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ORIGINAL RESEARCH

Cash holdings and the bargaining power of R&D-intensive targets

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Abstract Prior literature suggests that R&D-intensive firms hold large amounts of cash due to financing constraints. This paper examines whether such firms could also use cash holdings as a strategic bargaining tool in M&A transactions. Using a large sample of takeover bids announced between 1980 and 2012, we demonstrate that cash holdings positively impact R&D-intensive targets' takeover premiums and announcement-period abnormal returns. These effects disappear in non-R&D-intensive firms. Controlling for various endogeneity and financing concerns, we also find that R&D-intensive firms build up cash holdings in anticipation of becoming a takeover target. Further analysis indicates that in R&D-intensive firms, such cash holdings are valued highly by the market. Taken together, our findings shed new light on the strategic bargaining role of corporate cash holdings in the outcomes of acquisitions targeting R&D-intensive firms.

Keywords R&D intensity · Corporate cash holdings · Bargaining power · Takeover premiums · Announcement-period CARs · Ex ante takeover probability

JEL Classification G30 · G34

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1 Introduction

Corporate research and development (R&D) investment plays a significant role in the long-term economic growth (Solow 1957). Over the last three decades, the average R&D-to-sales ratio for U.S. R&D-reporting firms has increased substantially from 0.027 in 1980 to 0.155 in 2012, and this increase is accompanied by the rising share of R&D in total investment.[1] To acquire innovative capital, a firm can either invest in internal R&D programs or purchase other firms that have large R&D investments (Phillips and Zhdanov 2013). The latter has become an increasingly popular channel for firms to gain access to innovative assets and thus to potential new products.[2] Phillips and Zhdanov (2013) show that instead of engaging in "R&D race" with small firms, large firms may let small firms invest in R&D, and subsequently acquire them to gain access to innovative capital and valuable intangible assets. Bena and Li (2013) find that companies with large patent portfolios and low R&D expenses are acquirers while companies with high R&D expenses and slow growth in patent output are targets. More recently, Lin and Wang (2016) document evidence that R&D-intensive firms are associated with higher takeover probability even after controlling for various R&D-related factors. These studies suggest that acquisitions targeting R&D-intensive firms are an important component of the M&A market.

Though prior studies on mergers and acquisitions (M&A) have documented significantly positive announcement returns for target shareholders (Jensen and Ruback 1983; Jarrell et al. 1988; Andrade et al. 2001), relative bargaining power and bilateral negotiations between the target and its acquirer remain important determinants of merger outcomes (Schwert 2000; Comment and Schwert 1995; Boone and Mulherin 2006; Povel and Singh 2006; Officer 2003, 2004; Ahern 2012). Despite the increasing interest in M&A transactions involving R&D-intensive firms, little is known about the factors that affect R&D-intensive targets' bargaining position. Sevilir and Tian (2012) find that acquisitions targeting innovative firms generate positive acquirer announcement returns. They also show that the pre-acquisition innovation output of the target firm positively impacts the stock performance of the combined firm. However, Sevilir and Tian (2012) mainly focus on acquirers. In this paper, we examine R&D-intensive targets and propose that these targets' bargaining power varies with cash levels. We also investigate the implications of this cash effect for R&D-intensive targets' ex-ante bargaining strategies.

Cash holdings are a valuable asset in R&D-intensive firms and can be used to their advantage in the M&A market. Prior studies show that: 1) Due to its limited collateral value and severe information asymmetries (Arrow 1962; Hall and Lerner 2009), firm-level R&D investment is hard to finance using external sources of capital; and 2) Due to its intangible asset base created from human capital investment which would be lost upon discontinuation of R&D spending (Hall 2002; Lach and Schankerman 1988), firm-level R&D investment is subject to high adjustment costs associated with altering the path of R&D spending. Thus, corporate cash holdings of R&D-intensive firms play an important role in not only financing risky, new R&D projects and avoiding underinvestment problems when alternative financing sources are unavailable but also smoothing existing R&D investment and avoiding expensive adjustment costs (Brown and Petersen 2011). The

[1] The share of R&D in total investment [R&D/(R&D + Capital expenditures + Acquisitions)] rose from 0.259 in 1980 to 0.493 in 2012. These numbers are based on a sample of all public R&D reporting firms in the Compustat database, excluding financial and utility firms.

[2] High technology firms such as Microsoft, Google, and Apple frequently acquire firms that are in the process of developing competing/supporting technologies.

availability of corporate cash holdings in R&D-intensive targets signals resource independence and can enhance such firms' bargaining power by enabling them to negotiate better offer prices.

Using a large sample of takeover bids announced between 1980 and 2012, we find significant variations in the merger outcomes of R&D-intensive targets that hold different levels of cash. Our univariate analyses indicate that the takeover premiums and announcement-period cumulative abnormal returns (CARs) for R&D-intensive targets are significantly higher when they hold higher levels of cash. In our multivariate analyses, we find that higher cash holdings have a positive and economically significant impact on R&D-intensive targets' takeover premiums and CARs: a one standard deviation increase (0.202) in cash holdings increases the 41-day offer premium (3-day CAR) by 3.94% (14.85%) for a firm that spends 20% of its revenues on R&D investment. Further, we document that this cash effect is absent in non-R&D-intensive targets and is not driven by a pure R&D effect on merger outcomes. Overall, these results are consistent with the hypothesis that cash holdings enhance the bargaining power of R&D-intensive targets.

This positive cash effect on the merger outcomes of R&D-intensive targets has important implications for these firms' ex ante bargaining strategies. When faced with a higher probability of becoming a takeover target, R&D-intensive firms have strong incentives to increase the level of cash holdings in order to enhance their ex ante bargaining power. To examine this hypothesis, we follow previous literature (Billett and Xue 2007; Bhanot et al. 2010) and construct ex ante takeover probability using a two-stage instrumental variable approach, which mitigates endogeneity concerns associated with omitted variables and reverse causality. In the first stage, we model ex-ante takeover probability as a latent variable by regressing the takeover dummy variable on a panel of lagged firm characteristics, along with the instrumental variables (state density of takeovers and industry density of takeovers). We then use the predicted takeover probability to measure the firm's takeover exposure at the beginning of the year. Next, we analyze whether R&D-intensive firms increase cash holdings as they face higher probability of being targeted by regressing cash holdings on the interaction between R&D intensity and takeover exposure. This approach allows us to capture the strategic response of R&D-intensive firms prior to receiving an actual bid.

We find strong empirical evidence to support our prediction that R&D-intensive firms hold more cash to enhance their bargaining power as the probability of receiving a takeover bid increases. Our results are both statistically significant and economically meaningful. *Ceteris Paribas*, a firm in which 20% of the revenues are invested in R&D increases cash holdings by 17.09% in response to a 10-percentage-point increase in ex ante takeover probability. We further demonstrate that these results are persistent for at least two years into the future following the increase in takeover exposure. We also consider an alternative measure of takeover probability and employ other econometric techniques to address endogeneity concerns. We obtain consistent findings using the alternative measure of takeover exposure, and our results are robust to firm fixed effects as well as a propensity score matching approach. In addition, our results are robust to a sub-period analysis and are more pronounced in the more recent sub-period (2000–2012). Together, these results suggest that takeover exposure in the market for corporate control plays an important role in R&D-intensive firms' cash policies.

Finally, we examine how the marginal value of cash associated with higher takeover exposure varies with R&D intensity. According to the bargaining power hypothesis, cash holdings in R&D-intensive targets benefit shareholders by enabling target firms to negotiate better deals. We thus expect cash held by R&D-intensive firms in anticipation of a

takeover bid to receive positive valuation from the market. Using the methodology of Faulkender and Wang (2006), we find consistent evidence that the marginal value of cash associated with higher ex ante takeover probability in R&D-intensive firms is significantly higher.

Our study contributes to three strands of literature. First, we advance the line of research that examines the effect of bargaining strategies and negotiation processes on merger outcomes. This literature finds that takeover premiums are positively associated with the adoption of antitakeover measures (Comment and Schwert 1995), target firms' hostility toward acquirers (Schwert 2000), target lockup options (Burch 2001), target termination fees (Officer 2003; Bates and Lemmon 2003), and sequential negotiation procedures (Povel and Singh 2006). This literature also documents a negative effect on takeover premiums when target CEOs have higher illiquid stock and option holdings (Cai and Vijh 2007) and when the target industry exhibits a greater reliance on its acquirer's industry (Ahern 2012). We shed new light on an important determinant of the merger outcomes for R&D-intensive target firms by showing that cash holdings are positively associated with these firms' takeover premiums and announcement-period CARs. Our paper also provides evidence that holding higher levels of cash is value-increasing to shareholders when R&D-intensive firms become takeover targets in the M&A market.

Second, our paper extends the literature on the importance of cash holdings to R&D-intensive firms. While the unique nature of R&D investment makes it difficult to obtain debt financing (Arrow 1962; Hall and Lerner 2009), increasingly volatile cash flow and equity financing ultimately lead R&D-intensive firms to rely on cash for funding and smoothing (Brown and Petersen 2011). Consistently, Bates et al. (2009) show that the increase in R&D intensity is partially responsible for the large buildup in cash holdings among U.S. firms from 1980 to 2006. Through documenting a positive association between the cash levels of R&D-intensive targets and their bargaining power, we demonstrate that the role of cash holdings goes beyond financing and smoothing R&D investment and is reflected in the M&A negotiation process.

Third, our paper contributes to the literature on agency costs of cash holdings in the market for corporate control. Extant evidence mostly focuses on acquiring firms and suggests a value-destroying role of high cash levels in acquisitions (Harford 1999; Moeller et al. 2005). While Jensen (1986) argues that the takeover market monitors corporate cash holdings by targeting cash-rich firms, the merger outcomes of cash-rich target firms, if such firms are actually targeted,[3] have received little attention. Our study fills this gap by examining the effect of cash holdings on takeover premiums and target announcement-period CARs. We document a positive cash effect but our results are significant only for R&D-intensive target firms. Thus, the evidence is inconsistent with an alternative explanation that this positive cash effect on takeover premiums and target CARs is driven by target firms' agency issues.

Our study highlights how managers can choose alternative strategies to promote shareholders' interests. In M&A transactions, managers of R&D-intensive targets sometimes negotiate with a weak position, especially when they have limited access to capital. We show that firms with R&D base can preserve cash and negotiate better terms with potential acquirers than those that do not have large cash holdings. The recent takeover fight between Allergen and Valeant demonstrates how this strategy helped Allergen defend itself against the acquisition attempt from Valeant. Since enhanced negotiating power can transfer into increased shareholder wealth for the shareholders of R&D-intensive targets,

[3] Harford (1999) documents evidence that cash-rich firms are less likely to be targeted.

our study thus presents important implications for top management pursuing the goal of value maximization.

The remainder of the paper is organized as follows. Section 2 reviews related literature and develops testable hypotheses. Section 3 presents sample selection and descriptive statistics. Section 4 presents empirical results on the association between cash holdings and the merger outcomes for R&D-intensive target firms. Section 5 investigates implications of the cash effect on R&D-intensive target firms' ex ante bargaining strategies. Section 6 summarizes and concludes the paper.

2 Literature review and hypothesis development

2.1 Literature review

2.1.1 R&D and M&A transactions

M&A activity plays an important role in replenishing the innovation pipelines of modern firms. Higgins and Rodriguez (2006) argue that firms facing time-to-market pressure find it too slow to develop R&D investments internally and thus resort to external acquisitions of new technologies. Aghion and Tirole (1994) analyze the organization of R&D activities in an incomplete contract framework. They suggest that establishing independent research units and giving property rights to the research unit is a more efficient approach to pursue innovative capital when it is more important to motivate employees to discover. Employees' lack of motivation to work on risky projects may be severe in large, multi-divisional firms that suffer from agency problems and inefficient investment due to internal power struggles (Rajan et al. 2000; Rotemberg and Saloner 1994; Scharfstein and Stein 2000). In this case, acquiring innovation in the M&A market is a good way to boost research productivity. Sevilir and Tian (2012) find that a firm can significantly increase its number of patents and citations on patents by acquiring innovative firms with greater R&D and patenting intensity. Examining industrial sections where innovation and technology are important, Blonigen and Taylor (2000) find that firms with low R&D intensity are more likely to initiate acquisitions. Similarly, Bena and Li (2013) show that acquirers in the M&A market exhibit higher innovation output but lower R&D expenses than their targets.

On the other hand, firms in an active takeover market have stronger incentives to engage in R&D programs and exit through strategic sales upon successful innovation. Katz and Shapiro (1986) argue that the revenues from licensing and sale of intangible property may be an important component of the incentives to conduct R&D activities. Theoretically analyzing incumbency and R&D incentives, Gans and Stern (2000) suggest that the prospect of cooperation at the commercialization stage between an established firm and a startup innovator shapes R&D incentives. Prior literature also documents empirical evidence on the positive association between takeover market intensity and R&D incentives. Phillips and Zhdanov (2013) find that firms' incentives to innovate and conduct R&D increases with the probability of becoming a takeover target. Lin and Wang (2016) find that R&D intensity is positively and significantly associated with takeover probability.

2.1.2 Bargaining power in M&A transactions

Most literature on M&A presents target firms as "winners" due to the significantly positive abnormal announcement returns they receive. However, existing evidence demonstrates that factors influencing bargaining power and negotiation process nonetheless play an important role in the merger outcomes of target firms. Analyzing the adoption of anti-takeover measures, Comment and Schwert (1995) show that poison pills and control share laws are associated with higher takeover premiums for target shareholders. They conclude that antitakeover measures increase the bargaining power of target firms rather than entrench incumbent management by systematically deterring takeovers. Schwert (2000) finds that a target firm's hostility toward the acquirer firm in takeover negotiations is largely a reflection of strategic bargaining which leads to higher average premiums for target shareholders. Burch (2001) suggests that target managers use lockup options to enhance bargaining power. He finds that deals with lockup options have higher target announcement returns and lower bidder announcement returns. Officer (2003) argues that target termination fees are used by managers to encourage bidding participation through the protection of deal-related investments. He provides evidence that merger deals with target termination fees experience significantly higher premiums and success rates.

Similarly, Bates and Lemmon (2003) find that termination fee provisions serve as an efficient contracting device and benefit target shareholders by increasing deal completion rates and target premiums. Povel and Singh (2006) demonstrate that target firms can use a sequential procedure to extract optimal transaction price when faced with bidders that are not equally well informed. Cai and Vijh (2007) find that target CEOs with higher illiquid stock and option holdings are less likely to bargain and more likely to accept a low premium. Examining the division of total merger gains, Ahern (2012) indicates that a target firm's share of gains varies with its bargaining power, which is determined partially by its market power and customer-supplier relations in the product market. Bargaining power may be even more important for R&D-intensive targets because they are more likely to receive lower takeover premiums due to information asymmetries (Aboody and Lev 2000; Qi et al. 2015).

2.1.3 Cash holdings and R&D investment

The strategic role of cash holdings in enhancing R&D-intensive targets' bargaining power builds on a growing body of literature that examines the importance of cash holdings to R&D activities. Examining a panel of small firms in high-tech industries, Himmelberg and Petersen (1994) find that cash holdings significantly impact both the R&D and physical investment in R&D-intensive firms due to moral hazard and adverse selection problems. Pinkowitz and Williamson (2007) show that the value of cash is highest in R&D-intensive industries such as computers, computer software, electronic equipment, and pharmaceuticals. Hall and Lerner (2009) argue that liquidity constraints can disadvantage R&D investment of established firms. Schroth and Szalay (2010) demonstrate theoretically and empirically that firms holding more cash are more likely to win patent races. Brown and Petersen (2011) find that firms most likely affected by financing frictions rely heavily on costly cash holdings to smooth R&D. Lyandres and Palazzo (2015) show that innovative firms can use cash holdings to discourage their rivals from developing and implementing innovative ideas.

Prior literature also documents a positive association between R&D intensity and cash holdings. Bates et al. (2009) find that an increase in R&D investment is a major factor behind the drastic increase in the average cash-to-assets ratios in U.S. industrial firms from 1980 to 2006. Falato et al. (2013) suggest that firms' growing reliance on intangible capital shrinks debt capacity and leads to higher levels of cash holdings. They provide empirical evidence that intangible capital is the most important firm-level determinant of corporate cash holdings. Extending Bates et al. (2009), He and Wintoki (2016) show that R&D investment alone is able to explain more than 20% of the increase in aggregate cash holdings of U.S. firms over 1980–2012. In the next section, we focus on the interaction effect of R&D intensity and cash holdings in the M&A market and develop hypotheses on how cash holdings may strengthen R&D-intensive targets' bargaining position.

2.2 Hypothesis development

Corporate cash holdings play an important role in financing R&D investment because R&D-intensive firms have difficulty obtaining external funds for the following reasons. First, R&D investment cannot be used as collateral to raise debt financing. R&D differs from ordinary investment in that fifty percent or more of R&D spending comprises of wages and salaries paid to highly educated scientists and engineers (Hall and Lerner 2009). This investment in human and organizational capital creates an intangible asset base that is difficult to verify and liquidate, resulting in limited collateral value. Second, severe information asymmetries associated with R&D investment (Aboody and Lev 2000) induce outside investors to demand a higher required rate of return on their investment, thus increasing the cost of equity to managers. Third, Brown and Petersen (2011) show that the primary sources of finance for R&D investment, i.e. cash flow and equity, have become increasingly volatile over time. Cash reserves in R&D-intensive firms signal financing availability that is independent of internal operations and external equity cycles, and have meaningful implications for both new and ongoing R&D investment. On the one hand, cash reserves can be used to finance new R&D projects and benefit shareholders by reducing underinvestment problems (Harford 1999). On the other hand, cash reserves can be used to smooth the investment path of ongoing R&D projects and avoid high adjustment costs. This is important for R&D-intensive firms because the discontinuation of ongoing R&D projects due to funding constraints would destroy accumulated human and organizational capital base (Hall and Lerner 2009). Meanwhile, hiring and training new technology workers in future periods when funding is available often entail substantial costs (Brown and Petersen 2011).

The link between financing availability and bargaining power is proposed by the incomplete contracting framework that models ownership and cash flow rights (Grossman and Hart 1986; Hart and Moore 1988). Aghion and Tirole (1994) adapt this framework to analyzing contractual agreements between R&D firms and their financiers. They propose that ex ante bargaining power of the two parties determines the allocation of the property right on an innovation. If an R&D firm is cash constrained and the financier has ex ante bargaining power, the R&D firm is unable to compensate the financier for a transfer of the property right, leading to an inefficient allocation of the ownership and control. Extending the analysis of Aghion and Tirole (1994), Lerner et al. (2003) hypothesize that the variations in the availability of public market financing affect the bargaining power of R&D firms. Using 200 alliance agreements between small biotechnology firms and large corporations during periods of diminished public financing, they find evidence that limited availability of public financing significantly reduces the bargaining power of R&D firms.

Specifically, they show that the majority of the control rights are likely to be assigned to the larger corporate partner and that such alliances are less successful than other alliances in which the R&D firm retains a large fraction of the control rights. Further, Cornaggia et al. (2015) find that increases in the supply of state-level finance enable small, innovative firms to remain independent instead of being acquired by public corporations.

Similar to Lerner et al. (2003), we argue that an R&D-intensive target's bargaining power varies with cash holdings. Our argument is based on the importance of cash holdings to R&D-intensive firms which is a function of unavailability and volatility of alternative financing sources. High cash holdings in an R&D-intensive target signal to the market that the firm has the ability to finance and smooth its own investment, and this financing capability is independent of volatility in cash flow and equity issues. Since it is unlikely for a cash-rich R&D-intensive firm to put itself up for sale due to liquidity reasons, such firm is more resistant against low-priced offers and can negotiate more favorable terms with the acquirer. We thus expect the enhanced bargaining power for cash-rich R&D-intensive target firms to translate into higher takeover premiums and target announcement returns. Because our argument is built on a number of fundamental differences in the characteristics between R&D investment and ordinary investment, we do not expect to observe a similar effect of cash holdings on the bargaining power of non-R&D-intensive targets.

3 Sample selection and descriptive statistics

We retrieve a sample of takeover bids announced between 1/1/1980 and 12/31/2012 from Thompson's Securities Data Corporation's (SDC) Mergers and Acquisitions database. We require that neither the target nor the acquirer is a financial or utility firm. Following prior studies, we delete spinoffs, recapitalizations, self-tender offers, exchange offers, repurchases, minority stake purchases, privatizations, and acquisitions of remaining interest. We also require the target to be a U.S. public firm with accounting information on Compustat and daily stock return data on CRSP at least one year prior to the deal announcement. This selection procedure yields a final sample of 8630 acquisitions. For robustness, we rebuild our sample excluding incomplete acquisitions, and obtain very similar results.

We present the annual distribution of our takeover sample in Fig. 1. The total number of takeovers increased sharply from 1980 reaching a peak in 1989, but declined dramatically

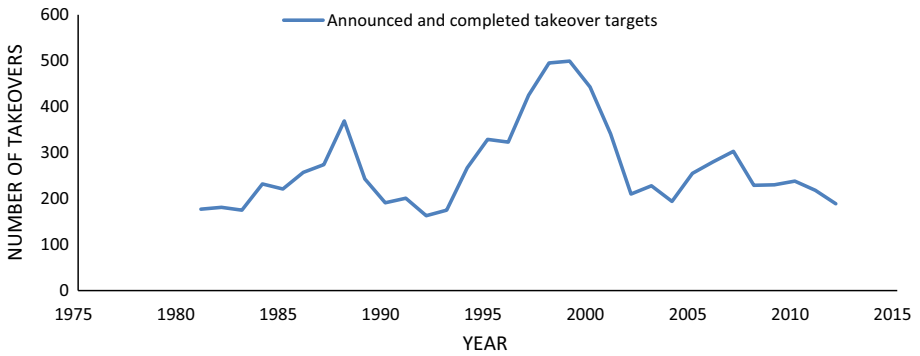

Fig. 1 Annual distribution of the takeover sample between 1980 and 2012

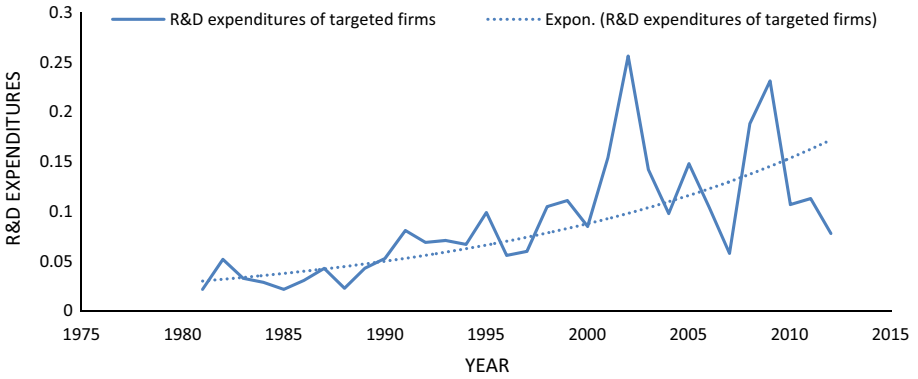

Fig. 2 Average R&D expenditures of takeover targets between 1980 and 2012. R&D expenditures are scaled by sales, and missing values are set to zero

in 1990 partially due to economic recession and the collapse of the junk bond market. In 1999, the total number of takeovers peaked for the second time during our sample period and then decreased in the following years. This pattern in our sample is consistent with the overall trend in mergers and acquisitions between 1980 and 2001 documented by Moeller et al. (2004) and Vijh and Yang (2013). Figure 2 illustrates the average R&D expenditures for takeover targets during our sample period. We show that the average R&D-to-sales ratio has increased dramatically for target firms in the 2000–2012 period compared with the 1980–1999 period. The average R&D-to-sales ratio of target firms at the peak in 2003 is almost eight times of that in 1981.

We obtain deal characteristics from SDC and construct target firm characteristics based on data from Compustat and CRSP. Since the acquirer is either public or private, we build acquirer firm characteristics using data collected from Compustat for public acquirers and from SDC for private acquirers. We use takeover premiums and target CARs to measure the value effect of cash holdings on R&D-intensive targets. The 41-day takeover premium is the percentage premium paid by the acquirer for target shares relative to the target stock price 41 days prior to acquisition announcement date (Betton et al. 2009). The initial offer price is from SDC while the target stock price is from CRSP. Alternatively, we measure takeover premiums using the 4-week takeover premiums from SDC. To calculate CARs for targets, we use the CRSP's value-weighted NYSE/AMES/NASDAQ return as the market return and estimate daily abnormal stock returns using the market-adjusted model. We then sum up daily abnormal returns over the 3-day event window $(-1, +1)$ around the announcement date (day 0) to obtain 3-day CARs. The 5-day CARs are calculated by summing up daily abnormal returns over the 5-day event window $(-2, +2)$ around the announcement date (day 0). Prior M&A literature (e.g., Moeller et al. 2004; Levi et al. 2010; Cai and Sevilir 2012; Harrison et al. 2014) has identified a number of firm and deal characteristics that impact the outcomes of M&A transactions. Firm characteristics include firm size, Tobin's Q, leverage, sales growth, and pre-announcement stock price run-up. In terms of deal characteristics, in addition to the method of payment (all-cash deal and stock deal), diversification acquisition, relative deal size, tender offer, deal attitude, and competition, we also

Table 1 Sample summary statistics

Variable	N	Mean	Std.	5th	Median	95th
Dependent variable						
41-day takeover premium	3640	0.474	1.238	−0.090	0.352	1.272
4-week takeover premium	5592	0.490	1.396	−0.081	0.378	1.302
Target CAR [− 1, + 1]	7569	0.185	0.272	−0.096	0.136	0.627
Target CAR [− 2, + 2]	7564	0.196	0.278	−0.100	0.150	0.655
Independent variable						
Target Ln (assets)	8630	5.010	1.863	2.098	4.869	8.261
Target Tobin's Q	8602	1.707	1.361	0.751	1.285	4.012
Target ROA	8630	0.058	0.216	−0.354	0.108	0.268
Target book leverage	8586	0.254	0.229	0.000	0.218	0.704
Target sales growth	8103	0.176	0.570	−0.315	0.077	0.878
Target cash	8627	0.167	0.202	0.003	0.082	0.629
Target R&D	8630	0.125	0.593	0.000	0.000	0.345
Target stock price run-up	7852	0.142	0.853	−0.659	0.013	1.275
Acquirer Ln(assets)	4295	7.114	2.204	3.431	7.129	10.745
Acquirer Tobin's Q	3892	1.981	0.054	1.889	2.000	2.000
Acquirer ROA	3891	0.070	3.049	−0.090	0.138	0.305
Acquirer book leverage	3892	0.257	0.112	0.070	0.259	0.438
Acquirer cash	3873	0.164	0.181	0.006	0.095	0.564
All-cash deal	8630	0.367	0.482	0.000	0.000	1.000
Stock deal	8630	0.237	0.425	0.000	0.000	1.000
Diversifying acquisition	8630	0.598	0.490	0.000	1.000	1.000
Relative deal size	3344	0.370	0.498	0.005	0.164	1.894
Tender offer	8630	0.210	0.407	0.000	0.000	1.000
Friendly acquisition	8630	0.864	0.342	0.000	1.000	1.000
Competition	8630	0.098	0.298	0.000	0.000	1.000
Target termination fee provision	8630	0.370	0.483	0.000	0.000	1.000
Target lockup option	8630	0.053	0.224	0.000	0.000	1.000

This table presents summary statistics of the takeover sample, which consists of 8630 acquisitions announced between 1980 and 2012. Variables are defined in "Appendix"

include target termination fee provision and target lockup options to control for their potential positive effects on target shareholder wealth.[4]

Table 1 reports summary statistics for the dependent and independent variables used in the merger outcome regressions. Detailed variable definitions are included in "Appendix". We winsorize continuous variables at the top and bottom 1% percentile values to avoid the impact of extreme values. The average 41-day takeover premium in our sample is 47.4%, very close to the average takeover premium of 45% reported in Betton et al. (2009). Our average 3-day CAR for target firms is 18.5%, comparable to the 7-day CAR of 22.16%

[4] Bates and Lemmon (2003) and Officer (2003) document that target termination fee provisions are associated with higher takeover premiums. Burch (2001) finds that though target lockup options inhibit competition, deals with lockup options have higher target announcement returns.

reported in Officer (2003). On average, all-cash (stock) deals account for about 36.7% (23.7%) of our sample. The frequency of tender offers is 21% and about 9.8% of our M&A deal sample have a competing bidder. Further, the average relative deal size is 37% of acquirer's market value of equity and the deal attitude is labeled as "Friendly" for around 86.4% of all deals. Generally, these deal characteristics of our deal sample are similar to those reported in Betton et al. (2009) and Levi et al. (2010). Finally, the number of takeover bids including a target termination fee is 37% in our sample, consistent with Officer (2003) who reports an average 42% for a merger and tender offer bid sample from 1988 to 2000.

Regarding the target firm characteristics, we show that the average target firm has total assets of $150 million [exp (5.01)] and a Tobin's Q of 1.71. The average return on assets is 5.8% and average book leverage is 25.4%. The average target firm experiences sales growth of 17.6%. On average, the target stock's pre-announcement stock price run-up is 14.2%. Moreover, the average target firm has a cash-to-assets ratio of 16.7% and invests 12.5% of its sales in R&D.

In terms of the acquirer characteristics, the average acquirer firm appears to be larger compared with the average target firm, with total assets of $1229 million [exp (7.11)]. In addition, the average acquirer has higher Tobin's Q (1.98) and better performance as measured by ROA (7%). Generally, our statistics on both target and acquirer firm characteristics are comparable to those reported in Levi et al. (2010) and Cai and Sevilir (2012).

4 Empirical results—R&D intensity, cash holdings, and merger outcomes

4.1 Univariate analysis

To investigate the effect of cash holdings on R&D-intensive targets' merger outcomes, we begin by dividing our takeover sample into subsamples based on R&D intensity and cash levels. Specifically, we first categorize targets in the upper (lower) 50 percentile of R&D intensity as R&D-intensive (non-R&D-intensive) targets. We further divide the R&D-intensive targets into two subsamples based on cash levels and classify those in the upper 50 percentile of cash levels as cash-rich R&D-intensive targets and those in the lower 50 percentile of cash levels as cash-poor R&D-intensive targets. We repeat the same sorting procedure for non-R&D-intensive targets. The above process yields four subsamples, i.e., cash-rich (cash-poor) R&D-intensive targets and cash-rich (cash-poor) non-R&D-intensive targets. We then proceed to compare the takeover premiums and CARs of different subsamples and we present the results in Table 2.

In Panel A of Table 2, the univariate analyses are conducted between cash-rich and cash-poor R&D-intensive targets. We show that the mean (50.6%) and median (39.5%) 41-day takeover premium for cash-rich R&D-intensive targets are significantly higher than the mean of 44.6% and median of 35.7% for cash-poor R&D-intensive targets. Similar patterns hold for the 3-day mean and median CAR. Cash-rich R&D-intensive targets experience a 23% average abnormal return, which is significantly higher than the 18.9% average abnormal return earned by cash-poor R&D-intensive targets. We find consistent results using alternative measures of takeover premiums and CARs.

In Panel B, we compare the means and medians of cash-rich and cash-poor non-R&D-intensive targets. Across all four target valuation measures, higher cash levels of non-

Table 2 Univariate analysis

	41-day takeover premium			4-week takeover premium			Target CAR [− 1, + 1]			Target CAR [− 2, + 2]		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Panel A. R&D-intensive targets												
a. Cash-rich targets	1101	0.506	0.395	1514	0.485	0.411	1726	0.230	0.172	1725	0.240	0.186
b. Cash-poor targets	755	0.446	0.357	1193	0.473	0.405	1739	0.189	0.142	1739	0.196	0.154
p value of *t* test: a − b		0.009			0.046			0.000			0.000	
p value of Wilcoxon test: a − b			0.000			0.581			0.000			0.000
Panel B. Non-R&D-intensive targets												
a. Cash-rich targets	885	0.391	0.312	1441	0.429	0.343	2027	0.158	0.117	2024	0.170	0.129
b. Cash-poor targets	898	0.405	0.335	1442	0.443	0.355	2075	0.170	0.122	2074	0.182	0.140
p value of *t* test: a − b		0.488			0.417			0.108			0.146	
p value of Wilcoxon test: a − b			0.358			0.284			0.087			0.167

This table compares the takeover premiums and target CARs of different subsamples obtained from double sorting based on R&D intensity and cash holdings of target firms. We conduct *t* tests to compare differences in means and Wilcoxon signed-rank tests to compare differences in medians

R&D-intensive targets appear to be associated with lower means and medians in general, but these differences are statistically insignificant. Together, results from these univariate comparisons are consistent with the bargaining power hypothesis. Since various firm and deal characteristics tend to affect target shareholder value, we proceed to examine the robustness of our finding using multivariate regressions.

4.2 Multivariate analysis

To investigate the effect of cash holdings on R&D-intensive targets' shareholder value in a multivariate setting, we estimate the following regression model:

$$\begin{aligned} Depend_{it} = {} & \alpha_0 + \alpha_1 \, Target\ R\&D\ intensity_{it} * Target\ cash\ holdings_{it} + \alpha_2 \, Target\ R\&D_{it} \\ & + \alpha_3 \, Target\ cash\ holdings_{it} + \sum Target\ firm\ characteristics_{it} \\ & + \sum Acquirer\ firm\ characteristics_{it} + \sum Deal\ characteristics_{it} \\ & + \sum Industry\ fixed\ effects_j + \sum Year\ fixed\ effects_t + \varepsilon_{it} \end{aligned} \tag{1}$$

where dependent variables are takeover premiums or CARs. The main independent variables of interest are target R&D intensity, target cash holdings, and the interaction between target R&D intensity and target cash holdings. The coefficient on target R&D intensity measures the conditional effect of R&D intensity on target shareholder value when targets hold relatively little cash. The coefficient on target cash holdings captures the conditional effect of cash holdings on the shareholder wealth of non-R&D-intensive target firms. The coefficient on the interaction term measures how the effect of R&D intensity on target shareholder value varies with target cash levels.

Table 3 reports regression results using the 41-day and 4-week takeover premiums as the dependent variables. Columns (1) and (3) show that the coefficient estimates on the interaction term $Target\ R\&D\ intensity_{it}$ * $Target\ cash\ holdings_{it}$ are positive and significant ($p < 0.05$), suggesting that the effect of cash holdings on takeover premiums becomes stronger as target R&D spending intensifies. For example, for a target firm with 5% R&D investment, a one standard deviation increase (0.202) in cash holdings increases the 41-day takeover premium by 0.98%.[5] In contrast, for a target firm where 20% of its revenue is invested in R&D, a one standard deviation increase (0.202) in cash holdings increases the 41-day takeover premium by 3.94%.

Table 4 provides regression results using the target 3-day and 5-day CARs as the dependent variables. We obtain consistent results in columns (1) and (3), and our estimation coefficients on the interaction term are stronger in magnitude relative to those reported in Table 3. For example, for a target firm with 5% R&D investment, a one standard deviation increase (0.202) in cash holdings increases the target 3-day CAR by 3.71%. In contrast, in a target firm where 20% of its revenue invested in R&D, a one standard deviation increase (0.202) in cash holdings increases the target 3-day CAR by 14.85%.

[5] Based on the coefficient estimate in column (1) of Table 3, we calculate the change in the 41-day takeover premium for a target firm with a 5% R&D investment, given a one standard deviation increase in target cash holdings (0.202) as follows: Δ41-day takeover premium = 0.343*0.05*0.202 = 0.00, 346. Thus, Δ41-day takeover premium % = 0.00, 346/Median 41-day takeover premium = 0.00, 346/0.352 = 0.98%.

Table 3 R&D intensity, cash holdings, and takeover premiums

	41-day takeover premium		4-week takeover premium	
	(1)	(2)	(3)	(4)
Target R&D * target cash	0.343**	0.185	0.275**	0.312***
	(0.043)	(0.120)	(0.036)	(0.009)
Target R&D	−0.183	−0.089	−0.121	−0.223
	(0.126)	(0.296)	(0.116)	(0.156)
Target cash	−0.049	0.018	0.051	0.011
	(0.509)	(0.130)	(0.414)	(0.284)
Target Ln(assets)	−0.042***	−0.036**	−0.039***	−0.053***
	(0.003)	(0.026)	(0.000)	(0.000)
Target Tobin's Q	−0.032***	−0.039***	−0.028***	−0.036***
	(0.005)	(0.003)	(0.000)	(0.003)
Target ROA	−0.152	−0.256	−0.075	−0.247
	(0.297)	(0.186)	(0.284)	(0.107)
Target book leverage	0.259*	0.221	0.105*	0.197**
	(0.088)	(0.042)	(0.092)	(0.024)
Target sales growth	−0.006	−0.005	0.014	−0.014
	(0.854)	(0.911)	(0.543)	(0.735)
Target stock price run-up	−0.020***	−0.035	−0.014***	−0.033
	(0.001)	(0.208)	(0.000)	(0.195)
Target Gindex		0.006		−0.002
		(0.168)		(0.564)
Acquirer Ln(assets)	0.014	0.029**	0.016***	0.041***
	(0.177)	(0.030)	(0.000)	(0.004)
Acquirer Tobin's Q	−0.010	−0.238	0.004	−0.353
	(0.814)	(0.540)	(0.917)	(0.258)
Acquirer ROA	0.084	0.408**	0.046	0.450***
	(0.464)	(0.023)	(0.553)	(0.001)
Acquirer book leverage	−0.080	−0.037	−0.004	−0.087
	(0.217)	(0.820)	(0.913)	(0.576)
Acquirer cash	0.286*	0.162	0.148**	0.117
	(0.056)	(0.151)	(0.024)	(0.218)
All-cash deal	0.028	0.006	−0.014	0.021
	(0.529)	(0.889)	(0.631)	(0.619)
Stock deal	0.051	−0.045	−0.004	−0.038
	(0.316)	(0.336)	(0.895)	(0.448)
Diversifying acquisition	0.055*	0.031	0.031*	−0.008
	(0.088)	(0.304)	(0.086)	(0.758)
Relative deal size	0.007	0.072*	0.004*	0.131***
	(0.445)	(0.082)	(0.054)	(0.001)
Tender offer	0.076**	0.051	0.082***	0.092**
	(0.019)	(0.164)	(0.000)	(0.016)
Friendly acquisition	0.098**	−0.019	−0.002	−0.067
	(0.065)	(0.657)	(0.932)	(0.152)
Competition	−0.004	−0.060*	0.143***	0.053
	(0.929)	(0.079)	(0.000)	(0.267)
Target termination fee provision	0.035	0.089**	0.030	0.080**
	(0.492)	(0.014)	(0.208)	(0.027)
Target lockup option	0.087	0.012	0.026	0.006
	(0.259)	(0.822)	(0.367)	(0.989)

Table 3 continued

	41-day takeover premium		4-week takeover premium	
	(1)	(2)	(3)	(4)
Constant	0.507*** (0.001)	0.752 (0.385)	0.664*** (0.001)	1.011 (0.184)
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Obs.	1815	585	2613	713
Adjusted R-squared	0.046	0.156	0.076	0.165

This table presents the results of OLS regressions using the sample of 8630 takeovers from 1980 to 2012. Variables are defined in "Appendix". All regressions use White's heteroskedasticity-consistent standard errors and control for industry and year fixed effects. *p* values are reported in parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10% level, respectively

Comment and Schwert (1995) find that antitakeover measures enhance target firms' bargaining power and positively impact target shareholder wealth by increasing takeover premiums. Thus, our results could be driven by antitakeover provisions adopted by R&D-intensive target firms. We conduct additional analyses by including the target firm's Gindex in our regressions and results are presented in columns (2) and (4) in Tables 3 and 4, respectively. Although controlling for target Gindex significantly reduces our sample size, we still obtain consistent results for most of our valuation measures. Overall, our results shown in Tables 3 and 4 are consistent with the bargaining power hypothesis.

5 R&D intensity, takeover probability, and cash holdings

Our results so far suggest that larger cash holdings are beneficial to the shareholders of R&D-intensive target firms in the M&A market. However, it is not clear whether potential target firms' intention to negotiate better deals with potential acquirers play a role in the build-up of cash holdings.[6] In this scenario, R&D-intensive firms will be particularly motivated to hold more cash when they face increased probability of receiving a takeover bid. We examine this prediction using a two-stage estimation procedure. In the first stage, we estimate ex ante takeover probability by regressing a binary takeover dummy variable on a vector of industry and firm characteristics that are found to significantly influence a firm's probability of becoming a takeover target. In the second stage, we analyze how the interaction between ex ante takeover probability and R&D intensity impacts the firm's level of cash holdings.

5.1 Sample construction and summary characteristics

We obtain our sample from several different sources. We begin with the Compustat/CRSP merged database and select all firm-years with available accounting and stock return data for the sample period from 1980 to 2012. We require firm-years to have positive assets and sales, and we exclude financial firms (SIC codes 6000-6999) and utilities (SIC codes

[6] Bates et al. (2009) show that increase in R&D intensity is one of the main factors driving cash build-up for US industrial firms from 1980 to 2006.

Table 4 R&D intensity, cash holdings, and target CARs

	Target CAR [− 1, + 1]		Target CAR [− 2, + 2]	
	(1)	(2)	(3)	(4)
Target R&D * target cash	0.500***	0.218***	0.440**	−0.239***
	(0.000)	(0.000)	(0.012)	(0.000)
Target R&D	0.002	−0.075	−0.005	−0.094
	(0.911)	(0.136)	(0.980)	(0.168)
Target cash	−0.043	0.009	−0.047	0.009
	(0.298)	(0.179)	(0.262)	(0.206)
Target Ln(assets)	−0.032***	−0.041***	−0.031***	−0.040***
	(0.000)	(0.003)	(0.000)	(0.002)
Target Tobin's Q	−0.033***	0.044***	−0.034***	−0.045***
	(0.000)	(0.000)	(0.000)	(0.000)
Target ROA	0.058	−0.084	0.020	−0.128
	(0.191)	(0.473)	(0.656)	(0.289)
Target book leverage	0.068**	0.148*	0.067*	0.144*
	(0.048)	(0.082)	(0.057)	(0.086)
Target sales growth	−0.008	0.035	−0.004	0.041
	(0.483)	(0.202)	(0.698)	(0.164)
Target stock price run-up	−0.006*	0.006	−0.007**	0.005
	(0.065)	(0.678)	(0.041)	(0.736)
Target Gindex		0.003		0.004
		(0.222)		(0.187)
Acquirer Ln(assets)	0.028***	0.033**	0.028***	0.032**
	(0.000)	(0.011)	(0.000)	(0.017)
Acquirer Tobin's Q	−0.017	−0.005	−0.019	−0.028
	(0.480)	(0.998)	(0.439)	(0.881)
Acquirer ROA	0.068	0.323***	0.086*	0.381***
	(0.177)	(0.002)	(0.090)	(0.001)
Acquirer book leverage	−0.019	0.086	−0.020	0.117
	(0.499)	(0.421)	(0.415)	(0.284)
Acquirer cash	0.050	0.046	0.058	0.051
	(0.239)	(0.463)	(0.175)	(0.436)
All-cash deal	0.032***	0.033	0.035***	0.032
	(0.000)	(0.257)	(0.000)	(0.288)
Stock deal	−0.021	0.015	−0.025	0.013
	(−0.021)	(0.573)	(0.180)	(0.622)
Diversifying acquisition	0.018	0.008	0.020*	0.011
	(0.196)	(0.697)	(0.065)	(0.604)
Relative deal size	−0.001	0.026	0.002**	0.016
	(0.140)	(0.239)	(0.026)	(0.585)
Tender offer	0.083***	0.085***	0.086***	0.085***
	(0.000)	(0.002)	(0.000)	(0.002)
Friendly acquisition	−0.048	−0.011	−0.040	−0.006
	(0.128)	(0.725)	(0.185)	(0.855)
Competition	−0.075***	−0.039*	−0.075***	−0.038*
	(0.000)	(0.080)	(0.000)	(0.099)
Target termination fee provision	0.015***	0.040	0.012***	0.038
	(0.000)	(0.113)	(0.005)	(0.145)
Target lockup option	0.036**	0.005	0.041**	0.010
	(0.023)	(0.903)	(0.013)	(0.792)

Table 4 continued

	Target CAR [− 1, + 1]		Target CAR [− 2, + 2]	
	(1)	(2)	(3)	(4)
Constant	0.085 (0.547)	0.130 (0.774)	0.140 (0.374)	0.130 (0.774)
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Obs.	2723	806	2723	806
Adjusted R-squared	0.136	0.184	0.132	0.178

This table presents the results of OLS regressions using the sample of 8630 takeovers from 1980 to 2012. Variables are defined in "Appendix". All regressions use White's heteroskedasticity-consistent standard errors and control for industry and year fixed effects. *p* values are reported in parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10% level, respectively

4900-4999). We extract data on institutional ownership from Thomson Financial 13F Institutional Holdings database.

We then merge the initial Compustat/CRSP sample with our takeover sample of 8630 takeover bids announced between 1/1/1980 and 12/31/2012 to determine whether a firm was a takeover target in a specific year. We drop a firm-year for which the lagged values are missing for the main variables used in the takeover probability estimation. Our final sample includes 75,247 firm-year observations corresponding to 10,051 unique firms. The total number of takeover targets in our final sample equals 5021.

Table 5 Panel A presents the descriptive statistics on the main variables used in Eqs. (2) and (3). The mean of takeover targets is 0.067, suggesting that 6.7% of our sample firms were targeted at least once during our sample period. The average values of the variables used to predict takeover probability in Eq. (2), are in general comparable to those reported in previous studies (e.g., Cai et al. 2015). Control variables used in Eq. (3), including cash flow, industry sigma, net working capital, capital expenditures, acquisition, R&D, and dividend, are also similar to those in prior studies (e.g., Gao et al. 2013). Table 5 Panel B compares the difference in the means of the targeted and non-targeted samples. We show that targeted firms are generally smaller (4.845 vs. 5.316) and less profitable (0.067 vs. 0.089), have lower growth opportunities (1.686 vs. 1.874), free cash flow (0.039 vs. 0.050), and institutional ownership (0.383 vs. 0.400), and hold more debt (0.248 vs. 0.226) than non-targeted firms.

5.2 Main results

In this section, we start by estimating ex ante takeover probability for firm *i* at the beginning of year *t*, which is measured by the predicted probability of firm *i* becoming a takeover target during year *t*. In Sect. 5.2.2, we interact ex ante takeover probability with R&D intensity to determine whether R&D-intensive firms hold more cash as a strategic response to the increased probability of being targeted. Finally in Sect. 5.2.3, we investigate how the market assesses the value of cash holdings in R&D-intensive firms with higher takeover exposure.

Table 5 Summary statistics for the takeover probability and cash holdings sample

	N	Mean	Std.	5th	Median	95th
Panel A: Summary statistics						
Takeover dummy	75,247	0.067	0.250	0.000	0.000	1.000
State density of takeovers	75,247	0.051	0.032	0.000	0.050	0.102
Industry density of takeovers	75,247	0.050	0.030	0.000	0.046	0.098
Ln(market equity)	75,247	5.285	2.176	1.978	5.141	9.227
Tobin's Q	75,247	1.862	1.492	0.786	1.390	4.556
ROA	75,247	0.088	0.172	−0.201	0.122	0.285
Book leverage	75,247	0.228	0.200	0.000	0.200	0.601
Sales growth	75,247	0.113	0.320	−0.303	0.086	0.606
Tangibility	75,247	0.304	0.226	0.034	0.248	0.776
Cash flow	75,247	0.050	0.198	−0.218	0.080	0.202
Institutional ownership	75,247	0.399	0.288	0.013	0.365	0.896
Cash	75,247	0.157	0.189	0.004	0.080	0.590
Ln(assets)	75,247	5.521	1.835	2.556	5.452	8.446
Cash flow volatility	75,236	0.064	0.024	0.029	0.063	0.108
NWC	73,344	0.117	0.190	−0.163	0.105	0.442
Capex	74,441	0.067	0.069	0.007	0.046	0.207
Dividend dummy	75,247	0.401	0.490	0.000	0.000	1.000
R&D	75,247	0.086	0.163	0.000	0.000	0.289
Acquisition	72,049	0.020	0.055	0.000	0.000	0.134
SA index	75,247	−3.183	0.731	−4.408	−3.209	−1.924

	Targeted firms (1)	Non-targeted firms (2)	*t* test (1) − (2) (*p* value)
Panel B: Univariate comparison			
State density of takeovers	0.058	0.050	0.007*** (0.000)
Industry density of takeovers	0.055	0.049	0.006*** (0.000)
Ln(market equity)	4.845	5.316	−0.470*** (0.000)
Tobin's Q	1.686	1.874	−0.188*** (0.000)
ROA	0.067	0.089	−0.022*** (0.000)
Book leverage	0.248	0.226	0.022*** (0.000)
Sales growth	0.112	0.112	0.000 (0.985)
Tangibility	0.299	0.303	−0.004 (0.325)
Cash flow	0.039	0.050	−0.011** (0.026)
R&D	0.080	0.076	0.004 (0.177)

Table 5 continued

	Targeted firms (1)	Non-targeted firms (2)	*t* test (1) − (2) (*p* value)
Institutional ownership	0.383	0.400	−0.017*** (0.000)
Obs.	5021	70,226	

The sample includes 75,341 firm-year observations corresponding to 10,051 unique firms from 1980 to 2012. Variable definitions are included in "Appendix". Panel A reports the descriptive statistics for main variables. Panel B presents univariate comparisons of mean values of takeover probability variables between targeted and non-targeted firms. *p* values are reported in parentheses. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively

5.2.1 *Ex-ante takeover probability*

We estimate the following probit model and use predicted values of the dependent variable to measure ex ante takeover probability:

$$\Pr(\textit{Takeover dummy} = 1)_{it} = \Phi(Z_{it-1}\beta_1) \tag{2}$$

where *Takeover dummy* takes a value of one if firm i was targeted in year t, and zero otherwise. Z includes a constant and a set of firm and industry characteristics motivated by prior studies (Palepu 1986; Comment and Schwert 1995; Cremers et al. 2009; Skouratova and Wald 2013). Specifically, we include size of market equity, Tobin's Q, ROA, book leverage, sales growth, asset tangibility, cash flow, R&D intensity, and institutional ownership. We also include year dummies and two-digit SIC industry dummies to control for general economic trends and industry-specific cycles that affect merger and acquisition intensity. Following Billett and Xue (2007), we use one year lagged ($t - 1$) variables to estimate ex ante takeover probability perceived at the beginning of year t.

Since we use the predicted takeover probability to examine whether firms having a greater takeover probability are also likely to hold more cash, our empirical design may raise endogeneity concerns due to unobserved omitted variables that are positively correlated with a firm's takeover exposure and its future levels of cash holdings. If the unobserved heterogeneity is constant over time, including firm fixed effects in the estimation can largely mitigate these endogeneity concerns. However, if the unobserved heterogeneity is time-varying, fixed-effects estimations are not sufficient to address the potential endogeneity problems. Further, endogeneity concerns could arise from a reverse causality effect because firms with excess cash build-up from large free cash flows are more likely to become takeover targets in the market for corporate control (Jensen 1986). Therefore, we adopt several econometric methods to ensure that our cash holding results are not solely driven by these endogenous relations.

First, to address the reverse causality issues, we adopt a two-stage instrumental variable approach and instrument the takeover dummy variable with state and industry densities of takeover bids. State takeover density is computed as the annual average value of the takeover dummies for all firms headquartered in firm i's state, excluding firm i. Industry takeover density is computed as the annual average value of the takeover dummies for all firms in firm i's two-digit SIC industry, excluding firm i. Cai et al. (2014) find that a firm's geographic location has significant impact on its takeover exposure. Thus, there may exist significant variations in the state density of takeover bids, allowing us to achieve

identification. Similarly, Mitchell and Mulherin (1996) argue that firms are affected by industry-wide merger waves. Conceptually, while lagged state or industry densities of takeover bids may be correlated with current takeover bids, we do not expect them to impact an individual firm's cash holdings directly except through their effects on the firm's ex ante takeover probability.

Another concern of our empirical design resides in the binary nature of the first-stage dependent variable, which demands a non-linear function form in estimation. However, employing non-linear estimations in the first stage is associated with potential risk of misspecification (Angrist and Krueger 2001). Alternatively, we use linear probability model (LPM) to estimate ex ante takeover probability in the first stage. Angrist and Krueger (2001) argue that using linear regressions for the first-stage estimates generates consistent second-stage estimates even with a dummy endogenous variable.

Table 6 column (1) presents the probit regression results from estimating Eq. (2) and column (2) presents the LPM results. Both the probit and LPM estimations yield coefficients consistent with existing literature. Specifically, a firm is more likely to be targeted if its industry undergoes high merger activity because shocks to an industry's economic, technological, or regulatory environment lead to merger waves (Mitchell and Mulherin 1996). Large firms and firms with high Tobin's Q are less likely to be targeted because transaction costs associated with acquiring a firm are likely to increase with the target size and undervalued firms are more attractive targets (Palepu 1986). Less profitable firms have high takeover exposure because management inefficiency is associated with high takeover interest (Palepu 1986). Firms with large free cash flow are more likely to be targeted (Jensen 1986). The positive association between institutional ownership and takeover exposure shows that firms with strong shareholder control are likely to be targeted, consistent with prior argument that takeovers are more likely to occur as shareholder control increases (Shleifer and Vishny 1986).

We also note that in both the probit and LPM estimations, instrumental variables, i.e., state and industry densities of takeovers, are positively and significantly associated with the takeover dummy variable ($p < 0.01$). Further, we conduct three standard IV tests to support the validity of our instrumental variables. The test statistics are presented in Table 6. The under-identification test has an Anderson canon LM statistic of 296.09 with a p value of 0.000, which rejects the null of under-identification. The weak identification test shows a Cragg-Donald Wald F-statistics of 148.64, much larger than the critical value of 10 required by Stock and Yogo (2005) for weak identification. Finally, the Sargan test for over-identification has a statistics of 0.589 with a p value of 0.442, thus we fail to reject the null hypothesis that the instruments in the second-stage estimation are exogenous.

5.2.2 R&D intensity, takeover probability, and cash holdings

To investigate whether R&D-intensive firms maintain a higher level of cash holdings when ex ante takeover probability is greater, we begin by performing some univariate tests on subsamples sorted by takeover probability and R&D intensity. We first classify firms into R&D-intensive and non-R&D-intensive subsamples based on their R&D intensity. For each subsample of firms, we then compare the mean cash holdings between subgroups of firms identified by their takeover exposure. We use ex ante takeover probability estimated from Eq. (2) to measure a firm's takeover exposure. We categorize firms in the upper 50th percentile of takeover probability as high-takeover-exposure firms and firms in the lower 50th percentile as low-takeover-exposure firms. The results are presented in Table 7 Panel A. Focusing on firms in the upper 50th percentile of R&D intensity, we find that high-

Table 6 Predicting takeover probability

	Model 1—Probit (1)	Model 2—LPM (2)
State density of takeovers$_{(t-1)}$	2.829*** (0.000)	0.337*** (0.000)
Industry density of takeovers$_{(t-1)}$	2.529*** (0.000)	0.139*** (0.000)
Ln(market equity)$_{(t-1)}$	−0.063*** (0.000)	−0.006*** (0.000)
Tobin's Q$_{(t-1)}$	−0.035*** (0.000)	−0.005*** (0.000)
ROA$_{(t-1)}$	−0.517*** (0.000)	−0.044*** (0.000)
Book leverage $_{(t-1)}$	0.256*** (0.000)	0.027*** (0.000)
Sales growth$_{(t-1)}$	0.035 (0.122)	0.002 (0.537)
Tangibility$_{(t-1)}$	−0.049 (0.158)	−0.017*** (0.000)
Cash flow$_{(t-1)}$	0.315** (0.019)	0.015** (0.029)
R&D$_{(t-1)}$	0.088** (0.019)	0.013** (0.012)
Institutional ownership$_{(t-1)}$	0.330*** (0.000)	0.038*** (0.000)
Constant	−2.057*** (0.000)	0.030*** (0.000)
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Obs.	75,247	75,247
Number of targets	5021	5021
Pseudo R^2/adjusted R^2	0.030	0.018
IV test statistics		
Under-identification test (Anderson canon. corr. LM statistic)		296.09 ($p = 0.000$)
Weak identification test (Cragg-Donald Wald F statistic)		148.64
Over-identification test (Sargan statistic)		0.589 ($p = 0.442$)

This table presents the regression results from two alternative models used to predict takeover probability. Column 1(2) presents the coefficient estimates for the Probit model (LPM). Variables are defined in "Appendix". All regressions use White's heteroskedasticity-consistent standard errors and control for industry and year fixed effects. *p* values are reported in the parentheses. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively

takeover-exposure firms hold a significantly higher level of cash than low-takeover-exposure firms. The difference in cash levels between the two groups of firms widens when we focus on firms in the upper 30th percentile of R&D intensity. In contrast, for subgroups with low R&D intensity, either in the 50th or the 30th percentile, high-takeover-exposure

Table 7 Takeover probability, R&D intensity, and cash holdings—baseline results

	High-takeover-exposure firms	Low-takeover-exposure firms	Difference (p value)
Panel A: Univariate analysis			
Upper 50 percentile of R&D intensity	0.260	0.193	0.067*** (0.000)
Lower 50 percentile of R&D intensity	0.103	0.106	−0.003** (0.023)
Upper 30 percentile of R&D intensity	0.315	0.237	0.078*** (0.000)
Lower 30 percentile of R&D intensity	0.103	0.106	−0.003** (0.014)

	Model 1—Probit			Model 2—LPM		
	Ln(cash) (1)	$Ln(cash)_{(t+1)}$ (2)	$Ln(cash)_{(t+2)}$ (3)	Ln(cash) (4)	$Ln(cash)_{(t+1)}$ (5)	$Ln(cash)_{(t+2)}$ (6)
Panel B: Multivariate analysis						
$RD_{(t-1)}$*TOPROB	20.009*** (0.000)	22.856*** (0.000)	21.054*** (0.000)	22.744*** (0.000)	25.523*** (0.000)	23.174*** (0.000)
TOPROB	−2.293*** (0.000)	−2.140*** (0.000)	−2.061*** (0.000)	−1.291*** (0.000)	−1.221*** (0.000)	−0.942** (0.032)
$RD_{(t-1)}$	2.701*** (0.000)	2.467*** (0.000)	2.650*** (0.000)	2.264*** (0.000)	2.035*** (0.000)	2.241*** (0.000)
$Ln(assets)_{(t-1)}$	−0.021*** (0.000)	−0.028*** (0.000)	−0.029*** (0.000)	−0.022*** (0.000)	−0.029*** (0.000)	−0.030*** (0.000)
Tobin's $Q_{(t-1)}$	0.120*** (0.000)	0.104*** (0.000)	0.096*** (0.000)	0.118*** (0.000)	0.103*** (0.000)	0.095*** (0.000)
Book $leverage_{(t-1)}$	−2.654*** (0.000)	−2.542*** (0.000)	−2.441*** (0.000)	−2.644*** (0.000)	−2.532*** (0.000)	−2.436*** (0.000)
Cash $flow_{(t-1)}$	0.242*** (0.000)	0.176*** (0.000)	0.130*** (0.000)	0.252*** (0.000)	0.188*** (0.000)	0.142*** (0.000)

Table 7 continued

	Model 1—Probit			Model 2—LPM		
	Ln(cash) (1)	$Ln(cash)_{(t+1)}$ (2)	$Ln(cash)_{(t+2)}$ (3)	Ln(cash) (4)	$Ln(cash)_{(t+1)}$ (5)	$Ln(cash)_{(t+2)}$ (6)
Cash flow volatility $_{(t-1)}$	4.782*** (0.000)	5.195*** (0.000)	5.289*** (0.000)	4.786*** (0.000)	5.210*** (0.000)	5.296*** (0.000)
$NWC_{(t-1)}$	−1.890*** (0.000)	−1.931*** (0.000)	−1.845*** (0.000)	−1.890*** (0.000)	−1.931*** (0.000)	−1.845*** (0.000)
$Capex_{(t-1)}$	−2.253*** (0.000)	−2.406*** (0.000)	−2.224*** (0.000)	−2.529*** (0.000)	−2.414*** (0.000)	−2.229*** (0.000)
$Dividend_{(t-1)}$	−0.213*** (0.000)	−0.231*** (0.000)	−0.260*** (0.000)	−0.216*** (0.000)	−0.233*** (0.000)	−0.261*** (0.000)
$Acquisition_{(t-1)}$	−1.830*** (0.000)	−1.707*** (0.000)	−1.678*** (0.000)	−1.825*** (0.000)	−1.703*** (0.000)	−1.675*** (0.000)
SA $index_{(t-1)}$	0.026* (0.051)	0.021 (0.164)	0.017 (0.310)	0.023* (0.087)	0.019 (0.217)	0.016 (0.349)
Constant	−1.759*** (0.000)	−1.408*** (0.000)	−1.389*** (0.000)	−1.749*** (0.000)	−1.388*** (0.000)	−1.375*** (0.000)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	69,371	57,872	48,679	69,371	57,872	48,679
Adjusted R^2	0.368	0.351	0.337	0.369	0.353	0.339

This table presents regression results from estimating Eq. (3). Panel A reports univariate tests of mean cash levels between various subsamples of different takeover exposure and R&D intensity. Panel B reports baseline regression results. Variables are defined in "Appendix". All regressions use White's heteroskedasticity-consistent standard errors and control for industry and year fixed effects. *p* values are reported in the parentheses. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively

firms actually hold significantly less amount of cash than low-takeover-exposure firms. This univariate analysis provides preliminary evidence to support our hypothesis that R&D-intensive firms are more likely to increase cash levels when faced with high takeover exposure. However without controlling for various relevant factors, univariate analysis alone may not give an accurate description of the true relations among variables. We proceed to analyze our hypothesis using the following regression model:

$$\begin{aligned} LN(Cash)_{it} = {} & a_0 + a_1 RD_{it-1} * TOPROB_{it} + a_2 TOPROB_{it} + a_3 RD_{it-1} + a_4 Tobin's Q_{it-1} \\ & + a_5 SIZE_{it-1} + a_6 CF_{it-1} + a_7 NWC_{it-1} + a_8 CAPEX_{it-1} + a_9 LEV_{it-1} \\ & + a_{10} SIGMA_{it-1} + a_{11} DIV_{it-1} + a_{12} AQ_{it-1} + a_{13} SA_{it-1} \\ & + \sum Industry\,fixed\,effects_j + \sum Year\,fixed\,effects_t + \varepsilon_{it} \end{aligned} \tag{3}$$

where the dependent variable is the log of cash over total assets measured at the end of year t.[7] $TOPROB_{it}$ is the predicted value from the first stage estimation and measures ex ante takeover probability at the beginning of year t. Following prior literature on cash holdings (Opler et al. 1999; Dittmar and Mahrt-Smith 2007; Bates et al. 2009, Brick and Liao 2016), we control for a set of characteristics that proxy for a firm's usual needs of cash arising from operations, financing, and investments. These characteristics include Tobin's Q, firm size (*SIZE*), cash flow (*CF*), net working capital (*NWC*), capital expenditures (*CAPEX*), book leverage (*LEV*), industry volatility of cash flows (*SIGMA*), dividend payment (*DIV*), and acquisition (*AQ*). Further, since financing frictions could force firms with poor access to external capital markets to hold more cash (Opler, et al. 1999), we also control for a firm's level of financial constraints using the SA index developed by Hadlock and Pierce (2010). We calculate SA index using the following equation:

$$\text{SA index} = -0.737 * SIZE + 0.043 * SIZE^2 - 0.040 * AGE \tag{4}$$

where *SIZE* is the natural log of book assets deflated to the 2004 dollars, and *AGE* is the number of years the firm has been on Compustat with a non-missing stock price. In calculating this index, we follow Hadlock and Pierce (2010) and replace *SIZE* with the natural log of $4.5 billion and *AGE* with thirty-seven years if the actual values exceed these thresholds.

Table 7 Panel B presents the baseline regression results for cash holdings. Columns (1) through (3) provide results using ex ante takeover probability (*TOPROB*) estimated from the probit model in Table 6 while columns (4) through (6) use ex ante takeover probability from the linear probability model. The main variables of interest are RD_{it-1} * $TOPROB_{it}$, $TOPROB_{it}$, and RD_{it-1}. In column (1), the coefficient estimate on the stand-alone R&D intensity is positive and significant, indicating that R&D intensity boosts cash holdings even when firms are not exposed to potential takeovers. This result is consistent with the evidence documented in Bates et al. (2009) that increase in R&D expenditures is one of the primary changes in firm characteristics that explain the increase in cash holdings from 1980 to 2006. Meanwhile, the coefficient estimate on takeover probability is negative and significant, suggesting that firms with a higher takeover exposure are more likely to reduce cash holdings.

[7] We also use dependent variables measured at the end of years $t + 1$ and $t + 2$ to examine the degree of persistence in an R&D-intensive firm's strategic response to takeover exposure and find consistent results.

Table 8 Robustness

	Model 1— Probit			Model 2— LPM		
	Ln(cash) (1)	$Ln(cash)_{(t+1)}$ (2)	$Ln(cash)_{(t+2)}$ (3)	Ln(cash) (4)	$Ln(cash)_{(t+1)}$ (5)	$Ln(cash)_{(t+2)}$ (6)
Panel A: Firm fixed effects regression						
$RD_{(t-1)}$*TOPROB	9.921***	9.879***	4.859***	12.291***	12.406***	7.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
TOPROB	−0.881***	−0.552**	−0.222	−0.203	−0.256	−0.070
	(0.000)	(0.028)	(0.465)	(0.588)	(0.537)	(0.877)
$RD_{(t-1)}$	0.153	0.642	0.447	0.493	0.960	0.707
	(0.382)	(0.100)	(0.290)	(0.160)	(0.190)	(0.300)
$Ln(assets)_{(t-1)}$	−0.112***	−0.082***	−0.040*	−0.113***	−0.082***	−0.040*
	(0.000)	(0.000)	(0.076)	(0.000)	(0.000)	(0.077)
Tobin's $Q_{(t-1)}$	0.057***	0.025***	0.012***	0.057***	0.024***	0.012***
	(0.000)	(0.000)	(0.006)	(0.000)	(0.000)	(0.009)
Book $leverage_{(t-1)}$	−1.308***	−0.795***	−0.422***	−1.304***	−0.792***	−0.423***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Cash $flow_{(t-1)}$	0.068**	0.051*	0.064**	0.072**	0.056**	0.067**
	(0.038)	(0.067)	(0.037)	(0.023)	(0.048)	(0.030)
Cash flow volatility $_{(t-1)}$	3.928***	3.843***	3.425***	3.935***	3.849***	3.422***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NWC_{(t-1)}$	−0.829***	−0.558***	−0.240***	−0.830***	−0.559***	−0.240***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Capex_{(t-1)}$	−1.898***	−1.332***	−0.865***	−1.899***	−1.333***	−0.865***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Dividend_{(t-1)}$	−0.011	−0.055***	−0.069***	−0.011	−0.056***	−0.069***
	(0.500)	(0.003)	(0.001)	(0.493)	(0.003)	(0.001)
$Acquisition_{(t-1)}$	−1.045***	−0.809***	−0.648***	−1.045***	−0.810***	−0.648***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
SA $index_{(t-1)}$	−0.056	0.097	0.216***	−0.057	0.096	0.216***
	(0.330)	(0.134)	(0.003)	(0.323)	(0.137)	(0.000)

Table 8 continued

	Model 1— Probit			Model 2— LPM		
	Ln(cash) (1)	$Ln(cash)_{(t+1)}$ (2)	$Ln(cash)_{(t+2)}$ (3)	Ln(cash) (4)	$Ln(cash)_{(t+1)}$ (5)	$Ln(cash)_{(t+2)}$ (6)
Constant	−1.904*** (0.000)	−1.567*** (0.000)	−1.459*** (0.000)	−1.900*** (0.000)	−1.556*** (0.000)	−1.463*** (0.000)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.680	0.673	0.675	0.680	0.637	0.675
Obs.	69,371	57,872	48,679	69,371	57,872	48,679

	Targeted firms (1)	Non-targeted firms (2)	*t* test (1) − (2) (*p* value)
Panel B: Diagnostic analysis of the PSM sample			
State density of takeovers	0.058	0.058	0.000 (0.434)
Industry density of takeovers	0.055	0.055	0.000 (0.662)
Ln(market equity)	4.845	4.804	0.041 (0.206)
Tobin's Q	1.686	1.708	−0.022 (0.249)
ROA	0.067	0.080	−0.013 (0.657)
Book leverage	0.248	0.238	0.010 (0.691)
Sales growth	0.112	0.110	0.002 (0.408)
Tangibility	0.299	0.283	0.016 (0.200)

Table 8 continued

	Targeted firms (1)	Non-targeted firms (2)	*t* test (1) − (2) (*p* value)
Cash flow	0.039	0.038	0.001 (0.761)
R&D	0.080	0.072	0.008 (0.000)
Institutional ownership	0.383	0.382	0.001 (0.502)
Obs.	5021	4356	

	Model 1—Probit			Model 2—LPM		
	Ln(cash)	$Ln(cash)_{(t+1)}$	$Ln(cash)_{(t+2)}$	Ln(cash)	$Ln(cash)_{(t+1)}$	$Ln(cash)_{(t+2)}$
Panel C: Propensity-score-matching analysis						
$RD_{(t-1)}$*TOPROB	5.947*** (0.000)	7.122*** (0.000)	5.721** (0.000)	5.631*** (0.000)	7.322*** (0.000)	5.896** (0.024)
TOPROB	0.276 (0.271)	−0.398 (0.209)	−0.093 (0.809)	1.364 (0.450)	0.453 (0.249)	0.662 (0.187)
$RD_{(t-1)}$	−0.240 (0.769)	−0.445 (0.641)	0.413 (0.741)	−0.173 (0.815)	−0.633 (0.513)	0.252 (0.849)
$Ln(assets)_{(t-1)}$	−0.044*** (0.000)	−0.038* (0.079)	−0.036 (0.193)	−0.041*** (0.000)	−0.037* (0.094)	−0.034 (0.166)
Tobin's $Q_{(t-1)}$	0.138*** (0.000)	0.133*** (0.000)	0.110*** (0.000)	0.156*** (0.000)	0.146*** (0.000)	0.123*** (0.000)
Book $leverage_{(t-1)}$	−2.769*** (0.000)	−2.535*** (0.000)	−2.211*** (0.000)	−2.696*** (0.000)	−2.485*** (0.000)	−2.156*** (0.000)
Cash $flow_{(t-1)}$	0.269*** (0.000)	0.169 (0.589)	0.094 (0.945)	0.332*** (0.000)	0.202 (0.438)	0.121 (0.917)
Cash flow volatility $_{(t-1)}$	4.845*** (0.000)	5.903*** (0.000)	6.919*** (0.000)	5.583*** (0.000)	6.454*** (0.000)	7.753*** (0.000)

Table 8 continued

	Model 1—Probit			Model 2—LPM		
	Ln(cash)	$Ln(cash)_{(t+1)}$	$Ln(cash)_{(t+2)}$	Ln(cash)	$Ln(cash)_{(t+1)}$	$Ln(cash)_{(t+2)}$
$NWC_{(t-1)}$	−1.702*** (0.000)	−1.712*** (0.000)	−1.545*** (0.000)	−1.779*** (0.000)	−1.764*** (0.000)	−1.602*** (0.000)
$Capex_{(t-1)}$	−2.310*** (0.000)	−2.197*** (0.000)	−1.738*** (0.000)	−2.100*** (0.000)	−2.064*** (0.000)	−1.601*** (0.000)
$Dividend_{(t-1)}$	−0.172*** (0.000)	−0.186*** (0.000)	−0.115** (0.014)	−0.167*** (0.000)	−0.182*** (0.000)	−0.112** (0.017)
$Acquisition_{(t-1)}$	−1.846*** (0.000)	−1.310*** (0.000)	−1.573*** (0.000)	−1.880*** (0.000)	−1.131*** (0.000)	−1.576*** (0.000)
SA $index_{(t-1)}$	−0.016 (0.379)	−0.037 (0.229)	0.015 (0.888)	−0.012 (0.489)	−0.037 (0.288)	0.014 (0.971)
Constant	−2.533*** (0.000)	−3.339*** (0.000)	−3.452*** (0.000)	−2.688*** (0.000)	−3.481*** (0.000)	−3.546*** (0.000)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	9377	5256	4288	9377	5256	4288
Adjusted R^2	0.391	0.351	0.313	0.388	0.350	0.312
	1980–1999			2000–2012		
	Ln(cash) (1)	$Ln(cash)_{(t+1)}$ (2)	$Ln(cash)_{(t+2)}$ (3)	Ln(cash) (4)	$Ln(cash)_{(t+1)}$ (5)	$Ln(cash)_{(t+2)}$ (6)
Panel D: Sub-sample period						
$RD_{(t-1)}$*TOPROB	12.460*** (0.000)	14.125*** (0.000)	8.063** (0.011)	30.777*** (0.000)	30.623*** (0.000)	31.214*** (0.000)
TOPROB	−2.237*** (0.000)	−2.234*** (0.000)	−1.759*** (0.000)	−2.672*** (0.000)	−2.011*** (0.000)	−2.252*** (0.000)
$RD_{(t-1)}$	3.393*** (0.000)	3.515*** (0.000)	4.299*** (0.000)	2.017*** (0.000)	1.801*** (0.000)	1.645*** (0.000)

Table 8 continued

	1980–1999			2000–2012		
	Ln(cash) (1)	$Ln(cash)_{(t+1)}$ (2)	$Ln(cash)_{(t+2)}$ (3)	Ln(cash) (4)	$Ln(cash)_{(t+1)}$ (5)	$Ln(cash)_{(t+2)}$ (6)
$Ln(assets)_{(t-1)}$	−0.052*** (0.000)	−0.048*** (0.000)	−0.030*** (0.004)	−0.001 (0.901)	−0.008 (0.279)	−0.020** (0.024)
Tobin's $Q_{(t-1)}$	0.100*** (0.000)	0.085*** (0.000)	0.084*** (0.000)	0.139*** (0.000)	0.123*** (0.000)	0.109*** (0.000)
Book $leverage_{(t-1)}$	−2.948*** (0.000)	−2.836*** (0.000)	−2.722*** (0.000)	−2.323*** (0.000)	−2.186*** (0.000)	−2.068*** (0.000)
Cash $flow_{(t-1)}$	0.278*** (0.000)	0.164** (0.013)	0.217*** (0.008)	0.193*** (0.000)	0.142*** (0.000)	0.063 (0.104)
Cash flow volatility $_{(t-1)}$	4.025*** (0.000)	5.483*** (0.000)	5.666*** (0.000)	2.473*** (0.000)	2.542*** (0.000)	3.060*** (0.002)
$NWC_{(t-1)}$	−1.939*** (0.000)	−1.986*** (0.000)	−1.890*** (0.000)	−1.741*** (0.000)	−1.767*** (0.000)	−1.706*** (0.000)
$Capex_{(t-1)}$	−2.609*** (0.000)	−2.516*** (0.000)	−2.477*** (0.000)	−2.184*** (0.000)	−1.949*** (0.000)	−1.508*** (0.000)
$Dividend_{(t-1)}$	−0.191*** (0.000)	−0.210*** (0.000)	−0.236*** (0.000)	−0.256*** (0.000)	−0.274*** (0.000)	−0.308*** (0.000)
$Acquisition_{(t-1)}$	−1.682*** (0.000)	−1.599*** (0.000)	−1.597*** (0.000)	−1.932*** (0.000)	−1.759*** (0.000)	−1.707*** (0.000)
SA $index_{(t-1)}$	−0.032 (0.157)	−0.003 (0.886)	0.041 (0.142)	0.059*** (0.002)	0.035* (0.077)	0.001 (0.937)
Constant	−1.888*** (0.000)	−1.936*** (0.000)	−1.842*** (0.000)	−1.726*** (0.000)	−2.017*** (0.000)	−2.097*** (0.000)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 8 continued

	1980–1999			2000–2012		
	Ln(cash) (1)	$Ln(cash)_{(t+1)}$ (2)	$Ln(cash)_{(t+2)}$ (3)	Ln(cash) (4)	$Ln(cash)_{(t+1)}$ (5)	$Ln(cash)_{(t+2)}$ (6)
Obs.	37,618	32,778	28,751	31,753	25,094	19,928
Adjusted R^2	0.314	0.299	0.286	0.417	0.400	0.388

This table presents the results of robustness testing. Panel A reports firm fixed effects regression results. Panel B presents the results of a diagnostic analysis comparing the mean values between the targeted sample and a propensity-score-matched control sample. Panel C presents regression results using the propensity-score-matched sample. Panel D reports regression results for different subsample periods. Variables are defined in "Appendix". All regressions use White's heteroskedasticity-consistent standard errors and control for year fixed effects. *p* values are reported in the parentheses. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively

To examine how cash holdings vary by the level of R&D intensity and takeover exposure, we interact R&D intensity with takeover exposure. The interaction term RD_{it-1} * $TOPROB_{it}$ has a coefficient estimate that is positively and significantly associated with cash levels at the end of year t, implying that the impact of takeover exposure on cash holdings becomes stronger as R&D intensity increases. To put it into perspective, if takeover exposure increases by 10 percentage points, cash holdings increase by 17.09% for a firm that spends 20% of its revenue on R&D investment.[8] Column (4) presents the results estimated using *TOPROB* from the LPM model of Table 6. We continue to find a positive and significant coefficient on the interaction term RD_{it-1} * $TOPROB_{it}$. Similar to Column (1), the coefficient on $TOPROB_{it}$ is negative and the coefficient on RD_{it-1} is positive. Both these coefficients are significant at the 1% level. In columns (2), (3), (5), and (6), we examine the persistence of the above effect using cash holdings at the end of years $t + 1$ and $t + 2$, and we document consistent results. Together, these results support our prediction that R&D-intensive firms are strongly incentivized to increase cash holdings when faced with higher probability of being targeted in the M&A market.

5.2.3 Robustness of results: endogeneity issues

Our empirical analysis is likely endogenous due to potential problems of omitted variables, reverse causality, and selection bias. In Table 7, we use a two-stage instrumental variable (IV) approach to address endogeneity concerns associated with reverse causality. To mitigate endogeneity problem due to time-invariant unobservable heterogeneity, we employ firm fixed effects regressions to re-estimate Eq. (3) and present results in Table 8 Panel A. We show that the coefficient estimates on the interaction term between R&D intensity and ex ante takeover probability remain significantly positive although the magnitude becomes smaller.

Another potential endogeneity concern is selection bias. The univariate comparisons in Table 5 Panel B indicate that there are significant differences in observable firm characteristics between targeted (treatment group) and non-targeted (control group) firms. Consequently, it is possible that firms more likely to be targeted have characteristics that are associated with higher cash levels. To address this issue, we employ propensity score matching by first running a probit regression of the takeover dummy variable on the one-year lagged explanatory variables used in Eq. (2), which include state density of takeovers, industry density of takeovers, size of market equity, Tobin's Q, sales growth, asset tangibility, cash flow, ROA, book leverage, and institutional ownership. We then use the nearest neighbor matching method to generate a control sample for the targeted firms. To evaluate the effectiveness of the matching process, we repeat the univariate analysis in Table 5 Panel B and present results in Table 8 Panel B. We find that the takeover characteristics of the non-targeted control sample are not statistically different from those of the targeted firms in the propensity-score-matched sample. Table 8 Panel C presents the regression results using the matched sample. We continue to find a positive and significant association between the interaction term RD_{it-1} * $TOPROB_{it}$ and firms' cash levels.

Next, we analyze whether our results hold across different time periods by performing a sub-period analysis. We separate our sample into two sub-periods 1980–1999 and

[8] Based on the coefficient estimates in column (1) of Table 7, the percentage change in cash holdings for a firm with a 20% R&D spending is calculated as follows: (20.009*0.20 − 2.293)*0.1 = 17.088%.

2000–2012.[9] Table 8 Panel D presents the regression results from re-estimating Eq. (3) for each sub-period. We show that the association between RD_{it-1} * $TOPROB_{it}$ and firms' cash levels is still positive and significant at the 1% level in both sub-periods. Further, we note that the magnitudes of the coefficient estimates on the interaction term in the 2000–2012 period are generally higher than those in the 1980–1999 period.[10] These results are consistent with the trend in Fig. 1 that the average R&D intensity of targeted firms in the second sub-period is higher than that in the first sub-period.

5.2.4 R&D intensity, takeover probability, and the value of cash

Our results in the previous sections demonstrate that higher levels of cash holdings have a significant and positive impact on R&D-intensive targets' takeover premiums and announcement-period CARs in the M&A market. Therefore, this positive cash effect on target shareholder wealth strongly incentivizes R&D-intensive firms to increase cash holdings when faced with higher probability of being targeted. In this section, we assess the value of an additional dollar of cash holdings associated with higher takeover exposure and greater R&D intensity. The value of corporate cash holdings likely depends on the motivation for holding cash reserves. If holding cash reserves serves the interests of shareholders by enhancing management's bargaining power and thereby enabling them to negotiate better deals for shareholders, the marginal dollar of cash holdings should be associated with a positive valuation from the market.[11] On the contrary, if cash accumulation is merely a manifestation of agency problems, cash will be dissipated quickly in ways that do not increase shareholder wealth (Luo and Hachiya 2005; Iskandar-Datta and Jia 2013). As a result, the marginal dollar of corporate cash holdings would likely receive a negative valuation from the market.[12] To investigate the impact of R&D intensity and takeover exposure on the value of cash holdings, we employ the Faulkender and Wang (2006) methodology and estimate the following regression model:

$$\begin{aligned} R_{i,t} - \mathrm{R}^{\mathrm{B}}_{\mathrm{i,t}} = {} & \lambda_0 + \lambda_1 RD_{it-1} * TOPROB_{it} * \Delta \mathrm{C_{i,t}} + \lambda_2 RD_{it-1} * TOPROB_{it} + \lambda_3 \Delta\, \mathrm{C_{i,t}} \\ & + \lambda_4 TOPROB_{it} + \lambda_5 RD_{it-1} + \lambda_6 \Delta\, \mathrm{E_{i,t}} + \lambda_7 \Delta\, \mathrm{NA_{i,t}} + \lambda_8 \Delta\, \mathrm{RD_{i,t}} + \lambda_9 \Delta\, \mathrm{I_{i,t}} + \lambda_{10} \Delta\, \mathrm{D_{i,t}} \\ & + \lambda_{11} \mathrm{C_{i,t-1}} + \lambda_{12} \mathrm{C_{i,t-1}} + * \Delta\, \mathrm{C_{i,t}} + \lambda_{13} \mathrm{MLEV_{i,t}} + \lambda_{14} \mathrm{MLEV_{i,t}} * \Delta\, \mathrm{C_{i,t}} + \lambda_{15} \mathrm{NF_{i,t}} \\ & + \lambda_{16} \mathrm{SA_{i,t}} + \sum Industry\, fixed\, effects_j + \sum Year\, fixed\, effects_t + \varepsilon_{\mathrm{i,t}} \end{aligned} \tag{5}$$

[9] Although we control for time fixed effects in all of our estimations but we analyze cash holdings for these two periods separately as the period before 2000 was unusual in terms of M&A activities.

[10] In untabulated analysis, we divide our sample into four sub-periods, i.e. 1980–1995, 1996–2001, 2002–2006, and 2007–2012, we still obtain consistent results.

[11] Stráska and Waller (2010) reach a similar conclusion by studying the value impact of antitakeover provisions on certain firms with characteristics that indicate low bargaining power in takeover contests. They show that adopting more antitakeover provisions enhances bargaining power and is associated with a positive value impact on such firms.

[12] Pinkowitz et al. (2006) show that a dollar of liquid assets is worth much less to minority investors in countries with poor investor protection. Dittmar and Mahrt-Smith (2007) report similar results that a dollar of cash is valued significantly less in a poorly governed firm.

Table 9 Takeover probability, R&D intensity, and the value of cash

	Dependent variable: excess stock return					
	Model 1—Probit			Model 2—LPM		
	(1)	(2)	(3)	(4)	(5)	(6)
RD_{t-1}* TOPROB * Δcash	11.621*** (0.000)	12.493*** (0.000)	3.504*** (0.000)	14.498*** (0.000)	15.161*** (4.920)	3.289*** (0.007)
RD_{t-1}* TOPROB	−1.378 (0.275)	1.868 (0.645)	−0.439 (0.741)	−2.637 (0.482)	2.625* (0.075)	0.101 (0.629)
ΔCash	1.263*** (0.000)	1.347*** (0.000)	1.248*** (0.000)	1.250*** (0.000)	1.322*** (0.000)	1.253*** (0.000)
TOPROB	1.640*** (0.000)	2.918*** (0.000)	0.269 (0.136)	2.314*** (0.000)	5.775*** (0.000)	0.320** (0.025)
RD_{t-1}	0.126 (0.251)	0.625*** (0.005)	0.094 (0.906)	0.217 (0.463)	0.765*** (0.000)	−0.180 (0.414)
ΔEarnings	0.471*** (0.000)	0.398*** (0.000)	0.492*** (0.000)	0.469*** (0.000)	0.388*** (0.000)	0.492*** (0.000)
ΔNet assets	0.210*** (0.000)	0.187*** (0.000)	0.186*** (0.000)	0.210*** (0.000)	0.188*** (0.000)	0.187*** (0.000)
ΔR&D	0.656*** (0.000)	1.013*** (0.000)	1.804*** (0.000)	0.663*** (0.001)	1.037*** (0.000)	1.812*** (0.000)
ΔInterest	−1.726*** (0.000)	−1.190*** (0.000)	−1.241*** (0.000)	−1.699*** (0.000)	−1.151*** (0.000)	−1.247*** (0.000)
ΔDividends	2.487*** (0.000)	1.249*** (0.000)	2.802*** (0.000)	2.550*** (0.000)	1.321*** (0.000)	2.833*** (0.000)
Lagged cash	0.263*** (0.000)	0.699*** (0.000)	0.301*** (0.000)	0.255*** (0.000)	0.648*** (0.000)	0.301*** (0.000)
Lagged cash * Δcash	−0.417*** (0.000)	−0.372*** (0.000)	−0.333** (0.000)	−0.417*** (0.000)	−0.362*** (0.000)	−0.331** (0.016)
Market leverage	−0.527*** (0.000)	−1.067*** (0.000)	−0.454*** (0.000)	−0.542*** (0.000)	−1.134*** (0.000)	−0.454*** (0.000)
Market leverage * Δcash	−0.760*** (0.000)	−0.787*** (0.000)	−0.820*** (0.000)	−0.750*** (0.000)	−0.794*** (0.000)	−0.832*** (0.000)
Net financing	−0.047** (0.020)	−0.024 (0.264)	−0.020 (0.646)	−0.047** (0.018)	−0.018 (0.243)	−0.020 (0.225)
SA index	−0.037*** (0.000)	0.268*** (0.000)	−0.049*** (0.000)	−0.039*** (0.000)	0.240*** (0.000)	−0.052*** (0.000)
Constant	−0.120*** (0.000)	0.787*** (0.000)	−0.274** (0.000)	−0.164*** (0.000)	0.495*** (0.000)	−0.314*** (0.000)
Fixed effects	Industry	Firm	Industry	Industry	Firm	Industry
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	48,248	48,248	6592	48,248	48,248	6592
Adjusted R^2	0.184	0.241	0.211	0.184	0.247	0.211

This table presents regression results from estimating Eq. (5). Column 1 (2) uses industry (firm) fixed effects. Column 3 uses a propensity-score-matched sample. Variables are defined in "Appendix". All regressions use White's heteroskedasticity-consistent standard errors and control for year fixed effects. *p* values are reported in the parentheses. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively

where $R_{i,t}$ is the stock return for firm i during fiscal year t and $R^{B}_{i,t}$ is firm i's Fama and French 25 portfolio benchmark return during year t.[13] RD_{it-1} is R&D expenditures scaled by total sales and $TOPROB_{it}$ is ex ante takeover probability at the beginning of year t. The remaining independent variables control for firm specific characteristics that are potentially correlated with the value of cash holdings. These variables include cash holdings of firm i in year t ($C_{i,t}$), earnings before interest and extraordinary items ($E_{i,t}$), total assets net of cash ($NA_{i,t}$), R&D expenditures ($RD_{i,t}$), interest expenses ($I_{i,t}$), total dividends ($D_{i,t}$), net financing during year t ($NF_{i,t}$), market leverage ($MLEV_{i,t}$), and degree of financial constraints ($SA_{i,t}$). $\Delta X_{i,t}$ represents the one year change in variable X ($X_{i,t} - X_{i,t-1}$). All $\Delta X_{i,t}$ as well as $NF_{i,t}$ and $C_{i,t-1}$ are scaled by the market value of equity at the end of year $t - 1$.

The regression results from estimating Eq. (5) are presented in Table 9. The results in columns (1) through (3) use ex ante takeover probability estimated from the probit model of Table 6 while results in columns (4) through (6) use ex ante takeover probability based on the linear probability model. In columns (1) and (2), we present the baseline regression results using OLS, in columns (2) and (5) we present the firm fixed regression results, and in columns (3) and (6) we present the estimation results using the propensity-score-matched sample. Across all specifications, we find that the interaction of R&D intensity, takeover exposure, and change in cash holdings ($RD_{it-1} * TOPROB_{it} * \Delta$ Cash) has a positive and significant ($p < 0.05$ or better) coefficient. Comparing with the results from Faulkender and Wang (2006), we find that the value of cash increases substantially more for firms that are highly R&D intensive and face a high takeover threat. These results indicate that an additional dollar held by an R&D-intensive firm with high takeover exposure is value-increasing.

The coefficient estimates on the control variables are in general consistent with those reported in Faulkender and Wang (2006). Similar to Faulkender and Wang (2006), we document negative and significant coefficients ($p < 0.01$) on $C_{i,t-1} * \Delta C_{i,t}$ and $MLEV_{i,t} * \Delta C_{i,t}$, suggesting that the marginal value of cash decreases with larger cash holdings and higher leverage. Together, our results that the market places positive valuation on an additional dollar of cash held by R&D-intensive firms in anticipation of possible takeover bids provides further support for the bargaining power hypothesis.

6 Conclusion

This paper examines the strategic bargaining role of cash holdings in M&A transactions that target R&D-intensive firms. We find that cash holdings positively impact R&D-intensive targets' shareholder wealth in the M&A market. This cash effect is stronger as targets' R&D spending becomes more intensive. For a one standard deviation increase (0.202) in cash holdings, the resultant increase in the 41-day takeover premium rises from 0.98 to 3.94% if the target's R&D intensity increases from 5 to 20%. Our results are consistent with the bargaining power hypothesis which argues that higher levels of cash holdings strengthen R&D-intensive targets' bargaining position in the M&A market.

The positive association between cash levels and R&D-intensive targets' bargaining power has important implications for R&D-intensive firms' ex ante bargaining strategies.

[13] Given that the Fama and French 25 portfolios are formed at the end of each June while the fiscal year-end of a firm could be any month during the year, a firm could belong to two portfolios in any year t. Therefore, following Faulkender and Wang (2006), we adjust the benchmark return by annualizing the monthly returns of the portfolio the firm belongs to each month.

R&D-intensive firms have strong incentives to hold more cash when they face increased probability of becoming a takeover target. We find that an increase of 10 percentage points in takeover probability incentivizes a firm with 20% R&D investment to increases cash holdings by 17.09%. To address potential endoneneity concerns in our model specification, we adopt a multi-pronged approach. Specifically, we use two-stage instrumental variable regressions to address the problems associated with time-varying omitted variables and reverse causality, firm fixed effects regressions to deal with time-invariant omitted variables problem, and propensity score matching method to mitigate selection bias. We continue to find consistent results indicating that takeover exposure positively affects R&D-intensive firms' cash levels. To further support the bargaining power hypothesis, we examine how the market values a marginal dollar of cash associated with takeover exposure in R&D-intensive firms. We find that such cash holdings receive positive valuations. These results indicate that cash holdings intended to enhance an R&D-intensive firms' ex ante bargaining power are value-increasing.

Future studies could extend this line of research and examine whether other firm specific characteristics such as the level of debt or maturity of debt have any impact on how R&D-intensive targets use cash holdings to negotiate better terms in M&A transactions. Level of debt or maturity of debt could impact a firm's need for cash and in turn its negotiability of terms and conditions in M&A deals. Another aspect that needs to be examined is whether certain governance mechanisms or CEO characteristics encourage a specific growth strategy. For example, a CEO with highly incentivized compensation could be tempted to opt for an acquisition instead of long-term internal development of R&D investment projects if her options or restricted stocks are about to mature. It would be interesting to study these aspects of strategic choices that R&D-intensive firms make.

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Appendix

See Table 10.

Table 10 Variable definition

Panel A: Dependent variables of merger outcomes	
41-day takeover premium	(Initial offer price/target stock price 41 days prior to acquisition announcement date) − 1
4-week takeover premium	(Initial offer price/target stock price 4 weeks prior to acquisition announcement date) − 1
Target CAR [− 1, + 1]	Cumulative abnormal stock returns over the 3-day period (−1, + 1) around announcement date, where abnormal stock returns are calculated using the market adjusted model by subtracting daily returns on CRSP's value-weighted index from daily raw returns
Target CAR [− 2, + 2]	Cumulative abnormal stock returns over the 5-day period (−2, + 2) around announcement date, where abnormal stock returns are calculated using the market adjusted model by subtracting daily returns on CRSP's value-weighted index from daily raw returns

Table 10 continued

Panel B: Target and acquirer characteristics	
Assets	Book value of total assets (AT)
Tobin's Q	Market value of total assets divided by book value of total assets. Market value of assets is calculated as book value of total assets minus book value of common equity (CEQ) plus common shares outstanding (CSHO) times stock price (PRCC_F)
ROA	Income before extraordinary items (IB) divided by book value of total assets
Book leverage	The sum of short-term debt (DLC) plus long-term debt (DLTT) divided by book value of total assets
Sales growth	$(SALE_t - SALE_{t-1})/SALE_{t-1}$
Cash	Cash and short-term investments (CHE) divided by book value of total assets
R&D	R&D expenditures (XRD) divided by total sales (SALE). Missing values are set to zero
Stock price run-up	Buy-and-hold abnormal return (BHAR) during the 200 trading days ending two months before the announcement date with CRSP value-weighted return as the market index
Panel C: Deal characteristics	
All-cash deal	Dummy variable equal to one for 100% cash-financed deals and zero otherwise
Stock deal	Dummy variable equal to one for deals at least partially stock financed and zero otherwise
Diversifying acquisition	Dummy variable equal to one if acquirer and target do not share the same two-digit SIC industry and zero otherwise
Relative deal size	Deal value divided by acquirer market value of equity
Tender offer	Dummy variable equal to one if tender offers are received and zero otherwise
Friendly acquisition	Dummy variable equal to one for friendly takeovers and zero otherwise
Competition	Dummy variable equal to one if a deal has competing bidders and zero otherwise
Target termination fee provision	Dummy variable equal to one if a target termination fee provision is present and zero otherwise
Target lockup option	Dummy variable equal to one if a target lockup option is present and zero otherwise
Panel D: Takeover probability and cash variables	
Takeover dummy	A dummy equal to one if the firm is a takeover target in a given year *t* and zero otherwise
State density of takeovers	The annual average value of the takeover dummy for all firms headquartered in firm *i*'s state
Industry density of takeovers	The annual average value of the takeover dummy for all firms in firm *i*'s two-digit SIC industry
Market equity (ME)	Stock's closing price at the fiscal year-end (PRCC_F) * number of shares (CSHO)
Tobin's Q	Market value of total assets divided by book value of total assets. Market value of assets is calculated as book value of total assets minus book value of common equity (CEQ) plus common shares outstanding (CSHO) times stock price (PRCC_F)
Sales growth	$(SALE_t - SALE_{t-1})/SALE_{t-1}$
Tangibility	Net plant, property, and equipment (PPENT)/total assets (AT)
Cash	Cash and short-term investments (CHE) divided by book value of total assets
ROA	Income before extraordinary items (IB) divided by book value of total assets.
Book leverage	The sum of short-term debt (DLC) plus long-term debt (DLTT) divided by book value of total assets

Table 10 continued

Institutional ownership	Sum of all institutional ownership/total shares outstanding
Assets	Book value of total assets (AT)
Cash flow	[Operating income (OIBDP) − interest expense (XINT) − taxes (TXT)]/total assets (AT)
Industry sigma	Average of prior ten year standard deviations of cash flow ratios (CF/assets) for firms in the same industry defined by the two-digit SIC codes
NWC	[Current assets (ACT) − current liabilities (LCT) − cash and equivalents (CHE)]/total assets (AT)
Capex	Capital expenditure (CAPEX)/total assets (AT)
Dividend dummy	Dummy variable equal to one if the firm paid a positive dividend and zero otherwise
R&D	R&D expenditures (XRD) divided by total sales (SALE). Missing values are set to zero
Acquisition	Acquisition expenditures (AQC)/total assets (AT)
SA index	SA index $= -0.737*SIZE + 0.043*SIZE^2 - 0.040*AGE$ (Hadlock and Pierce (2010)), where *SIZE* is the natural log of book assets deflated to the 2004 dollars, and *AGE* is the number of years the firm has been on Compustat with a non-missing stock price
Panel E: Variables of cash value	
Excess return	Stock return − Fama-French 25 portfolios benchmark return
ΔCash	$(Cash_t - Cash_{t-1})/ME_{t-1}$, Cash = CHE
Earnings	Earnings before extraordinary items (IB) + interest (XINT) + deferred tax and investment tax credits (TXDITC)
Net assets (NA)	Total assets (AT) − Cash (CHE)
ΔEarnings	$(Earnings_t - Earnings_{t-1})/ME_{t-1}$
ΔNet assets	$(NA_t - NA_{t-1})/ME_{t-1}$
ΔR&D	$(R\&D_t - R\&D_{t-1})/ME_{t-1}$, R&D = R&D expenditures (XRD)
ΔInterest	$(Interest_t - Interest_{t-1})/ME_{t-1}$, Interest = Interest expense (XINT)
ΔDividends	$(Divdends_t - Dividends_{t-1})/ME_{t-1}$, Dividends = Common dividends (DVC)
Lagged cash	$Cash_{t-1}/ME_{t-1}$, Cash = CHE
Market leverage	[Short-term debt (DLC) + long-term debt (DLTT)]/[Short-term debt (DLC) + long-term debt (DLTT) + Market value of equity (ME)]
Net financing	[Equity issuance (SSTK) − equity repurchase (PRSTKC) + debt issuance (DLTIS) − debt reduction (DLTR)]$_t/ME_{t-1}$

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