Available online at www.sciencedirect.com
SCIENCE DIRECT®
Journal of Banking & Finance 27 (2003) 491–510
Journal of BANKING & FINANCE
www.elsevier.com/locate/econbase

Evidence of a bank lending channel in the UK

Zhangkai Huang

St. Hugh's College, University of Oxford, Oxford, OX2 6LE, UK

Abstract

Using balance sheet data for a panel of UK listed firms, we find evidence of a bank lending channel of monetary transmission. A higher interest rate induces more bank lending to listed companies, but this effect diminishes if monetary policy becomes tight enough to impose severe constraints on bank loan lending. The dynamic behaviour of bank debt versus non-bank debt shows that the lending channel works through cutting back loan supplies to small, bank-dependent firms while restricting the bank's ability to provide financial assistance to other firms. We see cross-sectional differences between bank-dependent and non-bank-dependent listed companies, and between listed and non-listed companies: Both can contribute to the size effect of investment. Small firms bear most of the reductions in bank loan supplies, and since they do not have many alternatives to bank finance, they suffer more from monetary tightening than big firms. This is consistent with inventory behavior. Furthermore, we have found that big, non-bank-dependent firms can benefit more from the bank–firm relationship than small, bank-dependent firms.

JEL classification: G20; G21; E50
Keywords: Bank lending channel; Interest rates; Monetary policy; Dynamic panel

1. Introduction

The textbook model of monetary economics focuses on the role of interest rates and cost of capital. Monetary policy affects interest rates and, through changes in the cost of capital, investment. In the past decade, researchers have been looking at other channels of monetary policy transmission caused by capital market imperfections and the uniqueness of bank loans as against other forms of debt. The bank lending channel of monetary transmission mechanism states that monetary

E-mail address: zhangkai.huang@sbs.ox.ac.uk (Z. Huang).

0378-4266/03/$ - see front matter
PII: S0378-4266(02)00388-6

contractions reduce bank loan supplies to the real sector, causing credit-constrained investment to decrease. (See Mishkin (1995), Kashyap and Stein (1993a) and Bernanke et al. (1996) for a survey on the literature.)

The lending view stresses the limited access to capital markets for certain companies and this implies cross-sectional differences in the financing and investment behavior of firms. Gertler and Gilchrist (1994), using aggregate data from quarterly financial report, find small firms, which are most likely to be bank-dependent, bear most of the shocks in monetary contraction. Similar results have been found by Vermeulen (2000) using data on European firms. Kashyap et al. (1994) find that tight money intensifies the correlation between liquidity and inventory investment for bank dependent firms, which may suggest the existence of a bank lending channel.

Another way to study the lending view is to look at the cyclical behavior of the debt structure of the firm. A key assumption of the bank lending channel is that there is a unique supply shock to bank loans in tight money due to a reduction in bank deposits. Therefore, bank loans should be more volatile than other forms of debt during periods of tight money, so that contractions in bank loans do not merely reflect reductions in firms' debt capacity or fluctuations in the general credit supplies in the economy. Using Federal Reserve flow of funds data, Kashyap et al. (1993b) find that commercial paper increases relative to other short-term debt after a monetary contraction, possibly because firms have to turn to public debt market when they experience losses in bank loans. By analyzing the mix of aggregate bank and non-bank loans, Oliner and Rudebusch (1995, 1996b) find that increases in the federal funds rate reduce the proportion of bank loans, however, they do not find supportive evidence for any cross-sectional differences between small and large firms as predicted by the lending story.

While most of the past studies have used aggregate data of bank loans to analyze the bank lending channel, we are interested in a more detailed picture which comes from studies on firm level data. To our knowledge, this study is the first to use bank loan data at the firm level. Such data allow us to test the cross-sectional differences in bank borrowing among different types of firms. Firm level accounting data is available for listed companies in many countries. However, the use of public companies data imposes one problem: we know from past studies that small firms bear most of the effect of tight monetary policy, and since public firms are already big firms in the economy, we may fail to observe a lending channel. On the other hand, the lending channel may have asymmetric effects in and out of periods where there are strong negative monetary shocks, and this may provide us with a way to look at the lending channel using data from public firms. Indeed Kashyap et al. (1993b) study compares the inventory investment behavior of American listed companies in the early 1980s recession, which is money-driven, with that in other recessions where there are no obvious monetary contractions. Thus we may still observe a lending channel for public firms when a big monetary contraction comes even if we fail to do so in periods of smaller and less obvious monetary shocks.

We see two conditions for the lending view to hold: first, there is a unique supply shock to bank loans in periods of tight money which cannot be fully insulated by

banks, this causes a reduction in the bank loans available to the firm, and the proportion of bank debt in total debt of the firm declines as a result; second, bank loans and corporate bonds must not be perfect substitutes so that such structural changes lead to reductions in the debt volume available to the firm and reductions in investment thereafter.

We form two hypotheses based on the above argument to test the bank lending channel:

H1: Tight money, by reducing bank loan supplies to the firm, changes the firm's debt structure in the direction of a smaller proportion of bank loans.

H2: Reductions in bank loans cannot be perfectly offset by increases in other forms of debt, thus leading to reductions in firm's debt volume.

Big firms, whose information is less opaque to public and thus suffer less from adverse selection and moral hazard problems in capital market, can afford a larger debt capacity than small firms. Hence reductions in the bank loans might be heterogeneous across firms in the sense that big firms may not experience much reduction in bank loan supplies in periods of tight money, and even if they do, they may switch to other forms of debt finance more easily than small firms. We therefore make two additional hypotheses to test the asymmetric effects of the channel:

H3: Small firms bear most of the reductions in bank loans caused by tight money.

H4: Big firms can easily find alternative debt finance even if they experience a reduction in bank loans so that there are no changes in the debt volume available to them in periods of tight money.

In other words, there are cross-sectional differences in H1 and H2.

The rest of the paper is organized like this: Section 2 discusses relevant theory and empirical specification, Section 3 describes the data, the test results are provided in Sections 4 and 5 concludes.

2. Theory and empirical specification

*2.1. The choice bet*w *een bank and bond finance*

It is well known that there is a life cycle in the firm's debt financing behavior. Firms borrow from banks initially but may later go to public debt market for debt finance. There are a few papers trying to explain this phenomenon. Diamond (1991) argues that banks perform delegated monitoring of firms by taking diversified portfolios. Rajan (1992) suggests that banks have the advantages of flexible financing decision which prevent a firm's projects from going awry. The cost of this credit is that banks can seek rents from the project. Bolton and Scharfstein (1996) show that the optimal debt structure balances the benefits of deterring strategic defaults, where

managers choose to default so as to divert cash to themselves, against the costs of inefficient liquidation in a liquidity default. Chemmanur and Fulghieri (1994), Bolton and Freixas (2000) also point out the financial flexibility of bank finance which comes at a cost and the inefficient liquidation cost implied by bond finance. These studies all suggest that small, risky, low credit firms will rely on bank finance while big, safe, high credit firms rely on bond finance. It is also known that the bank–firm relationship may help the firm out of financial difficulty (Hoshi et al., 1990, 1991), a feature that is absent in bond financing.

Given the differences between direct and intermediated debt finance, one may expect that the optimal balance between the two might change when business conditions change. Kashyap et al. (1993b) present a simple framework to model the changes in the optimal debt structure over time. The firm's choice function is

$$\min C = r_B B + r_N N - f(B/D)D \quad \text{s.t. } B + N = D, \tag{1}$$

where C is cost of borrowing, $r_B B$ and $r_N N$ are interest payments on bank debt and non-bank debt respectively. f is a function of the relationship benefit of bank borrowing which may partly offset the cost of bank loans.

The first order conditions imply

$$r_B - r_N = f'(B/D). \tag{2}$$

Let MP denote the stance of monetary policy and differentiate Eq. (2) with respect to MP, we have

$$\frac{d(B/D)}{d(MP)} = \frac{1}{f''(B/D)} \frac{d(r_B - r_N)}{d(MP)}. \tag{3}$$

Assuming that the bank–firm relationship benefit rises with the share of bank loans subject to diminishing marginal returns, f is an increasing concave function, hence f' must be positive and f'' must be negative. Therefore, Eq. (3) shows that the optimal debt structure moves inversely with the spread between interest rates on bank loans and non-bank debt. In times of tight money, bank loans experience an additional supply shock due to loss of bank deposits. As the spread between interest rates on bank loans and non-bank debt rises, the so called bank lending channel would reduce the proportion of bank loans in the firm's debt structure. This reduction might be heterogeneous across firms. When risk increases in periods of tight money, lenders will be more reluctant to lend to firms with poor information availability or weak balance sheets. Besides, some researchers (Hoshi et al., 1990, 1991) have suggested that firms with close relationship with banks can seek more financial assistance from the bank in times of difficulty. Both imply that f may also increase in firm size. Therefore small firms may bear most of the reductions in bank loans. Furthermore, since small firms largely depend on bank debt for external financing and cannot easily find alternatives to it, reductions in bank loans should have a larger impact on the financing of small firms than big firms.

2.2. Empi ical$_S$ pecification

Based on the previous discussion, we propose the following baseline specification:

$$\mathrm{BD}_{i,t} = \alpha + \beta \mathrm{BD}_{i,t-1} + \lambda \Delta F_t + \gamma X_{i,t} + \mu_t + v_i + \epsilon_{i,t}, \tag{4}$$

where BD is the firm's debt structure; F is the log of base rate, an indicator for monetary policy, and X is a matrix of control variables which includes inventory investment and gearing. μ_t is a time fixed effect, v_i is an unobserved firm fixed effect, and $\epsilon_{i,t}$ is a serially uncorrelated error term which is also uncorrelated with all variables at time $t-1$. We would like to find out whether changes in monetary policy lead to changes in the firm's debt structure as predicted by the bank lending channel story. We define BD as the stock of total bank loans over stock of total debt.

The above specification is similar to Oliner and Rudebusch (1995, 1996b) who use aggregate time-series data from the quarterly financial report. However, since the credit view stresses that the effect of a lending channel is most obvious in a contractionary monetary shock, one may object that this only tests the effect of the overall monetary policy, rather than a monetary shock, on the firm's debt structure. Besides, since our sample consists of listed companies which are already large firms and have access to capital market, the effect of a lending channel may not be obvious without an obvious monetary shock. We try to test the shock effect of tight money on the firm's debt structure by constructing a dummy for tight money periods:

$$\mathrm{BD}_{i,t} = \alpha + \beta \mathrm{BD}_{i,t-1} + \lambda_1 \Delta F_t T + \lambda_2 \Delta F_t (1-T) + \gamma X_{i,t} + \mu_t + v_i + \epsilon_{i,t}, \tag{5}$$

where T is a dummy which indicates if the economy is in tight money or not. Thus λ_1 measures the effect of changes in monetary policy in tight money periods, and λ_2 measures the effect of changes in monetary policy out of tight money periods. We notice that T might be highly correlated with F, the log of base rate, yet we think this should not bias our results even if T is solely determined by F. This is because the effect of changes in monetary policy on bank loan supply is asymmetric over time. During periods of loose monetary conditions, banks are probably able to insulate their loan supplies from changes in monetary policy, however, such ability will be restricted during periods of tight monetary conditions. In other words, changes in interest rates have a larger effect on bank loan supplies when interest rates are already high than when interest rates are low. Thus the above equation will effectively capture such asymmetric effect and we expect λ_1 to be larger (in absolute value) and more significant than λ_2.

Because of the lagged dependent variable, the within estimator is inconsistent. Arellano and Bond (1991) suggest using the GMM estimator which is efficient and consistent. Eqs. (4) and (5) are first differenced to eliminate firm fixed effects, and the model variables lagged two and three periods are used as instruments. We report results from both the one-step estimator and the second-step estimator. Both estimators are consistent but the one-step estimator is not efficient. However the second-step estimator is likely to be biased downward in small samples and Arellano and Bond (1991) recommend using the one-step results for inference on coefficients. Since

our sample is large and has enough time-series observations, we report results from both estimators.

We then turn to the debt volume effect of changes in monetary policy by running the following regression:

$$\Delta D_{i,t} = \alpha + \beta \Delta D_{i,t-1} + \lambda \Delta F_t + \gamma X_{i,t} + \mu_t + v_i + \epsilon_{i,t}, \tag{6}$$

where D is the log of the firm's stock of debt, X is a matrix of control variables which includes inventory investment and bank-dependence. We define D as bank loans and total debt alternatively.

The asymmetric effect of changes in monetary policy over time is estimated in the following regression:

$$\Delta D_{i,t} = \alpha + \beta \Delta D_{i,t-1} + \lambda_1 \Delta F_t T + \lambda_2 \Delta F_t (1 - T) + \gamma X_{i,t} + \mu_t + v_i + \epsilon_{i,t}. \tag{7}$$

If bank loans and other forms of debt are not perfect substitutes and firms cannot offset losses in bank loans by turning to the public debt market, any structural changes captured in regression (4) and (5) should also lead to changes in debt volume accordingly. As before, Eqs. (6) and (7) are estimated using a first-differenced GMM estimator.

Reductions in debt finance finally lead to reductions in investment. Firms which depend on banks for debt finance will be more likely to be financially constrained. This should be most distinct during periods of tight money when there is a reduction in bank loan supplies and bank-dependent firms are forced to cut back inventory investment. We therefore run an inventory investment regression to provide additional evidence on the bank lending channel:

$$\Delta N_{i,t} = \alpha + \beta \Delta N_{i,t-1} + \gamma X_{i,t} + \lambda \mathrm{BD}_{i,t-1} + \mu_t + v_i + \epsilon_{i,t}, \tag{8}$$

where N is the log of inventory, X is a matrix of control variables which includes the sales scaled by capital stock, and changes in sales. We expect a negative sign on $\mathrm{BD}_{i,t-1}$ since bank-dependence implies potential financial constraint.

$$\Delta N_{i,t} = \alpha + \beta \Delta N_{i,t-1} + \gamma X_{i,t} + \lambda_1 \mathrm{BD}_{i,t-1} T + \lambda_2 \mathrm{BD}_{i,t-1} (1 - T) + \mu_t + v_i + \epsilon_{i,t}. \tag{9}$$

We expect the negative impact of bank-dependence on inventory investment to be most obvious in periods of tight money and λ_1 should be larger (in absolute value) and more significant than λ_2.

3. Data and descriptive statistics

We collect annual balance sheet data of UK listed companies from Datastream. The uniqueness of this dataset is the separation between bank debt and other forms of debt in the balance sheet. It consists of 1024 non-financial firms between accounting year 1975 and 1999. We delete observations where bank debt is missing and firms without four years of consecutive records. We keep firms whose accounting years end in the fourth or the first quarter of a calendar year so that they operate under

Table 1
Descriptive statistics

		Bank-dependent	Non-bank-dependent
D	Mean	1688.79	194.9046
	Median	112.1389	41.0573
B	Mean	426.417	147.8559
	Median	26.9128	31.2864
K	Mean	3630.74	331.1448
	Median	253.3871	72.9513
BD	Mean	0.3824	0.8049
	Median	0.3273	0.9114
SK	Mean	5.5462	9.5118
	Median	3.9234	5.4058
Number of firms		512	512

Descriptive statistics about bank-dependent and non-bank-dependent firms. These are 1024 British firms are taken from Datastream database between 1975 and 1999. The classification criterion is the average ratio of bank loans over total debt across sample period. We split this ratio at the 50th percentile, which happens to be 0.62, so that each group has 512 firms. Data have been deflated against retail price index and are in £million except ratios. *D* is total stock of debt; *B* is total stock of bank loans; *K* is capital stock, which we take to be fixed assets; BD is the ratio of bank loans over total debt, SK is sales scaled by capital stock.

similar macroeconomic conditions (a firm whose accounting year ends in the first quarter is regarded as operating in the preceding calendar year). We divide firms into two groups: bank-dependent and non-bank-dependent. The criteria we use is the average ratio of bank loans over total debt across years. We split the sample at the 50th percentile so that each group has 512 firms. The descriptive statistics are shown in Table 1. Bank-dependent firms have an average bank-debt ratio of 0.8049, which is twice as much as that of non-bank-dependent firms. We can also see that bank-dependent firms are on average much smaller than non-bank-dependent firms. This is consistent with the view that small firms depend on banks for debt financing.

We are interested in finding out the components of other forms of debt apart from bank loans. Unfortunately, we are not able to get this information from Datastream. Limited access to individual companies' accounts tells us that this mainly consists of public borrowing for big firms, and for small, bank-dependent firms, loans from non-bank financial institutions and capitalized leases usually constitute a large share of non-bank borrowings. We use gross debt in our regression rather than net debt for two reasons: first, we would like to assess the supply side effect of changes in bank loans, so the gross figure is more appropriate than the net; second, Datastream does not allow us to distinguish between cash holdings and securities, thus it is not possible to derive net bank loans and net bonds.

Our interest rate indicator for changes in monetary policy is the selected banks' base rate from Datastream. Over time, the Bank of England uses different money market targets in implementing monetary policy. From 13 October 1972 to 1981, the London Clearing Banks linked their base rates to the minimum lending rate set by the Bank of England. With the introduction of the band one dealing rates on 20 August 1981, banks' base rates moved more flexibly since the Bank of

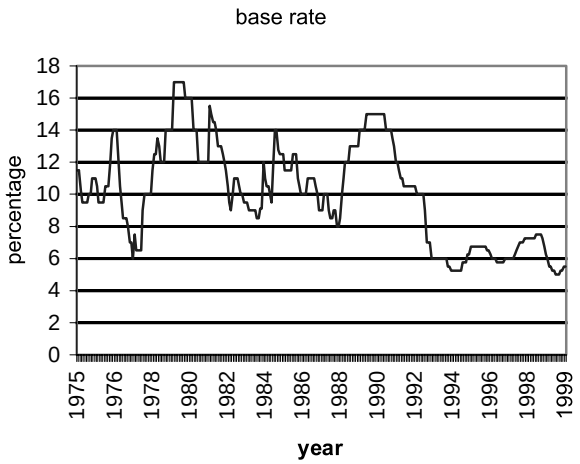

Fig. 1. London clearing bank base rate.

England's stop rate in its open market operations is no longer published. From 3rd March 1997, the Bank of England expanded its open market operations to the Gilt Repo market and the repo rate became one of its targets. In general, changes in the Bank of England's targeting rates would signify a marked change in the level of clearing banks' base rates. Therefore we choose the base rate as our indicator for monetary policy.

Between 1975 and 1999, the base rate reaches a very high position in the early 1980s and early 1990s, see Fig. 1. To have a clear picture of the UK monetary policy during this period, we calculate a monetary condition index. A monetary condition index is a weighted average of changes in interest rate and exchange rate:

$$\mathrm{MCI}_t = A_{\mathrm{R}}(r_t - r_{\mathrm{b}}) + A_{\mathrm{S}}(q_t - q_{\mathrm{b}}), \tag{10}$$

where r_t is the short-term interest rate, q_t is the log of the exchange rate, and r_{b} and q_{b} are interest rate and exchange rate at the base period, which is quarter one of 1984 in our case (see Batini and Turnbull (2000) for a survey on the monetary condition indices for the UK).

Fig. 2 shows the monetary condition index based on the IMF model. We can see that the index reaches two peaks in 1980 and 1990, and starts to decline after that. This is consistent with the usual view that monetary policy became very tight during these two periods. Therefore we set 1980 and 1990 as periods of big monetary shocks. [1] We are aware of the lack of obvious tight money periods in this study, but we could still make meaningful inference since we are mainly interested in cap-

[1] Oliner and Rudebusch (1996a) take a similar approach to estimate the asymmetric effect of cash flow on investment by interacting the cash flow with a dummy which equals one after a monetary tightening. Guariglia (1999) and Vermeulen (2000) estimate the financial accelerator effect by interacting the coverage ratio with a dummy which equals one in periods of recession.

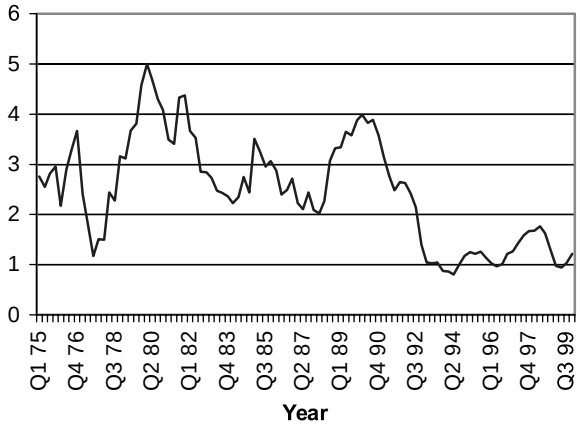

Fig. 2. UK monetary condition index: The index is calculated according to the IMF model for the UK. The short-term interest rate is the three month LIBOR rate, the exchange rate is the sterling effective exchange rate index. The model gives a weight of 3 to interest rate and a weight of 1 to exchange rate in calculation.

turing the asymmetric effect of changes in monetary policy across different periods, and regression 5, 7, and 9 would still be able to tell us the difference in bank lending behavior in and out of periods of tight money. Indeed some recent studies (Guariglia, 1999; Vermeulen, 2000) show that this approach is fruitful in testing the asymmetric effect of certain variables in different types of macroeconomic conditions.

4. Results

4.1. Evidence of a bank lending channel

The results of the tests on the effect of monetary policy on firm's debt financing are shown in Tables 2–4. Both the one-step and the two-step estimators pass the Sargan test for overidentification. However, there is some sign of second-order autocorrelation for one-step estimates on the non-bank-dependent sample in Tables 3 and 4.

From Table 2 we can see that tightening of monetary policy reduces the proportion of bank loans in the bank-dependent firms' debt structure and increases this proportion for firms which are not bank-dependent. This is not surprising if we recall Oliner and Rudebusch's (1995, 1996b) result that tight money shift funds from small firms to big firms. [2] Thus for big firms, increases in interest rate indicate financial difficulty and banks are likely to offer financial assistance to these firms. This cross-sectional difference is consistent with the bank lending story since bank-dependent firms will bear most of the reductions in bank loans. Interacting changes in the log of

[2] This is also consistent with Diamond (1991), which predicts that a decrease in future profitability will cause more bank loans relative to other forms of debt to firms with high ratings.

Table 2
The effect of monetary policy on the debt structure

	Bank-dependent		Non-bank-dependent		Bank-dependent		Non-bank-dependent	
	GMM1	GMM2	GMM1	GMM2	GMM1	GMM2	GMM1	GMM2
BD_{t-1}	0.4387***	0.4386***	0.5597***	0.5596***	0.4365***	0.4364***	0.5596***	0.5597***
	(0.0249)	(0.0002)	(0.0209)	(0.0014)	(0.0251)	(0.0001)	(0.0209)	(0.0014)
ΔN_t	0.0204	0.0205***	0.0248	0.0239***	0.0071	0.0072***	0.0209	0.0201***
	(0.0198)	(0.0001)	(0.02)	(0.0013)	(0.0207)	(0.0001)	(0.0208)	(0.0013)
ΔG_t	0.0334**	0.0333***	0.0789***	0.0785***	0.0329**	0.0329***	0.0793***	0.0792***
	(0.0149)	(0.0000)	(0.0171)	(0.0005)	(0.0150)	(0.0000)	(0.017)	(0.0006)
ΔF_t	−0.0083***	−0.0083	0.0143	0.0141***				
	(0.0140)	(0.0001)	(0.0165)	(0.0009)				
$\Delta F_t T$					−0.1553*	−0.154***	−0.0199	−0.0235***
					(0.0912)	(0.0007)	(0.0751)	(0.005)
$\Delta F_t(1-T)$					−0.0012	−0.0015***	0.0162	0.0162***
					(0.0144)	(0.0002)	(0.0169)	(0.0009)
Diagnostics tatistics (P-value)								
Sargan		0.4884		0.3681		0.5452		0.3437
$m2$	0.1788	0.1934	0.7559	0.7544	0.2218	0.2398	0.7194	0.7145

Regressions on bank-dependent and non-bank-dependent firms. The dependent variable is BD_t, the ratio of bank loans over total debt stock. The independent variables are BD_{t-1}, the lagged bank-debt ratio; ΔN_t, changes in the log of inventory; ΔG_t, changes in the log of gearing, which is the debt–asset ratio; ΔF_t, changes in the log of base rate. T is a dummy for tight money periods, which equals one in 1980 and 1990. The regression is estimated using the Arellano and Bond's (1991) differenced GMM. Sargan is the Sargan test for over-identification, $m2$ is the test for second-order autocorrelation. GMM1 is the one-step GMM estimator with robust standard errors, GMM2 is the two-step estimator. To deal with potential problem of endogeneity, both ΔN_t and ΔG_t are treated as pre-determined. Standard errors are in brackets.

*Significant at 10% level.

**Significant at 5% level.

***Significant at 1% level.

Table 3
The effect of monetary policy on the volume of bank loans

	Bank-dependent		Non-bank-dependent		Bank-dependent		Non-bank-dependent	
	GMM1	GMM2	GMM1	GMM2	GMM1	GMM2	GMM1	GMM2
ΔB_{t-1}	−0.1037***	−0.1037***	−0.1817***	−0.1812***	−0.1007***	−0.1008***	−0.1808***	−0.1803***
	(0.0218)	(0.0000)	(0.0272)	(0.0003)	(0.0217)	(0.0001)	(0.0272)	(0.0003)
ΔN_t	0.9610***	0.9610***	0.6485***	0.6491***	0.8378***	0.8380***	0.6135***	0.6140***
	(0.1198)	(0.0004)	(0.1201)	(0.001)	(0.1146)	(0.0004)	(0.1242)	(0.0011)
BD_{t-1}	−1.8967***	−1.8971***	−1.0638***	−1.0648***	−1.9192***	−1.9175***	−1.0693***	−1.0714***
	(0.2179)	(0.0005)	(0.2115)	(0.0031)	(0.2191)	(0.0009)	(0.211)	(0.0025)
ΔF_t	0.1826**	0.1824***	0.3146***	0.3126***				
	(0.0714)	(0.0003)	(0.0935)	(0.0011)				
$\Delta F_t T$					−1.3894***	−1.383***	−0.0363	−0.0302**
					(0.4995)	(0.0042)	(0.4484)	(0.0145)
$\Delta F_t(1-T)$					0.2583***	0.2590***	0.3348***	0.3332***
					(0.0694)	(0.0004)	(0.0934)	(0.0009)
Diagnostic statistic (P-value)								
Sargan		0.8197		0.7509		0.8468		0.6997
$m2$	0.5924	0.6310	0.0454	0.0760	0.5932	0.6302	0.0470	0.0765

Regressions on bank-dependent and non-bank-dependent firms. The dependent variable is ΔB_t, changes in the log of bank debt. The independent variables are ΔB_{t-1}, the lagged changes in the log of bank debt; ΔN_t, changes in the log of inventory; BD_{t-1}, the lagged bank-debt ratio; ΔF_t, changes in the log of bank base rate. T is a dummy for tight money periods, which equals one in 1980 and 1990. The regression is estimated using the Arellano and Bond's (1991) differenced GMM. Sargan is the Sargan test for over-identification, $m2$ is the test for second-order autocorrelation. GMM1 is the one-step GMM estimator with robust standard errors, GMM2 is the two-step estimator. To deal with potential problem of endogeneity, both ΔN_t and BD_{t-1} are treated as pre-determined. Standard errors are in brackets.

*Significant at 10% level.

**Significant at 5% level.

***Significant at 1% level.

Table 4
The effect of monetary policy on the volume of debt

	Bank-dependent		Non-bank-dependent		Bank-dependent		Non-bank-dependent	
	GMM1	GMM2	GMM1	GMM2	GMM1	GMM2	GMM1	GMM2
ΔD_{t-1}	−0.1329***	−0.1329***	−0.1038***	−0.1031***	−0.1325***	−0.1326***	−0.1026***	−0.1021***
	(0.0248)	(0.0000)	(0.0374)	(0.0015)	(0.0248)	(0.0000)	(0.0376)	(0.0015)
ΔN_t	0.7681***	0.7683***	0.4748***	0.4756***	0.7028***	0.7022***	0.4507***	0.4514***
	(0.101)	(0.0004)	(0.0859)	(0.0031)	(0.0979)	(0.0004)	(0.0889)	(0.003)
BD_{t-1}	−0.4572***	−0.4556***	−0.2545**	−0.2525***	−0.4693***	−0.4690***	−0.2545**	−0.2510***
	(0.1634)	(0.0014)	(0.1075)	(0.006)	(0.1624)	(0.0004)	(0.1078)	(0.0054)
ΔF_t	0.2287***	0.2286***	0.1551***	0.1548***				
	(0.0559)	(0.0004)	(0.0536)	(0.0035)				
$\Delta F_t T$					−0.5596*	−0.5607***	−0.1145	−0.1471***
					(0.3225)	(0.0015)	(0.2292)	(0.0171)
$\Delta F_t(1-T)$					0.2669***	0.2670***	0.1698***	0.1705***
					(0.0561)	(0.0004)	(0.0552)	(0.0035)
Diagnostics tatistics (P-value)								
Sargan		0.7918		0.6018		0.8084		0.6622
$m2$	0.6008	0.6466	0.0225	0.0554	0.659	0.7010	0.0245	0.0593

Regressions on bank-dependent and non-bank-dependent firms. The dependent variable is ΔD_t, changes in the log of total debt. The independent variables are ΔD_{t-1}, the lagged changes in the log of total debt; ΔN_t, changes in the log of inventory; BD_{t-1}, the lagged bank-debt ratio; ΔF_t, changes in the log of base rate. T is a dummy for tight money periods, which equals one in 1980 and 1990. The regression is estimated using the Arellano and Bond's (1991) differenced GMM. Sargan is the Sargan test for over-identification, $m2$ is the test for second-order autocorrelation. GMM1 is the one-step GMM estimator with robust standard errors, GMM2 is the two-step estimator. To deal with potential problem of endogeneity, both ΔN_t and BD_{t-1} are treated as pre-determined. Standard errors are in brackets.

*Significant at 10% level.

**Significant at 5% level.

***Significant at 1 level.

interest rate with dummies which indicate periods of tight money, we can see that monetary policy also has asymmetric effects across time. For bank-dependent firms, the one-step result shows that the reduction in the bank-debt ratio is significant in tight money periods only, and the two-step result shows that the magnitude of the reduction in the bank-debt ratio is much larger in tight money periods, as evidenced by a coefficient of -0.1553 on changes in interest rate during these periods as against a coefficient of -0.0015 during other periods. For non-bank-dependent firms, the bank's ability of providing financial assistance to the firm may be weakened in a big negative monetary shock because of the bank lending channel where the supplies of bank loans are severely constrained. This is well-illustrated in the last column of Table 2. Changes in interest rates no longer push up the bank-debt ratio for big firms when interacted with a dummy for tight money periods. Indeed, the bank-debt ratio of big firms is reduced by increases in interest rate during periods with large monetary contractions. In general, Table 2 shows that movements in the debt structure of the firm are consistent with the theory of the bank lending channel, which is most significant in big monetary shocks like the ones in 1980 and 1990.

Do changes in the debt structure imply changes in the volume of bank loans in the same direction? From Table 3, we see that tight money leads to more bank lending to listed companies, bank-dependent and non-bank-dependent alike. [3] This suggests that the decline in the bank-debt ratio after a monetary tightening of small listed firms in Table 2 is not caused by reductions in bank lending, but by relative increases in the proportion of other forms of debt. We argue that this indicates the benefit of bank–firm relationship is mostly taken by big listed firms, and the shift of funds to small listed companies mainly consists of non-bank debt. That is why we observe an increase in the volume of bank loans and a decrease in the bank-debt ratio for small firms at the same time. However, when the constraint on bank loan supplies becomes severe enough as one may expect to happen in 1980 and 1990 according to the bank lending story, financial assistance from the bank disappears. When changes in the base rate is interacted with a dummy for periods of tight money, both the one-step and the two-step results show that increases in interest rate during tight money periods reduce bank loan supplies to bank-dependent firms. For those which are not bank-dependent, the one-step result shows that increases in interest rate fail to induce financial assistance from the bank during tight money periods as in other periods. Indeed the two-step result shows that volume of bank loans available to big firms decline with increases in interest rate during periods of tight money just as small firms, although the magnitude of such a decline is much smaller than that of small firms. Combined with results in Table 2, we can see that although our sample firms are relatively large firms in the economy and tight money may not have much effect on them, we can still observe a distinctive bank lending channel when monetary condition becomes tight enough. During periods of big negative monetary

[3] This coincides with Oliner and Rudebusch's (1995, 1996b) finding that a positive innovation in the federal funds rate increases bank loan supplies to big manufacturing firms in the US. Since our sample consists of listed companies which are already larger than other firms in the economy, they may actually get more bank loans in tight money.

shocks, declines in the volume of bank loans reduce the bank-debt ratio of the firm, and this is most obvious and significant for bank-dependent firms.

For the lending view to hold, changes in debt structure and volume of bank loans must lead to changes in the volume of total debt. That is, bank loans must not be perfect substitutes with other forms of debt, and losses in bank loans cannot be offset by increases in other debts, therefore total debt declines. To see if this is true, we turn to Table 4. Table 4 shows that a tight monetary policy tends to increase total debt credit extended to listed companies as found by Oliner and Rudebusch (1995, 1996b). The asymmetric effect of monetary policy in and out of big monetary shocks provides further evidence on the bank lending channel. When interacted with a dummy for tight money, increases in interest rate reduce the volume of total debt of bank-dependent firms. And for big firms which are not bank-dependent, the one-step result shows that increases in total debt disappear in tight money periods, and the two-step result shows that big firms also experience reductions in total debt during periods of tight money, although the size of the reduction in much smaller than that of bank-dependent firms. Our results suggest that big firms do not experience as much reduction in bank loans during periods of tight money as small firms do, and that with more alternatives to bank loans, they can offset reduction in bank loans supplies better than do small firms. This well explains the finding that small firms bear most effects of the monetary shock.

4.2. Cont ol va iables

The control variables we use in regressions 4 and 5 are changes in the log of inventory, a proxy for investment spending; and changes in the log of the firm's debt–asset ratio, which intends to capture changes in the firm's borrowing pattern. Both of them have positive effect on the bank-debt ratio of the firm. This is consistent with the fact that bank finance is the most important source of external finance (Mayer, 1988), and if the firm borrows more to finance increasing investment, it usually raises bank debt.

The control variables we use in regressions 6 and 7 are changes in the log of inventory and the lagged bank-debt ratio. Changes in the log of inventory have positive effects on changes in the volume of bank loans and total debt, which is not surprising since increases in investment will push up debt borrowing. The lagged bank-debt ratio, which is a measure of bank-dependence, has negative effects on changes in the volume of bank loans and total debt. From previous discussion we also know that it is the big firms, classified as non-bank-dependent by us, that benefit most from bank's ability to extend necessary credit: (1) Big firms usually experience increases in bank borrowing after increases in interest rate, and although they experience a reduction in bank loans in periods of tight money, the magnitude of the reduction is not as large as that of small firms; (2) although small firms experience increases in bank borrowing after an increase in interest rate, such increases are not as large as increases in other forms of debt as evidenced by a decrease in the bank-debt ratio. Therefore we suggest that bank-dependence not only constrains the firm's ability to seek alternative debt finance, it also makes it more difficult to

get additional bank finance. It seems that the bank–firm relationship works mainly for firms which are not bank-dependent and thus have a larger capacity for bank loans. Such capacity might have come from the larger bargaining power in the bank–firm relationship of these non-bank-dependent firms, or perhaps non-bank-dependent firms are usually large and mature and have a long relationship with the bank.

4.3. Evidence f om the inv s tment eg ss ion s

Regressions 8 and 9 intend to capture the effect of monetary policy on inventory investment and the results are shown in Table 5. We can see that for bank-dependent firms, bank-dependence has negative effects on changes in inventory as expected. For other firms, bank-dependence is not significant under the one-step estimator, and even if it becomes significant under the two-step estimator, its magnitude is only half of that of bank-dependent firms, as evidenced by a coefficient of -0.0492 versus a coefficient of -0.1036 for bank-dependent firms. The negative impact of bank-dependence is larger in periods of tight money than in other periods. Inventory investment of both groups of firms are more sensitive to bank-dependence in tight money. Table 5 reconfirms previous cross-sectional studies that link investment behavior with financial constraint. We argue that bank-dependence is one of the sources of potential financial constraint, and that changes in monetary policy, by changing bank loans supplies, can affect the severity of this constraint.

4.4. Relation w ith p eviou s tudie s

Previous studies (Gertler and Gilchrist, 1994, and others) explain the size effect of monetary policy, i.e. small firms bear most of the effect of tight money, by the fact that small firms depend on banks for external debt finance. Thus when tight money works by reducing bank loan supplies as predicted by the bank lending channel of monetary transmission mechanism, small firms will suffer more than big firms. Oliner and Rudebusch (1995, 1996b) also show that there is a shift of funds from small firms to big firms after a monetary shock, which constitutes an additional factor in generating the size effect. Our tests provide further evidence using data of listed companies. We have shown that reductions in the bank-debt ratio and the volume of bank loans are most obvious for our bank-dependent firms, which are smaller than other firms. Thus the reductions in bank loans have asymmetric effects across firms, which help to generate the size effect captured in investment studies.

Kashyap et al. (1993b) find relative increases in commercial paper financing after tight money, which may indicate a relative decline in bank debt. Oliner and Rudebusch (1995, 1996b) find that changes in the interest rate indicator for monetary policy, which is the federal funds rate in their case for American firms, has negative effects on the proportion of bank loans relative to other forms of debt. Our study shows that changes in the interest rate indicator for monetary policy in the UK, which is the base rate, has positive effects on the proportion of bank loans relative to other forms of debt for big firms. For small firms, although increases in interest

Table 5
The effect of monetary policy on inventory investment

	Bank-dependent		Non-bank-dependent		Bank-dependent		Non-bank-dependent	
	GMM1	GMM2	GMM1	GMM2	GMM1	GMM2	GMM1	GMM2
ΔN_{t-1}	−0.2008***	−0.2008***	−0.1540***	−0.1541***	−0.1948***	−0.1949***	−0.1520***	−0.1506***
	(0.0335)	(0.0001)	(0.0357)	(0.0006)	(0.0348)	(0.0001)	(0.0361)	(0.0006)
SK_{t-1}	0.2041***	0.2039***	0.1689***	0.169***	0.1972***	0.1970***	0.1588**	0.1609
	(0.0584)	(0.0003)	(0.0658)	(0.0018)	(0.0584)	(0.0003)	(0.0671)	(0.0019)
ΔS_t	1.1441***	1.1444***	0.7067***	0.7067***	1.1081***	1.1084***	0.6854***	0.6853***
	(0.1152)	(0.0003)	(0.1251)	(0.0015)	(0.1280)	(0.0005)	(0.1292)	(0.0016)
ΔS_{t-1}	0.1250**	0.1249***	0.1436***	0.1451***	0.1292**	0.129***	0.1500***	0.1511***
	(0.0565)	(0.0003)	(0.0429)	(0.0013)	(0.0566)	(0.0004)	(0.0432)	(0.0011)
BD_{t-1}	−0.1034***	−0.1036***	−0.0516	−0.0492***				
	(0.0353)	(0.0004)	(0.0334)	(0.0017)				
$BD_{t-1}\,T$					−0.1547***	−0.1549***	−0.1494***	−0.1431***
					(0.0448)	(0.0004)	(0.0502)	(0.0026)
$BD_{t-1}(1-T)$					−0.0981***	−0.0982***	−0.0432	−0.0389***
					(0.0351)	(0.0003)	(0.0338)	(0.0019)
Diagnostics tatistics (P-value)								
Sargan		0.9982		0.9862		0.9988		0.9881
$m2$	0.6126	0.6843	0.1606	0.1274	0.5938	0.6691	0.1666	0.1339

Regressions on bank-dependent and non-bank-dependent firms. The dependent variable is ΔN_t, changes in the log of inventory. The independent variables are ΔN_{t-1}, the lagged changes in the log of inventory; SK_{t-1}, lagged sales scaled by lagged capital stock; ΔS_t and ΔS_{t-1}, changes in the log of sales; BD_{t-1}, the lagged bank-debt ratio. T is a dummy for tight money periods, which equals one in 1980 and 1990. The regression is estimated using the Arellano and Bond's (1991) differenced GMM. Sargan is the Sargan test for over-identification, $m2$ is the test for second-order autocorrelation. GMM1 is the one-step GMM estimator with robust standard errors, GMM2 is the two-step estimator. To deal with potential problem of endogeneity, SK_{t-1}, ΔS_t and ΔS_{t-1} are treated as pre-determined. Standard errors are in brackets.

*Significant at 10% level.

**Significant at 5% level.

***Significant at 1% level.

rate reduce the bank-debt ratio, the reduction is not caused by decline in the volume of bank loans, but rather by the relative increases in other forms of debt. We argue that this is indeed consistent with their results. The difference is due to different firm sizes in our study and theirs. The use of the Federal Reserve flow of funds data for the whole American economy by Kashyap et al. (1993b, 1996), as well as the use of the quarterly financial report data which includes a large number of non-listed companies by Oliner and Rudebusch (1995, 1996b), allow a broad coverage of companies, while our sample of listed firms may already be biased towards large firms. Our study shows that banks are able to extend more credit to firms in financial difficulty which might be caused by rises in interest rates. Given that our sample consists of relatively big firms, this is consistent with the previous finding that tight money causes a shift of funds from small firms to large firms: This represents a shift of funds to listed companies in our study. However, we have also shown that in a big negative monetary recession shock like the one in 1980 and 1990, banks fail to shift more funds to big firms probably because of a severe constraint on loan supplies, and indeed there is a contraction of bank loan supplies to these firms. In this case both the bank-debt ratio and the volume of bank loans as well as the volume of total debt decline. We conclude that the bank lending channel mainly works through cutting back bank loan supplies to small firms in times of tight money while restricting the bank's ability to provide financial assistance to big firms when a big monetary shock comes which severely constrains bank loan supplies.

4.5. Robu tne$_{SS}$ te t

In regression 5, 6 and 9, we interact an independent variable with a dummy which equals one in 1980 and 1990. Since the dummy has only two positive observations, the coefficient on the interactive term may not be precisely determined because of the lack of variability, and one may expect it is not significant. Although we have significant coefficients on the interactive term, we consider alternative definitions of the dummy to address the issue. Since the bank lending channel implies that the effect of monetary tightening on bank loan supply should be most obvious during periods of tight money, we set the dummy to be one in a year when (1) there are positive changes in the monetary condition index, i.e. there is a monetary tightening, and (2) the monetary condition index in the previous year is already above a high level. We set this arbitrary level to be 2.5 and 2 and get 4 (1976, 1980, 1989 and 1990) and 7 (1976, 1979, 1980, 1985, 1988, 1989, 1990) positive observations of the dummy respectively. [4] Results of regression 5, 6, and 9 are similar to what we see in the previous section. However, the effect on bank loan supply is not as obvious, especially when the dummy has seven positive observations. This reconfirms the statement that the bank lending channel is most effective in periods of tight money.

[4] Year 1980 and 1990 happen to be time periods when (1) there are positive changes in the monetary condition index, and (2) the monetary condition index in the previous year has already reached 3.

We use base rate as an indicator for changes in monetary policy in our regressions. To see whether our results are robust using alternative monetary policy indicators, we also try the overnight London Interbank Offer Rate (LIBOR). The results are largely the same.

We have also used real interest rate as an indicator for changes in monetary policy. Bank of England calculates implied forward inflation rate from index-linked government bond's yield curves using Fisher's identity. The series is available from mid-1980s. We deduct the implied forward inflation rate from both base rate and the overnight LIBOR rate. The test results from the real interest rate are also consistent with the bank lending channel theory. However, since we do not have the 1980 period in this sample, where monetary condition is notoriously tight, the effect of the bank lending channel appear to be weaker than the previous regressions which include the 1980 episode.

The classification criteria of the firms in our sample is bank-dependence, which is the dependent variable in regression 1 and 2. To correct potential biases caused by this, we have tried the traditional size classification. It turns out that the two criterion would split the sample in the same way and we have got similar sub-samples. This is not surprising since small firms tend to depend on banks for debt finance. The regression results on the sub-samples split by size are therefore largely the same as before.

5. Conclusion

Using balance sheet data for a panel of UK listed firms, we have found evidence that tight money reduces bank loan supplies to firms. The reduction in bank loans lowers the bank-debt ratio of the firm. Furthermore, bank loans and other forms of debt do not appear to be perfect substitutes and losses in bank loans lead to losses in total debt. The evidence confirms the existence of a bank lending channel of monetary policy transmission mechanism, which can explain both changes in the debt structure and changes in the debt volume. Consistent with the predictions of the theory, this channel is most significant for firms which are bank-dependent and during periods when there is a strong negative monetary shock. In other periods, a tougher monetary policy does not seem to reduce bank loan supplies to these firms, and indeed bank borrowing increases. This is possibly because banks can fully insulate loans supply from small changes in monetary policy, or because public companies, which are usually bigger than private companies, capture most of the benefit of bank–firm relationship.

Our study reinforces the previous microeconomic research on the credit channel. We have found both cross-sectional differences and time-varying differences in the firm's bank borrowing behavior. Previous studies have tried to document different investment behavior in and out of times of tight money, and across firms with different sizes. Our study suggests that reductions in bank loans due to tight money, together with the failure to substitute bank loans with other forms of debt, do indeed contribute to the differences in investment behavior of firms with different sizes. And this is confirmed by our study on the investment behavior of firms. Fur-

thermore, we have found that big, non-bank-dependent firms can benefit more from the bank–firm relationship than small, bank-dependent firms.

Our study generates different but consistent results from studies using datasets which include non-listed firms. Combined with these studies, we can see that there might be two types of cross-sectional differences: the difference between public and non-listed companies, which proxies the size effect captured in previous studies; and among public companies, the difference between bank-dependent and non-bank-dependent companies. The broad picture may suggest that tight money reduces bank loan supplies to non-listed companies which are small and have no access to capital market, and that it increases bank loan supplies to public companies, especially those which depend less on banks for external debt finance. However, if the monetary policy becomes tight enough, public companies, especially those which are small and bank-dependent, will start to suffer from losses in bank loans.

Acknowledgements

The author is grateful to Colin Mayer, Oren Sussman, Tim Jenkinson, Misa Tanaka, seminar participants at Oxford University, Imperial College, Bank of England, and an anonymous referee for useful comments.

References

Arellano, M., Bond, S., 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Review of Economic Studies 58, 277–297.

Batini, N., Turnbull, K., 2000. Monetary condition indices for the UK: A survey. External MPC Unit Discussion Paper No.1, Bank of England.

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

Bolton, P., Freixas, X., 2000. Equity, bonds, and bank debt: Capital structure and financial market equilibrium under asymmetric information. Journal of Political Economy 108, 324–351.

Bolton, P., Scharfstein, D., 1996. Optimal debt structure and the number of creditors. Journal of Political Economy 104, 1–25.

Chemmanur, T., Fulghieri, P., 1994. Reputation, renegotiation, and the choice between bank loans and publicly traded debt. Review of Financial Studies 7, 475–506.

Diamond, D., 1991. Monitoring and reputation: The choice between bank loans and directly placed debt. Journal of Political Economy 99, 689–721.

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

Guariglia, A., 1999. The effect of financial constraints on inventory investment: Evidence from a panel of UK firms. Economica 66, 43–62.

Hoshi, T., Kashyap, A., Scharfstein, D., 1990. The role of banks in reducing the costs of financial distress in Japan. Journal of Financial Economics 27, 67–88.

Hoshi, T., Kashyap, A., Scharfstein, D., 1991. Corporate structure, liquidity, and investment – evidence from Japanese Industrial Groups. Quarterly Journal of Economics 106, 33–60.

Kashyap, A., Lamont, O., Stein, J., 1994. Credit conditions and the cyclical behavior of inventories. Quarterly Journal of Economics 109, 565–592.

Kashyap, A., Stein, J., 1993a. Monetary Policy and Bank Lending. NBER Working Paper No. 4317.

Kashyap, A., Stein, J., Wilcox, W., 1993b. Monetary policy and credit conditions: Evidence from the composition of external finance. American Economic Review 83, 78–98.

Kashyap, A., Stein, J., Wilcox, W., 1996. Monetary policy and credit conditions: Evidence from the composition of external finance: Reply. American Economic Review 86, 310–314.

Mayer, C., 1988. New issues in corporate finance. European Economic Review 32, 1183–1186.

Mishkin, F., 1995. Symposium on the monetary transmission mechanism. Journal of Economic Perspectives 9 (4), 3–10.

Oliner, S., Rudebusch, G., 1995. Is there a bank lending channel for monetary policy? Federal Reserve Bank of San Francisco Economic Review 2, 3–20.

Oliner, S., Rudebusch, G., 1996a. Is there a broad credit channel for monetary policy? Federal Reserve Bank of San Francisco Economic Review 1, 3–13.

Oliner, S., Rudebusch, G., 1996b. Monetary policy and credit conditions: Evidence from the composition of external finance: Comment. American Economic Review 86, 300–309.

Rajan, R., 1992. Insiders and outsiders: The choice between informed and arm's length debt. Journal of Finance 47, 1367–1400.

Vermeulen, P., 2000. Business fixed investment: Evidence of a financial accelerator in Europe. Working Paper No. 37, European Central Bank.