)	(51.75)	(43.78)	(53.22)	(54.89)	(55.29)	(44.43)	(50.99)	(63.08)	(27.64)	(92.02)
$STBANK_{it}/STD_{it}$	0.788	0.697	0.999	0.797	0.759	0.787	0.795	0.799	0.747	0.843	0.596
	(0.30)	(0.32)	(0.27)	(0.29)	(0.34)	(0.30)	(0.31)	(0.30)	(0.33)	(0.25)	(0.40)
$TOTBANK_{it}/TOTD_{it}$	0.687	0.621	0.871	0.693	0.667	0.678	0.733	0.690	0.676	0.737	0.525
	(0.32)	(0.31)	(0.23)	(0.31)	(0.352)	(0.32)	(0.33)	(0.32)	(0.32)	(0.28)	(0.39)
$TANG_{it}/A_{it}$	0.331	0.336	0.326	0.378	0.174	0.334	0.318	0.340	0.295	0.336	0.315
	(0.14)	(0.15)	(0.13)	(0.12)	(0.06)	(0.14)	(0.14)	(0.15)	(0.12)	(0.14)	(0.13)
$TC_{it}/A_{i(t-1)}$	0.174	0.181	0.161	0.170	0.189	0.172	0.184	0.139	0.316	0.163	0.209
	(0.10)	(0.11)	(0.09)	(0.09)	(0.13)	(0.10)	(0.11)	(0.06)	(0.11)	(0.10)	(0.11)
$TD_{it}/A_{i(t-1)}$	0.287	0.287	0.291	0.274	0.326	0.300	0.321	0.258	0.400	0.280	0.305
	(0.13)	(0.14)	(0.12)	(0.12)	(0.16)	(0.12)	(0.14)	(0.11)	(0.16)	(0.13)	(0.13)
$TC_{it}/(TC_{it} + STD_{it})$	0.664	0.666	0.611	0.665	0.657	0.670	0.632	0.637	0.770	0.580	0.921
	(0.22)	(0.21)	(0.23)	(0.22)	(0.24)	(0.22)	(0.23)	(0.23)	(0.17)	(0.19)	(0.10)
$(TC_{it} - TD_{it})/A_{i(t-1)}$	−0.112	−0.106	−0.131	−0.104	−0.137	−0.107	−0.137	−0.119	−0.084	−0.117	−0.096
	(0.10)	(0.09)	(0.10)	(0.09)	(0.12)	(0.09)	(0.12)	(0.09)	(0.13)	(0.10)	(0.10)
No. of observations	3283	1977	857	2533	750	2724	559	2631	652	2480	803

Notes: The table reports sample means. Standard deviations are presented in parentheses. The subscript i indexes firms, and the subscript t, time, where $t = 1982–2000$. $BANKDEP_{it}$ is equal to 1 if firm i's ratio of short-term bank debt to total short-term debt (the mix) is in the highest quartile of the distribution of the mixes of all firms belonging to the same industry as firm i in year t, and 0 otherwise. $LOWCOLL_{it}$ is equal to 1 if firm i's ratio of tangible assets to total assets falls in the lower quartile of the distribution of the corresponding ratios of all firms operating in the same industry as firm i in the year t, and 0 otherwise. $SMALL_{it}$ is equal to 1 if firm i's total real assets are in the lowest quartile of the distribution of the total assets of all firms belonging to the same industry as firm i in year t, and 0 otherwise. $HIGHTC_{it}$ is equal to 1 if the ratio of trade credit to total assets for firm i in year t is in the highest quartile of the distribution of the corresponding ratios of all firms belonging to the same industry as firm i in year t, and 0 otherwise. $HIGHTC1_{it}$ is constructed in the same way but focuses on the ratio between the firm's trade credit and the sum of its short-term debt and trade credit. Emp is the total number of the firm's employees; A, its total real assets; I, the logarithm of its inventory stock; ΔI, its inventory investment; S, the logarithm of its sales; ΔS, its sales growth; COV, its coverage ratio; STBANK, its short-term borrowing from banks; STD, its total short-term debt; TOTBANK, its total (short- and long-term) borrowing from banks; TOTD, its total (short- and long-term) debt; $TANG_{it}$, its tangible assets; TC, its trade credit (accounts payable); and TD, its trade debt (accounts receivable).

firm's coverage ratio. Eq. (1) gives the equation for inventory growth that we initially estimate.[11]

$$\Delta I_{it} = \beta_0 + \beta_1 \Delta S_{it} + \beta_2 \Delta S_{i(t-1)} + \beta_3 (I_{i(t-1)} - S_{i(t-1)}) + \beta_4 \mathrm{COV}_{it} + v_i + v_t + v_{jt} + e_{it}. \quad (1)$$

The subscript i indexes firms; j, industries; and t, time, where $t = 1982–2000$. The term $(I_{i(t-1)} - S_{i(t-1)})$ can be interpreted as reflecting the influence of a long-run target inventory level. Differences in the logarithms of sales are included in the regression to capture the short-run dynamics. This gives the specification an error-correction format. We expect β_1, β_2, and β_4 to be positive and β_3 to be negative.[12]

The error term in Eq. (1) is made up of four components: v_i, which is a firm-specific component; v_t, a time-specific component accounting for possible business cycle effects; v_{jt}, a time-specific component which varies across industries accounting for industry-specific shifts in inventory investment demand (see Carpenter and Guariglia, 2003, for a discussion of this effect); and e_{it}, an idiosyncratic component. We control for v_i by estimating our equation in first-differences; for v_t by including time dummies; and for v_{jt} by including industry dummies interacted with time dummies in all our specifications.

3.2. Tests for the offsetting hypothesis

In order to formally verify the extent to which the existence of a trade credit channel weakens the traditional credit channel of transmission of monetary policy, we undertake two tests. The first one consists in estimating an augmented version of Eq. (1), which includes the trade credit to beginning-of-period assets ratio among the regressors. We then verify whether the presence of trade credit in the equation reduces the significance of the coefficient associated with the coverage ratio. If both the coverage ratio and the trade credit variable enter the equation with positive coefficients, then one can conclude that there is evidence that both credit and trade credit channels are operating. If adding trade credit reduces the size and significance of the coefficient associated with the coverage ratio, then this could be seen as evidence in favor of the hypothesis that the trade credit channel actually weakens the traditional credit channel (see De Blasio, 2003, for a similar approach).

As financially constrained firm-years are more likely to be affected by financial variables (including trade credit) than unconstrained firm-years, we also perform this test differentiating the effects of the coverage ratio and trade credit variables on the inventory investment of firm-years more and less likely to face financing constraints. More specifically, we estimate equations of the following type (including and excluding the terms in trade credit):[13]

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[11] See Benito (2005), Choi and Kim (2001), Guariglia (1999), and Kashyap et al. (1994), for similar reduced-form specifications.

[12] The error-correction term, $(I_{i(t-1)} - S_{i(t-1)})$ can in fact be interpreted as a term capturing the cost of inventories being far from a target level that is proportional to sales. Therefore, if inventories are higher (lower) than the target, one would expect inventory investment to decline (rise).

[13] We also estimated more general versions of all our equations with interaction terms, which also included the interaction dummy variables in levels among the regressors. Since the latter variables were never precisely determined, we omitted them from our preferred specifications. Note that the inclusion of the dummies did not change the magnitude and significance of the coefficients associated with the other regressors.

$$\begin{aligned}\Delta I_{it} = {} & \beta_0 + \beta_1\,\Delta S_{it} + \beta_2\,\Delta S_{i(t-1)} + \beta_3(I_{i(t-1)} - S_{i(t-1)}) \\ & + \beta_{41} * \mathrm{COV}_{it} * \mathrm{CONSTRAINED}_{it} \\ & + \beta_{42} * \mathrm{COV}_{it} * (1 - \mathrm{CONSTRAINED}_{it}) \\ & + \left\{\beta_{51} * \left(\frac{\mathrm{TC_{it}}}{A_{i(t-1)}}\right) * \mathrm{CONSTRAINED}_{it}\right. \\ & \left. + \beta_{52} * \left(\frac{\mathrm{TC}_{it}}{A_{i(t-1)}}\right) * (1 - \mathrm{CONSTRAINED}_{it})\right\} + v_i + v_t + v_{jt} + e_{it},\end{aligned} \tag{2}$$

where TC_{it} denotes firm *i*'s accounts payable at time *t*; A_{it}, its total assets; and the ratio between these two variables, the percentage of the firm's total assets which is financed by trade credit, and where the dummy $\mathrm{CONSTRAINED}_{it}$ indicates in turn $\mathrm{BANKDEP}_{it}$, $\mathrm{LOWCOLL}_{it}$ and SMALL_{it}.

The second way in which we test the offsetting effect of the credit channel by the trade credit channel consists in estimating a variant of Eq. (2), in which the effect that the coverage ratio plays on firm-years' inventory accumulation is differentiated across the following three sub-categories of firm-years: financially constrained firm-years which make a relatively low use of trade credit; financially constrained firm-years which make a relatively high use of trade credit; and financially healthy firm-years. Our estimating equation takes the following form:

$$\begin{aligned}\Delta I_{it} = {} & \beta_0 + \beta_1\,\Delta S_{it} + \beta_2\,\Delta S_{i(t-1)} + \beta_3(I_{i(t-1)} - S_{i(t-1)}) \\ & + \beta_{411} * \mathrm{COV}_{it} * \mathrm{CONSTRAINED}_{it} * (1 - \mathrm{HIGHTC}(1)_{it}) \\ & + \beta_{412} * \mathrm{COV}_{it} * \mathrm{CONSTRAINED}_{it} * \mathrm{HIGHTC}(1)_{it} \\ & + \beta_{42} * \mathrm{COV}_{it} * (1 - \mathrm{CONSTRAINED}_{it}) \\ & + \beta_{51} * \left(\frac{\mathrm{TC}_{it}}{A_{i(t-1)}}\right) * \mathrm{CONSTRAINED}_{it} \\ & + \beta_{52} * \left(\frac{\mathrm{TC}_{it}}{A_{i(t-1)}}\right) * (1 - \mathrm{CONSTRAINED}_{it}) + v_i + v_t + v_{jt} + e_{it}.\end{aligned} \tag{3}$$

If the trade credit channel does play an offsetting effect on the credit channel, then one would expect the coverage ratio to only affect the inventory investment of those financially constrained firm-years that make less use of trade credit. Constrained firm-years making a higher use of trade credit should not be affected by changes in their liquidity positions as much as other firm-years, as they can use trade credit to overcome the liquidity constraints (see Valderrama, 2003, for a similar approach).[14]

3.3. Estimation methodology

We estimate all equations in first-differences, to allow for firm-specific, time-invariant effects. Given the possible endogeneity of the regressors, we use a first-difference generalized method of moments (GMM) approach.[15] Two or more lags of each of the regressors including the interaction terms are used as instruments.

[14] Valderrama (2003) estimated regressions for investment in fixed capital, not inventory investment. Furthermore, she did not interact her explanatory variables with dummies indicating high/low use of trade credit by firms, but with a variable indicating the actual share of trade credit in short-term debt.

[15] See Arellano and Bond (1991) on the application of the GMM approach to panel data.

In order to evaluate whether the model is correctly specified, we use two criteria: the Sargan test (also known as J test) and the test for second-order serial correlation of the residuals in the differenced equation ($m2$). If the model is correctly specified, the variables in the instrument set should be uncorrelated with the error term in the relevant equation. The J test is the Sargan test for overidentifying restrictions, which, under the null of instrument validity, is asymptotically distributed as a χ^2 with degrees of freedom equal to the number of instruments less the number of parameters. The $m2$ test is asymptotically distributed as a standard normal under the null of no second-order serial correlation of the differenced residuals, and provides a further check on the specification of the model and on the legitimacy of variables dated $t - 2$ as instruments in the differenced equation.[16]

4. Empirical results

4.1. First test of the offsetting hypothesis

Column 1 of Table 2 presents the estimates of Eq. (1) performed on the full sample. We can see that sales growth has a positive and significant effect on inventory accumulation whereas the coefficient associated with lagged sales growth is poorly determined. The coefficient on the error-correction term attracts the expected negative sign, and the coefficient on the coverage ratio, a positive sign, suggesting that financial factors matter in determining inventory investment. Although small, the latter coefficient (0.0007) suggests that a one standard deviation rise in the coverage ratio increases inventory investment by about 3.6%. Compared to a mean inventory growth of 2.3% over the period considered in estimation, this is quite a large effect. Neither the Sargan test nor the test of second-order autocorrelation of the residuals indicate problems with the specification of the model or the choice of the instruments.

Column 2 of Table 2 presents the estimates of Eq. (1) augmented with the trade credit to assets ratio. We can see that the latter variable attracts a positive, relatively large, and statistically significant coefficient (0.707), which suggests that if the trade credit to assets ratio increases by one standard deviation, inventory investment rises by circa 7.3%. This can be seen as evidence in favor of the presence of a trade credit channel of transmission of monetary policy. Yet, because the coefficient associated with the coverage ratio (0.0006) is still positive, statistically significant, and of similar magnitude as in column 1, we can conclude that although the trade credit channel seems to be stronger, there is no overwhelming evidence that the latter channel offsets the credit channel: both channels seem to be operating side by side. It is noteworthy that comparing the Sargan statistics in columns 1 and 2 suggests that adding the trade credit to assets ratio to Eq. (1) generally improves the specification of the model.[17]

[16] If the undifferenced error terms are i.i.d., then the differenced residuals should display first-order, but not second-order serial correlation. In our Tables, we report both the test for first-order ($m1$) and the test for second-order serial correlation of the differenced residuals ($m2$). Note that neither the J test nor the $m2$ test allow to discriminate between bad instruments and model specification.

[17] Following De Blasio (2003), we also tried to differentiate the effects of the coverage ratio and trade credit across periods of recession and tight monetary policy and other periods. These results, which are not reported for brevity but are available from the authors upon request, suggest that both our financial variables have a stronger effect on firms' inventory investment in periods of recession/tight monetary policy.

Table 2
Results of the first test of the offsetting hypothesis

Dependent variable: ΔI_{it}	Full sample		$\text{CONSTRAINED}_{it} = \text{BANKDEP}_{it}$		$\text{CONSTRAINED}_{it} = \text{LOWCOLL}_{it}$		$\text{CONSTRAINED}_{it} = \text{SMALL}_{it}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔS_{it}	1.016***	0.838***	0.994***	0.776***	1.056***	0.800***	0.969***	0.813***
	(0.12)	(0.13)	(0.10)	(0.08)	(0.10)	(0.11)	(0.09)	(0.09)
$\Delta S_{i(t-1)}$	−0.010	−0.0007	0.033	0.019	−0.010	0.004	0.004	−0.009
	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
$I_{i(t-1)} - S_{i(t-1)}$	−0.915***	−0.825***	−0.861***	−0.745***	−1.036***	−0.831***	−0.868***	−0.800***
	(0.13)	(0.13)	(0.09)	(0.08)	(0.11)	(0.11)	(0.09)	(0.09)
COV_{it}	0.0007***	0.0006***						
	(0.0002)	(0.0002)						
$\text{COV}_{it} * \text{CONSTRAINED}_{it}$			0.0009***	0.0009***	0.0012**	0.001**	0.001**	0.001**
			(0.0003)	(0.0003)	(0.0005)	(0.0004)	(0.0005)	(0.0004)
$\text{COV}_{it} * (1 - \text{CONSTRAINED}_{it})$			0.0004	0.0002	0.0003*	0.0003	0.0004**	0.0004**
			(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0002)
$(\text{TC}_{it}/A_{i(t-1)})$		0.707**						
		(0.32)						
$(\text{TC}_{it}/A_{i(t-1)}) * \text{CONSTRAINED}_{it}$				0.854***		0.690***		0.814***
				(0.28)		(0.28)		(0.33)
$(\text{TC}_{it}/A_{i(t-1)}) * (1 - \text{CONSTRAINED}_{it})$				0.972***		0.952***		0.752***
				(0.25)		(0.28)		(0.23)
Sample size	3283	3283	2834	2834	3283	3283	3283	3283
$m1$	−2.372	−2.786	−3.879	−4.706	−1.874	−3.118	−3.645	−3.929
$m2$	−0.899	−1.779	−1.389	−1.953	−1.724	−2.367	−1.207	−1.812
Sargan/Hansen (p-value)	0.220	0.370	0.383	0.602	0.294	0.126	0.362	0.619

Notes: The dummy variable CONSTRAINED_{it} indicates in turn BANKDEP_{it}, LOWCOLL_{it}, and SMALL_{it}. All specifications were estimated using a GMM first-difference specification. The figures reported in parentheses are asymptotic standard errors. Time dummies and time dummies interacted with industry dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroskedasticity. $m1$ ($m2$) is a test for first- (second-) order serial correlation in the first-differenced residuals, asymptotically distributed as $N(0, 1)$ under the null of no serial correlation. The J statistic is a test of the overidentifying restrictions, distributed as χ^2 under the null of instrument validity. Instruments in column (1) are $(I_{i(t-2)} - S_{i(t-2)})$; $\Delta S_{i(t-2)}$; $\text{COV}_{i(t-2)}$ and further lags. Instruments in column (2) also include $\text{TC}_{i(t-2)}/A_{i(t-3)}$ and further lags. Instruments in columns (3), (5), and (7) are $(I_{i(t-2)} - S_{i(t-2)})$; $\Delta S_{i(t-2)}$; $\text{COV}_{i(t-2)} * (\text{CONSTRAINED}_{i(t-2)})$; $\text{COV}_{i(t-2)} * (1 - \text{CONSTRAINED}_{i(t-2)})$ and further lags. Instruments in columns (4), (6), and (8) also include $(\text{TC}_{i(t-2)}/A_{i(t-3)}) * (\text{CONSTRAINED}_{i(t-2)})$; $(\text{TC}_{i(t-2)}/A_{i(t-3)}) * (1 - \text{CONSTRAINED}_{i(t-2)})$ and further lags. Time dummies and time dummies interacted with industry dummies were always included in the instrument set. Also see notes to Table 1.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Columns 3–8 of Table 2 present the estimates of two versions of Eq. (2): excluding and including the trade credit to assets ratio variables. In columns 3 and 4, the mix is used to partition firm-years into financially constrained and healthy; in columns 5 and 6, the ratio of the firm's tangible assets to its total assets is used; and in columns 7 and 8, the level of the firm's total real assets.[18] The results in column 3, which exclude the trade credit variables, show that the estimated effect of the coverage ratio on inventory investment is significant only at bank-dependent firm-years. Furthermore, the point-estimate on the coverage ratio for bank-dependent firm-years (0.0009) is larger than the corresponding point-estimate for the full sample reported in column 1 (0.0007). This finding is consistent with the existence of a credit channel of transmission of monetary policy. If a firm's coverage ratio increases, this suggests in fact an improvement in its financial position. Especially if the firm is more likely to face financing constraints, this will allow it to accumulate more inventories.[19]

Column 4 indicates that when the trade credit to assets ratio is included in the equation, it appears to significantly affect the inventory accumulation at both more and less bank-dependent firm-years in a similar way (the point-estimates are respectively equal to 0.85 and 0.97 for the two types of firm-years).[20] Moreover, the addition of the trade credit variables to the equation does not affect the size and significance of the coefficients on the coverage ratio variables. Once again, this result suggests that the credit channel and the trade credit channel operate side by side, the latter being stronger than the former. Similar results were obtained when the firm-years were divided into relatively more and less financially constrained using their ratio of tangible assets to total assets (columns 5 and 6), and their level of real assets as sample sorting criteria (columns 7 and 8). In the latter case, it is worth noting that the coverage ratio attracts a positive and precisely determined coefficient both for small and large firm-years, which is, however, always bigger for the former group. Comparing the Sargan statistics in columns 3 and 4; and 7 and 8, confirms that adding the trade credit variables generally improves the specification of the model.[21]

4.2. Second test of the offsetting hypothesis

Table 3 reports the results of the estimation of Eq. (3), where the effect of the coverage ratio on the inventory accumulation of financially constrained firm-years is differentiated across firm-years making low and high use of trade credit. This differentiation is aimed at assessing the extent to which financially constrained firm-years can use trade credit to overcome liquidity constraints. Columns 1–3 use the ratio of trade credit to assets as an indicator for whether a firm makes high or low use of trade credit. Focusing on column

[18] Note that the number of observations in columns 3 and 4 is slightly smaller than the corresponding number in the other columns, due to the fact that for some firm-years, data on the mix were missing.

[19] To check robustness, we interacted all the regressors with the $CONSTRAINED_{it}$ and $(1 - CONSTRAINED_{it})$ dummies. In line with the results reported in column 3 of Table 2, we found that the coefficients associated with the coverage ratio were only significant for the constrained firms. Yet, the Sargan test indicated problems with this specification.

[20] This result is consistent with Nilsen (2002), who found that, although they are assumed to have wider access to other cheaper forms of credit, large firms also make a significant use of trade credit.

[21] All our results were robust to using alternative bank-dependence and size sample separation criteria, based respectively on the firms' ratio of total (short- and long-term) bank borrowing to total (short- and long-term) borrowing, and their total number of employees. These results are not presented for brevity but are available from the authors upon request.

Table 3
Results of the second test of the offsetting hypothesis

Dependent variable: ΔI_{it}	Interaction vars.:					
	BANKDEP_{it}; HIGHTC_{it} (1)	LOWCOLL_{it}; HIGHTC_{it} (2)	SMALL_{it}; HIGHTC_{it} (3)	BANKDEP_{it}; HIGHTC1_{it} (4)	LOWCOLL_{it}; HIGHTC1_{it} (5)	SMALL_{it}; HIGHTC1_{it} (6)
ΔS_{it}	0.721***	0.707***	0.715***	0.687***	0.747***	0.779***
	(0.08)	(0.10)	(0.09)	(0.07)	(0.10)	(0.08)
$\Delta S_{i(t-1)}$	0.0193	0.008	0.005	0.011	0.003	0.0008
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
$I_{i(t-1)} - S_{i(t-1)}$	−0.706***	−0.766***	−0.711***	−0.682***	−0.783***	−0.763***
	(0.07)	(0.10)	(0.08)	(0.07)	(0.09)	(0.07)
$\text{COV}_{it} * \text{CONSTRAINED}_{it} * (1 - \text{HIGHTC(1)}_{it})$	0.0009***	0.001**	0.0006*	0.0007*	0.0005*	0.0009**
	(0.0003)	(0.0004)	(0.0003)	(0.0004)	(0.0003)	(0.0004)
$\text{COV}_{it} * \text{CONSTRAINED}_{it} * (\text{HIGHTC(1)}_{it})$	−0.0003	−0.0002	0.001	0.0005	0.0004	0.0007**
	(0.00005)	(0.0005)	(0.001)	(0.0004)	(0.0004)	(0.0004)
$\text{COV}_{it} * (1 - \text{CONSTRAINED}_{it})$	0.0004**	0.0003	0.0003*	0.0002	0.0003	0.0003*
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
$(\text{TC}_{it}/A_{i(T-1)}) * \text{CONSTRAINED}_{it}$	0.993***	0.884***	0.870***	1.176***	0.814***	0.851***
	(0.27)	(0.27)	(0.33)	(0.25)	(0.25)	(0.26)
$(\text{TC}_{it}/A_{i(t-1)}) * (1 - \text{CONSTRAINED}_{it})$	1.069***	1.200***	0.791***	1.266***	1.075***	0.825***
	(0.23)	(0.26)	(0.21)	(0.23)	(0.25)	(0.19)
Sample size	2834	3283	3283	2834	3283	3283
$m1$	−5.016	−3.574	−5.170	−5.529	−3.790	−5.242
$m2$	−1.885	−2.429	−1.685	−1.938	−2.197	−1.730
Sargan/Hansen (p-value)	0.631	0.287	0.990	0.819	0.691	0.983

Notes: The dummy variable CONSTRAINED_{it} indicates in turn BANKDEP_{it}, LOWCOLL_{it}, and SMALL_{it}. Instruments in all columns are $(I_{i(t-2)} - S_{i(t-2)})$; $\Delta S_{i(t-2)}$; $\text{COV}_{i(t-2)} * (\text{CONSTRAINED}_{i(t-2)}) * (\text{HIGHTC(1)}_{i(t-2)})$; $\text{COV}_{i(t-2)} * (\text{CONSTRAINED}_{i(t-2)}) * (1 - \text{HIGHTC(1)}_{i(t-2)})$; $\text{COV}_{i(t-2)} * (1 - \text{CONSTRAINED}_{i(t-2)})$; $(\text{TC}_{i(t-2)}/A_{i(t-3)}) * (\text{CONSTRAINED}_{i(t-2)})$; $(\text{TC}_{i(t-2)}/A_{i(t-3)}) * (1 - \text{CONSTRAINED}_{i(t-2)})$ and further lags. Also see Notes to Tables 1 and 2.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

1, where the mix is used to partition firm-years into financially constrained and healthy, we can see that the coverage ratio attracts a positive and statistically significant coefficient for those constrained firm-years that make a relatively low use of trade credit. The coefficient for the unconstrained firm-years is also precisely determined, but much smaller in magnitude. A similar finding characterizes columns 2 and 3, where the ratio of the firm's tangible assets to its total assets, and the level of its assets are respectively used to partition firm-years into more and less likely to face liquidity constraints. In all three specifications, the trade credit variables are positive and precisely determined both for the constrained and the unconstrained firm-years.

Finally, columns 4–6 of Table 3 use the ratio of trade credit to trade credit plus short-term debt as an indicator for whether a firm makes high or low use of trade credit. Column 4 partitions firm-years into constrained and unconstrained using the mix as a sorting device; column 5, using the firm's ratio of tangible assets to total assets; and column 6, the level of its total assets. In all cases, the coverage ratio term for small firm-years making a low use of trade credit attracts a positive and precisely determined coefficient. The corresponding coefficients for constrained firm-years making a high use of trade credit, and the unconstrained firm-years are either poorly determined (columns 4 and 5) or smaller in magnitude (column 6). The variables in trade credit are always precisely determined for all types of firm-years.[22]

These results can be seen as evidence in favor of an offsetting effect of the credit channel by the trade credit channel. Those firm-years that are more likely to face financial constraints seem in fact to be less constrained by their coverage ratios if they make a relatively high use of trade credit. This suggests that using trade credit can help firms to offset liquidity problems. In all specifications in Table 3, neither the Sargan test, nor the test for second-order autocorrelation of the residuals indicate any major problems with the model specification, nor the choice of instruments.

Overall, our two sets of tests suggest that there is some evidence that both the credit channel and the trade credit channel of transmission of monetary policy operate in the UK, the latter being stronger than the former. Our second set of results also suggests that there is some evidence that the trade credit channel weakens the credit channel. These results are in line with the findings in Atanasova and Wilson (2004), Kohler et al. (2000), and Mateut et al. (in press).

5. Net trade credit

As suggested by our descriptive statistics in Table 1, firms do not limit themselves to receive trade credit from their suppliers: they also offer credit to their own customers.[23]

[22] Our results were robust to using the ratio of the firm's trade credit to its total current liabilities as an alternative criterion to define high and low trade credit usage.

[23] In periods of recession and/or tight monetary policy, offering trade credit to their customers might be a way used by firms to help customers in difficulty to stay in business. By doing so, suppliers may actually benefit in the longer run, through future sales made to those customers (Atanasova and Wilson, 2001). Calorimis et al. (1995) provide evidence that in periods of recession, large firms borrow in order to extend more finance to their financially constrained customers. Extending credit to other firms might also provide a signal of financial health. This is particularly relevant to small start-up firms, which face problems of reputation when entering new markets. These firms may decide to use trade credit as a signal of reputation and commitment (Petersen and Rajan, 1997).

In order to take into account the role of receivables as well as payables in our analysis, we present a set of results based on net trade credit, i.e. on the difference between accounts payable and accounts receivable. These results are presented in Tables 4 and 5.[24]

When we estimate a simple inventory investment regression augmented with the coverage ratio, we can see that the coefficient associated with the latter variable is positive and statistically significant (Table 4, column 1). This does not change when the net trade credit to beginning-of-period assets ratio is added to the regression. Yet, the coefficient associated with the net trade credit variable is negative and poorly determined (Table 4, column 2). This finding might be due to the fact that firms' accounts payable and receivable are similar in magnitude, making the net amount of funding provided to firms via trade credit relatively small.[25]

When the effects of the coverage ratio and the net trade credit variable are differentiated for firm-years with high and low levels of bank-dependence, we can see that the coverage ratio only affects inventory investment at more bank-dependent firm-years, and that the coefficients associated with the net trade credit variable are always negative and poorly determined (Table 4, columns 3 and 4). Similar results hold when the ratio of the firm's tangible assets to its total assets, or the level of its total assets are used as sample separation criteria (Table 4, columns 5–8). In those specifications, however, the coverage ratio also affects the inventory investment at less financially constrained firm-years, although the coefficients for the latter group are always smaller than those for the financially constrained group.

Table 5 presents the results of our second test of the offsetting hypothesis. As in Table 4, the coefficients associated with the net trade credit variable are in most cases poorly determined. In columns 1–3, the effect of the coverage ratio on the inventory investment at constrained firm-years is differentiated for firm-years with relatively high and low net trade credit to assets ratio.[26] We can see that only the inventory investment at financially constrained firm-years with relatively low net trade credit to assets ratio is affected by the coverage ratio. This supports the offsetting hypothesis.

In columns 4–6 of Table 5, we differentiate the effect of the coverage ratio on the inventory investment of financially constrained firm-years, for firm-years with positive and negative net trade credit.[27] The coverage ratio only affects the inventory investment at those financially constrained firm-years with negative net trade credit. This result supports once

[24] We thank an anonymous referee for suggesting this experiment. It has to be noted that the sample size in these tables is generally slightly smaller than the sample size in Tables 2 and 3. This is due to missing values associated with the accounts receivable variable.

[25] There is evidence that this is the case in Table 1, where we can see that in our full-sample, the ratio of trade credit to assets is 0.174, whereas the ratio of trade debt to assets is 0.287. Moreover, accounts payable and receivable are strongly correlated: the coefficient of correlation between the two variables is 0.93 in our full-sample.

[26] For this purpose, we make use of the dummy variable $HIGHNETTC_{it}$, which is equal to 1 if the ratio of firm i's net trade credit to total assets in year t is in the highest quartile of the distribution of the corresponding ratios of all the firms in that particular industry and year, and 0 otherwise.

[27] For this purpose, we make use of the dummy variable $POSNETTC_{it}$, which is equal to 1 if firm i's net trade credit is positive in year t, and equal to 0 otherwise. While a split based on the net trade credit to assets ratio still makes sense, a split based on the ratio between net trade credit and the sum of net trade credit and short-term debt is more difficult to interpret. For this reason, in Table 5, we replaced the latter with a split based on positive versus negative net trade credit.

Table 4
Results of the first test of the offsetting hypothesis with net trade credit

Dependent variable: ΔI_{it}	Full sample		$\text{CONSTRAINED}_{it} = \text{BANKDEP}_{it}$		$\text{CONSTRAINED}_{it} = \text{LOWCOLL}_{it}$		$\text{CONSTRAINED}_{it} = \text{SMALL}_{it}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔS_{it}	1.024***	0.943***	1.001***	0.931***	0.997***	0.938***	0.977***	0.917***
	(0.10)	(0.09)	(0.01)	(0.09)	(0.09)	(0.07)	(0.09)	(0.07)
$\Delta S_{i(t-1)}$	0.004	0.003	0.035	0.035	−0.004	−0.021	0.008	−0.0004
	(0.04)	(0.03)	(0.037)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
$I_{i(t-1)} - S_{i(t-1)}$	−0.918***	−0.843***	−0.869***	−0.879***	−0.915***	−0.805***	−0.862***	−0.783***
	(0.10)	(0.10)	(0.09)	(0.086)	(0.11)	(0.07)	(0.10)	(0.07)
COV_{it}	0.0006**	0.0005**						
	(0.0002)	(0.0002)						
$\text{COV}_{it} * \text{CONSTRAINED}_{it}$			0.0009***	0.0008***	0.001***	0.0004*	0.0009**	0.0009**
			(0.0003)	(0.0003)	(0.0004)	(0.0002)	(0.0004)	(0.0004)
$\text{COV}_{it} * (1 - \text{CONSTRAINED}_{it})$			0.0004	0.0003	0.0004*	0.0003	0.0004**	0.0003*
			(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
$(\text{NETTC}_{it}/A_{i(t-1)})$		−0.108						
		(0.11)						
$(\text{NETTC}_{it}/A_{i(t-1)}) * \text{CONSTRAINED}_{it}$				−0.036		−0.314*		−0.413*
				(0.25)		(0.18)		(0.24)
$(\text{NETTC}_{it}/A_{i(t-1)}) * (1 - \text{CONSTRAINED}_{it})$				−0.199		−0.048		−0.400*
				(0.22)		(0.19)		(0.21)
Sample size	3251	3251	2808	2808	3251	3251	3251	3251
$m1$	−3.124	−3.635	−3.931	−3.915	−2.930	−5.275	−3.804	−5.505
$m2$	−0.984	−0.981	−1.402	−1.929	−1.067	−0.482	−0.967	−0.717
Sargan/Hansen (p-value)	0.327	0.188	0.365	0.857	0.607	0.631	0.306	0.725

Notes: NETTC indicates net trade credit, i.e. the difference between accounts payable and accounts receivable. The dummy variable CONSTRAINED_{it} indicates in turn BANKDEP_{it}, LOWCOLL_{it}, and SMALL_{it}. Instruments in column (1) are $(I_{i(t-2)} - S_{i(t-2)})$; $\Delta S_{i(t-2)}$; $\text{COV}_{i(t-2)}$. Instruments in column (2) also include $\text{NETTC}_{i(t-2)}/A_{i(t-3)}$. Instruments in columns (3), (5), and (7) are $(I_{i(t-2)} - S_{i(t-2)})$; $\Delta S_{i(t-2)}$; $\text{COV}_{i(t-2)} * (\text{CONSTRAINED}_{i(t-2)})$; $\text{COV}_{i(t-2)} * (1 - \text{CONSTRAINED}_{i(t-2)})$ and further lags. Instruments in columns (4), (6), and (8) also include $\text{NETTC}_{i(t-2)}/A_{i(t-3)} * (\text{CONSTRAINED}_{i(t-2)})$; $\text{NETTC}_{i(t-2)}/A_{i(t-3)} * (1 - \text{CONSTRAINED}_{(t-2)})$ and further lags. Time dummies and time dummies interacted with industry dummies were always included in the instrument set. Also see Notes to Tables 1 and 2.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 5
Results of the second test of the offsetting hypothesis with net trade credit

Dependent variable: ΔI_{it}	Interaction vars.:					
	$BANKDEP_{it}$; $HIGHNETTC_{it}$ (1)	$LOWCOLL_{it}$; $HIGHNETTC_{it}$ (2)	$SMALL_{it}$; $HIGHNETTC_{it}$ (3)	$BANKDEP_{it}$; $POSNETTC_{it}$ (4)	$LOWCOLL_{it}$; $POSNETTC_{it}$ (5)	$SMALL_{it}$; $POSNETTC_{it}$ (6)
ΔS_{it}	0.958***	0.928***	0.930***	0.941***	0.941***	0.952***
	(0.08)	(0.07)	(0.08)	(0.08)	(0.07)	(0.08)
$\Delta S_{i(t-1)}$	0.030	−0.023	−0.006	0.033	−0.024	−0.009
	(0.03)	(0.03)	(0.03)	(0.03)	(0.033)	(0.03)
$I_{i(t-1)} - S_{i(t-1)}$	−0.882***	−0.814***	−0.784***	−0.887***	−0.815***	−0.827***
	(0.08)	(0.07)	(0.07)	(0.08)	(0.07)	(0.07)
$COV_{it} * CONSTRAINED_{it} * (1 - HIGHNETTC_{it}/POSNETTC_{it})$	0.0007**	0.0005*	0.0007*	0.0009***	0.0005**	0.0008**
	(0.0003)	(0.0002)	(0.0004)	(0.0003)	(0.0002)	(0.0004)
$COV_{it} * CONSTRAINED_{it} * (HIGHNETTC_{it}/POSNETTC_{it})$	0.0003	−0.0008	0.0003	−0.0016	0.002	0.001
	(0.0007)	(0.001)	(0.0004)	(0.008)	(0.001)	(0.001)
$COV_{it} * (1 - CONSTRAINED_{it})$	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004*
	(0.0003)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0002)
$(NETTC_{it}/A_{i(t-1)}) * CONSTRAINED_{it}$	0.072	−0.321*	−0.365	−0.091	−0.272	−0.465*
	(0.24)	(0.18)	(0.24)	(0.26)	(0.17)	(0.26)
$(NETTC_{it}/A_{i(t-1)}) * (1 - CONSTRAINED_{it})$	−0.096	−0.009	−0.328	−0.216	−0.029	−0.323
	(0.22)	(0.19)	(0.21)	(0.23)	(0.19)	(0.21)
Sample size	2808	3251	3251	2808	3251	3251
*m*1	−4.242	−5.212	−5.616	−4.324	−5.523	−5.442
*m*2	−1.818	−0.576	−0.590	−1.957	−0.517	−0.821
Sargan/Hansen (*p*-value)	0.970	0.850	0.871	0.993	0.991	0.944

Notes: NETTC indicates net trade credit, i.e. the difference between accounts payable and accounts receivable. The dummy variable $CONSTRAINED_{it}$ indicates in turn $BANKDEP_{it}$, $LOWCOLL_{it}$, and $SMALL_{it}$. The dummy variable $HIGHNETTC_{it}$ is equal to 1 if the ratio of net trade credit to total assets for firm i in year t is in the highest quartile of the distribution of the corresponding ratios of all the firms in that particular industry and year, and 0 otherwise. $POSNETTC_{it}$ is equal to 1 if firm i's net trade credit is positive in year t, and 0 otherwise. Instruments in all columns are $(I_{i(t-2)} - S_{i(t-2)})$; $S_{i(t-2)}$; $COV_{i(t-2)} * (CONSTRAINED_{i(t-2)}) * (HIGHNETTC_{i(t-2)}/POSNETTC_{i(t-2)})$; $COV_{i(t-2)} * (CONSTRAINED_{i(t-2)}) * (1 - HIGHNETTC_{i(t-2)}/POSNETTC_{i(t-2)})$; $COV_{i(t-2)} * (1 - CONSTRAINED_{i(t-2)})$; $(NETTC_{i(t-2)}/A_{i(t-3)}) * (CONSTRAINED_{i(t-2)})$; $(NETTC_{i(t-2)}/A_{i(t-3)}) * (1 - CONSTRAINED_{i(t-2)})$ and further lags. Also see Notes to Tables 1 and 2.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

again the offsetting hypothesis: those firm-years which are provided with a net increase in funding via trade credit will not have to reduce their investment in inventories should their coverage ratio decline. Consequently, in periods of recession and tight monetary policy, they are unlikely to be too strongly affected by the credit channel.

6. Conclusions

In this paper, we have used a panel of 609 UK firms over the period 1980–2000 to test for the presence of a trade credit channel of transmission of monetary policy and for whether this channel offsets the credit channel. We have conducted two sets of tests to achieve this objective. First, we have augmented a traditional error-correction inventory investment equation with the coverage ratio and the trade credit to assets ratio, and we have estimated it differentiating the effects of the latter two variables for financially constrained and financially healthy firm-years. Our second test consisted in the estimation of an augmented inventory investment error-correction equation, where the effects of the coverage ratio were differentiated across financially constrained firm-years making a low use of trade credit; financially constrained firm-years making a high use of trade credit; and financially healthy firm-years.

The results of our first test suggested that both credit and trade credit channels of transmission of monetary policy operate side by side in the UK, the latter having stronger effects than the former. Those of our second test, according to which the coverage ratio generally does not affect the inventory investment of those constrained firm-years making a relatively high use of trade credit, also showed some evidence in favor of the fact that the trade credit channel weakens the credit channel.

When we replaced trade credit with net trade credit, with the aim of jointly considering the roles played by trade credit received and extended, we found that although net trade credit did not directly affect inventory investment, the coverage ratio ceased to affect inventory investment at firm-years provided with a net increase in funding via trade credit. These findings, which support the offsetting hypothesis, are important as they suggest that the trade credit channel is likely to dampen the effects of contractionary monetary policies, and more in general to make the recessions that generally follow these policies less severe.

In the light of our results, we can conclude that a possible explanation for why, contrary to the mainstream literature, authors such as Kaplan and Zingales (1997) and Cleary (1999) found that those firms facing tighter financing constraints actually exhibit a lower sensitivity of investment to financial variables could be that these firms make a heavy use of trade credit, offsetting therefore their liquidity constraints. An alternative explanation could be that these firms are actually financially distressed. They might therefore have reached the minimum level of investment necessary to carry on production: further reductions in investment would therefore be impossible, even in response to declines in cash flow. Financially distressed firms might also be required by their creditors to use their cash flow to meet interest payments and/or improve the liquidity of their balance sheet (Fazzari et al., 2000; Allayannis and Mozumdar, 2004).

In order to shed more light on these alternative explanations, the behavior of those financially constrained firms, which face the most severe financing constraints should be carefully analyzed. As firms belonging to the latter category are more likely not to be quoted on the stock market, datasets which contain unquoted firms should be used for this purpose. This is on the agenda for future research.

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Appendix. Definitions of the variables used

Total number of employees (Emp): It is defined as Datastream variable 219 (v219), i.e. the average number of employees as disclosed by the company.
Total assets (A): It is defined as v392, i.e. the sum of tangible fixed assets, intangible assets, investments, other assets, total stocks and work-in-progress, total debtors and equivalent, and cash and cash equivalents.
Inventories (I): They are defined as the logarithm of v364, which includes finished goods, raw materials, work-in-process less any advances paid, and any other stocks.
Sales (S): It is defined as the logarithm of v104, i.e. the amount of sales of goods and services to third parties relating to the normal industrial activities of the company.
Coverage ratio (COV): It is defined as (v137 + v144)/(v150 + v151), where
- v137 is net profit derived from normal activities of the company after depreciation and operating provisions;
- v144 includes dividend income, interest received, rents, grants and any other non-operating income;
- v150 shows interest on loans which are repayable in less than five years;
- v151 shows interest on loans which are repayable in five years or more.

Short-term-debt (STD): It is defined as v309, which includes bank overdrafts, loans, and other short-term borrowing. The current portion of long-term debt is also included.
Short-term bank borrowing (STBANK): It is defined as variable v387 (which is part of v309), and represents bank borrowing due within one year.
Total debt (TOTD): It is the sum of short-term debt (STD) and long-term debt. The latter is defined as variable v321, i.e. the total loan capital repayable after one year. It includes debentures, bonds, convertibles, and "debt like" hybrid financial instruments (such as leasing finance and hire & purchase).
Total bank borrowing (TOTBANK): It is the sum of short-term bank borrowing (STBANK) and long-term bank borrowing. The latter is defined as variable v275 (which is part of v321), and represents bank borrowing due after one year.
Tangible assets (TANG): It is defined as v339, which includes land and buildings, plant and machinery, construction in progress, and other fixed assets, net of accumulated depreciation.
Trade credit (TC): It is defined as v276, which includes trade payables within and after one year relating to the normal business activities of the company.
Trade debt (TD): It is defined as v287, which includes trade receivables within and after one year relating to the normal business activities of the company.
Net trade credit (NETTC): It is defined as trade credit (TC) minus trade debt (TD).
Deflators: All variables are deflated using the aggregate GDP deflator.

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