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The Effect of Cash Flow on Investment: An Empirical Test of the Balance Sheet Theory*

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Abstract

Using a large data set on investments and accounting information for private firms, we put the balance sheet theory to test. We find that firm cash flow has a positive impact on investment and that the effect is enhanced for firms which are more likely to be financially constrained. We also find that the investment-cash flow sensitivity is significantly larger and more persistent during the first half of our sample period, which includes a severe banking crisis and recession. Our results suggest that financial constraints matter more in periods characterized by adverse economic conditions.

Keywords: Financial frictions; Balance sheet channel; Financial accelerator; Investment; Cash flow.

JEL: C33; E22; E44.

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1 Introduction

As a result of the global financial crisis, the impact of financial shocks on real variables is clearly a key issue for economists and policymakers. According to the neoclassical theory of investment, firm investment is only determined by economic fundamentals, and not by financial variables such as cash flow. But in the presence of financial frictions due to imperfect information between borrowers and lenders, financial variables can have an effect on investment.

The purpose of this paper is to test the balance sheet theory by exploring the effect of cash flow on investment. To this end, we make use of an exhaustive Swedish data set containing detailed firm-level information for the period 1989-2005. Our data set distinguishes our empirical analysis from earlier work in two ways. Firstly, existing empirical work testing the balance sheet theory mainly studies large publicly traded firms (see, e.g., Fazzari, Hubbard, and Petersen (1988), and Gilchrist and Himmelberg (1995, 1999)). In contrast, our data set mainly contains information on smaller firms where balance sheet effects are likely to be more important. Secondly, our sample covers a severe banking crisis and recession period.[1] This long sample period allows us to investigate the effect of cash flow on investment in periods characterized by adverse economic conditions, which is when financing constraints are expected to be more binding. Thus, this paper contributes to the existing literature by testing the balance sheet theory on an exhaustive sample of small firms and by evaluating the effects during a severe crisis period.

We find that a positive cash flow shock has a positive effect on investment, even using the entire sample of firms. In accordance with the balance sheet theory, we also find that invest-

[1] The crisis of the early 1990's is the most severe financial and economic crisis that Sweden has witnessed in modern times. GDP fell for three consecutive years accompanied by a severe contraction of bank credit (see Table A1). In contrast, the global financial crisis of 2008 lead to a sharp fall in exports but a quick recovery.

ments of constrained firms are consistently more sensitive to cash flow than the investments of unconstrained firms. These results confirm previous findings in the literature, but using a data set that includes many small private firms. Our results further show that the effect is significantly larger during the recession period. More specifically, the effect of cash flow on investment for constrained firms is three to five times larger during the recession period as compared with the non-recession period, which is when financial constraints are likely to be binding. Thus, our results indicate that financial frictions matter more during periods characterized by adverse economic conditions.

We interpret our results as suggesting that firms with higher agency costs are likely to face reduced access to external financing in an economic downturn which, in turn, forces them to rely on internally generated funds to finance their investments. These results align with previous empirical work showing that bank loan supply decreases during periods characterized by tight monetary and economic conditions (Jiménez, Ongena, Peydró, and Saurina (2012)) and that firms that suffer from financial frictions are likely to be more affected during such adverse periods (Gertler and Gilchrist (1994), and Bernanke, Gertler, and Gilchrist (1996)).

Our empirical results are of general interest, not least because of the global financial crises, when the impact of financial frictions on investment became one of the most important macroeconomic issues. According to the balance sheet theory, monetary policy causes changes in firm investment not only directly by affecting the level of interest rates, but also indirectly through its impact on firms' balance sheets. For example, Bernanke, Gertler, and Gilchrist (1999) have developed a dynamic macroeconomic "financial accelerator" model, where financial frictions amplify the economy's response to monetary and other shocks. In the presence of financial frictions, it is more difficult and costly for firms to finance investments with external funds than with internal funds. In particular, the external finance premium depends on the strength of a firm's balance sheet, which hence affects firm investment.

The standard empirical method which is used to investigate the importance of financial frictions for investment is to estimate the effect of cash flow (a proxy for net worth or balance sheet strength) on investment, controlling for fundamental determinants of investment. Schiantarelli (1995) and Hubbard (1998) provide excellent surveys of the empirical literature.[2] Most papers find a positive impact of cash flow on investment, which indicates that financial frictions influence investment decisions and that a balance sheet channel exists in the monetary transmission mechanism. A well-known potential problem with the standard method is that cash flow may not only be correlated with liquidity, but also with investment opportunities, which would cause estimates to be biased. In the early literature, a common solution to this problem was to include Tobin's Q in the regression to control for investment opportunities.

However, even in the absence of financial frictions, measured Tobin's Q may not be a sufficient control variable for investment opportunities, for example due to excess stock market volatility. A common approach in the more recent literature is to estimate separate regressions for groups of firms which, a priori, are more or less likely to be credit constrained, for example small vs. large firms. The purpose is to investigate if cash flow has a larger impact on investment for the more constrained firms (as predicted by the balance sheet theory), which is also the typical empirical finding. An underlying assumption is that measurement problems related to Tobin's Q are equally important for all firms. However, the method may give misleading results if Tobin's Q is relatively less informative about investment opportunities (and cash flow more informative) for small, young firms than for large, established firms. A larger coefficient

[2] For examples of more recent work, see Chatelain et al. (2003), Carpenter and Guariglia (2008) and Martinez-Carrascal and Ferrando (2008).

on cash flow for small firms than for large firms may be a result of such variation across firms in the explanatory power of Tobin's Q, rather than in the importance of liquidity constraints.

This paper uses a method developed by Gilchrist and Himmelberg (1995, 1999), which is specifically designed to deal with potential differences across firms in the information content of cash flow. Investment opportunities are summarized by a sales-based measure of the marginal product of capital (MPK). Cash flow is divided into two parts: one fundamental part which may contain information about investment opportunities, and one financial part which is orthogonal to investment opportunities. Gilchrist and Himmelberg (henceforth GH) estimate a vector autoregression (VAR) model with investment, MPK and cash flow, and investigate the impulse response of investment to a cash flow shock. By construction, the cash flow shock does not affect current MPK. To control for any predictive value of cash flow for future MPK, the impulse response of MPK is also studied. Separate VAR models are estimated for constrained and unconstrained firms. Thus, the method controls for any differences in the informational content of cash flow across the two groups of firms. If the financial part of cash flow (which does not contain any information about investment opportunities) still affects investment, then the availability of internal funds matters for firm investment, as predicted by the balance sheet theory.

The rest of this paper is organized as follows. Section 2 provides a theoretical background and discusses different empirical methods, in particular the Gilchrist-Himmelberg method. Section 3 describes the data set and Section 4 presents the empirical analysis. Section 5 concludes the paper. An additional discussion of data issues and robustness checks is presented in the online appendix.

2 Testing for financial frictions: theoretical background and empirical methods

Before discussing empirical tests for financial frictions, it is useful to briefly outline a benchmark model without any financial frictions. In the neoclassical investment model, investment is only determined by real factors. The model can be used as a basis for the empirical specifications.

2.1 Benchmark neoclassical investment model

In the standard neoclassical model, a firm maximizes the expected discounted value of future dividend payments:[3]

$$V_{i,t} = E_t \left[\sum_{s=0}^{\infty} \beta_{t+s} d_{i,t+s} \right] \tag{1}$$

where $V_{i,t}$ is the expected present discounted value of future dividends of firm i in period t, $d_{i,t+s}$ denotes the dividend payment in period $t+s$, β_{t+s} is the discount factor used for payments occurring in period $t+s$ and E_t is the standard expectations operator.

The dividend payout function is:

$$d_{i,t}\left(K_{i,t}, I_{i,t}\right) = p_t \left[F\left(K_{i,t}\right) - G\left(I_{i,t}, K_{i,t}\right)\right] - p_t^k I_{i,t} \tag{2}$$

where $K_{i,t}$ is the real capital stock, $I_{i,t}$ is real gross investment, p_t is the price of output, p_t^k is the price of capital goods, $F\left(K_{i,t}\right)$ is the production function, and $G\left(I_{i,t}, K_{i,t}\right)$ is an adjustment cost function. Both functions $F\left(K_{i,t}\right)$ and $G\left(I_{i,t}, K_{i,t}\right)$ are assumed to exhibit constant returns to scale and there is perfect competition. The adjustment costs are quadratic and subject to

[3] This presentation follows Cummins, Hassett, and Oliner (2006). The model was originally developed by Hayashi (1982).

technology shocks $\varepsilon_{i,t}$:

$$G(I_{i,t}, K_{i,t}) = \frac{b}{2}\left(\frac{I_{i,t}}{K_{i,t}} - a - \varepsilon_{i,t}\right)^2 K_{i,t}. \tag{3}$$

Given these standard assumptions, investment is described by the following regression equation:

$$\left(\frac{I}{K}\right)_{i,t} = a + \frac{1}{b}\left[\frac{V_{i,t}}{p_t^k (1-\delta) K_{i,t-1}} - 1\right]\frac{p_t^k}{p_t} + \varepsilon_{i,t} = a + \frac{1}{b}Q_{i,t} + \varepsilon_{i,t} \tag{4}$$

where Q denotes average q, which is the total value of the firm relative to the replacement cost of its capital. Naturally, investment decisions are not based on the average value of capital, but rather on the marginal value of capital. Marginal q is defined as the shadow value of capital (the expected marginal contribution of an additional unit of capital to future profits). However, marginal q is unobservable, and hence empirical studies need to use some measure of average q, usually based on the stock market value of the firm. Fortunately, under the above assumptions, marginal and average q are equal.

Under the "null hypothesis" of perfect capital markets (no financial frictions), equation (4) perfectly describes a firm's investment behavior. In this special case, there is no theoretical reason for including any additional explanatory variables. Most empirical research uses equation (4) as a point of departure and tests the neoclassical theory by investigating whether financial factors do, in fact, add explanatory value in empirical investment equations.

2.2 Empirical tests of financial frictions

There are several different ways of introducing financial frictions in theoretical models.[4] A general result in the theoretical literature is that asymmetric information in one form or another—adverse selection, moral hazard or costly state verification—gives rise to an external finance

[4] However, the purpose of this paper is to empirically test for financial frictions rather than theoretical modeling. See Gertler (1988) for a broad survey with a focus on theoretical models, and Bernanke, Gertler, and Gilchrist (1999) for a representative model.

premium. External finance is more expensive than internal finance, and the premium is larger when the borrowing firm's balance sheet is in poor condition and the required loan is large. Thus, in the presence of financial frictions, a firm's access to internal funds affects its investment decisions.

A standard approach in the empirical literature is to augment equation (4) with cash flow (a measure of changes in the firm's liquidity position):

$$\left(\frac{I}{K}\right)_{i,t} = a + \frac{1}{b}Q_{i,t} + \gamma\left(\frac{CF}{K}\right)_{i,t} + \varepsilon_{i,t}. \tag{5}$$

Under the null hypothesis of perfect capital markets, the estimated coefficient on cash flow, γ, should be insignificantly different from zero. In contrast, under the alternative hypothesis of financial frictions, the estimated γ should be positive and significant. Schiantarelli (1995) and Hubbard (1998) provide excellent surveys of the empirical literature.

A potential problem when estimating equation (5) is that there may be measurement error in stock-market based measures of Q, so that measured Q is an imperfect control for fundamentals. Such measurement error could, for example, be due to excess stock-market volatility, as discussed by Blanchard, Rhee, and Summers (1993) and Shiller (2000). Intuitively, if non-fundamental factors such as bubbles may influence equity prices, stock-market based control variables for fundamental investment opportunities are imperfect. Moreover, cash flow is likely to not only be correlated with a firm's liquidity position, but also with its investment opportunities. Thus, the estimated coefficient on cash flow may turn out to be positive and significant even if, in fact, firms are not financially constrained and there are no deviations from the benchmark model in subsection 2.1.

In an attempt to solve this problem, Fazzari, Hubbard, and Petersen (1988) and many subsequent papers investigate the effect of cash flow on investment for different categories of firms. If the importance of financial frictions varies across firms, the impact of cash flow on investment should also vary. Firms are divided into groups which, a priori, are more or less likely to be financially constrained. Specifically, Fazzari et al. divide firms into different groups based on firm dividend policy. A high dividend signals that a firm is not credit constrained—if it were, dividends would be cut. Therefore, the investment of high-dividend firms should not be sensitive to cash flow. Conversely, a low dividend signals that a firm is credit constrained, which causes cash flow to be a determinant of investment. In the presence of financial frictions, the sensitivity of investment to cash flow should be larger for credit-constrained (low-dividend) firms, which is also a common finding in the empirical literature. Other variables which have been used to divide firms into groups according to the importance of financial frictions are firm size, the existence (or not) of a bond rating and membership in a company group. The prediction of the balance sheet theory is that cash flow has a larger effect on investment for firms which are small and/or do not have a bond rating, since they are less monitored by external analysts. Moreover, firms which are independent of company groups do not have access to a group's internal capital market to alleviate financing constraints, which makes their investment more sensitive to cash flow.

However, there is a potential problem with the sample-split method when applied to equation (5). As pointed out by Poterba (1988), the method assumes that the amount of measurement error in Q is the same for small, young companies as for larger, established companies (and that cash flow is equally informative about investment opportunities for both groups of firms). However, it is likely that measurement error is more severe for small, young firms (and that cash flow is more informative about investment opportunities), whose valuation is subject to more uncertainty and is more dependent on current profitability. If so, a finding that cash flow has an especially large effect on investment for small companies is only to be expected and does not constitute any evidence in favor of a balance sheet channel.[5]

An alternative empirical method which has been used in the literature is to estimate the firm's first-order condition for the capital stock (the Euler equation), derived under the null hypothesis of perfect capital markets. Some early papers using this approach are Whited (1992) and Bond and Meghir (1994). A rejection of the Euler equation model (using a test of overidentifying restrictions) is interpreted as evidence in favor of financial frictions. However, there are some drawbacks with this approach. First, as shown by, for example, Oliner, Rudebusch, and Sichel (1996), the estimates suffer from parameter instability, thus making the results sensitive to model specification. Moreover, as shown in the consumption literature by Zeldes (1989), the method may fail to detect financial frictions which are approximately constant over time.[6] Against this background, Gilchrist and Himmelberg developed yet another empirical method which is described in the following subsection.

2.3 The Gilchrist-Himmelberg empirical method

The papers by Gilchrist and Himmelberg (1995, 1999) study large, publicly traded U.S. manufacturing firms from the Compustat database for the periods 1979-1989 and 1980-1993, respectively. Another paper by Love and Zicchino (2006) uses the same methodology to investigate how cross-country differences in the level of financial development affect investment-cash flow

[5] Some other criticisms of the investment-cash flow sensitivity literature are that: (i) it is not necessarily true that investment-cash flow sensitivities measure the degree of financing constraints (see Kaplan and Zingales, 1997 and 2000, and Gomes (2001)), and (ii) the positive coefficient on cash flow disappears when the earnings forecasts of equity analysts are used to construct Q (see Cummins, Hassett, and Oliner (2006)).

[6] See Gilchrist and Himmelberg (1995) and Schiantarelli (1995) for further discussion and additional references.

sensitivities. They use firm-level panel data on large publicly traded firms in 36 countries from the Worldscope database for the period 1988-1998. The main finding is that the importance of financial frictions for investment behavior is larger in countries with low financial development. The same methods are also used by Gilchrist, Himmelberg, and Huberman (2005) who study the effect of stock price bubbles on corporate investment.

The GH method divides cash flow into two parts: one part which may contain information about investment opportunities (as summarized by the marginal product of capital, MPK), and another part which is orthogonal to investment opportunities. The idea is to first estimate a VAR model with investment, MPK and cash flow, and then investigate the impulse response of investment to a cash flow shock. By construction, the cash flow shock is orthogonal to *current* MPK. To control for any predictive value of cash flow for *future* MPK, the impulse response of MPK is also studied.

Separate VAR systems are estimated for firms which are likely to be constrained vs. unconstrained. Thus, the method controls for any differences in the informational content of cash flow across the two groups of firms. If the part of cash flow which does not contain any information about investment opportunities still affects investment, the availability of internal funds matters for investment, which constitutes evidence in favor of the balance sheet channel. A larger effect for constrained than unconstrained firms would provide additional supportive evidence.[7]

The GH method is particularly useful for data sets (such as the one used in this paper) with many smaller, non-quoted firms, since it does not require a stock-market based measure of Q to control for fundamentals in the investment regressions. Instead, GH (1999) use a sales-based

[7] GH also develop a second, more structural method to control for possible information in cash flow about investment opportunities (current and future MPK). Following Love and Zicchino (2006), we do not use this alternative method, which has been criticized for not properly identifying the effect of cash flow on investment (see, for example, footnote 11 in Cummins, Hassett, and Oliner (2006)).

measure of MPK to control for fundamentals. Assuming a Cobb-Douglas production function and profit-maximizing behavior, the following expression can be derived for MPK:

$$MPK = \theta \frac{S}{K} \tag{6}$$

where θ is a parameter and S denotes sales. The parameter θ, which can differ across industries, is related to the capital share of output and the (firm-level) price elasticity of demand. Hence, up to a scale parameter, the sales-to-capital ratio measures MPK.[8]

GH also assume that, on average, firms are at their equilibrium capital stocks, which implies that the marginal benefit of an additional unit of capital is equal to the marginal cost of capital:

$$MPK = r + \delta \tag{7}$$

where r is the risk-adjusted discount rate and δ is the depreciation rate of capital.

To compute MPK from equation (6), the parameter θ must first be estimated for each industry. Substituting equation (6) into equation (7), and taking the average over all firms $i \in I(j)$ and years $t \in T(i)$ in industry j, and solving for θ gives the estimator:

$$\widehat{\theta}_j = \left(\frac{1}{N_j} \sum_{i \in I(j)} \sum_{t \in T(i)} \left(\frac{S}{K} \right)_{i,t} \right)^{-1} (r + \delta_j) \tag{8}$$

where N_j is the number of observations for industry j. Finally, we can use the estimated $\widehat{\theta}_j$ from equation (8) in equation (6), which gives an estimated MPK for each firm and year:

$$\widehat{MPK}_{i,t} = \widehat{\theta}_j \left(\frac{S_{i,t}}{K_{i,t}} \right). \tag{9}$$

[8]Another possible measure of MPK, which is used by GH in their earlier paper, is based on operating income rather than sales. As discussed in GH (1999), the operating-income based measure requires the possibly unrealistic assumptions of zero fixed costs and perfect competition, which makes the measure less reliable.

While GH assume that the depreciation rates δ are the same for all industries, we allow for industry-specific depreciation rates. The industry-specific depreciation rates are calculated as a weighted average of depreciation rates for buildings (which is assumed to be constant across industries) and industry-specific depreciation rates for machines which are reported in Table A2 in the appendix. While depreciation rates for machines can differ across industries, most of the increased precision gained from the industry-specific depreciation rates is likely to come from the different composition of machines and buildings in total capital across industries.

Despite its advantages over using Tobins' Q, the G-H methodology also has some weaknesses. First, marginal productivity of capital does not necessarily equal the marginal cost of capital for financially constrained firms that face reduced access to external capital markets. If the marginal productivity is higher than the cost of capital, the estimate of θ_j will have a downward bias. However, this would only have an effect on the estimated level of MPK and not on the shock responses. Second, the above methodology assumes that θ_j is constant across firms and time in a given industry. In reality, we observe variation of the sales-to-capital ratio across time and across firms in a given industry. Since we do not consider the uncertainty in $\widehat{\theta}_j$ in our subsequent VAR-model, we may underestimate the standard errors of the model coefficients.

The empirical model is a reduced-form panel data VAR. It is reasonable to assume that investment shocks may affect MPK and cash flow contemporaneously, and that shocks to MPK can affect cash flow in the same period. In contrast, given the time lags involved in investment decisions, it seems reasonable that there is no contemporaneous effect of MPK shocks or of cash flow shocks on investment. Crucially, for our ability to identify the balance sheet channel we assume that there is no impact from a cash-flow shock on current MPK.

Following the Cholesky ordering implied above—investment, MPK, and cash flow—the considered firm- and time-fixed effects VAR-model is on the form:

$$y_{i,t} = Ay_{i,t-1} + f_i + e_t + v_{i,t} \tag{10}$$

where $y_{i,t}$ is a (3×1) vector including investment, MPK, and cash flow; A is a (3×3) coefficient matrix; f_i is a (3×1) vector of firm-fixed effects; and e_t is a (3×1) vector of time-fixed effects. The (3×1) vector $v_{i,t}$ contains reduced-form errors, which are combinations of the underlying structural shocks, as determined by the Cholesky ordering. The reduced-form errors $v_{i,t}$ are assumed to be orthogonal to lags of $y_{i,t}$.

To control for aggregate shocks, time effects are removed by using deviations from year-specific means (an alternative method would be to use year dummies). Furthermore, firm effects are removed by using deviations from forward means (Helmert transformation or forward orthogonal deviations). Arellano and Bover (1995) developed this method to improve the efficiency of estimators for models with predetermined (but not strictly exogenous) variables, for example lagged dependent variables. The methodology is standard in the panel VAR literature, and it is described in more detail in Appendix 8.1 in GH (1999).

3 The data set

The firm-level data set used in this paper is the result of merging two separate data sets, which were provided by Sveriges Riksbank. The first data set is from Upplysningscentralen AB (UC), a major Swedish credit bureau, and contains balance-sheet and income statement data for the period 1989-2005. The second data set is from Statistics Sweden (SCB) and contains investment data for the period 1985-2005. Statistics Sweden provided identification numbers to make it possible to identify the same firm in both data sets. However, the accounting years in the UC data did not always coincide with the calendar years in the Statistics Sweden investment data, so the time periods were not the same for a given firm and "year". This issue needed to be dealt with before merging the two data sets. Details on this procedure and other data issues are available in the appendix.

Between 1985 and 1996, the data set does not cover all smaller firms. Firms with less than 20 employees are generally omitted and many non-manufacturing firms with less than 50 employees are missing. In contrast, from 1996 and onwards all Swedish firms are included in the dataset. In total, around 200,000 firms are observed each year from 1996 and onwards corresponding to 2.4 million firm-year observations (before sample restrictions and data cleaning).

Our benchmark sample is an unbalanced panel of firms in the manufacturing sector with at least 20 employees and observed in the period 1989-2005. We do not require firms to have existed during the entire sample period, which makes the panel unbalanced. This is in order to get a representative sample which includes firms which may have been started during the sample period and firms in financial distress which may have disappeared during the sample period. In order for the data to be comparable across time we restrict our sample to firms with at least 20 employees.

There are three reasons for restricting the benchmark sample to the manufacturing sector. First, it facilitates the comparison of results with GH (1999) and most other papers in the literature, which only study manufacturing firms. Second, the calculation of the capital stock at replacement cost is more reliable.[9] Finally, data availability is better for the manufacturing sector than for other industries.

Regarding the benchmark definition of capital and investment, both machines and buildings

[9] See, for example, footnote 11 in Chatelain et al. (2003).

are included. There are two reasons for not only including machines but also buildings. First, it facilitates the comparison of results with GH (1999) and most other papers in the literature, which use the broader definition of capital and investment. Second, only information on total investment is available for the entire sample period.[10]. After the data cleaning procedures described in the appendix, a total of 35,396 firm-year observations remain in the benchmark sample.

It is well known that the book value of capital is an imperfect measure of the replacement value of a firm's capital stock. To get a better measure, we estimate the capital stock using the perpetual inventory method:

$$K_{i,t} = (1 - \delta_{i,t})\, K_{i,t-1} \frac{p_t^k}{p_{t-1}^k} + I_{i,t} \tag{11}$$

where $K_{i,t}$ is the nominal capital stock of firm i at the end of period t, $\delta_{i,t}$ is the depreciation rate, p^k is the price of capital and $I_{i,t}$ is the nominal investment during period t. The recursive formula requires an initial value for capital, and we use the initial book value of capital. In the empirical analysis, all variables enter as ratios (e.g. I/K). Since both producer prices and investment goods prices of Swedish manufacturing firms remained relatively constant between 1989 and 2005, the use of nominal variables will not affect the results.

The variables which are needed for the empirical analysis are I/K, MPK and CF/K. I denotes nominal investment, and the definition of nominal K is clear from the perpetual inventory formula above (equation (11)). The estimated MPK has also been defined (see equation (9)). The definition of nominal cash flow CF is similar to that used by GH (1999) who define cash flow as the sum of net income before extraordinary items and depreciation

[10] For 1996, Statistics Sweden had data-collection problems and the separate variables for investments in machines and buildings are missing.

(Compustat data items 18 and 14, respectively). We define cash flow as profits after financial income and expense (a measure of net income from which taxes have not been deducted), minus taxes, plus depreciation. Table 1 presents summary statistics for the variables I/K, MPK and CF/K used in the empirical analysis. A Harris-Tzavelis unit root test of a balanced panel rejects the null hypothesis of a unit root at a 5 percent significance level.

Before proceeding to the empirical estimation, it is necessary to use observable firm characteristics to classify all firms as either "constrained" or "unconstrained". In their original paper, Fazzari, Hubbard, and Petersen (1988) used firms' dividend policy to make this classification, and several other criteria have been used in the subsequent literature. The GH papers use dividend payout, firm size and the presence (or not) of a bond rating. Our data set includes information on dividend payout, firm size and membership in a company group. Since there is no perfect measure of financial constraints we use all three indicators separately to produce three alternative sample splits between constrained and unconstrained firms.

For the first indicator, dividend payout, we calculate the fraction of time during a firm's existence when the firm pays out a positive dividend. Around 28 percent of the firm-years are associated with dividend payments (see table 1). We consider the 90^{th} percentile, corresponding to firms paying dividends at least 75 per cent of the time, a reasonable cutoff point and classify firms with a dividend-payment fraction below the 90^{th} percentile as constrained (DIV=0), and firms with a dividend-payment fraction above the 90^{th} percentile as unconstrained (DIV=1).

The second sample-split indicator is firm size, which we measure by the average number of employees. Table 1 shows that although 75 percent of the firms have fewer than 110 employees, the average number of employees is 160 due to the presence of a small number of very large firms. The 90^{th} percentile corresponds to firms with less than 277 employees. This is in line with the cutoff of 250 employees which is the European Union definition of small and medium sized enterprises. We therefore classify firms with less than 277 employees as constrained (SIZE=0) and firms with more than 277 employees as unconstrained (SIZE=1).

The third indicator is membership in a company group. For each firm, we calculate the fraction of time that the firm belongs to a company group. Then, we use the 90^{th} percentile of the group-membership fraction value as the cut-off point: firms with a lower value are classified as constrained (GROUP=0) and firms with a higher value are classified as unconstrained (GROUP=1).

It can be noted that GH use the 66^{th} percentile as a cut-off for firm size and dividend payout. For the size measure, this corresponds to firms with yearly real sales of 364 million dollars. Since our sample covers much smaller firms, the average yearly sales of large firms is 17 million dollars, whereas the small firms have average sales of less than a million dollars. This indicates that a comparison of the exact percentiles used as cut-off points can be misleading. Nevertheless, we find that using a 75^{th} percentile cutoff does not significantly change our results. In contrast, using the 66^{th} percentile gives similar results for the dividend-based sample split, but diminishes the differences between samples for the other sample splits, which are more related to firm size. Using the 66^{th} percentile would, for our sample, classify firms with 80 employees as unconstrained which seems unreasonable.

[Insert Table 1 about here.]

4 Empirical analysis

In the empirical analysis, we first estimate the VAR model, and then investigate the impulse responses of investment and MPK to cash flow shocks. To identify shocks to current cash flow which are orthogonal to current MPK, we have assumed the Cholesky ordering I/K, MPK and CF/K. We first estimate the model for a benchmark sample of all firms. We then investigate how the results differ across different types of firms as well as across recession and non-recession periods. The results of this analysis is summarized in table A3 in the appendix. In the appendix we also scrutinize the robustness of our results with respect to diffent sample selection, Cholesky ordering and definition of capital etc.

4.1 Impulse responses for the benchmark sample

The benchmark sample consists of manufacturing firms with at least 20 employees during the period 1989-2005. The impulse responses for the benchmark sample are presented in Figure 1. The top right-hand graph in Figure 1 shows how investment responds to a one-standard-deviation cash flow shock. The effect is positive, statistically significant and substantial in economic terms. The peak effect on I/K is 0.02, which can be compared to an average I/K ratio of 0.21 for all firms in Table 1. Thus, the peak impact corresponds to around 10 percent of the average investment-capital ratio. The cumulative effect over six years is almost 0.04, corresponding to around 20 percent of the average investment to capital ratio. The peak effect is reached after one year and half of the cumulative effect is reached within two years (see Table A3).

[Insert Figure 1 about here.]

In contrast, the response of MPK to a cash flow shock is weak and insignificant. If the positive response of investment to cash flow had been due to a positive effect of cash flow on future fundamentals (i.e. future MPK), we would have found a positive response of MPK. Hence, there is no evidence that the positive effect of cash flow on investment is a spurious result of any predictive value of cash flow for future fundamentals.

Most of the remaining impulse responses in Figure 1 are less central for the purposes of this paper, but there are some interesting exceptions.[11] For example, the top graph in the middle column shows that investment increases following a positive MPK shock, as would be expected. It is also interesting to note that a positive MPK shock causes an increase in cash flow. Hence, it is important to control for MPK when studying the effect of cash flow on investment. To sum up, the key result for the benchmark sample is that cash flow affects investment, which constitutes preliminary evidence in favor of the balance sheet channel. The next subsection studies different categories of firms and different time periods separately.

4.2 Impulse responses for sub-samples of constrained vs. unconstrained firms, and recession vs. non-recession periods

As discussed in Section 3, we classify firms as financially unconstrained or constrained in three different ways. For each classification, we estimate separate panel VAR models for the unconstrained and constrained sub-samples. This is followed by separate estimation for the early,

[11] Looking at the impulse responses, the confidence bands are collapsing around the point estimates for the response of I/K and MPK to an I/K shock. There are two reasons for this. The first reason is that the standard error of the estimate of the effect of an I/K shock in time t on I/K and MPK in time $t+1$ is very low. The second reason is that the coefficients for the effect of an I/K shock in time t on MPK and CF/K in time t are very small. This means that there is little feedback from MPK and CF/K in period t to I/K in period $t+1$ and thus very little uncertainty around that estimate. These effects combined lead to the very low uncertainty around the estimate of the effect of an I/K shock on I/K and MPK.

recession part of the sample period, and for the late, non-recession part. Finally, we estimate models for the constrained and unconstrained firms in the recession and non-recession periods.

Figure 2 presents impulse responses to cash flow shocks for the sub-samples of high-dividend (unconstrained) firms and low-dividend (constrained) firms. For the high-dividend firms there is hardly any investment response following a cash flow shock. MPK actually falls, but the effect is barely significant. In contrast, for the low-dividend firms there is a significant and long-lasting effect of cash flow on investment. The cumulative effect is 0.04 and thus in line with the benchmark sample (see Table A3). The impact of cash flow on MPK is close to zero and not significant. Thus, as predicted by the balance sheet theory, investment by constrained firms is more sensitive to changes in cash flow than investment by unconstrained firms.

[Insert Figure 2 about here.]

The corresponding impulse response functions for large (unconstrained) and small (constrained) firms are presented in Figure 3. MPK increases in response to a positive cash flow shock, but not significantly. For both categories of firms, investment responds positively to a cash flow shock, but the effect is somewhat more persistent for small constrained firms. However, the difference between constrained and unconstrained firms is not as clear as for the dividend policy classification.

[Insert Figure 3 about here.]

The third division between unconstrained and constrained firms is based on group membership, and the results are similar to the large-small firm division discussed above. Figure 4 shows the impulse responses for group (unconstrained) firms and for non-group (constrained) firms.

The impact of cash flow on investment is somewhat larger for constrained firms, and there are no significant increases in MPK. As in the previous cases, half the effect is obtained within two years.

[Insert Figure 4 about here.]

We also estimate separate panel VARs for the early, recession period, during which a larger fraction of firms is likely to be constrained, and for the late, non-recession period. The impulse responses are shown in Figure 5. The effect of cash flow on investment is more than four times as large during the recession compared to the non-recession (see Table A3). Moreover, there is hardly any response of MPK to cash flow shocks during either of the two sub-periods.

[Insert Figure 5 about here.]

The difference between the recession and non-recession periods does not depend on the specific definition of the recession period. For example, estimation using the start date 1990 rather than 1989 gives nearly identical results. However, if the recession is defined more narrowly, the results are even more striking; the estimated investment-cash flow sensitivity is around twice as large for the main recession years 1990-1994 as for the entire period 1989-1996.

To further explore the role of financial frictions during economic downturns, we divide the recession and non-recession periods with respect to the three constraint indicators.[12] Firstly, the top panels in Figure 6 show impulse responses to cash flow shocks for the sub-samples of high-dividend (unconstrained) firms and low-dividend (constrained) firms. For the non-recession

[12] The double sample split gives rise to few observations on the unconstrained firms in the two sub-periods. We therefore obtain a high estimation uncertainty and wide confidence bands for the group of unconstrained firms. None of the impulse responses are distinct from zero at a 99-percent confidence level for the unconstrained (high-dividend, large, and group) firms, whereas the impulse responses for the constrained (low-dividend, small, and non-group) firms are separate from zero at a 99-percent confidence level during the recession period but not significant (99-percent level) during the non-recession period.

period there is a positive investment response for both the high- and low-dividend firms, but it is only significant in the first year. For the recession period there is no response for high-dividend firms but a large and persistent response for low-dividend firms.[13] The cumulative effect for the low-dividend firms amounts to an 0.07 which corresponds to a 33 percent increase in the average investment-to capital ratio for this category of firms (see Table A3). Secondly, the middle panels in Figure 6 show impulse response functions for large (unconstrained) and small (constrained) firms. The graphs show that small firms exhibit a positive and persistent effect of cash flow on investment during the recession period of 0.10, whereas there is no effect for large firms in neither of the sub-periods. Finally, the bottom panels in Figure 6 report results based on group membership. The impact of cash flow on investment is not significant for group (unconstrained) firms and small and significant for non-group (constrained) firms during the non-recession period. On the other hand, during the recession period we observe a positive and significant response for both group and non-group firms. Thus, these results suggest that the positive cash flow sensitivity of investment for constrained firms is substantially more pronounced during the recession period whereas the cash flow sensitivity of investment for unconstrained firms generally is insignificant in both the recession and non-recession periods.

[Insert Figure 6 about here.]

Taken together, using several different sample splits, the investment of constrained firms is consistently more sensitive to cash flow than the investment of unconstrained firms. We

[13] By splitting the firms based on time and dividend payments we obtain relatively few observations for the sample of high-dividend firms during the recession period (1,055 observations). Although we truncate our sample with respect to the 1^{st} and 99^{th} percentile, the estimates for the small sample are influenced by a few large positive values for the cash flow to capital (CF/K) variable which lead to a high estimation uncertainty and very wide confidence intervals. To deal with this, for the sample of high-dividend firms in the recession period, we have chosen to eliminate observations for CF/K that exceed 200 percent (3 observations) to obtain more reasonable estimates and associated standard errors.

also find that the investment-cash flow sensitivity is significantly larger during the 1989-1996 period, which includes a severe recession. By splitting the recession and non-recession period with respect to the three constraint indicators we show that investment-cash flow sensitivity for the constrained firms is substantially larger during the recession period when access to external financing is likely to be more restricted.

The online appendix reports results from the estimation of our baseline model on samples that include small and non-manufacturing firms. It shows that results are generally qualitatively robust to the choice of lag length, Cholesky ordering, definition of capital/investment and the inclusion of smaller and/or non-manufacturing firms. However, when using a balanced panel of firms, the estimated response of investment to cash flow is weak.

5 Conclusions

This paper uses reduced-form VAR methods on firm-level panel data for the period 1989-2005 to test the balance sheet theory. The main empirical results are that: (i) cash flow has a significant effect on investment, (ii) the effect is especially important for financially constrained firms, and (iii) the investment-cash flow sensitivity is significantly larger for constrained firms during recession periods. The results confirm previous findings for a wide cross-section of firms as well as across a longer time-period. Cash flow shocks do not have any predictive value for future MPK, neither for constrained nor for unconstrained firms. Hence, the difference in investment-cash flow sensitivity across firms is not due to any difference in the information content of cash flow for investment opportunities. Moreover, a positive MPK shock causes both investment and cash flow to increase, which shows the importance of controlling for MPK

when investigating investment-cash flow sensitivities. The results are generally robust to different procedures for the classification of firms as constrained or unconstrained, as well as different specification choices, variable definitions and samples. Thus, our results favor the balance sheet theory, where the status of balance sheets affects the economy's response to monetary and other shocks. Our results further suggest that financially constrained matter more during crisis periods.

The results in this paper provide micro-level support for the introduction of financial frictions in macro-level empirical models, which are needed to study the quantitative importance of financial frictions for monetary transmission. In a recent paper, Christiano, Trabandt, and Walentin (2011) add financial frictions to a general-equilibrium macro model of the Swedish economy. They find that the presence of financial frictions causes monetary policy to have an increased effect on investment.

A possible extension of the analysis in this paper would be to study differences across firms in the dynamics of employment and inventories in response to cash flow shocks. As discussed by, for example, Gilchrist and Himmelberg (1999), firms do not only use external financing for investment, but also to finance labor inputs and inventories, which should cause cash flow to matter for the cyclical dynamics of these other variables as well.

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Table 1

Summary statistics

Panel A.				Percentiles		
Variable	Sample	Mean	Std dev	25^{th}	Median	75^{th}
CF/K	Benchmark	0.40	0.94	0.10	0.25	0.49
I/K	Benchmark	0.21	0.43	0.04	0.11	0.23
MPK	Benchmark	0.05	0.08	0.02	0.03	0.06
Dividend-payment fraction	Benchmark	0.28	0.29	0.00	0.19	0.50
Average number of employees	Benchmark	160.29	578.61	30.33	52.93	110.50
Group membership fraction	Benchmark	0.32	0.38	0.00	0.08	0.67
CF/K	DIV=1	0.54	0.95	0.20	0.33	0.57
	DIV=0	0.38	0.93	0.09	0.24	0.48
I/K	DIV=1	0.22	0.42	0.05	0.12	0.24
	DIV=0	0.20	0.43	0.04	0.10	0.22
MPK	DIV=1	0.04	0.07	0.02	0.03	0.04
	DIV=0	0.05	0.08	0.02	0.03	0.06
CF/K	SIZE=1	0.37	0.72	0.12	0.28	0.52
	SIZE=0	0.40	0.96	0.10	0.25	0.49
I/K	SIZE=1	0.17	0.27	0.06	0.12	0.20
	SIZE=0	0.21	0.44	0.04	0.10	0.23
MPK	SIZE=1	0.04	0.06	0.02	0.03	0.05
	SIZE=0	0.05	0.08	0.02	0.03	0.06
CF/K	GROUP=1	0.47	1.08	0.13	0.30	0.59
	GROUP=0	0.39	0.92	0.10	0.25	0.48
I/K	GROUP=1	0.20	0.42	0.05	0.11	0.21
	GROUP=0	0.21	0.43	0.04	0.11	0.23
MPK	GROUP=1	0.05	0.09	0.02	0.03	0.05
	GROUP=0	0.05	0.08	0.02	0.03	0.06

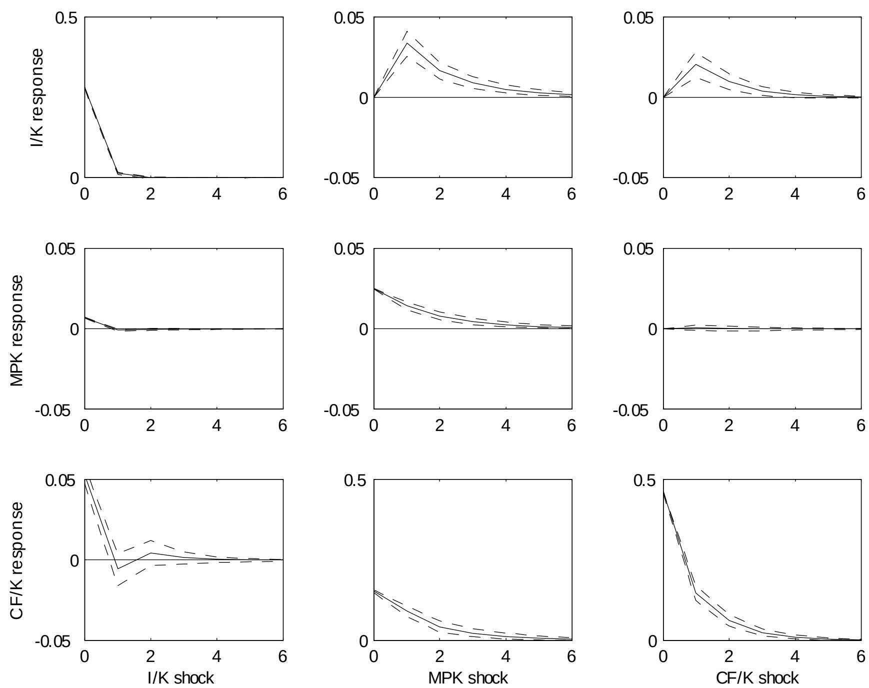
Table 1—Continued

Panel B.	Firm-year observations	Median # of employees/firm	Firm-year observations Recession (1989-1996)	Non-recession (1997-2005)
All firms	35,396	53	12,954	22,442
DIV=1	4,077	40	1,055	3,022
DIV=0	31,319	55	11,899	19,420
SIZE=1	3,555	560	1,516	2,039
SIZE=0	31,841	46	11,438	20,403
GROUP=1	3,765	107	1,485	2,280
GROUP=0	31,631	49	11,469	20,162

Note: Panel A presents summary statistics for the ratio of cash flow to capital (CF/K), the ratio of investment to capital (I/K), and a sales-based measure of the marginal productivity of capital (MPK). More details on variable definitions are given in Section 3. The variable DIV, SIZE, and GROUP take the value 1 for unconstrained firms and the value 0 for constrained firms. Panel B presents the number of firm-year observations for the three constraint classifications and for the recession and non-recession periods.

Figure 1

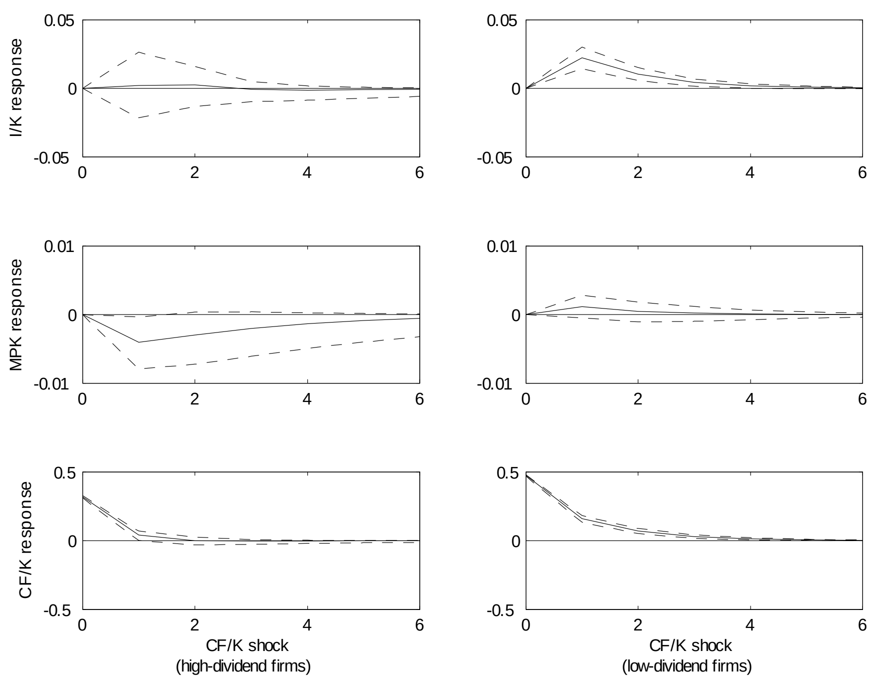
Benchmark results



Note: this figure shows impulse responses for the benchmark sample. Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

Figure 2

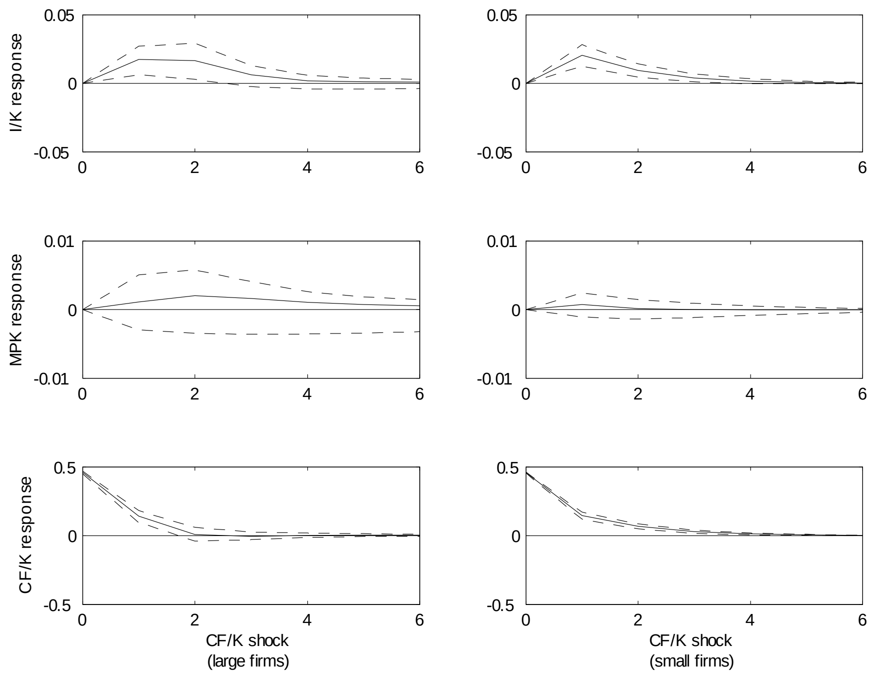
High-dividend and low-dividend firms



Note: this figure shows impulse responses for the high-dividend firms (left column) and low-dividend firms (right column). Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

Figure 3

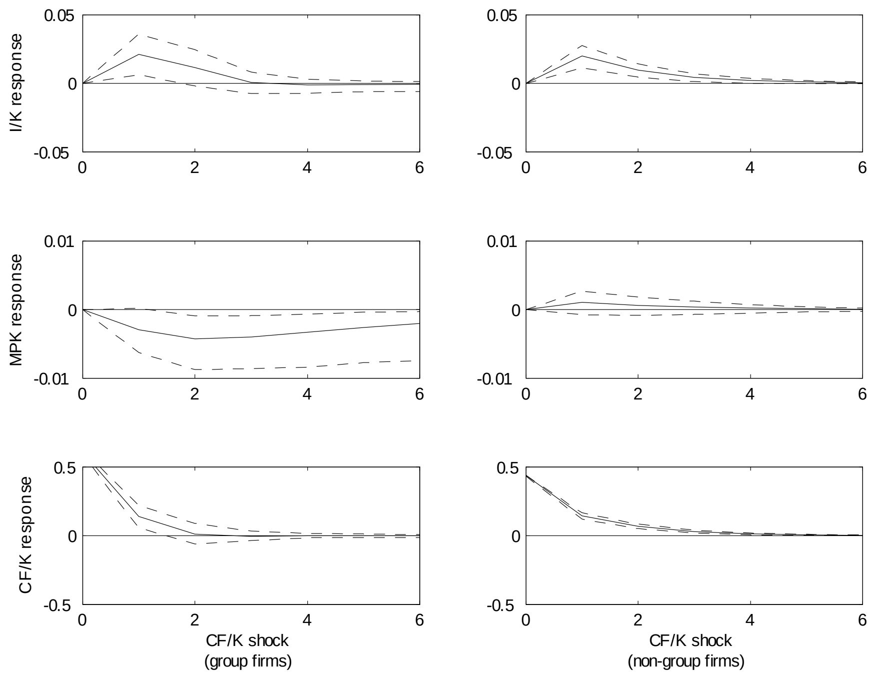
Large and small firms



Note: this figure shows impulse responses for large firms (left column) and small firms (right column). Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

Figure 4

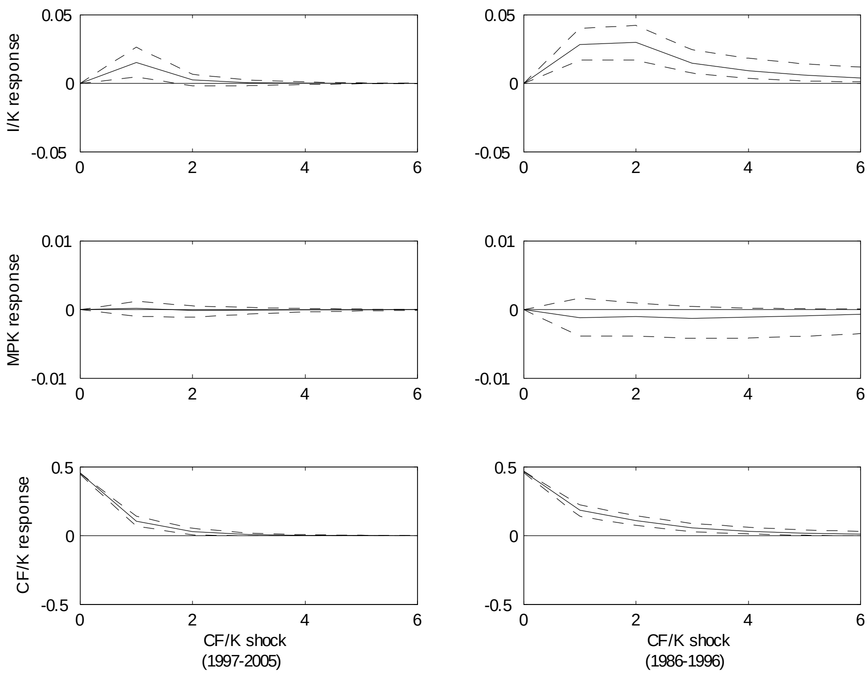
Group and non-group firms



Note: this figure shows impulse responses for group firms (left column) and non-group firms (right column). Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

Figure 5

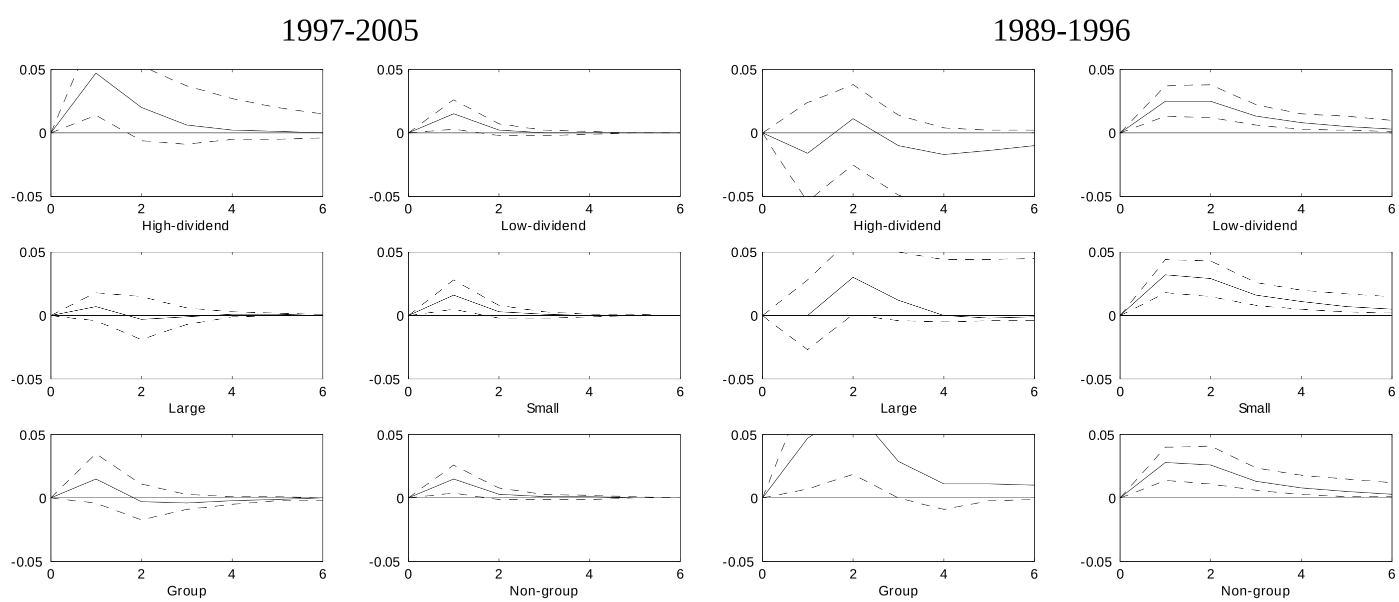
Non-recession and recession period



Note: this figure shows impulse responses for the late, non-recession period (left column) and the early, recession period (right column). Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

Figure 6

Constrained and unconstrained firms during the non-recession and recession periods



Note: this figure shows impulse responses of investment (I/K) to cash flow shock: the top panels report impulse responses for high-dividend firms and low-dividend firms during the non-recession (1997-2005) and recession (1989-1996) period; the middle panels reports impulse responses for large and small firms during the non-recession and recession period; and the bottom panels report impulse responses for group and non-group firms during the non-recession and recession period. Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

6 Online Appendix

6.1 Further data description

As discussed in section 3, in order to merge the two data sets we needed to match accounting years with calendar years. The calendar year variable in the data from Statistics Sweden (SCB) was constructed from the underlying accounting periods according to the following specific rules (which we also use to create a corresponding calendar year variable in the UC data):

For the period 1985-1995, if the accounting-period end date is May 1 or later during year x, the observation is assigned to year x. If the accounting-period end date is April 30 or earlier during year x, the observation is assigned to year x-1.

For the period 1996-2002, firms with more than 50 employees were treated according to the above rule. For firms with 50 or fewer employees, if the accounting-period end date occurs during year x (regardless of month), the observation is assigned to year x.

For the period 2003-2005, firms with more than 500 employees were treated according to the rule for 1985-1995. For firms with 500 or fewer employees, if the accounting-period end date occurs during year x (regardless of month), the observation is assigned to year x.[14]

This procedure for creating a calendar year variable in the UC data may cause duplicates when a company has two reports during the same year, for example due to a change of reporting period. To deal with duplicate observations, we follow the rule used by Statistics Sweden, which is to keep the one observation per firm and year with the latest reporting period end date. Very few observations are lost in this procedure.

[14] To be precise, Statistics Sweden only uses this rule for the manufacturing sector. The definition of a "large" company is somewhat different for the non-manufacturing sector. Since the benchmark sample only includes firms from the manufacturing sector, this is not a major problem.

Following Gilchrist and Himmelberg, we remove the time effects by using deviations from year-specific means and the firm effects by using deviations from forward means. It should be noted that there is a minor problem with the use of deviations from year-specific means because of differences between calendar and accounting years. For example, the calendar year 1997 does not correspond to the same accounting year for all firms, but we use deviation from calendar-year means.

In the Statistics Sweden data, all variables are scaled in order to correspond to 12-month values even for firms with an accounting period of more or less than 12 months. We scale all variables in the UC data in the same way.

From the initial sample, we remove all observations for which there is not sufficient data to calculate the variables needed or which have unreasonable values for some variables, for example a negative capital stock. Following GH (1999), we first calculate the ratios needed for the analysis (see Table 3 in their paper), and then we remove outliers (observations with ratios below the 1st or above the 99^{th} percentile). We also remove firms with fewer than four observations, and we require that all observations for a firm are consecutive.

In our benchmark sample, we only include manufacturing firms with at least 20 employees. One reason is data availability. During the period 1985-1995 the Statistics Sweden data does not cover all smaller firms, and we want our sample to be comparable over time given our interest in comparing the recession period and the non-recession period. For the non-manufacturing sector, data availability is even more limited. During the period 1985-1995 the Statistics Sweden data includes all non-manufacturing firms with at least 50 employees, but not all firms with 20-49 employees. In the pre-96 period, only a small random sample of non-manufacturing firms with fewer than 50 employees is observed each year.

In sum, our baseline sample is constructed as follows. The original sample consists of 2,398K observations. After omitting (i) banks, insurance companies, and utilities (-165K), (ii) observations with missing values and observations with a negative capital stock (-627K), (iii) outliers (-79K), (iv) firms that do not have consecutive observations (-431K), and (v) firms with less than 4 observations (-136K) we obtain a sample consisting of 951K observations. Our benchmark sample is then obtained by further omitting firms with less than 20 employees (-874K) and non-manufacturing firms (-42K), resulting in a sample containing 35K observations.

In Table A1 we report descriptive statistics for the various samples used in the analysis. By comparing our benchmark sample with the sample including non-manufacturing and small firms we see that the firms in the benchmark sample on average have lower CF/K, I/K, and MPK. The firms in the benchmark sample are also on average less constrained, as given by the dividend-payment fraction, number of employees, and the group membership fraction. If we compare large with small firms we see that large firms on average have lower I/K. Larger firms are also on average less constrained with respect to dividend-payment fraction and group membership fraction. Finally, comparing manufacturing with non-manufacturing firms, we see that manufacturing firms on average have lower CF/K, I/K, and MPK. For the constraint variables we see that manufacturing firms on average have a slightly higher dividend-payment fraction, are substantially larger and are more likely to belong to a corporate group. When we compare the period of recession and banking crisis with the non-recession period we see that firms in the latter sample are on average smaller and less likely to belong to a group. This is due to the more comprehensive sampling of small firms in the non-recession period starting in 1996. The average dividend payout ratio is lower in the recession which is consistent with the hypothesis that firms are more financially constrained in this period. However, the average of

CF/K, I/K, and MPK do not differ much across the recession and non-recession period.

[Insert Table A1 about here.]

Equation (11) in the text describes the perpetual inventory method used to calculate the capital stock. We calculate industry-specific depreciation rates for total capital (machines and buildings) by taking an average of industry-specific depreciation rates for machines and buildings, respectively, weighted by the relative shares of machines and buildings in the industry's capital. To define an industry, we use two-digit SNI codes (SNI69 for the period 1985-1989 and SNI92 for the period 1990-2005).

The industry-specific depreciation rates for machines and buildings are taken from a publication by the U.S. Bureau of Economic Analysis (2003).[15] For buildings, we use the depreciation rate 0.0314 for all sectors. This number is taken from "Private nonresidential structures, industrial buildings" on page 31, but there are only minor differences compared to other sectors. The depreciation rates for machines are taken from the same source, and are presented in Table A2 below.

[Insert Table A2 about here.]

The price of capital in the perpetual inventory formula is calculated from gross fixed capital formation in current and fixed prices, respectively (from national accounts data available on the web page of Statistics Sweden).The the risk-adjusted discount rate is assumed to be 0.06 in line with Gilchrist-Himmelberg (1995), footnote 16.

[15] The reason for using US depreciation rates is that Statistics Sweden uses depreciation rates from the US Bureau of Economic Analysis to calculate industry-specific depreciation rates for the Swedish National accounts. These industry-specific depreciation rates may differ somewhat from the US rates due to the application of different weights for the capital goods. However, there are no official data on depreciation rates used in the Swedish National accounts.

6.2 Robustness tests

Section 4 in the main text presents evidence that investment of financially constrained firms is consistently more sensitive to cash-flow than investment of unconstrained firms. Moreover, financially constrained firms are much more sensitive to cash-flow shocks in the recession period when acess to external finance is likely to be more limited. This online appendix presents results of some additional robustness tests.

We test the residuals from our benchmark VAR-model for autocorrelation. Regressing the residuals on a constant terms and applying Wooldrige's test for serial correlation (implemented in Stata by the command xtserial) does not indicate the presence of serial correlation in the residuals.

The choice of lag length in the panel VAR could potentially matter for the results. As shown in Figure A2, estimation with 1 lag (rather than 2 lags) produces similar results.

It is well known that different Cholesky orderings can give different results. The results reported above are based on the identification assumptions of Gilchrist and Himmelberg (1999), but the alternative ordering used by Love and Zicchino (2006)–MPK, cash flow and investment–gives similar results overall (see Figure A3). However, for the sample splits based on size and group membership, there is a large and immediate response of investment for the unconstrained firms. On the other hand, the difference between recession and non-recession periods is even more striking than for the GH ordering.

[Insert Figure A2 about here.]

[Insert Figure A3 about here.]

Another choice which may affect the results is the definition of capital and investment, where both machines and buildings are included. As can be seen in Figure A4, similar results are obtained by only including machines (which is only possible for the period 1996-2005 because of data availability constraints).

[Insert Figure A4 about here.]

The benchmark sample only includes manufacturing firms with at least 20 employees. When we include even smaller manufacturing firms (which is only possible for the period 1996-2005 because of data availability constraints), the differences between constrained and unconstrained firms are somewhat less clear (see Figure A5). However, cash flow shocks have positive effects on investment in all cases. When also including all non-manufacturing firms, there are substantial investment responses for the unconstrained firms as well (see Figure A6).[16]

[Insert Figure A5 about here.]

[Insert Figure A6 about here.]

Finally, an exception to the general robustness of the results occurs for a balanced panel of firms. A possible explanation could be that the small sample of firms for which all necessary data are available in each year consists of established firms, which are less affected by financial constraints.The response of investment to cash flow is weak and insignificant (see Figure A7). A complementary explanation is that data availability constraints necessarily limits the sample period to 1997-2005, when the investment-cash flow sensitivity is weaker than in the earlier recession period, as shown in Figure 6.

[Insert Figure A7 about here.]

[16] There are many firms with fewer than 20 employees, all of which are likely to be more financially constrained than larger firms. In order to avoid misclassifying small, constrained firms as unconstrained, we use the 97^{th} percentile as the cutoff between constrained and unconstrained.

Table A1

Summary statistics for different samples

Sample	CF/K		I/K		MPK		Dividend-payment fraction		Average number of employees		Group membership fraction	
1. Benchmark (manufacturing firms with 20 or more employees)												
Mean	0.40	*	0.21		0.05	*	0.28	*	160	*	0.32	*
Median	0.25	*	0.11		0.03	*	0.19	*	53	*	0.08	*
Std dev	0.94		0.43		0.08		0.29		597		0.38	
# of obs							35,396					
2. All firms (manufacturing and non-manufacturing firms)												
Mean	0.62		0.31		0.08		0.24		14		0.08	
Median	0.26		0.07		0.04		0.11		2		0.00	
Std dev	1.96		0.78		0.13		0.31		150		0.23	
# of obs							950,609					
3. Large firms (20 or more employees)												
Mean	0.62		0.26	*	0.08	*	0.30	*	136	*	0.30	*
Median	0.30	*	0.13	*	0.04	*	0.19	*	43	*	0.00	*
Std dev	1.60		0.56		0.14		0.32		512		0.38	
# of obs							76,856					
4. Small firms (fewer than 20 employees)												
Mean	0.62		0.31		0.08		0.24		4		0.06	
Median	0.25		0.07		0.04		0.11		2		0.00	
Std dev	1.99		0.80		0.13		0.31		9		0.20	
# of obs							873,753					

Table A1—Continued

Sample	CF/K		I/K		MPK		Dividend-payment fraction		Average number of employees		Group membership fraction	
5. Benchmark sample recession period (1989-1996)												
Mean	0.42		0.21		0.05	*	0.24	*	177.56	*	0.34	*
Median	0.26		0.11	*	0.03	*	0.13	*	62.94	*	0.13	*
Std dev	0.89		0.39		0.07		0.27		597.56		0.39	
# of obs							12,954					
6. Benchmark sample non-recession period (1997-2005)												
Mean	0.39		0.20		0.05		0.30		150.32		0.30	
Median	0.25		0.10		0.03		0.20		46.88		0.06	
Std dev	0.96		0.44		0.09		0.31		567.16		0.38	
# of obs							22,442					
7. All manufacturing firms												
Mean	0.46	*	0.27	*	0.07	*	0.26	*	41	*	0.12	*
Median	0.24	*	0.08	*	0.03	*	0.13	*	5	*	0.00	*
Std dev	1.41		0.68		0.12		0.31		285		0.27	
# of obs							153,875					
8. All non-manufacturing firms												
Mean	0.65		0.31		0.08		0.24		9		0.07	
Median	0.26		0.07		0.04		0.11		2		0.00	
Std dev	2.05		0.80		0.14		0.31		105		0.22	
# of obs							796,734					

Note: the table presents summary statistics for different samples. 'CF/K' is the ratio of cash flow to capital. 'I/K' is the ratio of investment to capital. 'MPK' is a sales-based measure of the marginal productivity of capital. 'Dividend-payment fraction' is the fraction of time during a firm's existence that it pays out dividend. 'Average number of employees' is the average number of employees for each firm during the sample period. 'Group membership fraction' is the fraction of time during a firm's existence it belongs to a corporate group. More details on variable definitions are given in Section 3. The star (*) reported next to the mean and median values denote that these values are statistically different at the 1 percent level. The benchmark sample is compared with all firms, the sample of large firms with small firms, the recession period with the non-recession period and the sample of manufacturing firms with non-manufacturing firms. Differences in means are assessed using a Student's t-test and differences in medians are assessed using the Wilcoxon-Mann-Whitney test.

Table A2

Industry-specific depreciation rates for machines

Depreciation rates for two-digit SNI69 code industries for 1985-1989		Depreciation rates for two-digit SNI92 code industries for 1990-2005			
Industry	Depr. Rate	Industry	Depr. Rate	Industry	Depr. Rate
11	0.12	1	0.12	32	0.12
12	0.12	2	0.12	33	0.12
13	0.12	5	0.12	34	0.12
21	0.15	10	0.15	35	0.12
22	0.15	11	0.15	36	0.11
23	0.15	12	0.15	37	0.11
29	0.15	13	0.15	40	0.05
31	0.11	14	0.15	41	0.05
32	0.11	15	0.11	45	0.16
33	0.11	16	0.11	50	0.17
34	0.11	17	0.11	51	0.17
35	0.11	18	0.11	52	0.17
36	0.11	19	0.11	55	0.15
37	0.11	20	0.11	60	0.12
38	0.11	21	0.11	61	0.12
39	0.11	22	0.11	62	0.12
41	0.05	23	0.11	63	0.12
42	0.05	24	0.11	64	0.11
50	0.16	25	0.11	70	0.11
61	0.17	26	0.12	71	0.12
62	0.17	27	0.12	72	0.31
63	0.15	28	0.12	73	0.14
71	0.12	29	0.12	74	0.15
72	0.11	30	0.12		
93	0.11	31	0.12		

Note: the table presents the assumed industry-specific depreciation rates for machines in Sweden at the two-digit SNI code level. For each Swedish industry, the closest possible U.S. industry-specific depreciation rate from the U.S. Bureau of Economic Analysis (2003) is used.

Table A3

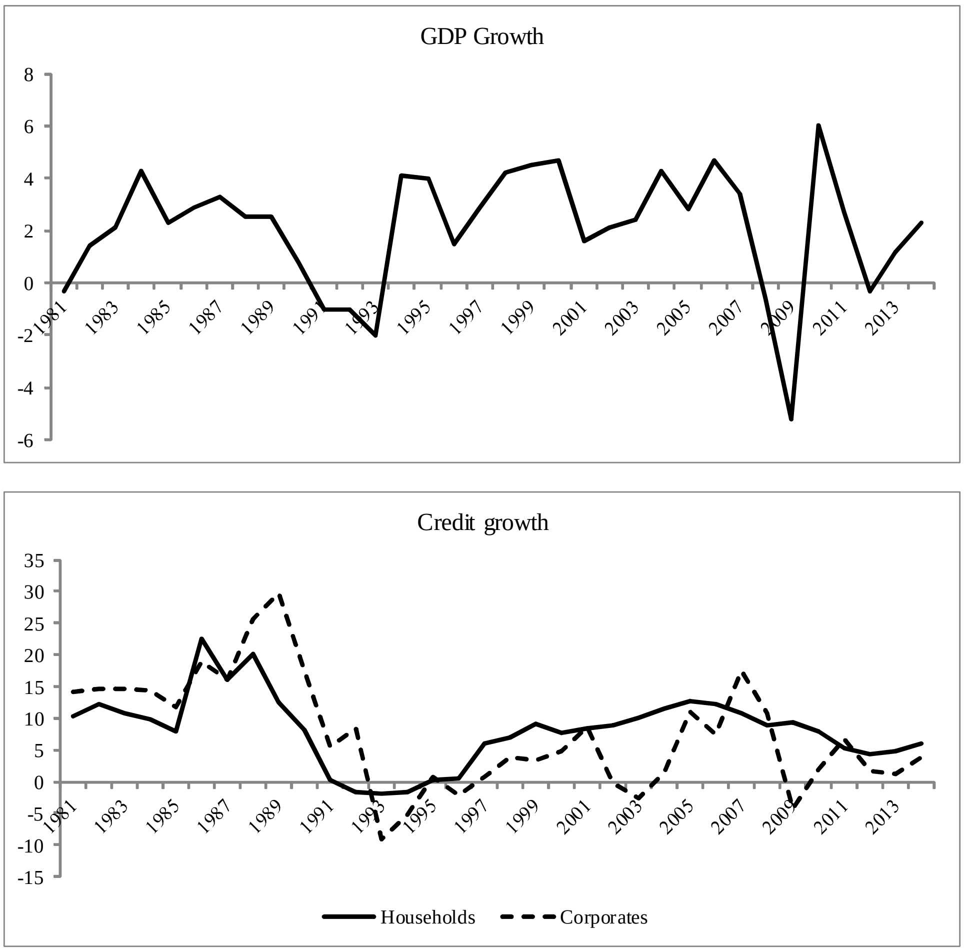
Measures of effects

Sample	Figure	Total effect of cash flow on I/K	MPK	CF/K	Persistance I/K	MPK	CF/K
Benchmark	1	0.04	0.00	0.44	2	2	1
High dividend	2	0.00	-0.01	0.15	1	2	1
Low dividend	2	0.04	0.00	0.48	2	2	1
Large firms	3	0.05	0.01	0.35	2	3	1
Small firms	3	0.04	0.00	0.45	2	1	1
Group firms	4	0.03	-0.02	0.40	2	3	1
Non-group firms	4	0.04	0.00	0.45	2	2	1
Non-recession	5	0.02	-0.00	0.33	2	5	1
Recession	5	0.09	-0.01	0.61	2	4	1
Non-recession, High dividend	6	0.08	-0.00	0.21	2	1	1
Non-recession, Low dividend	6	0.02	0.00	0.35	1	1	1
Non-recession, Large	6	0.01	0.00	0.19	1	2	1
Non-recession, Small	6	0.02	0.00	0.35	2	3	1
Non-recession, Group	6	0.01	-0.01	0.38	1	3	1
Non-recession, Non-group	6	0.02	0.00	0.33	2	2	1
Recession, High dividend	6	0.00	-0.09	-0.06	3	4	6
Recession, Low dividend	6	0.07	0.01	0.68	2	3	2
Recession, Large	6	0.04	0.00	0.57	3	5	1
Recession, Small	6	0.10	-0.01	0.64	2	4	1
Recession, Group	6	0.18	-0.03	0.57	3	3	1
Recession, Non-group	6	0.09	0.00	0.60	2	4	2

Note: The total effect is measured as the area under the impulse-response function to a cash flow shock. The persistance of the effect is measured as the number of years required to achieve half of the total effect.

Figure A1

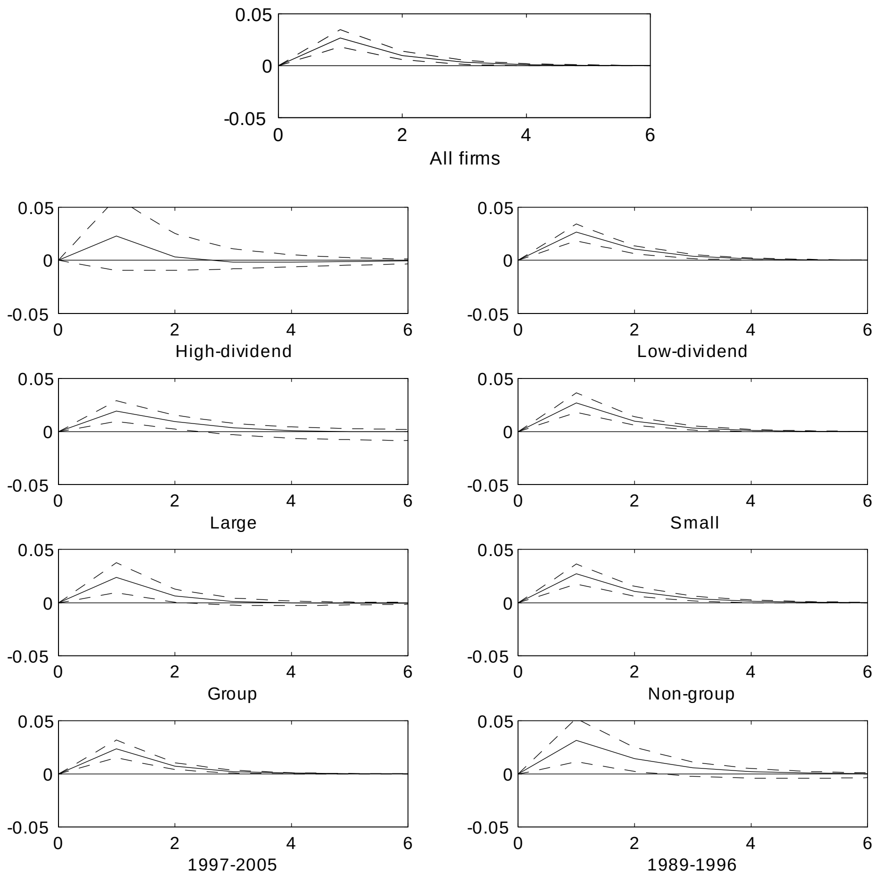
Swedish GDP and credit growth



Note: this figure shows yearly real GDP growth (upper panel) and yearly nominal credit growth (lower panel) for the period 1981 to 2014. The source of the data is Statistics Sweden.

Figure A2

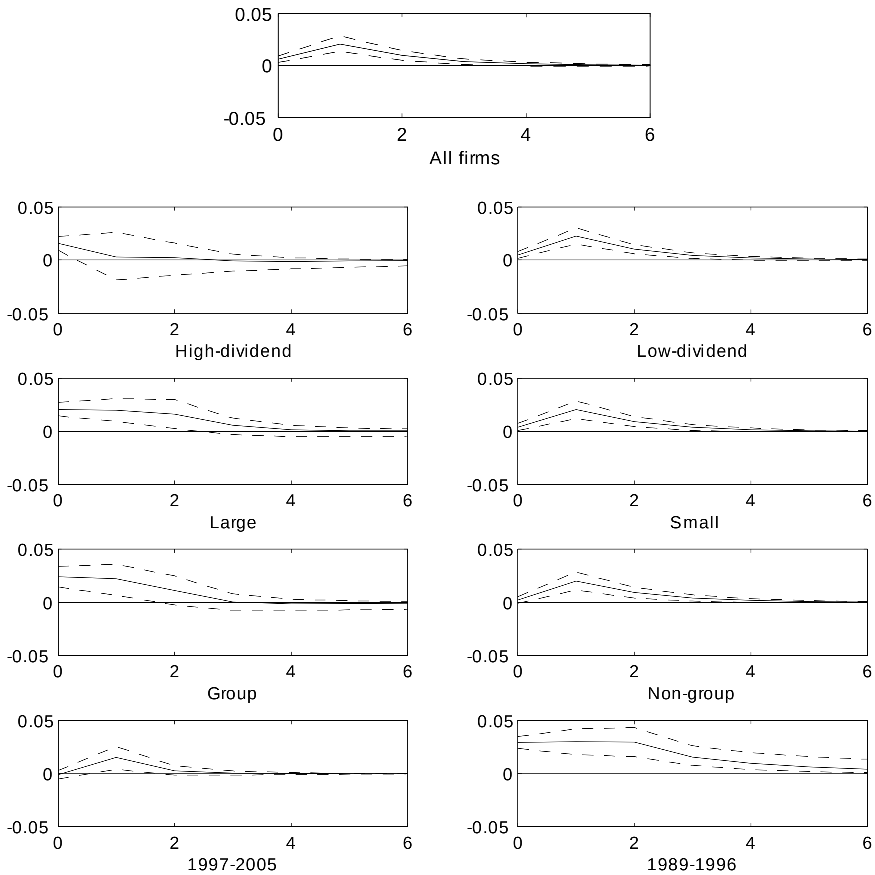
Different lag structure



Note: this figure shows impulse responses of investment (I/K) to cash flow shock with 1-lag VAR for the period 1989-2005. Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

Figure A3

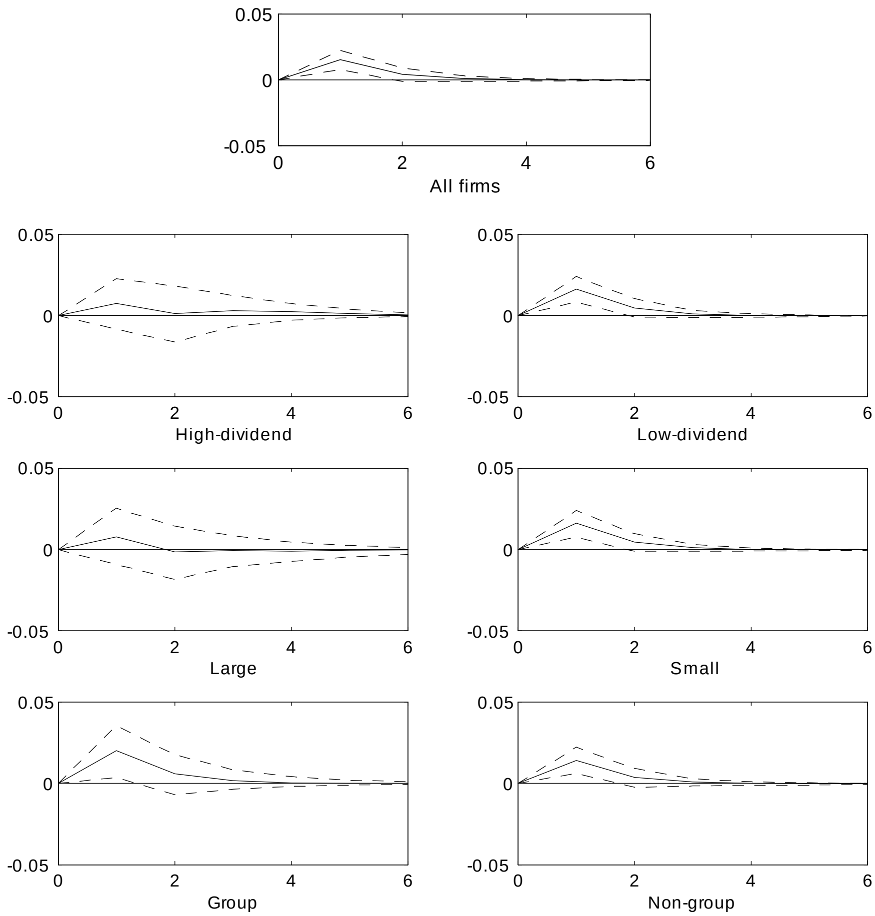
Love-Zicchino Cholesky ordering



Note: this figure shows impulse responses of investment (I/K) to cash flow shock with Love-Zicchino Cholesky ordering for the period 1989-2005. Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

Figure A4

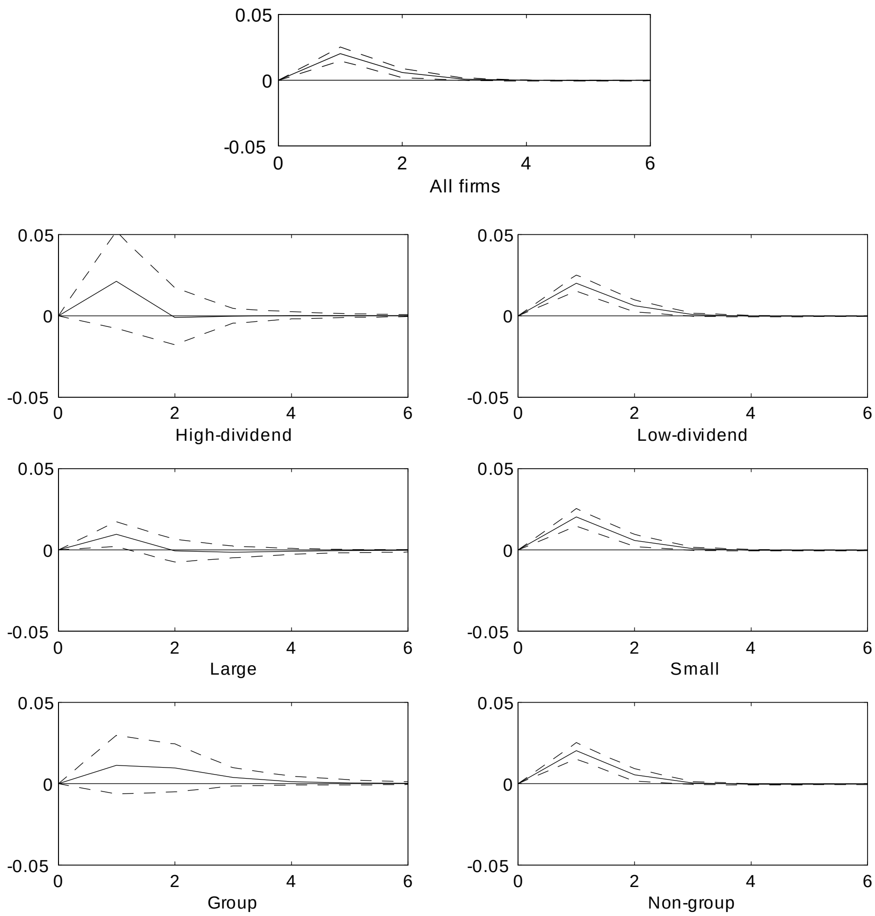
Alternative definition of capital



Note: this figure shows impulse responses of investment (I/K) to cash flow shock with only machines (not buildings) included in the definition of capital for the period 1996-2005. Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

Figure A5

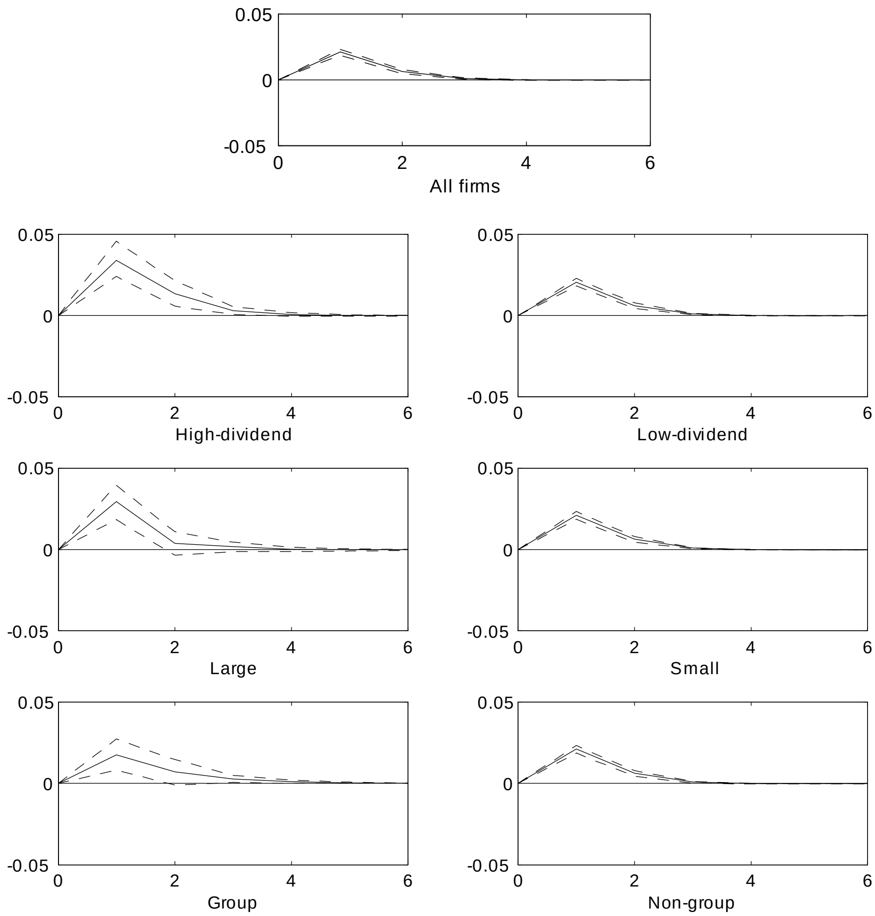
All manufacturing firms



Note: this figure shows impulse responses of investment (I/K) to cash flow shock for sample of all manufacturing firms for the period 1996-2005. Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

Figure A6

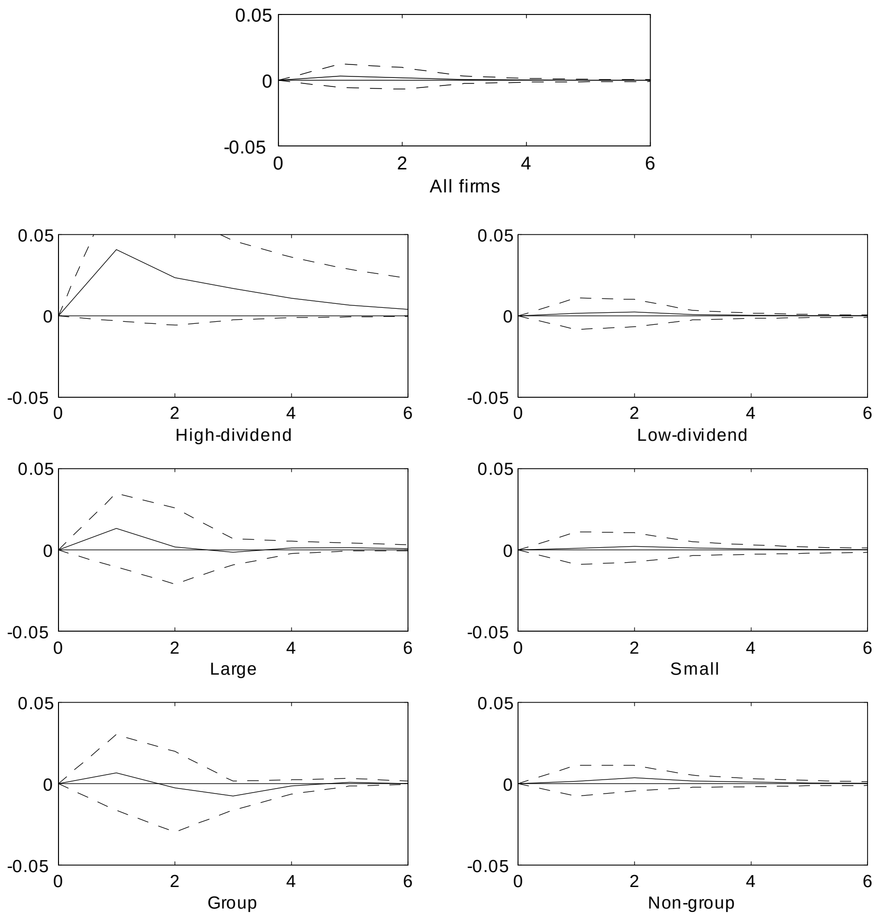
All manufacturing and non-manufacturing firms



Note: this figure shows impulse responses of investment (I/K) to cash flow shock for sample of all manufacturing and non-manufacturing firms for the period 1996-2005. Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

Figure A7

Balanced panel



Note: this figure shows impulse responses of investment (I/K) to cash flow shock with a balanced panel of firms for the period 1997-2005. Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

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