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

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Abstract

This paper tests the balance sheet theory, where the status of balance sheets affects the economy's response to monetary and other shocks. The theory predicts a positive effect of cash flow on investment, given fundamental determinants of investment. I use an empirical method developed by Gilchrist and Himmelberg (1995, 1999), which has previously only been used to study very large, publicly traded firms. In contrast, this paper uses a large Swedish data set with many smaller firms, where balance sheet effects are likely to be especially important. I find that a firm's cash flow has a positive impact on its investment, controlling for any information in cash flow about investment opportunities. As predicted by the balance sheet channel, the estimated effect of cash flow on investment is especially large for firms which, a priori, are more likely to be financially constrained (low-dividend, small and non-group firms). Moreover, the investment-cash flow sensitivity is significantly larger and more persistent during the first half of the sample period, which includes a severe banking crisis and recession, than during the second half.

Keywords: Financial frictions, balance sheet channel, financial accelerator, investment, cash flow.
JEL codes: C33, E22, E44, E55.

1 Introduction

In the current international 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 it is not affected 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 for a balance sheet channel in the monetary transmission mechanism by studying the effect of cash flow on investment. However, the empirical results are of more general interest, not least in the current international financial crisis, when the impact of financial constraints on investment is 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 so-called 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 balance sheet strength) on investment, controlling for fundamental determinants of investment. Schiantarelli (1995) and Hubbard (1998) provide

excellent surveys of the empirical literature.[1] 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 on cash flow for small firms than for large firms may be a result of 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

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

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. The authors 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, which constitutes evidence in favor of the balance sheet channel. Gilchrist and Himmelberg (henceforth GH) also study differences in investment-cash flow sensitivity across firms. The balance sheet theory predicts that the effect of cash flow on investment is especially large for firms which are likely to be financially constrained.

GH use firm-level panel data on large, publicly traded U.S. manufacturing firms. The key contribution of this paper is to extend their analysis by studying a much broader set of firms. I apply the GH methodology to a large, Swedish firm-level panel data set covering the period 1989-2005. Importantly, the data set includes many smaller firms where financial frictions are likely to be especially important. The GH methodology is particularly useful when studying smaller, non-publicly traded firms, since it does not require any data on the stock market value of a firm (which, in contrast, is needed when using Tobin's Q to control for fundamentals).

Another contribution of this paper is that the sample period includes the Swedish banking crisis in the early 1990's. This crisis was followed by a severe recession, during which GDP contracted by around 2% per year. Thus, it is possible to divide the sample into two parts and test whether the effect of cash flow is larger during a recession, when more firms are likely to be financially constrained.

I find that a positive cash flow shock has a positive effect on investment, even using the entire sample of firms. As expected, the effect is especially strong for financially constrained firms and, in particular, during the recession period. There are only two previous papers using similar firm-level data from Sweden. One paper is by Hansen (1999) who uses Euler equation methods with data from the period 1979-1995 and finds evidence in favor of a balance sheet channel. My paper uses a larger and more recent data set, as well as an alternative method. Another related study by Jacobson, Lindé, and Roszbach (2005) uses the aggregate default frequency as a measure of firm-level finances and finds substantial spillover effects on macroeconomic variables. However, the paper does not focus specifically on testing for the presence of a balance sheet channel.

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, including robustness checks. Section 5 concludes the paper.

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:[2]

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

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 technology

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

shocks $\varepsilon_{i,t}$:

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

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

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

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.[3] A general result in the theoretical literature is that asymmetric infor-

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[3] 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.

mation in one form or another—adverse selection, moral hazard or costly state verification—gives rise to an external finance 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.[4]

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.[5] 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. A recent paper by Love and Zicchino (2006) uses the same methodology to investigate how cross-country differences

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[4]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)).

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

in the level of financial development affect investment-cash flow 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.[6]

The GH method is particularly useful for data sets (such as that used in this paper) with many smaller, non-quoted firms, since it does not require a

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[6] 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), I 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)).

stock-market based measure of Q to control for fundamentals in the investment regressions. Instead, GH (1999) use a sales-based 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:

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

where π denotes profits, 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.[7]

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:

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

[7] 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.

where N_j is the number of observations for industry j. While GH assume that the depreciation rates $\delta_{i,t}$ are the same for all industries, I allow for industry-specific depreciation rates (which are reported in Table 2 in the appendix).

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:

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

The empirical model is a reduced-form panel data VAR with the assumed Cholesky ordering investment, MPK and cash flow:

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

$$E\left(v_{i,t} \mid y_{i,t-1}, f_i, e_t\right) = 0 \Rightarrow E\left(y_{i,t-1}v_{i,t+s}\right) = 0 \ \forall \ s \geq 0 \tag{11}$$

and with the following definitions:

$$y_{i,t} = \left(\frac{I_{i,t}}{K_{i,t}}, MPK_{i,t}, \frac{CF_{i,t}}{K_{i,t}} \right) \tag{12}$$

$$f_i = \text{firm effect} \tag{13}$$

$$e_t = \text{time effect} \tag{14}$$

$$v_{i,t}^{I/K} = \eta_{i,t}^{I/K} \tag{15}$$

$$v_{i,t}^{MPK} = \rho_1 \eta_{i,t}^{I/K} + \eta_{i,t}^{MPK} \tag{16}$$

$$v_{i,t}^{CF/K} = \rho_2 \eta_{i,t}^{I/K} + \rho_3 \eta_{i,t}^{MPK} + \eta_{i,t}^{CF/K}. \tag{17}$$

The $v_{i,t}$ terms are the reduced-form errors, which are combinations of the underlying structural errors $\eta_{i,t}$, as determined by the Cholesky ordering. The assumed ordering implies that investment shocks may affect MPK and cash flow contemporaneously, and that MPK shocks are allowed to affect cash flow in the same period. In contrast, there is no contemporaneous effect of MPK

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shocks on investment or of cash flow shocks on any of the other variables. In-
tuitively, given the time lags involved in investment decisions, it is reasonable
to assume that other shocks do not have any contemporaneous effect on invest-
ment. The reduced-form errors $v_{i,t}$ are assumed to be orthogonal to lags of $y_{i,t}$
(see equation (11)).

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. From 1996, all Swedish firms are included, but many smaller
firms were excluded during the earlier period, and for many observations the
data are incomplete. Around 200,000 firms are observed each year from 1996,
and the original sample consists of 2.4 million firm-year observations (before
any data cleaning and sample restrictions).

SCB 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 SCB 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. The calendar year variable in the SCB data was constructed from the underlying accounting periods according to specific rules. Using the same rules, I created a calendar year variable in the UC data based on the available accounting periods. Finally, I could use the calendar year variables, along with the firm identification number, to merge the two data sets.[8]

My benchmark sample is an unbalanced panel of firms in the manufacturing sector with at least 20 employees for the period 1989-2005. I 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 small firms (which may have been started during the sample period) and firms in financial distress (which may have disappeared during the sample period).

During the pre-1996 period, data availability is severely limited for manufacturing firms with fewer than 20 employees (only a small random sample is observed each year). Therefore, I focus on manufacturing 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. During the pre-1996 period, only a small random sample of non-manufacturing firms with fewer than 50 employees is observed each year.

Regarding the benchmark definition of capital and investment, both machines and buildings are included. There are two reasons for not only including

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[8] Details on this procedure and other data issues are available in the appendix.

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

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]

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, I estimate the capital stock using the perpetual inventory method:

$$K_{i,t} = (1 - \delta_{i,t}) K_{i,t-1} \frac{p_t^k}{p_{t-1}^k} + I_{i,t} \qquad (18)$$

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 I use the initial book value of capital. In the empirical analysis, all variables enter as ratios (e.g. I/K), so the use of nominal variables does not affect the results (as long as prices of final goods and capital goods evolve in a similar way, which they did over the sample period).

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 (18)). 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 (Compustat data items 18 and 14, respectively). I 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.

Before proceeding to the empirical estimation, it is necessary to use observ-

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

able 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. My data set includes information on dividend payout, firm size and membership in a company group. As a robustness check, I use all three indicators separately to produce three alternative sample splits between constrained and unconstrained firms.

For the first indicator, dividend payout, I calculate the fraction of time during a firm's existence when the firm pays out a positive dividend. I classify firms with a dividend-payment fraction value below the 90th percentile as constrained (DIV=0), and firms with a dividend-payment fraction value above the 90th percentile as unconstrained (DIV=1).[11] The second sample-split indicator is firm size, as measured by the number of employees. Small firms are classified as constrained (SIZE=0) and large firms as unconstrained (SIZE=1), using the 90th percentile for firms' average number of employees as the cut-off value. The third indicator is membership in a company group. For each firm, I calculate the fraction of time that the firm belongs to a company group. Then, I use the 90th 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). For the benchmark sample, this procedure results in the following three alternative sample splits. First, firms who pay dividends at least (less than) 75% of the time are unconstrained (constrained). Second, firms with at least (less than) 277 employees on average are unconstrained (constrained). Finally, firms which always belong to a

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[11]I use the 90th percentile as the cut-off point in all three sample splits. In contrast, GH use the 66th percentile as the cut-off for dividend payout and size. The reason is that the firms in my sample are, on average, much smaller than those in the GH sample. If I used the 66th percentile, many small and constrained firms would be misclassified as unconstrained, thus leading to incorrect inference regarding any differences between sub-samples.

company group are unconstrained, and firms which are independent of company groups at least some of the time are constrained.

Table 1 presents summary statistics for the variables used in the empirical analysis. After the data cleaning procedures described in the appendix, a total of 35,396 firm-year observations remains in the benchmark sample (denoted "all firms" in Table 1). The main reasons for the large decrease in the number of observations are missing data and the fact that most firms have fewer than 20 employees.

4   Empirical analysis

To identify shocks to current cash flow which are orthogonal to current MPK, a recursive ordering of contemporaneous shocks must be assumed. Following GH, I use the Cholesky ordering I/K, MPK and CF/K in the main specifications, but also check for robustness by using alternative orderings. In the empirical analysis, I first estimate the VAR model, and then I investigate the impulse responses of investment and MPK to cash flow shocks.

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 impact corresponds to around 10% of the average investment-capital ratio.

Table 1

Summary statistics for different samples

		Mean	Std dev	Percentile		
				25%	Median	75%
CF/K	(all firms)	0.40	0.94	0.10	0.25	0.49
I/K	(all firms)	0.21	0.43	0.04	0.11	0.23
MPK	(all firms)	0.05	0.08	0.02	0.03	0.06
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

	Firm-year observations	Median # of employees/firm
All firms	35,396	53
DIV=1	4,077	40
DIV=0	31,319	55
SIZE=1	3,555	560
SIZE=0	31,841	46
GROUP=1	3,765	107
GROUP=0	31,631	49

Note: the table 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 product of capital (MPK). More details on variable definitions are given in Section 3. The variables DIV, SIZE and GROUP take the value 1 for unconstrained firms and the value 0 for constrained firms.
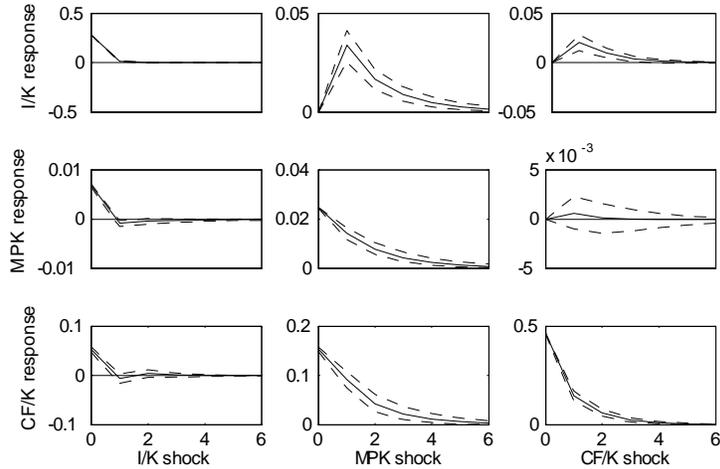
Figure 1: Impulse responses for the benchmark sample. Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

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. 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, I classify firms as financially unconstrained or financially constrained in three different ways. For each classification, I estimate separate panel VAR models for the unconstrained and constrained sub-samples. This is followed by separate estimation for the early, recession part of the sample period, and for the late, non-recession part.

Figures 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, unconstrained sample of 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, constrained firms, there is a significant and long-lasting effect of cash flow on investment. The impact of cash flow on MPK is positive, but 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.

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 larger and more persistent for small, constrained firms. However, the difference between constrained and unconstrained firms is not as clear as for the dividend policy classification.
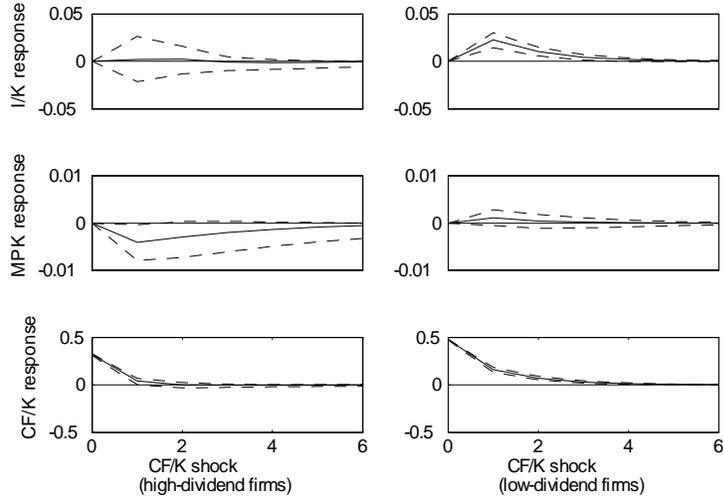
Figure 2: Impulse responses for high-dividend firms (left column) and low-dividend firms (right column). Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.
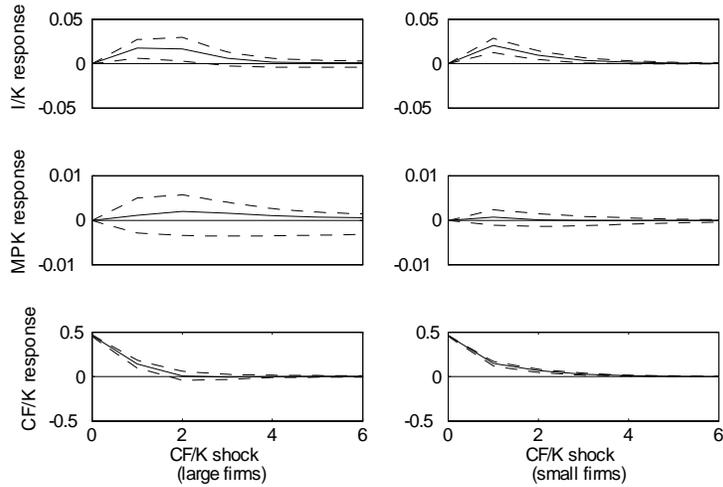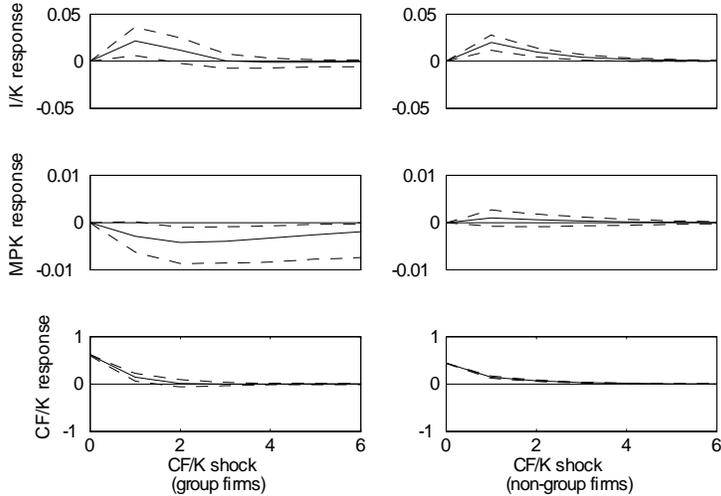

Figure 3: Impulse responses for large firms (left column) and small firms (right column). Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

Figure 4: 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.

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. Once more, the impact of cash flow on investment is somewhat larger and more longer-lasting for constrained firms, and there are no significant increases in MPK.

The final division is based on time rather than firm characteristics. I 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 much larger and much more persistent during the recession. Moreover, there is hardly any response of MPK to cash flow shocks during either of the two sub-periods.
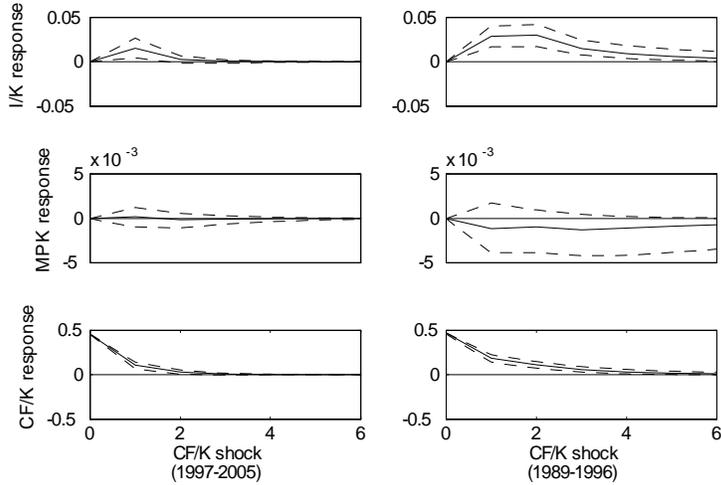
Figure 5: Impulse responses for the late, non-recession period (left column) and the early, recession period (right column). Horizontal axis shows response horizon (years). Dashed lines denote 90-percent confidence intervals generated by Monte Carlo with 1000 draws.

To summarize, using several different sample splits, the investment of constrained firms is consistently more sensitive to cash flow than the investment of unconstrained firms. In particular, the investment-cash flow sensitivity is larger during the 1989-1996 period, which includes a severe recession.

4.3 Robustness tests

As seen above, the main empirical results are at least qualitatively similar for the different sample splits, which is reassuring from a robustness perspective. In this section, I discuss some additional robustness tests. The main results are 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. The key impulse response functions, showing

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the response of investment to cash-flow shocks, are presented in the appendix (Figures 6-11).

The choice of lag length in the panel VAR does not matter for the results. Estimation with 1 lag (rather than 2 lags) produces very similar results, both qualitatively and quantitatively, as shown in Figure 6.

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 qualitatively similar results in most cases (see Figure 7). However, for several sample splits, there is a large and immediate response of investment for the constrained firms.

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 8, very similar results are obtained by only including machines (which is only possible for the period 1996-2005 because of data availability constraints).

The benchmark sample only includes manufacturing firms with at least 20 employees. When I 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 9). 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 constrained firms as well (see Figure 10).[12]

Finally, an exception to the general robustness of the results occurs for a balanced panel of firms. The response of investment to cash flow is weak and insignificant (see Figure 11). One possible explanation is that data avail-

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[12] 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, I use the 97th percentile as the cutoff between constrained and unconstrained.

ability constraints necessarily limits the sample period to 1997-2005, when the investment-cash flow sensitivity is weaker than in the earlier period, which includes a severe recession. Another 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.

5   Conclusions

This paper uses reduced-form VAR methods on firm-level panel data from the period 1989-2005 to investigate whether there exists empirical evidence of a balance sheet channel in Sweden. The main empirical results are that: i) cash flow has a significant effect on investment and ii) the effect is especially strong for constrained firms and, in particular, during recessions. 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, the empirical results provide clear evidence in favor of a balance sheet channel in the monetary transmission mechanism in Sweden.

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 (2007) 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.

Appendix

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 I 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.[13]

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, I follow the rule used by SCB, 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.

Following Gilchrist and Himmelberg, I 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 I use deviation from calendar-year means.

In the SCB 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. I scale all variables in the UC data in the same way.

Another scaling issue is that the SCB variables are defined in thousands of Swedish kronor and the UC variables in Swedish kronor. To have all variables defined in the same units, I divide the UC variables by 1000.

From the initial sample, I 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.

In my benchmark sample, I only include manufacturing firms with at least 20 employees. One reason is data availability. During the period 1985-1995 the SCB data does not cover all smaller firms, and I want my sample to be

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[13] To be precise, SCB 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.

comparable over time. For the non-manufacturing sector, data availability is even more limited. During the period 1985-1995 the SCB data includes all non-manufacturing firms with at least 50 employees, but not all firms with 20-49 employees.

Equation (18) in the text describes the perpetual inventory method used to calculate the capital stock. I 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, I 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). For buildings, I 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 2 below.

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).

Following GH (1999), I first calculate the ratios needed for the analysis (see Table 2 in their paper), and then I remove outliers (observations with ratios below the 1st or above the 99th percentile). I also remove firms with fewer than four observations, and I require that all observations for a firm are consecutive.

Table 2

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	0.1179	1	0.1179	32	0.1225
12	0.1179	2	0.1179	33	0.1225
13	0.1179	5	0.1179	34	0.1225
21	0.15	10	0.15	35	0.1225
22	0.15	11	0.15	36	0.1072
23	0.15	12	0.15	37	0.1072
29	0.15	13	0.15	40	0.05
31	0.1072	14	0.15	41	0.05
32	0.1072	15	0.1072	45	0.155
33	0.1072	16	0.1072	50	0.165
34	0.1072	17	0.1072	51	0.165
35	0.1072	18	0.1072	52	0.165
36	0.1225	19	0.1072	55	0.15
37	0.1225	20	0.1072	60	0.1232
38	0.1225	21	0.1072	61	0.1232
39	0.1072	22	0.1072	62	0.1232
41	0.05	23	0.1072	63	0.1232
42	0.05	24	0.1072	64	0.11
50	0.155	25	0.1072	70	0.1072
61	0.165	26	0.1225	71	0.1232
62	0.165	27	0.1225	72	0.3119
63	0.15	28	0.1225	73	0.1350
71	0.1232	29	0.1225	74	0.15
72	0.11	30	0.1225		
83	0.1072	31	0.1225		

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, I use the closest possible U.S. industry-specific depreciation rate from the U.S. Bureau of Economic Analysis (2003).
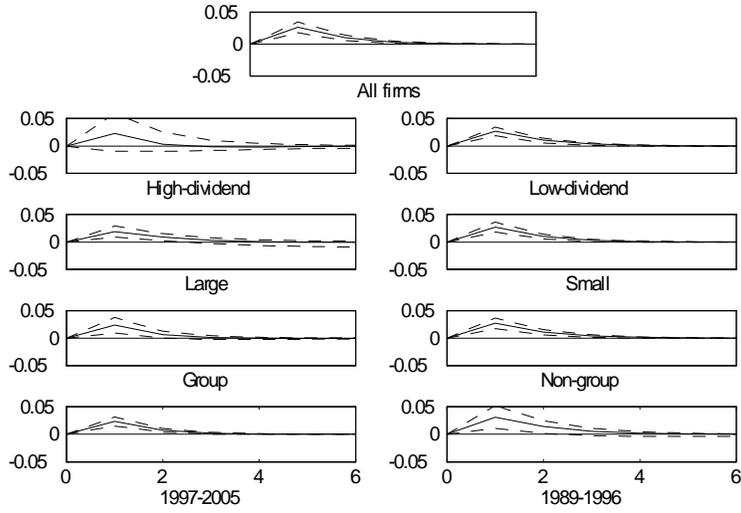
Figure 6: Impulse responses of investment (I/K) to cash flow shock with 1-lag VAR for the period 1989-2005.
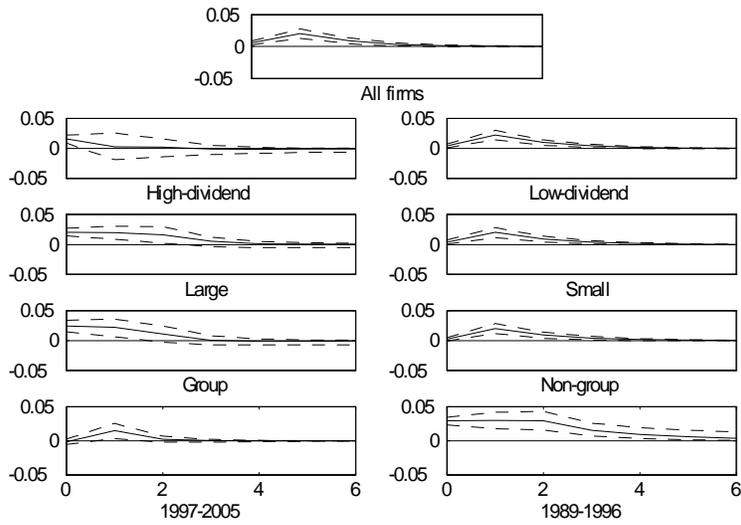

Figure 7: Impulse responses of investment (I/K) to cash flow shock with Love-Zicchino Cholesky ordering assumption for the period 1989-2005.
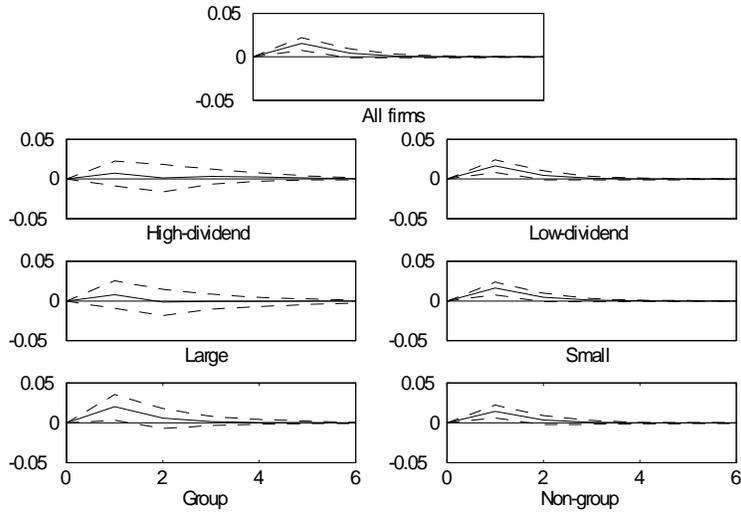
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Figure 8: Impulse responses of investment (I/K) to cash flow shock with only machines (not buildings) included in definition of capital for the period 1996-2005.
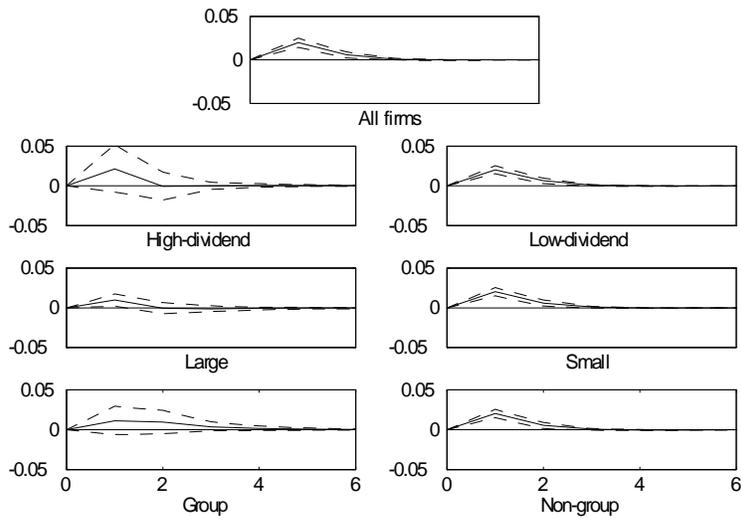

Figure 9: Impulse responses of investment (I/K) to cash flow shock for sample of all manufacturing firms for the period 1996-2005.
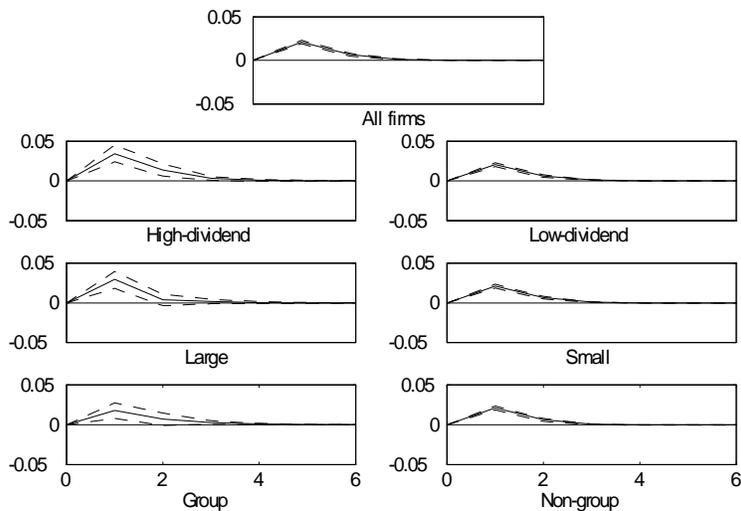
Figure 10: Impulse responses of investment (I/K) to cash flow shock for sample of all manufacturing and non-manufacturing firms for the period 1996-2005.
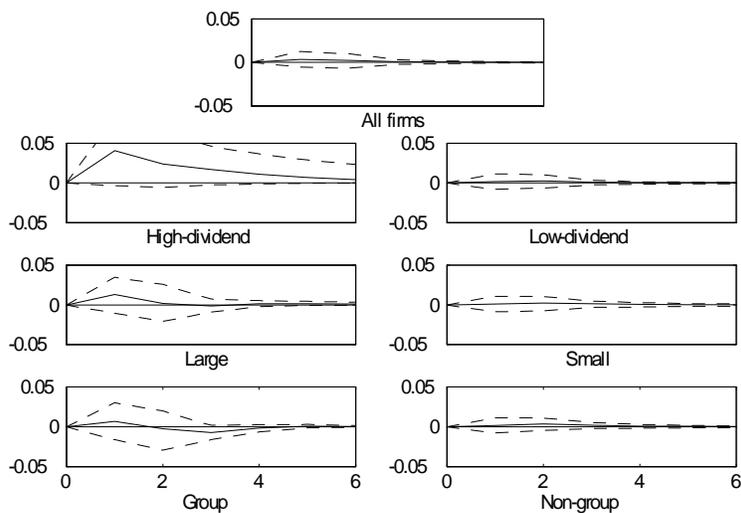

Figure 11: Impulse responses of investment (I/K) to cash flow shock with a balanced panel of firms for the period 1997-2005.

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