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Costly external finance, corporate investment, and the subprime mortgage credit crisis ☆

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ABSTRACT

We study the effect of the recent financial crisis on corporate investment. The crisis represents an unexplored negative shock to the supply of external finance for non-financial firms. Corporate investment declines significantly following the onset of the crisis, controlling for firm fixed effects and time-varying measures of investment opportunities. Consistent with a causal effect of a supply shock, the decline is greatest for firms that have low cash reserves or high net short-term debt, are financially constrained, or operate in industries dependent on external finance. To address endogeneity concerns, we measure firms' financial positions as much as four years prior to the crisis, and confirm that similar results do not follow placebo crises in the summers of 2003–2006. Nor do similar results follow the negative demand shock caused by September 11, 2001. The effects weaken considerably beginning in the third quarter of 2008, when the demand-side effects of the crisis became apparent. Additional analysis suggests an important precautionary savings motive for seemingly excess cash that is generally overlooked in the literature.

1. Introduction

The ongoing financial crisis that began in August 2007 as a result of consumer defaults on subprime mortgages has had dramatic effects on the U.S. financial sector. The effects include several regional bank failures, the collapse and fire sale of Bear Stearns in March 2008, the sudden bankruptcy of Lehman Brothers on September 15, 2008, and the seizure of Washington Mutual by federal regulators on September 25, 2008, in the largest bank failure in U.S. history. In general, U.S. financial institutions have seen enormous declines in capital related to write-downs of bad loans and plummeting values of collateralized debt obligations.

These huge losses have resulted in an increased interest in risk management on the part of financial institutions, and have lowered both their capacity and their willingness to take on risk. Evidence of tighter lending standards and withdrawn lines of credit abounds.[1] In addition, loan spreads suddenly skyrocketed when the crisis began in August 2007, as shown in Fig. 1.

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[1] For an overview of the financial consequences of the subprime mortgage crisis, see Greenlaw, Hatzius, Kashyap, and Shin (2008). See also Gorton (2008) for insights on the causes of the crisis.

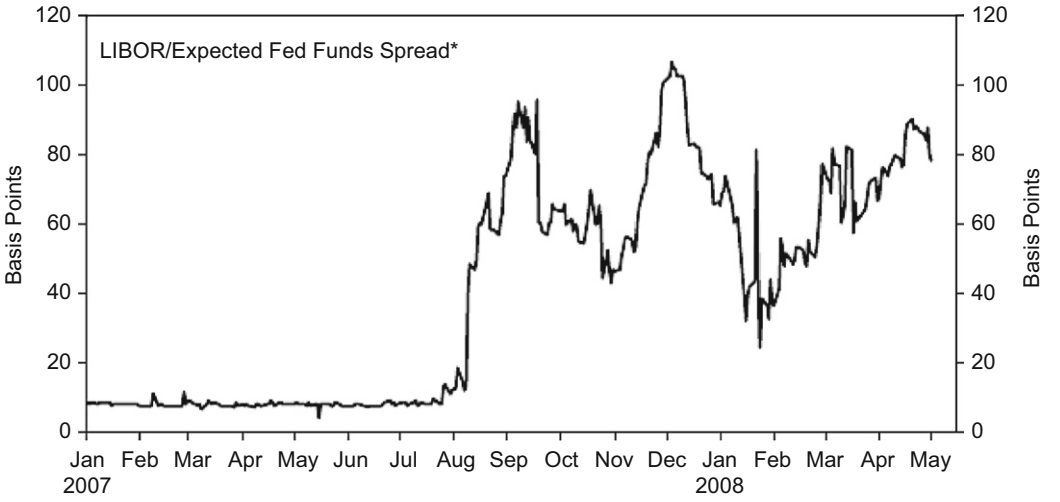

Fig. 1. London Interbank Offered Rate (LIBOR) – Overnight Indexed Swap Rate (OIS, Daily), as reported by Greenlaw, Hatzius, Kashyap, and Shin (2008).

The historic magnitude of the current financial crisis emphasizes the importance of understanding how shocks to the supply of external capital affect the real economy. In this paper, we provide evidence on this issue by studying the effects of the crisis on corporate investment.

The hypotheses we take to the data are based on standard models of investment with financing frictions (cf. Jaffee and Russell, 1976; Stiglitz and Weiss, 1981; Holmstrom and Tirole, 1997). In theory, negative shocks to the supply of external finance, together with the presence of financing frictions, might hamper investment if firms lack sufficient financial slack to fund all profitable investment opportunities internally. Moreover, theory suggests that such effects should be particularly severe in firms that face relatively greater costs in raising external capital or relatively greater need to do so (i.e., are financially constrained or dependent on external finance).

To investigate these ideas, we employ a differences-in-differences approach in which we compare the investment of firms before and after the onset of the crisis as a function of their internal financial resources (cash reserves and net debt), external financing constraints, and dependence on external finance, controlling for firm fixed effects and observable measures of investment opportunities, specifically *Q* and cash flow. Consistent with our interest in supply effects, most of our analysis focuses on the first year of the crisis (July 1, 2007–June 30, 2008), the mainly financial phase of the crisis, though in a final step we consider how our main results change when we extend the sample through March 31, 2009, a period in which the demand-side effects of the crisis strengthened considerably.[2] We are mostly interested in studying the role of firms' financial positions in mitigating or worsening the impact of the crisis on investment. Inferences may be confounded, however, if variation in these financial positions is endogenous to unobserved variation in investment opportunities.

Our base specification, as well as the rest of our analysis described below, is designed to address this issue. Because changes in a firm's financial positions as the crisis unfolds may be related to unobserved changes in its investment opportunities, we purge our specifications of this variation by using (only) the firm's financial positions measured *one year prior* to the start of the crisis, specifically at the end of the last fiscal quarter ending prior to July 1, 2006. Our base specification regresses firm-level quarterly investment over July 1, 2006–June 30, 2008 on an indicator variable for whether the quarter in question is after the onset of the crisis, and on the interaction of this indicator variable with the firm's cash reserves measured one year prior to the start of the crisis, controlling for firm fixed effects, *Q*, and cash flow.[3] Of course, the firm fixed effects subsume the level effect of cash (because cash is measured only once per firm) and control for all sources, observed or unobserved, of time-invariant variation in investment opportunities across firms.

Thus, our main framework is similar to an instrumental variables approach in which the identifying assumption is that year-before financial positions are not positively correlated with unobserved within-firm *changes* in investment opportunities (i.e., unobserved firm-specific demand shocks) following the onset of the

[2] In our empirical analysis, we date the beginning of the crisis as July 1, 2007 to split the pre- and post-crisis periods evenly by calendar quarter. This balanced approach has the advantage of averaging out any seasonal patterns in the data (e.g., Shin and Kim, 2002). Given that the crisis actually began in August 2007, our approach is conservative.

[3] Following most of the investment literature, our main measure of corporate investment is capital expenditures scaled by total firm assets. Our main results continue to hold for other measures of corporate spending, such as SG&A and R&D.

crisis. Results from placebo (i.e., nonexistent) crises in other time periods and the September 11 demand shock (described below) provide confidence in the validity of this identifying assumption. Further reducing endogeneity concerns, our main results continue to hold when we measure cash reserves as much as *four years prior* to the onset of the crisis.

Moreover, as additional and distinct sources of identification, we conduct cross-sectional analyses based on firm-level measures of financial constraints and industry-level measures of dependence on external finance, which are commonly used in the investment and growth literatures to identify supply effects. The results, which we describe in detail below, provide further support for the interpretation of a causal effect of a supply shock generated by the crisis on corporate investment.

Using the base specifications described above, we find that corporate investment declines by 6.4% of its unconditional mean following the onset of the crisis. Specifically, investment declines by 0.109% of assets relative to an unconditional mean of 1.695% of assets per quarter. The magnitude of the decline is comparable to that suggested by aggregate statistics. The Bureau of Economic Analysis reports average quarterly seasonally-adjusted gross private domestic investment of $2.078 trillion over July 1, 2007–June 30, 2008, compared to $2.164 trillion over the prior year, which is a decline of 4%.

Consistent with an important supply shock mitigated by internal financial resources, post-crisis investment is significantly positively related to cash reserves. We estimate that investment declines by 0.179% of assets for a zero-cash firm. A one-standard-deviation (25th to 75th percentile) increase in year-before cash reserves mitigates the decline by 0.104 (0.124) percentage points, or 58% (69%) of the decline for a zero-cash firm. Because the correlation between year-before cash and cash during the crisis period is less than one, these estimates should be interpreted as a lower bound on the importance of cash reserves during the crisis. We discuss the economic magnitudes of our additional analyses throughout the body of the paper.

Importantly, we do not find similar results when we repeat these specifications for the September 11 shock or for placebo (nonexistent) crises on July 1 of 2003–2006. Because the September 11 shock to the economy was mostly a demand shock (Tong and Wei, 2008), these results strengthen our confidence in our identifying assumption. Specifically, if it is generally the case that year-before cash reserves proxies for susceptibility to an economy-wide demand shock, we would have expected to find similar results for the September 11 event, which we do not. The lack of similar results for placebo crises in the summers of 2003–2006 (in which there were no economy-wide shocks comparable to the financial crisis or September 11) provides further confidence that our results are not spuriously driven by some mechanical factor. In fact, the estimates from these placebo crises suggest that, if anything, our base specifications are biased away from finding the results we do.

Further consistent with a causal effect of a supply shock, we find that the decline in post-crisis investment is significantly greater for firms that are financially constrained.[4] As we do with firms' internal financial resources, we measure financial constraints one year prior to the onset of the crisis. In addition, all of our point estimates suggest that the impact of internal resources on post-crisis investment is stronger for financially constrained firms. The economic magnitudes of the point estimate differences are large, but are statistically significant for only three of our five measures of financial constraints, in testimony to the inherent noisiness of investment regressions over short time periods and of financial constraint measures themselves.[5]

A standard criticism of financial constraints as an identification device is that because measures of financial constraints are based on firm-level variables, they are to some extent endogenous to choices made by the firm, and in particular may be endogenous to unobserved variation in investment opportunities. However, because we measure financial constraints one year prior to the onset of the crisis, this criticism is relatively less salient to our analysis than to most prior work, and would only apply if there is a relation between year-before financial constraints and unobserved changes in investment opportunities following a shock one year later.

Nevertheless, we next consider industry-level measures of variation in need for external capital, which are commonly argued to be more plausibly exogenous to an individual firm. We find that the post-crisis decline in investment is particularly severe for firms in industries that are historically more dependent on external finance or external equity finance (Rajan and Zingales, 1998). We also find that the impact of internal resources (cash) on post-crisis investment is stronger for these firms. All of these findings are both economically and statistically significant, and further reinforce our interpretation of a causal supply effect.

We next show that our results continue to hold for a different measure of short-term liquidity, specifically net short-term debt (which includes the portion of long-term debt maturing in less than one year), but there is no similar impact of long-term debt. Net short-term debt has a significantly negative effect on post-crisis changes in investment, whereas net long-term debt does not.[6] Because net short-term debt represents a looming reduction in liquidity in times when refinancing is difficult or costly, whereas long-term debt does not, these findings reinforce the interpretation of our results as a supply effect.

[4] Following Almeida, Campello, and Weisbach (2004) and Whited and Wu (2006), we use five measures of financial constraints based on: (i) the Kaplan-Zingales (1997) index, (ii) the Whited-Wu index, (iii) firm size, (iv) firm payout, and (v) bond ratings.

[5] Moreover, the theoretical prediction for this interaction is not entirely clear. In standard models in the investment-cash flow literature, the analogous second partial derivative of investment with respect to internal resources and financing constraints cannot be signed without additional non-standard assumptions concerning the form of the firm's production function and/or cost of external finance function (see Kaplan and Zingales, 1997).

[6] We again measure these financial variables one year prior to the onset of the crisis. Taken literally, all such short-term debt expires prior to the onset of the crisis. Instead, the reader should view year-before debt as an instrument for debt at the onset of the crisis, as with year-before cash.

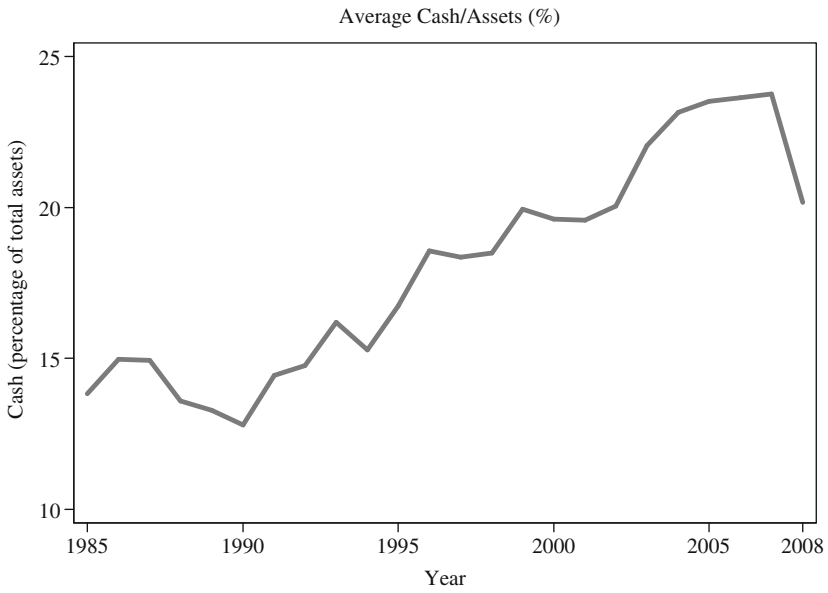

Fig. 2. Cross-sectional average cash (as a percentage of total assets) for non-financial firms, from 1985 to 2008 (*source*: Compustat).

In an important extension to our main results, we show that the results continue to hold when we consider firms' "excess" cash holdings (again measured one year prior to the onset of the crisis), using the definitions of excess cash provided by Opler, Pinkowitz, Stulz, and Williamson (1999) and Dittmar and Mahrt-Smith (2007). Seemingly excess cash is positively related to post-crisis investment, suggesting an important precautionary savings role for seemingly excess cash that has not been emphasized in the literature.[7] Instead, most prior work on excess cash emphasizes agency costs while controlling for precautionary cash based on historical data. To the extent that events of the magnitude of the current crisis are rare, our findings suggest that the optimal level of precautionary cash may be difficult for firm managers and academic researchers to estimate.

Overall, our findings regarding the importance of internal resources, financial constraints, and external finance dependence for corporate investment during the subprime crisis are consistent with models of capital rationing that predict internal resources should be relatively more important following a contraction in the supply of external financing. Further consistent with our findings, Fig. 2 shows a striking decline in cash balances (as a percentage of assets) of non-financial firms by the end of the second quarter of 2008.

We also investigate the efficiency implications of the relation between cash reserves and post-crisis investment by examining stock returns following the onset of the crisis as a function of firms' internal financial resources (cash). In an efficient market, the implications of a lack or availability of funds during a credit crisis will be impounded into stock prices. Consistent with a precautionary benefit of cash, a cash-rich portfolio (comprising firms in the top quintile) outperforms a cash-poor portfolio (comprising firms in the bottom quintile) by about 15 percentage points in raw as well as abnormal returns by the end of 2007. These results suggest that the higher post-crisis investment of cash-rich firms is efficient. Fig. 3, which plots the monthly returns of the two portfolios during 2007, shows a clear parallel trend before the crisis. The divergence in portfolio returns following the onset of the crisis suggests that the crisis was not anticipated by the market.

In a final step, we investigate how our main results change when we extend the post-crisis sample to March 31, 2009. On the one hand, as the crisis lengthens and deepens, the supply effects presented above may intensify. On the other hand, the demand-side effects of the crisis strengthened considerably beginning in the third quarter of 2008, particularly following the stock market meltdown of September–October 2008. If in this period firms' demand for investment decreased to such an extent that the tightened supply of external finance caused by the crisis was not the binding constraint, then we would not expect to see a relation between cash reserves and investment in the data (at the extreme, if no firm wanted to invest, cash on hand would be irrelevant for investment). Put differently, to observe the effects of a supply shock in the data it must not only be the case that a supply shock occurred, but also that it was binding on sufficiently many firms. Another possibility, consistent with the decline in cash balances shown in Fig. 2, is that firms may have spent their financial buffer stocks in the early parts of the crisis, leaving even previously high-cash firms with insufficient resources to mitigate subsequent investment declines. This possibility amounts to a weakening of our "instrument" (second quarter 2006 cash) over time. If so, we again would not expect to see a relation between cash reserves and investment.

[7] Our results have parallels to Fazzari and Petersen (1993), who find a "smoothing" effect of working capital, including cash, on investment for some groups of firms.

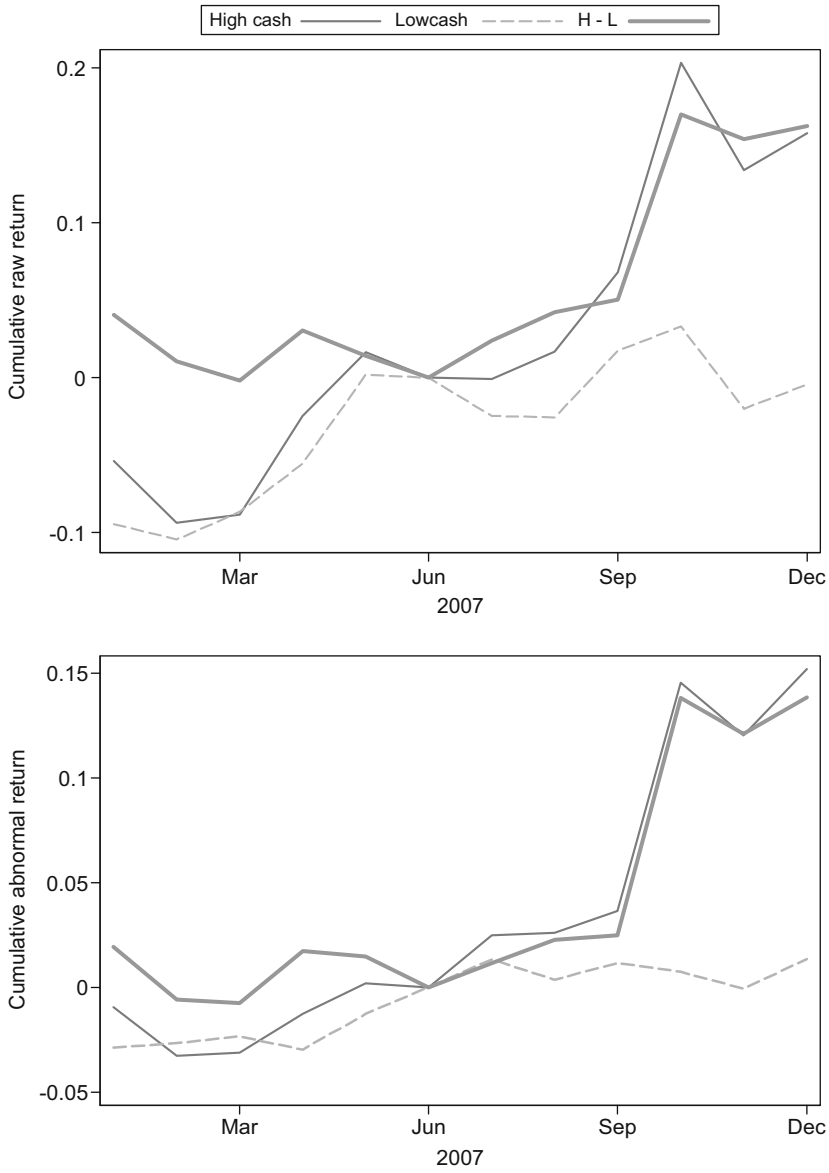

Fig. 3. Cash-sorted portfolio returns. Firms are sorted into high-cash (top quintile) and low-cash (bottom quintile) portfolios based on cash balances in the fourth quarter of 2006. The figures show cumulative monthly value-weighted returns for the two portfolios around June 2007. Returns are Fama-French style-adjusted in the second figure.

We find that corporate investment continued to decline over the three quarters July 1, 2008–March 31, 2009. In contrast to our main results, however, this result is largely explained by changing investment opportunities captured by *Q* and cash flow. Moreover, we do not find a significant effect of cash reserves (again measured in the second quarter of 2006) on investment in this late-crisis period, although the point estimates continue to be positive. All of these results are consistent with a reduction in investment demand making supply constraints less important. Consistent with a weakening of our "instrument" over time, the average firm's cash balance declines from 19.0% of firm assets in the second quarter of 2006 to 15.8% of firm assets in the second quarter of 2008, and the cross-sectional standard deviation of firm cash balances also shrinks from 21.3% to 18.4%. This decline in cash reserves is statistically significant at the 1% level.

This paper proceeds as follows. Section 2 discusses related literature. Section 3 describes our data and empirical strategy. Section 4 presents our empirical results. Section 5 concludes.

2. Related literature

Our work is related and contributes to several branches of literature. A growing number of papers study the causes and

consequences of the financial crisis. Most of this work focuses on financial aspects of the crisis and seeks to understand whether loose lending standards and/or securitization contributed to the problem (e.g., Dell'Ariccia, Igan, and Laeven, 2008; Demyanyk and van Hemert, 2008; Keys, Mukherjee, Seru, and Vig, 2008; Mian and Sufi, 2009).

A smaller set of papers study the real effects of the crisis on the corporate sector. To our knowledge, we are the first to study the impact of the financial crisis on corporate investment using archival data. Tong and Wei (2008) focus on explaining stock price changes following the crisis, and find that stock price declines were more severe for more financially constrained firms, which is consistent with our results. Ivashina and Scharfstein (2009) find that banks sharply curtail lending to the corporate sector during the crisis. Campello, Graham, and Harvey (2009) survey corporate managers and find evidence that firms forego profitable investment opportunities during the crisis as a result of binding external financing constraints, which is consistent with our results. In a recent working paper, Almeida, Campello, Laranjeira, and Weisbenner (2009) also study corporate investment in the crisis using archival data, relying on variation in long-term debt maturity for identification, which limits their sample of interest to the relatively few firms with substantial amounts of long-term debt. In contrast, our identification strategy allows us to consider a much broader and more representative set of firms. Their approach is similar in spirit to our results on short-term debt (which includes maturing long-term debt), and their results are consistent with ours.

This paper is also related to work studying the real effects of the crisis on consumers. Puri, Rochell, and Steffen (2009) find evidence of a supply effect whereby German banks affected by the crisis tighten lending to retail customers significantly more than non-affected banks, controlling for loan demand and loan applicant quality.

Our work is also related to a classic line of research in corporate finance on the ways in which financial constraints and fluctuations in the supply of capital might affect investment (e.g., Fazzari, Hubbard, and Petersen, 1988; Hoshi, Kashyap, and Scharfstein, 1991; Kaplan and Zingales, 1997). More recently, Lemmon and Roberts (2009) study the effects of the collapse of the junk-bond market in the early 1990s on the investment of firms who were historically dependent on junk-bond financing. Dell'Ariccia, Detragiache, and Rajan (2008) find that banking crises hinder growth more in industries that are more dependent on external finance. Arslan, Florackis, and Ozkan (2006) find evidence consistent with a hedging role of cash for the investment of Turkish firms in the Turkish financial crisis of 2000–2001.

This paper is also related to a growing body of research on corporate cash holdings. The predominant approach to understanding corporate demand for cash is the precautionary saving theory introduced by Keynes (1936). Under this theory, firms hold cash to protect themselves against adverse cash-flow shocks. Consistent with this theory, the evidence presented in Opler, Pinkowitz, Stulz, and Williamson (1999) suggests that industry-level cash-flow volatility is a key determinant of corporate cash holdings. More recently, Almeida, Campello, and Weisbach (2004) show that firms save cash out of their cash flows only when they are financially constrained and run the risk of underinvesting in future states of the world. Their results are in line with Modigliani and Miller's (1958) insight that cash only matters to the company when financial markets are not frictionless. Consistent with this and with our results, Faulkender and Wang (2006) find that the marginal value of cash holdings is greater for financially constrained firms. Acharya, Almeida, and Campello (2007) present further evidence supporting the hedging role of cash, particularly in states of the world when cash flows are low and investment opportunities are high. Bates, Kahle, and Stulz (2009) report a sharp increase in corporate cash holdings over time and tie it to a parallel increase in cash-flow volatility. Our results are consistent with previous work that finds smoothing benefits of working capital, including cash (Fazzari and Petersen, 1993), and provide further evidence on the precautionary benefits of cash holdings when credit tightens and firms are financially constrained or dependent on external finance.

Finally, our work adds to the literature exploring the consequences of "excess" corporate cash holdings. Most prior work focuses on the "dark side"—the potential for managerial abuse due to agency problems (e.g., Dittmar and Mahrt-Smith, 2007; Harford, 1999; Harford, Mansi, and Maxwell, 2008; Pinkowitz, Stulz, and Williamson, 2006). In contrast, our results show a "bright side", or precautionary savings motive—seemingly excess cash may in fact benefit firms in times of dislocation in markets for external finance.

3. Data and empirical strategy

3.1. Sample

Our sample consists of quarterly data on publicly traded firms available on Standard and Poor's Compustat, extracted from the April 30, 2009 data update. The data exist through March 2009, although coverage is incomplete for the first quarter of 2009. We define the beginning of the credit crisis as July 1, 2007, which is conservative in that most observers point to August 2007 as the true beginning of the crisis.[8] Because of our interest in exploring the supply effects of the crisis, we focus most of our analysis on the first year of the crisis (July 1, 2007–June 30, 2008), when the crisis was mainly a financial phenomenon. In a final step to our analysis, we examine how our results change when we extend the sample to March 31, 2009.[9]

[8] While any precise dating of the beginning of the crisis is somewhat arbitrary, our results are not sensitive to alternative dates in July and August 2007 because most fiscal quarters around the onset of the crisis end in either June or September.

[9] We obtain results similar to our main results when we pool together all post-crisis quarters for which we have complete data, but avoid this approach in our main analysis in order to highlight the differences between the early and later parts of the crisis.

We begin our main sample in July 1, 2006 in order to equally divide the main sample period into pre- and post-crisis periods. This balanced approach has the additional advantage of averaging out any seasonal patterns in the data (e.g., Shin and Kim, 2002). We exclude financial firms and utilities, defined as firms with SIC codes inside the intervals 4900–4949 and 6000–6999. For the relatively few firms that change their fiscal year during our sample period, we keep the most recent fiscal year convention. Following Almeida, Campello, and Weisbach (2004), we exclude firms with market capitalization less than $50 million (roughly the inflation-adjusted equivalent of their $10 million screen in 1971 dollars) as of the end of the last fiscal quarter ending before July 1, 2006 (or, if missing, as of the end of 2005), and firms that experience a quarterly asset or sales growth greater than 100% at some point during our sample period. These sample screens eliminate the smallest firms (representing less than 0.2% of firms by market capitalization) with volatile accounting data and firms that have undergone mergers or other significant restructuring and whose investment patterns may be skewed as a result. Our final sample consists of 26,421 quarterly observations for 3,668 firms. With the exception of Tobin's *Q* (computed as in Kaplan and Zingales, 1997), we winsorize all variables at the 1st and 99th percentiles to lessen the influence of outliers. We handle outliers in Tobin's *Q* by bounding *Q* above at 10, following the alternative measure of Baker, Stein, and Wurgler (2003), because winsorized *Q* exceeds 10 in our sample. In the Appendix, we detail the construction of the various variables that we use in analysis throughout the paper.

3.2. Empirical strategy

To analyze the impact of the financial crisis on corporate investment, we employ a differences-in-differences approach in which we compare the investment of firms before and after the onset of the crisis as a function of their internal financial resources (cash reserves and net debt), external financing constraints, and dependence on external finance, controlling for firm fixed effects and observable measures of investment opportunities, specifically *Q* and cash flow. Following much of the investment literature, most of our analysis measures investment as capital expenditures divided by total assets (in percentage points).[10]

We are mostly interested in studying the role of firms' financial positions in mitigating or worsening the impact of the crisis on investment. Inferences may be confounded, however, if variation in these financial positions as the crisis unfolds is endogenous to unobserved variation in investment opportunities.

Our base specification, as well as the rest of our analysis described fully below, is designed to address this issue. Because changes in a firm's financial positions as the crisis unfolds may be related to unobserved changes in its investment opportunities, we purge our specifications of this variation by using (only) the firm's financial positions measured *one year prior* to the start of the crisis, specifically at the end of the last fiscal quarter ending prior to July 1, 2006. Our base specification regresses firm-level quarterly investment over July 1, 2006–June 30, 2008 on an indicator variable for whether the quarter in question is after the onset of the crisis, and on the interaction of this indicator variable with the firm's cash reserves measured one year prior to the start of the crisis, controlling for firm fixed effects, *Q*, and cash flow. Of course, the firm fixed effects subsume the level effect of cash (because cash is measured only once per firm) and control for all sources, observed or unobserved, of time-invariant variation in investment opportunities across firms. Standard errors are heteroskedasticity-consistent and clustered at the firm level, following Bertrand, Duflo, and Mullainathan (2004).

Thus, our main framework is similar to an instrumental variables approach in which the identifying assumption is that year-before financial positions are not positively correlated with unobserved within-firm *changes* in investment opportunities (i.e., unobserved firm-specific demand shocks) following the onset of the crisis.

We conduct several additional sets of tests to address concerns that our results may be due to confounding effects. These include (i) demonstrating that our main results continue to hold when we measure cash as much as four years prior to the onset of the crisis; (ii) demonstrating that we do not obtain similar results for placebo (i.e., nonexistent) crises in other time periods, nor following the negative demand shock to the economy caused by the events of September 11; and (iii) using firm-level measures of financial constraints and industry-level measures of dependence on external finance as additional and distinct sources of identification.

Table 1 provides summary statistics for the July 1, 2006–June 30, 2008 sample. The average quarterly capital expenditure is 1.7% of firm assets. The average cash position measured one year prior to the onset of the crisis is 19.0% of firm assets. Short-term debt and long-term

Table 1
Summary statistics.
This table reports summary statistics for the main sample of firm-year-quarter observations from July 1, 2006 to June 30, 2008. Cash is cash and short-term investments. Tobin's *Q* is the ratio of market value of assets to book value of assets following Kaplan and Zingales (1997), and is bounded above at 10. Cash flow is operating income before depreciation and amortization. Cash and debt variables are measured exactly once per firm, at the end of the last fiscal quarter ending before July 1, 2006.

	Mean	St. dev.	N Obs
Capital expenditure/assets (%)	1.695	2.301	26,421
Cash/assets	0.190	0.213	3,668
Short-term debt/assets	0.035	0.071	3,567
Long-term debt/assets	0.169	0.198	3,630
Cash flow/assets (%)	2.446	6.072	25,857
Tobin's *Q*	1.772	0.831	26,391
Market capitalization ($ millions)	5,313	20,813	26,505
Assets ($ millions)	5,121	23,418	27,129

[10] As we show in Table 9, we find similar results for other types of investment or corporate spending such as research and development, sales, general, and administrative expenses, investment in net working capital, and investment in inventory.

debt measured one year prior to the crisis are, on average, 3.5% and 16.9% of firm assets, respectively. The average quarterly cash flow is 2.4% of assets. The average Tobin's *Q* is 1.8, average market capitalization is $5.3 billion, and average assets are $5.1 billion.

4. Results

4.1. Nonparametric results

Table 2 presents nonparametric results in which we sort firms into terciles based on their financial positions as of July 1, 2006, and compare investment before the onset of the crisis (July 1, 2007) to investment after within each tercile. The comparisons are based on cross-sectional averages of firm-level time-series averages over the four quarters before and after the crisis.

Panel A of Table 2 shows that investment declines significantly for low-cash firms after the crisis, declines somewhat (but not statistically significantly) for medium-cash firms, and is essentially flat for high-cash firms. Investment declines by an economically significant 12.5% for low-cash firms, from 2.01% of assets to 1.76% of assets per quarter.

Panel B shows that investment declines significantly for high short-term debt firms, but insignificantly for medium and low short-term debt firms. Panel C shows that net short-term debt (short-term debt minus cash), which is a measure of short-term liquidity, yields more pronounced differences than short-term debt alone. Investment declines by 11.4% for firms with high net short-term debt, from 1.99% of assets to 1.76% of assets per quarter.

Overall, consistent with our main hypotheses, these results suggest that the tightened supply of external finance following the onset of the crisis hurt investment mainly in firms lacking sufficient short-term liquidity, either because of small cash reserves or because of large short-term obligations.

In the analyses that follow, we investigate these patterns in more detail using multivariate regressions.

Table 2
Investment before and after the credit crisis.

This table presents difference-in-means estimates of firm-level quarterly investment (measured as the ratio of capital expenditures to total assets, in percentage points). Before crisis refers to the period July 1, 2006 to June 30, 2007. After crisis refers to the period July 1, 2007 to June 30, 2008. The reported means are cross-sectional averages of within-firm time-series averages for the relevant periods. To be included in the analysis, a firm must have capital expenditure data both before and after the crisis. Cash reserves is the ratio of cash and short-term investments to total assets at the end of the last fiscal quarter ending before July 1, 2006. ST debt is the ratio of short-term debt to total assets at the end of the last fiscal quarter ending before July 1, 2006. Net ST debt is the ratio of short-term debt minus cash to total assets at the end of the last fiscal quarter ending before July 1, 2006. Low, Medium, and High correspond to the first, second, and third terciles, respectively.

	Before crisis	After crisis	*t*-Statistic (difference)
Panel A: Cash reserves and average investment			
Low cash reserves	2.010	1.758	2.707
Medium cash reserves	1.875	1.795	0.937
High cash reserves	1.346	1.344	0.022
Panel B: Short-term debt and average investment			
Low ST debt	1.768	1.690	0.773
Medium ST debt	1.727	1.621	1.332
High ST debt	1.766	1.605	1.916
Panel C: Net short-term debt and average investment			
Low net ST debt	1.359	1.341	0.226
Medium net ST debt	1.915	1.815	1.123
High net ST debt	1.988	1.761	2.416

4.2. Post-crisis investment and cash reserves: base regressions

Table 3 presents estimates from our base specification described in Section 3.2 above. Columns 1 and 2, which do not include controls for investment opportunities but do include firm fixed effects, establish the basic patterns in the data.

Column 1 shows that quarterly investment as a fraction of assets by the average firm declined by 0.109 percentage points following the onset of the crisis, a decline of 6.4% relative to an unconditional mean of 1.695% of assets per quarter. The magnitude of the decline is comparable to that suggested by aggregate statistics. The Bureau of Economic Analysis reports average quarterly seasonally-adjusted gross private domestic investment of $2.078 trillion over July 1, 2007–June 30, 2008, compared to $2.164 trillion over the prior year, which is a decline of 4%.

Column 2 of Table 3 shows that this decline is substantially greater for firms that had low cash reserves one year before the onset of the crisis. The coefficient estimates imply a 0.185 percentage point decline in investment for a firm with no cash reserves (measured one year prior to the onset of the crisis), and no decline for a firm holding 45.6% of assets in cash.

Columns 3 and 4 of Table 3 further control for contemporaneous firm investment opportunities as measured by Tobin's *Q* and the ratio of cash flow to assets. The estimated coefficients on the "After" indicator variable as well as the interaction of this variable with cash reserves remain economically large and statistically significant.

The estimates in column 4 imply that investment declines by 0.179% of assets for a zero-cash firm, and that cash reserves of 36.5% of assets eliminate this decline. Additionally, the standard deviation of cash reserves (reported in Table 1) is 21.3%, and the interquartile range (not reported) is 25.4%, so the estimates in column 4 imply that a one-standard-deviation (25th to 75th percentile) increase in cash reserves mitigates the decline by 0.104 (0.124) percentage points, or 58% (69%) of the decline for a zero-cash firm. Because the correlation between year-before cash and cash during the crisis period is less than one, these estimates should be interpreted as a lower bound on the importance of cash reserves during the crisis.

Columns 5 and 6 of Table 3 present two robustness tests. Column 5 confirms that our results are robust to including fixed effects for each of the Fama-French 48

Table 3
Cash reserves and investment before and after the credit crisis.

This table presents estimates from panel regressions explaining firm-level quarterly investment for quarters with an end-date between July 1, 2006 and June 30, 2008. Investment is capital expenditures divided by total assets in percentage points. After is an indicator variable equal to one for fiscal quarters with an end-date after July 1, 2007, the approximate beginning of the credit crisis. Cash reserves is the ratio of cash to total assets at the end of the last fiscal quarter ending before July 1, 2006. *Q* is the ratio of market value of assets to book value of assets following Kaplan and Zingales (1997), and is bounded above at 10. Cash flow is operating income before depreciation and amortization divided by total assets in percentage points. All regressions include firm fixed effects. Specification 5 further includes industry-year-quarter fixed effects based on Fama-French 48-industry definitions. Standard errors (in brackets) are heteroskedasticity-consistent and clustered at the firm level, except for specification 6 which reports robust standard errors clustered by both firm and time (year-quarter) using the method of Petersen (2009). ***, **, or * indicates that the coefficient estimate is significant at the 1%, 5%, or 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
After	−0.109***	−0.185***	−0.172***	−0.179***		−0.179*
	[0.023]	[0.030]	[0.030]	[0.031]		[0.094]
After x Cash reserves		0.406***	0.476***	0.490***	0.481***	0.490***
		[0.103]	[0.105]	[0.109]	[0.110]	[0.185]
Q			0.202***	0.194***	0.180***	0.194***
			[0.046]	[0.049]	[0.050]	[0.059]
Cash flow				−0.022**	−0.023***	−0.022***
				[0.009]	[0.009]	[0.008]
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.721	0.721	0.726	0.728	0.730	0.728
N Obs	26,421	26,382	25,842	24,937	24,797	24,937

industries interacted with fixed effects for each of our eight calendar quarters (which subsume the "After" indicator variable). These fixed effects control for time-varying investment opportunities at the industry level. Column 6 of Table 3 shows that our main results in column 4 are robust to clustering standard errors by both firm and time (calendar quarter) using the method described in Thompson (2009) and Petersen (2009).

4.3. Cash reserves four years prior, placebo crises, and the 9/11 negative demand shock

Table 4 presents several analyses to address potential concerns with our base specification. First, there may be some concern that year-before cash reserves may reflect anticipation of the crisis and that if so, this may confound the interpretation of our results. Loosely speaking, this amounts to a concern that year-before cash is not sufficiently predetermined. If so, we would not expect to observe results similar to our main results if we measure cash reserves further back in time.

To address this concern, we repeat our base specification measuring cash reserves *four years* prior to the onset of the crisis, as of the last fiscal quarter ending before July 1, 2003. Column 1 of Table 4 reports the results. The coefficient on the interaction between the "After" indicator variable and this new measure of cash reserves is still large and highly statistically significant, though somewhat smaller in magnitude compared to that in Table 3, consistent with a weakening instrument due to the greater lag. We obtain similar results (not reported) if we instead measure cash reserves two or three years prior to the onset of the crisis.

A related concern is that perhaps cash reserves at a given point in time are generally positively correlated with unobserved within-firm changes in investment opportunities from the following year to the year after that. That is, perhaps firms choose to have high cash reserves at time t precisely because they expect their investment opportunities to be greater in year t+2 compared to year t+1 (in ways that are missed by our controls for *Q* and cash flow). This could potentially explain why we find a positive relation between cash reserves in the second quarter of 2006 and within-firm changes in investment from the pre-crisis to the post-crisis periods. If so, such a correlation should be a general feature of the data that should be apparent in other time periods.

To address this issue, we repeat our base specifications for placebo (i.e., nonexistent) crises occurring on July 1 of 2003, 2004, 2005, and 2006 (measuring cash reserves one year prior to those dates). The results are displayed in columns 2–5 of Table 4. For none of these placebo crises do we observe a significantly positive relation between year-before cash reserves and post-placebo crisis investment. In fact, two of the four coefficients are significantly *negative*, suggesting that, if anything, whatever endogenous effects there may be as a general feature of the data are actually biasing us *away* from finding our main results.

Another possible concern is that our results may reflect susceptibility to a demand shock, rather than a supply shock. To the extent that the first year of the crisis entails an economy-wide demand shock, our inferences may be confounded if year-before cash reserves proxies for susceptibility to that shock. If so, we would expect to find results similar to our main results following a significant economy-wide negative demand shock.

To address this concern, we repeat our base specification for the negative demand shock caused by the events

Table 4
Cash reserves four years prior, placebo regressions, 9/11 negative demand shock.

This table presents several specifications for validation purposes. All variables are defined in Table 3. In column 1, Cash reserves is measured at the end of the last fiscal quarter ending before July 1, 2003 to explain firm-level quarterly investment for two years [−1,+1] around July 1, 2007, the approximate beginning of the credit crisis. Columns 2–5 report placebo regressions explaining firm-level quarterly investment for two years [−1,+1] around placebo crises occurring on July 1 of 2003, 2004, 2005, and 2006, respectively. In these placebo regressions, After is an indicator variable equal to one for fiscal quarters with an end-date after the placebo crisis, and Cash reserves is measured at the end of the last fiscal quarter ending one year before the placebo crisis. Column 6 reports a similar regression explaining firm-level quarterly investment for two years [−1,+1] around September 11, 2001, the events of which led to a negative demand shock. All regressions include firm fixed effects. Standard errors (in brackets) are heteroskedasticity-consistent and clustered at the firm level. ***, **, or * indicates that the coefficient estimate is significant at the 1%, 5%, or 10% level, respectively.

Specification:	Cash 2003 Q2	Placebo 2003	Placebo 2004	Placebo 2005	Placebo 2006	9/11 Demand
	(1)	(2)	(3)	(4)	(5)	(6)
After	−0.123***	−0.056**	0.102***	0.062**	−0.048*	−0.412***
	[0.032]	[0.023]	[0.022]	[0.026]	[0.027]	[0.028]
After x Cash reserves	0.246***	−0.154*	0.039	−0.234***	0.102	−0.287***
	[0.094]	[0.082]	[0.083]	[0.087]	[0.078]	[0.104]
Q	0.157***	0.216***	0.229***	0.323***	0.273***	0.193***
	[0.048]	[0.035]	[0.036]	[0.045]	[0.047]	[0.026]
Cash flow	−0.017*	−0.008	−0.009	−0.008	−0.007	−0.006
	[0.009]	[0.007]	[0.006]	[0.007]	[0.006]	[0.006]
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.728	0.715	0.766	0.787	0.794	0.673
N Obs	21,142	21,719	21,436	23,406	23,546	21,637

of September 11, 2001. Tong and Wei (2008) carefully explain that 9/11 had both a significant and almost entirely demand-side effect on the economy. Column 6 of Table 4 shows the results. Investment declines significantly after 9/11, consistent with an important negative demand shock, but unlike our main results, year-before cash reserves is significantly negatively related to post-9/11 investment.[11]

Taken together, the results in Table 4 suggest that it is unlikely that our main results are either endogenously driven by some spurious or mechanical factor or mainly reflect demand-side, rather than supply-side, effects. Our cross-sectional analyses using financial constraints and external finance dependence in the next two subsections further address these potential concerns.

4.4. Post-crisis investment and financial constraints

We next consider how the effects of the crisis vary in the cross-section of firms by financial constraints. Standard models of investment with financing constraints suggest that fluctuations in the supply of external finance will have a more pronounced effect on firms that are ex ante financially constrained. We consider several measures of financing constraints: the Kaplan-Zingales (1997) index, the Whited-Wu (2006) index, firm size as measured by total assets, payout ratio, and bond ratings.[12] All of these measures are standard in the investment literature, and we detail their construction in the Appendix. For the Kaplan-Zingales index, the Whited-Wu index, firm size, and payout ratio, we classify firms as constrained or unconstrained by dividing the sample at the median as of June 30, 2006.[13] Note that to the extent below-median firms have longer or shorter panel data than above-median firms, the number of observations in the table can be different. For bond ratings, we consider a firm constrained if it has short-term or long-term debt outstanding but does not have a bond rating as of June 30, 2006, and unconstrained otherwise (this includes firms with zero debt and no debt rating). Thus, like we do for cash reserves, we measure financial constraints one year prior to the onset of the crisis.

Panel A of Table 5 shows that investment declines for both unconstrained and constrained firms following the onset of the crisis, and that the decline is significantly greater for financially constrained firms. Every point estimate goes in this direction, and the differences are statistically significant in one-tailed tests for four of the five measures of financial constraints, the exception being the Whited-Wu index (three of the five are significant in a two-tailed test).[14] The coefficient estimates across the five measures of financial constraints average a decline of

[11] In untabulated analyses, we also confirm that our main results in Table 3 are robust to (i) a specification in which we investigate the relation between quarterly investment and one-quarter-lagged cash reserves; (ii) a specification in which we collapse the time-series by measuring the dependent variable as the firm-level difference between average quarterly investment from July 1, 2007 to June 30, 2008 and average quarterly investment from July 1, 2006 to June 30, 2007, and the independent variables as the corresponding changes in *Q* and cash flow over the same periods and the level of cash reserves as of the last quarter ending before July 1, 2006; and (iii) specifications in which we control for *Q* and cash flow lagged 1–4 quarters.

[12] Faulkender and Petersen (2006) find that bond ratings exogenously affect a firm's access to debt financing.

[13] In untabulated analysis, we follow Almeida, Campello, and Weisbach (2004) and instead sort firms into deciles and compare the top three and bottom three deciles. This approach yields similar, and generally statistically stronger, results to those presented below.

Table 5
Financial constraints, cash reserves, and investment before and after the credit crisis.

This table presents estimates from panel regressions explaining firm-level quarterly investment for quarters with an end-date from July 1, 2006 to June 30, 2008. The regressions are estimated separately for subsamples of firms formed on the basis of financial constraints measured at the end of the latest fiscal year ending before July 1, 2006. For the first four measures of financial constraints (Kaplan-Zingales (1997) index, Whited-Wu (2006) index, firm assets, payout ratio), the subsamples comprise firms with financial constraint measures below and above the sample median. For bond ratings, the low subsample comprises unrated firms that have positive debt, and the high subsample comprises the rest (this includes firms with zero debt and no debt rating). All other variables are defined in previous tables. All regressions include firm fixed effects. Standard errors (in brackets) are heteroskedasticity-consistent and clustered by firm. ***, **, or * indicates that the coefficient estimate is significant at the 1%, 5%, or 10% level, respectively. *p*-Values are reported at the bottom of each panel for stated null and alternative hypotheses on the estimated coefficients *A* (*After*) and *AxC* (*After x Cash reserves*) for financially constrained (C) and unconstrained (U) subsamples.

Panel A: Change in investment for financially unconstrained and constrained firms

	Kaplan-Zingales index		Whited-Wu index		Firm assets		Payout ratio		Bond ratings	
	Low	High	Low	High	Big	Small	High	Low	High	Low
After	−0.046**	−0.157***	−0.071***	−0.113***	−0.069***	−0.143***	−0.082***	−0.170***	−0.046*	−0.170***
	[0.022]	[0.041]	[0.024]	[0.037]	[0.024]	[0.040]	[0.032]	[0.039]	[0.028]	[0.038]
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.617	0.711	0.685	0.744	0.739	0.711	0.645	0.754	0.735	0.707
N Obs	12,514	12,570	12,569	12,659	13,045	13,058	9,380	9,335	13,340	12,955
A H_o:C=U, H_a:C < U		0.009		0.172		0.057		0.041		0.004

Panel B: Change in investment for unconstrained and constrained firms conditional on cash reserves

	Low	High	Low	High	Big	Small	High	Low	High	Low
After	−0.099***	−0.212***	−0.072**	−0.235***	−0.100***	−0.268***	−0.088*	−0.254***	−0.102***	−0.252***
	[0.037]	[0.049]	[0.035]	[0.055]	[0.035]	[0.059]	[0.048]	[0.056]	[0.039]	[0.050]
After x Cash reserves	0.283**	0.789*	0.129	0.607***	0.324*	0.635***	0.177	0.643***	0.345***	0.643***
	[0.112]	[0.419]	[0.187]	[0.142]	[0.169]	[0.145]	[0.196]	[0.183]	[0.133]	[0.178]
Q	0.119***	0.237**	0.229***	0.139***	0.139**	0.209***	0.187**	0.208***	0.105*	0.265***
	[0.038]	[0.097]	[0.068]	[0.053]	[0.055]	[0.059]	[0.079]	[0.067]	[0.060]	[0.072]
Cash flow	−0.002	−0.022*	−0.034	−0.006	−0.017*	−0.022**	−0.001	−0.024**	−0.016	−0.028***
	[0.005]	[0.012]	[0.033]	[0.006]	[0.010]	[0.010]	[0.013]	[0.012]	[0.012]	[0.011]
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.629	0.716	0.701	0.749	0.747	0.718	0.663	0.756	0.735	0.719
N Obs	11,727	11,975	11,740	12,040	12,095	12,527	8,764	8,859	12,540	12,271
A H_o:C=U, H_a:C < U		0.035		0.007		0.007		0.012		0.008
AxC H_o:C=U, H_a:C > U		0.122		0.020		0.082		0.042		0.090

0.151% of assets per quarter for constrained firms, which is almost three times larger than the decline of 0.063% of assets for unconstrained firms.

Panel B of Table 5 adds our controls for contemporaneous investment opportunities (*Q* and cash flow), and examines whether cash reserves are more important for financially constrained firms in mitigating post-crisis investment declines. Again, we measure cash reserves one year prior to the onset of the crisis.

In Panel B, the coefficient on the "After" indicator variable corresponds to the post-crisis investment decline for a zero-cash firm. For all our measures of financial constraints, the decline is statistically significantly greater for financially constrained firms, and the magnitude of the decline is roughly two to three times greater.

Moreover, the estimates for the interaction of the "After" indicator variable and cash reserves in Panel B of Table 5 suggest that the relation between cash reserves and post-crisis investment is stronger for firms that are financially constrained. Every point estimate is in this direction, and four of the five differences are statistically significant in one-tailed tests (two of the five in two-tailed tests). To illustrate magnitudes, the Whited-Wu index results suggest a decline in investment of 0.235% of assets per quarter for a constrained, zero-cash firm (which is 14% of the unconditional sample mean given in Table 1), and no decline for a constrained firm with 38.7% of assets in cash. The coefficient estimates for the other measures of financial constraints suggest similar magnitudes.

Overall, Table 5, in which we find the strongest effects for financially constrained firms, provides further evidence of a causal supply effect of the crisis on corporate investment.

4.5. Post-crisis investment and external finance dependence

A standard criticism of financial constraints as an identification device is that because measures of financial constraints are based on firm-level variables, they are to

[14] For this and all similar tests throughout the paper, we compute the significance of the difference by pooling the subsamples into a single regression in which we interact every independent variable with an indicator for whether the firm is constrained.

some extent endogeneous to choices made by the firm, and in particular may be endogenous to unobserved variation in investment opportunities. However, because we measure financial constraints one year prior to the onset of the crisis, this criticism is relatively less salient to our analysis than to most prior work, and would only apply if there is a relation between year-before financial constraints and unobserved changes in investment opportunities following a shock that occurs one year later.

Nevertheless, we next consider industry-level measures of variation in need for and cost of external capital, which are commonly argued to be more plausibly exogenous to an individual firm, and thereby can further help us identify supply effects. To the extent that the financial crisis affected the supply of external financing, we expect its effect to be stronger in industries in which, for exogenous reasons, firms rely more on external financing. We also hypothesize that the effect may be stronger in industries characterized by high asymmetric information, following the logic of Myers and Majluf (1984), Greenwald, Stiglitz, and Weiss (1984), and Himmelberg and Petersen (1994) that asymmetry of information makes external financing more costly, especially when external financing is raised to finance risky investments.

We follow Rajan and Zingales (1998) and rank industries by their external finance dependence and external equity dependence. The construction of these measures at the firm level is detailed in the Appendix. We compute these measures over the period 2000–2005 using annual data from Compustat. To smooth temporal fluctuations and reduce the effects of outliers, we sum the firm's use of external finance and investment over 2000–2005 and then take the ratio of these sums. To construct industry-level measures, we use the industry median at the three-digit SIC code level rather than the average, to prevent the information from outlier firms swamping that of typical firms in the industry.

We also consider a measure of industry-level asymmetric information, productivity growth dispersion, which is computed as the cross-sectional standard deviation in productivity growth over 2000–2005 within a three-digit SIC industry (please see Appendix). A high dispersion suggests a greater role for idiosyncratic factors in firm performance, which in turn suggests it would be more difficult for potential investors to learn about the quality of the firm by examining aggregate information about the industry in which the firm operates.

Panel A of Table 6 shows that investment declines significantly following the onset of the crisis for firms in industries historically dependent on external finance or characterized by high asymmetric information. The estimates are comparable in magnitude to those in previous tables, ranging from 0.126% to 0.212% of assets per quarter. Interestingly, there is no significant evidence of a decline for firms in industries that are not historically dependent on external finance. The differences between external finance dependent and non-dependent firms are statistically significant, whereas the differences for firms in high and low information asymmetry industries are not.

Panel B of Table 6 adds our controls for contemporaneous investment opportunities (Q and cash flow), and examines whether cash reserves are more important for external finance dependent firms in mitigating post-crisis investment declines. Again, we measure cash reserves one year prior to the onset of the crisis. The coefficients on the "After" indicator variable, which corresponds to the post-crisis investment decline for a zero-cash firm, all imply economically and statistically significantly larger declines for dependent firms.

The estimates of the interaction of the "After" indicator variable and cash reserves in Panel B of Table 6 suggest that the relation between cash reserves and post-crisis investment is much stronger for firms in industries that are historically dependent on external finance or equity finance. The differences are statistically significant. The differences according to information asymmetry are in the same direction but not statistically significant.

To illustrate the magnitude of the effect, the estimates imply a decline in investment of 0.333% of assets per quarter for an external finance dependent, zero-cash firm (which is 20% of the unconditional sample mean given in Table 1), and no decline for a dependent firm with 37.2% of assets in cash.

Overall, the evidence in Table 6 provides yet further evidence of a causal effect on corporate investment of the supply shock caused by the credit crisis.

4.6. Post-crisis investment and leverage

Table 7 extends the analysis of Table 3 to measures of pre-crisis firm leverage. We are particularly interested in short-term debt, which represents a looming reduction in liquidity in times when rolling over debt is difficult or costly. Our measure of short-term debt includes long-term debt maturing in less than one year. In contrast, long-term debt with greater maturity does not have an immediate effect on corporate liquidity. Thus, to the extent that the crisis resulted in a decreased supply or higher costs of debt financing, we would expect post-crisis investment declines to be greater for firms with high net short-term debt (short-term debt minus cash reserves), but expect no similar effect for long-term debt.[15]

Table 7 presents evidence consistent with these ideas. Consistent with our identification strategy, we measure all debt positions one year prior to the onset of the crisis. Because winsorizing at the 1%/99% level does not suffice to remove influential outliers from these debt measures, we restrict the sample to firms with debt less than 50% of assets, and net debt within $\pm 50\%$ of assets. Column 1 shows that there is a negative, but not quite statistically significant, relation between short-term debt positions and post-crisis changes in investment. Column 4 shows that the relation for net short-term debt, which represents net short-term liquidity, is statistically significant. Col-

[15] Almeida, Campello, Laranjeira, and Weisbenner (2009) adopt a similar approach to that presented in Table 7, and further explore the role of debt maturity on investment during the crisis.

Table 6
External finance dependence, information asymmetry, and investment before and after the crisis.

This table presents estimates from panel regressions explaining firm-level quarterly investment for quarters with an end-date from July 1, 2006 to June 30, 2008. The regressions are estimated separately for subsamples of firms formed on the basis of industry-level measures of external-finance dependence, equity dependence, and information asymmetry estimated from 2000 to 2005. External-finance dependence is the industry-median proportion of investment not financed by cash flow from operations; Equity dependence is the industry-median ratio of equity to investment (following Rajan and Zingales, 1998). Information asymmetry is the industry standard deviation of productivity growth, as measured by the ratio of sales to the number of employees. For all measures, the low and high subsamples comprise firms with external-finance dependence and information asymmetry measures below and above the sample median, respectively. All other variables are defined in previous tables. All regressions include firm fixed effects. Standard errors (in brackets) are heteroskedasticity-consistent and clustered by firm. ***, **, or * indicates that the coefficient estimate is significant at the 1%, 5%, or 10% level, respectively. *p*-Values are reported at the bottom of each panel for stated null and alternative hypotheses on the estimated coefficients *A* (*After*) and *AxC* (*After x Cash reserves*) for external-finance dependent (D) and non-dependent (N) subsamples.

	External-finance dependence		Equity dependence		Information asymmetry	
Panel A: *Change in investment and external finance dependence*						
	Low	High	Low	High	Low	High
After	−0.005	−0.212***	−0.041	−0.169***	−0.098***	−0.126***
	[0.024]	[0.041]	[0.027]	[0.038]	[0.033]	[0.039]
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.652	0.714	0.664	0.727	0.649	0.754
N Obs	13,073	12,905	12,483	13,495	11,811	11,755
A H_o:D=N, H_a:D < N		0.000		0.003		0.293
Panel B: *Change in investment and external finance dependence conditional on cash reserves*						
	Low	High	Low	High	Low	High
After	−0.010	−0.333***	−0.077**	−0.269***	−0.136***	−0.242***
	[0.029]	[0.054]	[0.035]	[0.052]	[0.046]	[0.055]
After x Cash reserves	0.134	0.894***	0.297**	0.704***	0.352*	0.612***
	[0.110]	[0.217]	[0.121]	[0.194]	[0.195]	[0.149]
Q	0.197***	0.193**	0.166***	0.246***	0.153**	0.191***
	[0.064]	[0.077]	[0.063]	[0.078]	[0.075]	[0.070]
Cash flow	−0.018*	−0.026*	−0.012	−0.035*	0.001	−0.027**
	[0.010]	[0.015]	[0.008]	[0.018]	[0.009]	[0.011]
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.660	0.720	0.669	0.735	0.653	0.760
N Obs	12,258	12,255	11,762	12,751	11,019	11,138
A H_o:D=N, H_a:D < N		0.000		0.001		0.071
AxC H_o:N=D, H_a:N < D		0.001		0.038		0.144

Table 7
Leverage and investment before and after the credit crisis.

This table presents estimates from panel regressions explaining firm-level quarterly investment for quarters with an end-date from July 1, 2006 to June 30, 2008. Leverage is as of the last fiscal quarter ending before July 1, 2006, and is measured as short-term debt in column 1, long-term debt in column 2, total debt in column 3, net short-term debt (short-term debt minus cash) in column 4, net long-term debt (long-term debt minus cash) in column 5, and net debt (short- and long-term debt minus cash) in column 6, all normalized by total assets. All other variables are defined in previous tables. All regressions include firm fixed effects. Standard errors (in brackets) are heteroskedasticity-consistent and clustered at the firm level. ***, **, or * indicates that the coefficient estimate is significant at the 1%, 5%, or 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
After	−0.067**	−0.151***	−0.128***	−0.165***	−0.130***	−0.125***
	[0.028]	[0.036]	[0.037]	[0.031]	[0.026]	[0.027]
After x Leverage	−0.787	0.303	0.092	−0.612***	−0.006	−0.113
	[0.524]	[0.188]	[0.176]	[0.193]	[0.113]	[0.109]
Q	0.169***	0.180***	0.181***	0.218***	0.201***	0.220***
	[0.049]	[0.046]	[0.047]	[0.064]	[0.060]	[0.058]
Cash flow	−0.018**	−0.019**	−0.019**	−0.023**	−0.024**	−0.024**
	[0.008]	[0.008]	[0.008]	[0.011]	[0.011]	[0.011]
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.729	0.741	0.741	0.730	0.742	0.744
N Obs	24,237	23,087	22,260	21,637	21,396	20,716
Leverage:	ST Debt	LT Debt	Debt	Net ST debt	Net LT debt	Net debt

umns 2, 3, 5, and 6 show that there are no similar significant relations for long-term or total debt.

The estimates in column 4 of Table 7 suggest a post-crisis decline of 0.165% of assets per quarter for a firm with zero net short-term debt, a decline of 0.070% of assets per quarter for a firm with the average net short-term debt in our sample (−15.5% of assets, see Table 1), and a decline of 0.215% of assets per quarter for a firm with net short-term debt one standard deviation (23.7%) above the average.

Because net short-term debt represents a looming reduction in liquidity in times when refinancing is difficult or costly, whereas long-term debt does not, these findings reinforce the interpretation of our main results as a supply effect.

4.7. Post-crisis investment and "excess" cash

Table 8 investigates the role of "excess" cash in mitigating investment declines following the crisis. We compute excess cash as follows. First, we estimate a regression to establish the "normal" cash holdings for a U.S. firm. This step is based on the work of Opler, Pinkowitz, Stulz, and Williamson (1999) and Dittmar and Mahrt-Smith (2007). Excess cash is then defined as the difference between actual cash and predicted, or normal cash. In the excess cash literature, this predicted cash is taken as a measure of firms' optimal cash holdings, and most prior work focuses on agency problems stemming from cash holdings above the optimum.

Previous literature on optimal cash identifies several reasons for firms to hold cash. First, cash holdings are required to support the day-to-day operations of the firm, as suggested by Keynes' (1936) transaction cost motive. To this end, most empirical models of cash holdings control for firm size, as well as cash substitutes such as working capital. Other motives for holding cash include accumulating precautionary cash in anticipation of new investment opportunities when external finance is costly. Thus, most models include controls for cash flow, investment opportunities, cash-flow volatility, and access to financial markets measured by firm size. Finally, macroeconomic conditions might also affect cash holdings, and therefore most models include year fixed effects.

Importantly, while existing empirical models of optimal cash allow firms to adjust their cash holdings to take into account cash-flow risk, this risk is usually estimated over ten or fewer previous years. To the extent that a credit crisis such as the current one occurs much less frequently than that, the methodology does not take into account the risk of an extreme "credit crunch" that threatens to significantly dry up external sources of funding. If some firms take these risks into account and consequently hold more cash, existing empirical models of optimal cash may incorrectly classify them as holding cash in excess of what is optimal.

Therefore, we hypothesize that seemingly excess cash may allow firms to fund investment during the crisis that they otherwise would not be able to fund. To investigate this idea, we employ two specifications to estimate normal cash, following Opler, Pinkowitz, Stulz, and Williamson (1999) and Dittmar and Mahrt-Smith (2007):

$$cash_{i,t} = \beta_0 + \beta_1 SIZE_{i,t} + \beta_2 CF + \beta_3 NWC + \beta_4 (Industry\ CF\ Volatility)_{i,t} + \beta_5 (M/B)_{i,t} + Year\ Dummies + \varepsilon_{i,t}$$

$$cash_{i,t} = \beta_0 + \beta_1 SIZE_{i,t} + \beta_2 CF + \beta_3 NWC + \beta_4 (Industry\ CF\ Volatility)_{i,t} + \beta_5 (M/B)_{i,t} + \beta_6 DEBT + \beta_7 CAPEX + \beta_8 DIVIDEND\_DUMMY + Year\ Dummies + \varepsilon_{i,t}$$

We call the first specification "baseline specification" and the second specification "extended specification." We estimate these models for the period 1995–2004 and compute excess cash as the residual cash at the end of the last fiscal quarter ending before July 1, 2006.

Table 8 presents results for excess cash analogous to those for cash in Table 3. Consistent with our hypothesis, seemingly excess cash is positively related to post-crisis investment. The estimates from the baseline specification imply a decline in post-crisis investment of 0.078% of assets per quarter for a firm with zero excess cash, and no decline for a firm with excess cash equal to 11.0% of assets. In untabulated analysis, we estimate the sensitivity of post-crisis investment to excess cash for subsamples of firms formed on the basis of various measures of financial constraints, analogous to the specifications in Panel B of Table 5. Every point estimate suggests that the relation between seemingly excess cash and post-crisis investment is stronger for financially constrained firms, but the difference is only statistically significant for five of the ten specifications, in part because excess cash is an estimated, and therefore noisy, quantity.

Table 8
"Excess" cash and investment before and after the credit crisis.

This table presents estimates from panel regressions explaining firm-level quarterly investment for quarters with an end-date from July 1, 2006 to June 30, 2008. Excess cash is the residual cash to total assets at the end of the last fiscal quarter ending before July 1, 2006. Excess cash is defined relative to two models of optimal cash holdings, as presented in Opler et al. (1999) (in columns 1 and 2) and modified in Dittmar and Mahrt-Smith (2007) (in columns 3 and 4), estimated over the period from 1995 to 2004. All other variables are defined in previous tables. All regressions include firm fixed effects. Standard errors (in brackets) are heteroskedasticity-consistent and clustered at the firm level. ***, **, or * indicates that the coefficient estimate is significant at the 1%, 5%, or 10% level, respectively.

	Baseline specification		Extended specification	
	(1)	(2)	(3)	(4)
After	−0.103***	−0.078***	−0.096***	−0.071***
	[0.023]	[0.024]	[0.023]	[0.025]
After x Excess cash	0.679***	0.708***	0.822***	0.858***
	[0.118]	[0.124]	[0.125]	[0.130]
Q		0.182***		0.179***
		[0.049]		[0.049]
Cash flow		−0.021**		−0.021**
		[0.009]		[0.009]
Firm fixed effects	Yes	Yes	Yes	Yes
R^2	0.719	0.725	0.719	0.725
N Obs	25,619	24,309	25,619	24,309

A possible alternative interpretation of our findings on excess cash is that they reflect agency problems in the form of inefficient overinvestment, rather than the mitigation of underinvestment. To address this concern, in untabulated analysis we investigate an implication of this agency hypothesis, whether the propensity to invest out of excess cash post-crisis is greater for poorly governed firms (using the governance index of Gompers, Ishii, and Metrick, 2003).[16] We do not find any evidence of this.

Overall, the evidence in this section suggests a precautionary savings role for seemingly excess cash that has not been emphasized in the extant literature. Most prior work focuses on the "dark side"—the potential for managerial abuse due to agency problems (e.g. Dittmar and Mahrt-Smith, 2007; Harford, 1999; Harford, Mansi, and Maxwell, 2008; Pinkowitz, Stulz, and Williamson, 2006). In contrast, our results emphasize a "bright side"—seemingly excess cash may in fact benefit firms in times of dislocation in markets for external capital. During the crisis, so-called "excess" cash is not in fact excessive. This suggests that existing models of excess cash are incomplete to the extent that they cannot take into account the probability and consequences of rare credit crunches, which are difficult to estimate.

4.8. Stock return performance and cash

We next investigate the efficiency implications of the relation between cash reserves and post-crisis investment. We examine stock returns following the onset of the crisis as a function of firms' internal financial resources (cash). To the extent that the market efficiently prices in all available information, the implications of a lack or availability of funds during a credit crisis will be impounded into stock prices.

Fig. 3 plots value-weighted raw and Fama-French size and book-to-market style-adjusted monthly returns for two portfolios formed on the basis of firms' cash holdings at the end of 2006. Consistent with the precautionary benefit of cash, the cash-rich portfolio (comprising firms in the top quintile) outperforms the cash-poor portfolio (comprising firms in the bottom quintile) by about 15 percentage points in raw as well as abnormal returns by the end of 2007. The parallel trend between the two portfolios is evident before the crisis. The fact that most of the difference in returns is concentrated in the post-crisis period is a good diagnostic sign that the crisis was not anticipated by the market. These findings support the interpretation that financial liquidity had a value-enhancing impact on investment during the crisis.

4.9. Alternative corporate spending measures

Our analysis so far follows most of the investment literature and focuses on capital expenditures to assets as a measure of investment. In principle, we would expect to see similar effects of cash reserves for other measures of investment or corporate spending. Table 9 duplicates our main specification for four other measures of corporate spending: sales, general, and administrative expense; research and development expense; net working capital excluding cash; and inventories studied by Kashyap, Lamont, and Stein (1994). All spending measures are scaled by total firm assets. The results are consistent with the view that other kinds of corporate spending were impacted similarly to capital expenditures.

Table 9
Other corporate spending before and after the credit crisis.

This table presents estimates from panel regressions explaining alternative firm-level quarterly spending measures for quarters with an end-date from July 1, 2006 to June 30, 2008. SG&A is sales, general, and administrative expense. R&D is research and development expense. NWC is net working capital excluding cash. Inventory is total inventories. All spending measures are divided by total assets and expressed in percentage points. All other variables are defined in previous tables. All regressions include firm fixed effects. Standard errors (in brackets) are heteroskedasticity-consistent and clustered at the firm level. ***, **, or * indicates that the coefficient estimate is significant at the 1%, 5%, or 10% level, respectively.

	SG&A	R&D	NWC	Inventory
After	−0.034	−0.084*	−0.584***	−0.102*
	[0.041]	[0.047]	[0.135]	[0.054]
After x Cash reserves	1.375***	0.715***	1.541***	1.167***
	[0.220]	[0.212]	[0.530]	[0.235]
Q	0.607***	0.418***	0.040	0.106
	[0.097]	[0.107]	[0.228]	[0.119]
Cash flow	−0.186***	−0.138***	0.135***	−0.033***
	[0.037]	[0.022]	[0.046]	[0.012]
Firm fixed effects	Yes	Yes	Yes	Yes
R^2	0.951	0.881	0.916	0.976
N Obs	23,244	11,913	24,253	24,098

4.10. Extending the post-crisis sample

In a final step, we investigate how our main results change when we extend the post-crisis sample to March 31, 2009. On the one hand, as the crisis lengthens and deepens, the supply effects presented above may intensify. On the other hand, the demand-side effects of the crisis increased substantially beginning in the third quarter of 2008, particularly following the stock market meltdown of September–October 2008. If in this period firms' demand for investment decreased to such an extent that the tightened supply of external finance caused by the crisis was not the binding constraint, then we would not expect to see a relation between cash reserves and investment in the data (at the extreme, if no firm wanted to invest, cash on hand would be irrelevant for investment). Put differently, to observe the effects of a supply shock in the data it must not only be the case that a supply shock occurred, but also that it was binding on sufficiently many firms. Another possibility, consistent with the decline in cash balances shown in Fig. 2, is that firms may have spent their financial buffer stocks in the early parts of the crisis, leaving even previously high-cash firms with insufficient resources to mitigate subsequent

[16] Fee, Hadlock, and Pierce (2009) adopt a similar approach to address a similar concern.

Table 10
Cash reserves and investment before, after, and late-after the credit crisis.

This table presents estimates from panel regressions explaining firm-level quarterly investment for quarters with an end-date between July 1, 2006 and March 31, 2009. After is an indicator variable equal to one for fiscal quarters with an end-date between July 1, 2007 and June 30, 2008, the first year following the approximate beginning of the credit crisis. Late-after is an indicator variable equal to one for fiscal quarters with an end-date after July 1, 2008, which includes a negative shock to demand following the market meltdown in September–October 2008. Cash reserves is the ratio of cash to total assets at the end of the last fiscal quarter ending before July 1, 2006. All other variables are defined in previous tables. All regressions include firm fixed effects. Specification 5 further includes industry-year-quarter fixed effects based on Fama-French 48-industry definitions. Standard errors (in brackets) are heteroskedasticity-consistent and clustered at the firm level, except for specification 6 which reports robust standard errors clustered by both firm and time (year-quarter) using the method of Petersen (2009). ***, **, or * indicates that the coefficient estimate is significant at the 1%, 5%, or 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
After	−0.100***	−0.174***	−0.160***	−0.164***		−0.164*
	[0.023]	[0.029]	[0.030]	[0.031]		[0.093]
After x Cash reserves		0.396***	0.460***	0.473***	0.465***	0.473***
		[0.104]	[0.106]	[0.110]	[0.111]	[0.182]
Late-after	−0.110***	−0.109***	−0.043	−0.060		−0.060
	[0.029]	[0.038]	[0.041]	[0.040]		[0.074]
Late-after x Cash reserves		−0.012	0.128	0.159	0.159	0.159
		[0.142]	[0.138]	[0.133]	[0.134]	[0.169]
Q			0.197***	0.200***	0.189***	0.200***
			[0.050]	[0.051]	[0.053]	[0.056]
Cash flow				−0.021***	−0.022***	−0.021***
				[0.007]	[0.007]	[0.005]
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.703	0.704	0.708	0.712	0.713	0.712
N Obs	31,842	31,791	31,189	30,102	29,935	30,102

investment declines. This possibility amounts to a weakening of our "instrument" (second quarter 2006 cash) over time. If so, we again would not expect to see a relation between cash reserves and investment.

To investigate these ideas, in Table 10 we extend our main specifications in Table 3 by adding the three quarters July 1, 2008–March 31, 2009 to the sample and designating these quarters with the indicator variable "Late after". We also include the interaction of this indicator variable with cash reserves measured, as before, as of the last fiscal quarter ending before July 1, 2006. As noted in Section 3.1, our data for the first quarter of 2009 are incomplete, which may introduce some bias, but we obtain similar results to those discussed below if we instead end the sample in the fourth quarter of 2008.[17]

Table 10 shows that corporate investment continued to decline over the three quarters July 1, 2008–March 31, 2009 relative to the pre-crisis period. In contrast to our main results, however, the decline in this period is largely explained by changing investment opportunities captured by Q and cash flow (the "Late after" indicator variable becomes statistically insignificant when these controls are added). Moreover, we do not find a significant effect of cash reserves (again measured in the second quarter of 2006) on investment in this late-crisis period, although the point estimates continue to be positive and large in magnitude, with magnitudes about one-third of those for the "After" period. All of these results are consistent with a reduction in investment demand making supply constraints less important. Consistent with a weakening of our "instrument" over time, and with Fig. 2, the average firm's cash balance declines from 19.0% of firm assets in the second quarter of 2006 to 15.8% of firm assets in the second quarter of 2008, and the cross-sectional standard deviation of firm cash balances also shrinks from 21.3% to 18.4%. This decline in cash reserves is statistically significant at the 1% level.

5. Conclusion

We study the effect of the financial crisis that began in August 2007 on corporate investment. The crisis represents an unexplored negative shock to the supply of external finance for non-financial firms. We focus on the mainly financial phase of the crisis, or the year July 1, 2007–June 30, 2008. We find that corporate investment declines significantly following the onset of the crisis, controlling for firm fixed effects and time-varying measures of investment opportunities. Using our base specifications, we find that corporate investment declines by 6.4% of its unconditional mean following the onset of the crisis, specifically by 0.109% of assets relative to an unconditional mean of 1.695% of assets (per quarter).

Consistent with a causal effect of a supply shock, the decline is greatest for firms that have low cash reserves or high net short-term debt, are financially constrained, or operate in industries dependent on external finance. To address endogeneity concerns, we measure these financial positions as much as four years prior to the crisis and

[17] We obtain similar results to those presented in previous tables when we pool together all post-crisis quarters. While our conclusions from previous tables are therefore applicable to the full post-crisis sample period taken as a whole, we treat the "After" and "Late After" periods separately in Table 10 to highlight the important differences in results in the two periods.

confirm that we do not find similar results following placebo crises in the summers of 2003–2006. We also do not find similar results following the negative demand shock caused by the events of September 11.

We estimate that investment declines by 0.179% of assets for a zero-cash firm. A one-standard-deviation (25th to 75th percentile) increase in year-before cash reserves mitigates the decline by 0.104 (0.124) percentage points, or 58% (69%) of the decline for a zero-cash firm. Because the correlation between year-before cash and cash during the crisis period is less than one, these estimates should be interpreted as a lower bound on the importance of cash reserves during the crisis.

In a final step, we find that corporate investment continued to decline over the three quarters July 1, 2008–March 31, 2009, during which the demand-side effects of the crisis strengthened considerably, especially following the stock market meltdown in September–October 2008. In contrast to our main results, however, this result is largely explained by changing investment opportunities captured by Q and cash flow. In this period, our measure of cash reserves has an insignificantly positive effect on investment. These results are consistent with a weakening of our "instrument" (second quarter 2006 cash) as firms' financial positions evolve as the crisis lengthens and deepens, and with sharply decreased demand for investment making supply constraints less important during this period.

Appendix

Variable definitions: All names in parentheses refer to the Compustat item name.

Investment=quarterly capital expenditure/total assets (atq). Because capital expenditure is reported on a year-to-date basis in quarterly financial statements, we subtract the previous quarter's capital expenditure from the current quarter's capital expenditure (capxy) for fiscal quarters 2, 3, and 4.

Cash=Cash and short-term investments (cheq)/total assets (atq).

Short-term debt=Debt in current liabilities (dlcq)/total assets (atq).

Long-term debt=Long-term debt (dlttq)/total assets (atq).

Cash flow=Operating income before depreciation (oibdq)/total assets (atq).

Tobin's Q=Market value of assets (total assets (atq)+market value of common equity (cshoq∗prccq)−common equity (ceqq)−deferred taxes (txdbq))/(0.9∗book value of assets (atq)+0.1∗market value of assets).

After=Indicator variable equal to one if the observation's calendar time is after June 30, 2007.

Kaplan-Zingales (1997) index=−1.002∗Cash flow+0.283∗Q+3.319∗Debt−39.368∗Dividends−1.315∗Cash.

Whited-Wu (2006) index=−0.091∗Cash flow+0.062∗Dividend dummy+0.021∗Long-term debt−0.044∗Size+0.102∗Industry sales growth−0.035∗Sales growth.

Payout ratio=(Cash dividends (dvp+dvc)+repurchases (prstkc))/income before extraordinary items (ib).

SG&A=Selling, general, and administrative expenses (xsgaq)/sales (saleq).

R&D=R&D expense (xrdq)/total assets (atq).

NWC=Net working capital excluding cash (current assets (actq)−current liabilities (lctq)−cash (cheq))/total assets (atq).

Inventory=Total inventories (invtq)/total assets (atq).

External finance dependence=(Capital expenditures (capx)−funds from operations (fopt))/capital expenditures (capx). When fopt is missing, funds from operations is defined as the sum of the following variables: Income before extraordinary items (ibc), depreciation and amortization (dpc), deferred taxes (txdc), equity in net loss/earnings (esubc), sale of property, plant, and equipment and investments−gain/loss (sppiv), and funds from operations−other (fopo).

External equity dependence=ratio of the net amount of equity issued (sale of common and preferred stock (sstk)−purchase of common and pref. stock (prstkc)) to capital expenditures (capx).

Productivity growth dispersion=Industry standard deviation of productivity growth. Productivity is defined as sales (sale)/number of employees (emp).

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