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The substitution of bank for non-bank corporate finance: evidence for the United Kingdom

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Abstract

This paper investigates the extent to which changes in the quantity and cost of non-bank finance impact on the quantity and interest cost of UK-owned banks' corporate lending. The results give some support to the view that there is substitution between market finance and bank loans — loan growth rises (falls) during periods when corporate bond spreads widen (decline). In particular, bank loans seem to substitute for other forms of finance in some periods of market stress such as in 1998 Q3. Moreover, this increase in credit seems to be supplied on unchanged terms, perhaps suggesting that banks passively accommodate changes in corporate loan demand. During other episodes of disturbances in non-bank finance, such as when bond or commercial paper issuance falls sharply, banks appear to increase their loan rates, perhaps reflecting greater perceived borrower risk or some reduction in banks' own risk appetite.

Key words: Bank and non-bank finance, substitutes and complements.

JEL classification: E51, G21, G32.

Summary

The aim of this paper is to investigate empirically the links between alternative forms of corporate debt finance using data on the UK economy. Based on a small panel data set of UK-owned banks for the 1986 Q3-2001 Q3 period, we estimate equations for the quantity of bank credit to the corporate sector. In particular, we investigate the extent to which changes in non-bank finance — either from (bond and other debt securities) markets or from non-bank financial institutions — affect the growth in corporate loans of UK-owned banks. In doing so, we aim to investigate the degree of substitutability or complementarity between bank and non-bank finance. Moreover, we examine whether these relationships are different in periods when non-bank finance falls sharply to assess whether bank credit acts as a back-up source of funding when other forms of finance are not readily available.

In order to understand the potential interaction between bank and non-bank markets, an important distinction relates to the separate influences of supply and demand factors. But there is an identification issue: observed changes in corporate bank and non-bank finance will reflect movements in both the supply of and demand for external funds and it is difficult to disentangle the two. To address this issue, we exploit information on the average interest rates banks charge on their corporate loan portfolios. By considering how these loan rates respond to developments in non-bank finance markets in conjunction with the changes in the amount of credit extended, we hope to throw light on whether supply or demand influences are more important, particularly during periods of stress in non-bank finance.

Our results suggest that there is substitutability for companies between bond finance and bank loans from the large UK-owned banks. In particular, the growth in bank lending of the major UK-owned banks increases around some periods of bond market stress as well as during more tranquil periods when bond spreads widen. In general, the loan rates of the large UK banks are not found to be sensitive to changes in non-bank finance. This could reflect a relatively flat loan supply curve whereby banks increase the amount of credit extended when, for example, bond spreads rise substantially without increasing their loan rates. This would be consistent with firms using their arranged loan facilities with banks to absorb shocks in the availability of other forms of external finance. In this way, banks may passively accommodate shifts in the demand for bank loans that are associated with disturbances in non-bank finance.

However, there are some variations in the results for different forms of non-bank finance. This suggests that banks' responses may depend on the nature of the shock. In periods when bond spreads widen sharply, bank loans would seem to provide alternative finance for corporates, at largely unchanged interest rates. This would be indicative of companies switching their demand for external finance away from capital market financing to bank loans, and is consistent with the notion of substitutability between alternative forms of finance. However, disruptions to the amount of corporate bond and commercial paper issuance seem to be associated with an increase in loan rates and either a fall or unchanged bank lending growth. This appears to be consistent with higher corporate demand for bank finance being choked off by a decline in loan supply by banks.

1 Introduction

Greenspan (1999, 2000) has argued that recent crises in the United States have not been very costly to the economy because 'multiple avenues of financial intermediation' have allowed substitutability between different forms of finance. So, for example, in the early 1990s a capital crunch in the banking sector was thought to have been partially offset by an increase in market finance while conversely in 1998 the drying up of liquidity in financial markets was offset by an increase in bank finance. Similarly, according to Knight (1998) and Stone (2000), the reliance on bank finance may have contributed to the magnitude of the costs of the 1998 financial crises in east Asia with one of the subsequent recommendations being the need for emerging market economies to develop their securities markets. More recently, in the United States it has been argued that banks may have been playing a role of 'lender of last resort' as companies have reverted to using back-up credit lines with their banks because the commercial paper market has dried up.(1)

The aim of this paper is to investigate empirically the links between alternative forms of corporate debt finance using data on the UK economy. Based on a small panel data set of UK-owned banks for the 1986 Q3-2001 Q3 period, we estimate reduced-form equations for the quantity of bank credit to the corporate sector. In particular, we investigate the extent to which large changes in non-bank finance — either from (bond and other debt securities) markets or from non-bank financial institutions — affect loan growth of UK-owned banks.

One of the main problems in estimating reduced-form bank loan equations is the difficulty in distinguishing between demand and supply factors. We use data on individual banks' loan interest rates to help identify which of these have been more important.

Our results suggest that there is substitutability for companies between bond finance and bank loans from the large UK-owned banks. This provides some support for Greenspan's substitution hypothesis between market and bank finance. In particular, the growth in bank lending of the major UK banks increases around some periods of bond market stress — measured by sharp rises in bond yields such as in Autumn 1998 (although not in periods of sharp falls in the quantity of corporate bond or bill issuance) — as well as during more tranquil periods when bond spreads widen. Although the loan rates of the large UK banks are found to be, perhaps not surprisingly, sensitive to short-term monetary policy rates, we find no evidence that they change in reaction to sharp increases in bond spreads. Our interpretation of this is that companies face a relatively flat loan supply schedule in the short run and so in times of market stress they can increase their utilisation of credit lines with banks on existing terms (ie banks seem to play a role as lender of penultimate resort to the corporate sector but without charging a penal interest rate).

The rest of the paper is organised as follows. Section 2 describes the related background literature. Section 3 sets out the particular problems associated with separating the supply and demand effects on corporate finance and the implications for investigating the substitutability issue. Section 4 outlines our basic research design and the hypotheses we investigate. Section 5

(1) See, for example, *The Economist* March 2–8 2002, page 94 'Holding the bag?', and the *Financial Times* 26 February 2002 'The age of easy money ends', Peter Martin, page 21.

describes the panel data set for UK banks and the data for non-bank finance. Section 6 presents our empirical results while Section 7 offers some concluding remarks.

2 Related background literature

2.1 Theoretical

Traditional theories of corporate finance tend to focus on isolating the factors that influence firms' demand for alternative sources of funds. For example, the 'pecking-order' theory suggests that firms will always prefer the least expensive method of finance (see Myers and Majluf (1984)). In particular, internally generated funds are typically preferred to other funds, followed by debt finance and finally equity finance — equity issuance may be feasible but firms tend to see it as costly partly because of the information that such issuance may reveal about their operations to investors and competitors (so called information dilution costs). Similarly, the trade-off model predicts that dividend and leverage decisions are based on a trade-off between a number of costs and benefits relating to, for example, costs in the event of bankruptcy, taxes, cash-flow considerations and stock holder-debt holder agency issues (see, for example, Fama and French (2002)).

However, these theoretical models are generally applicable only when the circumstances for raising funds are 'normal'; it is not clear that the model predictions would be the same if (unexpected) disturbances disrupt the normal channelling of funds to firms. Moreover, these partial equilibrium models do not capture changes in the behaviour of the suppliers of external finance. In particular, the asymmetric information that exists between borrowers and lenders and the inability of lenders to write complete contracts give rise to well-known agency problems associated with debt contracts — adverse selection ahead of providing funds and moral hazard once funds have been provided. Anticipating such potential actions by borrowers, the supply of external funds — intermediated or otherwise — will duly be affected.

A number of papers have followed Townend's (1979) costly-state verification framework. In this set-up, banks have the ability to monitor their borrowers and then verify the return of their projects. Capital markets are unable to do this because of the free-rider problem. Therefore, only firms perceived to be creditworthy are able to borrow from the capital market (as well as from banks). Less creditworthy firms are forced either to borrow from banks and at higher interest rates, reflecting the cost of monitoring, or self-finance their projects.

Diamond (1991) suggests that substitutability between bank and bond finance is most likely to apply to large companies with established reputations. Holstrom and Tirole (1997) develop a theoretical model in which bank monitoring plays an important role in facilitating bond finance. Because banks are assumed to be informed investors, when the supply of bank loans falls, bond finance also declines since there is less monitoring being undertaken — that is bonds complement changes in bank loans. In contrast, following a decline in the availability of bond finance, banks, as informed investors, can take up the slack — capital constraints permitting. If so, this would imply loans substitute for bond finance.

Bolton and Freixas (1998, 2000) propose a formal model of financial markets and corporate finance that try to incorporate both supply and demand influences on the availability of finance within an equilibrium set-up with asymmetric information. The model is highly stylised. But based on two general observations — (i) equity issuance imposes a cost for firms in disseminating information and (ii) bank lending is more flexible although more expensive than bond finance — the authors show that the market for corporate finance becomes segmented: the riskiest firms are either unable to obtain external funding or are constrained to issue equity; somewhat safer firms take out bank loans which are flexible but incur an intermediation charge while the safest firms issue debt securities. In this set-up, banks can help firms in times of distress (ie when their risk of default increases) because they can exploit their superior information/borrower screening skills and they have flexibility in being able to restructure their loans, for example, through securitisation. In equilibrium, banks choose to increase their supply of loans, provided that they can price effectively for the extra risk and they are not capital constrained. In this way bank loans may substitute for other forms of finance.

An important feature of the Bolton and Freixas result relates to banks' ability to securitise their assets. In particular, because bank loans are typically senior to other forms of finance — they receive higher priority in the event of liquidation of the firm — banks have an incentive to liquidate the firm (inefficiently) when it is in financial distress. To overcome this incentive, banks are assumed to be able to securitise the safe (asset-backed) portion of any increase in loans they make to firms in distress. In doing so, this enables banks to use their capital in a more efficient way.

In practice, however, outside of the United States, loan securitisation in the corporate sector is not well developed. Nonetheless, other theories offer explanations why banks may choose to supply more loans even to riskier borrowers whose capital structure may offer banks an incentive to liquidate. Banks that develop long-term relationships with their customers may be willing to sustain losses from refinancing companies during periods of financial distress. Such theories rely on the ability of banks to anticipate higher returns from successively restructured borrowers in the future compared with the current proceeds from bankruptcy. In this way, a bank may substitute intertemporally between lower returns today in favour of higher returns in the future using its own capital/liquidity position as a short-term buffer for customers. It may do so provided that borrowers credibly commit to future business from the bank. The market power of the lender might also be an important influence. Such intertemporal subsidisation would not be possible in a fully competitive market since firms would only pay the market rate of interest.

2.2 Empirical

Although there are many empirical studies that examine competing forms of finance, there appear to be few that explicitly address the question of how bank and non-bank finance interact during periods of turbulence in either market.

Indirect evidence for the substitutability of non-bank finance for bank finance (although not *vice versa*) is provided by the literature on the credit channel of monetary policy. One of the necessary conditions for the existence of a separate bank lending channel of monetary policy is that non-bank finance is not a perfect substitute for bank loans.[2] That is, a decline in the availability of bank finance should not be offset by an increase in finance from other sources. A number of papers have considered this issue using data on US banks (see Kashyap *et al* (1993), Oliner and Rudebusch (1995), Kashyap and Stein (2000), Kishan and Opiela (2000), and Altunbas *et al* (2002)). In addition, a number of European Central Bank papers provide evidence on the bank lending channel in several European Monetary Union countries, eg Brissimis *et al* (2001), de Haan (2001), Ehrmann *et al* (2001), Farinha and Marques (2001). On aggregate UK banking system data, Cuthbertson (1985) estimates the determinants of bank lending for the corporate sector using a single equation approach while Brigden and Mizen (1999) estimate a dynamic system consisting of corporate bank lending, deposits and investment.

A difficulty with all these studies is distinguishing between a reduction in loan supply and demand especially since often they are affected by the same factors (such as an increase in corporate distress). Peek, Rosengren and Tootell (2000) using data in the United States find implicitly that other forms of finance do not offset declines in the supply of bank finance. They find that overall GDP growth fell following a reduction in loan supply — proxied by an increase in the share of banks' assets with a CAMEL rating of five. Similarly, Bernanke and Lown (1991) show that bank capital may have restricted the supply of bank lending in the United States during the early 1990s, and, while overall credit demand may also have fallen during this period, there is little evidence that borrowers were able to switch into other forms of credit. Any decline in loan supply is likely to hurt smaller firms in particular since there is evidence that these firms do not have the same access to credit markets as large, well-known firms — see for example Gertler and Gilchrist (1994).

The above studies concentrate on whether there is substitutability for bank finance when banks are faced with an adverse shock. The focus of this paper, however, is whether bank loans substitute or not when adverse shocks hit non-bank finance. One paper that does consider directly the substitution of bank loans for market finance in periods of market stress is Davis (2001). He estimates reduced-form equations to describe how total corporate debt finance and its constituent parts — aggregate bank loans and securities finance — is determined in four major economies (United States, United Kingdom, Japan and Canada). He finds evidence that during the market crisis in 1998 Q3, in the United States at least, bank finance substituted for a decline in market finance (but during banking crises, such as the US capital crunch in 1991 Q1 and the UK small banks' crisis in 1991, market finance was unaffected).[3] However, in a more recent paper, using flow of funds data over the 1970-99 period in the United States, Davis and Ioannidis (2002) find that bond finance complemented declines in the supply of bank loans to the corporate sector. They interpret this as evidence that bond issuance is partly dependent on loans being provided beforehand since this would signal that banks have monitored the borrower. This

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[2] For a separate bank lending channel to exist monetary policy must also, in the first instance, be able to affect the total volume of bank intermediation and bank loans and securities should not be perfect substitutes.

[3] Davis' interpretation, however, was more generous to financial markets suggesting that multiple forms of finance smooth the effects of crisis. His results are consistent with the idea that securities finance is unaffected by large cyclical movements (and occasional structural declines) in bank finance. So total finance to the economy is smoother than would be the case if only bank finance was available. That said, although there is evidence of bank finance stepping in to offset abnormal falls in market finance there is no evidence of market finance stepping in to offset losses in bank finance.

suggests that the impact on the economy of any decline in bank loan supply will be exacerbated by a contraction in market finance. But again they find that following the 1998 Q3 bond market crisis bank lending increased thus substituting for the decline in market finance.

However, in a recent study, Franks and Sussman (2003) investigate the extent to which three large UK commercial banks — that collectively account for more than two thirds of all lending to the sector — provide finance to small and medium UK companies when they are in financial distress. In a sample of 542 distressed firms, they find not a single case where banks increased the size of the company's loan during the period of company stress. In contrast, some firms in financial distress were able to obtain more trade credit from their corporate customers. The only indication of supportive behaviour by banks is the tendency for them not to increase their interest rate lending spreads to reflect increased risk exposure during rescue.

3 Substitutability between bank and non-bank finance

In order to understand the potential interaction between bank and non-bank markets, an important distinction relates to the separate influences of supply and demand factors. But there is an identification issue: observed changes in corporate bank and non-bank finance will reflect movements in both the supply of and demand for external funds and it is difficult to disentangle the two. Figure 1 attempts to illustrate the problem in the case of an adverse disturbance in non-bank finance — the same analysis could be applied to disturbances to bank credit.

A reduction in the supply of non-bank finance (panel A) should increase the cost of non-bank finance and encourage borrowers to increase their demand for bank finance. If the supply shock is specific to the non-bank market, bank loans should increase (point B in panel A(i)) — there will be a substitution into bank loans. If investors switch their savings into banks (ie thereby providing more loanable funds for banks), then the increase in loans may be accentuated by banks increasing their loan supply (point C in panel A(i)). But note in this case the impact on loan interest rates will depend on the magnitude of the shifts in loan supply and demand curves and the sensitivity of loan supply and demand to changes in loan rates. An important characteristic of bank loans relates to their potential contingent nature: firms and individuals can organise loan facilities that can be drawn down should the need arise. In this way, bank loans can provide some form of liquidity insurance in the same way as bank deposits.[4] That is, through pre-arranged committed loan facilities, banks offer their customers access to funds to cushion against their short-term liquidity needs.[5] This suggests that the loan supply curve might be quite flat — in the

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[4] Rajan (1996) suggests that this ability of banks to offer liquidity on demand on both sides of their balance sheet is one of the key features that distinguish banks from other financial intermediaries.

[5] More precisely, *committed* loan facilities may be drawn down at the borrower's request, whereas with uncommitted credit lines banks have discretion about extending further credit. In fact, in practice the drawing-down of bank loan commitments may not be automatic – the US experience is that banks retain some measure of discretion over whether to honour their commitments through so-called 'material adverse change' clauses (MAC). A MAC specifies that a bank may choose not to extend credit under a facility if, in the bank's opinion, a borrower's financial condition has deteriorated. To the extent that banks invoke such MACs, the supply of bank credit can be restricted at the same time as demand for loans increases. However, it seems likely that reputation considerations, the maintenance of on-going relationships, or indeed administrative costs of continually reviewing commitments etc, mean that banks may not want to alter their loan commitments and potential exposures a great deal. For example, banks that have a reputation for invoking MACs as a reason not to extend credit may struggle to attract customers.

short run at least — if companies have access to bank credit facilities at unchanged terms and conditions (shown as the dotted line in panel A(i)).

However, if the reduction in supply of non-bank finance is mirrored by a decline in the supply of bank finance, for example, because of a generalised increase in risk aversion, bank lending itself may decline. The effect on the overall quantity of finance will depend on the relative shifts in loan demand and supply (point C in panel A(ii)). In the figure, the fall in non-bank finance is complemented by a decline in bank lending and bank loan rates increase.

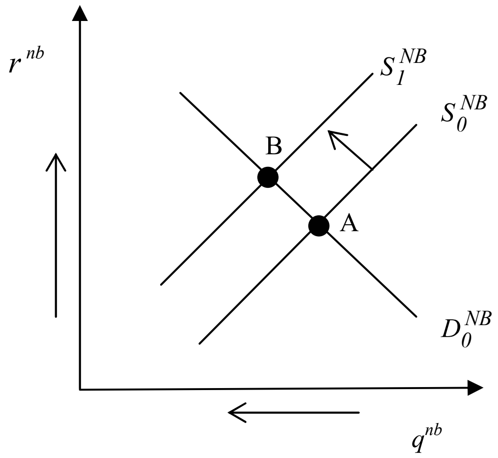
Panel B shows the impact of a decline in the demand for non-bank finance (other than due to a change in the cost of finance) — this is represented by a leftward shift in the D^{NB} curve. The most likely cause of such a shift is a generalised fall in corporate demand for spending and thus borrowing. This would also be expected to reduce the demand for bank loans. So in this case a fall in non-bank finance will be complemented by a decline in bank loans and bank loan rates would be expected to decline.

Although it is difficult to disentangle the effects on loan demand and supply of an adverse shock to non-bank finance, the illustrations suggest that information on changes in the quantity and price (interest rate) of loans may help identification. If the adverse shock to non-bank finance is a specific supply one then the quantity of bank loans should increase. However, the impact on lending rates is unclear. An increase in demand by corporates for bank finance might put upward pressure on lending rates. But if corporates have available credit facilities then, in the short run at least, lending quantities might increase at unchanged interest rates. It is possible, in fact, that lending rates might decline if investors switch savings into bank deposits. A generalised reduction in the supply of external finance, on the other hand, should result in a fall in the quantity of bank loans and a rise in lending rates. If the decline in non-bank finance reflects a general fall in corporate demand for funds then both bank lending and loan rates would be expected to decline.

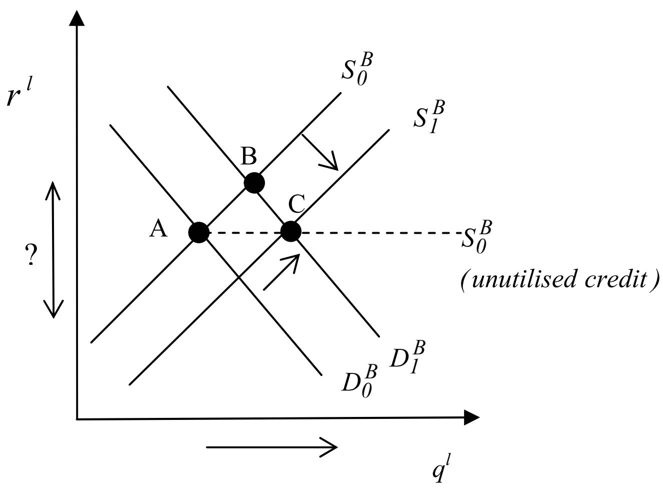
Figure 1: 'Market crunch' — impact on corporate bank loans

Panel A

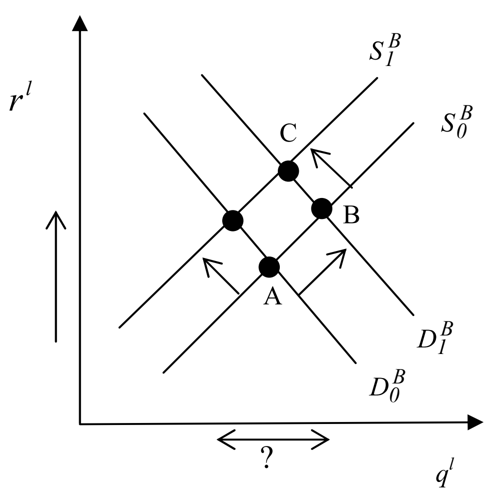
A. Decline in supply of non-bank finance



A(i) Increase in supply of bank finance — investors switch savings into bank deposits

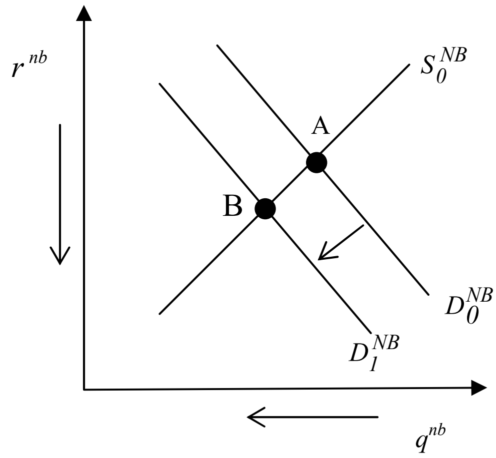


A(ii) Decrease in supply of bank finance — generalised increase in risk aversion

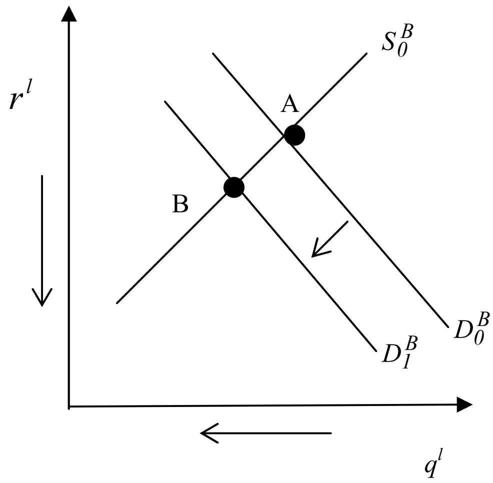


Panel B

B. Decline in demand for non-bank finance



B(i) Decrease in demand for bank finance



Notation

r^{nb}	interest rate on non-bank finance
r^l	interest rate on bank loans
q^{nb}	quantity of non-bank finance
q^l	interest rate on bank loans
D^{NB}	demand schedule for non-bank finance
D^B	demand schedule for bank loans
S^{NB}	supply schedule for non-bank finance
S^B	supply schedule for bank loans

4 A model of bank credit

4.1 Basic model

The assumed underlying supply and demand functions for corporate bank credit are given by the following specification, where subscripts refer to bank *i* in period *t* and expected signs of the coefficients are given in parenthesis.

$$\ln L_{it}^{d} = \nu_i + \alpha_0 + \underset{(-)}{\alpha_1}(r_{it}^{l} - r_{it}^{d}) + \underset{(+)}{\alpha_2}(r_t^{b} - r_t^{g}) + \underset{(+)}{\alpha_3}(r_t^{e} - r_t^{g}) + \underset{(+)}{\alpha_4} \ln y_t + u_{1it} \tag{1}$$

$$\ln L_{it}^{s} = \omega_i + \beta_0 + \underset{(+)}{\beta_1}(r_{it}^{l} - r_t) + \underset{(-/0)}{\beta_2}(r_t^{b} - r_t^{g}) + \underset{(-)}{\beta_3}(r_t^{e} - r_t^{g}) + \underset{(+)}{\beta_4} X_{it} + u_{2it} \tag{2}$$

There are two endogenous variables in the model the (logarithm) level of nominal bank loans (L_{it}) and r_{it}^{l}, the bank loan rate. Corporate loan demand (L_{it}^{d}) is affected negatively by the spread of the own loan rate on credit (r_{it}^{l}) over the deposit rate (r_{it}^{d}), reflecting the cost for corporates of financing planned expenditure through bank borrowing compared with running down bank deposits. It depends positively on the cost of alternative forms of finance — proxied here by the cost of capital terms for bonds (r_t^{b}) and equities (r_t^{e}) respectively, both relative to a similar maturity, (risk-free) government bond rate (r_t^{g}). Changes in loan demand should also depend positively on general economic activity, and this is captured by a term for the (logarithm of) nominal investment (y_t).[6]

Loan supply (L_{it}^{s}) is assumed to depend on the spread of the lending rate over the interbank rate $(r_{it}^{l} - r_t)$ rather than on the lending rate alone. The spread term may reflect mark-up pricing by banks that pass on increases in their funding costs to lending rates. Or alternatively this term may reflect the return for banks of investing in loans rather than in short-term financial assets such as treasury bills or interbank deposits.

The supply of bank loans is also likely to be affected by problems of asymmetric information between banks and borrowers. These give rise to agency costs associated with adverse selection in advance of lending and moral hazard after the financing has taken place. To capture such agency costs we include a term for the average firm credit quality, which we proxy by the difference between an average corporate bond rate and a ten-year (risk-free) government bond rate ($r_t^{b} - r_t^{g}$). The expected sign on this term is either negative or zero. If this default risk can be effectively priced, then such agency costs may already be reflected in the interest cost of the loan and the term should not be significant. Also, given their greater ability to screen and monitor borrowers, banks may be willing to take on the lower quality credit, especially if it is extended as part of a long-term ongoing relationship with a customer. On the other hand, given adverse selection problems, banks may be unwilling to extend loans even if they can price for the increase

[6] The study focuses on nominal variables because, as will become clear later, our interest is in the short-term interaction between types of external finance for firms following some disturbance in one particular market. Contracts for finance are typically made in nominal terms.

in risk (equilibrium credit rationing), in which case loans may be restricted implying the sign is negative - see for example Stiglitz and Weiss (1981).

A generalised increase in uncertainty may also make it harder for lenders to screen borrowers, increasing adverse selection problems and thus potentially reducing credit supply. We include a term for the equity risk premium, $(r_t^e - r_t^g)$ in the loan supply equation to capture this effect.(7) Finally, the willingness of banks to lend may be tempered by their ability to do so, as influenced by their own financial health. To capture such supply effects, we include individual bank balance sheet characteristics (X_{it}), in particular capitalisation and liquidity (relative to the UK banking sector average). These variables may be expected to positively affect bank loan supply.

Assuming that the bank credit market clears, solving out for the loan rate between **(1)** and **(2)**, the reduced form of the model can be represented as:

$$\ln L_{it} = \phi_i + \delta_0 + \underset{(-)}{\delta_1 r_t} + \underset{(+)}{\delta_2 r_{it}^d} + \underset{(?)}{\delta_3 (r_t^b - r_t^g)} + \underset{(?)}{\delta_4 (r_t^e - r_t^g)} + \underset{(+)}{\delta_5 \ln y_t} + \underset{(+)}{\delta_6 X_{it}} + \varepsilon_{it} \qquad \textbf{(3)}$$

where δ_j are reduced-form parameters in the model and expected signs of the coefficients are given in brackets.

4.2 Dynamic adjustment

Equation **(3)** is a static model and represents an equilibrium or steady-state situation. A number of previous studies have considered such a model where the effects of past loan realisations on current loans extended are ignored (see, for example Kashyap and Stein (1995), Kishan and Opiela (2000)). But it seems likely that lagged values of the explanatory variables as well as past loans themselves will have an influence on current realised loans. For example, due to long-term contractual commitments, changes in economic activity may take some time to fully impact on loan demand. Similarly, it may be costly for borrowers to switch banks, and consequently lagged loans may affect current loans.(8)

To capture such dynamic effects, we therefore posit an autoregressive distributed lag (ARDL) model for the bank credit market, which we reparameterise into levels and difference form.(9)

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(7) An alternative explanation for including the equity risk premium is that it may pick up the aggregate (ie non-diversifiable) risk component of the external finance premium that borrowers have to pay. See Bernanke, Gertler and Gilchrist (1999).

(8) In the case of bank-specific variables, a potential endogeneity problem arises. Therefore, these variables should typically enter the model with at least one lag.

(9) Any ARDL model $A(L)y_t = \mu + B_1(L)x_{1t} + B_2(L)x_{2t} + ... + B_k(L)x_{kt} + \varepsilon_t$ can be re-formulated into a model in levels and differences:

$$A(L)y_t = \Delta y_t + [A(1)y_{ti1} + \gamma_1 \Delta y_{ti1} + ... + \gamma_{pi1} \Delta y_{ti1(pi1)}]$$

$$B(L)x_t = B(1)x_{ti1} + \delta_0 \Delta x_{t1} + +\delta_1 \Delta x_{ti1} + ... + \delta_{qi1} \Delta x_{ti1(qi1)}$$

where

$$A(L) = 1 - \alpha_1 L - ...... - \alpha_p L^p = A(1)L + (1-L)(1 + \gamma_1 L + ... + \gamma_{pi1} L^{pi1})$$

$$B(L) = \beta_0 + \beta_1 L + ... + \beta_q L^q = B(1)L + (1-L)(\delta_0 + \delta_1 L + ... + \delta_{qi1} L^{qi1})$$

and A(1) and B(1) correspond to the sums of the α and β coefficients respectively while γ_j and δ_j correspond to the coefficients on $\Delta y_{ti,,j}$ and $\Delta x_{ti,,j}$.

$$\Delta_4 \ln L_{it} = \phi_i + \delta_0 + \sum_{k=1}^{K} \delta_k \Delta_4 \ln L_{it-k} + \sum_{k=0}^{K} \lambda_k \Delta_4 r_{t-k} + \sum_{k=0}^{K} \phi_k \Delta_4 r^d_{it-k} + \sum_{k=0}^{K} \mu_k \Delta_4 (r^b_{t-k} - r^g_{t-k}) + \sum_{k=0}^{K} \eta_k \Delta_4 (r^e_{t-k} - r^g_{t-k})$$
$$+ \sum_{k=0}^{K} \chi_k \Delta_4 \ln y_{t-k} + \sum_{k=0}^{K} \vartheta_k \Delta_4 X_{it-k} + \gamma_1 \ln L_{it-4} + \gamma_2 r_{t-4} + \gamma_3 r^d_{it-4} + \gamma_4 (r^b_{t-4} - r^g_{t-4}) \quad \textbf{(4)}$$
$$+ \gamma_5 (r^e_{t-4} - r^g_{t-4}) + \gamma_6 \ln y_{t-4} + \gamma_7 X_{it-4} + \varepsilon_{it}$$

From an estimation point of view, switching to levels and differences is helpful in isolating short-run and long-run influences on loans — equation **(4)** can be thought of as an unrestricted error correction model.[(10)] The short-run behaviour is captured by the lagged difference variables, while the long-run information is contained in the lagged variables in level form. A further implication of equation **(4)** is that the dependent variable is now the growth of loans rather than the level. To control for seasonal patterns in the data that may otherwise lead to spurious results, equation **(4)** is formulated in fourth differences corresponding to annual bank lending growth.[(11)]

4.3 Non-bank finance - normal vs abnormal periods

The above specifications are assumed to describe changes in bank credit on average over time and across banks. But from a temporal perspective, at least, it seems likely that the structural influences on bank loan supply and demand may differ depending on overall conditions in the market for external finance. In particular, we are most interested in what happens to bank credit during periods of stress in financial markets and/or at non-bank financial institutions. That is, during periods of dislocation in non-bank finance, do UK banks support their corporate borrowers by extending greater credit or do they also tighten credit conditions?

There are no unambiguous ways of isolating such abnormal episodes — we experiment with two main approaches. First, on the grounds that sudden sharp falls in the quantity of non-bank finance, or increases in the price at which that finance can be obtained, are more likely to reflect exogenous disturbances, we investigate those periods when bond and commercial paper issuance fall or the bond spread rises by the largest amounts. Appendix A describes more precisely how these abnormal periods were determined. Second, we examine a period when there is a general consensus that financial markets underwent a period of significant turbulence that led to a contraction in issuance and/or widening in spreads. In particular, we consider 1998 Q3 — the period of market turbulence following the sovereign default on Russian bonds and the rescue of LTCM (a detailed description of what happened during this period can be found in Box 1).

In terms of regression model **(4)**, we consider three different measures of stress periods in non-bank finance. These are defined by the following dummy variables:

(i) *dumspread* = 1 during periods of the largest rises in the bond spread. Else *dumspread*=0.

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(10) It is unrestricted because the long-run equilibrium relationship between the variables in levels and the short-run disequilibrium adjustment are not separately identified.
(11) That is, the unrestricted ECM model is derived from a general autoregressive distributed lag model including eight lags of the dependent and independent variables (ARDL(8,8) model). Reformulating this ARDL model yields an ECM model in fourth differences, as detailed in equation **(4)**.

(ii) *dumnonbk* = 1 or *dummarket* = 1 during periods of the largest falls in the flows of non-bank credit or market finance (bonds or commercial paper). Else *dumnonbk* = 0, *dummarket* =0.
(iii) *dum98Q3* = 1 in 1998 Q3, else *dum98q3* =0. This is a 'known' period of stress in financial markets.

Experimenting with dummies for abnormal falls in the quantity of bond issuance as well as abnormal increases in bond spreads (ie prices) in the equation serves a number of purposes. First, since the bond spread data refer to secondary market instruments they may not pick up all of the influences of abnormal changes in primary debt markets. Second, and more generally, an abnormal drying up in the supply of market finance may not be entirely reflected in market prices. Third, developments in non-tradable debt markets, such as non-bank credit, may not be fully captured by *bond* market spreads. Fourth, from 1997, the spread data are based on a basket of sterling issued corporate bonds, rated A- to AA-;(12) prior to this the series is based on collection of bonds issued by major UK corporates. Consequently, the spread data are only likely to reflect developments for firms in the top-end of the credit quality distribution. In contrast, the issues data also refer to instruments issued by lower-rated firms.

Our interest is in the short-run impact of disturbances in non-bank finance on bank lending, and so we apply the dummy terms to the coefficients on the terms in differences. More specifically, we included these dummies in the equation in two different ways. The difference in the bond spread is already included in the basic model ($\Delta_4(r^b - r^g)_{t-k}$). In addition, $\Delta_4(r^b - r^g)_{t-k}$ is interacted with the dummy variable *dumspread*. This means that the effect of the alternative cost of finance terms in normal times is separated from the effect in abnormal times. The same formulation is carried out for the *dum98Q3* term, since this period corresponds to one of the largest increases in the bond spread. For the other dummy variables, we include them as simple intercept dummies implying that these terms capture the extent to which the average loan growth in the abnormal periods is higher (or lower) than in normal periods.

More formally, we estimate variants of the reduced-form ECM equation **(4)** that in addition include one of the following terms capturing abnormal episodes.

$$\sum_{k=0}^{K} \rho_k \, dumspread_{t-k} * \Delta_4 \left(r^b - r^g\right)_{t-k} \text{ or } \sum_{k=0}^{K} \rho_k \, dum98Q3_{t-k} * \Delta_4 \left(r^b - r^g\right)_{t-k} \qquad \textbf{4(a)}$$

$$\sum_{k=0}^{K} \tilde{\rho}_k \, dumnonbk_{t-k} \text{ or } \sum_{k=0}^{K} \tilde{\rho}_k \, dummarket_{t-k} \qquad \textbf{4(b)}$$

In such a set-up, a test of the significance of the coefficients on the dummy terms amounts to a test of the equality of the particular effects in normal and stress periods. That is, the null hypothesis HO: $\sum_{k=0}^{K} \rho_k = 0$ is the same as testing HO: $\mu_{stress} - \mu_{normal} = 0$ where μ refers to coefficient on the change in the bond spread in equation **(4)**.

(12) Although these ratings are high for a typical company, the UK market for bonds with lower credit ratings is quite small and trading is often insignificant.

If the null hypothesis cannot be rejected it would suggest that the relationship between bank and non-bank finance is not statistically different in stress periods compared with normal periods.

This test is typically a two-tailed test where the alternative hypothesis is:

HA: $\mu_{stress} - \mu_{normal} \neq 0$

But single-tailed tests may offer further insights into the potential differences in how bank and non-bank finance interact during stress periods. Specifically, if the alternative hypothesis

HA: $\mu_{stress} - \mu_{normal} < 0$

cannot be rejected it would suggest that bank credit growth changes by less than in normal periods when bond spreads widen sharply. Thus, if bank loans substitute for bond finance in normal periods this result would imply the degree of substitutability is less in stress periods. By the same token, if

HA: $\mu_{stress} - \mu_{normal} > 0$

cannot be rejected, bank loan growth would seem to react more in stress periods than in normal periods. Assuming substitutability in normal periods, this would translate into greater substitution of bank loans for non-bank finance in stress periods.(13)

Similar hypotheses can be tested for the intercept dummy terms, described in **4(b)**. If bank loan growth is unaffected by abnormally large falls in the quantities of market or non-UK bank finance then $\tilde{\rho}_k = 0 \ \forall k$.(14) If, however, the impact is positive (negative) there is evidence of substitutability (complementarity) in abnormal times with the size of the impact given by $\sum_{k=0}^{K} \tilde{\rho}_k$.

In formulating these hypotheses, our focus is the impact of shocks to non-bank finance on the short-run dynamic adjustment of bank credit. In particular, we assume that the long-run relationship is unaffected by such disturbances. This means that, if loan growth is *temporarily* higher or lower during stress periods, unless the effects are unwound in future periods it will have a *permanent* impact on the level of loans.

(13) The easiest way to convert a two-tailed test into a one-tailed test is to divide in half the p-value (and when the alternative hypothesis goes in the opposite direction of the sign of the t-statistic the revised p-value should be deducted from one).
(14) Note the basic and auxiliary regressions are estimated without a constant term. Hence the effects in abnormal periods can be read directly from the coefficients on the intercept dummy terms.

4.4 Exploiting information on bank loan interest rates as an aid to identification

As noted above, an important element in understanding the interaction between bank and non-bank finance is the separation of supply and demand effects. We explore this identification issue through estimating reduced-form equations for average yields on banks' loans.(15)

From equations **(1)** and **(2)**, we can eliminate the loan growth terms and derive the reduced-form equation with the interest cost of loans (r_{it}^{l}) as the dependent variable, ie:

$$r_{it}^{l} = \delta_0' + \delta_1' r_t + \delta_2' r_{it}^{d} + \delta_3'(r_t^{b} - r_r^{g}) + \delta_4'(r_t^{e} - r_t^{g}) + \delta_5' \ln y_t + \delta_6' X_{it} + \upsilon_{it} \qquad \textbf{(5)}$$

As before, we reformulate the model into an ECM representation of the form:

$$\Delta_4 r_{it}^{l} = \delta_0' + \sum_{k=1}^{K} \delta_k' \Delta_4 r_{it-k}^{l} + \sum_{k=0}^{K} \lambda_k' \Delta_4 r_{t-k} + \sum_{k=0}^{K} \phi_k' \Delta_4 r_{it-k}^{d} + \sum_{k=0}^{K} \mu_k' \Delta_4 (r_{t-k}^{b} - r_{t-k}^{g}) + \sum_{k=0}^{K} \eta_k' \Delta_4 (r_{t-k}^{e} - r_{t-k}^{g})$$
$$+ \sum_{k=0}^{K} \chi_k' \Delta_4 \ln y_{t-k} + \sum_{k=0}^{K} \vartheta_k' \Delta_4 X_{it-k} \, [+ long \;\; run] + \varepsilon_{it}' \qquad \textbf{(6)}$$

Again, we can also include dummies for the abnormal periods in non-bank credit markets, ie *dumnonbk, dummarket, dumspread* and *dum98Q3*. By considering the results of the interest rate and loan growth rate regressions together we may find clues as to whether bank credit supply or demand responded to disturbances in non-bank markets. In particular, the stylised model presented in Figure 1 indicates that particular patterns in price and quantity space could be suggestive of shifts in demand or supply of bank credit. These are summarised in Table A.

The descriptions in Table A are only suggestive of the possible pattern of movements in the supply and demand schedules. In particular, the analysis assumes that credit markets clear so that demand equilibrates with the available supply via movements in the loan interest rate. In fact, credit markets may be prone to rationing, at least during periods of turbulence, where borrowers cannot obtain finance regardless of the rate charged. Moreover, the impact of disturbances in non-bank finance on bank credit quantities and 'prices' will depend on the interest elasticities of demand and supply for bank and non-bank finance. For example, if bank loan supply is more elastic than bond markets (as might be the case if banks can overcome the problems of asymmetric information better than financial markets, through collateral, building long-term relationships etc), then a switch in demand from bonds to loans could be associated with little change in terms and conditions (ie the bank loan supply curve may be quite flat). In this case, bank credit may substitute for market finance without loan rates increasing.

(15) In traditional simultaneous equation systems, exclusion restrictions are typically placed on the underlying structural equations in order to uncover the underlying structural demand and supply effects from estimated reduced-form form parameters. This requires the model to be identified, ie there needs to exist at least one single exclusion restriction in a two-equation model. Although this would be satisfied in our model, in practice, it is difficult to truly isolate factors that only affect supply and not demand and *vice versa*. For that reason, we use the alternative identification approaches outlined above.

Table A: Interpretation of changes in bank loan quantities and prices following an adverse shock to non-bank finance

Non-bank market development	Bank response	Effect on bank credit		Implication
		Quantity	Interest rate ('price')	
Abnormal rise in 'price' of non-bank finance	No supply response	Positive	Positive/zero	Increase in demand for bank loans (borrowers switch to where funds are more available/cheaper). Price effect is positive if the supply schedule is upward sloping but zero if it is horizontal.
	Supply response	Negative	Positive	Leftward shift in the supply schedule of bank credit; (increase in risk aversion more than offsets increase in demand).
	Supply response	Positive	Negative	Increase in supply of bank loans more than offsets an increase in demand.
Abnormal fall in quantity of non-bank finance	No supply response	Positive	Positive/zero	Increase in demand for bank loans (borrowers switch to where funds are more available/cheaper). Price effect is positive if the supply schedule is upward sloping but zero if it is horizontal.
	Supply response	Negative	Positive	Leftward shift in the supply of bank credit; (eg increase in risk aversion more than offsets increase in demand).
	Supply response	Positive	Negative	Increase in supply of bank loans more than offsets an increase in demand.
	Generalised decline in demand for finance	Negative	Negative	Downward shift in demand for bank credit; (generalised decline in external finance).

5 Data description

5.1 Bank-level data

We used a data set containing quarterly data on 58 UK-owned banks over the period 1986 Q3-2001 Q3.(16) The number of banks included was dictated largely by data availability. In particular, we concentrate on those banks that report detailed expenditure and income data from which we obtain banks' implied loan and deposit yields. The initial sample captures a significant part of the UK-banking system (although later as discussed below we focused on the largest UK banks).(17)

(16) We also experimented with data including UK operating foreign-owned banks. But these data were extremely volatile and at no stage did we find robust equations for corporate lending by these banks.
(17) More precisely, the initial sample of banks accounts for around 95% of total UK-owned banks' sterling assets. Several data cleaning procedures resulted in the exclusion of 3 banks from the initial data set of 58 banks (see Appendix B).

A panel data set was chosen to analyse the relationship between bank and non-bank lending for a number of reasons. First, bank-specific effects on lending are likely to be important and are missing in aggregate lending models; thus the panel regression may overcome potential omitted variable bias. Second, panel data models increase the precision of parameter estimates due to the higher degrees of freedom available with a larger sample size. This is helpful when considering the differential effects in normal and abnormal periods.

Our measure of loans to the UK non-financial corporate sector includes loans to both private non-financial companies and to unincorporated businesses. To avoid the potential for obtaining spurious results simply because of the recent increase in loan securitisations by some UK banks, we added securitisations back to the stock of loans before calculating growth rates.

For the most part, our regression analysis concentrates on sterling borrowing by UK firms. This is because the bulk of borrowing by UK private non-financial companies (PNFCs) and unincorporated businesses (UBs) is denominated in sterling — at the end of 2001 Q3, the aggregate stock of sterling lending by bank and building societies to PNFCs and UBs combined was around £276 billion, more than five times the corresponding figure for foreign currency borrowing. Moreover, to the extent that UK companies borrow in foreign currency, it seems likely that at least some of this may be arranged with banks and other financial intermediaries operating overseas and these are not covered by our sample.

A downside of focusing on sterling borrowing (and, as a corollary, other forms of sterling debt finance) is that an important facet of corporate finance may be overlooked, namely the ability of companies, particularly multinationals, to optimise their financing requirements globally across currencies and providers. However, since the payoffs and motives for such financing choices are not likely to be well captured through the regression analysis proposed above, we think it is sensible to restrict attention to same currency borrowing and debt finance, and in particular focus on sterling markets.

In terms of the information on interest rates, we would ideally have liked to use 'price' data on marginal borrowing costs since these will be more relevant to a bank's decision to supply more/less credit. Unfortunately, we do not observe marginal interest rates but instead must rely on average yields received on loans and paid on deposits. However, it seems reasonable to assume that the marginal cost of funds for most banks will be above their average funding costs (especially for retail funded banks who benefit from a significant and relatively inert deposit base from households). Consequently, changes in average yields should be positively correlated with marginal interest costs.

Also, the loan rate data refer to average yields on all sterling and foreign currency loans to all UK residents — separate income data, from which the yields were derived, were not available specifically for sterling corporate loans. Nonetheless, the overall loan rates should at least be suggestive of movements in bank credit conditions in the domestic bank credit market.

The data we use are unconsolidated — they refer to individual authorised banks irrespective of whether they are part of a larger banking group operating in the United Kingdom. For the most part, this should not be problematic, but unconsolidated data on bank capital is a difficult variable to measure. In particular, branches and subsidiaries may rely on non-capital funds from their parent organisations to support their balance sheets. For the purposes of this analysis, we define a hybrid measure of bank capital that adds together reported equity and other funds to deposits from the overseas parent bank relative to total assets. Although not a supervisory capital measure, it should nonetheless reflect any own-fund capital constraints on the banks should they arise. Such a measure also has the advantage of being available for all banks in our sample, even those that are not directly regulated by the UK supervisory agency.

Liquidity should be more straightforward to measure, although conceivably again, banks may manage their liquidity at the group level making interpretation difficult. For the larger UK-owned banks we use a narrower measure of liquidity that excludes market loans since these may be dominated by intragroup lending. For other banks we define the liquidity variable as the ratio of liquid assets, ie cash, bills, market loans, gilt repos and other repos, relative to total assets.(18)

5.2 Aggregate data

National accounts data are used for nominal fixed investment. As a measure of the domestic short-term market interest rate, we use the LIBOR three-months offer rate. To capture the cost of competing capital, we use an average corporate bond spread over a ten-year risk-free (real) interest rate. An estimate of the (real) cost of equity is obtained from a simple dividend discount model, which is based on the FTSE All-Share index. We construct the equity risk premium as the difference between the equity cost of capital and the same risk-free rate used for bonds.

The data on flows of sterling capital issues are net of redemptions. They are split into bond and commercial paper issued by UK PNFCs (ie they are on the same residency basis as our loan variable). Furthermore, the data exclude MFI holdings of bonds, which can be considered bank finance for firms albeit through other (non-loan) vehicles. For non-bank credit to firms, we use the flow of finance leasing and ‘other loans by UK residents’.

6 Empirical results

6.1 Preliminary estimation issues

6.1.1 Appropriate degree of pooling?

Given the panel structure of our data set, an important implicit assumption in the basic regression models described above is that the effects of our various explanatory variables on loan growth and loan interest rates are common across banks (ie the data can be pooled, so that $\pi_{ij} = \pi_j$, where π signifies the reduced-form form coefficient and *i* refers to bank *i* for each regressor, *j*). However, the UK banking sector consists of a number of potentially disparate institutions. To address the potential heterogeneity in our sample, we therefore chose to split the estimation

(18) Both capital and liquidity ratios are defined relative to the overall mean across periods and banks. This assumes that it is not the absolute amount of liquidity or capital that determines bank loan growth but rather the relative amounts (to the banking system as a whole).

sample of banks up into large and small/medium-sized UK-owned banks in a search for more stable common parameter relationships. This hopefully avoided the potential serious biases that might arise if the coefficients are genuinely related systematically to the right-hand side regressors.[19]

Given that a number of the smaller UK-owned banks are in fact part of larger UK-owned banking groups, we constructed a 'pseudo' consolidated group of seven major UK-owned banks.[20] We grouped the remaining banks in our sample together to form a sample of small/medium-sized UK-owned banks that were not part of a larger UK-owned banking group. In terms of market share, the UK-owned large banks collectively make up about 58% of total sterling loans to firms on average over our sample period while the market share of small/medium-sized UK-owned banks is relatively small at 11%.[21]

6.1.2 Establishing a long-run relationship as an important control variable

As noted above, our interest is in the impact of changes in non-bank finance on bank loan growth. One approach would therefore be to estimate equations simply in terms of differences, without the long-run levels terms. However, by not accounting for the potential long-run relationship between the variables, models constructed using only differenced data may be misspecified resulting in biased parameter estimates. Thus in our case, it may be that effects following shocks in non-bank markets are a response to past disequilibria between the (level) variables rather genuine short-run responses of bank lending to changes in non-bank finance in that period. To avoid this problem in estimation, we test for the existence of a long-run relationship (cointegration).

Appendix C presents the results of statistical tests for cointegration. These tests suggest that there is evidence of cointegration among the variables and that an important influence on short-run loan growth could therefore be adjustment back to equilibrium following previous disturbances. Typically, once the existence of long-run relationship is confirmed, the next step would be to seek to identify the long-run relationship so that a structural interpretation could be attached to the parameters.[22] We do not proceed along these lines for several reasons. First, our interest lies

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(19) As noted by Bartels (1996), the choice of whether to pool potentially disparate observations often involves a considerable degree of judgement. In particular, there may be a trade-off between efficiency gains from including theoretically problematic observations and the bias that might arise when the underlying parameter values differ significantly across cross-section units.

(20) Full consolidation would require detailed knowledge of banks' balance sheets and the intragroup connections. Here we simply aggregate the unconsolidated balance sheets of the individual banks that are in our sample but are actually part of a larger UK banking group. Changes in the composition of each banking group over time are taken into account.

(21) The remaining 31% market share of sterling lending to UK corporates is made by (locally based) foreign-owned banks which are not included in this study.

(22) Formally, the *unrestricted* ECM reduced-form model is:

$\Delta z_{it} = \sum_{j=1}^{p} \Gamma_j \Delta z_{it-j} + \Pi z_{it-p} + \varepsilon_{it}$ where $z_{it} = [y_{it}, x_{it}]$ is the vector of variables in the system. The matrix $\Pi = \alpha\beta'$ defines the cointegrating relationships (β) and the rate of adjustment, (α), of the variables to their steady-state values. But α, β are not uniquely identified – any linear combination of the vectors could be combined to generate the $\Pi = \alpha\beta'$ matrix. To identify the long-run relationships therefore requires the estimation of *restricted* ECM model with restrictions imposed on the loading and cointegrating vectors.

in the short-run effects of the non-bank variables. We therefore only seek to include the unrestricted ECM term as an important explanatory variable rather than isolating the long-run cointegrating and loading coefficients. Given that it appears that the levels of the variables move together in the long run (ie there is cointegration), including terms in levels is appropriate.

A second reason for not estimating the restricted ECM model is that there may be more than one cointegrating vector linking the variables. And indeed, Johansen tests on the variables suggest that there may be at least three cointegrating vectors. Single equation methods such as the ARDL approach implicitly assume that there exists a single cointegrating relationship between the variables. Without such an assumption, the estimators produce some linear combination of all long-run relationships present in the data.

Finally, since we have a panel data set there is the added complication of modelling the potential heterogeneity in the long-run equilibrium lending behaviour across banks. More specifically, bank-level heterogeneity could manifest itself in the speed of adjustment back to equilibrium and/or the long-run relationships between loans and the other explanatory variables. Recent methods have been developed that explicitly attempt to account for some of these heterogeneity issues (for example the Pooled Mean Group estimator developed in Pesaran, Shin and Smith (1998)). But in this analysis we choose to focus on the short-run effects and leave more precise modelling of the long-run relationships for future work.

6.1.3 Complications associated with dynamic panel data models

When estimating dynamic panel data models, standard (static) panel regression techniques may not be appropriate. The so-called fixed effects (or least squares dummy variable) and random effects models both produce inconsistent estimates of the coefficients. This is because the right-hand side variables are correlated with the error term, even if any individual bank-specific effects are removed by applying a linear transformation to the variables. Alternative estimators have been developed which rely on finding an appropriate instrument for the lagged dependent variable. However, the use of such instrumental variable (IV) estimators may not come without a cost. In particular, to the extent that the chosen instrument is not highly correlated with the lagged dependent variable, the standard errors of the IV estimated model parameters may be large.

The choice of the optimal estimator is ultimately subjective but it will likely depend on the sample size — both the number of cross section units (N), in our case banks — and the number of time periods (T). In theory, for fixed N the lagged dependent variable bias associated with least squares estimators is inversely proportional to T (Nickell (1981)). Monte Carlo simulations reported in Judson and Owen (1999) suggest that for small T, the bias can be quite large and provided N is relatively large, an IV-based estimator may be preferred over an ordinary least squares based estimator. [23] However, similar simulations by Beck and Katz (2004) suggest that if T is large relative to N, the least squares dummy variable estimator outperforms the more complicated instrumental variable techniques.

Given this ambiguity, we employ two different estimators — the simple least squares dummy variable estimator (LSDV) and the first-difference 'restricted' GMM estimator (AB-GMM) — see Arellano and Bond (1991). A comparison across these estimators provides a rudimentary robustness check of our results since it may indicate the potential importance of the lagged dependent variable bias.

6.2 Regression results

6.2.1 Loan growth to UK firms — basic model (ignoring abnormal periods)

The parsimonious model for both estimators is derived by testing down from a general form including up to two lags, eliminating insignificant lags of the variables in the short run. The aim is to include recent lags of the variables that seem important in providing information about current period loan growth but at the same time avoid overfitting the model. In particular, because the model is in fourth differences, a large number of lags is likely to lead to an overfitted model. For most variables, only the contemporaneous variables were significant, with few statistically significant terms for longer lags on the regressors. The lag structure employed also seemed to be sufficient to capture the persistence in loan growth and to eliminate second-order serial correlation as shown by the results of the Arellano-Bond test.

In terms of the basic model, the most robust relationships were found for the large UK-owned banks. Results for the small/medium UK-owned bank peer group were found to be less robust and therefore are not reported.

The regression results of sterling growth for the large UK-owned bank peer group are shown in Table B. Column (1) shows the results for the AB-GMM estimator; column (2) shows the results for the LSDV estimator. The results are similar across the estimators suggesting that the potential lagged dependent variable bias is relatively small.

Most of the control variables had the expected sign in the regressions. In particular, activity effects, proxied by aggregate nominal fixed investment,[24] were positive and significant in the long run while interest rates were negative indicating that the overall effect of restrictive monetary policy is to slow bank credit growth.

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[23] More precisely, Judson and Owen (1999), in a similar study to Kiviet (1995), conduct Monte Carlo experiments on different dynamic panel estimators. They find that as time dimension of the panel increases, the Anderson-Hsiao estimator, where the second lag of the dependent variable is used as an instrument in the first-differenced regression equation, performs particularly well. The Anderson-Hsiao estimator can be considered a 'restricted' GMM procedure, where the set of valid instruments is restricted to the second lag rather than optimising fully over the available instruments.

[24] As additional variables, we tried the growth rate in gross financial wealth and profits, but both of these were highly correlated with investment. As they did not seem to add additional explanatory power, we excluded these variables from the model.

Table B: Basic model for consolidated large bank sample, comparing AB-GMM and LSDV, dependent variable: loan growth (Δ4ln Loans$_t$)[(a)(b)]

	(1) AB-GMM	(2) LSDV
'Short run'		
Δ4ln Loans $_{t-1}$	0.76***	0.76***
	(0.000)	(0.000)
Δ4 Bond spread $_t$	8.54***	8.27***
	(0.008)	(0.003)
Δ4 Equity risk premium $_t$	-0.74	-0.11
	(0.346)	(0.898)
Δ4 Libor $_{t-2}$	-0.09	-0.19
	(0.704)	(0.385)
Δ4 ln Investment $_t$	0.07	0.12**
	(0.297)	(0.039)
Δ4 Deposit yield $_t$	0.06	0.06
	(0.486)	(0.719)
Capital ratio $_{t-1}$	-0.45***	-0.46**
	(0.000)	(0.030)
Liquidity ratio $_{t-1}$	0.26	0.21
	(0.109)	(0.240)
'Long run'		
ln Loans $_{t-4}$	-4.04***	-4.03***
	(0.000)	(0.008)
Bond spread $_{t-4}$	8.56***	8.31***
	(0.000)	(0.000)
Equity risk premium $_{t-4}$	-1.65**	-0.73
	(0.044)	(0.528)
Libor $_{t-4}$	-0.66***	-0.62**
	(0.001)	(0.016)
ln Investment $_{t-4}$	0.37	2.77**
	(0.885)	(0.025)
Deposit yield $_{t-4}$	0.04	0.06
	(0.580)	(0.797)
Number of observations	371	379
Number of banks	7	7
Arellano-Bond		
test of autocorrelated errors:		
H0:No first-order autocorrelation	-1.67	
p-value	0.10	
H0:No second-order autocorrelation	0.84	
p-value	0.40	
R-squared		0.87

(a) Robust p-values in parentheses.
(b) * significant at 10%; ** significant at 5%; *** significant at 1%.

For the largest UK banks, there is evidence of substitution between bonds and bank loans. The short-run coefficient implies that for a given 1 percentage point rise in the bond spread loans increase at the large banks on average by £1 billion year-on-year (for each of the seven banks). In contrast, there is little evidence that increases in uncertainty as proxied by movements in equity risk premia are associated with changes in bank lending. In these circumstances, firms' demand for finance and banks' willingness to supply credit would appear to be unaffected, although it might more simply suggest that bank loans are less substitutable for equity than for bond finance.

Aside from the lagged dependent variable, few of the bank-specific terms were statistically significant. The deposit rate had the expected positive sign in both the short run and long run but was statistically insignificant. However, the relative capital term was always negative and statistically significant in the regressions for the large UK-owned banks.(25) To the extent that banks' capital is adequately measured, the data show that the capital-asset ratio of the large UK-owned banks increased relative to the banking system average during the 1990s.(26) The introduction of the Basel 1 capital regime for internationally active banks may have encouraged large UK banks to switch lending away from relatively high risk-weighted corporate loans (as well as to increase their capital base).

6.2.2 Loan growth to UK firms in abnormal periods

Table C presents the regression coefficients on stress period dummies for the sample of seven large UK banks. These are based on regressions of the basic model including one variant of the dummies at a time. We use the LDSV procedure rather than the AB-GMM one since it is likely to be more appropriate for small cross-sectional samples.

To the extent that bank loans can be arranged speedily, particularly if existing credit lines and other sorts of facilities are in place, we might expect that the effect of any adverse shock to non-bank finance on bank credit should occur in the same quarter. However, since we cannot be certain that we have isolated the precise timing of any shock and because the shock itself may be persistent, we also consider the combined contemporaneous and lagged response of bank lending growth.(27) In this way, we can calculate the 'total' short-run effect of the shock to non-bank finance, albeit assuming that this is fully reflected in bank credit growth within two quarters. Of course, it should be borne in mind that another shock, perhaps unrelated to non-bank finance, may have occurred soon after the original disturbance, which could potentially distort our results.

(25) Both capital and liquidity are ratios and thus non-trended variables, suggesting that they should better explain *changes* in loan growth for particular banks or periods rather than the *level* of loans. Thus they are assumed to enter the short run of our equation. But as discussed above some caution is needed in interpreting the capital data because of its hybrid nature and in particular the imprecise way in which we consolidate the balance sheets.
(26) As discussed above some caution is needed in interpreting the capital data because of its hybrid nature and in particular the imprecise way in which we consolidate the balance sheets.
(27) In terms of the regressions for loan yields reported later there is another, more mechanical reason for including lagged effects. Since the loan rate data are based on average yields over one quarter, the effects of even significant changes in marginal rates are likely to be less pronounced and may also take a little time to be revealed in the average rate.

Table C: Short-run coefficients of the non-bank and market variables in the loan growth regressions, consolidated large bank sample [(a)]

Equation (4) including stress period dummies	(1) LSDV (contemporaneous)	(2) LSDV (contemporaneous plus lagged terms)
Bond spread (all periods)[(b)]	8.27***	8.27***
p-value (two-tailed)	(0.000)	(0.000)
Difference in bond spread coefficient between normal and abnormal periods (overall effect in normal periods in square brackets)	-4.68 [10.14***]	-6.22 [10.52***]
p-value (two-tailed test)	(0.238) [(0.000)]	(0.104) [(0.000)]
p-value (one-tailed test)	(0.119)	(0.052)
Difference in bond spread coefficient between normal and 1998 Q3 (overall effect in normal periods in square brackets)	-11.09 [9.16***]	-16.55*[9.71***]
p-value (two-tailed test)	(0.183) [(0.001)]	(0.094) [(0.001)])
p-value (one-tailed test)	(0.091)	(0.047)
Coefficient on dummarket (bond issues)	-2.26**	-1.73
p-value (two-tailed test)	(0.030)	(0.220)
p-value (one-tailed test)	(0.015)	(0.110)
Coefficient on dummarket (commercial paper issues)	-0.18	-0.084
p-value (two-tailed test)	(0.831)	(0.947)
p-value (one-tailed test)	(0.426)	(0.474)
Coefficient on dumnonbk (finance leasing)	-0.73	-0.73
p-value (two-tailed test)	(0.502)	(0.652)
p-value (one-tailed test)	(0.251)	(0.326)

(a) Results are based on the basic regression model as in Table B column (2), but including up to one lag of each of the stress period dummies separately. Where relevant, the p-values reported refer to both a two-tailed test: HO: $\sum_{k=0}^{K} \rho_k = 0$ HA: $\sum_{k=0}^{K} \rho_k \neq 0$ and a one-tailed test: HO: $\sum_{k=0}^{K} \rho_k = 0$ HA: $\sum_{k=0}^{K} \rho_k < 0$

(b) Based on the two-tailed test. * implies significant at 10%; ** implies significant at 5%; *** significant at 1%.

In most cases, the coefficients on the dummy terms are negative, but on the whole the differences between stress and non-stress periods are not statistically significant. This would seem to suggest that the degree of substitution between bank loans and alternative sources of external finance is broadly the same in stress periods as in more tranquil periods.

More specifically, the sensitivity of loan growth to a 1% point rise in bond spreads is found to be broadly the same in periods of the largest increase in loan spreads (including 1998 Q3) as in normal periods (ie the regression coefficient on $\Delta_4 (r^b - r^g)_{t-k}$ remains broadly the same). That is, there is substitution between bank loans and bond finance in periods when the bond market is disrupted. That said, there is some tentative evidence that loan growth substitutes less for non-bank finance when bond spreads widen sharply — allowing for the lagged effects of the disturbance in bond markets, it is not possible to reject the hypothesis that $\mu_{stress} - \mu_{normal} < 0$ at the 10% significance level. Of course, the larger average increase in bond spreads in abnormal periods implies that the rise in loan growth, *ceteris paribus*, is greater during these periods.

The one exception occurs during periods where there are unusually large falls in bond issuance. In such circumstances, loan growth would actually appear to fall (ie bank loans are complements to bonds). However, this effect would appear to be short-lived, with loan growth increasing in the period following the stress event, so that allowing for lags there does not appear to be a significant interaction between the quantity of bond and bank loan finance during these periods.

At face value, the results seem to provide some support for Greenspan's hypothesis of substitution between multiple channels of finance, at least for UK companies. In particular, loans continue to act as a substitute for bonds in periods of sharp rises in bond spreads just as they do during periods of more modest changes in spreads. However, serious disruptions in the amount of commercial paper issued — an instrument that may, at face value, be closer to bank loans for, say, working capital — appear to have had no impact on the growth in bank loans.

In the early part of our sample period, UK debt markets were less developed than they are now. *A priori*, one might expect there to be a stronger relationship between bonds, commercial paper and bank credit in more recent years as UK bond and commercial paper markets have broadened and deepened. However, stability tests provided little evidence of a structural break in the estimated relationship between loan growth and the market and non-bank credit variables. Similarly, broadening the definition of corporate lending to include foreign currency as well as sterling did little to alter the basic and auxiliary regression results.

6.2.3 Loan growth and loan interest rates

In order to investigate how far the changes in bank loan growth discussed above reflect the influences of bank supply or demand (or both), we look to see what happened to bank loan yields during the non-bank stress periods controlling for other factors that may have affected loan yields. We again concentrate on the results for large UK-owned banks. Results for the basic loan rate equation are shown in Table D. Results are reported for both the AB-GMM and LSDV procedures and again it makes little difference to the estimates.

Apart from the lagged dependent variable, the key variable affecting loan yields is the interbank rate. As expected, higher policy rates would appear to feed through into higher bank loan rates, presumably as banks pass on higher funding costs to borrowers. A higher deposit rate also leads to a higher loan rate, suggesting that conditions in broader deposit markets (for example, from households and corporates) exert some influence over loan yields over and above changes in the interbank rate. But this effect is short-lived — in the long run there does not appear to be a relationship between deposit and loan yields.

Table D: Basic model for consolidated large bank sample, comparing AB-GMM and LSDV, dependent variable: loan interest rate (Δ4 Loan yield$_t$)[(a)(b)(c)]

	(1) AB-GMM	(2) LSDV
'Short run'		
Δ4 Loan yield $_{t-1}$	0.17**	0.16**
	(0.011)	(0.022)
Δ4 Bond spread $_t$	0.53*	0.15
	(0.067)	(0.722)
Δ4 Equity risk premium $_t$	-0.29	-0.11
	(0.364)	(0.735)
Δ4 Libor $_t$	0.24***	0.23***
	(0.000)	(0.001)
Δ4 ln Nominal GDP $_{t-1}$	0.12	0.09
	(0.292)	(0.329)
Δ4 Deposit yield $_{t-1}$	0.11*	0.15**
	(0.067)	(0.021)
Capital ratio $_{t-1}$	0.02**	0.07***
	(0.041)	(0.003)
Liquidity ratio $_{t-1}$	0.07	0.05
	(0.289)	(0.340)
'Long run'		
Loan yield $_{t-4}$	-0.70***	-0.62***
	(0.000)	(0.000)
Bond spread $_{t-4}$	0.46	-0.16
	(0.203)	(0.711)
Equity risk premium $_{t-4}$	0.13	0.44
	(0.634)	(0.240)
Libor $_{t-4}$	0.39***	0.38***
	(0.000)	(0.000)
ln Nominal GDP $_{t-4}$	0.10	0.23
	(0.823)	(0.774)
Deposit yield $_{t-4}$	0.11	0.06
	(0.196)	(0.346)
Observations	359	368
Number of banks	7	7
Arellano-Bond test of autocorrelated errors:		
H0: No first-order autocorrelation	-2.24	
p-value	0.02	
H0:No second-order autocorrelation	1.05	
p-value	0.29	
R-squared		0.61

(a) Robust p-values in parentheses.
(b) * significant at 10%; ** significant at 5%; *** significant at 1%.
(c) GDP is the relevant activity scalar since the interest rate yields relate to UK loans to UK residents as a whole rather than corporates alone.

Turning to potential differential effects in normal and abnormal periods, Table E summarises the regression coefficients that use stress period dummies based on the LSDV procedure. The signs of the coefficients suggest that the effects of market stress events is generally to reduce (average) loan rates, but on the whole there is little evidence that effects are statistically different in stress and non-stress periods (ie the coefficients on the dummy terms are not statistically different from zero). This is true both for the single and two-tailed tests.

The exception is for commercial paper, where it would appear that loan rates rise when commercial paper issues fall sharply. Since banks play an important certification role in the issuance of commercial paper — typically providing back-up lines of credit — it could be that during stress periods banks tighten their credit standards to compensate for the risk that firms may not be able to roll over maturing paper and may therefore draw down on bank finance, (even if in the event firms do not take out more loan finance).

Table E: Short-run coefficients of the non-bank and market variables in the loan interest rate regressions, consolidated large bank sample[(a)]

Dependent variable: change in the loan rate	**(1) LSDV (contemporaneous)**	**(2) LSDV (contemporaneous plus lagged terms)**
Bond spread (all periods)[(b)]	0.15	0.15
p-value (two-tailed)	(0.722)	(0.722)
Difference in bond spread coefficient between normal and abnormal periods (overall effect in normal periods in square brackets)	-0.10 [0.18]	-0.42 [0.27]
p-value (two-tailed test)	(0.899) [(0.715)]	(0.672) [(0.616)]
p-value (one-tailed test)	(0.450)	(0.336)
Difference in bond spread coefficient between normal and 1998 Q3 (overall effect in normal periods in square brackets)	-1.37 [0.21]	0.12 [0.09]
p-value (two-tailed test)	(0.330) [(0.620)]	(0.951) [(0.833)]
p-value (one-tailed test)	(0.165)	(0.525)
Coefficient on dummarket (bond issues)	-0.01	0.51
p-value (two-tailed test)	(0.963)	(0.135)
p-value (one-tailed test)	(0.481)	(0.924)
Coefficient on dummarket (commercial paper issues)	0.50**	1.25***
p-value (two-tailed test)	(0.022)	(0.000)
p-value (one-tailed test)	(0.989)	(1.000)
Coefficient on dumnonbk (finance leasing)	0.25	0.14
p-value (two-tailed test)	(0.341)	(0.768)
p-value (one-tailed test)	(0.823)	(0.616)

(a) Results are based on the basic regression model as in Table D column (2), but including up to one lag of each of the stress period dummies separately. Where relevant, the p-values reported refer to both a two-tailed test: HO: $\sum_{k=0}^{K} \rho_k = 0$ HA: $\sum_{k=0}^{K} \rho_k \neq 0$ and a one-tailed test: HO: $\sum_{k=0}^{K} \rho_k = 0$ HA: $\sum_{k=0}^{K} \rho_k < 0$

(b) Based on the two-tailed test. * implies significant at 10%; ** implies significant at 5%; *** significant at 1%.

In summary, most of the effects on loan rates in stress periods are not statistically significant. This could reflect a relatively flat loan supply curve whereby banks increase the amount of credit extended when, for example, bond spreads rise substantially with little change in their loan rates. This would be consistent with firms using their arranged loan facilities with banks to absorb shocks in the availability of other forms of external finance. In this way, banks may passively accommodate shifts in the demand for bank loans that are associated with disturbances in non-bank finance.

However, taking the results for loan growth and loan rates together, there are some notable variations across the different forms of non-bank finance which suggest banks may react differently depending on the nature of the shock. In particular:

- in periods when bond spreads widen sharply, bank loans would seem to provide alternative finance for corporates, at largely unchanged interest rates. This would be indicative of a demand switch away from capital market financing to bank loans, and would perhaps be more in keeping with the notion of substitutability between alternative forms of finance alluded to by Greenspan.
- unusual falls in the amount of bond issuance seem to be associated with a temporary reduction in bank loan growth, which is quickly unwound.[28] But there is some evidence that bank loan rates also increase. Compared with our measure of bond spreads, the data on bond issues also cover lower quality borrowers. Consequently, it may be that lower quality borrowers turn to banks for external funds when bond issuance becomes difficult and banks respond by raising rates slightly. This would be consistent, with some steepening in banks' supply schedules with banks pricing for the additional risk they incur. Alternatively, it could be that although the underlying risk of borrowers may not have changed, banks simply charge more for finance — ie this would be consistent with a leftward shift in banks loan supply schedules.
- there appears to be little change in bank loan growth following disruptions in the commercial paper market. But loan rates do seem to increase. This situation could be consistent with some increase in demand for bank finance which is choked off by a leftward shift in bank loan supply as banks tighten credit standards.
- there is little evidence that disruptions in the finance leasing market has any significant effect on bank loan growth.

7 Concluding remarks

Set against the background of recent market innovation and, in particular, the expansion of tradable corporate debt securities markets, some have argued that the importance of banks has reduced. If firms, at least the large ones, can increasingly substitute between market and bank intermediated finance, banks may no longer act as the pivotal providers of liquidity, especially during periods of economic stress. If true, this would be a welcome development — multiple

[28] The reason behind the temporary fall in bank loan growth is unclear. It may be that that past periods of difficulties in bond issuance have tended to coincide with temporary falls in the general demand for credit.

channels of intermediation may offer diversification benefits so that one source of finance may be available when the market for other types of finance is disrupted.

We investigated this issue for UK firms by considering one part of the possible substitution channel, namely what happens to lending by UK banks when debt finance from markets and loans from other financial institutions dry up. Our results give some support to the view that there is substitution, for large corporates at least, between market finance and bank loans. In particular, we find clear statistical evidence that the growth in bank loans of large UK-owned banks rises (falls) during periods when corporate bond spreads widen (decline). Moreover, there is some evidence that bank loans continue to substitute for market finance in periods of market stress. Although the growth in bank lending does not appear to change much in reaction to large reductions in the quantity of corporate bond or bill issuance, it rises during periods of sharp increases in bond spreads, such as in 1998 Q3 and in more tranquil periods (when changes in bond spreads are more gradual). Moreover, this increase in credit seems to be supplied on unchanged terms suggesting that during these periods of market stress corporates utilise more of their bank credit facilities. But banks may not always be passive suppliers of credit during periods of disturbances in non-bank finance markets. We also find some evidence that when bond or commercial paper issuance falls sharply, banks tend to increase their loan rates, perhaps reflecting greater perceived risk of borrowers or a reduction in banks' own appetite for risk.

Appendix A: Defining abnormal episodes in UK non-bank finance markets

In economic terms, we are interested in episodes when either the demand for or the supply of non-bank finance has shifted significantly so that the quantity of such finance falls sharply. We also require those episodes to be independent of contemporaneous changes in bank credit.

Can we use statistical analysis to help? The blue lines in Charts A1-A4 plot the time series for each of the non-bank finance proxies: bond spreads, bond issues, commercial paper issues, and finance leasing. Given the enlargement of the UK corporate external finance market (especially bonds), the average quantity of non-bank finance has risen over time. To adjust for this we applied a Hodrick-Prescott (HP) filter to each of the quantity series — the spread series appeared to be more stationary and hence was not detrended. Examining the largest deviations around this trend may suggest periods when dislocations in the respective market may have taken place. In particular, we hypothesise that the largest falls in the flows/spreads may be suggestive of periods when the markets for non-bank finance were disrupted.

The HP filter can be thought of as picking up the (conditional) mean of each series so that deviations around the means may give some idea of the probability distribution of the series. Below some threshold, falls in the quantity of non-bank finance are statistically unlikely events — we take these to be abnormal events. More formally, we regress the series for the deviations for each non-bank finance series from its HP filter trend on a constant and isolate those negative residuals that are greater than one standard deviation. To further refine the abnormal periods, we:

(i) allow for possible changes in the variance of residual distribution by fitting a GARCH(1,1) model for the conditional variance equation;
(ii) exclude those residual observations when the large fall immediately followed an earlier large fall on the grounds that the shock actually occurred in earlier periods.

To summarise, Charts A1-A4 show the individual non-bank finance series, the HP filter trend for each series (where appropriate) and the abnormal periods as defined by the above procedures.

Chart A1: Periods in which bond spreads rose abnormally

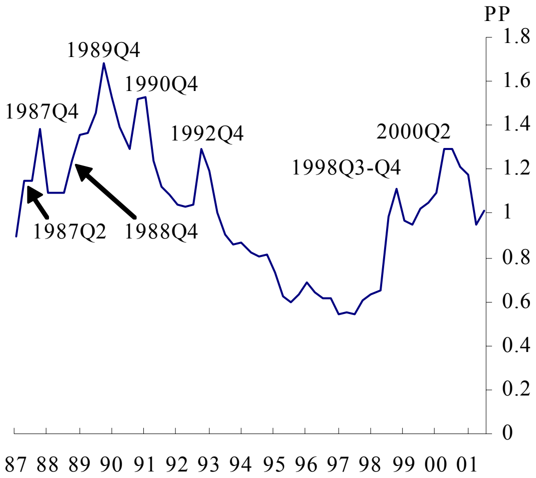


Chart A2: Periods in which sterling bond issues fell abnormally

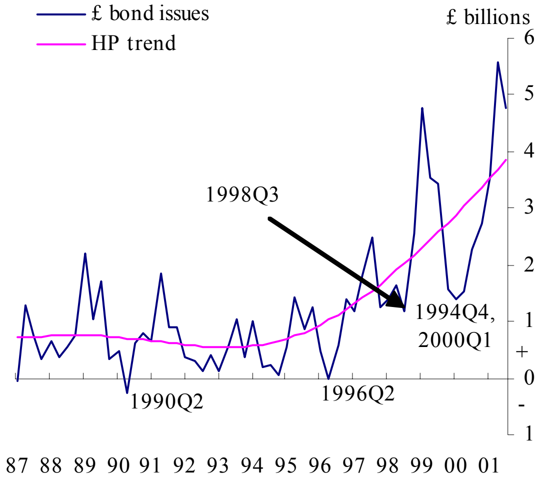


Chart A3: Periods in which sterling CP issues fell abnormally

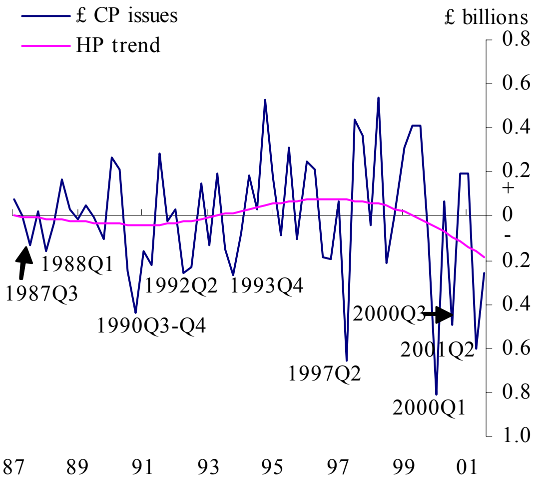
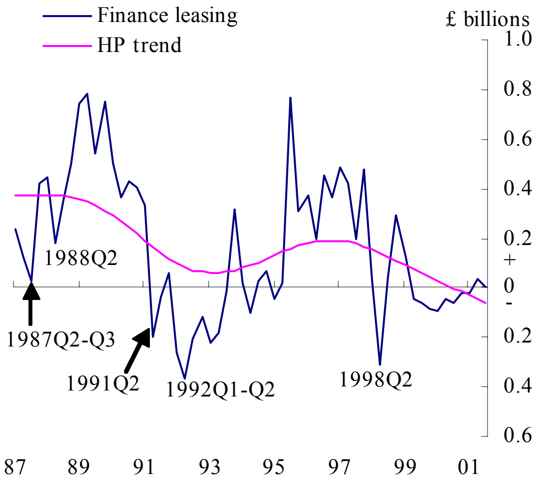


Chart A4: Periods in which finance leasing fell abnormally



Appendix B: Data cleaning procedures

An important preliminary stage in the empirical investigation was to ensure that the data were purged of potential irregularities that might impede the empirical estimation procedures. These fell into five principal categories: securitisations of loans, breaks in the data associated with mergers and acquisitions; unusual observations associated with the start-up or wind-down of a bank; outliers associated with potentially rogue (ie mismeasured) data points and genuine outliers associated with particular banks or periods.

Securitisations

Loan securitisation remains quite limited in UK banking, but it has increased in recent years. To overcome the potential distortions to the growth rates of bank lending we added back to the stock of loans the amount of the securitised asset. Growth rates were then calculated on the basis of this adjusted stock.

Treatment of mergers and acquisitions

Over the 1986-2001 period, a number of the banks in our sample were involved in mergers either as acquirers or acquirees. Since the data set we use refers solely to unconsolidated banks in the UK banking sector, the effect of any merger will typically only be relevant if: (i) banks within the UK banking sector merged with the business of the combined entities either reported by one of the existing banks or a new bank or (ii) a UK bank merged with a non-bank entity or a foreign bank and the combined business of the two entities was then reported by the UK bank. Type (i) is likely to be more important in terms of irregularities in our data and so we concentrated on this in terms of making adjustments to the data.

Mergers were treated in the following way:

- Where a new bank was created following the merger, the merging banks were removed from the sample. For the new bank, a synthetic aggregate stock of the merging banks' balance sheet was constructed going back to the beginning of the sample period.

- Where one of the merging banks acquired the business of the other bank(s), the data for the merged bank was considered as the data of this institution and no new bank appeared. Again, a synthetic aggregate of the merging banks' balance sheets was constructed going back to the beginning of the sample period. The acquired bank was removed from the data set.

Start-ups and wind-downs

A number of banks in the sample were either newly authorised or became inactive during the sample period. It is likely that such 'start-up' and 'wind-down' banks behave significantly different to other banks, at least during the early part of their lives or in periods near their end-date — for example, start-up banks may seek to build market share aggressively in particular markets. Consequently, we excluded observations on banks where they occurred within one year of the bank's authorisation or one year prior to a wind-up. The latter may occur for reasons other than bank failure — and indeed there have been few bank failures in the UK in recent years. For example, given the unconsolidated nature of the data set, banks may choose to switch business between reporting institutions, especially perhaps after a merger.

Outliers (I) — 'Rogue' data points

While we selected and screened the data to ensure that accurate data were collected, a number of implausible entries nonetheless remained. These were most probably related to misreporting on the part of the bank and/or human error associated with the original data collation process. But in some circumstances, it may also have reflected the unconsolidated nature of the data and the definitions of the balance sheet variables adopted.

The following adjustments were made to the data:

- the definition of bank capital resulted in some banks reporting negative capital. That is, because the data are unconsolidated, the institution may fund itself not with equity loan capital but with other liabilities that under normal definitions are not treated as capital. As a result, any loss arising from revaluing assets/liabilities, which should be written off against reserves, may lead to negative recorded capital.

  To overcome this, we constructed a hybrid capital measure that consisted of normal equity and debt capital plus the deposits of the overseas offices of the reporting institution.

- Occasionally the interest income and interest paid figures (from which the loan and deposit yields were constructed) were negative. This may have been due to errors in the data collation process that were not picked up at the time. But more probably the negative amounts reflect adjustments by the bank in respect of previous misreporting or estimation. Since there were only a few such negative data points we removed them from our sample.

Outliers (II) — Observations far from the mass of other observations

Examination of the sample suggested that a number of the very largest or very smallest growth rates were associated with those banks with small corporate loan portfolios. Since these banks may behave very differently from most banks in our sample on account of their presence in the corporate finance market, we chose to restrict the estimation sample to banks with sterling assets greater than £100 million of which more 5% where in the form of loans to firms. This resulted in the exclusion of 3 banks out of a possible 58.

Appendix C: Testing for cointegration

Recently, Pesaran *et al* (1996, 2001), have proposed a relatively straightforward approach to determine if there exists an equilibrium, or long-run, relationship between a set of variables based on a general ARDL model. This approach provides a test for examining the cointegrating relation of the underlying variables regardless of whether the series are I(0) or I(1) and so there is no need to pre-test for unit roots. The first step in the Pesaran *et al* (1996, 2001) approach involves testing the null hypotheses that no cointegrating relationship exists, using an F-statistic on the joint significance of the long-run coefficients (a so-called 'bounds test'). A long-run, or cointegrating, relationship exists among the variables if the hypothesis that the coefficient estimates on the lagged level variables are jointly equal to zero is rejected using critical values provided by Pesaran *et al* (2001).(29) The test for the existence of a long-run relationship was based on model **(4)** with restricted intercept (allowing for differences in the underlying level of loans for each bank) and no trend.

The results of the bounds test for cointegration are shown in Tables C1 and C2.(30) They would seem to indicate the existence of a long-run relationship between the variables and thus the importance of specifying the model with an error correction term.(31) While we found that the right-hand side variables affected loan growth, we could not rule out that bank loans affected two of the right-hand side variables — the deposit yield and the equity risk premium — suggesting that these variables may be endogenous in the loan growth regressions. However, a formal Durbin-Wu-Hausman test for endogeneity rejected the null hypothesis of endogeneity of the deposit yield and the equity risk premium. A similar result was found for an endogeneity test on the liquidity ratio and the capital ratio, which additionally had been lagged by one period.(32) We therefore proceeded with the model in which these variables were treated as (weakly) exogenous.

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(29) This statistic has a non-standard distribution irrespective of whether the series are I(0) or I(1). More precisely, two sets of asymptotic critical values (CV) — the lower bound CV (assuming all the variables are I(0) and the upper bound CV (assuming all the variables are I(1)), are computed by Pesaran *et al* (2001). If the computed F-statistic for the test lies above the upper bound, then the null of no cointegration can be rejected and we can conclude that a long-run relationship between the variables does exist. If the test statistic falls below the lower bound, then the null cannot be rejected. If the test statistic falls in between the bounds, the result is inconclusive.

(30) The ARDL approach developed in Pesaran and Shin (1999) was designed for a times series rather than a panel setting. In the latter, the appropriate critical values may be different from the ones developed by Pesaran *et al*, in particular if the residuals are correlated across banks. For that reason, we employ the Pesaran and Shin cointegration test for each of the MBBG members and small UK-owned banks separately.

(31) Although for two banks in the large UK-owned bank sample, this test is weakly rejected, the results below are not sensitive to the inclusion of these banks.

(32) For the capital ratio the null hypothesis of endogeneity is only rejected at the 5% level. But the results presented are robust to the exclusion of the capital ratio.

Table C1: Results of the Pesaran and Shin test for cointegration, dependent variable: Δ4ln Loans, UK-owned banks

	Test statistic[(a)(b)]		
	p=2,q=2	**p=3,q=3**	**p=4,q=4**
Large UK-owned banks			
1	8.45	4.35	13.10
2	10.69	9.40	5.78
3	8.21	3.69	3.74
4	4.75	4.10	2.37
5	3.23	4.60	5.53
6	3.61	3.77	2.54
7	0.87	1.00	2.38
Small UK-owned banks[(c)]			
1	5.76	2.84	3.09
2	4.42	7.68	4.33
3	5.55	5.67	4.96
4	3.77	2.99	5.39
5	2.92	1.17	23.51
6	5.25	2.73	2.6
7	7.42	3.35	6.58
8	3.25	2.31	1.55
9	4.93	4.32	3.55
10	10.82	6.8	48.23
11	8.03	6.64	8.24
12	1.7	0.92	1.76
13	6.32	27.07	8.04

(a) p denotes the number of lags of the dependent variable and q the number of lags of the independent variables in an ARDL(p,q) model.
(b) Critical value bounds of the F-statistic for k=5, α=0.05: I(0): 2.649 and I(1): 3.805.
(c) Only 13 of the small UK-owned banks had sufficient observations to carry out the cointegration test.

Table C2: Results of the Pesaran and Shin test for cointegration, dependent variable: Δ4 Loan yield, consolidated large bank sample

	Test statistic [(a)(b)]		
	p=2,q=2	**p=3,q=3**	**p=4,q=4**
Banks			
1	10.79	5.69	3.53
2	11.83	11.35	11.31
3	6.66	6.59	5.75
4	8.60	5.26	3.83
5	4.70	4.96	2.77
6	7.48	5.49	3.97
7	11.70	8.46	3.89

(a) Critical value bounds of the F-statistic for k=5, α=0.05: I(0): 2.649 and I(1): 3.805.
(b) p denotes the number of lags of the dependent variable and q the number of lags of the independent variables in an ARDL(p,q) model.

As an alternative to the Pesaran and Shin ARDL approach to establishing the existence of a long-run relationship between the variables in our model, we also considered tests for cointegration based on the Johansen procedure. Specifically, we estimated equation **(3)** (the reduced-form equation in levels) for each of the banks in our sample using the maximum likelihood vector autoregressive framework described in Johansen (1995). In addition, following Larsson, Lyhagen and Lothgren (2001), we also investigated panel tests of cointegration based on the individual bank-by-bank Johansen test statistics.[33] In the spirit of panel unit root tests, cross-section information may help to increase the power of the tests for cointegration.

Table C3 presents the individual bank and panel test results. Given the relatively small sample size, T=56, the maximum lag was restricted to four. Tests for autocorrelation and normality (not shown) appeared reasonable for most of the banks for this lag length.

Table C3: Johansen-based tests for cointegration, consolidated large bank sample [(a)]

	Test statistic $LR_iT(H(r)\,|H(4)$ where r is the no. of potential cointegrating vectors				
Bank-by-bank tests[(b)]	r=0	r=1	r=2	r=3	Rank(r_i)
1	284.2	178.3	92.6	60.3	3
2	334.6	234.3	144.1	71.9	3
3	241.1	158.5	103.6	52.0	3
4	289.5	178.9	120.4	66.6	3
5	296.9	203.4	133.5	81.9	4
6	278.3	173.2	111.5	62.4	3
7	262.4	174.4	114.5	66.8	3
Panel tests[(c)]	r=0	r=1	r=2	r=3	
$\Psi_{\overline{LR}}(H(r)\,|\,H(4))$	100.7	62.2	35.2	15.0	

(a) All tests are performed at the 5% significance level, (and assume a constant in the long-run cointegrating equation).
(b) The critical values for the bank-by-bank trace test statistic are 131.7, 102.14 and 76.07 for testing r=0, 1 and 2 respectively.
(c) The panel rank test has a critical value of 1.645.

The results for the bank-by-bank tests suggest that there may be several cointegrating relationships between the variables. Most of the individual tests suggest three cointegrating vectors. The panel test results also support the view that there are multiple long-run relationships; indeed they suggest that there may be four (or more) cointegrating relationships.

Note, however, that a feature of the Johansen procedure is that cointegrating vectors are only identified up to a linear transformation. Hence, it is impossible to attach a particular structural meaning to the estimated cointegration parameters without imposing restrictions on the likely nature of the link between the variables.

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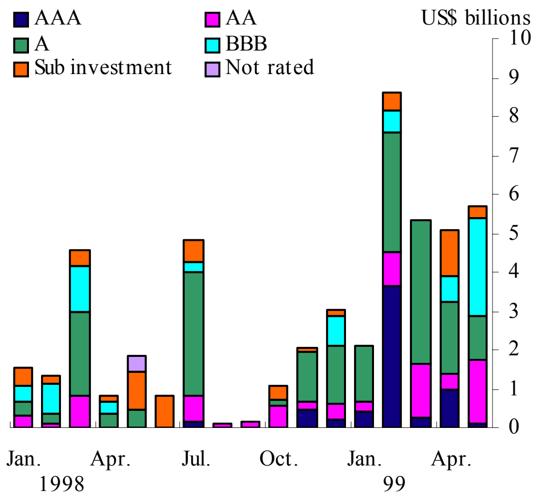
[33] Larsson *et al* (2001) develop a test based on Johansen's (1988) multivariate cointegration framework. Given N cross-section units with time dimension T, and a set of p I(1) variables, the heterogeneous vector error-correction model is given by: $\Delta z_{it} = \Pi_i z_{it-1} + \sum \Gamma_{ik}\Delta z_{it-k} + \varepsilon_{it}$ where Y is a (px1) vector of variables and the long-run matrix Π is of order (pxp). This equation is estimated for each unit, using the maximum likelihood method, and the trace statistic is calculated. The null hypothesis to be tested is that all N units have the same number of cointegrating vectors (r) among the p variables. In other words, H0: rank(Π) = r_i < r, against the alternative hypothesis, H1: rank(Π) = p for all i = 1...N.
The panel cointegration rank trace test statistic, Ψ is obtained by calculating the average of the N individual trace statistics, LR, and then standardising it as follows: $\Psi = \frac{\{\sqrt{N}[\frac{1}{N}LR_{iT} - E(Z)]\}}{\sqrt{Var(Z)}}$
Where E(Z) and Var(Z) are, respectively, the mean and variance of the asymptotic trace. This converges to a normal distribution N(0,1).

Box 1: Market credit 'crunch' — 1998 Q3

The impact of the Russian default in Summer 1998 and the subsequent near failure of the LTCM hedge fund in September prompted at the time very sharp rises in corporate bond spreads (by some 50 basis points in October 1998). It is difficult to assess to what extent that was attributable to a deterioration in credit assessments, a reduced appetite for risk, or a higher premium for liquidity, although at the time it was generally taken to signal an increase in fragility. In response, monetary policy was loosened in a number of countries.

There was clear evidence of reduced borrowing by corporates in international bond markets from August to October 1998 (Chart A). At the time, anecdotal evidence suggested that this stemmed mainly from a choice by corporates not to borrow in the bond markets at spreads that were regarded as being at temporarily high levels.

Chart A: International public bond issuance by UK PNFCs, by rating [(a)(b)(c)]



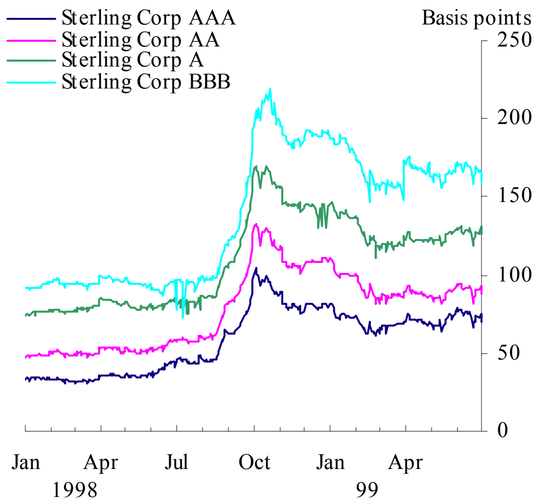
(a) PNFCs include following Dealogic categories: private corporates, private (others), private utilities and finance vehicles (private corporates and utilities). Following Dealogic industrial sectors are excluded: financial companies, banking finance, leasing companies, public works/utilities, trading and leasing.

(b) Data are classified by S&P ratings in Dealogic.

(c) Data are sorted by announcement date.

Sources: Dealogic and Bank calculations.

Chart B: UK corporate bond spreads by credit rating[(a)]



(a) Option-adjusted spreads over duration-matched gilts.

Source: Merrill Lynch.

Changes in investor risk aversion and the demand for liquidity could potentially raise the cost of borrowing for corporate bond issuers even if there were no rise in perceived default risk. There is some evidence that liquidity preference played a role in the widening of corporate bond spreads during the 1998 autumn crisis. First, spreads rose most for the least liquid instrument (smaller issues of lower credit quality — see Chart B). Also the spread between on-the-run and off-the-run US Treasuries increased by a factor of four between the beginning of September and October. A similar phenomenon was seen in the gilt market. Since in practice no default risk is attached to these government securities, the main factor driving this spread widening was probably demand for liquidity.

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