Cash flow, investment, and investment opportunities: New tests using UK panel data

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Abstract

The interpretation of the correlation between cash flow and investment is highly controversial. Some argue that it is caused by financial constraints, others by the correlation between cash flow and investment opportunities that are not properly measured by Tobin's *Q*. This paper uses UK firms' contracted capital expenditure to capture information about opportunities available only to insiders and thus not included in *Q*. When this variable is added in investment regressions, the explanatory power of cash flow falls for large firms, but remains unchanged for small firms. This suggests that the significance of cash flow stems from its role in alleviating credit frictions.

Keywords: Investment, Tobin's *Q*, Cash flow, Financial constraints.

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1. Introduction

The relationship between investment and cash flow has had a turbulent history. It was widely studied in the 1950s and 1960s (Meyer and Kuh, 1957; Kuh, 1963, etc.) Yet cash flow subsequently all but disappeared from the investment literature until its revival in the 1980s following the development of models of asymmetric information, and an empirical breakthrough in 1988 by Fazzari, Hubbard, and Petersen (FHP, thereafter). FHP (1988) estimated investment equations as a function of Tobin's *Q* and cash flow using firm-level data[1]. They found that cash flow tends to have a bigger effect on the investment of firms more likely to face financial constraints and interpreted this as evidence for the existence of information-driven capital market imperfections. A large literature on the relationship between cash flow and investment followed FHP's (1988) paper adopting similar techniques (see Hubbard, 1998; and Bond and Van Reenen, 2002, for surveys).

The reasons why cash flow matters for investment are, however, still controversial. Some researchers have argued that instead of being caused by financing constraints, the relationship between cash flow and investment could stem from the correlation between cash flow and omitted or mis-measured investment opportunities that are not captured by standard measures, particularly *Q*[2]. Consequently, several attempts have been made at constructing alternative measures of investment opportunities to test whether, once these opportunities are more adequately measured, cash flow still plays a significant effect on firms' investment (see Gilchrist and Himmelberg, 1995; Cummins et al., 1999; Erickson and Whited, 2000; Bond and Cummins, 2001; and Bond et al., 2002)[3].

Other researchers have re-examined the evidence in the original FHP (1988) paper and have re-interpreted the results, suggesting that higher sensitivities of investment to cash flow cannot be seen as evidence that firms are more financially constrained, and casting a dark cloud over the entire literature (Kaplan and Zingales, 1997).

The use of *Q* is based on the idea that investment opportunities, which are forward looking, can be captured by equity market participants, who are also forward looking. In particular, securities' prices and therefore financial markets' evaluations of investment

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[1] As marginal *Q* is not observable, it is generally proxied with average *Q* in empirical work. Hayashi (1982) illustrates the conditions under which the two measures are equivalent.
[2] As discussed in Bond and Cummins (2001) and Bond et al. (2002), this could happen if the Hayashi (1982) conditions are not satisfied or if *Q* is affected by measurement error, in the sense that stock market valuations are influenced by factors other than the present discounted value of expected future profits (e.g. bubbles).
[3] It has also been pointed out that holding constant investment opportunities, cash flow and investment could also be linked because managers tend to use internal funds for non-value-maximising projects. This is the "free cash-flow hypothesis" (see Jensen, 1986; and Hubbard et al., 1995).

prospects are a keystone in papers based on the *Q*-theory. However, in the presence of information asymmetries in capital markets, a tension is immediately introduced by the use of *Q*. In such circumstances suppliers of external funds are unable to accurately assess firms' investment opportunities, and it is quite likely that there will be gaps in the information sets of the firm's insiders and outsiders[4]. *Q* will thus only capture outsiders' evaluation of opportunities. It is possible that cash flow significantly affects investment simply because it is correlated with the insiders' evaluation of opportunities, which are not captured by *Q*.

The principal contribution of this paper is to clarify the role of cash flow in investment equations by introducing, alongside *Q*, a new proxy for expectations reflecting the firms' insiders' evaluation of opportunities, namely the firm's contractual obligations for future new investment projects. This variable should contain information about managers' forecasts of investment opportunities. To ensure that we capture information that is not contained in *Q* as well[5], we use *Q* at the beginning of the period, but contracts for future investment in the period when they are announced. Including both *Q* and contracted capital expenditure in our investment equations improves the degree to which investment opportunities are measured. If cash flow still plays a significant role on firms' investment, then we can be more confident it is because of the role it plays in alleviating credit frictions.

Another important aspect of our work is its contribution to the debate on the effects of financial constraints on investment, with a focus on the UK rather than the US. This is important because the controversy about how to interpret cash flow, and whether firms face significant financing constraints is much less developed in Europe than it has been in the US. However, the relative thinness and highly regulated banking and equity markets, the relatively small amount of venture capital financing, and the relative lack of corporate bond and commercial paper markets seem to make the idea of financing constraints which affect firm behaviour much more plausible to European researchers[6].

We use a panel of 722 UK firms over the period 1982 to 1999 to estimate investment regressions distinguishing firms into more and less likely to face financial constraints using

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[4] An important theoretical paper serving as the foundation for the financing constraint literature, Myers and Majluf (1984), uses this argument to motivate the information asymmetries.
[5] When new contracts are announced, presumably the information in the announcement will be reflected in the firms' share prices.
[6] Other studies that looked at the effects of financial constraints on investment in the UK include Devereux and Schiantarelli (1990); Blundell et al. (1992); Bond and Meghir (1994); and, more recently, Bond et al. (2002). A number of recent European Central Bank (ECB) discussion papers have looked at the effects of financial variables on various European countries' investment.

employees as a measure of size[7]. We find that although cash flow affects investment of both types of firms, its effect is stronger for small firms. We then add, alongside *Q*, our variable measuring the firm's contractual obligations for future new investment. This ensures an adequate measurement of investment opportunities. When this new variable is introduced, the explanatory power of cash flow falls for large firms, but remains unchanged for small firms. This suggests that at least for the latter, the significance of cash flow in investment equations is likely to be caused by information asymmetries in the capital markets.

The rest of the paper is laid out as follows. Section 2 summarises the main points of controversy about cash flow's role in determining firms' investment. Section 3 describes our data and presents some summary statistics. Section 4 presents our main econometric results. Section 5 concludes.

2. Why does cash flow matter for investment? Economic background and summary of the principal points of the controversy

For many years, we have known a tight relationship between internal funds and investment exists. As early as 1957, Meyer and Kuh stressed the importance of financial variables for investment and firms' seeming preference for internal funds. Research examining how firms' financing choices affected their investment was shelved in the 1960s, following the work by Modigliani and Miller (1958). This work led to the extensive development of neoclassical models of investment (e.g., Jorgenson, 1963; Hall and Jorgenson, 1967). According to these models, the main determinants of investment spending are real interest rates and taxes, and interest rates are set in centralised security markets, and are therefore independent of the firm's financial structure. The *Q*-theory of investment (Tobin, 1969; Hayashi, 1982) can be seen as a reformulation of the neoclassical theory, according to which investment demand can be explained by the ratio between the market value of the firm's capital stock and its replacement cost. Neither the neoclassical nor the *Q*-theory recognised any role of financial variables in determining investment. Moreover, both theories were based on the representative agent assumption and consequently overlooked all aspects of firms' heterogeneity.

The importance of how investment is financed was revived with the development of theoretical models of asymmetric information. Akerlof's (1970) landmark study on the role of asymmetric information in the market for "lemons" broke with established economic

[7] Size is widely used in the literature as a criterion to partition firms into more and less likely to face financing constraints (see for instance Devereux and Schiantarelli, 1990, Carpenter et al., 1994, 1998, etc.).

theory by illustrating how markets malfunction when buyers and sellers operate under different information sets. Researchers recognised that similar arguments could be applied to firms seeking funds from lenders (e.g., Stiglitz and Weiss, 1984).

In 1988, Fazzari, Hubbard and Petersen published an influential paper which had a significant methodological impact. They abandoned the representative firm assumption, and, using firm-level US data, examined differences in the sensitivity of investment to cash flow across groups of firms more or less likely to face financial constraints. This methodology allowed them to distinguish between different potential roles of cash flow. In particular, *Q*, which they included in their investment regressions as a proxy for firms' investment opportunities, might not properly measure them. If this were the case, then the coefficients on cash flow could be biased due to the correlation between cash flow and investment opportunities, and one would expect the effects of cash flow on investment to be approximately equal for all groups of firms.

Alternatively, cash flow could affect investment because capital markets are imperfect, and internal finance is cheaper than external finance. In this case, one would expect cash flow to play a stronger role on the investment of firms more likely to face financial constraints. Looking at the difference in the size of the cash flow coefficients for firms more and less likely to face financial constraints would therefore provide useful evidence about the existence of financial constraints.

FHP (1988) divided firms according to dividend policy, with high-dividend firms assumed less likely to face financial constraints. Their findings showed that cash flow tends to affect the investment of low-dividend firms significantly more than that of high-dividend firms, supporting the hypothesis that cash flow affects firms' investment because of capital market imperfections.

Almost immediately, research began to address the potential shortcoming of *Q* as measure of investment opportunities. One branch of literature "departed from the strategy of using proxies for marginal *Q* and relied on the Euler equation describing the firm's optimal capital stock to model the investment decision" (Hubbard, 1998, p. 209). In the absence of financial constraints, the standard Euler equation derived under the assumption of perfect capital markets should hold. In the presence of financial constraints, on the other hand, the standard Euler equation is mis-specified as financial variables belong in it. Whited (1992), Hubbard et al. (1995), and Ng and Schaller (1996) estimated the standard Euler equation and an Euler equation augmented with financial variables for various categories of firms. Using US data, they found that the standard Euler equation generally holds only for firms less likely to face financial constraints. Bond and Meghir (1994) reached a similar conclusion using UK data.

Another branch of literature attempted to identify the effect of capital market imperfections on investment without using *Q* as a measure of investment opportunities, but using alternative measures of investment fundamentals. For instance, Gilchrist and Himmelberg (1995) estimated a set of VAR forecasting equations for a subset of information available to the firm, and subsequently evaluated a linear expectation of the present discounted value of marginal profits, which they used as a measure of firms' investment opportunities[8]. They then estimated regressions of investment on the latter variable and cash flow. Since the informational content of cash flow as a forecasting variable is built in this new measure of investment fundamentals, if the coefficient on cash flow remains significant once the new variable is included in the investment regression, it is an indication of the presence of capital market imperfections. According to their results based on US data, the neoclassical model (without cash flow) only holds for firms less likely to face financial constraints, whereas cash flow significantly enters the regressions of constrained firms. These findings are in line with those in FHP (1988)[9].

An important challenge to the findings in FHP (1988) came from Kaplan and Zingales (1997). These authors focused on the low-dividend sub-sample of firms used in FHP (1988) and reclassified these firms on the basis of their degree of financing constraints, using information contained in the firms' annual reports as well as management's statements on liquidity. They found that investment of firms that appear less financially constrained is more sensitive to cash flow than investment of other firms and concluded that higher sensitivities of investment to cash flow cannot be interpreted as evidence that firms are more financially constrained. A heated debate followed the publication of Kaplan and Zingales' (1997) article (Chirinko, 1997; FHP, 2000; Kaplan and Zingales, 2000; and Cleary, 1999).

A further challenge to FHP (1988) came with Cummins et al. (1999), Bond and Cummins (2001), and Bond et al. (2002), who used firm-specific earnings forecasts from securities analysts to construct more accurate measures of the fundamentals that affect the expected returns on investment. In their investment specifications, they found that if one controls for expected profitability by using analysts' earnings forecasts, then the correlation between

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[8] Also see Gilchrist and Himmelberg (1999).

[9] Past this point, the controversy on how to interpret the role of cash flow appeared to simmer for a time, as the research agenda pursued how financing constraints affected different measures of firm activity including inventory investment (Carpenter et. al., 1994, 1998; Guariglia, 1999, 2000; and Guariglia and Schiantarelli, 1998); employment (Nickell and Nicolitsas, 1999); and R&D (Himmelberg and Petersen, 1994 and Bond et al., 1999).

investment spending and cash flow disappears in all sub-samples of firms[10]. Similar results were obtained in Erickson and Whited (2000) who regressed investment on a measure of *Q* adjusted for measurement error, and cash flow[11].

These challenges to the findings in FHP (1988) suggest that the controversy on what might cause the observed correlation between investment and cash flow is still open, and that the debate rages on. It must be noted that the majority of papers that made up the controversy are based on US data. Since financing constraints are notoriously more binding in Europe, using European data obviously represents an important step forward which needs to be taken to shed further light on this debate. Our paper takes this step.

3. Main features of the data and descriptive statistics

The data set

The data used in this paper consist of UK quoted company balance sheets collected by Datastream. We consider only the manufacturing sector. Investment is measured as the purchase of fixed assets by the firm. Cash flow is obtained as the sum of the firm's after-tax profits and depreciation. Our measure of the replacement value of capital stock is derived from the book value of the firm's stock of net fixed assets, using the investment data in a standard perpetual inventory formula. *Q* is calculated as the ratio between the sum of the market value of the firm and the firm's total debt and the replacement value of its capital stock[12].

Our data set includes a total of 6566 annual observations on 722 companies for the years 1982 to 1999. The sample has an unbalanced structure, with the number of years of observations on each firm varying between 3 and 18. By allowing for both entry and exit, the use of an unbalanced panel partially mitigates potential selection and survivor bias. We excluded companies that changed the date of their accounting year-end by more than a few weeks, so that the data refer to 12 month accounting periods. Firms that did not have complete records on investment, cash flow, *Q*, and contracted capital expenditure were also

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[10] Cummins at al. (1999) found that the coefficient on cash flow is generally insignificant even in specifications that simply drop lags of *Q* from the instrument set. This procedure also considerably improves the general specification of their model. Lags of *Q* are likely to be inappropriate instruments when the measurement error in *Q* is serially correlated.

[11] Gomes (2001) provides a theoretical challenge to the hypothesis that a significant coefficient on cash flow in an investment reduced-form regression can be seen as an indication of the existence of financial constraints (also see Cooper and Ejarque, 2001).

[12] More complete definitions of all variables used can be obtained from the authors upon request.

dropped, as well as firms with less than 3 years of continuous observations. Finally, to control for the potential influence of outliers, we removed observations in the 1% tail for each of the regression variables.

To test whether cash flow has a different impact on the investment of different types of firms, we partition firms according to whether they are more or less likely to face financing constraints using employees as a measure of size. In particular, we generate a dummy variable, $SMALL_{it}$, which is equal to 1 if firm i has less than 250 employees in year t, and 0, otherwise[13]. We allow firms to transit between size classes[14]. To check robustness, we will explore results for alternative cut-offs.

The contracted capital expenditure variable

The contracted capital expenditure variable, which we use as our new proxy for expectations, reflects the insiders' evaluation of investment opportunities. It is defined as contracts entered into for the future purchase of capital items, expenditure on machinery, equipment, plant, vehicles, and buildings, for which nothing has been paid by balance sheet date. Each firm is required to provide this information following paragraph 50(3) of the Fourth Schedule to the Companies Act 1985, as amended by the Companies Act 1989 and Statutory Instrument 1996 189. This contracted capital expenditure is likely to transform itself into actual investment in the subsequent year, or in subsequent years if the contracts are long-term. Even if the contracts are broken, however, the variable still contains information about managers' forecasts of investment opportunities. It is therefore reasonable to interpret this variable as an insider's expectation of future investment demand.

Summary statistics

Table 1 reports some descriptive statistics for the full sample and for the sub-samples of firm-years with high and low employment. The first column of figures presents variable means for the full sample, whereas columns 2 and 3 respectively refer to small and large firm-years. The average firm-year has 5101 employees, whereas the average large firm-year has 6079 employees, and the average small firm-year has 149 employees. Compared to large firm-years, small firm-years generally have lower investment, cash flow, contracted capital

[13] A firm with less than 250 employees is much smaller than a typical "small" US firm. However, this number is appropriate in a European context, where firms are typically smaller than in the US (see Bank of England, 2002, for a discussion of various definitions of small, medium, and large firms).

[14] For this reason, our empirical analysis will focus on firm-years rather than simply firms. See Bond and Meghir (1994), Kaplan and Zingales (1997), Guariglia and Schiantarelli (1998), and Guariglia (2000) for a similar approach.

expenditure, and sales growth. For the latter firm-years the investment to capital ratio is in fact 0.16, whereas it is 0.17 for the former. The corresponding figures for the cash flow to capital ratio are 0.24 and 0.29; for the contracted capital expenditure to capital ratio, 0.02 and 0.03; and for sales growth, 1.23 and 7.66. In contrast, small firm-years have a larger *Q* (4.43) than high employment-firm years (3.18).

4. Estimation results

Baseline specification

We initially estimate the following regression:

$$I_{it} / K_{i(t-1)} = a_0 + a_1 I_{i(t-1)} / K_{i(t-2)} + a_2\, Q_{i(t-1)} + a_3\, CF_{it} / K_{i(t-1)} + v_i + v_t + e_{it} \qquad (1)$$

Where *I* is the firm's investment; *K*, the replacement value of its capital stock; *Q*, Tobin's *Q*; and *CF*, the firm's cash flow. The subscript *i* indexes firms, and *t*, time, where t=1982-99. The error term in Equation (1) is made up of 3 components: v_i, which is a firm-specific component; v_t, a time-specific component accounting for possible business cycle effects; and e_{it}, an idiosyncratic component. We control for v_t by including time dummies in all our specifications.

Table 2 presents the estimates of Equation (1) for the full sample of firms. Column (1) reports the Ordinary Least Squares (OLS) estimates. The coefficients on the three regressors are statistically significant. In particular, cash flow is positively associated with investment. The OLS estimates are however likely to suffer from biases due to unobserved heterogeneity, and possible endogeneity of the regressors. Column (2) reports the estimates obtained using the Within Groups estimator, which controls for the former bias. The ρ coefficient, which represents the proportion of the total error variance accounted for by unobserved heterogeneity is equal to 0.30. This suggests that it is important to take unobserved firm-specific characteristics into account. The coefficient on the lagged dependent variable (0.164) is much smaller than the corresponding coefficient obtained in the OLS specification (0.326), which was obviously biased.

Since the OLS specification reported in column (1) is also likely to be biased due to the endogeneity of the contemporaneous cash flow variable, we report in column (3), the results based on an Instrumental Variable (IV) specification, where the cash flow variable is instrumented with one lag of itself, one lag of the contracted capital expenditure to capital ratio, and one lag of real sales and employment. In this specification, we can see that cash flow still has a positive and significant effect on investment.

The specifications reported in columns (1) and (2) however, only take into account the two biases characterising the OLS specification individually: the estimates obtained using the Within Groups estimator may still be affected by endogeneity[15], whereas the IV estimates are likely to be affected by unobserved heterogeneity. In column (4) of Table 2, we present the results of the estimation of our investment equation undertaken using our preferred estimator, namely the first-differenced Generalized Method of Moments (GMM) estimator, which takes the two biases simultaneously into account[16]. The instrument set includes $I_{it} /K_{i(t-1)}$, Q_{it}, $CF_{it} /K_{i(t-1)}$, the contracted capital expenditure to capital ratio, real sales, and employment, all lagged two and three times[17]. The estimated coefficient on the lagged dependent variable lies comfortably between the corresponding estimates obtained using OLS and the Within Groups estimator. This suggests that our GMM estimator is unlikely to suffer from a weak instrument bias (see Bond et al., 2001)[18]. Once again, the coefficient on the cash flow variable is positive and statistically significant. The coefficients associated with the lagged dependent variable and *Q* are comparable to those obtained in previous studies that focused on investment behaviour in the UK (see Devereux and Schiantarelli, 1990; Blundell et al., 1992). The *J* statistic has a marginal significance of 0.21 and the *m2* statistic shows no sign of second order serial correlation of the residuals[19]. Both tests suggest that the instruments are valid and that there is no gross mis-specification in the model[20].

All the specifications reported in Table 2 indicate that there is a positive relationship between cash flow and investment, similar to results obtained in previous studies for the UK and other countries. It is also important to note that the point estimates for cash flow are

[15] For panels where the number of time periods is relatively small, the estimates obtained using the Within Groups estimator are also inconsistent, as the transformed lagged dependent variable and the transformed error term are negatively correlated. This is generally referred to as the Nickell (1981) bias.

[16] When the first-difference estimator is used, unobserved heterogeneity is controlled for because the firm-specific component of the error term, v_i, drops out. The endogeneity bias is controlled for by instrumenting the regressors. See Arellano and Bond (1991) on the application of the GMM approach to panel data. The program DPD by Arellano and Bond (1998) has been used in estimation.

[17] The lag structure of the instruments in Q_{it} also helps to control for the time-varying component of the measurement error, which is likely to affect this variable (see Erickson and Whited, 2000; and Bond and Cummins, 2001, for a discussion of the measurement error likely to characterise *Q*).

[18] For this reason, we do not report the estimates obtained using the system-GMM estimator developed in Blundell and Bond (1998). These, however, are available from the authors upon request.

[19] If the model is correctly specified, the variables in the instrument set should be uncorrelated with the idiosyncratic component of the error term, e_{it}. The *J* statistic is the Sargan/Hansen test for overidentifying restrictions. The *m2* statistic tests for the second order autocorrelation of the residuals in the first-differenced equation.

[20] The GMM first-differenced estimator will be used in the estimation of all the specifications to follow.

quantitatively robust to the choice of estimator. But is this positive correlation caused by information asymmetries in capital markets that may lead to financing constraints, or by the relationship between cash flow and investment opportunities not captured by Q?

Introducing contracted capital expenditure and allowing for firm heterogeneity

We now estimate the following more general regression denoting the firm's contracted capital expenditure as *CONK*:

$$I_{it} / K_{i(t-1)} = a_0 + a_1 I_{i(t-1)} / K_{i(t-2)} + a_2\, Q_{i(t-1)} + a_3\, CF_{it} / K_{i(t-1)} + a_4\, CONK_{it} / K_{i(t-1)} + v_i + v_t + e_{it} \qquad (2)$$

Contracted capital expenditure is measured at end of period, and captures expectations of future profits known to insiders, which are obviously not included in beginning of period Q. Adding this variable to our investment specifications alongside Q is likely to ensure that both the insiders' and the outsiders' evaluations of investment opportunities are accounted for in the regression. If the cash flow term remains statistically significant, then this is likely to be due to information asymmetries in capital markets, leading to financing constraints.

Column (1) of Table 3 presents the GMM estimates of our extended investment model for the aggregate sample. We can see that the coefficient on the contracted capital expenditure variable is statistically significant and positive. It appears that the coefficient on the cash flow variable remains statistically significant, but drops from 0.103 in the model without contracted capital expenditure to 0.086 in the extended model. The fact that cash flow remains positively associated with investment, even after properly controlling for the firms' investment opportunities, is consistent with its role in capturing the severity of financing constraints.

If financial factors drive the positive relationship between cash flow and investment, then one would expect this relationship to be stronger for those firms more likely to face financial constraints. We estimate our investment equation interacting all the right hand side variables with the dummies $SMALL_{it}$ and $(1\text{-}SMALL_{it})$. This formulation allows the parameters of the model to differ across observations in the two sub-samples. We initially estimate the model including only lagged investment, Q, and cash flow, all interacted with the dummies $SMALL_{it}$ and $(1\text{-}SMALL_{it})$. Our instrument set includes the interactions of $I_{it} / K_{i(t-1)}$, Q_{it}, $CF_{it} / K_{i(t-1)}$, and $CONK_{it} / K_{i(t-1)}$ with the size dummies, and real sales and employments, all lagged two and three times.

The results are reported in column (2) of Table (3). Cash flow is positively and significantly associated with investment, for both small and large firm-years. Its coefficient is larger for the former, supporting the hypothesis that financial variables positively affect investment as a consequence of capital market imperfections. However, in this particular specification, cash flow could also proxy for investment opportunities. Moreover, the *J* test has a marginal significance of 0.014, indicating some problems related with the specification of the model or the choice of instruments. It is likely that in this case, the problem is of the former type, as this particular specification could be mis-specified because it does not properly take into account investment opportunities.

Our next specification includes contracted capital expenditure interacted with the size dummies as additional regressors to improve the measurement of investment opportunities. The GMM estimates of this extended model are presented in column (3) of Table 3. The coefficient on cash flow for large firm-years is now much smaller than in the previous specification, and less significant. On the other hand, the corresponding coefficient for small firm-years remains precisely determined and similar in magnitude. The coefficient on the contracted capital expenditure variable is statistically significant and equal to 1.05 for large firm-years, whereas it is poorly determined for small firm-years[21]. Contrary to the previous specification, the *J* and *m2* tests do not indicate any problems with the specification of the model or the choice of the instruments.

To formally test whether the inclusion of the contracted capital expenditure variables improves the specification of our investment model, we present a test of the extended investment model (which includes the contracted capital expenditure variables) versus the parsimonious one (without contracted capital expenditure variables)[22]. This test involves the construction of the chi-squared statistic suggested by Newey and West (1987). If a model is incorrectly specified, the *J* test for that model will tend to be relatively large. The difference in the *J* statistics between the model with and without the contracted capital expenditure variables, holding the weighting matrix fixed can be seen as a test of whether the

[21] The fact that the contracted capital expenditure variable is not precisely determined for small firms suggests that for those firms investment opportunities are properly captured by *Q*, whereas this is not the case for large firms. This might seem slightly puzzling, as one would expect the stock market to have less knowledge relative to smaller firms, which are usually younger and growing faster. One reason why *Q* might be a worse proxy for investment opportunities at large firms than at small firms could be because the former firms suffer from more severe agency problems. By constructing a proxy for the expected discounted stream of marginal profits to investment, which they call "Fundamental *Q*" and comparing its performance in investment equations to that of Tobin's *Q*, Gilchrist and Himmelberg (1995) also find evidence that *Q* is a worse proxy for investment for those firms less likely to face financial constraints.

[22] The null hypothesis is that the parsimonious model is acceptable, i.e. that there is no significant improvement in the specification of the model once the contracted capital expenditure variables are added.

improvement of specification which takes place when contracted capital expenditure is added is statistically significant[23]. The difference between the two *J* statistics is distributed as a chi-squared with two degrees of freedom[24]. The Newey-West statistic is in our case 1123.53, which is obviously statistically significant. This shows that there is a clear improvement in the specification of our investment model if contracted capital expenditure is added (also see Ng and Schaller, 1996, who make use of a similar test).

Our results suggest that for large firms, there is some evidence that the positive association between cash flow and investment, in the model that only includes lagged investment, *Q*, and cash flow as explanatory variables is caused by the correlation between cash flow and investment opportunities that are not properly captured by *Q*. The association becomes in fact weaker once the contracted capital expenditure variables are included in the regression. On the other hand, for small firms, the relationship between cash flow and investment is more likely to be caused by information asymmetries in the capital markets. Once the contracted capital expenditure variables are introduced in the model, cash flow remains in fact statistically significant, and its coefficient does not significantly drop. This can be seen as evidence in favour of the controversial hypothesis that financing constraints play a crucial role in explaining the positive link between cash flow and investment.

Robustness checks

A number of researchers who participated to the debate on the role of cash flow in explaining investment estimated specifications which did not include the lagged dependent variable as a regressor (see FHP, 1988; Kaplan and Zingales, 1997 etc.). To better compare our study and theirs, we estimated a GMM investment equation similar to that in column (3) of Table 3, but excluding the variables involving the lagged investment to capital ratio both from the set of regressors and from the instrument set. The results of this new specification are reported in column (1) of Table 4. Similarly to the specification in column (3) of Table 3, the coefficient on cash flow is significant for both small and large firm-years, but larger for the former, and the coefficient on the contracted capital expenditure variable is only significant for large

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[23] The instruments that we chose provide a set of moment restrictions of the following type: $E(Z^j_{it} e_{it})=0$, where Z^j_{it} is the j-th instrument for firm i in year t, and e_{it} is the idiosyncratic error term. The GMM estimator minimises a quadratic form, in the corresponding sample moments, using a weighting matrix given by a consistent estimate of the variance-covariance matrix of the moment restrictions themselves. See Arellano and Bond (1998) for more details.

[24] More in general, the degrees of freedom of the χ^2 statistic are given by the number of omitted parameters in the parsimonious model. Since the two models that we are comparing differ only by the presence of the two variables in contracted capital expenditure, we consider a χ^2 statistic with two degrees of freedom.

firm-years. In spite of these similarities, the *J*-test only has a marginal significance of 0.015, suggesting that the omission of the lagged dependent variable causes mis-specification in the model.

All the specifications that we reported in Tables 2 and 3 contain simple time dummies, defined at the aggregate level, which remove cyclical variation common to the entire manufacturing sector. However, there could be shifts in investment demand or expectations due to changes in industry-level conditions, such as industry demand shocks, or industry-wide technology changes (see Carpenter and Petersen, 2002). As a further robustness check, we report in column (2) of Table 4 the results of a specification of our more general investment model, which contains in addition to the standard time dummies, time dummies interacted with industry dummies, aimed at controlling for those industry-specific shifts in investment demand or expectations[25]. The results are very similar to those in column (3) of Table 3. In particular, the cash flow coefficient is marginally significant for large firm-years, and smaller in magnitude compared to the corresponding coefficient for small firm-years. Moreover, the contracted capital expenditure variable is statistically significant only for large firm-years.

Furthermore, we tested the robustness of our results to different criteria for splitting the sample between firm-years more and less likely to face financial constraints. Our main criterion defines in fact a firm as small in a given year if its total number of employees in that year is less than or equal to 250. We have tried to use other benchmark employment levels to classify firms into small and large, namely 200 and 300. As shown in columns (3) and (4) of Table 3, this has left our main results largely unchanged.

In column (5) of Table 4, we partition firms into more and less likely to face financial constraints using the coverage ratio as a sorting device[26]. A study by Milne (1991), based on interviews with banking practitioners in the UK, has suggested that bankers generally evaluate the ability of companies in the manufacturing sector to service and/or pay back their debts, on the basis of their coverage ratios[27]. As in Guariglia (2000), we consider the financial situation of firms relative to the situation of other firms in the industry in which that firm

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

[26] This variable is defined as the ratio of pre-tax and pre-interest earnings to total long and short-term interest payments.

[27] The coverage ratio has been used in previous studies to partition firms according to whether they are more or less likely to face financial constraints (Whited, 1992; Guariglia and Schiantarelli, 1998; Guariglia, 1999, 2000).

operates. In particular, we define as financially constrained within an industry those firms whose coverage ratios are, for both years t and t-1, in the lower quartiles of the distribution of the ratios of all the firms in that particular industry and year. We find little quantitative changes in the results, suggesting that our main conclusions are robust to different ways of splitting the sample.

Finally, because our main findings are based on a sample that does not eliminate those observations with a ratio of investment to capital greater than 1, which could be considered as outliers (see Cummins et al., 1999), we re-estimated our main investment model using a restricted sample only containing observations such that $I_{it} / K_{i(t-1)} \leq 1$[28]. The results are reported in column (6) of Table 4. They are once again qualitatively similar as those reported in column (3) of Table 3. In this last specification, contrary to the previous ones, the coefficient on contracted capital expenditure for small firm-years is precisely determined, suggesting that Q cannot be considered as a sufficient statistic for the investment opportunities of small firms.

Once the firms' investment opportunities are better accounted for by including the contracted capital expenditure variables in the regression (in addition to Q) the explanatory power of cash flow falls for large firms but remains unchanged for small firms. Overall our results support the view that the investment of small firms is constrained by access to internal finance, while this is not the case for large firms.

5. Conclusion

This paper sheds light on the highly controversial role played by cash flow in investment regressions. The debate is centred around understanding whether cash flow is an important determinant of investment because of its role in alleviating credit frictions or because it proxies for omitted or mis-measured investment opportunities.

We used a panel of 722 UK firms over the period 1982-99 to estimate investment equations as a function of lagged investment, Q, cash flow, and contracted capital expenditure. We argued that because in the presence of asymmetric information, gaps are likely to exist between the information sets of the firm's insiders and outsiders, Q is an imperfect measure of the firm's investment opportunities, as it only captures the equity market participants' (outsiders') evaluation of these opportunities. To improve the measurement of investment opportunities, we included the firm's contractual obligations for

[28] Only 104 observations in our main sample were such that $I_{it} / K_{i(t-1)} > 1$.

future new investment projects as an additional proxy. This variable is important as it captures information about opportunities available only to insiders and thus not measured in *Q*. Introducing it in our investment regressions alongside *Q* indeed improves the degree to which investment opportunities are measured. We found that when *Q* and the firm's contracted capital expenditure variable were both included in our regressions, the explanatory power of cash flow fell for large firms, but remained unchanged for small firms. Our results suggest that the significance of cash flow in investment equations stems from its role in alleviating credit frictions.

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Table 1: Descriptive statistics

	All firm-years	Firm-years such that $SMALL_{it}$=1	Firm-years such that $SMALL_{it}$=0
Number of employees	5100.92 (13808.3)	149.224 (64.58)	6078.97 (14917.7)
$I_{it} / K_{i(t-1)}$	0.170 (0.15)	0.159 (0.19)	0.172 (0.14)
Q_{it}	3.388 (4.35)	4.435 (6.50)	3.181 (3.75)
$CF_{it} / K_{i(t-1)}$	0.285 (0.39)	0.237 (0.56)	0.294 (0.34)
$CONK_{it} / K_{i(t-1)}$	0.030 (0.05)	0.019 (0.05)	0.033 (0.05)
Sales growth$_{it}$	8.894 (33.23)	1.234 (15.08)	7.659 (29.93)
Number of observations	6566	1083	5483
Number of firms	722		

Notes: The table reports sample means. Standard deviations are presented in parenthesis. $SMALL_{it}$ is a dummy variable equal to 1 if firm *i* has 250 employees or more at time t, and equal to 0 otherwise. The subscript *i* indexes firms, and the subscript *t*, time, where *t*=1982-99. *I* represents the firm's investment; *K*, the replacement value of its capital stock; *CF*, its cash flow; and *CONK*, its contracted capital expenditure.

Table 2: The Effects of cash flow on investment: alternative estimators

Dependent Variable: $I_{it} / K_{i(t-1)}$	OLS (pooled)	Within Groups estimator	IV (pooled)	First-diff. GMM
	(1)	(2)	(3)	(4)
$I_{i(t-1)} / K_{i(t-2)}$	0.326	0.164	0.325	0.206
	(0.02)	(0.01)	(0.011)	(0.02)
$Q_{i(t-1)}$	0.005	0.010	0.004	0.012
	(0.001)	(0.0006)	(0.0005)	(0.002)
$CF_{it} / K_{i(t-1)}$	0.102	0.125	0.110	0.103
	(0.011)	(0.005)	(0.009)	(0.025)
Sample size	6566	6566	5844	5844
ρ		0.302		
m2				-1.28
J (*p*-value)				0.213

Notes: Sample period: 1982-99 in columns (1) and (2); and 1983-99 in columns (3) and (4). The figures reported in parenthesis are asymptotic standard errors. Time dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroskedasticity. ρ represents the proportion of the total error variance accounted for by unobserved heterogeneity. *m2* is a test for second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. The *J* statistic is a test of the overidentifying restrictions, distributed as chi-square under the null of instrument validity. Instruments in column (3) are $CF_{it} /K_{i(t-1)}$, $CONK_{it} /K_{i(t-1)}$, real sales, and employment lagged once. Instruments in column (4) are $I_{it} /K_{i(t-1)}$, Q_{it}, $CF_{it} /K_{i(t-1)}$, $CONK_{it} /K_{i(t-1)}$, real sales, and employment lagged two and three times. The time dummies were always included in the instrument set.

Table 3: Introducing contracted capital expenditures and differentiating between small and large firm-years

Dependent Var.: $I_{it} / K_{i(t-1)}$	First-diff. GMM	First-diff. GMM	First-diff. GMM
	(1)	(2)	(3)
$I_{i(t-1)} / K_{i(t-2)}$	0.198		
	(0.02)		
$(I_{i(t-1)} / K_{i(t-2)}) * SMALL_{it}$		0.135	0.141
		(0.04)	(0.04)
$(I_{i(t-1)}\ K_{i(t-2)}) * (1\text{-}SMALL_{it})$		0.220	0.195
		(0.03)	(0.03)
$Q_{i(t-1)}$	0.012		
	(0.002)		
$Q_{i(t-1)} * SMALL_{it}$		0.016	0.017
		(0.003)	(0.003)
$Q_{i(t-1)} * (1\text{-}SMALL_{it})$		0.015	0.014
		(0.003)	(0.003)
$CF_{it} / K_{i(t-1)}$	0.086		
	(0.02)		
$(CF_{it} / K_{i(t-1)}) * SMALL_{it}$		0.115	0.117
		(0.04)	(0.04)
$(CF_{it} / K_{i(t-1)}) * (1\text{-}SMALL_{it})$		0.087	0.059
		(0.03)	(0.03)
$CONK_{it} / K_{i(t-1)}$	0.876		
	(0.22)		
$(CONK_{it} / K_{i(t-1)}) * SMALL_{it}$			0.106
			(0.40)
$(CONK_{it} / K_{i(t-1)}) * (1\text{-}SMALL_{it})$			1.049
			(0.25)
Sample size	5844	5844	5844
m2	1.884	-1.372	1.742
J (*p*-value)	0.221	0.014	0.111

Notes: Sample period 1983-99. $SMALL_{it}$ is a dummy variable equal to 1 if firm *i* has 250 employees or more at time *t,* and equal to 0 otherwise. Instruments in column (1) are $I_{it} / K_{i(t-1)}$, Q_{it}, $CF_{it} / K_{i(t-1)}$, $CONK_{it} / K_{i(t-1)}$, real sales, and employment lagged two and three times. Instruments in columns (2) and (3) are $(I_{it} / K_{i(t-1)}) * SMALL_{it}$, $(I_{it} / K_{i(t-1)}) * (1\text{-}SMALL_{it})$, $Q_{it} * SMALL_{it}$, $Q_{it} * (1\text{-}SMALL_{it})$, $(CF_{it} / K_{i(t-1)}) * SMALL_{it}$, $(CF_{it} / K_{i(t-1)}) * (1\text{-}SMALL_{it})$, $(CONK_{it} / K_{i(t-1)}) * SMALL_{it}$, $(CONK_{it} / K_{i(t-1)}) * (1\text{-}SMALL_{it})$, real sales, and employment, all lagged two and three times. Also see *Notes* to Table 2.

Table 4: Robustness checks

Dependent Var.: $I_{it} / K_{i(t-1)}$	Not including the lagged dependent variable	Including time dummies interacted with industry dummies	$SMALL_{it}=1$ if $emp_{it} \leq 200$	$SMALL_{it}=1$ if $emp_{it} \leq 300$	$SMALL_{it}=1$ if coverage $ratio_{it} \leq$ first quartile of the distribution	Deleting those obs. such that $I_{it} / K_{i(t-1)} > 1$
	(1)	(2)	(3)	(4)	(5)	(6)
$(I_{i(t-1)} / K_{i(t-2)})*SMALL_{it}$	…	0.133	0.176	0.155	0.005	0.119
		(0.04)	(0.04)	(0.03)	(0.04)	(0.05)
$(I_{i(t-1)} / K_{i(t-2)})*(1-SMALL_{it})$	…	0.191	0.192	0.203	0.238	0.190
		(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
$Q_{i(t-1)}*SMALL_{it}$	0.018	0.016	0.017	0.016	0.016	0.012
	(0.003)	(0.003)	(0.004)	(0.004)	(0.007)	(0.002)
$Q_{i(t-1)}*(1-SMALL_{it})$	0.016	0.014	0.014	0.014	0.018	0.008
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.002)
$(CF_{it} / K_{i(t-1)})*SMALL_{it}$	0.102	0.114	0.101	0.107	0.116	0.136
	(0.045)	(0.04)	(0.04)	(0.04)	(0.05)	(0.02)
$(CF_{it} / K_{i(t-1)})*(1-SMALL_{it})$	0.072	0.058	0.054	0.056	0.057	0.088
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)	(0.02)
$(CONK_{it} / K_{i(t-1)})*SMALL_{it}$	0.155	0.149	0.221	0.124	0.509	0.830
	(0.48)	(0.40)	(0.29)	(0.39)	(0.48)	(0.35)
$(CONK_{it} / K_{i(t-1)})*(1-SMALL_{it})$	1.060	0.988	1.102	1.066	0.886	1.045
	(0.27)	(0.24)	(0.26)	(0.25)	(0.23)	(0.20)
Sample size	5844	5844	5844	5844	3986	5740
m2	-0.776	1.439	2.190	1.744	1.366	2.303
J (*p*-value)	0.015	0.094	0.054	0.02	0.106	0.059

Notes: Sample period: 1983-99 in columns (1) to (4), and (6); 1983-97 in column (5). "Emp." is an abbreviation standing for "number of employees". $SMALL_{it}$ is a dummy variable equal to 1 if firm *i* has 250 employees or more at time *t*, and equal to 0 otherwise. All specifications were estimated using a first-difference GMM estimator. Instruments in column (1) are $Q_{it}*SMALL_{it}$, $Q_{it}*(1-SMALL_{it})$, $(CF_{it} / K_{i(t-1)})*SMALL_{it}$, $(CF_{it} / K_{i(t-1)})*(1-SMALL_{it})$, $(CONK_{it} / K_{i(t-1)})*SMALL_{it}$, $(CONK_{it} / K_{i(t-1)})*(1-SMALL_{it})$, real sales, and employment, all lagged two and three times. Instruments in the remaining columns are $(I_{it} / K_{i(t-1)})*SMALL_{it}$, $(I_{it} / K_{i(t-1)})*(1-SMALL_{it})$, $Q_{it}*SMALL_{it}$, $Q_{it}*(1-SMALL_{it})$, $(CF_{it} / K_{i(t-1)})*SMALL_{it}$, $(CF_{it} / K_{i(t-1)})*(1-SMALL_{it})$, $(CONK_{it} / K_{i(t-1)})*SMALL_{it}$, $(CONK_{it} / K_{i(t-1)})*(1-SMALL_{it})$, real sales, and employment, all lagged two and three times. Also see *Notes* to Table 2.