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Investment–cash flow sensitivity under changing information asymmetry

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ABSTRACT

Empirical studies on whether investments are sensitive to cash flows in imperfect markets often report conflicting results and have been criticized on conceptual and methodological grounds. Our study mitigates some of these problems using a research design that relates changes in investment–cash flow sensitivity to changes in the bid-ask spread measure of information asymmetry surrounding (i) implementation of the Sarbanes-Oxley (SOX) Act and (ii) deregulation of firms in the Transportation, Telecommunication, and Petroleum and Natural Gas industries. Consistent with our hypotheses, we find that information asymmetry decreases following SOX and that there is a corresponding decrease in the investment–cash flow sensitivity, pre- to post-SOX. Further, greater decreases in information asymmetry following SOX are associated with greater decreases in investment–cash flow sensitivity. The results for the deregulation sample are also consistent with our hypothesis, wherein we observe an increase in information asymmetry and corresponding increase in the investment–cash flow sensitivity following deregulation.

1. Introduction

This study revisits the long unresolved question of whether a firm's investments are sensitive to cash flows. The paper attempts to address some of the theoretical and methodological criticisms that have cast doubts on the (often contradictory) conclusions emerging from the vast body of extant empirical work starting with Fazzari et al. (1988; hereafter, FHP, 1988).

The Q model of investments predicts that in perfect capital markets where internal and external funds are perfect substitutes, the investment decision of a firm is solely a function of its investment opportunities and invariant to the firm's cash flow. In imperfect markets, however, the presence of agency and information asymmetry costs creates a wedge between internal and external funds, making the latter more costly. Now firms with low internal funds may invest less than the first-best level. Conventional wisdom then suggests that the more financially constrained the firm, either in terms of (i) capital market imperfections or (ii) its available internal funds, the less it invests and the greater is its investment–cash flow sensitivity.

Most empirical studies of the investment–cash flow sensitivity hypothesis consist of some variation of cross-sectional regressions of investment levels against the firms' cash flows after controlling for their growth opportunity. These regressions are typically carried out on subsamples of firms stratified according to some perceived degree of a priori financial constraints from capital market imperfections or availability of internal funds. Various studies have classified the sample into subgroups with different degrees of financial constraints based on dividend payout rates (FHP, 1988), bond rating (Gilchrist and Himmelberg, 1995), membership in industrial groups or keiretsus (Hoshi et al., 1991), probability of informed trading as a measure of information asymmetry (Ascioglu et al., 2008), institutional ownership and analyst coverage (Ağca and Mozumdar, 2008), investor horizon (Attig et al., 2012), and size. The specific hypotheses tested and supported in these studies are (i) that the coefficient of cash flows is positive on average and (ii), importantly, that the coefficient is significantly larger for the more financially constrained subsample than for the less financially constrained subsample. From the latter finding, the studies implicitly conclude that investment–cash flow sensitivity is a useful measure of financial constraint.

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There is a large and important body of empirical work based on the above methodology that is consistent with the investment–cash flow hypothesis, and there is ongoing interest in this line of research in the literature. However, some potential problems have been identified with the research design used in these studies, including (i) the appropriateness of the proxy measures of market imperfections/information asymmetry used to stratify the sample, (ii) the assumption that the investment–cash flow sensitivity increases monotonically with the degree of financial constraint (see Kaplan and Zingales, 1997; hereafter, KZ, 1997), (iii) the sensitivity of the results to different classification schemes used to stratify samples into more/less financially constrained firms based on capital market imperfection/information asymmetry and availability of internal funds,[3] (iv) the inability of the proxies used in the literature for asymmetric information or internal funds to disentangle the effect of financing constraints from firm-specific effects on the level of investment,[4] and (v) the possibility that the observed investment–cash flow sensitivity result could be due to biases arising out of the measurement errors in Tobin's Q. The impact of the measurement error in Q on the investment–cash flow sensitivity has not been satisfactorily resolved in the literature (Erickson and Whited, 2000, 2002; Cummins et al., 2006; Ağca and Mozumdar, 2012).

A recent study by Cleary et al. (2007; hereafter, CPR, 2007) captures the idea that two otherwise identical firms may face differently severe problems of information asymmetry. The model predicts that investment–cash flow sensitivity is *unambiguously higher* the *greater the asymmetry of information*, the correlation being positive (negative) for positive (negative) cash flow firms. We use this insight of CPR (2007) as the basis for a research design that mitigates some of these theoretical and empirical problems. First, we stratify the sample based on asymmetric information as a measure of the severity of financial constraint. Importantly, we estimate the *change* in investment–cash flow sensitivity resulting from exogenous shocks that decrease or increase the information asymmetry *for the same set of firms* in a time-series framework. The time-series framework surrounding events that change information asymmetry potentially mitigates some of the theoretical and empirical problems identified in the literature. It (i) resolves the monotonicity issue, (ii) more effectively separates the impact of firm-specific factors on investment from the impact of financial constraints by examining differences over time for the same firms, and (iii) results in some of the biases in the coefficients arising from measurement error on the Q variable canceling out since the research design focuses on the differences in the investment–cash flow coefficients. To the extent that the event itself can induce changes in the firm-specific factors and in Q, the corrections from examining differences in the investment–cash flow coefficients over time are partial. Finally, we use the bid-ask spread measure of information asymmetry as our proxy for capital market imperfection/financial constraint. This measure is generally accepted in the market microstructure literature and improves upon the broad proxies such as dividend payout rates used in FHP (1988) and related studies.

We study two events that exogenously impact a firm's information asymmetry. The first is the implementation of the Sarbanes-Oxley Act of 2002 (SOX). We hypothesize that the implementation of SOX, with its requirement of increased disclosures, decreases the information asymmetry between the firm and the market. Accordingly, following CPR (2007), we expect an unambiguous decrease (increase) in the firms' investment–cash flow sensitivity, pre- to post-SOX, for firms with positive (negative) cash flows, with larger changes for subsamples of firms with larger decreases in information asymmetry. Our results are consistent with these hypotheses.

The second exogenous shock we study is the deregulation of industries, which brings about significant changes in the operating and information structure of the firms in the industries. We hypothesize with supporting arguments that deregulation increases the information asymmetry between the firm and the market. Accordingly, we expect an unambiguous increase (decrease) in the firm's investment–cash flow sensitivity, pre- to post-deregulation for positive (negative) cash flow firms, with larger changes for subsamples of firms with larger increases in information asymmetry. We test these hypotheses for positive cash flow firms only because of the small sample size of negative cash flow firms and report results consistent with the hypotheses for positive cash flow firms.

To the best of our knowledge, this is the first paper that examines investment–cash flow sensitivity in a time-series framework surrounding events that exogenously change a firm's information asymmetry. Thus, the primary contributions of the paper are (i) the new research design that mitigates several of the problems outstanding in the literature as discussed above and (ii) the use of bid-ask spread as a direct measure of information asymmetry in testing the investment–cash flow hypothesis, the only paper to do so. Additionally, the paper provides insights into how the SOX regulation and industry deregulation have changed information asymmetry between the firm and the investors. Such changes have obvious and important implications on the decisions of corporations and investors.

The rest of the paper is organized as follows. Section 2 describes the research design and hypotheses of the study. Section 3 presents the empirical analyses and results for the SOX and deregulation events, respectively. Section 4 presents the results of several robustness tests, and Section 5 concludes the paper.

2. Research design and hypotheses

The main result of the CPR (2007) model is that for a given level of information asymmetry, a firm's investments are a U-shaped function of internal funds that reconciles the conflicting results of FHP (1988) and KZ (1997). In an extension of their model, CPR (2007) examine the U-shaped investments-internal funds function for high and low information asymmetry firms. The extended model predicts that when firms have positive internal funds, in the right segment of the U-curve, "*greater asymmetry of information should be associated with greater sensitivity of investments to changes in internal funds*." For sufficiently negative internal funds, in the left segment of the U-curve, the model predicts that the investment–cash flow sensitivity will still be higher, the higher the information asymmetry, but the correlation is now negative. The basis of our research design is the empirical prediction of the CPR (2007) model that with changing information asymmetry, the investment–cash flow sensitivity will *unambiguously* increase (decrease) with increases in information asymmetry for positive (negative) cash flow firms.

Previous empirical tests of the investment–cash flow sensitivity have typically used panel data to estimate the following cross-sectional regressions for subsamples of firms stratified by the perceived degree of a priori financial constraints, either based on proxy measures of capital market imperfection (FHP, 1988; and others) or availability of internal funds (KZ, 1997; and others):

$$\frac{I_{i,t}}{K_{i,t-1}} = \alpha + \beta_1\, Tobin's\, Q_{i,t} + \beta_2 \frac{CF_{i,t}}{K_{i,t-1}} + \varepsilon_{i,t} \quad \text{(R1)}$$

[3] See Fazzari et al. (1988), Kaplan and Zingales (1997), Cleary (1999), Allayannis and Mozumdar (2004).

[4] See Kaplan and Zingales (1997).

where,

I = Investments,

K = Capital stock,

Tobin's Q is a measure of the firm's investment opportunities,

CF = Cash flow.

The investment–cash flow hypothesis is then considered supported if the coefficient β_2 is significantly positive and higher in the subsamples that are perceived to be a priori more financially constrained.

In Section 1, we pointed out several problems with such an empirical design, as discussed in the literature. Our research design attempts to correct for some of these problems. We stratify the sample based on information asymmetry measured as the bid-ask spread as a proxy of the severity of financial constraint. Further, we test for time-series changes in the investment–cash flow sensitivity resulting from an exogenous change in information asymmetry. Accordingly, we estimate Eq. (R1) for the same set of firms in the pre- and post-event periods around the exogenous change in information asymmetry and test for the changes in investment–cash flow sensitivity.

We examine two events that exogenously impact a firm's information asymmetry: (i) the implementation of SOX, which is expected to reduce information asymmetry, and (ii) deregulation, which is expected to increase information asymmetry. Our primary hypotheses for the two information asymmetry-changing exogenous events are as follows.

2.1. Event: SOX

The Sarbanes-Oxley Act came into force in 2002 and introduced significant changes in the quality and extent of public firms' disclosures. It is arranged into eleven titles, of which Sections 302, 401, 404, 409, and 802 pertain specifically to improved and increased disclosure. For example, Sections 302 and 401 require the financial reports to be "accurate" and not contain "any material untrue statements or material omissions." Sections 302 and 404 require the issuer to publish information regarding "the scope and adequacy of the internal control systems" and make the signing officers responsible for them. Section 409 requires disclosures of information on "material changes in the financial conditions or operations of the firm on an urgent basis." Finally, Section 802 stipulates penalties of fines and/or imprisonment for "falsifying records." We argue that the Sarbanes-Oxley Act, with its increased and improved disclosure requirement, is expected to reduce information asymmetry, leading to the following hypotheses:

H1.a: Information asymmetry decreases following SOX, on average.

H1.b: The investment–cash flow sensitivity decreases following SOX for positive cash flow firms, on average:

$$\text{Coefficient } \beta_2 \text{ (post-SOX)} < \text{Coefficient } \beta_2 \text{ (pre-SOX)}$$

and increases for negative cash flow firms, on average:

$$\text{Coefficient } \beta_2 \text{ (post-SOX)} > \text{Coefficient } \beta_2 \text{ (pre-SOX)}.$$

H1.c: A greater decrease in information asymmetry following SOX is associated with a greater decrease in investment–cash flow sensitivity, pre- to post-SOX.

2.2. Event: Deregulation

We examine the deregulation of three industries: (i) Transportation (Fama-French industry code 40), (ii) Telecommunication (Fama-French industry code 32), and (iii) Petroleum and Natural Gas (Fama-French industry code 31). The deregulation of the Railroads and Trucking, Airlines, Cable Television, Crude Oil, and Natural Gas industries all involved elimination of entry/exit restrictions or price decontrol. For example, the Airline Deregulation Act of 1978 was aimed at reducing entry restrictions and fare controls. The Railroad Revitalization and Regulatory Reforms Act of 1976 (4R Act) allowed some flexibility to railroads to adjust rail rates. The Natural Gas Policy Act of 1978 called for gradual decontrol of new gas prices. It also began loosening entry and exit restrictions. In general, free entry and exit accompanied by the elimination of price controls is expected to lead to a more competitive and uncertain business environment, which in turn is expected to increase the information asymmetry between the managers and investors, leading to the following hypotheses:

H2.a: Information asymmetry increases following industry deregulation, on average.

H2.b: The investment–cash flow sensitivity increases following deregulation for positive cash flow firms, on average:

$$\text{Coefficient } \beta_2 \text{ (post-deregulation)} > \text{Coefficient } \beta_2 \text{ (pre-deregulation)}$$

and decreases for negative cash flow firms, on average:

$$\text{Coefficient } \beta_2 \text{ (post-deregulation)} < \text{Coefficient } \beta_2 \text{ (pre-deregulation)}.$$

H2.c: A greater increase in information asymmetry following deregulation is associated with a greater increase in investment–cash flow sensitivity, pre- to post-deregulation.

3. Empirical analysis

This section presents the empirical analysis of the tests of Hypotheses H1 and H2 pertaining to SOX and deregulation as the respective events changing the information asymmetry.

3.1. Methodology and data

The methodology used to test the hypotheses and the data measurements are common to both events.

3.1.1. Methodology

3.1.1.1. Test of hypotheses H1.a and H2.a. To test the hypotheses that information asymmetry decreases or increases following the implementation of SOX or deregulation, respectively, we test for the sign and significance of the change in measures of information asymmetry pre- to post-event. Our primary measure of information asymmetry derived from the market microstructure literature is the firm's bid-ask spread.[5] We estimate bid-ask spreads from daily high and low prices based on the methodology of Corwin and Schultz (2011). Further, to test whether the significant decrease or increase in bid-ask spread following SOX or deregulation is necessarily attributable to the events, we estimate regressions of the bid-ask spread against the event dummy variable and three control variables—(i) trading volume (liquidity), (ii) market value of equity (size), and (iii) Tobin's Q (growth)—that may affect the bid-ask spread.

[5] We repeated our analyses using two other measures of information asymmetry, the standard deviation of market model residual and the ratio of market model residual variance to total variance of market returns. The results are qualitatively similar.

3.1.1.2. Test of hypotheses H1.b and H2.b. We estimate two sets of regressions for the positive and negative cash flow subsamples for the SOX event and for the positive cash flows only for the deregulation event. The first regression, specified as R1 above, estimates the basic specification separately for the pre- and post-event periods. A significantly lower (higher) β_2 in the post-SOX period for the positive (negative) cash flow subsamples, respectively, is consistent with H2.a, and a significantly higher β_2 in the post-deregulation period for the positive cash flow sample is consistent with hypothesis H2.b.

In the second regression, we estimate a pooled regression of the panel data, including interaction terms between the event dummy variable (=1 for the post-event period) and the independent variables in an "all unrestricted" specification:

$$\frac{I_{it}}{K_{it-1}} = \alpha + \beta_1\, Tobin's\, Q_{it} + \beta_2 \frac{CF_{it}}{K_{it-1}} + \beta_3\, Event_{Dum} + \beta_4\, Event_{Dum} * \frac{CF_{it}}{K_{it-1}} + \beta_5\, Event_{Dum} * Tobin's\, Q_{it} + \varepsilon_{it} \quad \text{(R2)}$$

A significantly negative (positive) β_4 for the positive (negative) cash flow SOX subsamples, respectively, is consistent with hypothesis H1.b, and a significantly positive β_4 for the deregulation sample is consistent with hypothesis H2.b.

It is possible that pooling the data may deflate the standard error of the coefficients because of time-series dependence of observations for each firm, thereby overstating their significance. The standard panel data approach of including firm fixed effect to control for time dependence across firm-specific observations may not be feasible since we have only three data points for the three years of data for each firm. Instead, to control for dependence among these three data points, we calculate the time-series mean of the variables for every firm and then estimate a regression with each firm having one data point pre- and post-event. We also carry out a Chow Fisher *F* test for a structural shift in the regression attributable to just the change in the cash flows, pre- to post-event. To do so, we re-estimate a third regression with all variables unrestricted except the cash flow variable in an "all but cash flow unrestricted" specification. The Chow Fisher *F* statistic is then calculated using the residual sum of squares from the "all unrestricted" specification (R2) and the "all but cash flow unrestricted" specification.

3.1.1.3. Test of hypotheses H1.c and H2.c. To test the hypotheses that a greater change in information asymmetry pre- to post-event is associated with a greater change in investment–cash flow sensitivity, we create three subsamples based on the terciles of changes in the estimated bid-ask spread. We estimate separate regressions of specification R2 for the top and bottom terciles and compare coefficient β_4 across the two subsamples. A finding that the decrease in investment–cash flow sensitivity is larger in the top tercile with the greatest reduction in information asymmetry would be consistent with Hypothesis H1.c for SOX. A finding that the increase in investment–cash flow sensitivity is larger in the top tercile with the greatest increase in information asymmetry would be consistent with Hypothesis H2.c for deregulation.

3.1.2. Data

3.1.2.1. Variable measurement. The data are obtained from COMPUSTAT, and the variables for the regression specifications R1 and R2 are defined and measured as in KZ (1997).[6] *Investment (I)* is the annual capital expenditure (COMPUSTAT item CAPX). *Capital stock (K)* is net property, plant, and equipment, or PP&E (COMPUSTAT item PPENT). *Tobin's Q* is the market value of assets divided by the book value of assets. Market value of assets is the sum of the book value of assets (COMPUSTAT item AT) plus market value of equity (product of COMPUSTAT item CSHO and COMPUSTAT item PRCC_F) minus the sum of the book value of common equity (COMPUSTAT item CEQ) and deferred taxes (COMPUSTAT item TXDB). *Cash flow (CF)* is the sum of income before extraordinary items (COMPUSTAT item IBC) and depreciation (COMPUSTAT item DP).

[6] Following FHP (1988), we also scale the variables by total assets. The results are qualitatively similar.

3.2. Event: SOX

This section presents the empirical analysis of the tests of Hypotheses H1.a, H1.b, and H1.c pertaining to the implementation of SOX as the event that changes the information asymmetry. We test all the hypotheses on the positive and negative cash flow subsamples.

3.2.1. Sample and descriptive statistics

Our base sample of firms for the SOX event consists of all US firms listed on NYSE, AMEX, or NASDAQ that are present in CRSP and COMPUSTAT for each of the years pre-and post-SOX. The event year is 2002. The pre-event years are 1999, 2000, and 2001, and the post-event years are 2003, 2004, and 2005. We exclude financial companies (SIC 6000–6999) and utility companies (SIC 4900–4999) to exclude possible effects of regulation on the analysis. We also exclude firms with assets less than $75 million, as SOX does not apply to these firms. Our sample of all firms consists of 1681 firms in the pre-SOX period and 1730 firms in the post-SOX period as more firms came into compliance with SOX. The number of firms common to both periods is 1610. The regression results reported in this paper are for all firms in the pre- and post-event periods, to avoid survivorship bias. The results are qualitatively similar for the common set of firms.

To test Hypothesis H1.b, we stratify the primary sample into subsamples of positive and negative cash flow firms. We calculate the mean cash flow of each firm over three years for the pre- and the post-event periods. If the mean cash flow of a firm is positive (negative) for the pre- or post-event period, the firm is classified as a positive (negative) cash flow firm for that period. We identify 1468 positive cash flow firms in the pre-event period, 1481 in the post-event period, and 1300 firms that had positive cash flows in both periods. For the negative cash flow firms, the corresponding numbers are 213, 249, and 105, respectively. Again, our reported regression results are for all positive and negative cash flow firms in the pre- and post-event periods. The (unreported) results are somewhat stronger for the common set of 1300 positive cash flow firms and 105 negative cash flow firms.

A problem encountered in most studies in the SOX literature is the difficulty in identifying a control group of comparable firms that are not affected by SOX, since the Act is applicable to almost all US-listed firms. The absence of a control group is particularly problematic in studies related to the market reaction to or returns from SOX, as it becomes difficult to isolate the impact of SOX from the effect of the prevailing market trends and other confounding events surrounding the implementation of SOX. Zhang (2007), in her study on the market reaction around key SOX events, attempts to isolate the impact of SOX by (i) controlling for confounding news events, (ii) adjusting the US market returns by subtracting returns of the foreign markets in Canada, Europe, and Asia, and (iii) estimating abnormal US market returns from a market model with foreign returns. She reports that her main result of a negative market reaction to SOX is robust to these adjustments. Further, the problem is less severe in our study since we are examining changes pre- to post-SOX for largely the entire population of firms. Finally, for the deregulation event, we have a control firm for every sample firm and report results consistent with our hypotheses.

Table 1
Descriptive statistics: SOX.

	Pre		Post		Difference (Post − Pre)	
	Mean	Median	Mean	Median	Mean	Median
Panel A: All firms						
I_{it}/K_{it-1}	0.35	0.25	0.25	0.19	−0.10	−0.04
					(0.00)	(0.00)
Tobin's Q	2.36	1.64	1.88	1.51	−0.52	−0.09
					(0.00)	(0.00)
CF_{it}/K_{it-1}	0.14	0.32	0.25	0.32	0.15	0.01
					(0.01)	(0.09)
Total assets (millions)	2607.88	534.4	3241.84	748.97	633.96	214.57
					(0.00)	(0.00)
Bid-ask spread	0.73%	0.61%	0.39%	0.31%	−0.35%	−0.29%
					(0.00)	(0.00)
N	1681	1681	1730	1730	1610	1610
Panel B: Positive cash flow firms						
I_{it}/K_{it-1}	0.31	0.23	0.24	0.19	−0.07	−0.03
					(0.00)	(0.00)
Tobin's Q	2.13	1.55	1.83	1.49	−0.35	−0.04
					(0.00)	(0.00)
CF_{it}/K_{it-1}	0.64	0.38	0.66	0.40	0.01	0.01
					(0.67)	(0.16)
Total assets (millions)	2829.39	659.35	3584.62	894.27	755.23	234.92
					(0.00)	(0.00)
Bid-ask spread	0.69%	0.58%	0.34%	0.29%	−0.35%	−0.29%
					(0.00)	(0.00)
N	1468	1468	1481	1481	1300	1300
Panel C: Negative cash flow firms						
I_{it}/K_{it-1}	0.58	0.42	0.30	0.18	−0.29	−0.22
					(0.00)	(0.00)
Tobin's Q	3.96	3.11	2.14	1.63	−1.94	−1.17
					(0.00)	(−0.01)
CF_{it}/K_{it-1}	−3.33	−1.22	−2.22	−0.62	0.79	0.56
					(0.26)	(0.01)
Total assets (millions)	1081.26	185.69	1203.03	278.92	0.09	0.01
					(0.18)	(0.32)
Bid-ask spread	1.05%	0.94%	0.65%	0.56%	−0.37%	−0.29%
					(0.00)	(0.00)
N	213	213	249	249	105	105

The sample includes firms that are listed on NYSE, AMEX, or NASDAQ for which data are available on CRSP and COMPUSTAT, excluding financials, utilities, and firms with total assets less than $75 million. The event is the enactment of the Sarbanes-Oxley Act in 2002. Pre is the three-year period (1999, 2000, and 2001) prior to the event, and Post is the three-year period (2003, 2004, and 2005) after the event. The variables reported here are three-year averages of the Pre and Post periods. Investment (I_{it}) is defined as the capital expenditure for the fiscal year. Cash flow (CF_{it}) is calculated as the sum of earnings before extraordinary items and depreciation. Both investment and cash flow are deflated by capital (K_{it-1}), which is the net property, plant, and equipment (PP&E), at the beginning of the fiscal year. Tobin's Q is calculated as the market value of total assets divided by the book value of total assets, where market value of total assets is the sum of the book value of total assets and market value of equity minus the sum of the book value of common equity and balance sheet value of deferred taxes. Market value of equity is the product of number of shares outstanding and price per share at the fiscal year end. Bid-ask spread is calculated for each year using the methodology of Corwin and Schultz (2011). The *p*-values (in parentheses) for the mean are from bootstrapped *t*-tests. The *p*-values (in parentheses) for the median are for the Wilcoxon signed-rank test. Panel A presents the results for all firms in the sample, while Panels B and C present the results for firms that have positive and negative average cash flows, respectively, for the two periods.

3.2.1.1. Descriptive statistics. In Table 1 we report the means and the medians of investment, Tobin's Q, cash flow, and total assets for the pre- and post-SOX periods for the total sample of firms (Panel A), for the positive cash flow subsample (Panel B), and negative cash flow subsample (Panel C). The sample mean and median values in columns 1 through 4 are for the three-year averages of the variables in the pre- and post-years. Columns 5 and 6 report the mean and median values of the differences between the pre- and post-values for the firms for which data were available in both periods. For the median values of the differences, we report the *p*-value from the nonparametric Wilcoxon signed-rank test in column 6. Since the distribution of differences is likely to be non-normal, violating the assumptions of the standard *t*-test, we bootstrap a distribution of sample means and report the bootstrapped *p*-value for the means in column 5.

From Panels A, B, and C of Table 1, the mean (median) investment decreases significantly pre- to post-SOX for all three samples. In each case the decrease in investment is consistent with the reported decrease in growth opportunity as measured in Tobin's Q. The decline in Q and investments likely reflects the weakening economy and concerns about the efficacy of corporate governance that led to the implementation of SOX. The change in cash flow is significantly positive for the total sample largely from the cash flow increase (recovery) in the negative cash flow subsample. We report no significant change in the cash flow variable for the positive cash flow subsample. Finally, the median size (total assets) of the positive cash flow subsample is about three times larger than that of the negative cash flow subsample.

3.2.2. Results

3.2.2.1. Results for hypothesis H1.a. In Panels A, B and C of Table 1, we also report the bid-ask spread measure of information asymmetry pre- and post-SOX for the total sample, for the subsample of positive cash flow firms, and for the subsample of negative cash flow firms, respectively. We document a large and significant decline in the spread for all three samples. For the sample of all

Table 2
Regression results of bid-ask spread on the SOX dummy and control variables.

	Panel A: Positive cash flow firms			Panel B: Negative cash flow firms		
	Pre	Post	Pooled	Pre	Post	Pooled
Intercept	0.0105	0.0059	0.0099	0.0118	0.0118	0.0131
	(15.98)	(17.40)	(26.10)	(6.07)	(6.52)	(9.42)
SOX_Dum			−0.0033			−0.003
			(−16.91)			(−4.22)
Log(*Me*)	−0.0006	−0.0004	−0.0005	−0.0003	−0.0008	−0.0006
	(−5.23)	(−7.84)	(−8.15)	(−0.99)	(−2.79)	(−2.54)
Trading Vol	−0.0001	−0.0001	−0.0001	−0.0003	−0.0004	−0.0003
	(−2.03)	(−1.62)	(−2.73)	(−1.36)	(−0.97)	(−1.74)
Tobin's Q	0.0000	0.0002	0.0001	0.0002	0.0001	0.0002
	(0.23)	(2.19)	(0.78)	(1.02)	(0.35)	(1.33)
N	1433	1480	2913	209	248	457
R^2	0.023	0.041	0.116	0.016	0.033	0.066

Bid-ask spread is the dependent variable and is calculated on a yearly basis using the methodology of Corwin and Schultz (2011). Tobin's Q is the market value of assets divided by the book value of assets. Market value of assets is the sum of the book value of assets and market value of equity minus the sum of the book value of common equity and balance sheet deferred taxes. Market value of equity is the product of number of shares outstanding and price per share at the fiscal year end. *Me* is a three-year average of daily price per share multiplied by shares outstanding for the pre- and post-SOX periods. Trading Vol is the ratio of the number of shares traded divided by the number of shares outstanding. Trading Vol is calculated daily and averaged over the pre- and post-event periods. The numbers used in the regression analysis are three-year averages based on pre- and post-event periods. The event is SOX, and the event year is 2002. Pre is the period three years prior to the event, 1999, 2000, and 2001. Post is the three years after the event, 2003, 2004, and 2005. SOX_Dum is 0 for the pre-SOX period and 1 for the post-SOX period. Every firm has one observation for the Pre period and Post period each, the average of the Pre and the Post period, respectively. The numbers in parentheses are the *t*-statistics.

firms, the decline in the spread is about 48%. Coates (2007), drawing from Jain et al. (2006), reports a comparable 40% decline in quoted spreads, pre-SOX to 270 days after, with "qualitatively similar results for effective spreads (reflecting actual trade) as well as the portion of the spreads related to likely adverse selection." We also address the concern that the large drop in the bid-ask spread could be the result of the decimalization of the prices, which began in August 2000 and was fully implemented by April 2001. We re-estimate the spreads for the pre- and post-event periods using (i) only the data for 2001 and 2003 and (ii) only the data for April–Dec. 2001 and April–Dec. 2003. The declines in the spreads for these two periods are 33% and 35%, respectively. Thus, the decline in the spreads continues to be large and significant using only the post-decimalization data. Also, using the shorter 9-month and one-year estimation windows mitigates some of the concerns of confounding events surrounding SOX.

From the regression results in Table 2, we confirm that our documented result of a significant decrease in bid-ask spread following SOX is indeed attributable to the SOX event. After controlling for (i) trading volume (liquidity), (ii) the market value of equity (size), and (iii) Tobin's Q (growth) as other determinants of bid-ask spread, we report a significantly negative coefficient for the SOX dummy for positive and negative cash flow firms.

Overall, the empirical evidence is consistent with hypothesis H1.a that the increased and improved firm disclosure required by SOX has reduced the information asymmetry between the firm and the investors.

3.2.2.2. Results for hypothesis H1.b. Hypothesis H1.b predicts that the decrease in information asymmetry following the implementation of SOX is associated with a decline in investment–cash flow sensitivity for positive cash flow firms and an increase in the sensitivity for negative cash flow firms. Panels A and B of Table 3 report the regression estimates of the model specifications R1 and R2 described in Sections 2 and 3.1.1 for the positive and negative cash flow subsamples, respectively. We estimate the first specification, R1, separately in the pre- and post-SOX period and test for the significance of the change in β_2. From columns 1 and 2 of Panel A, the coefficient β_2 declines from 0.13 to 0.09. The decline is statistically significant, as evidenced by the significantly negative coefficient β_4 of the SOX dummy–cash flow interaction term (with a *t*-statistic of −5.32) in the estimate of the "all unrestricted" specification R2. The Chow Fisher *F* statistic of 27.98 is significantly positive, suggesting a structural shift from the cash flow variable alone. Panel B reports an increase in β_2 from −0.04 to −0.02 and a significantly positive coefficient β_4 of the SOX dummy-cash flow interaction term (with a *t*-statistic of 3.00) in the pooled regression for the negative cash flow subsample. The results from these regression estimates are consistent with Hypothesis H1.b of a declining investment–cash flow sensitivity post-SOX for positive cash flow firms and increasing investment–cash flow sensitivity post-SOX for negative cash flow firms, on average.

An ongoing criticism of the cross-sectional regressions used in the studies on investment–cash flow sensitivity is that measurement errors in Q could lead to biased coefficients. We expect some of these concerns to be mitigated in our time-series approach surrounding exogenous shocks to information asymmetry. Although our hypotheses are based on the difference in investment–cash flow sensitivity coefficient, pre- to post-event, canceling out some of the biases in the coefficient estimates from measurement errors in Q, the correction is by no means complete. The traditional Tobin's Q, measured as a firm's market-to-book ratio, may be subject to error to the extent that the market overvalues or undervalues the firm. To address this problem, we include an estimate of such misvaluation based on Dong et al. (2012) as a control variable in the regression for the positive cash flow subsample. Dong et al. (2012) estimate the intrinsic value of a firm's equity (*V*) using the residual income model. Misvaluation is then defined as *E*/*V*, where *E* is the market value of equity.

In unreported results we document that the results are qualitatively similar with an added control variable for misvaluation. The coefficient β_4 of the cash flow variable interacted with the SOX dummy is significantly negative with a *t*-statistic of −3.57 in the "all unrestricted" specification R2, and the Chow Fisher *F* statistic is significant. Thus, Hypothesis H1.b is supported after controlling for the misvaluation.

3.2.2.3. Results for hypothesis H1.c. Tests of Hypothesis H1.b report that the investment–cash flow sensitivity decreases pre- to post-SOX, on average, for positive cash flow firms, consistent with the SOX-induced decrease in information asymmetry. In

Table 3
Regression results of investment on cash flow and Tobin's Q: SOX.

	Panel A: Positive cash flow firms			Panel B: Negative cash flow firms		
	Pre	Post	Pooled	Pre	Post	Pooled
Intercept	0.12	0.11	0.12	0.22	0.06	0.22
	(12.47)	(13.27)	(14.41)	(4.23)	(1.72)	(5.14)
Tobin's Q	0.05	0.04	0.05	0.05	0.09	0.05
	(13.64)	(9.58)	(15.76)	(5.30)	(6.48)	(6.44)
CF_{it}/K_{it-1}	0.13	0.09	0.13	−0.04	−0.02	−0.04
	(17.94)	(17.50)	(20.73)	(−6.06)	(−3.55)	(−7.36)
SOX_Dum			−0.01			−0.16
			(−0.62)			(−2.67)
SOX_Dum × CF_{it}/K_{it-1}			−0.05			0.03
			(−5.32)			(3.00)
SOX_Dum × Tobin's Q			−0.01			0.04
			(−1.53)			(1.92)
Chow Fisher *F* test	27.98			8.81		
	(0.00)			(0.00)		
N	1468	1481	2949	213	249	462
R^2	0.342	0.280	0.336	0.282	0.265	0.339

The sample includes firms that are listed on NYSE, AMEX, or NASDAQ for which data are available on CRSP and COMPUSTAT, excluding financials, utilities, and firms with total assets less than $75 million. The event is the enactment of the Sarbanes-Oxley Act in 2002. Pre is the three-year period (1999, 2000, and 2001) prior to the event, and Post is the three-year period (2003, 2004, and 2005) after the event. Investment (I_{it}) is defined as the capital expenditure for the fiscal year. Cash flow (CF_{it}) is calculated as the sum of earnings before extraordinary items and depreciation. Both investment and cash flow are deflated by capital (K_{it-1}), which is the net property, plant, and equipment (PP&E), at the beginning of the fiscal year. Tobin's Q is calculated as the market value of total assets divided by the book value of total assets, where market value of total assets is the sum of the book value of total assets and market value of equity minus the sum of the book value of common equity and balance sheet value of deferred taxes. Market value of equity is the product of number of shares outstanding and price per share at the fiscal year end. SOX_Dum is 0 for the Pre period and 1 for the Post period. The numbers used in the regressions are the averages of the variables for the three years in the Pre and Post periods, respectively. The numbers in parentheses are the *t*-statistics. The number in parentheses for the Chow Fisher *F*-statistic is the corresponding *p*-value. Panel A presents the results for firms with positive average cash flows, and Panel B presents the results for firms with negative average cash flows for the respective periods.

Table 4
Tercile regressions of investment on cash flow and Tobin's Q for positive cash flow firms: SOX.

	First tercile			Third tercile			First vs. third
	Pre	Post	Pooled	Pre	Post	Pooled	
Panel A: Bid-ask spreads							
Mean	0.90%	0.23%		0.44%	0.44%		
Mean difference	−0.67%			−0.01%			
	(0.00)			(0.66)			
Median	0.79%	0.19%		0.37%	0.37%		
Median difference	−0.58%			−0.01%			
	(0.00)			(0.42)			
Panel B: Regression results							
Intercept	0.13	0.14	0.13	0.13	0.13	0.13	
	(6.73)	(9.96)	(8.27)	(7.63)	(8.06)	(8.71)	
Tobin's Q	0.05	0.04	0.05	0.04	0.01	0.04	
	(5.58)	(5.28)	(6.85)	(6.22)	(1.60)	(7.10)	
CF_{it}/K_{it-1}	0.15	0.05	0.15	0.12	0.12	0.12	
	(8.74)	(6.27)	(10.75)	(9.82)	(13.33)	(11.20)	
SOX_Dum			0.01			−0.00	
			(0.46)			(−0.10)	
SOX_Dum × CF_{it}/K_{it-1}			−0.09			0.00	
			(−5.06)			(0.08)	
SOX_Dum × Tobin's Q			−0.01			−0.03	
			(−0.70)			(−2.63)	
Chow Fisher *F* test	25.45			0.01			
	(0.00)			(0.94)			
Chow Fisher *F* test							15.97
							(0.00)
N	434	434	868	434	434	868	
R^2	0.275	0.189	0.271	0.319	0.330	0.338	

The event is SOX, and the event year is 2002. Pre is the three years prior to the event. Post is the three years after the event. Tercile1 includes the positive cash flow firms with the largest decline in information asymmetry (bid-ask spread), and tercile 3 includes the positive cash flow firms with the smallest decline in information asymmetry. Terciles are based on firms that are common in both the Pre and Post periods. Bid-ask spread is calculated for each year using the methodology of Corwin and Schultz (2011). In panel A, the numbers reported are three-year averages of bid-ask spreads based on the Pre and Post periods and the difference between the Post and Pre periods. The corresponding *p*-values (in parentheses) are of the bootstrapped *t*-tests for mean difference and Wilcoxon signed-rank test for the median. In panel B, investment (I_{it}) is the capital expenditure and is the dependent variable. Cash flow (CF_{it}) is the sum of earnings before extraordinary items and depreciation. Both investment and cash flow are deflated by capital (K_{it-1}), which is net property, plant, and equipment (PP&E), at the beginning of the fiscal year. Tobin's Q is the market value of assets divided by the book value of assets. SOX_Dum is 0 for the pre-SOX period and 1 for the post-SOX period. The numbers in parentheses are the *t*-statistics. The number in parentheses for the Chow Fisher test is the corresponding *p*-value. We test whether the interaction term of SOX_Dum with cash flow is significantly different between the first and third terciles using the Chow Fisher test. The *F* statistic and the corresponding *p*-value for that are reported in the last column of the table.

Hypothesis H1.c we test whether larger decreases in information asymmetry are associated with larger decreases in investment–cash flow sensitivity. We divide our sample of firms into terciles based on changes in the bid-ask spread measure of asymmetric information pre- to post-SOX and estimate the regressions for the top and bottom tercile. The top, tercile 1, consists of firms with the largest declines in information asymmetry, and the bottom, tercile 3, has firms with the smallest declines. The test is carried out on the larger subsample of positive cash flow firms. Hypothesis H1.c is supported if the decrease in investment–cash flow sensitivity is significantly greater for tercile 1 than for tercile 3.

Panel A of Table 4 reports the declines in information asymmetry, pre- to post-SOX, for terciles 1 and 3, and Panel B presents the regression estimates of the specification R1 and the "all unrestricted" specification R2 for the two terciles. The information asymmetry declines more in tercile 1 than in tercile 3 by design.[7] Importantly, the reduction in investment–cash flow sensitivity is statistically significant ($\beta_4 = -0.093/t = -5.06$) for the top tercile and significantly larger (F statistic of 15.97) than the statistically insignificant change in sensitivity for the bottom tercile ($\beta_4 = -0.00/t = 0.08$). Overall, our results show that a greater decrease in information asymmetry following SOX is associated with a greater decrease in investment–cash flow sensitivity, pre- to post-SOX, which is consistent with Hypothesis H1.c.[8]

3.3. Event: Deregulation

This section presents the empirical analysis of the tests of Hypotheses H2.a, H2.b, and H2.c pertaining to deregulation as the event that changes information asymmetry. In this analysis we test all the hypotheses on the positive cash flow subsample since the sample of negative cash flow firms, at 20, is small.

3.3.1. Sample, control and descriptive statistics

Our sample includes firms from deregulated industries within three broad industry classifications: (i) Transportation (Fama-French industry code 40), (ii) Telecommunication (Fama-French industry code 32), and (iii) Petroleum and Natural Gas (Fama-French industry code 30). We identify the first major deregulation event for the industry as the event year (0). The pre-deregulation period is defined as years −3, −2, and −1, and the post-deregulation period as years +1, +2, and +3. For the transportation group, the event years for the railroad industry and the airline industry are 1976 and 1978, respectively, with the introduction of the Railroad Revitalization and Regulatory Reforms Act of 1976 and Airlines Deregulation Act of 1978. For the telecommunication group, the event year for the cable television industry is 1979, with the elimination of price controls on pay channels. For the petroleum industry, 1979 is the event year, with the introduction of the Administrative Decontrol Plan of crude oil price. For the natural gas industry, the event year is 1978, with the enactment of the 1978 Natural Gas Policy.

In order to control for changes in informational asymmetry and cash-flow sensitivity that may have occurred for all firms during this period, we create a matched control sample of non-deregulated firms for each of our sample firms. The matching is done based on Tobin's Q, cash flow, and size (total assets), the three variables that affect investments. We form deciles of the sample firms based on the values of these three variables as of the year prior to our event year. The largest size and largest cash flow deciles are further subdivided into two subgroups to obtain a better match. Thus, the total sample of all firms is grouped into 1210 portfolios based on the size (11 portfolios), cash flow (11 portfolios), and Tobin's Q (10 portfolios). Each firm in the deregulated industry is assigned to one of these 1210 portfolios based on the cutoffs of Tobin's Q, cash flow, and size as of the year prior to the deregulation event. Similarly, all the potential non-deregulated control firms are assigned to one of those 1210 portfolios for every year. For every sample firm, there are one or more potential control firms. We select the control firm that has the lowest standardized distance from the sample firm based on Tobin's Q, cash flow, and size. Our final sample consists of 148 deregulated firms with positive cash flows, and 20 with negative cash flows in the pre-deregulation period. Only 108 positive cash flow firms survive in the post-deregulation period. Thirteen firms were delisted because of bankruptcy or failure to meet the requirements of the exchange or stopped trading for unknown reasons. Another 27 either merged with or were acquired by other firms. Our analysis in this section is carried out on 148 deregulated and matched non-deregulated control firms in the pre-event period and 108 deregulated and matched non-deregulated control firms in the post-event period.

3.3.1.1. Descriptive statistics. Panels A, B, and C of Table 5 report the descriptive statistics of the regression variables for the sample firms, for the control firms, and for their differences, respectively. The mean and median measures are for the three-year average values of the variables in the pre- and post-deregulation periods. Panel A shows that there is no significant change in capital investments as a percentage of PP&E or in Tobin's Q for the sample firms pre- to post-deregulation. The median size of the sample firms increases significantly, and the median cash flow decreases significantly following deregulation. Panel B presents the corresponding descriptive statistic for the control firms. For the control firms, there is a significant decline in investments scaled by PP&E and a significant increase in the median firm size. There is no significant change in Tobin's Q or the cash flow measure. In Panel C we report the differences in investment, Tobin's Q, cash flow, and size between the sample and control firms in the pre- and post-deregulation periods. Consistent with using Tobin's Q, cash flow, and size (total assets) as the matching criteria to identify the control sample, we report insignificant differences in the means of these variables in the pre-event period. Post-deregulation, we report that the control-adjusted investments and size are significantly higher for the deregulated firms. There is no significant difference in cash flows between the sample and control firms in the post-event period. The last two columns of Panel C report that the difference of the differences is significantly positive for the median firm size and significantly negative for the median cash flow measure.

3.3.2. Results

3.3.2.1. Results for hypothesis H2.a. In Panels A, B, and C of Table 5, we also report the bid-ask spread measures of information asymmetry and their differences, pre- and post-deregulation, for the sample and control firms. From Panel A, the mean and median values of the bid-ask spread increase significantly pre- to post-deregulation for the sample firms. Panel B reports no significant change in the bid-ask spread in the post-deregulation period for the control firms. Panel C reports the differences in the information asymmetry measure between the sample and control firms in

[7] From unreported descriptive statistics of terciles 1 and 3 in the pre-SOX period, we note that firms in tercile 1 with the largest decline in bid-ask spread in the post-event period have (i) higher mean Q, (ii) a larger proportion of high-tech firms, and (iii) a higher bid-ask spread in the pre-event period. The conclusion that larger declines in information asymmetry are associated with high-tech growth firms with high initial asymmetry is intuitively appealing.

[8] In unreported results, we find that the support for the hypothesis is stronger with quartile regression, with more significant declines in the investment-cash flow sensitivity in quartile 1 relative to quartile 4. There is also support for above/below median sample stratification.

Table 5
Descriptive statistics: Deregulation.

	Pre		Post		Difference (Post − Pre)	
	Mean	Median	Mean	Median	Mean	Median
Panel A: Sample firms						
I_{it}/K_{it-1}	0.34	0.31	0.33	0.27	−0.01	0.00
					(0.67)	(0.34)
Tobin's Q	1.16	0.99	1.32	1.07	0.12	0.02
					(0.23)	(0.14)
CF_{it}/K_{it-1}	0.31	0.27	0.28	0.22	−0.04	−0.05
					(0.06)	(0.00)
Total assets (millions)	1723.06	305.25	3090.41	579.59	887.70	185.55
					(0.29)	(0.00)
Bid-ask spread	2.00%	1.98%	2.24%	2.04%	0.31%	0.31%
					(0.00)	(0.00)
N	148	148	108	108	108	108
Panel B: Control firms						
I_{it}/K_{it-1}	0.29	0.24	0.23	0.20	−0.05	−0.02
					(0.01)	(0.00)
Tobin's Q	1.15	0.97	1.19	1.00	0.02	−0.01
					(0.76)	(0.64)
CF_{it}/K_{it-1}	0.31	0.25	0.31	0.26	0.00	0.01
					(0.89)	(0.10)
Total assets (millions)	1154.95	299.31	1686.36	402.93	216.70	86.80
					(0.58)	(0.00)
Bid-ask spread	2.07%	1.80%	2.03%	1.85%	0.11%	0.12%
					(0.35)	(0.01)
N	148	148	108	108	108	108
Panel C: Sample minus control						
I_{it}/K_{it-1}	0.05	0.06	0.10	0.05	0.04	0.02
	(0.04)	(0.00)	(0.00)	(0.00)	(0.22)	(0.22)
Tobin's Q	0.00	0.02	0.13	0.01	0.10	0.00
	(0.93)	(0.03)	(0.20)	(0.28)	(0.34)	(0.77)
CF_{it}/K_{it-1}	−0.01	0.00	−0.03	−0.02	0.04	−0.03
	(0.81)	(0.39)	(0.23)	(0.20)	(0.10)	(0.01)
Total assets (millions)	568.10	6.97	1404.00	72.56	671.00	92.08
	(0.18)	(0.01)	(0.06)	(0.00)	(0.43)	(0.00)
Bid-ask spread	−0.06%	0.20%	0.20%	0.10%	0.19%	0.10%
	(0.47)	(0.99)	(0.08)	(0.09)	(0.00)	(0.05)
N	148	148	108	108	108	108

The sample includes firms from the Transportation, Telecommunication, and Petroleum and Natural Gas industries, all of which were deregulated in the late 1970s. The firms in the sample are listed on NYSE, AMEX, or NASDAQ, and their data are available on CRSP and COMPUSTAT. Each sample firm has a control firm from a nonderegulated industry matched on Tobin's Q, cash flow, and size (total assets). The event is the first major deregulation event in that industry. The variables reported here are three-year averages of the Pre and Post periods, where Pre is the three years prior to the event and Post is the three years after the event. Panel A presents the results for the sample firms. Panel B presents the results for a sample of control firms. Panel C presents the results for the differences between the sample and control firms. Investment (I_{it}) is defined as the capital expenditure for the fiscal year. Cash flow (CF_{it}) is calculated as the sum of earnings before extraordinary items and depreciation. Both investment and cash flow are deflated by capital (K_{it-1}), which is the net property, plant, and equipment (PP&E), at the beginning of the fiscal year. Tobin's Q is calculated as the market value of total assets divided by the book value of total assets, where market value of total assets is the sum of the book value of total assets and market value of equity minus the sum of the book value of common equity and balance sheet value of deferred taxes. Market value of equity is the product of number of shares outstanding and price per share at the fiscal year end. Bid-ask spread is calculated for each year using the methodology of Corwin and Schultz (2011). The *p*-values (in parentheses) for the difference in the means are for the *t*-test. The *p*-values (in parentheses) for the difference in medians are for the Wilcoxon signed-rank test.

the pre-event period (columns 1 and 2) and in the post-event period (columns 3 and 4) and the difference of the differences (columns 5 and 6). From columns 5 and 6, the control-adjusted changes are significantly positive for the bid-ask spread, consistent with an increase in information asymmetry for the sample firms from pre- to post-deregulation. We also confirm that the increase in the bid-ask spread post-deregulation is attributable to the event by regressing the bid-ask spread against the event dummy controlling for other determinants of bid-ask spread, as in Table 2 for SOX. In unreported results we document that the coefficient of the deregulation dummy is significantly positive with a *t*-statistic of 2.93.

Overall, the finding of significant increases in the measures of information asymmetry for the sample firms and insignificant changes for the control firms is consistent with Hypothesis H2.a, which states that deregulation is associated with an increase in information asymmetry.

3.3.2.2. Results for hypothesis H2.b. Table 6 reports the regression estimates for the tests of Hypothesis H2.b that investment–cash flow sensitivity increases post-deregulation from the deregulation-induced increase in information asymmetry for positive cash flow firms. Panel A of Table 6 documents an increase in investment–cash flow coefficient β_2 pre- to post-deregulation from 0.09 to 0.46 on average for the sample firms. The coefficient β_4 of the interaction term in the "all unrestricted" specification R2 is a significantly positive 0.37 with a *t*-statistic of 2.67, consistent with a significant increase in the investment–cash flow sensitivity for the sample firms. The Chow Fisher *F* statistic for the cash-flow restricted versus the all-unrestricted model is also positive and highly significant. From Panel B of Table 6, we note that for the control firms, β_2 from the separate regressions in the pre- and post-event periods decreases from 0.41 to 0.29, with a statistically insignificant coefficient for the interaction coefficient β_4 in the pooled all-unrestricted model (column 6). The Chow Fisher *F* test

Table 6
Regression results of investment on cash flow and Tobin's Q for sample and control firms: Deregulation.

	Panel A: Sample firms			Panel B: Control firms		
	Pre	Post	Pooled	Pre	Post	Pooled
Intercept	0.07	0.10	0.07	0.07	0.09	0.07
	(1.78)	(2.66)	(1.65)	(2.78)	(3.83)	(3.12)
Tobin's Q	0.21	0.07	0.21	0.07	0.04	0.07
	(5.79)	(3.54)	(5.35)	(2.95)	(1.70)	(3.31)
CF_{it}/K_{it-1}	0.09	0.46	0.09	0.41	0.29	0.41
	(1.01)	(4.12)	(0.93)	(7.77)	(4.91)	(8.72)
Dereg_Dum			0.03			0.02
			(0.63)			(0.45)
Dereg_Dum × CF_{it}/K_{it-1}			0.37			−0.12
			(2.67)			(−1.32)
Dereg_Dum × Tobin's Q			−0.14			−0.03
			(−3.19)			(−0.79)
Chow Fisher *F* test	7.63			1.75		
	(0.00)			(0.18)		
N	148	108	256	148	108	256
R^2	0.274	0.280	0.276	0.185	0.376	0.442

The sample includes firms from the Transportation, Telecommunication, and Petroleum and Natural Gas industries, which were deregulated in the late 1970s. The firms in the sample are listed on NYSE, AMEX, or NASDAQ, and their data are available on CRSP and COMPUSTAT. Each sample firm has a control firm from a nonderegulated industry matched on Tobin's Q, cash flow, and size (total assets). The event is the first major deregulation event in that industry. Pre is the three-year period prior to the event, and Post is the three-year period after the event. Panel A presents the results for the sample firms. Panel B presents the results for a sample of control firms. Investment (I_{it}) is defined as the capital expenditure for the fiscal year. Cash flow (CF_{it}) is calculated as the sum of earnings before extraordinary items and depreciation. Both investment and cash flow are deflated by capital (K_{it-1}), which is the net property, plant, and equipment (PP&E), at the beginning of the fiscal year. Tobin's Q is calculated as the market value of total assets divided by the book value of total assets, where market value of total assets is the sum of the book value of total assets and market value of equity minus the sum of the book value of common equity and balance sheet value of deferred taxes. Market value of equity is the product of number of shares outstanding and price per share at the fiscal year end. Dereg_Dum is 0 for the Pre period and 1 for the Post period. The numbers used in the regressions are the averages of the variables for the three years in the Pre and Post periods, respectively. The numbers in parentheses are the *t*-statistics. The number in parentheses for the Chow Fisher *F* statistic is the corresponding *p*-value.

statistic for the cash-flow restricted versus all-unrestricted models is also statistically insignificant, suggesting that there is no corresponding significant change in the investment–cash flow sensitivity for control firms.[9]

We note in Table 6 that the sensitivity of investment to Tobin's Q is significantly positive in both the pre- and post-event periods for the sample firms but declines significantly from the pre- to the post-event period, as evidenced by the significantly negative coefficient of the interaction term between Dereg_Dum and Tobin's Q. Possible explanations for this finding are (i) Tobin's Q is a more noisy measure of the true growth opportunities in the post-event period because of the valuation changes and increased information asymmetry associated with deregulation, and (ii) the increased investment–cash flow sensitivity in the post-event period suggests that after deregulation firms have a greater need to align their investment levels with their cash flows, thereby possibly constraining their ability to align their investment levels to growth opportunities with as high a sensitivity as in the pre-event period.

Overall, the finding of a significant increase in the investment–cash flow sensitivity in the post-deregulation period for the sample firms relative to the control firms is consistent with Hypothesis H2.b that the deregulation-induced increase in information asymmetry increases the investment–cash flow sensitivity.

3.3.2.3. Results for hypothesis H2.c. A problem encountered in the test of Hypothesis H2.c is the small size of the terciles. Each tercile has only 36 observations. In unreported results we document only directional support for the hypothesis. There is, indeed, a larger increase in the investment–cash flow sensitivity coefficient for the top tercile ($\beta_4 = 0.44/t = 1.62$) than for the bottom tercile ($\beta_4 = 0.25/t = 0.90$). However, the difference in the change in sensitivity between the two terciles is not statistically significant (*F* statistic of 0.11 for the Chow Fisher *F* test). Our results only weakly support Hypothesis H2.c, possibly because of the small sample size.

4. Robustness and additional tests

We tested for the robustness of our regression results for the deregulation sample by developing an alternative control sample based on propensity score matching.[10] The propensity score matched sample was generated from a logistic regression of a binary variable (1 for deregulated firms, 0 otherwise) on Tobin's Q, cash flow, size (total assets), and bid-ask spread, as of one year before the deregulation event, thereby controlling for pre-deregulation growth opportunities, cash flow, size, and the level of information asymmetry. The regression results, reported in Table 7 for this propensity-matched control sample, are strikingly similar to those reported for the matched control sample in Table 6 and support Hypotheses H2.a and H2.b.

As additional robustness tests, we develop two other control samples: (i) a propensity-matched control sample based on Tobin's Q, cash flow, and size (total assets) and (ii) a control sample based on the closest match of just the bid-ask spread. In unreported results (available upon request), we find that in both samples, the results for the control firms are strikingly similar to the control firms reported in Tables 6 and 7. Hypotheses H2.a and H2.b are supported with all three alternative control firm samples. Since the deregulation events are industry specific, we acknowledge the limitations that we cannot match our control firms on industry and that our control firms may be different from the sample firms

[9] We also estimate a single regression with the pooled data of sample and control firms for the pre- and post-event periods with the cash flow variable interacted jointly with the sample dummy variable and the deregulation dummy variable. We find a significant positive coefficient for this joint interaction term, suggesting that there is a significant increase in the investment-cash flow sensitivity for the sample firms after the deregulation event relative to the control firms, consistent with the results in Table 6.

[10] We thank an anonymous referee for suggesting that we use propensity score matching to develop an alternative control sample.

Table 7
Regression results of investment on cash flow and Tobin's Q for sample and control firms with control firms based on propensity-score matching of Tobin's Q, cash flow, size, and bid-ask spread: Deregulation.

	Panel A: Sample firms			Panel B: Control firms		
	Pre	Post	Pooled	Pre	Post	Pooled
Intercept	0.07	0.10	0.07	0.12	0.10	0.12
	(1.78)	(2.66)	(1.65)	(5.04)	(3.93)	(5.12)
Tobin's Q	0.21	0.07	0.21	0.03	0.06	0.03
	(5.79)	(3.54)	(5.35)	(1.26)	(2.57)	(1.28)
CF_{it}/K_{it-1}	0.09	0.46	0.09	0.29	0.20	0.29
	(1.01)	(4.12)	(0.93)	(5.55)	(4.19)	(5.65)
Dereg_Dum			0.03			−0.02
			(0.63)			(−0.63)
Dereg_Dum × CF_{it}/K_{it-1}			0.37			−0.09
			(2.67)			(−1.27)
Dereg_Dum × Tobin's Q			−0.14			0.03
			(−3.19)			(0.86)
Chow Fisher *F* test	7.63			1.62		
	(0.01)			(0.20)		
N	148	108	256	148	108	256
R^2	0.274	0.280	0.276	0.274	0.304	0.287

The sample includes firms from the Transportation, Telecommunication, and Petroleum and Natural Gas industries, which were deregulated in the late 1970s. The firms in the sample are listed on NYSE, AMEX, or NASDAQ, and their data are available on CRSP and COMPUSTAT. Each sample firm has a control firm from a nonderegulated industry matched on Tobin's Q, cash flow, size (total assets), and bid-ask spread, using propensity-score matching. Propensity score is calculated by first estimating a logistic regression of a binary variable on Tobin's Q, cash flow, size (total assets), and bid-ask spread. The binary variable has a value of 1 for firms that underwent deregulation and 0 otherwise. The sample firms are matched with control firms based on the closest propensity score one year prior to the event. The event is the first major deregulation event in that industry. Pre is the three-year period prior to the event, and Post is the three-year period after the event. Panel A presents the results for the sample firms. Panel B presents the results for a sample of control firms. Investment (I_{it}) is defined as the capital expenditure for the fiscal year. Cash flow (CF_{it}) is calculated as the sum of earnings before extraordinary items and depreciation. Both investment and cash flow are deflated by capital (K_{it-1}), which is the net property, plant, and equipment (PP&E), at the beginning of the fiscal year. Tobin's Q is calculated as the market value of total assets divided by the book value of total assets, where market value of total assets is the sum of the book value of total assets and market value of equity minus the sum of the book value of common equity and balance sheet value of deferred taxes. Market value of equity is the product of number of shares outstanding and price per share at the fiscal year end. Dereg_Dum is 0 for the Pre period and 1 for the Post period. The numbers used in the regressions are the averages of the variables for the three years in the Pre and Post periods, respectively. The numbers in parentheses are the *t*-statistics. The number in parentheses for the Chow Fisher *F*-statistic is the corresponding *p*-value.

on some other measures of information asymmetry (such as analyst following) and stock liquidity. Therefore, there is some possibility that we have less than an adequate control. However, by matching our control firms on the bid-ask spread, Tobin's Q, cash flow, and size, the control firms are likely to be similar to the sample firms on other measures of information asymmetry and liquidity.

The Sarbanes-Oxley Act was passed in 2002, but the compliance period extended several years beyond. Although the compliance periods for most of the relevant provisions, such as sections 302, 401, 404, 409, and 802, are within our post-SOX window of years (+1, +3), we tested the robustness of our results to different post-event period windows. Columns 1 and 2 of Panel A of Table 8 show that our results are qualitatively similar for positive cash flow firms with significant decreases in investment–cash flow sensitivity following SOX when the post-event period window is years (+2, + 4) and years (+3, +5), respectively. Similarly, columns 1 and 2 of Panel B of Table 8 show that Hypothesis H1.b is also supported for negative cash flow firms for these alternative post-event period windows. Similar (unreported) results also obtain for longer windows of years (−4, −1) to years (+1, +4) and years (−5, −1) to years (+1, +5) for positive and negative cash flow subsamples.

CPR (2007) use sales growth as an additional control variable for investment opportunity. We test for the robustness of our inferences by adding the sales growth variable to our main specification of the model (Eq. R2) that tests for Hypotheses H1.b and H2.b. In column 3 of Panels A and B of Table 8, we report that our finding of decreasing/increasing investment–cash flow sensitivity for the positive/negative cash flow firms holds even after including sales growth as an additional control variable. In unreported results, the coefficient of the deregulation dummy-cash flow interaction term is positive, as hypothesized, but the significance decreases from $t = 2.67$ to $t = 1.87$ with the inclusion of the sales growth variable. In general, the results are stronger when either Tobin's Q or sales growth is in the model.

Since the period surrounding SOX corresponds to when the tech bubble burst, we test for the robustness of our results to the exclusion of high-tech companies from our sample. In columns 4 and 5 of Panels A and B of Table 8, we report that for positive and negative cash flow firms, our main inferences do not change when tech firms are excluded from the sample (column 4) or included with a control (dummy) variable for high-tech firms (column 5). Finally, we also note that the exclusion of the high-tech firms from the sample does not materially change the trends in the investments and growth opportunities, pre- to post-SOX, as reported in the Table 1 descriptive statistics.

The existing literature on the cross-sectional tests of the investment–cash flow hypothesis uses measures such as size, payout rates, and rated bonds to stratify the sample into constrained and unconstrained groups. We carry out additional tests relating our findings based on the bid-ask measure of information asymmetry/-financial constraint to the findings in the literature based on the "traditional" measures of financial constraint. A simple correlation matrix of these measures for the positive cash flow sample in the pre-SOX period shows statistically significant negative coefficients between the bid-ask spread and the traditional measures. This finding is consistent with the bid-ask spread/information asymmetry being lower for the less constrained firms that are larger, have higher payout rates, and rated bonds. However, the strength of the association does not appear to be very strong, ranging from −0.172 for the payout rate measure to −0.356 for the size measure of financial constraints. We also test the investment–cash flow Hypothesis H1.b on the terciles of constrained and unconstrained firms based on these traditional measures of financial constraint. From unreported results (available upon request), we note that the size variable increases significantly pre- to post-SOX for the

Table 8
Regression results of investment on cash flow, sales growth, and Tobin's Q with different post-event period windows, sales growth, and high-tech dummy: SOX.

	Robustness with respect to				
	Alternative post-SOX windows		Sales growth	High-tech firms	
	Pre: (−3, −1); Post: (2, 4)	Pre: (−3, −1); Post: (3,5)		High-tech firms excluded	With high-tech dummy
	[1]	[2]	[3]	[4]	[5]
Panel A: Positive cash flow firms					
Intercept	0.12	0.12	0.12	0.12	0.12
	(14.10)	(13.50)	(14.42)	(14.00)	(14.76)
Tobin's Q	0.05	0.05	0.05	0.04	0.05
	(15.42)	(14.76)	(15.75)	(11.82)	(14.32)
CF_{it}/K_{it-1}	0.13	0.13	0.13	0.13	0.13
	(20.29)	(19.42)	(20.66)	(18.25)	(20.11)
SOX_Dum	−0.00	−0.01	−0.01	−0.01	−0.02
	(−0.19)	(−0.67)	(−0.83)	(−0.95)	(−1.19)
SOX_Dum × CF_{it}/K_{it-1}	−0.05	−0.04	−0.05	−0.06	−0.05
	(−6.11)	(−4.56)	(−5.34)	(−6.45)	(−5.38)
SOX_Dum × Tobin's Q	−0.01	−0.00	−0.01	−0.00	−0.01
	(−1.04)	(−0.26)	(−1.60)	(−0.06)	(−0.99)
Sales growth			−0.00		
			(−0.04)		
SOX_Dum × Sales growth			0.02		
			(2.25)		
High-tech dummy					0.08
					(7.06)
N	2892	2760	2949	2600	2949
R^2	0.327	0.321	0.338	0.280	0.348
Panel B: Negative cash flow firms					
Intercept	0.22	0.22	0.21	0.23	0.21
	(4.97)	(5.17)	(5.05)	(4.20)	(4.68)
Tobin's Q	0.05	0.05	0.05	0.04	0.05
	(6.23)	(6.48)	(6.35)	(3.67)	(6.43)
CF_{it}/K_{it-1}	−0.04	−0.04	−0.04	−0.05	−0.04
	(−7.12)	(−7.41)	(−6.59)	(−7.27)	(−7.33)
SOX_Dum	−0.12	−0.13	−0.15	−0.18	−0.17
	(−1.79)	(−2.01)	(−2.52)	(−2.40)	(2.72)
SOX_Dum × CF_{it}/K_{it-1}	0.02	0.02	0.02	0.03	0.03
	(2.63)	(2.51)	(2.42)	(3.44)	(2.97)
SOX_Dum × Tobin's Q	0.01	0.01	0.03	0.06	0.04
	(0.66)	(0.73)	(1.58)	(2.33)	(2.02)
Sales growth			0.04		
			(5.61)		
SOX_Dum × Sales growth			0.03		
			(1.04)		
High-tech dummy					0.06
					(1.43)
N	429	412	462	350	462
R^2	0.322	0.349	0.395	0.314	0.349

The event is the implementation of the Sarbanes-Oxley Act (SOX) and the event year is 2002. Pre is the three-year period (1999, 2000, and 2001) prior to the event, and Post is alternative three-year periods after the event. Every firm has one observation for the Pre period and one observation for the Post period, and the numbers used are the averages of the Pre and the Post periods, respectively. Investment (I_{it}) is capital expenditure. Cash flow (CF_{it}) is calculated as the sum of earnings before extraordinary items and depreciation. Both investment and cash flow are deflated by capital (K_{it-1}), which is the net property, plant, and equipment (PP&E), at the beginning of the fiscal year. Tobin's Q is the market value of assets divided by the book value of assets. Market value of assets is the sum of the book value of assets and market value of equity minus the sum of the book value of common equity and balance sheet deferred taxes. Market value of equity is the product of number of shares outstanding and price per share at the fiscal year end. SOX_Dum is 0 for the pre-SOX period and 1 for the post-SOX period. Sales growth is the percentage increase in sales from the previous year. High-tech firms belong to industries with SIC codes 3571, 3572, 3575, 3577, 3578, 3661, 3663, 3669, 3674, 3812, 3823, 3825–3827, 3829, 4899, 7370–7375, 7378, and 7379. Low-tech industries are the rest of the industries. High-Tech Dummy is 0 for firms that do not belong to a high-tech industry and 1 for firms that belong to high-tech industries. Column 4 reports regression estimates with no firms from high-tech industries. Column 5 contains all firms, including those belonging to high-tech industries. The numbers in parentheses are the corresponding *t*-statistics.

constrained and unconstrained terciles, consistent with our descriptive statistics in Table 1. The more "sticky" variables, payout rate and rated bonds, show no significant change for either tercile. The bid-ask spread, however, decreases significantly in the constrained and unconstrained terciles under all stratification modes, consistent with Hypothesis H1.a. Further, the decline in the bid-ask spread is larger in the constrained tercile, presumably because the more constrained firms with higher initial information asymmetry benefit more from the increased disclosure following SOX, as we report in footnote 5. Hypothesis H1.b of declining investment–cash flow sensitivity pre- to post-SOX is not supported with the size criterion. The hypothesis is supported for the constrained tercile with the payout measure and for both terciles with the rated bond criterion. In all three cases, the decrease in investment–cash flow sensitivity is larger for the constrained firms, with the larger decrease in bid-ask spread consistent with Hypothesis H1.c.

Overall, there is some support for Hypothesis H1.b when the sample is stratified using the traditional measures of payout rate and bond rating. However, given that these measures themselves

do not change significantly pre- to post-SOX, the results seem to be driven by the changes in the associated bid-ask spreads, which decline significantly in all cases.

5. Conclusions

The extant investment–cash flow literature based on cross-sectional regressions is open to several criticisms, both conceptual and empirical. In this study we mitigate some of these problems reported in the literature by using a new research design. We stratify our sample using the bid-ask spread as the measure of information asymmetry, not cross-sectionally but in a time-series framework surrounding events that are expected to significantly change the firms' information asymmetry. Our bid-ask spread measure of financial constraint is a significant improvement over the traditional measures used in previous cross-sectional studies. We test for the significance of the changes in the cash-flow sensitivity for the same set of firms surrounding an exogenous shock to the firms' information asymmetry. This methodology mitigates the monotonicity assumption of the cross-sectional tests and allows us to better control for firm-specific impacts on investment. Further, we expect some of the biases in the investment–cash flow sensitivity coefficient from measurement errors in Q to cancel out when measuring the difference in the sensitivity pre- to post-event.

The two events we study are (i) the implementation of the Sarbanes-Oxley Act, which is expected to decrease information asymmetry from improved and increased disclosure, and (ii) the deregulation of industries, which is expected to increase information asymmetry, largely from the lifting of price controls and entry barriers.

We report that information asymmetry indeed decreases following SOX and that there is a commensurate decrease in the investment–cash flow sensitivity pre- to post-SOX, with a larger decline in the investment–cash flow sensitivity for the subsample which exhibits a greater decline in information asymmetry. For the deregulation event, we report support for the hypotheses that information asymmetry increases following deregulation, with a commensurate increase in investment–cash flow sensitivity, pre- to post-deregulation. There is only weak support for the hypothesis of a larger increase in the sensitivity for the tercile with the largest increase in information asymmetry, possibly because of the small number of observations in the terciles. Our results are robust with respect to alternative model specification, sample composition, estimation windows, and alternative propensity-score matched control samples. Overall, the results of the study support the hypothesis that investments are sensitive to cash flows.

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