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Disequilibrium in the UK corporate loan market

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Abstract

In the last decade, a debate has resurfaced about whether financial constraints stemming from asymmetric information and incentive problems play an important role in propagating monetary policy shocks. This paper investigates the monetary transmission mechanism in the UK and its impact on the availability of bank credit to small and medium size firms.

The empirical specification is based on a disequilibrium model that allows for the possibility of transitory credit rationing. Sample firms are classified endogenously into 'borrowing constrained' and 'borrowing unconstrained'. The analysis of credit rationing takes into account not only firm specific variables, but also important macroeconomic factors such as the prevailing monetary conditions and the stage of the business cycle.

We find that (i) firms' assets play an important role as collateral in mitigating borrowing constraints; (ii) during periods of tight monetary conditions corporate demand for bank credit increases, whereas the supply of bank loans is reduced; (iii) to avoid bank credit rationing smaller companies increase their reliance on interfirm credit; (iv) the proportion of borrowing constrained firms is significantly higher during the recession years of the early 1990s than at other times.

JEL classification: C31; E32; E51

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1. Introduction

Monetary policy impulses that induce only small increases in short-term interest rates often result in large and persistent reductions in aggregate demand

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(Bernanke et al., 1996). Such an effect might occur even when there are no significant changes in long-run interest rates (the proxy for the cost of capital). This fact is not well explained by the conventional theory of monetary policy transmission. Recent research, however, has identified a ‘credit channel’ of monetary policy transmission mechanism – a mechanism whereby credit market frictions may serve to propagate and amplify the effects of initial monetary shocks to the aggregate economy. Of considerable interest is whether contractionary monetary policy has a disproportionately large effect on smaller businesses (Berger and Udell, 1998; Gertler and Gilchrist, 1994).

The availability of external finance to small and medium size firms is likely to vary in important ways with the changes in business conditions and the fluctuations in the macroeconomic environment caused by monetary policy shocks. This study is an attempt to analyse, quantitatively, the determinants of the demand for and supply of bank loans, and to evaluate the importance of the credit channel of monetary policy transmission. A disequilibrium model is developed, which explicitly takes ‘borrowing constraints’ into consideration. The model is estimated on the basis of a panel data set of small and medium size UK firms for the period 1989–1999. The time span of the panel allows us to consider one major recession, that of 1990–1992. Many economists have argued that the slow recovery from that recession was due to a tight monetary policy aimed at curbing the rate of inflation coupled with an unwillingness of banks to extend credit.

The estimated coefficients of the model are consistent with the existence of a credit channel of monetary policy transmission. In particular, the results show that when monetary conditions are tight the availability of bank loans decreases although firms increase their demand for funds. The model allows us to identify those firms that are ‘borrowing constrained’. It can be seen that the early 1990s recession had a significant effect on the proportion of borrowing constrained firms. The endogenous classification of this study is a clear improvement over prior research in this area (e.g. Gilchrist and Zakrajsek, 1995; Hoshi et al., 1993), which separate firms exogenously into those thought to be more likely and those thought to be less likely to face significant financial constraints a priori. In these studies various proxies are used to identify firms that are likely to face borrowing constraints, for example using information about banking relationships, bond rating, dividend policy, etc. There are at least two problems using such sample splits. First, they are far too restrictive, as they do not allow for firms to switch between the constrained and the unconstrained groups over time. Second, some of the proxies used are an endogenous outcome of firms’ policy decisions (dividend policy, corporate structure, etc.) and therefore are not appropriate measures of credit rationing.

The remaining part of the paper is organised as follows. In Section 2, we provide a brief overview of the current state of the debate over the credit channel of monetary policy transmission mechanism. Section 3 formulates a disequilibrium model of corporate bank lending. Section 4 describes classification probabilities in the disequilibrium model. Section 5 presents the empirical specification of the model and the panel dataset to be used in the estimation procedure. Section 5.3 reports and interprets the estimation results and provides diagnostic tests to ensure robustness of the analysis.

In Section 6, the sample firms are classified as borrowing constrained and unconstrained. The implications of the findings for the monetary transmission mechanism are discussed. Finally, Section 7 concludes the paper and outlines some opportunities for future research.

2. Theoretical background

Smaller businesses have long been heavily reliant on short-term bank credit. Berger and Udell (1998) report that 70% of small firm finance is made up of the owners' own funds, commercial bank loans and trade creditors (pp. 691). Brewer et al. (1996) document that the small firms in their sample are more bank-dependent than large firms. The latter rely more heavily on equity finance. This fact means that shocks to the banking system are likely to have a disproportionately significant impact on the availability of external finance to small businesses.

Monetary conditions are an important factor that affects the willingness of banks to supply funds to companies. The role of credit market imperfections in the transmission of monetary shocks can usefully be divided into two separate channels. The first is the bank-lending channel of monetary policy and the second is the broad credit channel (see Bernanke and Gertler (1995) for an extensive survey). Both acknowledge the existence of credit market imperfections, a condition that is absent from the standard neo-classical model. The bank-lending channel clearly emphasises the importance of bank lending. It presumes that financial market imperfections can arise due to informational asymmetries between borrowers and lenders. Some borrowers are unable to obtain funding on the public capital markets without paying large premiums. Banks specialise in providing 'information intensive' loans and are therefore often able to reduce the premium on the finance for their borrowers. This is the case for smaller companies, which are particularly 'informationally opaque'. Monetary policy has real consequences for bank dependent borrowers because of its effect on the banks' ability to lend. Open market operations of the central bank lead to a contraction in reserves and therefore in a decrease in funds available for lending. As a result, bank-dependent borrowers are forced to seek funds at a higher cost or are unable to obtain funds at all and thus their own spending contracts.

The broad credit channel emphasises the importance of borrowers' characteristics. As with the bank lending channel, the existence of the credit channel depends on the assumption that capital markets are imperfect and that internal and external finance are not perfect substitutes. The key point for this mechanism is that the size of the premium on external finance depends on the firm's balance sheet condition. Following a contractionary monetary policy, firms' balance sheets deteriorate [1] and the

[1] There is a decline in the value of assets and therefore collateral and/or reduced cash flow resulting from a decline in demand.

premiums on external finance rise, exacerbating the effect of the shock. Bernanke et al. (1999) provide a comprehensive survey of the literature on the financial 'amplification' effect.

The extant empirical research generally confirms the two main implications of the credit channel view. First, monetary contraction reduces the supply of bank loans and second borrowers facing high agency costs of lending receive a relatively lower share of the credit extended (flight to quality) and therefore account for a proportionally greater part of the decline in economic activity. In an important paper, Kashyap et al. (1993) examined the behaviour of the flow of commercial paper and bank loans following a tightening of monetary policy. They show that following a monetary shock there is a sharp increase in the US commercial paper issuance, while bank loans are flat. Kashyap et al. suggest that tight monetary policy limits the supply of bank credit, which forces borrowers to substitute away from bank loans and into commercial paper. Gertler and Gilchrist (1993) and Oliner and Rudebusch (1996) provide a different interpretation of this fact. The idea is that there is a counter cyclical demand for short-term credit, which results from declines in firms' cash flows relative to short-term financing requirements. Although most firms will experience some increase in their need for short-term credit, they differ in their degree of access to credit markets. High-grade borrowers with access to the commercial paper market obtain funds more easily than lower quality borrowers who rely primarily on intermediated credit. As a consequence, commercial paper outstanding rises relative to bank loans subsequent to monetary tightening. Thus, borrowers substituting between loans and commercial paper need not explain the observed shift in the composition of corporate credit. Nevertheless, both interpretations are consistent with the flight to quality hypothesis.

Another indication of the flight to quality in bank lending is the behaviour of secured (collateralised) versus nonsecured credit. It has been confirmed by a number of studies (e.g. Berger and Udell, 1990), that smaller borrowers are much more likely to be required to post collateral than larger, more established borrowers. Finally, a comparison between the rates of issuance of publicly offered corporate bonds and private placements provides further insight. Recent research (see Carey et al., 1993) suggests that here, too, there is a flight to quality, as private placements fall sharply relative to public bond issues during recessions and periods of tight monetary conditions.

3. Disequilibrium model of corporate bank lending

One of the implications of the theory is that during periods of tight monetary conditions small and medium size firms cannot always borrow as much as they would like. If a firm faces credit rationing, the realised loan outstanding will be the minimum of the desired level of bank loans and the bank ceiling for the firm. In order to capture the possibility of such credit rationing we consider the following disequilibrium model of corporate bank lending:

$$\begin{aligned} l_t^{\mathrm{d}} &= \beta_1' x_{1t} + u_{1t}, \\ l_t^{\mathrm{s}} &= \beta_2' x_{2t} + u_{2t}, \\ l_t &= \min(l_t^{\mathrm{d}}, l_t^{\mathrm{s}}). \end{aligned} \tag{3.1}$$

The model consists of a demand equation, a supply equation and a transaction equation. The vectors x_{1t} and x_{2t} contain exogenous variables and the error terms u_{1t} and u_{2t} are distributed with zero mean and covariance matrix $\Sigma = \{\sigma_{ij}\}$. l_t^{d} and l_t^{s} are the demand for and the supply of bank loans, respectively, and are not observed. Only l_t the transaction quantity is observed. Note that the equilibrium model ($l_t^{\mathrm{d}} = l_t^{\mathrm{s}}$) is nested within our specification.

Next we define the probability density and the cumulative density functions of the observed amount of bank loans. Let

$$\begin{aligned} f_i(l_t) &\equiv \frac{1}{\sqrt{2\pi}\sigma_{ii}} \exp\left[\frac{-1}{2\sigma_{ii}^2}(l_t - \beta' x_{it})^2\right], \\ F_i(l_t) &\equiv \int_{l_t}^{\infty} f_i(l_t^i)\mathrm{d}l_t^i, \quad i = 1, 2, \end{aligned} \tag{3.2}$$

where $l_t^1 = l_t^{\mathrm{d}}$ and $l_t^1 = l_t^{\mathrm{s}}$.

Madala and Nelson (1974) showed that the likelihood of l_{t} is

$$h(l_t) = f_1(l_t)F_2(l_t) + f_2(l_t)F_1(l_t). \tag{3.3}$$

The model, therefore, can be estimated by the full-information maximum likelihood (FIML) approach with a numerical maximisation (EM algorithm) of the likelihood function.

4. Probability of excess demand for bank loans

In this section, we follow Gersovitz (1980) and derive the probability that firm i will face a borrowing constraint in period t. We consider the two main concepts of the probability that a particular observation corresponds to excess demand. These are the unconditional probability $\Pr(l_t^{\mathrm{d}} > l_t^{\mathrm{s}})$ and the probability conditional on the observed transaction, $\Pr(l_t^{\mathrm{d}} > l_t^{\mathrm{s}} | l_t)$.

The former is obtained as follows:

$$\begin{aligned} \Pr(l_t^{\mathrm{d}} > l_t^{\mathrm{s}}) &= \Pr(\beta_1' x_{1t} + u_{lt} > \beta_2' x_{2t} + u_{2t}) \\ &= \Pr\left[\frac{\beta_1' x_{1t} - \beta_2' x_{2t}}{\sigma} > \frac{u_{2t} - u_{1t}}{\sigma}\right] = \Phi\left[\frac{\beta_1' x_{1t} - \beta_2' x_{2t}}{\sigma}\right], \end{aligned} \tag{4.1}$$

where the error terms are assumed to be distributed normally; $\sigma^2 = \mathrm{var}(u_{2t} - u_{1t})$; Φ is the standard normal cumulative density function; $\beta_1' x_{1t}$ is the unconditional expectation $E(l_t^{\mathrm{d}})$ and $\beta_2' x_{2t}$ is the unconditional expectation $E(l_t^{\mathrm{s}})$. Since $\Phi[(\beta_1' x_{1t} - \beta_2' x_{2t})/\sigma > 0] > 0.5$, it follows that $E(l_t^{\mathrm{d}}) > E(l_t^{\mathrm{s}})$ if and only if $\Pr(l_t^{\mathrm{d}} > l_t^{\mathrm{s}}) > 0.5$.

Next, the conditional probability can be written as

$$\Pr(l_t^{\rm d} > l_t^{\rm s} | l_t) = \frac{f_1 F_2}{f_1 F_2 + f_2 F_1}. \tag{4.2}$$

Taking into account (3.3) and (4.1), the condition $\Pr(l_t^{\rm d} > l_t^{\rm s} | l_t) > 0.5$ requires

$$\int_{l_t}^{\infty} \exp\left[-\frac{1}{2}\left\{ \left(\frac{t - \beta_1' x_{1t}}{\sigma_{11}} \right)^2 + \left(\frac{l_t - \beta_2' x_{2t}}{\sigma_{22}} \right)^2 \right\} \right] - \exp\left[-\frac{1}{2}\left\{ \left(\frac{t - \beta_2' x_{2t}}{\sigma_{22}} \right)^2 + \left(\frac{l_t - \beta_1' x_{1t}}{\sigma_{11}} \right)^2 \right\} \right] {\rm d}t > 0. \tag{4.3}$$

A sufficient condition for the above is

$$\left(\frac{t - \beta_1' x_{1t}}{\sigma_{11}} \right)^2 + \left(\frac{l_t - \beta_2' x_{2t}}{\sigma_{22}} \right)^2 < \left(\frac{t - \beta_2' x_{2t}}{\sigma_{22}} \right)^2 + \left(\frac{l_t - \beta_1' x_{1t}}{\sigma_{11}} \right)^2 \quad \forall t > l_t, \tag{4.4}$$

which on expansion and cancellation of terms is equivalent to $\sigma_{11}^2 = \sigma_{22}^2$ and $\beta_1' x_{1t} > \beta_2' x_{2t}$.

Therefore if the two variances are sufficiently close to one another, the classification of regimes using the conditional and unconditional probabilities is likely to be close too. In Monte Carlo experiments, Gersovitz (1980) finds no substantial differences between conditional and unconditional probabilities. Based on the results derived above, the sample firms in this study are classified as constrained in period t if the probability that the demand for bank loans will exceed the supply of loans is higher than 0.5.

5. Empirical procedure

5.1. Model specification

Building on the works of Hancock and Wilcox (1994) and Ogawa (2000), we model the demand for bank loans as a function of the level of firm activity, firm's size, the availability of funds that are substitutes to bank loans and the bank loan premium. The supply of bank loans is modelled as a function of the value of firm's collateral, the risk perceived by the bank and the tightness of monetary policy.

Formally

$$x_{1t} = \left(\overset{+}{\text{activity}}, \overset{+}{\text{size}}, \overset{-}{\text{substitutes}}, \overset{-}{\text{loan premium}} \right),$$

$$x_{2t} = \left(\overset{+}{\text{collateral}}, \overset{-}{\text{risk}}, \overset{-}{\text{monetary conditions}} \right).$$

Empirically, the elements of the above vectors are measured as follows: the firm's activity is proxied by the level of sales (s); size is proxied by the level of total assets (a); the level of internally generated cash flow (cf), the obtained net trade credit (tc) and a dummy variable for access to public financial markets are used to control for the effect of substitute funds on the demand for bank loans. In the supply equation, the firm's collateral is measured by the level of total assets (a) and firm-specific risk (risk) is proxied by a dummy variable that reflects the firm's coverage ratio. A study by Milne (1991), based on interviews with banking practitioners in the UK, suggests that firm's coverage ratio is an important factor on which banks base their lending decisions. They find that a threshold of five in fact represents the level at which bankers might begin to feel concern about the ability of a company to service and/or pay back its debt. The variable risk takes the value of one when firm's coverage ratio in a given year is less than five and zero otherwise. Monetary conditions are measured using innovations to the Bank of England base rate (mc) derived form a vector autoregression (VAR) model. Details about the construction of the variable mc are provided in Appendix C. [2]

Because of the wide spread use of non-price terms (covenants, collateral, etc.) in bank lending contracts, we are unable to estimate individual firms' interest rate premiums and therefore the cost of lending. However, within a given year similar interest rates are observed for all the firms. Therefore including dummy variables for each year will capture the effect of the interest rates. The use of time dummy variables has the advantage of characterising the degree of small firms' dependence on bank loans over the cycle. [3] Further, dummy variables for each industry are added to the equation. These dummies are included to absorb some of the firm-specific effects that have a bearing on the demand for bank loans. [4] Thus, after modification and with the notation for the panel data explicit, the final form of the estimated system of equations is

$$\frac{l_{it}^{\mathrm{d}}}{a_{i,t-1}} = \beta_0 + \beta_1 \frac{s_{it}}{a_{i,t-1}} + \beta_2 \frac{\mathrm{cf}_{it}}{a_{i,t-1}} + \beta_3 \frac{1}{a_{i,t-1}} + \beta_4 \frac{\mathrm{tc}_{it}}{a_{i,t-1}} + \beta_7 \mathrm{DLEG}_{it} + \sum_{j=1}^{T} \varphi_j \mathrm{DYEAR}_j + \sum_{j=1}^{M} \psi_j \mathrm{DIND}_j + v_{1,it}, \tag{5.1}$$

$$\frac{l_{it}^{s}}{a_{i,t-1}} = \gamma_0 + \gamma_1 \frac{1}{a_{i,t-1}} + \gamma_2 \mathrm{RISK}_{it} + \gamma_3 MC_t + v_{2,it}, \tag{5.2}$$

$$l_{it} = \min(l_{it}^{\mathrm{d}}, l_{it}^{\mathrm{s}}), \tag{5.3}$$

[2] We would like to thank the referee for suggesting this way of measuring monetary conditions.

[3] The results remain qualitatively the same when we use log-linearly de-trended GDP, instead of year dummies, to measure the cycle.

[4] Variables could be expressed as deviations from their means to eliminate the firm specific effect but this would make numerical maximisation of the likelihood function intractable.

where the subscript i refers to the ith firm in the sample, DYEAR_j is the year dummy variable, [5] DIND_j is the industry dummy variable, M is the number of industries, DLEG_{it} is a dummy variable equal to one if the company t is publicly traded at time t and zero otherwise, $v_{1,it}$ and $v_{2,it}$ are the disturbances.

Note that the demand and supply equations are expressed in terms of ratios of firms' (end of previous year) total assets rather than levels. This specification alleviates the problem of heteroskedasticity possibly present in the sample data.

5.2. Data and descriptive statistics

The disequilibrium model of corporate bank lending is estimated using panel data of 639 UK firms, provided by Dun and Bradstreet International for the period 1989–1999. Details regarding the construction of the sample and the data series used in the analysis are provided in Appendix A.

Both active and inactive firms are included and the panel is not balanced. The use of an unbalanced panel, which allows for both entry and exit, partially mitigates potential selection and survival bias. Tables 1 and 2 provide the distribution of the observations over years and the industry breakdown for the sample firms for private and quoted firms. The majority of the sample firms are privately held. We expect that private firms will find it more difficult to acquire external finance than publicly held firms both because of information opacity and limited access to public capital markets.

Table 3 reports some descriptive statistics for all of the sample firms and the subsamples of public and private firms. The median company in the sample has 91 employees and £3.63 million in total assets. The statistics show that on average as much as 50% of these assets are financed by short-term funds. The bank loans represent 26.7%, internally generated funds are 35.8% and interfirm credit accounts for 36% of the short-term funding over the sample time period.

On average the public firms in the sample generate less cash flow to assets than the private firms and rely less heavily on interfirm credit and bank loans as sources of funds. The tests for differences in means and medians in Table 3 show that this difference in the capital structure of the subsamples of public and private firms is significant at conventional levels.

5.3. Estimation results

We turn now to the estimation and inference of the results from the disequilibrium model for corporate bank lending. The estimated coefficients are reported in Table 4. We carry out a standard Wald test of joint significance of the estimated coefficients. The values of the F statistics are 6.35 and 60.20 for the demand and supply equations respectively ($p = 0.000$ for both equations), confirming that the disequilib-

[5] Note that because total assets enter the equations in terms of a one period lag, we lose 1989 and therefore the year dummy variables are from 1991 to 1999.

Table 1
Distribution of observations over years

Year	All firms	Public	Private	Private[a]
1989	573	88	485	18
1990	610	93	517	18
1991	621	97	524	18
1992	622	97	525	18.5
1993	631	101	530	18.5
1994	599	98	501	19
1995	566	92	474	19.5
1996	554	88	466	18.9
1997	538	83	455	18
1998	523	83	440	18.8
1999	264	47	217	21
Observations	6101	967	5134	18.8

[a] Ratio is the proportion of publicly quoted firms relative to the number of privately held firms.

Table 2
Industry breakdown

Industry	All firms	Public	Private
Primary industry	6	2	4
MFG: food drink	46	9	37
MFG: chemicals petroleum plastic	71	8	63
MFG: metal engineering electronics	227	34	193
MFG: textile leather clothes	58	13	45
MFG: timber bricks ceramics glass rubber	67	15	52
Paper print publishing packing	74	9	65
Construction	17	1	16
Wholesale and retail distribution	21	4	17
Services	43	6	37
Missing	9	0	9
Firms	639	101	538

rium model is highly significant. The estimation results are strongly supportive of the predictions of the theory. First, consider the coefficient estimates of the demand equation. Both the coefficients of assets (the effect of changes in assets is via the constant term since the variable is in the denominator of $1/(a_{t-1})$) and sales have a significant positive effect on the desired demand for bank loans. On the other hand, cash flow and net trade credit obtained both have a negative effect on the demand for loans, indicating that they are important substitutes for bank borrowing. The extent to which the internal funds substitute for bank credit is about 0.003 whereas for net trade credit obtained it is 0.064. This means that £1 increase of internally generated funds will result in £0.003 decrease of bank borrowing and £1 increase in the acquired interfirm credit will reduce bank borrowing by £0.064. The finding suggests that although trade credit is a less desirable alternative of corporate financing, sample firms tend to have a higher rate of substitution between loans and interfirm credit than between loans and internally generated funds. Therefore trade credit may play a

Table 3
Descriptive statistics (639 UK manufacturing firms, 1989–1999)

Variable	Mean[a]	Median
All firms		
Employees	161 (204.88)	91
Assets (m£)	8.33 (14.60)	3.63
Sales/assets	2.01 (16.77)	1.57
Cash flow/assets	17.90% (2.50)	12.37%
Accounts payable/assets	18.00% (0.12)	15.39%
Bank loans/assets	13.33% (0.13)	9.857%
Public firms		
Employees	117 (126.818)	75
Assets (m£)	4.51 (5.91)	2.42
Sales/assets	1.67 (1.43)	1.49
Cash flow/assets	17.93% (1.91)	10.02%
Accounts payable/assets	15.83% (0.11)	14.20%
Bank loans/assets	12.41% (0.17)	5.69%
Private firms		
Employees	197.19 (242.33)	114
Assets (m£)	12.00 (19.00)	5.87
Sales/assets	1.79 (4.08)	1.58
Cash flow/assets	23.82% (3.61)	9.74%
Accounts payable/assets	18.36% (0.12)	15.69%
Bank loans/assets	13.81% (0.18)	7.42%
	t-Value[b]	*z*-Value[c]
Sales/assets	−1.565 (0.118)	−2.797 (0.005)
Cash flow/assets	−2.187 (0.029)	−5.658 (0.000)
Accounts payable/assets	−5.552 (0.000)	−5.469 (0.000)
Bank loans/assets	−2.265 (0.024)	−2.647 (0.008)

[a] Standard errors are reported in parenthesis.
[b] T tests for differences in means between public and private firms; p-values are reported in parenthesis.
[c] Mann–Witney tests for differences in medians between public and private firms; p-values are reported in parenthesis.

special role in alleviating credit rationing as firms switch from bank credit to trade credit when faced with borrowing constraints.

The accessibility to public financial markets also lowers the amount of the desired bank loans. However, the coefficient is small and only weakly significant ($t = 1.037$). One explanation is that because the quoted firms in the samples are relatively small they might find it relatively expensive to raise funds in public markets. Such a result confirms the fact that it may not be justifiable to separate firms a priori based on ownership, for example public versus private.

The coefficients of the time dummy variables are positive in the recession year of 1991 and 1992 and negative and generally declining from 1993 to 1999. This indicates that small and medium size firms are particularly dependent on bank finance during recessions. This coupled with the results from Oliner and Rudebusch (1992) and Morgan (1992) that after tightening of monetary policy bank credit ex-

Table 4
Estimated parameters of the disequilibrium model

Variables	Parameter estimates[a]
Desired demand for bank loans	
Constant	0.1105 (3.747)[b]
Sales/assets	0.0296 (8.545)[b]
Reciprocal of assets	24410 (3.773)[b]
Cash flow/assets	−0.003 (2.747)[b]
Trade credit/assets	−0.064 (−3.135)[b]
DLEG	0.0031 (1.037)
DYEAR	
1991	0.00529 (0.367)
1992	0.00540 (0.376)
1993	−0.0155 (−1.068)
1994	−0.0363 (−2.440)[b]
1995	−0.0534 (−3.471)[b]
1996	−0.0430 (−2.770)[b]
1997	−0.0504 (−3.210)[b]
1998	−0.0555 (−3.430)[b]
1999	−0.0482 (−2.333)[b]
Bank supply of bank loans	
Constant	0.2193 (45.673)[b]
Reciprocal of assets	62284 (13.541)[b]
RISK	−0.115 (−15.881)[b]
MC	−0.0012 (−2.391)[b]
Covariance matrix	
S.D. of demand equation	0.1948 (7.5192)[b]
S.D. of supply equation	0.4609 (8.3098)[b]
Correlation coefficient	0.6400 (3.3190)[b]

[a] The switching regression model is estimated by FIML. The top and bottom 1% of total assets are removed to control for the effect of outliers; *t* ratios are reported in parenthesis.

[b] Coefficients are significant at 5%.

tended to small firms contracts relative to large firms, confirms the idea that small firms bear the brunt of tight money.

The equation of bank loan availability is a priori plausible. The firm's total assets variable, as a standard proxy for collateral, appears to be an important determinant of loan availability. The increase in asset levels necessary for expanding the credit availability by £0.2193 is £1. The coefficient of the measure for risk is negative and highly significant as predicted. The coefficient of the measure of monetary policy conditions is consistent with the theoretical prediction of the credit channel view. As predicted by the credit channel view the supply of bank loans falls when monetary conditions tighten.

5.4. Further investigation

In this section, we consider several challenges to the robustness and interpretation of our results. In particular, we investigate whether technological changes in bank loans delivery have affected the demand for and supply of bank credit. We check the sensitivity of the estimation results to alternative measures of firm-specific risk and monetary policy conditions. Also, as 1999 is the final year in our sample and we only have information on half of the companies that were active in 1998 we drop 1999 from the sample data and repeat all of the above procedures.

It is possible that technological innovations such as credit scoring techniques and credit risk modelling introduced during the late 1990s have changed the delivery mechanism for bank loans, particularly to smaller firms. In order to ensure robustness of the result we split the sample into two subsamples: early 1990s data (1989–1994) and late 1990s data (1994–1999). [6] We estimate the model separately for the two subsamples and carry out Chow's stability test. The results from the test ($F = 17.96$, $p = 0.000$) reject the existence of a structural break in the banks operating environment over the sample time span.

We experiment with different proxies for firm-specific risk and monetary conditions. First, we re-estimate the model with the risk variable measured by the predicted probability of default derived from an estimated corporate failure prediction model. Details about the failure model's specification and estimation are provided in Appendix B. The initial results remain qualitatively the same.

In common with prior studies (e.g. Friedman and Kuttner, 1993; Gertler and Gilchrist, 1994) we experiment with two other proxies for monetary policy conditions: the real ex post base rate and the yield spread between three month treasury bills and 10 year treasury bonds. The estimation results do not appear to be sensitive to these changes.

In the initial estimation procedure, the top and bottom 1% of the distribution of total assets were removed in order to control for the effect of outliers on the estimation and inference of the results. Now we re-estimated the model using the whole data set. The coefficients of sales and assets have the wrong sign (negative) and are not statistically significant. This indicates the presence of aberrant observations in the sample of firms, which skew the estimation results. To avoid problems due to outliers it is justifiable to exclude them from the overall analysis.

Finally, we re-estimate the model without 1999. The results for this sub-sample are not materially different [7] and therefore we continue the analysis with the whole dataset.

6. The effect of monetary conditions on borrowing constraints

In this section, the proportion of firms in the sample, for which borrowing is constrained, is estimated. Following the results derived in Section 3 we define a 'borrowing-constrained firm in year t' as a firm whose probability that the desired demand

[6] 1994 is chosen as a sample split year for two reasons. First, the technological changes discussed above have become popular only in the last five years. Second, we are left with enough observation in each subsample so that the numerical maximization of the likelihood function is operational.

[7] Details about all checks for robustness are available from the corresponding author on request.

for bank loans in year t exceeds the maximum level available in the same year is greater than 0.5. [8] Our classification of firms into borrowing constrained and unconstrained departs from previous studies, which use firm's characteristics (partly endogenously chosen by the firm, e.g. size, ownership, bond rating, etc.) to separate firms a priori. We allow firms to switch between regimes of constrained and unconstrained, depending on the relative size of bank loan demanded to the maximum amount available over the business cycle. This implies that the severity of the borrowing constraints may vary significantly in relation to demand factors and business cycle dynamics. Our results help to explain the acknowledged existence of 'transitory' credit rationing.

Table 5 shows the proportion of borrowing constrained firms in the period from 1990 to 1999. [9] Over the whole sample period the average proportion of borrowing constrained firms is 42.7%. More importantly the results show that the proportion of borrowing constrained firms is significantly higher in the recession years of 1990–1992 and generally declines after that. In addition, note the slight increase in the proportion of constrained firm between 1996 and 1998. Fig. 1 in Appendix C shows the annual shocks to the Bank of England base rate over the sample time period. The graph confirms that a tightening of monetary policy (positive innovations) has occurred during the period of 1996–1998. These findings provide a strong support for a potent credit channel of monetary policy transmission that affects the availability of credit to smaller firms. Table 6 provides further analysis of the time pattern of the estimated classification probabilities. The results show that 11.2% of the sample firms have never been constrained, whereas 0.9% of the sample firms have been constrained over the entire time period.

Next we analyse the sensitivity of the cyclical pattern of our results to alternative measures of firm-specific risk and monetary conditions. We re-estimate the classifications probabilities for all the cases discussed in the previous section. Although the proportion of borrowing constrained firms changes slightly, the qualitative implications of the study remain the same.

Table 7 shows some sample descriptive statistics for both constrained and unconstrained firms. The t tests for differences in means and medians are significant at conventional levels. On average the borrowing constrained firms finance only 12.41% of their assets with bank loans whereas the unconstrained firms financed 13.81% of their assets by bank loans. Our proposition that constrained firms turn to trade credit when rationed by banks is confirmed by the differences in the use of trade credit by constrained and unconstrained firms (18.36% versus 15.83%). In addition, constrained firms appear to have higher sales to assets and cash flow to assets ratios than unconstrained firms. Such a finding is consistent with the results of Carpenter and Petersen (1998) that the fast growing smaller firms with profitable investment opportunities are the ones most likely to face financial constraints. The results of this

[8] As suggested by the referee, we experiment with a higher sample split threshold of 0.6 in order to control for the effect of estimation errors. The results are not qualitatively different.

[9] The result from the Fisher exact test supports the hypothesis that the values for every year are different from the value of the sample mean.

Table 5
Proportion of borrowing constrained firms (1989–1999)

Year	Percentage borrowing constrained firms (%)
1990	47.9
1991	47.8
1992	47.9
1993	41.5
1994	40.7
1995	39.6
1996	41.2
1997	38.6
1998	39.4
1999	35.1
1990–1999	42.7

Table 6
Percentage of borrowing constrained firms (1989–1999)

	Percentage borrowing constrained firms (%)
Never	11.5
Constrained once	13.7
Constrained twice	5.1
Constrained three times	4.9
Constrained four times	7.3
Constrained five times	14.3
Constrained six times	19.0
Constrained seven times	16.7
Constrained eight times	4.5
Constrained nine times	2.1
Constrained ten times	0.9

classification and their interpretation vary from the results derived from splitting the sample on the basis of ownership in Table 3. This finding supports the advantages of our methodology.

We consider the methodological approach undertaken in this study to be a significant improvement over most of the prior empirical literature on financial constraints, where firms are classified exogenously (see Sharpe (1994) for a study on employment; Bond et al. (1999) for a study on investment and R&D, Guariglia (1999) for a study on inventory). We find strong support that the severity of credit rationing depends not only on firms' specific characteristics but also on business cycle conditions.

7. Conclusions

On the basis of a large panel data set of small and medium size firms, this paper estimates a model of the demand for and supply of bank loans. The novelty of the

Table 7
Descriptive statistics for constrained and unconstrained firms

Variable	Mean	Median
Unconstrained firms		
Assets (m£)	7.8 (1.50)	3.25
Sales/assets	1.67 (1.43)	1.50
Cash flow/assets	17.93% (1.91)	10.02%
Accounts payable/assets	15.83% (0.11)	14.20%
Bank loans/assets	13.81% (0.18)	7.4%
Constrained firms		
Assets (m£)	8.10 (1.10)	4.14
Sales/assets	1.79 (4.07)	1.57
Cash flow/assets	28.52% (6.75)	13.04%
Accounts payable/assets	18.36% (0.12)	15.69%
Bank loans/assets	12.41% (0.17)	5.6%
	t-Value[a]	*z*-Value[b]
Sales/assets	−3.020 (0.003)	−16.552 (0.000)
Cash flow/assets	−1.920 (0.027)	−2.576 (0.010)
Accounts payable/assets	−6.355 (0.000)	−6.530 (0.000)
Bank loans/assets	2.860 (0.004)	4.179 (0.000)

[a] *T* tests for differences in means between unconstrained and constrained firms; *p*-values are reported in parenthesis.

[b] Mann–Witney tests for differences in medians between unconstrained and constrained firms; *p*-values are reported in parenthesis.

study is that our model explicitly allows for the possibility of credit rationing. The empirical specification used is based on the econometric technique for analysing market disequilibrium. Employing this technique has the virtue that we can separate sample firms endogenously into constrained and unconstrained on the basis of demand factors as well as measures of the business cycle dynamics. In addition, we can test for the existence of a credit channel of monetary policy transmission and its effect on the availability of bank finance to smaller businesses.

The empirical results of the study are as predicted by the theory. Firms' assets play an important role as collateral in mitigating borrowing constraints. Internal funds and interfirm credit are important substitutes for bank credit. The analysis confirms that separating firms exogenously into constrained and unconstrained on the basis of their ownership (public versus private) often may be misleading. The estimated coefficient of the dummy for a quoted firm is small and only weakly significant implying that the relatively small publicly traded companies in the sample tend to avoid using capital markets to raise funds.

The results are suggestive of the existence of a credit channel of monetary policy transmission. When monetary policy is tight, banks lower their supply of loans and the availability of external finance to the bank dependent borrowers is greatly reduced. In addition, the sample firms increase their demand for bank credit during these periods. We find support for the proposition that small firms bear the brunt of tight monetary policy. Given our approach to identification of constrained and unconstrained firms, future research can compare the differences in the investment and financing behaviour of the two types of firms.

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Appendix A. Sample selection and database

Currently the UK Dun and Bradstreet database consists of 1.6 million companies of which approximately 1 million are active. Of those companies 69% are public or private limited companies, 22% are sole traders and 9% are partnerships. Recently, a long-term research project on corporate finance and performance of UK small and medium size firms was undertaken, sponsored by Dun and Bradstreet. The sample firms were selected randomly as a stratified sample from Dun and Bradstreet SIC numbers. Conventional tests [10] were carried out to ensure that no selection bias is present in the sample. Dun and Bradstreet has agreed to provide detailed financial and behavioural profile of each company for every year of the sample period. The data collection process started in 1990 and has been updated annually until 1999. After selecting a representative sample of the small and medium size companies, the initial sample consisted of 650 firms. We removed those companies with missing or unreliable data and that reduced the sample to 639 companies over 11 years.

Series used in the empirical procedure

- Total assets (a) is the level of total assets.
- Loan outstanding (l) is computed as the sum of short-term loans payable and long-term loans payable.
- Sales (s) are net sales.
- Cash flow (cf) is defined as the net operating income plus depreciation.
- Net trade credit (tc) is calculated as the difference between the level of accounts payable and the level of accounts receivable.

Note that the reduced form equations of the model are expressed as ratios. Nevertheless, we convert all the series into real values with the appropriate deflator. The estimation of firm-specific risk (risk) and monetary conditions (mc) are discussed in the next sections.

[10] Tests for differences in age, size, profitability, industry and others showed no difference between the sample and the population.

Appendix B. Corporate failure prediction model

Credit reference agencies (e.g. Dun and Bradstreet, Equifax, ICC, etc.) calculate their risk score categories (e.g. D&B 1–4) based on standard *Z*-Score type models [11] including variables reflecting firm's gearing, liquidity, profitability and activity. Only recently in the UK, payment behaviour data (e.g. PAYDEX scores) have been incorporated in these models. The coefficients of credit reference agency models, however, are not re-estimated on a regular basis. Typically cross-sectional samples of 10,000 live and 10,000 failed companies [12] are drawn from the population of UK companies for which a linear discriminant or logistic regression is estimated based on selected financial ratios and scores for individual companies are calculated on an annual basis or more frequently if payment behaviour data is available. Typically the classification accuracy of these models is in the range of [65%, 75%].

We were able to estimate a *Z*-Score type model using logistic regression based on a Dun and Bradstreet sample of 7000 live and failed companies, which is representative of the UK population of firms and relevant to the sample time period of this study. The model specification is chosen as the 'best fit model'. The model and the estimated coefficients are

$$\begin{aligned}\Pr(\text{default}) = {} & 3.526 - 0.490\,\text{RETA} - 0.020\,\text{CURRAT} + 0.038\,\text{FFCL} \\ & - 0.247\,\text{LNASSET} + \text{error},\end{aligned} \tag{B.1}$$

where the probability of default is in the interval [0, 1]; RETA is the ratio of retained earnings to total assets; CURRAT is the current ratio; FFCL is the ratio of profit before interest and tax to current liabilities; LNASSET is the log of total assets. A risk score for each of the sample firms in each year of the sample time period is calculated as a fitted probability from Eq. (B.1).

Appendix C. Monetary VAR model

Next we attempt to estimate the prevailing monetary conditions in the UK over the period of 1989–1999. A significant fraction of the variation in Central Bank policy actions reflects policy makers' systematic response to the variations in the state of the economy. This systematic component is typically formalised with the concept of monetary reaction function. The unaccounted variation is formalised with the notion of a monetary policy shock. In this section, we follow Christiano et al. (1999). A monetary policy shock is identified with the disturbance term in an equation of the form

$$S_t = f(\Omega_t) + \varepsilon_t^s, \tag{C.1}$$

[11] For a detailed discussion on this point see Altman et al. (1995).

[12] In the UK D&B usually estimate models based on the probability of insolvency whereas in the US the outcome variable is often based on the probability of payment default.

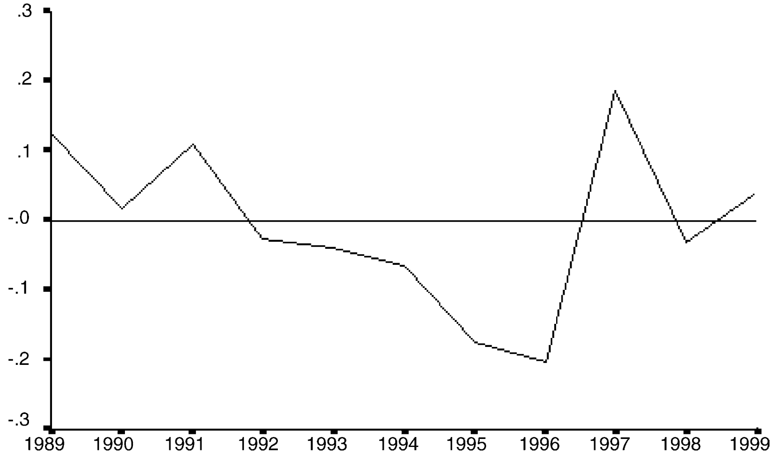

Fig. 1. Bank of England base rate innovations (1989–1999).

where S_t is the instrument of monetary policy, the Bank of England base rate, and f is a linear function that relates S_t to the information set Ω_t. The random variable ε_t^s is a monetary policy shock. A fundamental tool in the literature on monetary policy is the vector autoregression (VAR). Consider the following VAR model:

$$Y_t = A(L)Y_{t-1} + u_t, \tag{C.2}$$

where Y_t is a vector consisting of the elements of the information set, $A(L)$ is a matrix polynomial of the lag operator and $Eu_tu_t' = \Sigma$. In general, each element of u_t reflects the effect of all the fundamental economic shocks and there is no reason to presume that any element of u_t corresponds to a particular economic shock, say for example, a shock to monetary policy. One common solution to this problem is to use a priori information about the logical causal ordering among the variables in the VAR to transform the covariance matrix of shocks into a diagonal matrix (Cholesky decomposition). This identifying assumption is known as the recursiveness assumption and although not without controversy is the most widely used identifying assumption.

We estimate a three variable VAR, where the monetary policy instrument (base rate) is ordered last and the information set includes current and lagged value of output (log index of industrial production) and inflation (log retail price index). Notice that under the recursiveness assumption the elements of the information set do not change in the impact period of a monetary policy shock. The two lag VAR [13] model is estimated using quarterly data over the sample period 1988.Ql to 1999.Q4.

Since the policy shocks measures are by construction serially uncorrelated and the corporate dataset is annual, we first smooth (using MA(3)) and then aggregate the shocks for consistency and ease of interpretation. We characterise monetary policy

[13] Conventional test (BIC and AIC) suggest two lag specification.

as tight (contractionary) when the smoothed policy shock is positive and loose (expansionary) when the smoothed policy shock is negative. Fig. 1 contains the series of shocks to the base rate.

References

Altman, E., Marco, G., Varretto, F., 1995. Corporate distress diagnosis: Comparisons using linear discriminant analysis and neural networks (the Italian experience). Journal of Banking and Finance 18, 505–529.

Berger, A.N., Udell, G.F., 1998. The economics of small business finance: The roles of private equity and debt markets in the financial growth cycle. Journal of Banking and Finance 22, 613–673.

Bernanke, B., Gertler, M., 1995. Inside the black box: The credit channel of monetary policy transmission. Journal of Economic Perspectives 9 (4), 27–48.

Bernanke, B., Gertler, M., Gilchrist, S., 1996. The financial accelerator and the flight to quality. The Review of Economics and Statistics 78, 1–15.

Bernanke, B., Gertler, M., Gilchrist, S., 1999. Agency costs, net worth, and business fluctuations in a quantitative business cycle framework. In: Woodford, M., Taylor, J. (Eds.), Handbook of Macroeconomics. Elsevier, Amsterdam.

Berger, A., Udell, G., 1990. Collateral, loan quality, and bank risk. Journal of Monetary Economics 25, 21–42.

Bond, S., Harhoff, D., Van Reenen, J., 1999. Investment, R&D and financial constraints in Britain and Germany. Working Paper, The Institute for Fiscal Studies.

Brewer, G., Jackson, H., Worthington, W., 1996. How are small firms financed? Evidence from small business investment companies. Economic Perspective, Federal Reserve Bank of Chicago, Chicago, November–December, pp. 2–18.

Carey, M., Prowse, S., Rea, J., Udell, G., 1993. The economics of the private placement market. Staff study, Board of Governors, Washington, DC.

Carpenter, R., Petersen, B., 1998. Is the growth of small firms constrained by internal finance. Working Paper.

Christiano, L., Eichenbaum, M., Evans, C., 1999. Monetary policy shocks: What have we learned and to what end? In: Woodford, M., Taylor, J. (Eds.), Handbook of Macroeconomics. Elsevier, Amsterdam.

Friedman, B., Kuttner, K., 1993. Economic activity and the short-term credit markets: An analysis of prices and quantities. Brookings Papers on Economic Activity, 193–284.

Gersovitz, M., 1980. On classification probabilities for the disequilibrium model. Journal of Econometrics 14, 239–246.

Gertler, M., Gilchrist, S., 1993. The role of credit market imperfections in the monetary transmission mechanism: Arguments and evidence. Scandinavian Journal of Economics 95 (1), 42–64.

Gertler, M., Gilchrist, S., 1994. Monetary policy, business cycles, and the behaviour of small manufacturing firms. Quarterly Journal of Economics 109 (2), 309–340.

Gilchrist, S., Zakrajsek, E., 1995. The importance of credit for macro-economic activity: Identification through heterogeneity. In: Peek, J., Rosengren, E., (Eds.), Is Bank Lending Important for the Transmission of Monetary Policy? Federal Reserve Bank of Boston.

Guariglia, A., 1999. The effects of financial constraints on inventory investment: Evidence from a panel of UK firms. Economica 60, 43–62.

Hancock, D., Wilcox, J., 1994. Bank capital and the credit crunch: The role of risk-weighted and unweighted capital regulations. American Real Estate and Urban Economics Association Journal 3 (2), 31–51.

Hoshi, T., Scharfein, D., Singleton, K., 1993. Japanese corporate investment and Bank of Japan guidance of commercial bank lending. In: Singleton, K. (Ed.), Japanese Monetary Policy. NBER, Cambridge, MA, pp. 63–94.

Kashyap, A., Stein, J., Wilcox, D., 1993. The monetary transmission mechanism: Evidence from the composition of external finance. American Economic Review 83.

Madala, G., Nelson, F., 1974. Maximum likelihood methods for models of markets in disequilibrium. Econometrica 42, 1003–1030.
Milne, A., 1991. Financial effects on inventory investments. Mimeo. London Business School.
Morgan, D., 1992. The lending view of monetary policy and bank loan commitments. Unpublished paper. Federal Reserve Bank of Kansas City.
Ogawa, K., 2000. Demand for bank loans and investment under borrowing constraints: A panel study of Japanese firm data. Journal of the Japanese and International Economies 14, 1–21.
Oliner, S., Rudebusch, G., 1992. Sources of the financing hierarchy for business investment. Review of Economics and Statistics 74, 643–654.
Oliner, S., Rudebusch, G., 1996. Is there a broad channel for monetary policy. Federal Reserve Bank of San Francisco Economic Review, 3–20.
Sharpe, S., 1994. Financial market imperfections, firm leverage, and the cyclicality of employment. American Economic Review 84 (4), 1060–1074.