Inventory investment and cash flow

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Abstract

This paper uses a panel of UK manufacturing firms to examine whether the effect of cash flow on inventory investment reflects the presence of financially constrained firms. Financially constrained firms are identified using a number of criteria, including the criterion suggested by Bond and Meghir (1994) based on the firm's financial policy. The main finding is that the effect of cash flow on inventory investment is concentrated among firms identified as financially constrained using either their financial policy or a criterion based on their current ratio. This suggests that there is no unique criterion for identifying financially constrained firms using financial information in company accounts. Contrary to what previous studies have found, using firm size or the coverage ratio to define financially constrained firms does not reduce the effect of cash flow on the inventory investment of unconstrained firms. This raises doubts about whether these are accurate indicators of whether a firm is financially constrained. Combined with Bond and Meghir's similar findings for fixed investment, the results in this paper suggest that cash flow effects form part of the monetary transmission mechanism.

1 Introduction

Changes in inventory investment are an important feature of business cycle fluctuations, particularly during recessions. Whitaker (1996), for example, shows that in an arithmetic sense inventory disinvestment accounted for 53% of the fall in GDP in the recession in the early 1980s and 38% of the fall in GDP in the recession at the beginning of the 1990s. One explanation for this is that capital market imperfections mean that the inventory investment of some firms depends, at least partly, on the availability of cash flow, which is heavily pro-cyclical; ie some firms are financially constrained.(1) If the inventory investment of some firms does depend upon cash flow then this effect forms part of the monetary transmission mechanism, acting to magnify and propagate the real effects of a monetary shock.

An obvious way of testing the hypothesis that it is only the inventory investment of financially constrained firms that is affected by availability of cash flow is to use panel data, as this allows firms to be divided into financially constrained and unconstrained. A number of papers have done this, including Guariglia and Schiantarelli (1995) and Milne (1991) for the United Kingdom and Carpenter, Fazzari and Peterson (1994) and Kashyap, Lamont and Stein (1994) for the United States. A key issue with this approach is what criteria should be used to identify which firms are more likely to be financially constrained, and in particular do these criteria allow firms to switch from being financially constrained to unconstrained, and *vice versa*, over time? A variety of criteria have been used in the literature, including the coverage ratio (Guariglia and Schiantarelli), firm size (Carpenter *et al*), and bond ratings (Kashyap *et al*). In general these criteria have not allowed firms to switch between being financially constrained and unconstrained. Therefore this paper uses a criterion suggested by Bond

(1) A large number of papers have looked at the relationship between cash flow and fixed investment; see Schiantarelli (1995) and Hubbard (1997) for reviews of this literature.

and Meghir (1994), which is based on the idea that firms face a hierarchy of funds, and which allows firms to switch from being financially constrained and unconstrained over time. But, to check how robust these results are, three alternative criteria based, respectively, on the current ratio, the interest coverage ratio and firm size, all of which allow firms to switch over time, are also used.

The main finding of the paper is that the effect of cash flow on inventory investment is concentrated among firms that are identified as financially constrained by either their financial policy or their current ratio. This suggests that there is no unique way of identifying financially constrained firms using financial information in company accounts. Cash flow, however, still has an effect upon the inventory investment of unconstrained firms. This is possibly because cash flow is capturing expectations about future demand which are not being controlled for by other variables in the model, although this does not explain why cash flow has a significantly larger effect upon the inventory investment of constrained firms than on unconstrained firms. Contrary to what other articles have found, if either firm size or the coverage ratio are used to identify financially constrained firms then there is no reduction in the effect of cash flow on the inventory investment of unconstrained firms. This casts doubt on whether these criteria are good at identifying financially constrained firms.

The finding that the effect of cash flow on inventory investment is concentrated among firms identified as financially constrained by their financial policy is very similar to what Bond and Meghir report for fixed investment. Taken together, these results suggest that one way in which monetary shocks are magnified and propagated through the economy is via the effect of cash flow on the investment activities of financially constrained firms. A monetary shock causes a change in spending in interest-sensitive sectors of the economy, so firms producing for these areas of the economy experience a change in cash flow (fixed costs magnify the effect of a change in sales on profits, especially in the short run). This change in cash flow

leads to a change in the investment activities of financially constrained firms, which in turn magnifies and further propagates the shock through the economy.

The rest of the paper is organised as follows. The following section briefly explains why capital market imperfections mean that the inventory investment of some firms may depend upon cash flow. The third section discusses what criteria can be used to identify firms who are more likely to be financially constrained, and how inventory investment is modelled. The fourth section briefly describes the dataset and the estimation procedure used. The fifth section sets out the results, and in the final section some conclusions are drawn.

2 Theoretical background

Models of inventories

There are numerous models of inventories in the literature, reflecting the large number of reasons suggested for why firms hold inventories. For example, firms may hold inventories to smooth production costs, to avoid stockouts, etc.[(2)] Typically in these models the financial position of the firm has no effect upon its inventory behaviour. Inventory behaviour is determined by the marginal cost of holding inventories, which consists of the cost of finance (the opportunity cost to the firm of holding inventories) as well as storage costs, the risk of obsolescence, etc, and the marginal benefits of holding inventories, which depend upon the reason why firms are assumed to be holding inventories.

For example, in the production smoothing model of inventories the firm faces rising costs of production. If sales vary over time then the firm's cost-minimising strategy is to equate the marginal costs of production in

(2) See Blinder and Maccini (1991) for a survey of inventory research.

different time periods subject to the cost of holding inventories.[3] So the firm's inventory investment depends upon expected sales, the existing stock of inventories and the cost of finance. Alternatively, in the (S,s) model of inventories the marginal cost of supply is assumed to be constant, with a fixed cost per delivery.[4] The firm optimally sets a minimum level of inventories (s), below which it is not prepared to let inventories fall, and an optimal upper level (S). When inventories reach the lower level, this triggers the firm to place an order and restore inventories to the upper limit. The size of the optimal inventory order (the quantity S-s) is determined by the marginal benefits of holding inventories (the benefits of avoiding a stockout, etc) and the marginal cost of holding inventories (the cost of finance, etc).

Capital market imperfections

Implicitly these models of inventories are assuming that internal and external funds are perfect substitutes, so the cost of finance and hence the marginal cost of holding inventories does not depend upon the source of finance.[5] However, there is now a large theoretical literature on capital market imperfections which argues that external funds (debt and new equity finance) are a more costly substitute for internally generated funds (cash flow), and hence firms face a 'hierarchy' of finance (Myers (1984)). If the cost of finance does depend upon the source of finance then the investment activities of some firms, and in particular their inventory investment, will be affected by the availability of low-cost internal cash flow.[6]

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(3) The production smoothing model seeks to explain why production firms hold stocks of finished goods they have produced. It does not seek to explain why firms hold stocks of raw materials, or why retailers hold stocks.
(4) The (S,s) model seeks to explain why firms hold stocks of raw materials and why retailers hold inventories.
(5) In the absence of capital market imperfections the Modigliani and Miller theorems hold, so internal and external funds are perfect substitutes and firms are indifferent between them.
(6) Informational asymmetries also raise the possibility that non-investment aspects of firm behaviour may be affected by the firm's financial position, for example productivity growth, see Nickell and Nicolitsas (1995).

Among the most prominent of these capital market imperfections in the literature is the asymmetry of information between investors and lenders and a firm's management: investors and lenders (even professional) are likely to be less well informed about a firm's performance and prospects than the firm's management. This informational asymmetry can cause both adverse selection and moral hazard problems. Adverse selection arises because investors are unable to distinguish between the quality of different firms. Therefore investors value firms at the population average, and the cost of external funds incorporates an implicit premium to safeguard investors against the possibility that the borrower is a poor-quality firm – a lemon (see Myers and Majluf (1984)). In addition, in the case of debt finance, adverse selection raises the possibility that even in equilibrium some firms may have no access to debt finance (see Stiglitz and Weiss (1981)). This could occur because, as interest rates increase, low-risk 'good' borrowers withdraw from the credit market leaving only riskier 'bad' borrowers. Faced with this possibility, risk-adverse lenders may resort to credit rationing rather than solely relying on the interest rate to allocate credit.

The problem of moral hazard arises because investors only have a limited ability to observe managers' actions. Debt investors face the problem that managers, acting in the interest of shareholders, have an incentive to engage in excessively risky projects. If these projects are successful then shareholders get a large payback, whereas if they are unsuccessful then debt holders bear most of the costs. To protect themselves against this possibility, debt investors will incorporate a premium into the cost of debt finance and impose restrictions on managers' actions in the form of debt covenants. Shareholders face the problem that managers may act in their own rather than shareholders' interests. Therefore shareholders have to monitor managers' behaviour, and the cost of equity finance includes a premium to cover the cost of this monitoring (see Jensen and Meckling (1976)).

Other capital market imperfections that may increase the relative cost of external funds are the transactions costs firms incur when they raise new equity, and the costs associated with bankruptcy (deadweight bankruptcy costs). Informal evidence suggests that in the case of new equity finance these transactions costs, for example the cost of having the share issue underwritten, can be substantial, especially for small equity issues. But even in the case of debt finance, firms incur transactions costs; for example the costs of evaluating any collateral for the loan and monitoring the position of the loan. Deadweight bankruptcy costs mean that the cost of debt finance increases as a firm's level of gearing rises, to compensate lenders for the increased risk of bankruptcy associated with the firm's higher level of gearing.

The UK tax system, however, reduces the cost of external finance for most firms.(7) Under an imputation system such as the United Kingdom has had since 1973, a full tax paying firm will prefer to issue new equity rather than use internal funds if the following condition holds:

$$(1-m)/\ [(1-z)(1-c)] > 1 \qquad \textbf{(1)}$$

where *m* is the tax rate on dividend income, *z* is the capital gains tax rate, and *c* is the rate of imputation. Over the sample of data used in this paper, 1977-94, this condition is likely to be satisfied for most UK firms, as institutional investors, who hold the majority of shares, pay no income or capital gains tax.(8)(9) In the case of debt finance the tax advantage arises because interest rate payments are tax-deductible. A full tax paying firm will prefer debt to internal finance if the following condition holds:

$$(1-m)/\ (1-z) > 1-r \qquad \textbf{(2)}$$

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(7) This incentive was removed in the July 1997 Budget.

(8) The only shareholders who face a higher income than capital gains tax rate are higher-rate taxpayers.

(9) The attractiveness of new equity issues is reduced if a firm is tax exhausted – ie it is unable to offset all its advance corporation tax against its mainstream corporation tax – as this lowers the effective rate of imputation. However, the number of firms who are tax exhausted has fallen substantially since the 1984 reforms were introduced.

where *r* is the corporate tax rate. This condition is also likely to hold for most UK firms, although the attractiveness of debt finance will be reduced if the firm makes a loss.

Implications

The existence of capital market imperfections means that firms will prefer to use one source of investment finance rather than another source. Providing that the tax advantages of issuing new equity do not completely offset the increase in its cost arising from informational asymmetries and transactions costs, then firms will prefer to use cash flow to finance investment rather than issue new equity.(10) In the case of debt finance, at low levels of gearing its tax advantage will probably offset the increasing in its cost arising from informational asymmetries, etc. Therefore firms will borrow until these tax advantages are just offset by the increase in the cost of debt arising from the higher level of gearing. Above this level of gearing firms will prefer to finance their investment using cash flow rather than debt finance. This suggests that above the optimal level of borrowing firms have a hierarchy of finance preferring to use cash flow first, followed by debt finance and finally issuing new equity.

If firms do have such a hierarchy of finance, then the investment, particularly inventory investment, of some firms will be constrained by a lack of cash flow. These firms will be those who do not have sufficient cash flow to finance all of the inventory investment that they would like to undertake, given the cost of holding inventories associated with the cost of cash flow, but either find this inventory investment unprofitable at the higher cost of holding inventories associated with the higher cost of external funds, or find that they have no access to external funds. So the level of investment undertaken by these firms will be determined by the availability of cash flow.

(10) If the tax advantages of equity issues do exceed the increase in its cost then firms may prefer to pay dividends and finance themselves by issuing new shares, up to the limit imposed by the tax system.

The investment of firms who have sufficient cash flow to finance all their inventory investment, or who find it profitable to finance their investment using external funds, is unaffected by the availability of cash flow.

The reason why the inventory investment of financially constrained firms will be especially affected by the availability of cash flow is because firms seek to equate the marginal returns, net of adjustment costs, across their various types of investment. Given that inventories are likely to have relatively low adjustment costs compared with other types of investment, such as fixed investment or R&D, they should bear the brunt of any adjustment arising from a fall in cash flow if the firm is financially constrained. In addition, by improving cash flow, inventory disinvestment helps to relax the financial constraints on other types of investment. However, the extent to which inventories bear the brunt of any adjustment is limited, because at the margin it becomes more costly for firms to reduce inventories as the level of inventories falls, for example because of the increase in the cost of a stockout.

3 Empirical formulation

Identifying financially constrained firms

The previous section argued that only the inventory investment of financially constrained firms would be affected by the availability of cash flow. An obvious way of testing this hypothesis is to use firm panel data, as this allows the sample to be divided into those more likely to be financially constrained and those more likely to be unconstrained, and hence allows us to test directly whether it is only the inventory investment of the former which is affected by the availability of cash flow.

A key issue with this panel data approach is how to identify firms who are more likely to be financially constrained. The hierarchy of funds model suggests that the financial policy of firms can be used to identify which firms are more likely to be financially constrained. Firms are more likely to be unconstrained if they either pay dividends and issue no new shares (these firms can finance their entire investment programme using cash flow), or if they pay no dividends and issue shares (these firms find it profitable to finance their investment programme using external funds).(11) This is the criterion used by Bond and Meghir in their work on financial constraints and fixed investment. A significant advantage of this criterion is that it allows firms to switch from being financially constrained to unconstrained over the sample period. If sample averages (for example average dividend payout ratios), or pre-sample characteristics (for example firm size at the beginning of the period) are used, then firms are assumed to be financially constrained for the whole sample period.

In the United Kingdom, however, a large number of firms simultaneously pay dividends and issue new shares, which runs counter to the predictions of the hierarchy of funds approach. One explanation for this is that the tax advantages of issuing new equity outweigh the increase in its cost arising from informational asymmetries and transactions costs. Alternatively, it may be because firms use dividends to convey information about the longer-term prospects of the firm to their shareholders. In this case firms may be reluctant to reduce dividend payments below a certain point, even if this means forgoing profitable investment opportunities, as the reduction would be interpreted as indicating a deterioration in the firm's prospects. To allow for the signalling role of dividends, Bond and Meghir use a modified criterion which identifies a firm as more likely to be financially unconstrained if it pays 'normal' dividends and issues no new equity.

(11) In practice there are very few UK quoted firms who pay no dividends and issue new shares.

Given that there may be problems with using a firm's financial policy to identify whether or not a firm is more likely to be financially constrained, three other criteria are also used – firm size, interest coverage (the ratio of interest payments to operating profits) and the current ratio (the ratio of current assets to current liabilities).[12] Firm size has frequently been used as an indicator of whether or not a firm is more likely to be financially constrained. For example, Carpenter *et al* use firm size in their work using US firm data, and Devereux and Schiantarelli (1990) use it in their work on financial effects and fixed investment using data on UK firms. The basic idea is that, in general, larger firms have access to a wider range of suppliers of finance than smaller firms, and as a consequence larger firms are less likely to be financially constrained than smaller firms.

Interest coverage has also been used as an indicator in a number of articles, for example Guariglia and Schiantarelli (1998) and Milne (1994). The coverage ratio is used because it provides an indication of a firm's ability to service its debts and hence the probability of bankruptcy occurring. The lower a firm's coverage ratio the more likely it is that the firm will be financially constrained, owing to the higher probability that it may encounter problems servicing its debts. Interview evidence in Milne suggests that the level of interest coverage at which bankers start to become concerned about firms is approximately five. With the exception of Nickell and Nicolitsas, the current ratio has not been used as an indicator of whether a firm is likely to be financially constrained. However, in financial analysis it is frequently interpreted as a broad indicator of a firm's short-term financial position, and hence its credit-worthiness; for example see Holmes and Sugden (1994). A fall in a firm's current ratio below its 'normal' level is a warning signal that

(12) Other criteria that have been used to identify financially constrained firms included average dividend payout ratios – Fazzari, Hubbard and Petersen (1988), and firm age – Devereux and Schiantarelli (1990).

a firm may be facing liquidity problems, and hence means that the firm is more likely to be financially constrained.

Modelling inventories

Most empirical work on inventory investment is based on either a variant of the production smoothing model or the stock adjustment model.[13] The latter model assumes that inventory investment can be broken down into anticipated inventory investment, which occurs because there is a gap between the firm's target level of inventories and its actual level inventories at the beginning of the period, and unanticipated investment, which occurs because of unanticipated changes in the firm's sales; see Lovell (1961).[14]

However, the empirical performance of both of these models has been disappointing. Most value-added data show that, contrary to the predictions of the standard production smoothing model, the variance of production exceeds that of sales; for example see Guariglia and Schiantarelli (1998) for the United Kingdom and Milne (1994) for the United States. Even extensions of the standard model which do not predict this, for example production smoothing models which allow for cost shocks, perform poorly, failing standard mis-specification tests; see West (1995). In the case of the stock adjustment model, the estimated coefficients imply that firms close the gap between their actual and desired stock of inventories at an implausibly slow rate – for example see Feldstein and Auerbach (1976) – and that inventories do not play a significant role in absorbing demand shocks – for example see Blinder (1986).

(13) The lack of appropriate data means that there have been only a couple of attempts to estimate (S,s) models, for example Blinder (1981).
(14) The stock adjustment model is not explicitly derived from theory, although Blinder and Maccini (1991) show that the production smoothing model can justify key features of the stock adjustment model.

Given the disappointing empirical performance of both the production smoothing model and stock adjustment models, and because the available data are annual data on total inventories, a relatively unstructured model of inventory investment is used. Total firm inventory investment ($I_{i,t}$) is modelled as a function of the lagged stock of inventories ($N_{i,t-1}$), the lagged level of sales ($S_{i,t-1}$), the current change in sales ($\Delta S_{i,t}$), current cash flow ($CF_{i,t}$), a firm-specific fixed effect (b_1) and a set of industry-specific time dummies (TD_t).(15)

$$I_{i,t} = b_i + b_1 N_{i,t-1} + b_2 S_{i,t-1} + b_3 \Delta S_{i,t} + b_4 CF_{i,t} + TD_t + u_{i,t} \quad \textbf{(3)}$$

where i indicates firm i.

Given that this equation is specified in levels and there are large differences between the firms in terms of size, all the variables are scaled by the real net capital stock, (ie the dependent variable is $I_{i,t}/K_{i,t}$, to control for heteroscedasticity.(16)

The aim in estimating this unstructured model is to see whether, even after taking account of the standard determinants of inventory investment in a general manner, cash flow still has an effect on inventory investment, and in particular whether any cash flow effect is concentrated among firms identified as more likely to be financially constrained.(17) Two extensions to the above equation are also estimated to see how robust the results are. In

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(15) Firms were allocated to one of nine industries – metals and metals goods; minerals and mineral products; chemicals; mechanical engineering; electrical and instrument engineering; motor vehicles and other transport equipment; food, drink and tobacco; textiles clothing and footwear; and other manufacturing – on the basis of their principal industry in terms of sales.

(16) Similar results were obtained when firm employment was used as the scaling variable.

(17) One reason why cash flow may have an effect on inventory investment in this model is that it is capturing expectations about future demand that are not captured by other variables in the model. But this would not explain why any cash flow effect was concentrated among financially constrained firms.

the first extension a lagged dependent variable is added to the equation, and in the second the lagged change in sales is added.

4 Data and estimation

Data

Company accounts data drawn from Datastream are used. The panel consists of 527 quoted firms and covers the period 1977-94. The sample is restricted to those companies whose main activity in terms of sales was in manufacturing, and for which at least eight consecutive years of data are available. This sample selection criterion generated 7,229 firm-year observations, 76% of the maximum number of observations available for a panel with these dimensions.(18)

Company accounts provided data on the nominal stock of inventories held by the firm at the end of the accounting year, nominal sales and nominal cash flow – cash flow is defined as the sum of depreciation plus operating profits minus taxation.(19) Given that most firms operate a 'first in, first out' (FIFO) inventory policy, the stock of nominal inventories was deflated by the average two-digit producer price in the three months prior to the end of the firm's accounting year, as under a FIFO inventory policy it is during this period that a firm's stock of inventories is most likely to have been accumulated. Real inventory investment is given by the change in the stock of real inventories. Nominal sales and cash flow were deflated by the average two-digit price during the firm's accounting year. The data for the various criteria used to identify which firms are more likely to be financially

(18) See the Data appendix for details on the balance of the panel.
(19) Similar results were obtained using a gross measure of cash flow.

constrained – dividend payments, new equity issues, firm size, interest coverage and the current ratio – were also taken from company accounts.[20]

Estimation

The firm-specific fixed effects are eliminated from the equation for inventory investment by taking orthogonal deviations. Taking orthogonal deviations transforms the data by expressing each observation as the deviation from the average of future observations in the sample with each deviation weighted to standardise the variance – see Arellano and Bover (1995). Both cash flow and the change in sales are treated as potentially endogenous, so the equation is estimated by instrumental variables. This is done using the Generalised Method of Moments (GMM) procedure proposed by Arellano and Bond (1988 and 1991). This procedure uses variables dated t-2 or earlier as instruments and calls upon more instruments as the period of estimation advances. The actual instruments used are all the moment restrictions dated between t-2 and t-6 on cash flow and sales. The validity of the instrument set is checked by testing the residuals in first differences for first and second-order serial correlation and a Sargan test: if the undifferenced errors are iid then the differenced residuals should display first-order, but not second-order, serial correlation.

5 Results

The results are set out in Tables A and B. The first column of Table A reports the results of estimating the equation for inventory investment using the whole sample. The lagged stock of inventories has a significant negative effect upon inventory investment, and the lagged level of sales has a significant positive effect. This is consistent with the idea that firms have

(20) See the Data appendix for further details.

a target level of inventories, but the difference in the size of the coefficients on these variables means that firms do not have a constant inventory-sales ratio target. The change in sales has a significant positive effect upon inventory investment, so an increase in sales causes firms to increase their inventory investment, possibly to maintain a target level of inventories. Finally, even after controlling for the standard determinants of inventories in a general manner, current cash flow has a significant positive effect upon firm inventory investment. This result also holds when a lagged dependent variable is included in the regression and when the lagged change in sales is included.[21]

(21) For the sake of brevity these results are not reported, although they are available from the author on request.

Table A

Dependent variable: $I_{i,t}$ **Sample period: 1979-94** **Explanatory variables**	**(1)**	**(2)**	**(3)**
$N_{i,t-1}$	-0.3205 (0.0206)	-0.2612 (0.0446)	-0.3082 (0.0544)
$S_{i,t-1}$	0.0223 (0.0448)	0.0154 (0.0016)	0.0200 (0.0085)
$\Delta S_{i,t}$	0.0470 (0.0074)	0.0676 (0.0560)	0.0655 (0.0534)
$CF_{i,t}$	0.5117 (0.0281)	0.3370 (0.1569)	0.3769 (0.1283)
$D*N_{i,t-1}$		-0.1156 (0.0386)	-0.0457 (0.0522)
$D*S_{i,t-1}$		0.0098 (0.0089)	0.0037 (0.0093)
$D*\Delta S_{i,t}$		0.0143 (0.0545)	-0.0132 (0.0534)
$D*CF_{i,t}$		0.2433 (0.0832)	0.2376 (0.0758)
Test statistics			
m_1 **(p-value)**	-2.858 (0.00)	-2.648 (0.00)	-2.695 (0.01)
m_2 **(p-value)**	1.112 (0.27)	1.171 (0.24)	-1.124 (0.26)
z_1 **(p-value)**	175.38 (0.00)	1298.32 (0.00)	1010.95 (0.00)
z_2 **(p-value)**	531.65 (0.00)	547.95 (0.00)	535.97 (0.00)
Sargan (dof) **(p-value)**	158.71 (137) (0.10)	303.80 (274) (0.10)	290.40 (274) (0.24)
No of firms	527	527	527
No of observations	5648	5648	5648

Notes: All variables are scaled by the real net capital stock. Robust one-step standard errors in parentheses. m_i is a test for serial correlation of order *i* using residuals in first differences, z_1 is a χ^2 test of the joint significance of the reported coefficients, z_2 is a χ^2 test of the significance of the time dummies, and the Sargan test is a χ^2 test of the over-identifying restrictions.

To see whether it is only the inventory investment of financially constrained firms which is affected by the availability of cash flow, a dummy variable ($D_{i,t}$) is defined which is zero when dividends are positive and no new shares are issued (ie when the firm is financially unconstrained) in both the current and previous period, and one in all other cases (ie when the firm is financially constrained). The reason for setting $D_{i,t}$ equal to zero only when the firm is unconstrained in both the current and previous period is that, even if a firm is currently unconstrained, if it was constrained during the previous period then there will be some unwinding effect during the current period as the firm restores its stock of inventories to their desired level. This unwinding effect will appear as a cash flow effect on inventory investment in the current period. Obviously if a firm was unconstrained during the previous period but is financially constrained during the current period, then current cash flow will have an effect on current inventory investment.(22) The dummy variable is interacted with all the explanatory variables and the model re-estimated.(23) To allow for the endogeneity of this dummy variable the interactive terms are instrumented using the same GMM procedure.

The results are set out in column (2). The first four coefficients relate to the sub-sample which is defined as financially unconstrained (firms for whom $D_{i,t}$=0). The remaining four coefficients estimate the difference in the coefficients on each variable between financially constrained and financially unconstrained firms. The main differences compared with the estimates in column (1) are the coefficients on current cash flow and on the lagged stock of inventories. Among the firms defined as unconstrained, the coefficient on the cash flow variable is substantially smaller than for the sample as a whole, although it is still positive and significant. Moreover, among the

(22) The effect of cash flow on inventory investment is likely to be larger for firms who are financially constrained in both the current and previous periods than for firms who are constrained in just one of these periods.

(23) The reason for interacting the dummy variable with all the explanatory variables and not just cash flow is to allow for the possibility that not only does the inventory investment of financially constrained firms depend upon cash flow, but it also responds differently to the standard determinants of inventory investment.

firms defined as financially constrained, the coefficient on cash flow is significantly different from that for the unconstrained firms, and the difference is positive. This suggests that the inventory investment of financially constrained firms is more sensitive to the availability of internal finance than that of financially unconstrained firms.

Column (3) contains the results based on Bond and Meghir's alternative criterion, which allows for the reluctance of firms to reduce their dividend payments because of signalling. Firms are now defined as more likely to be financially unconstrained ($D_{i,t}$=0) if they issue no new shares and their ratio of dividend payments to capital stock is at least equal to three-quarters the average for the firm over the sample period in both the current and previous period. This criteria produces similar results to those in column (2). The coefficient on cash flow for unconstrained firms is smaller than for the sample as a whole, and the interaction between cash flow and the dummy variable is positive and significant. The only difference between the results is that the coefficient on the interaction between the lagged stock of inventories and the dummy variable is negative.

Taken together, the results in columns (2) and (3) suggest that the positive effect of cash flow on inventory investment found in column (1) reflects, to an extent, the presence of financially constrained firms, and that controlling for the presence of these firms reduces this effect, but does not eliminate it. These findings are very similar to those reported by Bond and Meghir for fixed investment. They found that although the effect of cash flow on fixed investment was concentrated among firms defined as financially constrained by their financial policy, cash flow still had an effect upon the fixed investment of unconstrained firms. One possible reason why cash flow still has an effect upon the inventory investment of unconstrained firms even after allowing for the presence of constrained firms, is that it is capturing expectations about future demand which are not being controlled for by the other variables in the model. This possibility does not, however, explain

why cash flow has a significantly larger effect on the inventory investment of financially constrained firms than on financially unconstrained firms.

Table A used the firm's financial policy to identify whether or not the firm is financially constrained. But, as noted in Section 3, there may be problems with doing this, which may explain why Table A still shows that the inventory investment of unconstrained firms is affected by current cash flow. Therefore in Table B three alternative criteria for identifying whether or not a firm is more likely to be financially constrained are used. In column (1) a firm is identified as being financially constrained ($D_{i,t}$=1) if its current ratio is less than its sample average and less than its level in the previous period, ie the firm's current ratio is below its 'normal' level. This produces very similar results to those in columns (2) and (3) in Table A. The coefficient on current cash flow for unconstrained firms is smaller than for the sample as a whole, although it is still significant and positive, and the coefficient on the dummy cash flow variable is positive and significant. This suggests that there is no unique criterion for identifying financially constrained firms using financial information from company accounts.

Table B

Dependent variable: $I_{i,t}$ **Sample period: 1979-94** **Explanatory variables**	**(1)** **Current ratio**	**(2)** **Coverage ratio**	**(3)** **Firm size**
$N_{i,t-1}$	-0.3100 (0.0503)	-0.3107 (0.0593)	-0.3854 (0.0585)
$S_{i,t-1}$	0.0233 (0.0065)	0.0227 (0.0092)	0.0259 (0.0096)
$\Delta S_{i,t}$	0.0456 (0.0252)	0.0345 (0.0367)	0.0184 (0.0128)
$CF_{i,t}$	0.4056 (0.0935)	0.5114 (0.1033)	0.6426 (0.0376)
$D*N_{i,t-1}$	-0.0483 (0.0200)	-0.0953 (0.0496)	0.1186 (0.0723)
$D*S_{i,t-1}$	0.0073 (0.0656)	0.0138 (0.0077)	0.0058 (0.0121)
$D*\Delta S_{i,t}$	0.0271 (0.0171)	0.0457 (0.0369)	0.1063 (0.0279)
$D*CF_{i,t}$	0.2012 (0.0803)	-0.2959 (0.1193)	-0.5957 (0.1155)
Test statistics			
m_1 **(dof)** **(p-value)**	-2.664 (0.01)	-2.735 (0.00)	-3.127 (0.00)
m_2 **(dof)** **(p-value)**	1.144 (0.25)	1.069 (0.29)	0.882 (0.38)
z_1 **(dof)** **(p-value)**	365.72 (0.00)	299.80 (0.00)	1779.26 (0.00)
z_2 **(16)** **(p-value)**	475.43 (0.00)	433.99 (0.00)	524.72 (0.00)
Sargan (dof) **(p-value)**	298.96 (274) (0.14)	318.83 (274) (0.03)	294.91 (274) (0.19)
No of firms	527	527	527
No of observations	5648	5648	5648

Notes: See Table A.

In column (2) the dummy variable is defined as equal to one if a firm's interest coverage is less than five in both the current and previous period. The results suggest that the coverage ratio does not provide a good indication of whether or not a firm is financially constrained. In particular,

the coefficient on the interaction of cash flow and the dummy variable is negative and significant, which counter-intuitively suggests that cash flow has a smaller effect upon the inventory investment of firms with low coverage ratios than it has on firms with high coverage ratios.[24] Guariglia and Schiantarelli found that firms with low and with high coverage ratios both have incentives to bunch their production rather than smooth it.

Finally, in column (3) the dummy variable is defined as equal to one if the firm has less than five hundred employees in both the current and previous period, ie the firm is a medium or small-sized firm. The results suggest that smaller quoted firms are not financially constrained. Indeed, the negative coefficient on cash flow implies that cash flow has a significantly smaller effect on inventory investment among smaller firms than among larger firms. This is the opposite of what Carpenter *et al* and Gertler and Gilchrist (1994) report for the United States. They both found that the inventory investment of smaller firms was more sensitive to current cash flow than the inventory investment of larger firms. It also differs from what Devereux and Schiantarelli found for fixed investment for the United Kingdom. The difference with Gertler and Gilchrist may reflect the different samples being used, as their sample includes non-quoted firms whereas the sample in this paper consists just of quoted firms, and one of the reasons why a small firm is quoted is that it has overcome any disadvantages associated with its size. This, however, does not explain the difference with the other two papers, as both Carpenter *et al* and Devereux and Schiantarelli use samples of quoted firms.

6 Conclusion

Using a panel of UK manufacturing firms, this paper has examined the relationship between inventory investment and cash flow, and in particular

(24) The regression in column (2) also fails the Sargen test at the 5% level, which could reflect mis-specification of the equation.

whether the effect of cash flow on inventory investment is concentrated among firms that are more likely to be financially constrained. A number of criteria were used to identify financially constrained firms, including those based on the financial policy of the firm suggested by Bond and Meghir. All the criteria allowed firms to switch between being financially constrained and unconstrained over the sample period.

The main finding was that the effect of cash flow on inventory investment is concentrated among firms that are identified as financially constrained on the basis of either their financial policy or their current ratio. This suggests that there is no unique criterion for identifying financially constrained firms using financial information in company accounts. Despite controlling for the presence of financially constrained firms, cash flow was still found to have an effect upon the inventory investment of unconstrained firms. This could be because cash flow is capturing expectations about future demand which are not captured by other variables in the model, although this does not explain why cash flow has a significantly larger effect on the inventory investment of financially constrained firms than on unconstrained firms. In contrast to other studies, using either firm size or the coverage ratio to identify financially constrained firms did not reduce the effect of cash flow on the inventory investment of unconstrained firms. This raises doubts about whether these are good indicators of whether a firm is financially constrained or not. The findings of this paper, combined with the similar results for fixed investment which Bond and Meghir report, suggest that one way in which monetary shocks are magnified and propagated through the economy is via the effect of cash flow on the investment activities of financially constrained firms.

Data appendix

Structure of the panel

The panel is unbalanced, and the distribution of firms by the number of consecutive years of data available is as follows.

No of years	No of firms	No of years	No of firms	No of years	No of firms
8	51	13	21	18	127
9	44	14	34	19	39
10	51	15	22		
11	51	16	11		
12	44	17	32		

Firm-level data

Stock of nominal inventories ($pN_{i,t}$): Total stocks plus work in progress, Datastream item 364.

Inventory investment ($I_{i,t}$): $= \Delta N_{i,t}$.

Nominal sales ($pS_{i,t}$): Total sales, Datastream item 104.

Nominal cash flow ($pCF_{i,t}$): This is the sum of depreciation (Datastream item 136) and operating profits (Datastream item 137) minus taxation (Datastream item 172).

Employment: Total number of employees, Datastream item 219.

Dividends: Ordinary dividends, Datastream item 187

Equity issues: Total new equity issued, Datastream item 153.

Interest coverage: Ratio of interest payments (Datastream item, 153) to operating profits (Datastream item 137).

Current ratio: Ratio of current liabilities (Datastream item 389) to current assets (Datastream item 376).

Net capital stock at replacement cost. This was calculated using the same method used by Blundell, Bond, Devereux and Schiantarelli in their article, 'Investment and Tobin's Q: Evidence from company panel data', *Journal of Econometrics*, Vol 51, pages 233-57.

Industry-level data

Output price ($p_{j,t}$): Two-digit producer price index numbers of output (home sales), Tables 18.1 and 18.3, *Annual Abstract of Statistics*.

The industry data was matched with the firm data on the basis of each firm's principal operating industry in terms of sales.

References

Arellano, M and Bond, S (1988), 'Dynamic panel data estimation using DPD: a guide for users', *IFS Working Paper* No 88/15.

Arellano, M and Bond, S (1991), 'Some tests of specification for panel data', *Review of Economic Studies*, Vol 58, pages 277-97.

Arellano, M and Bover, O (1995), 'Another look at the instrumental variables estimation of error components models' *Journal of Econometrics*, Vol 68, No 1, pages 29-51.

Blinder, A (1981), 'Retail inventory investment and business fluctuations', *Brookings Papers on Economic Activity*, Vol 2, pages 443-505.

Blinder, A (1986), 'Can the production smoothing model of inventories be saved?' *Quarterly Journal of Economics*, Vol 101, pages 431-53.

Blinder, A and Maccini, L (1991), 'The resurgence of inventory research: what have we learned?', *Journal of Economic Surveys*, Vol 5, No 4, pages 291-328.

Bond, S and Meghir, C (1994), 'Dynamic investment models and the firms financial policy', *Review of Economic Studies*, Vol 61, pages 197-222.

Carpenter, R, Fazzari, S and Peterson, B (1994), 'Inventory investment, internal finance fluctuations and the business cycle', *Brookings Papers on Economic Activity*, No 2, pages 75-138.

Devereux, M and Schiantarelli, F (1990), 'Investment, financial factors, and cash flow: evidence from UK panel data', in Hubbard, R G (ed), *Asymmetric information, corporate finance and investment*, Chicago: University of Chicago.

Fazzari, S, Hubbard, R and Petersen, B (1988), 'Financial constraints and corporate investment', *Brookings Papers on Economic Activity*, No 1, pages 141-95.

Feldstein, M and Auerbach, A, (1976), 'Inventory behaviour in durable goods manufacturing: the target-adjustment model', *Brookings Paper on Economic Activity*, Vol 24, pages 351-96.

Gertler, M and Gilchrist, S (1994), 'Monetary policy, business cycles and the behaviour of small manufacturing firms', *Quarterly Journal of Economics*, Vol 109, pages 309-40.

Guariglia, A and Schiantarelli, F (1998), 'Production smoothing, firms' heterogeneity and financial constraints: evidence from a panel of UK firms', *Oxford Economic Papers*, Vol 50, pages 63-78.

Holmes, G and Sugden, A (1994), *Interpreting company reports and accounts*, London, Woodhead-Faulkner.

Hubbard, G (1997), 'Capital market imperfections and investment', *NBER Working Paper No 5996*.

Jensen, M and Meckling W (1976), 'Theory of the firm: managerial behaviour, agency costs and ownership structure', *Journal of Financial Economics*, Vol 3, pages 305-60.

Kashyap, A Lamont, O and Stein, J (1994), 'Credit conditions and the behaviour of inventories', *Quarterly Journal of Economics*, Vol 109, pages 565-92.

Lovell, M (1961), 'Manufacturers' inventories, sales expectations and the accelerator principle', *Econometrica*, Vol 29, pages 293-314.

Milne, A (1991), 'Financial effects on inventory investments', *London Business School Discussion Paper No 11-91*.

Milne, A (1994), 'The production smoothing model of inventories revisited', *Economic Journal*, Vol 104, pages 399-407.

Myers, S (1984), 'The capital structure puzzle', *Journal of Finance*, Vol 39, pages 575-92.

Myers, S and Majluf N (1984), 'Corporate financing and investment decisions when firms have information that investors do not have', *Journal of Financial Economics*, Vol 13, pages 187-221.

Nickell, S and Nicolitsas, D (1995), 'How does financial pressure affect firms?', *Centre for Economic Performance Discussion Paper No 266*.

Schiantarelli, F (1995), 'Financial constraints and investment', in Peek, J and Rosengren, E (eds) 'Is bank lending important for the transmission of monetary policy?' Federal Reserve Bank of Boston, Conference Series No 39.

Stiglitz, J and Weiss, A (1981), 'Credit rationing in markets with imperfect information', *American Economic Review*, Vol 71, pages 393-410.

West, K (1995), 'Inventory Models' in Pesaran, M and Wickens, M (eds), *Handbook of Applied Econometrics*, Basil Blackwell, Oxford.

Whitaker, S (1996), 'Stockbuilding', *Bank of England*, memo.