Journal of Financial Economics 103 (2012) 393–410

Contents lists available at SciVerse ScienceDirect

Journal of Financial Economics

journal homepage: www.elsevier.com/locate/jfec

Investment-cash flow sensitivity cannot be a good measure of financial constraints: Evidence from the time series ☆

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ARTICLE INFO

Article history:
Received 23 July 2010
Received in revised form
5 May 2011
Accepted 9 May 2011
Available online 30 August 2011

JEL classification:
G01
G31
G32

Keywords:
Investment-cash flow sensitivity
Financial constraints
Credit crunch
Measurement error

ABSTRACT

Investment-cash flow sensitivity has declined and disappeared, even during the 2007–2009 credit crunch. If one believes that financial constraints have not disappeared, then investment-cash flow sensitivity cannot be a good measure of financial constraints. The decline and disappearance are robust to considerations of R&D and cash reserves, and across groups of firms. The information content in cash flow regarding investment opportunities has declined, but measurement error in Tobin's q does not completely explain the patterns in investment-cash flow sensitivity. The decline and disappearance cannot be explained by changes in sample composition, corporate governance, or market power—and remain a puzzle.

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1. Introduction

According to the q theory, marginal q is a sufficient statistic for investment behavior. However, Fazzari, Hubbard, and Petersen (1988), find a positive sensitivity of investment to cash flow, even after controlling for q. Their interpretation of investment-cash flow sensitivity is financial constraints. They argue that when there are financial constraints, external financing in the form of new debt and equity is not always available. Consequently, the investments of a financially constrained firm depend heavily on the availability of internal funds.

Many papers question the interpretation of investment-cash flow sensitivity as a measure of financial constraints. For example, Kaplan and Zingales (1997) study the annual reports of those firms classified as financially constrained by Fazzari, Hubbard, and Petersen (1988) and find that firms that appear less constrained actually exhibit greater investment-cash flow sensitivities. Also, Gomes (2001) shows that investment-cash flow sensitivities are theoretically neither necessary nor sufficient for financial constraints.[1] Despite

☆ A previous draft circulated under the title "Disappearing Investment-Cash Flow Sensitivity". We thank an anonymous referee, James Brown, Russell Cooper, Adlai Fisher, Kai Li, Hernan Ortiz-Molina, Nathalie Moyen, Jay Ritter, Toni Whited, Feng Zhang, and seminar participants at Concordia University, Pacific Northwest Finance Conference 2010, University of Hawaii, University of Colorado in Denver, Simon Fraser University, University of British Columbia paper discussion group, and Northern Finance Association Meeting 2011 for comments. Milka Dimitrova, Pablo Moran, and Siliang Zhang provided excellent research assistance. Huafeng Chen acknowledges financial support from the Social Sciences and Humanities Research Council of Canada.

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[1] Other papers that criticize the interpretation of investment-cash flow sensitivity as financial constraints include Cleary (1999), Erickson and Whited (2000), Alti (2003), and Moyen (2004). Fazzari, Hubbard, and Petersen (2000) dispute both the theoretical model and the empirical classification system in Kaplan and Zingales (1997).

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doi:10.1016/j.jfineco.2011.08.009

controversy regarding the interpretation, many studies use investment-cash flow sensitivity. For example, see Hoshi, Kashyap, and Scharfstein (1991), the references in Hubbard (1998), and more recently, Biddle and Hilary (2006), Almeida and Campello (2007), and Beatty, Liao, and Weber (2010).

We study investment-cash flow sensitivity over time and provide evidence that helps settle the debate. We find that investment-cash flow sensitivity has significantly declined in the past 40 years and has completely disappeared in recent years. Investment-cash flow sensitivity is about 0.3 in the 1960s. Since 1997, investment-cash flow sensitivity has been below 0.03. Investment-cash flow sensitivity has disappeared in manufacturing as well as nonmanufacturing firms. This finding is robust to alternative model specifications.

We further examine investment-cash flow sensitivity during the recent credit crunch. There is ample anecdotal and growing systematic evidence that U.S. firms have experienced a severe credit crunch since 2007. For example, Campello, Graham, and Harvey (2010) survey 1,050 Chief Financial Officers (CFOs) and find a significant percentage of the companies are constrained at the end of 2008. More than 50% of respondents report that they canceled or postponed their planned investments. Almeida, Campello, Laranjeira, and Weisbenner (2009) find that firms whose long-term debt was maturing immediately after the third quarter of 2007 significantly reduced investment compared to similar firms. However, using the most recent data, we find that investment-cash flow sensitivity is zero even during this period. If one believes that financial constraints have not completely disappeared, then investment-cash flow sensitivity cannot be a good measure of financial constraints.

We provide additional pieces of time-series evidence that support this view. First, we show that the interpretation of investment-cash flow sensitivity as a measure of financial constraints cannot be saved by the rising importance of R&D as a form of investment and firms with negative cash flows. We show that during the recent credit crunch, R&D-cash flow sensitivity is zero or negative, even for firms with positive cash flows. Second, we find that in the last ten years, investment-cash flow sensitivity has disappeared in firms with low and high dividend ratios, as well as in young and old firms. It has also disappeared among small and large firms, and firms with and without credit ratings. Therefore, regardless of whether these other characteristics are good measures of financial constraints, investment-cash flow sensitivity is no longer correlated with other measures of financial constraints in recent years. Third, we find no increasing trend in the volume of new issue activity (inverse proxy for credit rationing) during the past 40 years and therefore, lessening of credit rationing cannot explain the disappearance of investment-cash flow sensitivity.

Fourth, our results show that the disappearance cannot be explained by the decreasing importance of cash flow as a source of financing. Finally, the disappearance cannot be explained by the increasing level of cash reserves. While previous empirical evidence against investment-cash flow sensitivity as a measure of financial constraints primarily relies on potentially controversial classifications of constrained and unconstrained firms, we rely on less stringent assumptions to reach the conclusion.

If financial constraints cannot explain investment-cash flow sensitivity, what can explain the disappearance of such sensitivity? We find that the disappearance cannot be explained by the change in firm composition over the years as investment-cash flow sensitivity has disappeared in balanced panels of firms. Moreover, the disappearance is not driven by improvement in corporate governance, or by changes in market power over time.

Among the explanations we explore, the measurement error story fares the best. The measurement error story posits that investment-cash flow sensitivity arises because Tobin's q is an imperfect proxy for marginal q and cash flow contains information about investment opportunities. Consistent with this view, we find that the information content in cash flow regarding investment opportunities has declined over time, as evidenced by the declining patterns in the correlation between cash flow and Tobin's q, as well as in our estimate of the correlation between cash flow and the true marginal q. In accordance with the declining correlation between cash flow and Tobin's q, we find that cash flow has become less persistent over time.

However, even the Erickson and Whited (EW) (2000) generalized method of moments (GMM) measurement-error-free estimates of investment-cash flow sensitivities show a declining pattern and are positive, although less pronounced than their ordinary least squares (OLS) counterparts, in early years. Therefore, we conclude that the patterns in investment-cash flow sensitivity cannot be completely explained by the measurement error and remain a puzzle.

Allayannis and Mozumdar (2004), Chen (2004), Agca and Mozumdar (2008), and Brown and Petersen (2009) also find that investment-cash flow sensitivity has declined over time, up to 2006.[2] Part of our contribution is to show that investment-cash flow sensitivity has robustly and extensively declined and completely disappeared, even for R&D, and during the credit crunch. More importantly, we use the time-series variation as our identification strategy to test different explanations of investment-cash flow sensitivity.

In Section 2, we discuss the empirical model, define variables, describe data sources, and calculate summary statistics. Section 3 shows the decline and disappearance of investment-cash flow sensitivities. Section 4 provides

[2] Allayannis and Mozumdar (2004) find that investment-cash flow sensitivity is lower in the 1987–1996 panel than in the 1977–1986 panel without providing an explanation. Chen (2004) finds a decline in investment-cash flow sensitivity up to 2001 and interprets it as evidence of declining financial constraints. Agca and Mozumdar (2008) find a decline using ten-year rolling windows, with the last window being 1992–2001. They argue that the decline is possibly consistent with the reduction in market imperfection but do not provide a direct time-series analysis of the relation between the two. Brown and Petersen (2009) find a decline across three panels: 1970–1981, 1982–1993, and 1994–2006. They attribute the decline largely to R&D and decreases in financial constraints (increased availability of public equity as a source of funds).

additional time-series evidence that investment-cash flow sensitivity cannot be a good measure of financial constraints. In Section 5, we explore why investment-cash flow sensitivity has disappeared. Section 6 presents further robustness checks. Section 7 concludes.

2. Empirical model, variable definitions, data sources, and summary statistics

2.1. Empirical model

Following Fazzari, Hubbard, and Petersen (1988), we estimate investment-cash flow sensitivity as follows:

$$\frac{I_{it}}{K_{it-1}} = \alpha_i + \alpha_t + \beta_1 \times q_{it-1} + \beta_2 \times \frac{CF_{it}}{K_{it-1}} + \varepsilon_{it}, \quad (1)$$

where I_{it}/K_{it-1} is the firm's fixed investment, I_{it}, deflated by its beginning-of-period capital stock, K_{it-1}. q_{it-1} is a proxy for investment opportunities. CF_{it}/K_{it-1} is the firm's internal cash flow, CF_{it}, deflated by its beginning-of-period capital stock, K_{it-1}. β_1 is investment-q sensitivity. β_2 is investment-cash flow sensitivity.

2.2. Data sources, variable definitions, and sample selection

We construct the sample for our main tests by using Compustat FTP annual data from 1967 to 2006. For tests in the credit crunch period, we use quarterly data in the Xpressfeed format. We measure investment as the net capital expenditure. In the FTP annual version, this is data item 128. The Xpressfeed quarterly file provides the year-to-date net capital expenditure, capxy. We therefore set quarterly investment to be capxy (in the first fiscal quarter) or change in capxy (in the second, third, and fourth fiscal quarters). Hereafter, when we define a variable, we include the data item number in the FTP annual file and the variable name in the Xpressfeed quarterly files in parentheses. Capital is defined as net property, plant, and equipment, or net PPE (8, ppentq) hereafter. Tobin's q is calculated as the market value of assets minus the difference between the book value of assets (6, atq) and net PPE, divided by net PPE. The market value of assets is equal to the market value of common stock (25×199, cshoq $\times$ prccq), plus total liability (181, ltq), plus preferred stock (130, pstkq), minus deferred taxes (35, txditcq). Cash flow is the sum of income before extraordinary items (18, ibq), and depreciation and amortization (14, dpq).

To be consistent with previous research, our main tests include only manufacturing firms (the first digit of the Standard Industry Classification (SIC) code equals two or three) but we also study nonmanufacturing firms as a robustness check. We require firms to have valid observations for all variables in Eq. (1). To alleviate Compustat's backfilling bias, we also exclude firms for which we cannot compute the lagged cash flow to capital ratio, CF_{it-1}/K_{it-2}. Following Almeida, Campello, and Weisbach (2004), we exclude firms with asset or sales growth exceeding 100% to avoid potential business discontinuities caused by mergers and acquisitions. To mitigate outliers, we require that the firm's capital, book assets, and sales be at least $1 million in the previous year or quarter. We further winsorize all variables at the 1st and 99th percentiles of nonfinancial firms in each year or quarter.

2.3. Sample partition and summary statistics

In the baseline analysis, we divide manufacturing firms into three industry groups: durable goods, nondurables, and high-tech industries. Firms are classified into the high-tech industries if their three-digit SIC codes are 283, 357, 366, 367, 382, or 384. A firm is in the durable goods industries if it is not in the high-tech industries and the first two digits of its SIC code are between 24 and 25, or between 32 and 38, inclusive. A firm is in the nondurable goods industries if it is not in the high-tech industries and the first two digits of its SIC code are between 20 and 23, or between 26 and 31, inclusive. We do not include firms with two-digit SIC codes of 39 ("Miscellaneous Manufacturers") in any of the three industry groups. Forming industry groups helps maintain homogeneity of sample composition over time.

Within each industry group, we further divide the sample into eight consecutive five-year subsample periods: 1967 to 1971, 1972 to 1976, etc., until 2002 to 2006. Panel A of Table 1 reports the averages and medians for the variables that we use in our empirical model across industry groups and subsample periods. The investment-to-capital ratio does not change substantially in different subsample periods. Tobin's q changes with the level of the stock market, being high in the 1960s and late 1990s. Cash flow to capital ratios stay relatively constant over time.

Panel B of Table 1 presents the summary statistics for the quarterly data in the credit crunch period analysis between 2005 and 2009. The investment-to-capital ratio, Tobin's q, and the cash flow to capital ratio have all declined significantly towards the end of the sample period.

3. Investment-cash flow sensitivities have disappeared

3.1. Baseline regression results

Fig. 1 plots the estimation results for the primary specification in Eq. (1) for each of the three industry groups and each of the eight subsample periods. Firm and year fixed effects are included. The standard errors are heteroskedasticity-consistent and clustered at the firm level. Investment-q sensitivity β_1 is plotted against the left axis. Investment-cash flow sensitivity β_2 and R^2 are plotted against the right axis. Shaded areas indicate 95% confidence intervals.

For the durable goods industries, investment-cash flow sensitivity is 0.36 for the 1967 to 1971 sample period. It is statistically significant with the t-statistic equal to 9.90. However, investment-cash flow sensitivity monotonically declines over time. Between 2002 and 2006, investment-cash flow sensitivity is only 0.02. This estimate is economically and statistically indistinguishable from zero.

Table 1
Sample averages and medians of the regression variables.

This table reports the averages and medians for the variables in each industry and subsample period. I_{it}/K_{it-1} is the firm's capital expenditure, I_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous year's Tobin's q. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. The average I_{it}/K_{it-1} is calculated as the sum of investments across firms over the sum of net property, plant, and equipment. The averages of other variables are constructed in the same way. In Panel A, the data are from the Compustat annual FTP data. Panel B is based on Compustat quarterly data in the Xpressfeed format.

	Obs.	I_{it}/K_{it-1}		q_{it-1}		CF_{it}/K_{it-1}	
		Mean	Median	Mean	Median	Mean	Median
Panel A							
Durable goods							
1967–1971	2,922	0.21	0.20	1.85	1.66	0.26	0.31
1972–1976	3,912	0.21	0.19	1.19	0.65	0.29	0.33
1977–1981	3,772	0.28	0.23	0.95	0.79	0.30	0.38
1982–1986	3,688	0.22	0.18	1.15	1.22	0.25	0.27
1987–1991	3,278	0.24	0.17	1.43	1.37	0.27	0.26
1992–1996	3,528	0.22	0.19	1.67	1.84	0.27	0.31
1997–2001	3,803	0.24	0.19	2.29	2.00	0.28	0.30
2002–2006	2,967	0.23	0.15	1.97	2.25	0.30	0.32
Nondurables							
1967–1971	2,586	0.20	0.20	1.77	1.72	0.24	0.28
1972–1976	3,419	0.22	0.19	1.39	0.78	0.26	0.30
1977–1981	3,213	0.25	0.22	1.07	0.71	0.28	0.33
1982–1986	2,867	0.18	0.19	1.01	1.13	0.21	0.29
1987–1991	2,594	0.17	0.19	1.57	1.72	0.23	0.28
1992–1996	2,906	0.15	0.18	2.02	1.98	0.23	0.27
1997–2001	3,039	0.15	0.16	2.93	1.86	0.25	0.25
2002–2006	2,418	0.16	0.13	2.58	1.96	0.33	0.29
High-tech							
1967–1971	769	0.29	0.22	6.02	4.55	0.40	0.37
1972–1976	1,276	0.30	0.23	4.31	1.69	0.43	0.41
1977–1981	1,503	0.36	0.33	2.34	2.05	0.47	0.50
1982–1986	2,367	0.32	0.28	2.83	3.05	0.41	0.35
1987–1991	2,909	0.31	0.23	3.72	2.44	0.44	0.32
1992–1996	3,554	0.29	0.28	4.31	4.94	0.43	0.40
1997–2001	4,400	0.28	0.27	10.90	6.60	0.44	0.25
2002–2006	4,160	0.23	0.21	8.11	7.24	0.53	0.29
Panel B							
2005:1	1,383	0.03	0.04	4.54	5.17	0.10	0.09
2005:2	1,430	0.04	0.04	4.56	4.54	0.11	0.11
2005:3	1,446	0.04	0.04	4.53	4.49	0.11	0.10
2005:4	1,483	0.05	0.05	4.65	5.04	0.11	0.10
2006:1	1,400	0.04	0.04	4.42	5.00	0.11	0.10
2006:2	1,416	0.05	0.05	4.24	6.03	0.11	0.11
2006:3	1,437	0.05	0.05	4.12	5.48	0.11	0.11
2006:4	1,426	0.06	0.05	4.19	5.17	0.10	0.11
2007:1	1,372	0.04	0.04	4.51	5.64	0.11	0.10
2007:2	1,394	0.04	0.05	4.67	5.86	0.12	0.11
2007:3	1,394	0.04	0.05	4.89	6.26	0.07	0.11
2007:4	1,407	0.05	0.05	4.97	5.58	0.10	0.11
2008:1	1,360	0.04	0.05	4.72	5.30	0.11	0.10
2008:2	1,406	0.05	0.05	4.04	4.02	0.09	0.10
2008:3	1,427	0.05	0.05	3.97	3.50	0.11	0.10
2008:4	1,467	0.06	0.05	3.61	3.01	0.00	0.05
2009:1	1,486	0.04	0.03	2.95	1.56	0.06	0.03
2009:2	1,507	0.04	0.03	2.65	1.27	0.09	0.07
2009:3	1,437	0.03	0.03	2.98	2.19	0.10	0.08
2009:4	1,251	0.04	0.03	3.21	2.85	0.10	0.09

The difference between investment-cash flow sensitivity in the first subsample (0.36) and the last subsample (0.02) is highly statistically significant.

The nondurables and high-tech industries exhibit similar patterns. Cash flow sensitivities between 1967 and 1971 are estimated to be 0.49 and 0.27, respectively. Both estimates are statistically significant. They decline over time and in the last subsample period (2002 to 2006) are essentially zero. Investment-cash flow sensitivity in the nondurable goods industries between 2002 and 2006 has a t-statistic of 2.27, and is therefore statistically significant at conventional levels. But the coefficient is 0.02 and economically small. The sensitivity in the high-tech industries between 2002 and 2006 is slightly negative and statistically insignificant.

Consistent with the original study by Fazzari, Hubbard, and Petersen (1988), which covers the sample period of 1970 to 1984, investment-cash flow sensitivities are highly positive in the early part of the sample. Our results show that investment-cash flow sensitivities have declined substantially over time for all three industries, and have essentially disappeared in the last ten years.

3.2. Cross-sectional regressions by year

In the previous section, we divide the sample into five-year subsample periods and then study investment-cash flow sensitivities across subsample periods. The advantage of such grouping is that it allows firm fixed effects to vary across the subsample periods. The disadvantage, however, is that we only have eight subsample periods. Using an alternative approach, we first demean all variables by firm to remove the firm fixed effects for the entire 40-year sample period and then estimate a cross-sectional regression of investment on Tobin's q and cash flow in each year:

$$\frac{I_{it}}{K_{it-1}} = \beta_0 + \beta_1 \times q_{it-1} + \beta_2 \times \frac{CF_{it}}{K_{it-1}} + \varepsilon_{it}. \tag{2}$$

The estimation results of Eq. (2) are plotted in Fig. 2. We include all manufacturing firms in each regression. Again, we see a declining pattern in investment-cash flow sensitivity. In 1967, investment-cash flow sensitivity is 0.33 with a t-statistic of 8.93. In 2006, investment-cash flow sensitivity is only 0.02 with a t-statistic of 2.83. In fact, in each of the last ten years, the sensitivity is no higher than 0.03. We conclude that the decline and disappearance of investment-cash flow sensitivity is robust to model specifications.

3.3. Investment-cash flow sensitivity during the 2007–2009 credit crunch

The recent 2007–2009 credit crunch provides an interesting setting for examining investment-cash flow sensitivity. If investment-cash flow sensitivity is a valid measure of financial constraints and the credit crunch is real, then the sensitivity should be positive and large during 2007–2009. To examine this issue, we use the quarterly Compustat file in the Xpressfeed format from 2005 to 2009, although we can report that the annual file provides the same results. After we prepare the data, we demean all variables by firm to remove the firm fixed effects for manufacturing firms. We then estimate a cross-sectional regression of Eq. (2) in each quarter.

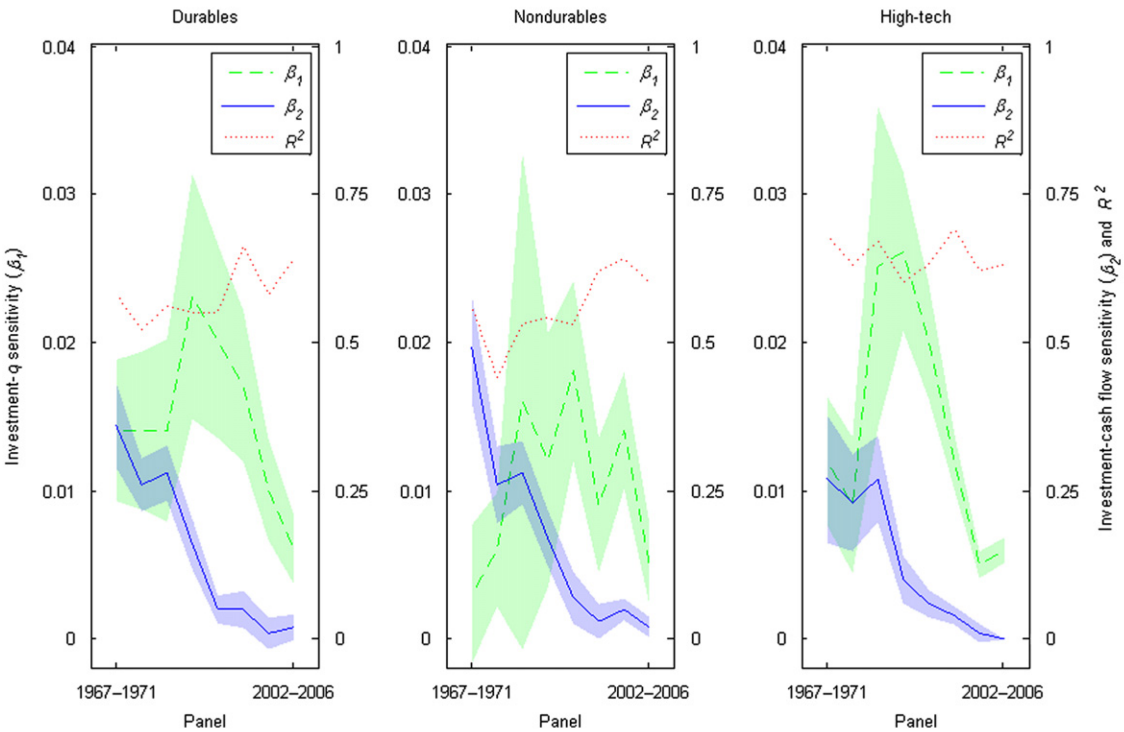

Fig. 1. Investment-cash flow sensitivity across industries over time. Investment-q sensitivity (plotted against the left axes) and investment-cash flow sensitivity (plotted against the right axes) are the estimated coefficients β_1 and β_2 in the regression of investment on Tobin's q and cash flow: $I_{it}/K_{it-1} = \alpha_i + \alpha_t + \beta_1 \times q_{it-1} + \beta_2 \times CF_{it}/K_{it-1} + \varepsilon_{it}$. I_{it}/K_{it-1} is the firm's capital expenditure, I_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous year's Tobin's q. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. Firm and year fixed effects are included. The regression is estimated on eight five-year panels (1967–1971, 1972–1977, …, 2002–2006) in each of the three industries. Shaded areas indicate 95% confidence intervals. Standard errors are heteroskedasticity consistent and clustered at the firm level. U.S. manufacturing firms in Compustat are divided into three industry groups. Firms are classified into the high-tech industries if their three-digit SIC codes are 283, 357, 366, 367, 382, or 384. A firm is in the durable goods industries if it is not in the high-tech industries and the first two digits of its SIC code are between 24 and 25, or between 32 and 38, inclusive. A firm is in the nondurable goods industries if it is not in the high-tech industries and the first two digits of its SIC code are between 20 and 23, or between 26 and 31, inclusive.

The results are reported in Table 2. Because investment is a flow variable and Tobin's q is a stock variable, investment-q sensitivity should be multiplied by four in the quarterly results to be comparable with annual results. Because both investment and cash flow are flow variables, investment-cash flow sensitivity is directly comparable between the quarterly results and annual results. In 11 out the 12 quarters from 2007 to 2009, investment-cash flow sensitivity is not statistically different from zero. In one quarter, investment-cash flow sensitivity is statistically significant and negative. Investment-cash flow sensitivity ranges from -0.01 to 0.01 and is not economically different from zero. To the extent that one believes that there has been a credit crunch since 2007, the evidence suggests that investment-cash flow sensitivity is not a good measure of financial constraints.

4. Can investment-cash flow sensitivity be saved as a good measure of financial constraints?

Fazzari, Hubbard, and Petersen (1988) argue that when firms are financially constrained, they have to consider their access to external financing when making investment decisions. Therefore, internal cash flow plays an important role in determining firms' investment. Consequently, they interpret positive investment-cash flow sensitivity as evidence for the existence of financial constraints. In this section, we take the FHP hypothesis as our null hypothesis and examine whether this view is consistent with the time-series evidence.

If investment-cash flow sensitivity is a good measure of financial constraints, then the disappearance of the sensitivity implies the disappearance of financial constraints. We first review evidence in recent literature regarding the existence of financial constraints in the 2007–2009 credit crunch. We then perform five tests to examine whether investment-cash flow sensitivity can be saved as a good measure of financial constraints. First, we examine whether the disappearance can be explained by the rising importance of R&D investment and firms with negative cash flows. Second, we examine the association of investment-cash flow sensitivity with other measures of financial constraints over time. Third, we examine the time-series behavior of the new issue activity to test whether the disappearance of investment-cash flow sensitivity can be explained by the decline in credit rationing.

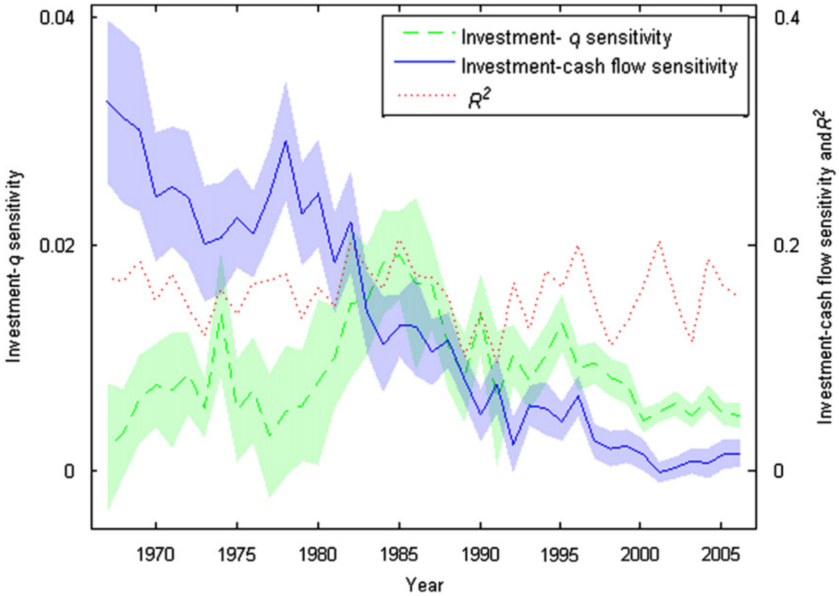

Fig. 2. Investment-cash flow sensitivity by year. Investment-q sensitivity (plotted against the left axis) and investment-cash flow sensitivity (plotted against the right axis) are the estimated coefficients β_1 and β_2 in the regression of investment on Tobin's q and cash flow: $I_{it}/K_{it-1} = \beta_0 + \beta_1 \times q_{it-1} + \beta_2 \times CF_{it}/K_{it-1} + \varepsilon_{it}$. I_{it}/K_{it-1} is the firm's capital expenditure, I_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous year's Tobin's q. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. All variables are demeaned by firm to remove the firm fixed effects. A cross-sectional regression is then estimated in each year between 1967 and 2006. The sample consists of all U.S. manufacturing firms in Compustat. Shaded areas indicate 95% confidence intervals. Standard errors are heteroskedasticity consistent.

Table 2
Investment-cash flow sensitivity in the 2007–2009 credit crunch.

This table reports coefficients estimated from regression of investment on Tobin's q and cash flow: $I_{it}/K_{it-1} = \beta_0 + \beta_1 \times q_{it-1} + \beta_2 \times CF_{it}/K_{it-1} + \varepsilon_{it}$. I_{it}/K_{it-1} is the firm's capital expenditure, I_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous period's Tobin's q. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. All variables are demeaned by firm to remove the firm fixed effects. A cross-sectional regression is then estimated in each period. The sample consists of all U.S. manufacturing firms in the quarterly Compustat fundamental data set (in the Xpressfeed format). Standard errors are heteroskedasticity consistent.

Quarter	q_{it-1}	t-Stat	CF_{it}/K_{it-1}	t-Stat	Obs.	R^2
2005:1	0.001	(3.41)	0.01	(0.91)	1,383	0.04
2005:2	0.001	(5.82)	−0.00	(−0.17)	1,430	0.07
2005:3	0.001	(4.29)	0.00	(0.16)	1,446	0.06
2005:4	0.001	(5.04)	−0.01	(−1.54)	1,483	0.06
2006:1	0.001	(3.94)	0.00	(0.05)	1,400	0.05
2006:2	0.001	(3.44)	−0.01	(−1.07)	1,416	0.04
2006:3	0.001	(4.44)	0.00	(0.40)	1,437	0.05
2006:4	0.001	(4.41)	−0.00	(−0.32)	1,426	0.03
2007:1	0.001	(5.14)	0.01	(0.91)	1,372	0.08
2007:2	0.002	(3.75)	−0.00	(−0.49)	1,394	0.05
2007:3	0.001	(4.55)	0.00	(0.10)	1,394	0.06
2007:4	0.001	(2.26)	0.00	(0.20)	1,407	0.02
2008:1	0.001	(4.94)	−0.01	(−1.93)	1,360	0.06
2008:2	0.001	(4.82)	−0.00	(−0.15)	1,406	0.05
2008:3	0.001	(4.62)	−0.01	(−2.38)	1,427	0.04
2008:4	0.001	(3.52)	0.00	(0.73)	1,467	0.02
2009:1	0.001	(5.41)	−0.00	(−0.64)	1,486	0.05
2009:2	0.001	(4.53)	0.01	(1.79)	1,507	0.05
2009:3	0.001	(6.34)	0.00	(0.03)	1,437	0.08
2009:4	0.001	(6.61)	0.00	(0.79)	1,251	0.06

Fourth, we examine the importance of cash flow as a source of financing over time. Finally, we test whether the disappearance of investment-cash flow sensitivity can be explained by increasing levels of cash reserves.

4.1. Evidence of financial constraints in the 2007–2009 financial crisis

Two recent papers point to the existence of financial constraints during the 2007–2009 credit crunch. Campello, Graham, and Harvey (2010) survey 1,050 Chief Financial Officers (CFOs) to directly assess whether their firms were credit constrained during the global financial crisis in 2008. Among the U.S. firms, 43% report that their companies' operations were not affected by difficulties in accessing the credit markets, 37% report that they were somewhat affected, and 20% report that they were very affected. Firms that report "very affected" have planned deeper cuts in technology spending, employment, and capital spending. Of the "very affected" U.S. CFOs, 86% say their investments in *attractive* projects were restricted during the credit crisis in 2008. More than half of the respondents say that they canceled or postponed their planned investments.

Almeida, Campello, Laranjeira, and Weisbenner (2009) find that firms whose long-term debt was largely maturing immediately after the third quarter of 2007 reduced investment by 2.5% more (on a quarterly basis) than otherwise similar firms whose debt was scheduled to mature well after 2008.

4.2. R&D-cash flow sensitivity for firms with positive cash flows

Brown and Petersen (2009) also note that investment-cash flow sensitivity has significantly declined up to 2006. However, they argue that R&D is an important form of investment that is typically not included in the traditional measure of investment. They find that R&D-cash flow sensitivity remains comparatively strong, particularly for firms with positive cash flows.

To test whether the disappearance of investment-cash flow sensitivity is simply due to the fact that firms have shifted their investment from physical investment to R&D, we now examine the time-series property of R&D-cash flow sensitivity after the end of the sample period in Brown and Petersen (2009). In particular, we examine R&D-cash flow sensitivity during the credit crunch, first for all firms, and then for firms with positive cash flows only.

We use the quarterly Compustat Xpressfeed data from 2005 to 2009, although our results are essentially the same if we work with annual data. Following Brown and Petersen (2009), we now scale R&D (xrdq) by total assets, because R&D is not included in physical capital. In some cases, a firm reports its annual R&D in one quarter, while reporting zero or missing R&D in other quarters in that year. We delete such cases for our analysis. We also scale cash flow by total assets and use market-to-book assets as q for consistency. After we prepare the data, we demean all variables by firm to remove the firm fixed effects for manufacturing firms. We then estimate the following regression in each quarter:

$$\frac{RD_{it}}{TA_{it-1}} = \beta_0 + \beta_1 \times q_{it-1} + \beta_2 \times \frac{CF_{it}}{TA_{it-1}} + \varepsilon_{it}. \quad (3)$$

The results are plotted in Fig. 3. The left panel plots R&D-cash flow sensitivity for all firms. In each quarter from 2007 to 2009, R&D-cash flow sensitivity is negative and mostly statistically significant. The right panel plots R&D-cash flow sensitivity for firms with positive cash flows. In nine out of 12 quarters from 2007 to 2009, R&D-cash flow sensitivities are slightly negative. In the remaining three quarters, R&D-cash flow sensitivities are positive; however, they are all statistically insignificant, with the highest t-stat being 0.87. They are also economically insignificant, with the highest coefficient being 0.03.

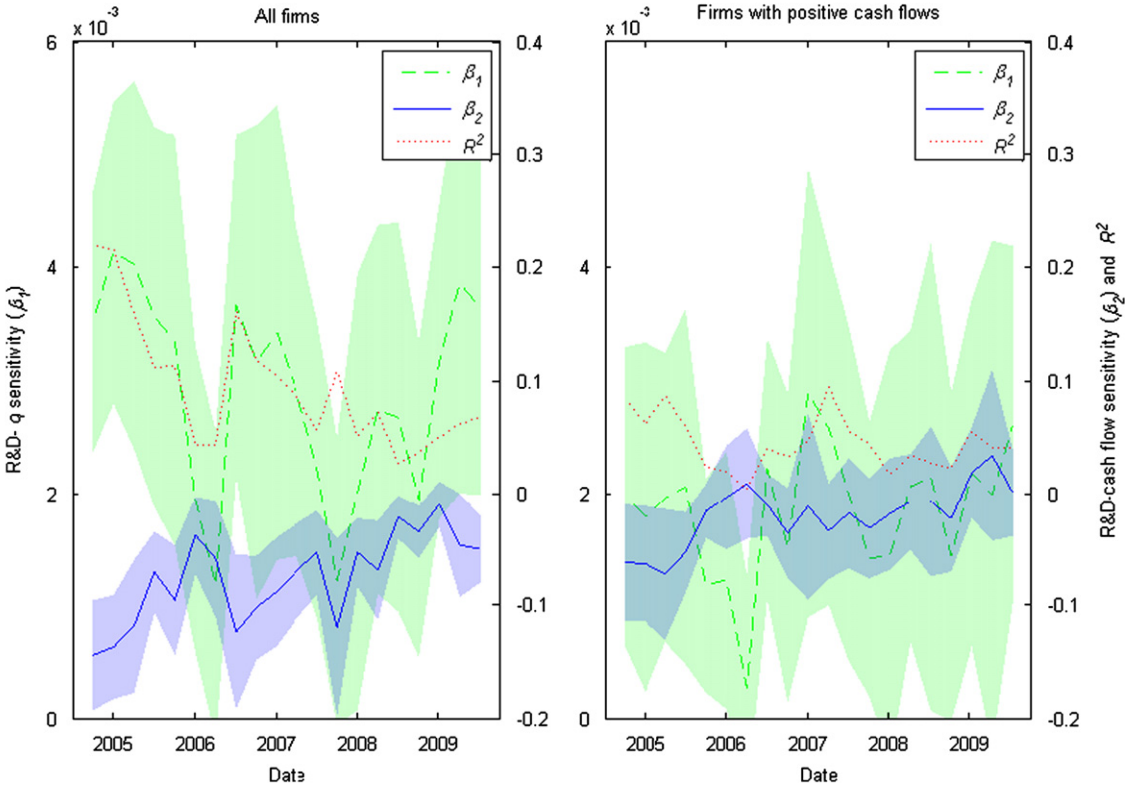

Fig. 3. R&D-cash flow sensitivity in the 2007–2009 credit crunch. R&D-q sensitivity (plotted against the left axes) and R&D-cash flow sensitivity (plotted against the right axes) are the estimated coefficients β_1 and β_2 in the regression of R&D on Tobin's q and cash flow: $RD_{it}/TA_{it-1} = \beta_0 + \beta_1 \times q_{it-1} + \beta_2 \times CF_{it}/TA_{it-1} + \varepsilon_{it}$. RD_{it}/TA_{it-1} is the firm's research and development expenses, RD_{it}, deflated by its beginning-of-period total assets, TA_{it-1}. q_{it-1} is the market-to-book assets ratio in the previous period. CF_{it}/TA_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period total assets, TA_{it-1}. All variables are demeaned by firm to remove the firm fixed effects. A cross-sectional regression is then estimated in each quarter between 2005 and 2009. The sample consists of all U.S. manufacturing firms in the Compustat Xpressfeed fundamental quarterly data set. Shaded areas indicate 95% confidence intervals. Standard errors are heteroskedasticity consistent. The left panel plots results for all firms. The right panel plots results for firms with positive cash flows.

The evidence shows that R&D-cash flow sensitivity has also disappeared, even for firms with positive cash flows. In untabulated results, we find the same pattern for total-investment-cash flow sensitivity, in which total investment includes both physical investment and R&D. We thus conclude that the rising importance of R&D and negative cash flows cannot save investment-cash flow sensitivity as a valid measure of financial constraints.

4.3. Evidence from sorts by dividends and firm age

One piece of evidence that supports the view that investment-cash flow sensitivities measure financial constraints is that the sensitivity seems to be correlated with other proxies of financial constraints. For example, Fazzari, Hubbard, and Petersen (1988) find that investment-cash flow sensitivities are higher among firms with lower dividends. Oliner and Rudebusch (1992) find that sensitivities are higher among younger firms. We now examine whether these relations still hold in our data set. We acknowledge that sorting by dividends is problematic because dividends are endogenous (see Blinder, 1988). We nonetheless perform the analysis based on dividends for comparability with the rest of the literature.

We measure the dividend capital ratio as the ratio of dividends (21) plus repurchases (115+change in 56) to the value of net PPE. We define low dividend firms as those with dividend capital ratios of less than 0.1 in each of the five years in one subsample period. The remaining firms are classified as high dividend firms. We estimate investment-cash flow sensitivity for each group and each five-year subsample period. The results are presented in Panel A of Table 3. Investment-cash flow sensitivity is higher for low dividend firms than for high dividend firms in the early part of the sample. Between 1967 and 1971, investment-cash flow sensitivity is 0.50 for low dividend firms and 0.36 for high dividend firms. However, investment-cash flow sensitivity has disappeared for both groups of firms in the last five years; between 2002 and 2006, investment-cash flow sensitivity is essentially zero for both low dividend and high dividend firms.

We also sort firms by their age. We define the firm age as the difference between the current year and the first year that a firm enters the Compustat database. We define young firms as those whose age is in the bottom tercile. Remaining firms are classified as old firms. We estimate investment-cash flow sensitivity for each group and each five-year subsample period. The results are presented in Panel B of Table 3. Between 1967 and 1971, investment-cash flow sensitivity is 0.43 for young firms and 0.35 for old firms. Between 2002 and 2006, investment-cash flow sensitivity has declined to zero and 0.01, respectively.

Thus, our results show that investment-cash flow sensitivity is no longer related to measures such as dividends or firm age. It has disappeared in firms with low and high dividends, and in firms young and old.

In unreported tables, we examine how investment-cash flow sensitivities have changed over time in small and large firms, and in firms with and without credit ratings. As do EW (2000), we find that in the early years, OLS investment-cash flow sensitivities are lower in firms that are smaller and without credit ratings, evidence against the sensitivity as a good measure of financial constraints. We further find that investment-cash flow sensitivity has also disappeared among small and large firms, and in firms with and without credit ratings.

Table 3
Investment-cash flow sensitivity by dividends and firm age.

This table reports coefficients estimated from regression of investment on Tobin's q and cash flow: $I_{it}/K_{it-1}=\alpha_i+\alpha_t+\beta_1\times q_{it-1}+\beta_2\times CF_{it}/K_{it-1}+\varepsilon_{it}$. I_{it}/K_{it-1} is the firm's capital expenditure, I_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous year's Tobin's q. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. The sample consists of all U.S. manufacturing firms in Compustat. Firm and year fixed effects are included but unreported. Standard errors are heteroskedasticity consistent and clustered at the firm level. p-Values are for the null hypothesis that the coefficients are the same between the first (1967–1971) and the last (2002–2006) subsample periods. In Panel A, firms are classified into the low dividend group if its dividends plus repurchases, divided by capital, is less than 0.1 in each of the five years in a subsample period. All other firms are in the high dividend group. In Panel B, young firms refer to firms with age in the bottom terciles, and old firms refer to all other firms.

	q_{it-1}	t-Stat	CF_{it}/K_{it-1}	t-Stat	Obs.	R^2
Panel A: Sort by dividends						
Low dividend						
1967–1971	0.014	(4.80)	0.50	(8.88)	2,220	0.55
1972–1976	0.016	(5.27)	0.30	(10.95)	4,190	0.50
1977–1981	0.029	(4.90)	0.29	(9.45)	3,660	0.60
1982–1986	0.035	(10.07)	0.14	(6.73)	3,085	0.56
1987–1991	0.022	(6.24)	0.07	(5.22)	2,810	0.51
1992–1996	0.010	(5.01)	0.07	(5.95)	3,415	0.54
1997–2001	0.005	(3.24)	0.04	(3.64)	2,745	0.55
2002–2006	0.006	(7.19)	0.01	(1.49)	2,615	0.56
p-Value	0.0088		0.0000			
High dividend						
1967–1971	0.009	(5.84)	0.36	(13.21)	4,229	0.60
1972–1976	0.008	(5.12)	0.24	(11.13)	4,645	0.54
1977–1981	0.014	(4.79)	0.26	(13.74)	5,052	0.64
1982–1986	0.023	(9.19)	0.12	(7.03)	6,066	0.61
1987–1991	0.019	(11.84)	0.06	(5.76)	6,186	0.63
1992–1996	0.013	(14.26)	0.03	(4.51)	6,827	0.72
1997–2001	0.005	(11.96)	0.01	(2.40)	8,818	0.64
2002–2006	0.006	(13.93)	0.00	(0.37)	7,137	0.67
p-Value	0.0213		0.0000			
Panel B: Sort by age						
Young						
1967–1971	0.010	(4.32)	0.43	(9.24)	2,017	0.74
1972–1976	0.011	(5.31)	0.24	(9.37)	2,930	0.60
1977–1981	0.022	(4.09)	0.28	(9.30)	2,811	0.68
1982–1986	0.024	(8.19)	0.10	(4.63)	2,862	0.65
1987–1991	0.021	(10.76)	0.06	(5.19)	3,083	0.66
1992–1996	0.013	(11.32)	0.02	(2.56)	3,540	0.75
1997–2001	0.006	(11.76)	0.01	(1.97)	4,009	0.73
2002–2006	0.005	(10.55)	−0.00	(−0.18)	3,428	0.70
p-Value	0.0375		0.0000			
Old						
1967–1971	0.010	(4.81)	0.35	(10.77)	4,432	0.57
1972–1976	0.009	(4.66)	0.28	(14.06)	5,905	0.51
1977–1981	0.017	(5.11)	0.25	(14.23)	5,901	0.60
1982–1986	0.023	(7.10)	0.14	(7.01)	6,289	0.57
1987–1991	0.016	(6.90)	0.06	(5.07)	5,913	0.56
1992–1996	0.011	(7.93)	0.05	(6.25)	6,702	0.62
1997–2001	0.005	(6.29)	0.01	(2.07)	7,554	0.57
2002–2006	0.007	(11.14)	0.01	(2.06)	6,324	0.65
p-Value	0.0939		0.0000			

4.4. Time-series variation of the volume of external financing

According to Fazzari, Hubbard, and Petersen (1988), financial constraints could come in the form of credit rationing. Under the credit rationing scenario, even when the apparent costs of debt and equity are low, firms can still be financially constrained if they cannot actually borrow or issue new equities. This kind of difficulty in external financing should be reflected in new issue activity of debt and equity. Less credit rationing should be reflected in more new issue activity. We now examine whether there is an increasing trend in new issue activity of debt and equity over time.

We measure the new debt issues, *Newdebt*, as the aggregate change in total debt (Compustat item 181), scaled by total assets. The new equity issues, *Newequity*, is the aggregate change in total equity (the sum of common stock (85), capital surplus (210), and preferred stock (130)), scaled by total assets. We construct *Newdebt* and *Newequity* from the Compustat FTP annual data using all nonfinancial firms.

Fig. 4 plots the time series of new issue activities. In 1967, new debt issuances account for 5.33% of total assets. In 2006, new issuances of debt only account for 2.44% of total assets. The declining trend of the new debt issue activity is statistically significant. New equity issuances account for 1.39% of total assets in 1967 and 1.12% in 2006. There is no statistically significant trend in the new equity issue activity over time. Because there is no increasing trend in new issue activity, the data do not support the view that the decline of investment-cash flow sensitivity is driven by lessening of credit rationing.

4.5. Has cash flow become an unimportant source of financing?

One possibility is that cash flow has become a less important source of financing compared to equity and debt financing. As a result, firms no longer rely on internal cash flow as a significant source of financing. To test this possibility, we calculate the percentage of investment that is financed by internal cash flow or external financing (debt and equity) in each of the three industries and eight subsample periods. Debt financing is measured as the change in total debt, and equity financing is measured as the change in total equity, which is the sum of common stock, capital surplus, and preferred stock.

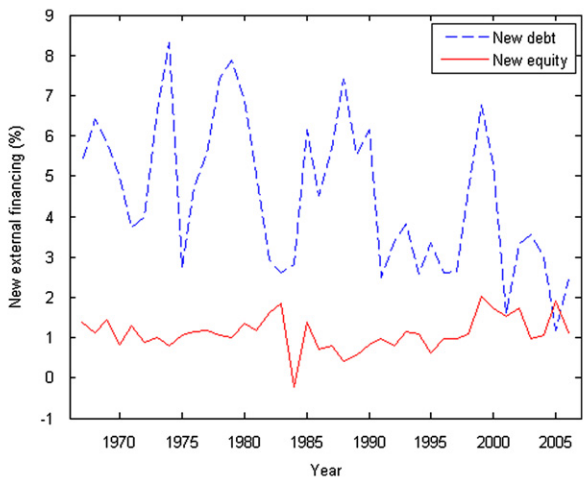

Fig. 4. New issue activity. *Newdebt* refers to the aggregate change in total debt, scaled by total assets. *Newequity* is the aggregate change in total equity (the sum of common stock, capital surplus, and preferred stock), scaled by total assets. *Newdebt* and *Newequity* are constructed from the annual Compustat data using all nonfinancial firms between 1967 and 2006.

Table 4 presents the relative weights of three financing sources. We find that all three industry groups rely heavily on internal cash flow for financing. While the percentage of cash flow as a source of financing has declined slightly for the durable goods industries (from 60% between 1967 and 1971 to 52% between 2002 and 2006), the percentages of internal cash flow have increased for both the nondurable goods (from 65% between 1967 and 1971, to 71% between 2002 and 2006) and the high-tech industries (from 60% between 1967 and 1971, to 65% between 2002 and 2006). On the other hand,

Table 4
Sources of financing.
This table reports the percentage of financing from internal cash flow, debt, and equity in each industry and time period. Internal cash flow is calculated as the sum of depreciation and amortization and the income before extraordinary items in Compustat. External financing includes debt financing (changes in total debt) and equity financing (changes in total equity, which is the sum of common stock, capital surplus, and preferred stock). We report the percentage of each financing source over the three sources of financing combined. U.S. manufacturing firms in Compustat are divided into three industry groups. Firms are classified into the high-tech industries if their three-digit SIC codes are 283, 357, 366, 367, 382, or 384. A firm is in the durable goods industries if it is not in the high-tech industries and the first two digits of its SIC code are between 24 and 25, or between 32 and 38, inclusive. A firm is in the nondurable goods industries if it is not in the high-tech industries and the first two digits of its SIC code are between 20 and 23, or between 26 and 31, inclusive.

Industry group	Time period	Cash flow (%)	Debt (%)	Equity (%)	External (%)
Durable goods	1967–1971	60.42	33.14	6.45	39.58
	1972–1976	64.70	32.46	2.84	35.30
	1977–1981	57.23	36.89	5.88	42.77
	1982–1986	59.68	31.83	8.49	40.32
	1987–1991	42.18	53.76	4.06	57.82
	1992–1996	50.74	42.41	6.85	49.26
	1997–2001	51.63	42.13	6.23	48.37
	2002–2006	51.99	42.57	5.44	48.01
Nondurables	1967–1971	65.38	29.19	5.44	34.62
	1972–1976	63.50	34.05	2.44	36.50
	1977–1981	62.59	35.38	2.03	37.41
	1982–1986	70.62	25.45	3.93	29.38
	1987–1991	66.04	30.00	3.96	33.96
	1992–1996	72.49	23.20	4.30	27.51
	1997–2001	66.68	27.25	6.07	33.32
	2002–2006	70.52	24.20	5.28	29.48
High-tech	1967–1971	59.50	30.40	10.09	40.50
	1972–1976	63.31	31.34	5.36	36.69
	1977–1981	61.40	31.86	6.73	38.60
	1982–1986	57.02	32.41	10.56	42.98
	1987–1991	57.05	35.55	7.40	42.95
	1992–1996	56.61	33.74	9.64	43.39
	1997–2001	54.50	25.68	19.83	45.50
	2002–2006	65.26	18.68	16.06	34.74

investment-cash flow sensitivity has essentially disappeared for all three industries. Therefore, we conclude that cash flow remains an important source of financing, and that changes in the importance of cash flow for financing cannot explain why investment-cash flow sensitivity has declined over time and disappeared in recent years.

4.6. Are firms spending out of cash reserves instead of cash flow now?

Bates, Kahle, and Stulz (2009) show that U.S. industrial firms now hold much greater cash reserves. Thus, it is possible that firms are still financially constrained but now finance their investments from their cash reserves rather than from cash flow. We study the time-series patterns of investment-cash reserve sensitivity and investment-cash flow sensitivity.

We estimate the following regression:

$$\frac{I_{it}}{K_{it-1}} = \alpha_i + \alpha_t + \beta_1 \times q_{it-1} + \beta_2 \times \frac{Cash_{it}}{K_{it-1}} + \beta_3 \times \frac{CF_{it}}{K_{it-1}} + \varepsilon_{it}, \qquad (4)$$

where $Cash_{it-1}/K_{it-1}$ represents the firm's cash and short-term investments (Compustat data item 1) in the previous year scaled by net PPE. The variables q_{it-1} and CF_{it}/K_{it-1} are defined as in Eq. (1). We estimate Eq. (4) for manufacturing firms for each of the five-year subsample periods from 1967 to 2006.

The results are reported in Table 5. The coefficient on $Cash_{it-1}/K_{it-1}$ is 0.11 between 1967 and 1971 but declines to 0.02 between 2002 and 2006. Consistent with our earlier results, investment-cash flow sensitivity declines from 0.34 in the first five-year subsample period to 0.01 in the last five-year subsample period. Investment-cash flow sensitivities are largely the same with or without controlling for the level of cash reserves. Thus, we conclude that cash reserves are unlikely to explain why investment-cash flow sensitivity has declined and disappeared.

Taken together, the tests we perform provide strong time-series evidence against the validity of investment-cash flow sensitivity as a measure of financial constraints.

5. Why has investment-cash flow sensitivity disappeared?

We test several possible explanations for the disappearance of investment-cash flow sensitivity. Specifically, we test whether the disappearance can be driven by changes in the composition of firms in our sample, corporate governance, market power, measurement errors in Tobin's q, or the information content of cash flow regarding investment opportunities.

5.1. Sample composition

One possible reason for the decline in investment-cash flow sensitivity is that the sample composition changes over time. New firms enter the sample in the later periods, and perhaps they differ from firms in the earlier sample. We use balanced panels to test whether new entrants are driving the result. We select three 20-year balanced panels and one 40-year balanced panel. A firm is included in a balanced panel only if it exists in every year of the 20- or 40-year sample periods. We then divide the sample periods into five-year subsample periods and estimate Eq. (1) for each.

Table 6 presents the results. The first panel covers the balanced panel from 1967 to 1986. This balanced panel has 437 manufacturing firms (2,185 observations in each five-year period). The cash flow sensitivity is 0.47 between 1967 and 1971 and declines to 0.10 between 1982 and 1986. The difference between these two numbers is highly significant. The second balanced panel covers the period from 1977 to 1996 and comprises 516 manufacturing firms. The cash flow sensitivity declines

Table 5
Investment-cash reserve sensitivity and investment-cash flow sensitivity.

This table reports coefficients estimated from regression of investment on Tobin's q, the cash to capital ratio, and the cash flow to capital ratio:

$$\frac{I_{it}}{K_{it-1}} = \alpha_i + \alpha_t + \beta_1 \times q_{it-1} + \beta_2 \times \frac{Cash_{it}}{K_{it-1}} + \beta_3 \times \frac{CF_{it}}{K_{it-1}} + \varepsilon_{it}.$$

I_{it}/K_{it-1} is the firm's capital expenditure, I_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous year's Tobin's q. $Cash_{it-1}/K_{it-1}$ is the firm's cash and short-term investments in the previous year, scaled by net property, plant, and equipment. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. The sample consists of all firms that are in the manufacturing industry in Compustat. Firm and year fixed effects are included but unreported. Standard errors are heteroskedasticity consistent and clustered at the firm level. p-Values are for the null hypothesis that the coefficients are the same between the first (1967–1971) and the last (2002–2006) subsample periods.

	q_{it-1}	t-Stat	$Cash_{it-1}/K_{it-1}$	t-Stat	CF_{it}/K_{it-1}	t-Stat	Obs.	R^2
1967–1971	0.009	(6.66)	0.11	(5.97)	0.34	(13.52)	6,447	0.59
1972–1976	0.008	(5.67)	0.09	(6.55)	0.23	(13.58)	8,833	0.54
1977–1981	0.017	(5.80)	0.07	(5.28)	0.25	(15.33)	8,712	0.62
1982–1986	0.019	(9.70)	0.08	(8.95)	0.11	(8.54)	9,151	0.61
1987–1991	0.016	(11.64)	0.05	(8.35)	0.05	(6.91)	8,995	0.62
1992–1996	0.008	(9.79)	0.05	(10.90)	0.04	(6.26)	10,242	0.71
1997–2001	0.003	(7.93)	0.04	(11.57)	0.02	(5.51)	11,563	0.66
2002–2006	0.004	(9.67)	0.02	(10.06)	0.01	(1.50)	9,751	0.67
p-Value	0.0001		0.0000		0.0000			

Table 6
Investment-cash flow sensitivity in balanced panels.

This table reports coefficients estimated from regression of investment on Tobin's q and cash flow: $I_{it}/K_{it-1} = \alpha_i + \alpha_t + \beta_1 \times q_{it-1} + \beta_2 \times CF_{it}/K_{it-1} + \varepsilon_{it}$. I_{it}/K_{it-1} is the firm's capital expenditure, I_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous year's Tobin's q. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. The regression is estimated in three 20-year balanced panels from 1967 to 2006 and one 40-year balanced panel. Within each balanced panel, the sample period is divided into five-year subsample periods. The sample consists of all manufacturing firms in Compustat. Firm and year fixed effects are included but unreported. Standard errors are heteroskedasticity consistent and clustered at the firm level. p-Values are for the null hypothesis that the coefficients are the same between the first and the last subsample periods.

	q_{it-1}	t-Stat	CF_{it}/K_{it-1}	t-Stat	Obs.	R^2
Panel 1						
1967–1971	0.007	(3.14)	0.47	(9.27)	2,185	0.55
1972–1976	0.007	(3.70)	0.30	(8.78)	2,185	0.50
1977–1981	0.018	(3.94)	0.23	(5.95)	2,185	0.54
1982–1986	0.022	(4.56)	0.10	(3.42)	2,185	0.61
p-Value	0.0072		0.0000			
Panel 2						
1977–1981	0.013	(2.52)	0.25	(4.88)	2,580	0.57
1982–1986	0.017	(4.88)	0.19	(7.65)	2,580	0.52
1987–1991	0.014	(3.41)	0.09	(4.15)	2,580	0.47
1992–1996	0.010	(2.34)	0.09	(3.88)	2,580	0.53
p-Value	0.6772		0.0037			
Panel 3						
1987–1991	0.014	(2.79)	0.11	(3.80)	1,705	0.51
1992–1996	0.011	(3.62)	0.10	(3.74)	1,705	0.55
1997–2001	0.006	(4.16)	0.07	(3.33)	1,705	0.52
2002–2006	0.008	(4.20)	0.05	(3.46)	1,705	0.60
p-Value	0.2997		0.0508			
Panel 4						
1967–1971	0.011	(2.45)	0.45	(6.75)	660	0.60
1972–1976	0.006	(2.63)	0.31	(3.48)	660	0.52
1977–1981	0.002	(0.34)	0.26	(3.50)	660	0.58
1982–1986	0.024	(2.40)	0.19	(2.44)	660	0.49
1987–1991	−0.006	(−0.69)	0.19	(2.76)	660	0.45
1992–1996	0.006	(0.71)	0.12	(1.56)	660	0.59
1997–2001	0.007	(4.34)	0.13	(3.71)	660	0.65
2002–2006	0.008	(5.08)	0.02	(1.53)	660	0.66
p-Value	0.5628		0.0000			

from 0.25 between 1977 and 1981 to 0.09 between 1992 and 1996. The difference between these two numbers is again significant with a p-value of less than 0.01. The third balanced panel covers the period from 1987 to 2006 and has fewer (341) manufacturing firms. This decrease in sample size is probably due to increased delisting activity in this sample period. Investment-cash flow sensitivity also declines, from 0.11 between 1987 and 1991 to 0.05 between 2002 and 2006. The difference is close to being statistically significant (with p-value slightly greater than 0.05). The lack of statistical significance is probably because investment-cash flow sensitivity is small to begin with in the early part of the balanced panel.

The fourth balanced panel covers the entire sample from 1967 to 2006. Because we require that firms have data in each of the 40 years, this balanced panel has only 132 manufacturing firms. The cash flow sensitivity is 0.45 between 1967 and 1971 and declines to 0.02 between 2002 and 2006. Investment-cash flow sensitivity in the last subsample period is economically and statistically insignificant.

Regardless of the periods spanned, all four balanced panels show declines of investment-cash flow sensitivity. In the 2002 to 2006 period, investment-cash flow sensitivity is 0.05 (for the 20-year balanced panel) or 0.02 (for the 40-year balanced panel). These numbers are essentially zero and only marginally higher than those estimated for the entire sample. Thus, we conclude that changes in the composition of firms in our sample cannot explain why investment-cash flow sensitivity has declined and disappeared.

5.2. Changes in corporate governance

One possible cause for investment-cash sensitivity is the empire building incentive of managers (free cash flow problem). We therefore test whether the decline and disappearance of investment-cash flow sensitivity are due to improvement in corporate governance over time. To test this hypothesis, we follow Gompers, Ishii, and Metrick (2003) and Bebchuk, Cohen, and Ferrell (2009) to construct G-index and E-index and then estimate investment-cash flow sensitivities in firms with high or low indices over time. The data are available from 1990 to 2006. Because the data are relatively sparse, we now use all nonfinancial firms with corporate governance indices. The results are reported in Table 7. A firm is classified as having poor governance if the firm has a G-index no less than 11 (Panel A) or an E-index no less than four (Panel B). A firm is classified as having good governance if the firm has a G-index less than 11 (Panel A) or an E-index less than four (Panel B). We estimate investment-cash flow sensitivity in five-year panels, except the first period, in which we only have two years: 1990 and 1991.

The results show that investment-cash flow sensitivity has declined and disappeared across firms with poor or good corporate governance over time. When we use the G-index, investment-cash flow sensitivity in firms with poor governance declines from 0.05 between 1990 and 1991 to 0.01 between 2002 and 2006. It declines in firms with good corporate governance from 0.08 to 0.01. When we use the E-index, investment-cash flow sensitivity in firms with poor governance declines from 0.07 between 1990 and 1991 to 0.02 between 2002 and 2006. It declines in firms with good governance from 0.08 to 0.01. More importantly, in the early years, firms with poor corporate governance exhibit investment-cash flow sensitivities that are lower than or similar to firms with good corporate governance. The evidence does not support the hypothesis that declining investment-cash flow sensitivity is a consequence of improvement in corporate governance.

5.3. Changes in market power

The q theory interpretation of investment-cash flow sensitivity focuses on the wedge between marginal q and average q. Hayashi (1982) shows that constant returns to scale and perfect competition (no market power) imply

Table 7

Investment-cash flow sensitivity by corporate governance indices.

This table reports coefficients estimated from regression of investment on Tobin's q and cash flow: $I_{it}/K_{it-1} = \alpha_i + \alpha_t + \beta_1 \times q_{it-1} + \beta_2 \times CF_{it}/K_{it-1} + \varepsilon_{it}$. I_{it}/K_{it-1} is the firm's capital expenditure, I_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous year's Tobin's q. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. The sample consists of all nonfinancial firms in Compustat. Firm and year fixed effects are included but unreported. Standard errors are heteroskedasticity consistent and clustered at the firm level. p-Values are for the null hypothesis that the coefficients are the same between the first (1990–1991) and the last (2002–2006) subsample periods. A firm is classified as having poor governance if the firm has a G-index no less than 11 (Panel A) or an E-index no less than four (Panel B). A firm is classified as having good governance if the firm has a G-index less than 11 (Panel A) or an E-index less than four (Panel B). Corporate governance indices are constructed from the Investor Responsibility Research Center database and follow Gompers, Ishii, and Metrick (2003) and Bebchuk, Cohen, and Ferrell (2009).

	q_{it-1}	t-Stat	CF_{it}/K_{it-1}	t-Stat	Obs.	R^2
Panel A: Sort by *G*-index						
Poor governance						
1990–1991	0.017	(2.27)	0.05	(1.42)	602	0.82
1992–1996	0.01	(2.69)	0.05	(2.56)	1,825	0.72
1997–2001	0.003	(2.22)	0.03	(0.99)	1,845	0.68
2002–2006	0.006	(5.03)	0.01	(0.51)	2,060	0.79
p-Value	0.1594		0.2631			
Good governance						
1990–1991	0.013	(3.28)	0.08	(2.82)	1,325	0.85
1992–1996	0.012	(5.93)	0.06	(3.81)	3,536	0.74
1997–2001	0.004	(5.47)	0.03	(2.18)	4,281	0.72
2002–2006	0.006	(10.81)	0.01	(1.60)	5,044	0.68
p-Value	0.0707		0.0115			
Panel B: Sort by *E*-index						
Poor governance						
1990–1991	0.043	(1.71)	0.07	(1.30)	359	0.83
1992–1996	0.004	(1.00)	0.05	(2.15)	1,036	0.70
1997–2001	0.004	(0.86)	0.02	(0.69)	1,180	0.68
2002–2006	0.004	(1.60)	0.02	(1.73)	1,551	0.74
p-Value	0.1180		0.3491			
Good governance						
1990–1991	0.012	(3.40)	0.08	(2.87)	1,568	0.85
1992–1996	0.012	(6.42)	0.06	(4.17)	4,325	0.73
1997–2001	0.004	(5.62)	0.03	(2.28)	4,946	0.72
2002–2006	0.006	(11.52)	0.01	(1.13)	5,553	0.69
p-Value	0.0949		0.0088			

the equality of marginal q with average q. Theoretical attempts at explaining investment-cash flow sensitivity have thus examined decreasing returns to scale (Gomes, 2001) and market power (Cooper and Ejarque, 2003; Hennessy and Whited, 2007). We now examine whether changes in market power can explain the decline and disappearance of investment-cash flow sensitivity.

Our following discussion is based on Cooper and Ejarque (2003). In their model, the profit function is $\pi(K,A) = AK^{\alpha}$, where K is capital and A is a measure of profitability. The curvature parameter α captures the market power. If $\alpha = 1$, then marginal q equals average q. In such a case, average q is the sufficient statistic for investment, and all other variables, including cash flow, are irrelevant. When $\alpha < 1$, there is a wedge between marginal q and average q. In such cases, average q is not sufficient for describing investment behavior, and cash flow, modeled as profits in Cooper and Ejarque (2003), plays a role.

An interesting exercise would be to simulate the data based on the model in Cooper and Ejarque (2003) and estimate investment-cash flow sensitivity on the resulting data. We can then examine how investment-cash flow sensitivity varies when the value of market power parameter α varies. In doing so, we would fix all other parameter values as in Cooper and Ejarque (2003). The authors kindly provided us with the results of such an exercise.

The results show that for parameter value of α between 0.1 and 0.9, increasing α has an effect of increasing investment-q sensitivity, increasing investment-cash flow sensitivity, and decreasing average q. For investment-cash flow sensitivity to decline from 0.26 to 0.04, α would need to change from 0.7 to 0.3. In the model, this change implies that average q would have to change from 2.82 to 10.55, and the coefficient of investment on q would have to go from 0.20 to -0.01. In the actual data, average q and the coefficient on q do change over time, but the changes are far smaller in magnitude than those suggested by the simulations. The coefficient on q is still positive and significant at the end of the sample period. More importantly, if changes in market power alone could explain the pattern in the data, a decline in investment-cash flow sensitivity should be accompanied by a decline in the coefficient on q and an increase of average q. Although in the data investment-cash flow sensitivity declines monotonically over time, the patterns in the coefficient on q and average q are not monotonic. First, in the first half of the sample from 1967 to 1986, the coefficient on q is mostly increasing, and average q is mostly decreasing; in the second half, the coefficient on q mostly declines and average q increases. Second, comparing the 2002–2006 period with the 1967–1971 period, we see that the coefficient on q decreases for durable goods and high-tech industries, but increases slightly for nondurable goods industry from 0.003 to 0.005. These observations lead us to believe that change in market power alone cannot explain the decline and disappearance of investment-cash flow sensitivity.

5.4. Measurement error of Tobin's q

If investment-cash flow sensitivity is due to measurement error in Tobin's q, the decline and disappearance of the sensitivity could be explained by the decrease in measurement error in Tobin's q, or the decrease in the information content in cash flow regarding investment opportunities over time, or both.

5.4.1. Changes in measurement error in Tobin's q

We now use Erickson and Whited (2000, 2002) GMM estimators to study whether measurement error can explain the patterns in investment-cash flow sensitivity. We estimate Eq. (2) using the GMM estimation method.[3] EW (2000) provide several different GMM estimators

[3] We thank Toni Whited for providing the estimation codes on her Web site.

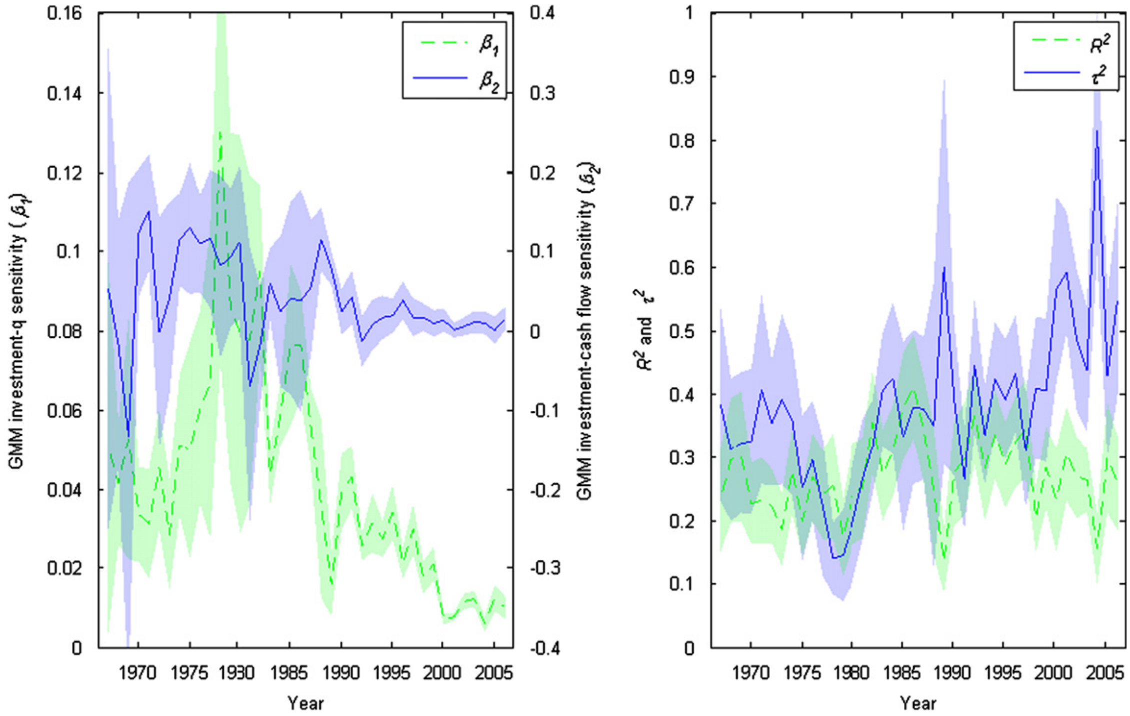

Fig. 5. GMM results. GMM investment-q sensitivity (plotted against the left axis) and GMM investment-cash flow sensitivity (plotted against the right axis) are the estimated coefficients β_1 and β_2 from the Erickson and Whited (2000) GMM5 (using the second to the fifth moments) estimators of investment on Tobin's q and cash flow: $I_{it}/K_{it-1} = \beta_0 + \beta_1 \times q_{it-1} + \beta_2 \times CF_{it}/K_{it-1} + \varepsilon_{it}$. I_{it}/K_{it-1} is the firm's capital expenditure, I_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous year's Tobin's q. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. All variables are demeaned by firm to remove the firm fixed effects. Estimation is done in each year between 1967 and 2006. The sample consists of all manufacturing firms in Compustat. τ^2 (plotted against the right axis) is a measure of the proxy quality of q. Shaded areas indicate 95% confidence intervals.

depending on the number of moments used in the estimation. We report the results using the GMM5 method (utilizing the second through the fifth moments). Unreported GMM4 results are qualitatively the same.

In implementing the GMM estimator, Erickson and Whited (forthcoming) point out that poor choices of starting values for the coefficient on q can lead to local optima and extreme value estimates. To ensure that we have the correct estimates, we start from 17 different starting points.[4] These 17 starting points can lead to more than one estimate (the theoretical upper bound is 17). We require the estimate of the variance of the measurement error to be nonnegative. We then choose the estimate that minimizes the objective function.[5]

Fig. 5 plots the GMM5 estimation results. In comparison with Fig. 2, the GMM coefficients on q are mostly larger and more significant than their OLS counterparts. The GMM coefficients on cash flow are mostly lower than their OLS counterparts and are sometimes not statistically different from zero. However, GMM investment-cash flow sensitivity still shows a pattern somewhat similar to the OLS estimators. Up until 1996, GMM investment-cash flow sensitivities are positive and statistically significant in 13 out of 30 years and are statistically insignificant in the other 17 years. Starting in 1997, GMM investment-cash flow sensitivities have been economically and statistically insignificant, ranging between zero and 0.02. Thus, we conclude that GMM cash flow sensitivities have also declined and disappeared.

The GMM estimator also allows us to examine the measurement proxy quality of q: τ^2. The following discussion is based on EW (2000). Denote x_i as the empirical q, z_i as cash flow, and χ_i as the unobservable true q. EW (2000) assume that

$$x_i = \gamma_0 + \chi_i + \varepsilon_i, \tag{5}$$

where ε_i is the measurement error in q and is independent of z_i and χ_i. τ^2 is the estimated R^2 of Eq. (5) and therefore ranges between zero (proxy for q is complete noise) and one (proxy for q is perfect).

In Fig. 5, τ^2 ranges between 0.14 (in 1978) and 0.81 (in 2004). It exhibits a time trend, increasing from 0.38 in

[4] The 17 starting points for the coefficient on q are: the GMM3 estimate, the two endpoints of the Gini interval (the bounds given by the OLS estimate b and the estimate implied from the reverse regression in Gini (1921)), the arithmetic and geometric means of the two endpoints of the Gini interval, 0.01, 0.02, 0.03, 0.04, 0.05, 0.1, b + 0.01, $2b$, $3b$, $4b$, $5b$, and $6b$.

[5] The requirement on the estimate of the variance of measurement error is only binding in 1967. All estimates lie within the Gini interval, except in 2004. In that year, the coefficient on q is 0.006, while the Gini interval is (0.007, 0.038).

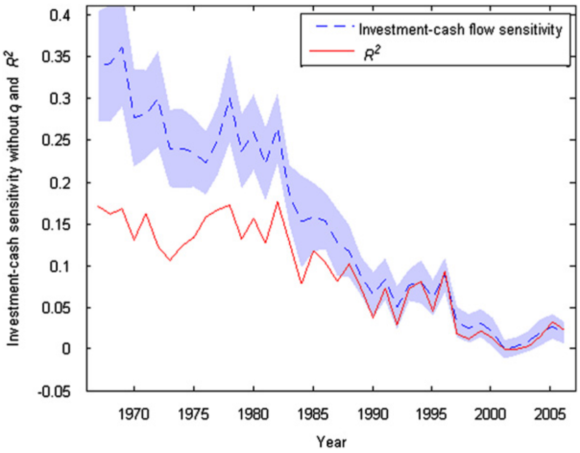

Fig. 6. Investment-cash flow sensitivity without q by year. Investment-cash flow sensitivity without q is the estimated coefficient β_1 from regression of investment on cash flow: $I_{it}/K_{it-1} = \beta_0 + \beta_1 \times CF_{it}/K_{it-1} + \varepsilon_{it}$. I_{it}/K_{it-1} is the firm's capital expenditure, I_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. All variables are demeaned by firm to remove the firm fixed effects. A cross-sectional regression is then estimated in each year between 1967 and 2006. The sample consists of all manufacturing firms in Compustat. The shaded area indicates the 95% confidence interval. Standard errors are heteroskedasticity consistent.

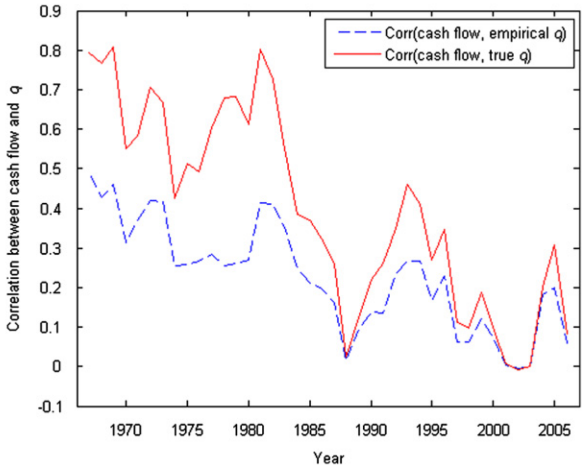

Fig. 7. Correlation between cash flow and q by year. The dashed line plots the correlation between cash flow, CF_{it}/K_{it-1}, and empirical Tobin's q, q_{it-1} in each year between 1967 and 2006. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous year's Tobin's q. The solid line plots the estimated correlation between cash flow and true q, which is equal to the correlation between cash flow and empirical Tobin's q scaled by the square root of τ^2 from Fig. 5. The sample consists of all manufacturing firms in Compustat. Variables are demeaned by firm before computing the correlation.

1967 to 0.55 in 2006. An unreported regression of τ^2 on a linear time trend shows that the increasing trend is statistically significant.[6]

Therefore, it is possible that the decline and disappearance of the sensitivity are explained by the decrease in measurement errors in Tobin's q over time. Further investigation, however, shows that such an explanation is unlikely. When we drop Tobin's q as a control for investment opportunities in Fig. 2, OLS investment-cash flow sensitivity also shows a strong declining and disappearing pattern. The results are reported in Fig. 6. We simply estimate the following regression:

$$\frac{I_{it}}{K_{it-1}} = \beta_0 + \beta_1 \times \frac{CF_{it}}{K_{it-1}} + \varepsilon_{it}. \quad (6)$$

We use all manufacturing firms and estimate the regression in each year between 1967 and 2006. Variables are demeaned to remove firm fixed effects before the estimation of the regression. We find that investment-cash flow sensitivity without controlling for Tobin's q declines steadily from 0.34 in 1967 to 0.02 in 2006. Because the decrease in measurement error does not affect this regression, it cannot be the main driver of the disappearance of investment-cash flow sensitivity.

5.4.2. *Changes in information content in cash flow regarding investment opportunities*

To examine the information content in cash flow of investment opportunities over time, we first examine the correlation between cash flow and Tobin's q. The dashed line in Fig. 7 plots the simple cross-sectional correlation between CF_{it}/K_{it-1} and q_{it-1} in each year between 1967 and 2006. We use all manufacturing firms and demean the variables by firm to remove firm fixed effects, although the simple correlation between cash flow and Tobin's q without demeaning the variables exhibits the same pattern. The correlation shows a striking decline. In the early years, it is highly positive. For example, it is 0.49 in 1967. It steadily declines over time. The correlation is lowest in 2002 when it is -0.01. It is 0.06 in 2006.

Taken literally, the correlation between cash flow and Tobin's q cannot explain the decline and disappearance of investment-cash flow sensitivity, since we do control for Tobin's q in computing investment-cash flow sensitivity. But if the correlation between cash flow and Tobin's q strongly declines, the correlation between cash flow and the true marginal q can also decline over time.

We now provide estimates of the correlations between cash flow and the true marginal q. Using the notations in EW (2000),

$$corr(z_i,\chi_i) = \frac{\mathrm{cov}(z_i,\chi_i)}{\sigma(z_i)\sigma(\chi_i)} = \frac{\mathrm{cov}(z_i,x_i-\varepsilon_i)}{\sigma(z_i)\sigma(x_i)}\frac{\sigma(x_i)}{\sigma(\chi_i)} = \frac{corr(z_i,x_i)}{\sqrt{\tau^2}}.$$

This means that the correlation of cash flow and true q is simply the correlation between cash flow and empirical q scaled by the square root of τ^2. Because we observe a declining trend in the correlation between cash flow and empirical q and an increasing trend in τ^2, we expect that

[6] This result is sensitive to sample selections and model specifications. We find a statistically increasing trend in nondurable goods and high-tech industries, but not in the durable goods industries. We also do not find a statistically increasing trend in τ^2 if we scale all variables by total assets, instead of by capital.

the correlation between cash flow and true q declines over time as well.

The solid line in Fig. 7 shows that this is true. Our estimate for the correlation between cash flow and true q is 0.79 in 1967. It is highest in 1969, 0.81. It declines over time. In 2002, it reaches its lowest value of -0.01. In 2006, it is 0.08. The declining information content in cash flow regarding investment opportunities is consistent with the measurement error view of investment-cash flow sensitivity.[7]

5.4.3. Cash flow persistence over time

What drives the declining correlation between cash flow and Tobin's q? Valuation models suggest that if cash flow becomes less persistent over time, i.e., there is less information in the current cash flow regarding future cash flow, then the correlation between cash flow and q could decline. We thus examine the persistence of cash flow over time.

In particular, we estimate the following model on eight five-year panels between 1967 and 2006 on manufacturing firms:

$$\frac{CF_{it}}{K_{it-1}} = \alpha_i + \alpha_t + \beta_1 \times \frac{CF_{it-1}}{K_{it-2}} + \varepsilon_{it}. \quad (7)$$

The results from the OLS estimation with fixed effects show a declining pattern for cash flow persistence. However, Nickell (1981) points out that the OLS estimation suffers a dynamic panel bias when there are fixed effects with the lagged dependent variable as a regressor. We therefore use the two-step first-differenced GMM developed by Arellano and Bond (1991). The model is estimated using first differences instrumented by all available lagged cash flow to capital ratios in each five-year panel up to year t-2.[8]

The results are plotted in Fig. 8. The shaded area indicates the 95% confidence interval and standard errors account for the finite sample correction in Windmeijer (2005). The results show that the persistence of cash flow has decreased over time. Between 1967 and 1971, the persistence coefficient is 0.63. Between 2002 and 2006, it declines to 0.22. The difference between the persistence coefficients in the 1967–1971 and 2002–2006 panels is statistically significant.

Overall, we find that the measurement-error story fares the best among the explanations we explore. There is evidence that the information content in cash flow regarding investment opportunities has declined over time. The GMM measurement-error-free estimates of investment-cash flow sensitivity are lower than their OLS counterparts and are sometimes zero in the early years. But even the measurement-error-free estimates of investment-cash flow sensitivity also exhibit a declining and disappearing pattern and are mostly positive in the early years. Therefore, we conclude that measurement errors in Tobin's q help but do not completely explain the patterns in investment-cash flow sensitivity.

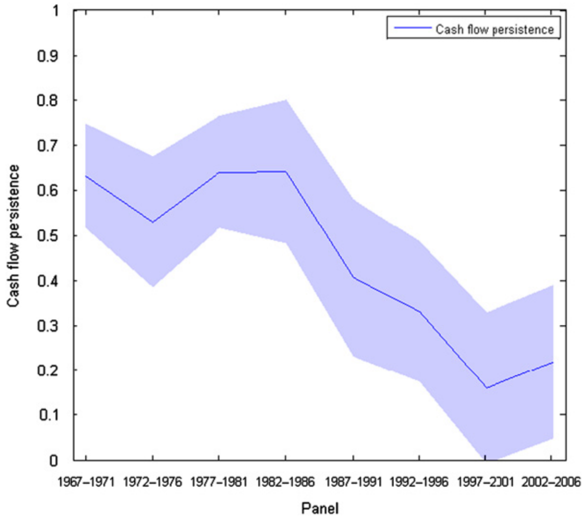

Fig. 8. Persistence in cash flow over time. Persistence in cash flow is the estimated coefficient β_1 in $CF_{it}/K_{it-1} = \alpha_i + \alpha_t + \beta_1 \times CF_{it-1}/K_{it-2} + \varepsilon_{it}$. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. $CF_{it-1}/K_{it-2}\tau^2$ is the cash flow to capital ratio in the previous year. The model is estimated using first differences instrumented by all available lagged dependent variables up to year $t-2$, in each of the eight five-year panels between 1967 and 2006. The sample consists of all manufacturing firms in Compustat. The shaded area indicates the 95% confidence interval and standard errors account for the finite sample correction in Windmeijer (2005).

6. Further robustness tests

Here, we show that investment-cash flow sensitivity has declined and disappeared in nonmanufacturing firms, that inventory investment-cash flow sensitivity has also declined and disappeared in recent years, and that our results are robust to an additional proxy for investment opportunities and alternative scaling variables and measures of Tobin's q.

6.1. Nonmanufacturing firms

Although many earlier studies limit their samples to manufacturing firms, we also study investment-cash flow sensitivity for nonmanufacturing firms. We estimate Eq. (1) for firms that are neither in the manufacturing industry (the first digit of the SIC is two or three), nor in the financial industry (the first digit of SIC equals six). We estimate the regression for each of the five-year subsample periods from 1967 to 2006 and study the pattern of investment-cash flow sensitivity over time.

[7] Interestingly, EW (2000) find that differences in investment-cash flow sensitivities across groups of firms are not due to different levels of measurement quality τ^2. Instead, they are primarily driven by differences in covariance structures between q and cash flow. Our time-series results are consistent with their cross-sectional findings.

[8] To determine the appropriate lags to include in the instrument variables, we first estimate Eq. (7) on the pooled 40-year panel and find that the Arellano-Bond test does not detect any second-order autocorrelation in first differences (p –value = 0.97). We therefore include all available lagged dependent variables in the five-year panel up to year t-2 as our instruments, although we can report that using the lagged variable in year t-2 alone produces qualitatively the same results.

Table 8
Investment-cash flow sensitivity in nonmanufacturing industry.

This table reports coefficients estimated from regression of investment on Tobin's q and cash flow: $I_{it}/K_{it-1} = \alpha_i + \alpha_t + \beta_1 \times q_{it-1} + \beta_2 \times CF_{it}/K_{it-1} + \varepsilon_{it}$. I_{it}/K_{it-1} is the firm's capital expenditure, I_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous year's Tobin's q. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. The sample consists of all firms that are neither in the manufacturing industry, nor in the financial industry in Compustat. Firm and year fixed effects are included but unreported. Standard errors are heteroskedasticity consistent and clustered at the firm level. p-Values are for the null hypothesis that the coefficients are the same between the first (1967–1971) and the last (2002–2006) subsample periods.

	q_{it-1}	t-Stat	CF_{it}/K_{it-1}	t-Stat	Obs.	R^2
1967–1971	0.011	(5.38)	0.34	(8.02)	3,214	0.64
1972–1976	0.006	(4.25)	0.25	(9.66)	6,245	0.59
1977–1981	0.022	(4.28)	0.26	(9.33)	7,049	0.64
1982–1986	0.027	(12.07)	0.12	(7.22)	8,149	0.64
1987–1991	0.022	(12.95)	0.06	(7.17)	8,691	0.67
1992–1996	0.013	(13.05)	0.03	(5.43)	10,201	0.72
1997–2001	0.006	(18.46)	0.00	(0.82)	12,380	0.66
2002–2006	0.005	(14.06)	0.01	(4.81)	10,546	0.67
p-Value	0.0032		0.0000			

The results are reported in Table 8. Investment-cash flow sensitivity declines significantly over time. Between 1967 and 1971, the sensitivity is 0.34. Between 2002 and 2006, the sensitivity declines to 0.01. Although the latter estimate is statistically significant, it is economically small. Thus we conclude that among nonmanufacturing firms, investment-cash flow sensitivity has also declined over time and essentially disappeared in recent years.

6.2. Inventory investment-cash flow sensitivities

Kashyap, Lamont, and Stein (1994) and Carpenter, Fazzari, and Petersen (1994) show that liquidity and internal cash flow also have a major impact on inventory investment. We now study the time-series pattern of inventory investment-cash flow sensitivity of manufacturing firms.

We estimate the following regression:

$$\frac{\Delta INV_{it}}{K_{it-1}} = \alpha_i + \alpha_t + \beta_1 \times q_{it-1} + \beta_2 \times \frac{INV_{it}}{K_{it-1}} + \beta_3 \times \frac{CF_{it}}{K_{it-1}} + \varepsilon_{it}, \tag{8}$$

where $\Delta INV_{it}/K_{it-1}$ is the firm's change in inventory, ΔINV_{it}, deflated by its beginning-of-period capital, K_{it-1}. INV_{it} is the inventory measured as Compustat data item 3 for firm i in year t. q_{it-1} and CF_{it}/K_{it-1} are defined as in Eq. (1). INV_{it-1}/K_{it-1} is the previous year's inventory, scaled by the previous year's capital. We estimate Eq. (8) for each of the five-year subsample periods from 1967 to 2006. In unreported results, we find the OLS estimate of inventory investment-cash flow sensitivity with fixed effects declines from 0.94 between 1967 and 1971 to 0.04 between 2002 and 2006. To address the dynamic panel bias, we use the first-differenced GMM. We find that the Arellano-Bond (1991) test does not detect any second-order autocorrelation in first differences. In each five-year panel, we use as instruments all available lagged dependent variables up to year $t-2$ and all available right-hand side variables up to year $t-1$, that is, $\Delta INV_{is}/K_{is-1}$, INV_{is}/K_{is}, and q_{is}, for s up to $t-2$, and CF_{is}/K_{is-1}, for s up to $t-1$.[9]

The results are reported in Table 9. The coefficients on Tobin's q are mostly positive. The coefficients on the lagged inventory variable are statistically insignificant. Inventory investment-cash flow sensitivity is 0.74 between 1967 and 1971. It monotonically declines across the eight subsample periods. Between 2002 and 2006, inventory investment-cash flow sensitivity declines to only 0.01. We therefore conclude that inventory investment-cash flow sensitivity exhibits similar patterns as investment-cash flow sensitivity and has also disappeared.

6.3. Additional proxy for investment opportunities and alternative scaling variables and measures of Tobin's q

In Jorgenson's (1963) neoclassical investment model, changes in output are important in determining investment demand. Sales reflect the market demand for a firm's product. A profit-driven firm should follow its sales figures closely and make its capital investment decisions accordingly. We therefore include change in sales as another proxy for investment opportunities. We find that all results are qualitatively the same when we include sales growth as another proxy for investment opportunities.

Our main results are remarkably robust to different scaling variables and different methods of constructing Tobin's q. Our results are qualitatively the same in the following settings: (1) when we scale all variables by total assets, instead of capital; (2) when we scale all variables by gross PPE, instead of net PPE; (3) when we follow Fazzari, Hubbard, and Petersen (1988) to construct Tobin's q and scale all variables by the replacement cost of capital; (4) when we follow EW (2000) to construct Tobin's q and scale all variables by the replacement cost of capital; and (5) when we scale all other variables by gross PPE but follow EW (2000) to construct Tobin's q.

7. Conclusion

We study the evolution of investment-cash flow sensitivities since the 1960s. We find that investment-cash flow sensitivity has declined over the entire sample period and has completely disappeared in recent years, even during the 2007–2009 credit crunch. If one believes that financial constraints have not completely disappeared, then investment-cash flow sensitivity cannot be a good measure of financial constraints. We perform further tests to examine whether investment-cash flow sensitivity can be saved as a valid measure. We examine whether the decline in this measure can be explained by the rising importance of R&D and firms with negative cash flows. We examine the relation between investment-cash flow sensitivity and other measures of financial

[9] Note that $\Delta INV_{is}/K_{is-1}$ and INV_{is}/K_{is} contain almost the same information. Dropping either of these two variables as an instrument variable does not change our results.

Table 9
Inventory investment-cash flow sensitivity in manufacturing industry.
This table reports coefficients estimated from regression of inventory investment on Tobin's q, lagged inventory, and cash flow:

$$\frac{\Delta INV_{it}}{K_{it-1}} = \alpha_i + \alpha_t + \beta_1 \times q_{it-1} + \beta_2 \times \frac{INV_{it}}{K_{it-1}} + \beta_3 \times \frac{CF_{it}}{K_{it-1}} + \varepsilon_{it}.$$

$\Delta INV_{it}/K_{it-1}$ is the firm's change in inventory, ΔINV_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. q_{it-1} is the previous year's Tobin's q. INV_{it-1}/K_{it-1} is the previous year's inventory, scaled by the previous year's net property, plant, and equipment. CF_{it}/K_{it-1} is the firm's internal cash flow (depreciation and amortization plus income before extraordinary items), CF_{it}, deflated by its beginning-of-period net property, plant, and equipment, K_{it-1}. The model is estimated using first-differenced GMM in each of the eight five-year panels between 1967 and 2006. The sample consists of all firms that are in the manufacturing industry in Compustat. Standard errors account for the finite sample correction in Windmeijer (2005).

	q_{it-1}	t-Stat	INV_{it-1}/K_{it-1}	t-Stat	CF_{it}/K_{it-1}	t-Stat	Obs.
1967–1971	0.007	(1.24)	0.06	(0.59)	0.74	(6.55)	4,672
1972–1976	0.002	(0.62)	−0.10	(−1.12)	0.69	(7.80)	6,674
1977–1981	−0.022	(−1.82)	0.04	(0.50)	0.48	(7.47)	6,459
1982–1986	0.044	(7.75)	−0.08	(−1.22)	0.23	(4.75)	6,583
1987–1991	0.026	(3.99)	0.02	(0.20)	0.22	(4.48)	6,381
1992–1996	0.010	(3.77)	0.04	(0.39)	0.09	(2.77)	7,201
1997–2001	0.009	(6.18)	0.10	(1.17)	0.08	(4.40)	7,814
2002–2006	0.006	(3.28)	−0.21	(−1.66)	0.01	(0.38)	6,898

constraints over time. We also examine the time-series pattern of the new issue activity. We examine whether the importance of cash flow as a source of financing has decreased over time. Finally, we examine whether the results are driven by increasing levels of cash reserves. Our evidence suggests that investment-cash flow sensitivity is not a good measure of financial constraints, and that future empirical work should not use this variable as a valid proxy for financial constraints.

Why has investment-cash flow sensitivity disappeared? We explore several possibilities but in the end, the disappearance remains puzzling. We find that measurement error in Tobin's q helps explain the decline in investment-cash flow sensitivity, and the information content in cash flow regarding investment opportunities has declined over time. However, measurement error does not completely explain the patterns in investment-cash flow sensitivity. The decline and disappearance are unlikely to be explained by changes in firm composition, improvement in corporate governance, or changes in market power. Future work in this area should be fruitful because a coherent account of why investment-cash flow sensitivities exist in the past and disappear in recent years can only lead to better explanations of investment-cash flow sensitivity and deepen our understanding of firm investment behavior.

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