Increase in cash holdings of U.S. firms: The role of healthcare and technology industries

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Abstract

We examine whether the high cash ratio and the secular increase in cash holdings of U.S. firms are driven by healthcare and technology industries. We find that these two industries have significantly increased their cash holdings from 1980 to 2015. It is only in these two industries that firms with riskier cash flow, financially constrained firms, R&D firms, low-efficiency firms, and firms with low institutional ownership and high board size dramatically increase their cash holdings. Similar firms in other industries do not substantially accumulate cash reserves. The explanatory powers of firm characteristics, industry characteristics, and industry competition on cash holdings in healthcare and technology industries are stronger than in other industries. Moreover, we find a causal effect of the 2008 financial crisis on the difference in cash holdings between healthcare and technology industries, and other industries.

Keywords: Cash holdings, industry effect, the precautionary motive, agency costs, R&D investment, industry competition

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1. Introduction

The static trade-off model of Shyam-Sunder & Myers (1999) suggests that firms should retain an optimal level of cash holdings that balances the marginal cost and benefit of cash holdings to maximize shareholder wealth. However, Bates, Kahle, & Stulz (2009) find that the average cash-to-assets ratio of U.S. firms has increased significantly since 1980. Their finding has received considerable attention in finance literature. This literature proposes three major explanations for large cash reserves. First, firms increase their cash holdings for precautionary motives. Firms hold extra cash as a buffer to hedge against future cash flow uncertainty (e.g., Acharya, Davydenko, & Strebulaev, 2012; Bates et al., 2009; Denis & Sibilkov, 2010; Han & Qiu, 2007; He & Wintoki, 2016; McLean, 2011; Pinkowitz, Stulz, & Williamson, 2016). Second, large cash holdings are associated with agency problems and corporate governance (e.g., Dittmar, Mahrt-Smith, & Servaes, 2003; Harford, 1999; Harford, Li, & Zhao, 2008; Nikolov & Whited, 2014; Ozkan & Ozkan, 2004). Third, multinational firms hold a significant amount of cash abroad because of higher repatriation taxes (e.g., Foley, Hartzell, Titman, & Twite, 2007). Moreover, Locorotondo Dewaelheyns, & Van Hulle (2014) and Phan, Nguyen, Nguyen, & Hegde (2019) report that cash holdings are related to business group affiliates and policy uncertainty. However, there is still no consensus among researchers on the explanations for the increase in cash holdings.

The increase in cash holdings has important implications for corporate profitability, growth opportunities, and corporate risk. Detecting the real reasons behind the secular increase in corporate cash holdings allows for a better understanding of a firm's financial policies and helps identify the efficiency of the firm's cash and investment management. In this study, we examine the role of healthcare and technology industries in explaining the substantial increase in cash holdings of U.S. firms. Our study is motivated by three streams of the empirical literature. First, the finance literature has long recognized the industry as an important determinant of cash holdings (e.g., Bates et al., 2009; Chudson,

1945; Dittmar et al., 2003; Harford, 1999; Harford et al., 2008; Kim, Mauer, & Sherman, 1998; Opler, Pinkowitz, Stulz, & Williamson, 1999; Simutin, 2010). Dittmar & Mahrt-Smith (2007) show that pharmaceutical products and technology industries have higher cash-to-assets ratios than other industries. Second, Brown, Fazzari, & Petersen (2009) report that young U.S. public firms in the high-technology industry dramatically increase their R&D investment and shift the supply of finance to internal cash flow and external share issues. McLean (2011) and McLean & Zhao (2018) demonstrate that share issuance has become a primary source of cash savings for U.S. and international firms in the most recent decade. Firms save an average of 60% of share issuance proceeds as cash for precautionary motives. Third, He & Wintoki (2016) and Pinkowitz et al. (2016) find that the increase in cash holdings is concentrated in R&D-intensive firms, while Begenau & Palazzo (2017) and Thakor & Lo (2015) show that R&D-intensive firms and firms in biopharmaceutical industry largely increase cash holdings due to the intensity of industry competition.

We hypothesize that the dramatic increase in cash holdings of U.S. firms is dominated by firms in healthcare and technology industries. These firms face higher industry competition. Therefore, they significantly increase R&D investment to improve their competitiveness. However, it is difficult for firms to fund R&D with debt finance because of the unique features of R&D investment, such as intangible assets and a higher degree of output uncertainty. They can only rely on external share issues for their capital supply. To avoid the shortfalls of future external share issues during poor economic times, firms in these two industries largely save cash from the proceeds of share issues, which drives the increase of their cash holdings. In other industries, however, R&D-intensive firms and firms with higher precautionary motives for holding cash do not dramatically increase their cash holdings in the same way that firms in healthcare and technology industries do.

Using common stocks traded in the U.S. for the period from 1980 to 2015, we classify firms into three industry groups based on their four-digit Standard Industrial Classification (SIC) code: healthcare, technology, and other industry

groups. We compare the increase in the cash-to-assets ratios between these industry groups by controlling for the proxies of precautionary motives, agency costs, and corporate governance. Following Bates et al. (2009) and Denis & Sibilkov (2010), we employ cash flow risk, financial constraints proxies, and R&D-to-sales ratio to capture the precautionary motive. We use the asset utilization ratio of Ang, Cole, & Lin (2000) and the expense ratio of Singh & Davidson (2003) as the proxies for agency costs. These measures can capture the efficiency of the management's control on the utilization of a firm's assets, and on the firm's selling, general, and administrative expenses. Drawing from Harford et al. (2008), we employ institutional ownership and board size as the proxies for corporate governance. We adopt a difference-in-differences analysis with a propensity score matching approach to investigate whether the 2008 financial crisis has caused larger cash holdings in healthcare and technology industries than in other industries.

We find that healthcare and technology industries significantly increase their cash holdings over our sample period. Moreover, the substantial increase in the cash holdings of firms with riskier cash flows, financially constrained firms, and R&D firms are concentrated in healthcare and technology industries, while similar firms in other industries do not exhibit such a large increase. Consistent with the agency motive and corporate governance literature, low-efficiency firms and firms with low institutional ownership and large board size reserve more cash. More importantly, the increase in cash holdings is dominated by these firms in healthcare and technology industries.

In line with our hypothesis, healthcare and technology industries are highly competitive and have higher R&D spending and net share issues than other industries. Industry competition is one of the important determinants of cash holdings for healthcare and technology industries, but not for other industries. Moreover, the impacts of firm and industry characteristics on cash holdings are significantly larger in magnitude in healthcare and technology industries than in other industries. Our difference-in-differences analysis shows that there is a causal effect of the 2008 financial crisis on the difference in cash holdings

between healthcare and technology industries and other industries.

The main contribution of this paper is to fill the identified research gap by highlighting the differences in the determinants of cash holdings between healthcare and technology industries and other industries. Bates et al. (2009), Lyandres & Palazzo (2016), Opler et al. (1999), and Qiu & Wan (2015) show that firm characteristics, industry characteristics, and industry competition are important determinants for cash holdings. We find that the cash flow and the cash flow risk have different impacts on cash holdings between healthcare and technology industries, and other industries. The explanatory power of industry competition on cash holdings is stronger for healthcare and technology industries than for other industries. Furthermore, the differences in firm characteristics and industry characteristics between healthcare and technology industries, and other industries are strong determinants of cash holdings.

The second contribution of this paper is to add to literature by providing a comprehensive examination of the industry effect on the increase in cash holdings. Bates et al. (2009), Denis & Sibilkov (2010), Harford et al. (2008), He & Wintoki (2016), and McLean (2011) report that large cash reserves are due to the precautionary motive, agency costs, corporate governance, and share issuance. We extend their studies by controlling for these proxies between healthcare and technology industries and other industries. We demonstrate that the increase in cash holdings is driven by healthcare and technology industries. Our results offer new insights into the increase in cash holdings and suggest that healthcare and technology industries play a crucial role in explaining the increase in cash holdings of U.S. firms. If the effects of these industries are ignored, the research conclusions could be misleading.

The rest of this paper is organized as follows. Section 2 reviews related literature and develops the hypotheses. Section 3 describes the data used. Section 4 presents the empirical results, and Section 5 offers some concluding remarks.

2. Related literature and hypotheses development

Keynes (1936) suggests that the transaction motive and precautionary motive are the two primary reasons for holding cash, while Jensen (1986) proposes the agency motive for a cash reserve. The dramatic increase in cash holdings enables U.S. firms to invest in R&D spending with higher risk, to enhance their competitiveness (Begenau & Palazzo, 2017; He & Wintoki, 2016; Pinkowitz et al., 2016; Thakor & Lo, 2015). Moreover, large cash holdings allow firms to pay back their shareholders through stock repurchase (Lazonick, 2014). In this section, we review the industry effect, R&D investment, precautionary motives, agency costs, corporate governance, and industry competition in relation to the increase in cash holdings and develop our hypotheses.

2.1. Healthcare and technology industries, R&D investment, and an increase in cash holdings

Prior literature has documented that cash holdings vary by industry. For instance, Harford (1999) reports a significant variation in cash holdings across industries for the period from 1950 to 1994. Thakor & Lo (2015) find that firms in biopharmaceutical industry hold more cash due to the interaction between R&D investment and market competition. Graham & Leary (2018) further show that the increase in cash holdings is concentrated in the technology and healthcare sectors.

The healthcare and technology industries have some distinctive features. Brown et al. (2009) find that young U.S. firms in high-technology industry dramatically increase R&D investment, which led to the 1990s R&D boom. R&D investment has a high degree of asymmetric information, agency problem, and uncertainty of output. In addition, R&D investment has higher adjustment costs and is dominated by intangible assets (Arrow, 1962; Hall, 2002). As a result, R&D investment requires large amounts of capital but cannot easily be pledged as collateral for borrowing. Brown et al. (2009) show that young U.S. firms in the high-technology industry rely almost entirely on internal cash flow and external share issuance. McLean (2011) demonstrates that U.S. firms save a

large amount of cash from share issuance proceeds during good economic times as a precautionary motive to avoid costly share issues during bad economic times. Meanwhile, He & Wintoki (2016) and Pinkowitz et al. (2016) evince that R&D-intensive firms significantly increase cash holdings. Motivated by these studies, healthcare and technology industries are expected to have more share issuance to finance their R&D investment and save a large amount of cash from share issuance proceeds for precautionary motives. This leads to our first testable hypothesis:

Hypothesis 1. *The secular increase in cash holdings of U.S. firms is dominated by firms in healthcare and technology industries. These two industries have higher R&D spending and net share issues than other industries.*

2.2. Precautionary motive and an increase in cash holdings

The precautionary motive predicts that a firm holds cash to prevent unexpected cash shortfalls. Several studies find that an increase in cash holdings is related to precautionary motives. For instance, Bates et al. (2009) and Opler et al. (1999) show that firms with negative income and higher cash flow risk tend to accumulate excess cash. Almeida, Campello, & Weisbach (2004), Denis & Sibilkov (2010), and Faulkender & Wang (2006) find that financially constrained firms have more investment opportunities, but face more difficulties in raising external capital than financially unconstrained firms. Therefore, they hold more cash for future investment. Duchin, Gilbert, Harford, & Hrdlicka (2017) and Han & Qiu (2007) find evidence that financially constrained firms increase their cash holdings against higher cash flow risk and avoid investing in risky financial assets due to precautionary motives. Acharya et al. (2012), Harford, Klasa, & Maxwell (2014), and Hugonnier, Malamud, & Morellec (2014) document that a higher level of cash holdings is associated with higher credit risk, refinancing risk, and capital supply uncertainty, respectively. Given the empirical evidence of precautionary motives for holding cash, we examine our second hypothesis by controlling for the precautionary motive variables.

Hypothesis 2. *The secular increase in cash holdings of firms with high cash flow risk and financial constraints is concentrated among firms in healthcare and technology industries, but not among similar firms in other industries.*

2.3. Agency costs, corporate governance, and an increase in cash holdings

Agency costs arise when the shareholders' objectives differ from the managers' objectives. The free cash flow theory developed by Jensen (1986) and Stulz (1990) suggests that managers prefer to hold cash within firms rather than increase payouts to shareholders. Holding extra cash allows managers to make investments without costly external finance. They also avoid monitoring by external capital providers. The free cash flow theory predicts that managers are likely to spend cash inefficiently by undertaking value-decreasing mergers to pursue their own interests (Jensen, 1986), which leads to agency costs. Harford (1999) provides evidence in support of the free cash flow theory and shows that firms with more cash reserves tend to engage in value-decreasing acquisitions. Anderson & Hamadi (2016), Dittmar & Mahrt-Smith (2007), and Harford et al. (2008) find that firms with poor corporate governance structures or concentrated ownership dissipate cash quickly on acquisitions and capital expenditures. Using data from the UK, Ozkan & Ozkan (2004) find that managerial ownership significantly influences the cash policy of UK firms.

Jensen & Meckling (1976) have developed a theory linking agency costs to corporate governance. They show that agency costs are associated with the costs of monitoring managers' performance, the incentive fees paid to the agent to ensure that the behavior of the agent is consistent with the best interests of shareholders, and the residual loss due to agent misbehavior. Harford et al. (2008) use institutional ownership, pay sensitivity, and board size to capture corporate governance. Shleifer & Vishny (1986) suggest that institutional shareholders could monitor management and reduce agency costs. For board size, the literature reports a mixed relationship between board size and agency costs. Jensen (1993) and Lipton & Lorsch (1992) argue that small boards should be more effective and have fewer agency problems. Eisenberg, Sundgren, & Wells

(1998), Singh & Davidson (2003), and Yermack (1996) find empirical evidence in line with this argument. In contrast, Harris & Raviv (2006) have developed a model and predict that a larger board size is better for monitoring and governance. Boone, Field, Karpoff, & Raheja (2007) report evidence that supports this prediction. Motivated by these papers, we test our third hypothesis by controlling for the measures of agency costs and corporate governance.

Hypothesis 3. *The secular increase in cash holdings of low-efficiency firms, firms with low institutional ownership, and large board size is dominated by firms in healthcare and technology industries, but not by similar firms in other industries.*

2.4. Industry competition and an increase in cash holdings

Existing literature provides strong evidence that firms' R&D investment and cash policies are associated with industry competition. Thakor & Lo (2015) report an interaction effect between competition, R&D investment, and cash holdings on biopharmaceutical firms. Lyandres & Palazzo (2016) argue that cash holdings are related to the intensity of industry competition. Specifically, a firm with large cash reserves is likely to invest more in R&D than a firm with small cash reserves. This can reduce the expected profit and marginal benefit of holding cash for the rival firm and, in turn, increase the competitiveness of the firm. Begenau & Palazzo (2017) find that the intensity of industry competition leads to an increase in R&D investment and cash holdings. As a result, we expect that large cash reserves for R&D investment of healthcare and technology industries are likely to be due to higher industry competition. This informs our fourth hypothesis as follows:

Hypothesis 4. *Industry competition is one of the significant determinants of cash holdings for healthcare and technology industries, but is insignificant for other industries.*

3. Data

Our sample consists of common stocks traded on the NYSE, AMEX, and NASDAQ in the period from 1980 to 2015.[1] We collect firm-level accounting data from the Center for Research in Security Prices (CRSP)/Compustat merged database. We employ the Herfindahl-Hirschman Index (HHI) and product fluidity as the measures of industry competition, including Compustat HHI, Fitted HHI, and Text-based (TNIC) HHI. The data of Fitted HHI, TNIC HHI, and product fluidity are obtained from Hoberg & Phillips' data library.[2] We use industry characteristics of product market rivalry data from Nicholas Bloom's research website.[3] To investigate the impact of corporate governance on cash holdings, we obtain institutional holdings data from the Thomson Financial Institutional Holdings (13F) database and board size data from the executive compensation (Execucomp) database. We remove heavily regulated utility firms (SIC codes 4900-4999), financial firms (SIC codes 6000-6999), and non-classifiable firms (SIC codes 9900-9999). We also exclude firms with non-positive values of total assets, cash-to-assets ratio, or sales for the sample years. This results in a panel of 181,720 observations for 16,629 unique firms.

3.1. Measures of cash holdings and firm characteristics

Several measures of cash holdings have been used in the literature, including cash-to-assets ratio (Bates et al., 2009; Han & Qiu, 2007; Harford, 1999; Li & Luo, 2017; Palazzo, 2012), cash-to-net assets ratio (Harford et al., 2008; Opler et al., 1999), log of cash-to-net assets ratio (Bates et al., 2009; Foley et al., 2007; Simutin, 2010), and cash-to-sales ratio (Harford, 1999; Harford et al., 2008).

[1] The start date for our sample is consistent with Bates et al. (2009). We identify common stocks as those with CRSP share codes 10 and 11.

[2] http://hobergphillips.usc.edu/. The Fitted HHI combines Compustat data with Herfindahl data from the U.S. Commerce Department and employee data from the Bureau of Labor Statistics (Hoberg & Phillips, 2010a). The TNIC HHI is based on the text-based network industry classification in the business description of 10-K filing in the SEC from 1996 to 2007 (Hoberg & Phillips, 2010b). The data on product market fluidity are available from 1997 to 2007.

[3] https://nbloom.people.stanford.edu/research.

Bates et al. (2009) report that using different measures of cash holdings does not affect the results. We, therefore, employ the cash-to-assets ratio as cash and marketable securities (data item CHE) to total assets (data item AT) in this study.

Bates et al. (2009) and Opler et al. (1999) highlight 10 firm characteristics that significantly influence corporate cash holdings, including market-to-book ratio (MB), firm size ($Size$), cash flow-to-assets ratio (CF), cash flow risk (CFR), net working capital-to-assets ratio (NWC), capital expenditures-to-assets ratio ($Capex$), leverage ratio ($Leverage$), research and development expense-to-sales ratio ($R\&D$), dividend payout dummy ($DivDummy$), and acquisition-to-assets ratio ($Acquisition$). McLean (2011) finds that share issuance is the major source of cash saving. We, therefore, add net share issue ($NetIssue$) as one of the determinants of cash holdings. Appendix A provides detailed descriptions of firm characteristics.

3.2. Measures of industry characteristics

Qiu & Wan (2015) find that industry characteristics also affect cash holdings. Following their study, we employ the industry characteristics of technology spillover ($Spill\_Tech$), product market rivalry ($Spill\_Sale$), return-on-assets ratio (ROA), and sales growth as the determinants of cash holdings.[4] Technology spillover refers to the involuntary leakage and the voluntary exchange of useful technological information (Griliches, 1992). Product market rivalry refers to business stealing (Bloom Schankerman, & Van Reenen, 2013). Qiu & Wan (2015) use a patent-weighted average of all rivals' R&D stocks to capture the technology spillover effect and use a sales-weighted average of all rivals' R&D stocks to capture the product market rivalry effect. Appendix B provides detailed descriptions of the industry characteristics.

[4]We did examine other industry characteristics of sales, stock return, and income volatility following Qiu & Wan (2015). The coefficients on these variables of healthcare and technology industries from the cross-sectional regression do not significantly differ from those of other industries.

3.3. Measures of precautionary motives

Following Bates et al. (2009), He & Wintoki (2016), and Opler et al. (1999), we use cash flow risk, financial constraints proxies, and R&D ratio as the measures to capture precautionary motives. We estimate cash flow risk as the standard deviation of the cash flow-to-assets ratio over the previous 10 years. We select firm size and dividend payout ratio as the proxies for financial constraints following Almeida & Campello (2007), Almeida et al. (2004), Denis & Sibilkov (2010), Faulkender & Wang (2006), Hahn & Lee (2009), and Li & Luo (2019).[5] Small firms and those with low dividend payout ratios are likely to be financially constrained firms because they have poor access to external finance. Appendix A provides detailed measures of firm size and dividend payout ratio. Following Hahn & Lee (2009), at the end of June of each year, t, we rank all firms into deciles, based on their firm size or payout ratio for the fiscal year ending in the calendar year $t-1$. We classify firms in the bottom three deciles of the total assets or payout ratio distribution as financially constrained firms, and those in the top three deciles as financially unconstrained firms.[6]

3.4. Proxies for agency costs

We use two efficiency ratios to capture agency costs, namely, the asset utilization ratio of Ang et al. (2000) and the expense ratio of Singh & Davidson (2003). The asset utilization ratio is the firm's sales divided by total assets. A low asset utilization ratio indicates that the management inefficiently utilizes its assets due to poor investment decisions and reflects higher agency costs. The expense ratio is the ratio of a firm's selling, general, and administrative expenses (data item $XSGA$) to sales (data item $SALE$). A firm with a high expense ra-

[5] We also examine two other financial constraints' proxies of bond rating and commercial paper rating and find similar patterns of the increase in cash holdings with the proxies of firm size and payout ratio. The results were not reported here but are available on request.

[6] When sorting firms based on their payout ratio, we follow Hahn & Lee (2009) and assign firms with zero payout or negative net income to the group of constrained firms.

tio is expected to have higher agency costs, resulting from larger managerial discretionary expenses, including managerial pay and perks consumption.

Following Harford et al. (2008), we use institutional ownership and board size to capture corporate governance.[7] Institutional ownership is the ratio of the number of shares owned by institutions divided by the number of shares outstanding. A firm with larger institutional ownership implies more monitoring and low agency costs. Board size is the ratio of the number of directors on the board divided by the log of total assets.

3.5. Proxies for industry competition

The HHI is a widely used measure of industry concentration, which links the size of firms to the industry. Following He & Wintoki (2016), we employ Compustat HHI, Fitted HHI, TNIC HHI, and product fluidity as the proxies for industry competition. The Compustat HHI is calculated as the sum of the squares of market shares of firms' sales within an industry according to the three-digit SIC code in Compustat, following Giroud & Mueller (2010). The Fitted HHI and TNIC HHI are developed by Hoberg & Phillips (2010a, 2010b). A lower value of HHI implies a more competitive industry. Product fluidity is another measure of market competition proposed by Hoberg, Phillips, & Prabhala (2014). A firm's product fluidity is the dot product between a vector of its own word used in the product descriptions and the vector of the aggregate change in the overall use of a given word. Fluidity measures the competitive threats faced by a firm. It captures how rivals change the product words that overlap with a firm's vocabulary and lies in the interval [0, 1]. Greater fluidity suggests that a firm's words overlap more with the aggregate change in product words of rivals, thus implying a higher competitive threat.

[7] We also examine the cash ratio based on the "pay sensitivity" of the corporate governance measure and find that there is no difference between firms with high and low pay sensitivity. The results are available from the authors.

4. Empirical results

4.1. Increase in cash holdings and the decrease in net leverage for three industry groups

We classify all stocks in our sample into three industry groups based on their four-digit Standard Industrial Classification (SIC) code, including healthcare, technology, and other industry groups. We plot the average cash ratios of these three industry groups over time in Fig. 1. We find a rising trend in cash holdings for healthcare and technology industries, and a stable trend for other industries from 1980 to 2015. Bates et al. (2009) report that after deducting cash from debt, the net leverage ratio shows a dramatic decrease and even falls to negative in some years. Fig. 2 illustrates the average net leverage ratios by year. It can be observed that the average net leverage ratios of healthcare and technology industries decrease significantly and turn to negative from 1992, while those of other industries are positive and stable over the sample period. The results are consistent with Hypothesis 1 that the increase in cash holdings and the negative net leverage of U.S. firms are largely dominated by healthcare and technology industries.

Table 1 presents the mean values of firm and industry characteristics of healthcare, technology, and other industries. "Difference" represents the spread in a variable between the average of healthcare and technology industries and that of other industries. Panel A of Table 1 shows that healthcare and technology industries have higher average cash ratios (31.8% and 27.0%, respectively) than that of other industries (12.2%). Additionally, firms in healthcare and technology industries have more investment opportunities with higher market-to-book ratio (MB) than firms in other industries have. Consistent with Bates et al. (2009), Li & Luo (2017), and Palazzo (2012), firms in healthcare and technology industries produce negative cash flows (CF) from their operations (-0.11 and -0.029, respectively). They have higher cash flow risk (CFR), lower leverage ($Leverage$), and pay lower dividends ($Payout$) to their shareholders. Moreover, firms in healthcare and technology industries spend more on R&D

and have more share issues.

Panel B of Table 1 shows that the industry characteristics are different between healthcare and technology industries and other industries. For instance, healthcare and technology industries have larger mean values in technology spillover ($Spill\_Tech$), product market rivalry ($Spill\_Sale$), and sales growth ($SalesGrowth$), but have smaller mean values in the return-on-assets ratio (ROA) than those of other industries.

4.2. Increase in cash holdings, precautionary motives, and R&D investment across industries

Bates et al. (2009) and Opler et al. (1999) find that large cash holdings are highly related to cash flow risk. Denis & Sibilkov (2010) and Han & Qiu (2007) find that financially constrained firms have greater cash reserves for precautionary motives. Following their studies, we classify the full sample into subsamples based on these variables and examine the increase in cash holdings of healthcare and technology industries, and other industries. Table 2 reports the average cash ratios of the subsamples. Under the cash flow risk classification of Table 2, "High" represents the subsample that consists of firms in the top three deciles, and "Low" represents the subsample that consists of firms in the bottom three deciles. "Difference" represents the spread in the cash ratios between the average of healthcare or technology industries and that of other industries. In line with precautionary motives for holding cash, firms with high cash flow risk reserve more cash than firms with low cash flow risk. More importantly, the cash ratio of firms with high cash flow risk in healthcare industry increases over ten-fold (from 5.5% to 56.0%) and that of firms in the technology industry increases more than four-fold (from 8.7% to 39.4%). However, the ratio of all firms with high cash flow risk across industries increases from 8.0% to 37.9%, and that of firms in other industries increases only from 9.8% to 18.3% over the sample period.

Table 2 also shows that financially constrained firms hold more cash than unconstrained firms based on the proxies of firm size and payout ratio, that

is, small firms and low dividend payers accumulate more cash. Moreover, constrained firms in healthcare and technology industries are the largest contributors to this higher increase in cash holdings, with an increase in the cash ratio from 13.4% to 53.6% for small firms in healthcare industry, and from 11.8% to 21.5% for small firms in other industries.

He & Wintoki (2016) report that large cash holdings are concentrated in R&D firms. To examine the relationship between the increase in cash holdings and R&D, we follow He & Wintoki (2016, Table 1) and define R&D firms as those that have R&D expenditures in any given year, and as non-R&D firms otherwise. We classify the full sample into R&D and non-R&D subsamples. Consistent with the findings of He & Wintoki (2016), Table 2 shows that the increase in cash holdings of R&D firms is larger than that of non-R&D firms. Moreover, the cash ratio increases from 9.6% to 46.3% for R&D firms in healthcare industry, and from 7.9% to 18.0% for R&D firms in other industries. This leads to the differences in the cash ratio between R&D firms in healthcare and technology industries and those in other industries increase from 0.9% to 20.0%.

Overall, our results are in line with the precautionary motives that firms with higher cash flow risk and more financial constraints, and R&D firms do accumulate more cash reserves than their respective counterparts. Consistent with Hypothesis 2, the dramatic increases converge on similar firms in healthcare and technology industries, but not in other industries.

4.3. Increase in cash holdings, agency costs, and corporate governance across industries

To explore the explanations of agency costs and corporate governance for the increase in cash holdings of industries, we classify the full sample into subsamples based on the agency costs' proxies of the asset utilization ratio and the expense ratio, and the corporate governance proxies of institutional ownership and board size. We follow an approach that is similar to the classification of high and low cash flow risks in Table 2. Table 3 presents the average cash ratios of the subsamples for healthcare, technology, and other industries. It can

be observed that firms with low asset utilization ratios or high expense ratios accumulate more cash than firms with high asset utilization ratios or low expense ratios. These results are in line with the free cash flow theory that firms with inefficient utilization of assets or inefficient management control of selling, general, and administrative expenses have larger cash reserves. Once again, the greater increase in cash holdings for low-efficiency firms is concentrated among firms in healthcare and technology industries.

Table 3 also shows that firms with low institutional ownership hold more cash than those with high institutional ownership. This is consistent with the argument of Shleifer & Vishny (1986) that firms with higher institutional ownership have lower agency costs and hold less cash. For the proxy of board size, the subsample with a large board size has a higher average cash ratio (34.6%) than the subsample with a small board size (20.7%).[8] Again, firms in healthcare and technology industries have higher average cash ratios than firms in other industries, in both the high and the low subsamples based on institutional ownership and board size.

In summary, the results provide support to the empirical finding on the agency motive for holding cash, that firms with low utilization of assets, high expense ratio, low institutional ownership, and large board size reserve more cash. Moreover, our results support the Hypothesis 3, that the increase in cash holdings of these firms is largely driven by firms in healthcare and technology industries, but not by similar firms in other industries.

4.4. Impact of the firm and industry characteristics on corporate cash holdings across industries

In this section, we first examine whether cash holdings are associated with the firm and industry characteristics. To remove the outlier effect on explanatory variables, we follow Bates et al. (2009) and winsorize leverage to have values between zero and one. We also winsorize the R&D-to-sales ratio, acquisition-to-

[8]The data of board size from the Execucomp database are available from 1997.

assets ratio, cash flow risk, and capital expenditures-to-assets ratio at the 1% level. In addition, we winsorize the bottom tails of the net working capital-to-assets ratio and cash flow-to-assets ratio, and the top tail of the market-to-book ratio at the 1% level. Table 4 presents the estimates of the firm and industry characteristics for cash holdings across industries. We remove R&D ratio from the independent variables because the ratio is highly correlated with the industry characteristics of technology spillover and product market rivalry. We present the estimates from the year fixed-effect and Fama & MacBeth (1973) (FM) regressions. "Difference" represents the estimate of the difference in a variable between the average of healthcare or technology industries and that of other industries from the FM regression. We control for cluster standard errors at the firm level following the approach of Cameron Gelbach, & Miller (2011).

Table 4 shows that the signs and significance of coefficients on the firm and industry characteristics for all firms across industries are similar to those reported by Bates et al. (2009) and Qiu & Wan (2015). However, the impacts of cash flow and cash flow risk on cash holdings vary significantly by industry. For instance, the coefficients on CF and CFR for other industries are strongly negative and positive, respectively, suggesting that firms in other industries do accumulate cash for the precautionary motives by hedging against low cash flow and high cash flow risk. However, these coefficients are insignificant for healthcare and technology industries except the coefficient for CFR, which is significantly negative for technology industry. These results imply that large cash holdings of healthcare and technology industries are not due to precautionary motives in terms of cash flow and cash flow risk. Our results are in line with the findings of Graham & Leary (2018) and Mclean & Zhao (2018). More importantly, the coefficients on $NetIssue$ are significantly positive for healthcare and technology industries, but insignificant for other industries. The results suggest that these two industries rely more on share issuance for cash reserves. The coefficients on industry characteristics of $Spill\_Tech$, $Spill\_Sale$, ROA, and $Salesgrowth$ also vary by industry. For example, cash holdings of the technology industry can be partially explained by technology spillover and product market rivalry, and

those of healthcare industry are associated with sales growth, but cash holdings of these two industries are irrelevant to their profitability.

Second, we investigate whether the increase in cash holdings can be explained by the changes in the firm characteristics following Bates et al. (2009). The estimates are reported in Table 5. The prefix "d" represents the change in each variable. The coefficients on $dR\&D$ and $dNetIssue$ for the different industries are significantly positive, suggesting that the increase in cash holdings can be partially explained by the differences in the increase in R&D and net share issues between healthcare and technology industries and other industries. Moreover, the increase in cash holdings is also largely affected by the differences in the changes in lagged cash ratio, firm size, net working capital, capital expenditure, and acquisition ratio of healthcare and technology industries over other industries.

4.5. Effect of industry competition on cash holdings across industries

Lyandres & Palazzo (2016) show that cash holdings are associated with industry competition. He & Wintoki (2016) find that large cash reserves of R&D-intensive firms are related to the intensity of industry competition. Therefore, we examine the effect of industry competition on cash holdings from the following cross-sectional regression:

$$Cash_{i,t} = \gamma_0 + \gamma_1 HHI_t + \gamma_2 X_{i,t} + \varepsilon_{i,t}, \tag{1}$$

where $Cash$ is the firm's cash-to-assets ratio; HHI is the measure of industry competition, including the Compustat HHI, Fitted HHI, TNIC HHI, and product fluidity, respectively; and X is a vector of control variables consisting of all firm and industry characteristics in Table 4.

Table 6 reports the mean values of the industry competition measures and the estimates from the cross-sectional regressions. Panel A shows that healthcare and technology industries have lower average HHI across the three HHI measures and higher product fluidity than other industries. This indicates that firms in healthcare and technology industries face a higher intensity of industry competition than firms in other industries.

Panel B of Table 6 shows that the coefficients on HHI are strongly negative across the three HHI measures, and those on product fluidity are strongly positive for all firms across industries for the sample period. These results suggest that the intensity of industry competition is one of the important determinants of cash holdings. More importantly, the coefficients on industry competition are significant at the 1% level across four industry competition measures for healthcare and technology industries, but insignificant for other industries under the HHI measures, with only one exception (under the TNIC HHI measure from the FM regression). These results are in line with our Hypothesis 4 and imply that the strong impact of industry competition on cash holdings is dominated by healthcare and technology industries.[9]

4.6. The exogenous shock of the 2008 financial crisis on firm cash holdings

The 2008 financial crisis as a credit supply shock caused U.S firms, particularly financially constrained firms, to cut their investments and sell more assets to obtain cash (Campello, Graham, & Harvey, 2010). If healthcare and technology industries are the main drivers of the increase in cash holdings, they are likely to hold more cash after the crisis compared to other industries. To examine this hypothesis, we perform the following difference-in-differences (hereafter DID) tests,

$$Cash_{i,t} = \alpha + \beta_0 Time_{i,t} + \beta_1 Treat_i + \beta_2 Time_{i,t} \times Treat_i + \beta_3 X_{i,t} + \varepsilon_{i,t} + \lambda_j + u_t, \quad (2)$$

where *Cash* is the firm's cash-to-assets ratio, *Time* is a dummy variable equal to one for years after 2008 and zero otherwise, *Treat* is a dummy variable equal to one for firms in healthcare and technology industries, and zero otherwise, $Time \times Treat$ is the interaction term, X is a vector of control variables consisting of all firm and industry characteristics in Table 4, λ_j and u_t are the industry and year fixed terms, and β_2 is the coefficient on the difference-in-differences (DID)

[9]We also examined the effect of industry competition on cash holdings for the separated sample periods and find that the effect of healthcare and technology industries varies over time. The results are not included in the paper, but are available from the authors on request.

estimate ($Time \times Treat$) that captures the causal effect of the 2008 financial crisis on the difference in cash holdings between healthcare and technology industries and other industries.

To avoid the problem that the results of the DID analysis are driven by the differences in the firm and industry characteristics between healthcare and technology industries and other industries, we employ a propensity score matching approach to produce a new treatment group and a control group using the nearest neighbor matching technique. Specifically, we define treated firms as those in healthcare and technology industries. Using this treatment dummy as the dependent variable, we estimate the probabilities from a logit model based on the firm and industry characteristics in Panel A of Table 7. Using the predicted probabilities, we calculate the propensity scores and select firms from the treatment and control groups that match with replacement, and propensity scores within $\pm 0.1\%$, that is, the maximum difference between the propensity score of each paired treatment and control firm does not exceed 0.1% in absolute value.[10]

Panel A of Table 7 reports the tests of the matching variables for the treatment and control groups within four years before and after the financial crisis. After matching, there are no significant differences in the firm and industry characteristics between the treated and control firms. We then conduct the DID regression for the matched treatment and control groups by focusing on a window of four years before and after the 2008 financial crisis. Therefore, the results from the DID analysis can be purely attributed to the difference in cash holdings between healthcare and technology industries and other industries. Panel B of Table 7 shows that the coefficient on $Time \times Treat$ is 0.022 ($t = 2.10$) for Model 4 after controlling for both industry and year fixed-effect. The results provide further evidence that firms in healthcare and technology industries significantly increase their cash holdings by 2.2% more than similar firms in other industries, following the 2008 financial crisis shock.

[10] Our results are also quantitatively similar to $\pm 0.5\%$ and $\pm 1\%$.

5. Conclusion

We examine whether the increase in cash holdings of U.S. firms is driven by firms in healthcare and technology industries. Notably, we find a large variation in cash ratio by industry. The high level of cash holdings, the substantial increase in cash holdings, and the negative net debt are largely dominated by firms in healthcare and technology industries. We control for the variables of precautionary motives, agency costs, and corporate governance and find that the increase in cash holdings of firms with riskier cash flow, financially constrained firms, R&D firms, low-efficiency firms, and firms with low institutional ownership and large board size are concentrated in healthcare and technology industries.

Our results from the cross-sectional regressions show that healthcare and technology industries dominate the impacts of firm and industry characteristics on the level of cash holdings, and the changes in cash holdings. Moreover, the effect of industry competition on cash holdings is mainly driven by healthcare and technology industries. The DID analysis employing the propensity score matching approach shows that the 2008 financial crisis partially causes the difference in cash holdings between healthcare and technology industries and other industries. Overall, our findings are in support of our hypotheses that firms in healthcare and technology industries largely save cash from share issuance proceeds for their R&D spending due to the intensity of industry competition, which drives the increase in cash holdings of U.S. firms.

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Table 1
Firm characteristics and industry characteristics across three industry groups

	All	Tech	Health	Others	Difference
Panel A: Firm characteristics					
Cash	0.237	0.270	0.318	0.122	0.172
	(25.24)	(21.19)	(22.95)	(46.53)	(15.54)
MB	2.458	2.503	3.121	1.750	1.061
	(35.27)	(19.72)	(37.54)	(48.17)	(13.79)
Size	4.625	4.354	4.224	5.298	-1.009
	(29.73)	(25.44)	(30.34)	(33.32)	(-65.29)
CF	-0.034	-0.029	-0.110	0.036	-0.105
	(-6.58)	(-3.92)	(-10.97)	(14.27)	(-14.10)
CFR	0.113	0.117	0.155	0.068	0.068
	(21.43)	(25.42)	(15.93)	(22.15)	(12.20)
Leverage	0.207	0.156	0.200	0.264	-0.086
	(44.83)	(23.11)	(35.56)	(76.02)	(-16.22)
NWC	0.094	0.110	0.068	0.104	-0.015
	(9.18)	(7.30)	(6.31)	(18.72)	(-2.06)
Capex	0.061	0.056	0.053	0.076	-0.022
	(19.02)	(14.53)	(15.18)	(28.88)	(-14.71)
Payout	0.065	-0.012	0.088	0.120	-0.082
	(0.71)	(-0.04)	(1.45)	(7.77)	(-0.61)
R&D	3.961	1.381	10.403	0.099	5.793
	(4.80)	(5.15)	(4.35)	(6.72)	(4.68)
Acquisition	0.021	0.019	0.023	0.022	-0.001
	(17.40)	(12.75)	(18.28)	(14.53)	(-0.57)
NetIssue	0.089	0.088	0.143	0.035	0.080
	(11.90)	(8.36)	(15.23)	(7.74)	(13.20)
Panel B: Industry characteristics					
Spill_Tech	13.588	13.861	13.678	13.225	0.544
	(98.83)	(101.75)	(87.66)	(108.82)	(19.08)
Spill_Sale	12.688	13.163	13.340	11.562	1.690
	(84.10)	(84.28)	(78.38)	(90.65)	(45.09)
ROA	0.013	0.015	-0.072	0.095	-0.124
	(1.68)	(1.57)	(-5.65)	(30.61)	(-14.69)
Sales growth	2.144	1.960	2.887	1.585	0.838
	(7.80)	(5.05)	(3.76)	(13.00)	(1.88)

This table reports the mean values of the firm and industry characteristics of technology (Tech), healthcare (Health), and other (Others) industries. "All" represents all industries. "Others" represents an industry group comprising firms that are not in technology and healthcare industries. "Difference" is the difference in mean values between the average of a variable of healthcare or technology industries and that of other industry group. Panels A and B present the firm and industry characteristics, respectively. Detailed descriptions of the characteristics are provided in Appendix A and B. The sample includes all common stocks on the NYSE, AMEX, and NASDAQ with positive cash-to-assets ratios, total assets, and sales. Financial firms (SIC codes 6000-6999), utilities (SIC codes 4900-4999), and non-classifiable firms (SIC codes 9900-9999) are excluded. The sample period is from 1980 to 2015. t-statistics are reported in parentheses.

Table 2
Increase in cash holdings of the subsamples based on precautionary motives for three industry groups

Year	All	Tech	Health	Others	Difference	All	Tech	Health	Others	Difference
	High cash flow risk					Low cash flow risk				
1980	0.080	0.087	0.055	0.098	-0.015	0.073	0.064	0.089	0.064	0.010
2006	0.378	0.393	0.497	0.243	0.192***	0.169	0.237	0.185	0.086	0.132***
2015	0.379	0.394	0.560	0.183	0.292***	0.138	0.204	0.127	0.082	0.096***
average	0.270***	0.276***	0.371***	0.164***	0.159***	0.132	0.184	0.132***	0.079***	0.079***
	(17.01)	(15.99)	(15.23)	(23.48)	(10.89)	(33.84)	(23.61)	(31.64)	(35.58)	(16.39)
	Large firm size					Small firm size				
1980	0.084	0.089	0.096	0.067	0.024***	0.121	0.111	0.134	0.118	-0.004
2006	0.181	0.280	0.175	0.088	0.158***	0.374	0.383	0.509	0.229	0.207***
2015	0.160	0.237	0.157	0.087	0.127***	0.372	0.366	0.536	0.215	0.227***
average	0.142***	0.201***	0.145***	0.079***	0.094***	0.289***	0.289***	0.390***	0.188***	0.152***
	(27.69)	(19.60)	(28.97)	(36.33)	(13.82)	(25.57)	(21.65)	(22.26)	(44.22)	(12.59)
	High payout ratio					Low payout ratio				
1980	0.105	0.115	0.100	0.099	0.010	0.100	0.094	0.120	0.086	0.012
2006	0.234	0.345	0.209	0.147	0.162***	0.333	0.366	0.457	0.176	0.224***
2015	0.233	0.302	0.263	0.132	0.161***	0.341	0.366	0.487	0.172	0.244***
average	0.182***	0.246***	0.185***	0.115***	0.100***	0.266***	0.285***	0.365***	0.147***	0.178***
	(25.46)	(19.80)	(25.17)	(31.86)	(13.47)	(26.61)	(21.36)	(25.02)	(44.24)	(16.16)
	R&D firms					Non-*R&D* firms				
1980	0.087	0.085	0.096	0.079	0.009	0.103	0.129	0.093	0.087	0.030***
2006	0.354	0.385	0.485	0.193	0.227***	0.182	0.242	0.176	0.128	0.088***
2015	0.326	0.336	0.463	0.180	0.200***	0.177	0.218	0.196	0.116	0.094***
average	0.269***	0.288***	0.373***	0.147***	0.184***	0.160***	0.198***	0.169***	0.114***	0.070***
	(22.25)	(20.16)	(21.61)	(25.94)	(17.54)	(47.26)	(29.42)	(29.03)	(56.59)	(20.71)

This table reports the average cash-to-assets ratios of the subsamples based on cash flow risk, firm size, payout ratio, and R&D expenditure for technology (Tech), healthcare (Health), and other (Others) industries. Cash flow risk is calculated by the standard deviation of the ratio of cash flow to total assets over the previous 10 years. At the end of June of each year, t, we sort firms into deciles based on their cash flow risk, firm size, and payout ratio for the fiscal year ending in the calendar year $t-1$. "High cash flow risk", "Large firm size", and "High payout ratio" represent the subsamples that contain firms in the top three deciles and "Low cash flow risk", "Small firm size", and "Low payout ratio" represents the subsamples that contain firms in the bottom three deciles. We define R&D firms as those that have R&D expenditures in any given year and non-R&D firms otherwise. The sample includes all common stocks on the NYSE, AMEX, and NASDAQ with positive cash-to-assets ratios, total assets, and sales. Financial firms (SIC codes 6000-6999), utilities (SIC codes 4900-4999), and non-classifiable firms (SIC codes 9900-9999) are excluded. The sample period is from 1980 to 2015. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 3
Increase in cash holdings of the agency costs and corporate governance subsamples for three industry groups

Year	All	Tech	Health	Others	Difference	All	Tech	Health	Others	Difference
			High					Low		
					Asset utilization ratio					
1980	0.073	0.079	0.061	0.077	-0.002	0.127	0.144	0.127	0.111	0.027**
2006	0.169	0.208	0.171	0.128	0.068***	0.412	0.474	0.580	0.182	0.340***
2015	0.174	0.203	0.188	0.131	0.068***	0.376	0.421	0.576	0.131	0.366***
average	0.143***	0.160***	0.166***	0.104***	0.060***	0.339***	0.392***	0.466***	0.158***	0.271***
	(24.42)	(20.00)	(21.30)	(30.02)	(13.50)	(29.56)	(26.29)	(24.97)	(42.40)	(17.82)
					Expense ratio					
1980	0.106	0.091	0.114	0.112	-0.014	0.074	0.107	0.039	0.075	0.015
2006	0.404	0.441	0.515	0.257	0.215***	0.132	0.178	0.125	0.093	0.068***
2015	0.380	0.406	0.509	0.225	0.225***	0.115	0.185	0.071	0.090	0.067***
average	0.309***	0.336***	0.392***	0.199***	0.165***	0.122***	0.155***	0.125***	0.087***	0.053***
	(22.58)	(19.56)	(21.03)	(31.65)	(13.30)	(34.35)	(31.63)	(15.16)	(39.74)	(12.67)
					Institutional ownership					
1980	0.082	0.075	0.091	0.081	-0.002	0.096	0.093	0.104	0.091	0.005
2006	0.251	0.340	0.298	0.116	0.211***	0.310	0.334	0.429	0.168	0.203***
2015	0.244	0.303	0.316	0.113	0.194***	0.311	0.335	0.444	0.154	0.220***
average	0.199***	0.259***	0.240***	0.099***	0.151***	0.240***	0.254***	0.332***	0.133***	0.160***
	(23.99)	(22.14)	(19.53)	(31.98)	(14.50)	(24.72)	(20.65)	(22.02)	(39.33)	(15.58)
					Board size					
1997	0.335	0.395	0.476	0.135	0.286***	0.149	0.222	0.123	0.101	0.087**
2006	0.346	0.380	0.460	0.197	0.214***	0.223	0.303	0.265	0.101	0.190***
2015	0.347	0.343	0.515	0.181	0.239***	0.195	0.278	0.208	0.099	0.164***
average	0.346***	0.372***	0.484***	0.183***	0.245***	0.207***	0.302***	0.215***	0.105***	0.154***
	(72.06)	(99.46)	(41.39)	(40.73)	(41.34)	(38.06)	(44.99)	(19.36)	(40.63)	(18.50)

This table reports the average cash-to-assets ratios of agency costs and corporate governance subsamples for technology (Tech), healthcare (Health), and other (Others) industries. We use the expense ratio and the asset utilization ratio as the proxies for agency costs, and use institutional ownership and board size as the proxies for corporate governance. At the end of June of each year, t, we sort firms into deciles based on their agency costs and corporate governance proxies for the fiscal year ending in the calendar year $t-1$. "High" represents the subsample that contains firms in the top three deciles based on the proxies for agency costs and corporate governance and "Low" represents the subsample that contains firms in the bottom three deciles based on the proxies for agency costs and corporate governance. The sample includes all common stocks on the NYSE, AMEX, and NASDAQ with positive cash-to-assets ratios, total assets, and sales. Financial firms (SIC codes 6000-6999), utilities (SIC codes 4900-4999), and non-classifiable firms (SIC codes 9900-9999) are excluded. The sample period is from 1997 to 2015 for board size and from 1980 to 2015 for the rest. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4
Determinants of cash holdings based on the firm and industry characteristics

	Panel A: The year fixed-effect				Panel B: The FM				
	All	Tech	Health	Others	All	Tech	Health	Others	Difference
_cons	0.225	0.155	0.279	0.256	0.218	0.202	0.365	0.256	0.028
	(7.35)	(1.79)	(1.57)	(9.06)	(13.74)	(4.13)	(6.23)	(24.91)	(0.64)
MB	0.021	0.020	0.010	0.020	0.025	0.030	0.009	0.024	-0.004
	(8.96)	(4.85)	(3.61)	(6.96)	(13.51)	(7.76)	(3.37)	(11.69)	(-1.49)
Size	-0.016	-0.016	-0.021	-0.012	-0.017	-0.017	-0.017	-0.012	-0.005
	(-9.56)	(-4.89)	(-3.79)	(-7.98)	(-21.09)	(-11.34)	(-4.79)	(-20.59)	(-2.05)
CF	-0.144	-0.055	-0.008	-0.207	-0.131	-0.090	0.085	-0.251	0.249
	(-3.77)	(-0.59)	(-0.06)	(-4.30)	(-3.87)	(-1.29)	(1.08)	(-6.94)	(4.27)
CFR	-0.030	-0.170	-0.093	0.131	-0.031	-0.190	0.025	0.132	-0.215
	(-0.68)	(-3.04)	(-0.96)	(1.68)	(-1.15)	(-4.27)	(0.34)	(3.08)	(-3.39)
NWC	-0.335	-0.453	-0.640	-0.202	-0.349	-0.459	-0.633	-0.209	-0.338
	(-15.13)	(-16.25)	(-6.15)	(-11.48)	(-24.98)	(-22.64)	(-20.35)	(-28.01)	(-14.30)
Capex	-0.623	-0.637	-0.814	-0.497	-0.717	-0.771	-0.908	-0.547	-0.292
	(-13.35)	(-9.70)	(-5.71)	(-11.55)	(-15.50)	(-10.73)	(-9.56)	(-18.28)	(-4.27)
Leverage	-0.364	-0.425	-0.449	-0.275	-0.341	-0.405	-0.407	-0.263	-0.143
	(-24.63)	(-15.12)	(-9.37)	(-15.28)	(-40.04)	(-24.00)	(-15.79)	(-39.85)	(-8.40)
DivDummy	-0.036	-0.017	-0.052	-0.016	-0.034	-0.015	-0.051	-0.019	-0.014
	(-7.69)	(-1.65)	(-4.03)	(-3.13)	(-16.03)	(-3.12)	(-6.42)	(-6.90)	(-2.05)
Acquisition	-0.242	-0.378	-0.397	-0.156	-0.267	-0.351	-0.450	-0.188	-0.213
	(-11.38)	(-9.00)	(-8.29)	(-8.31)	(-14.80)	(-11.51)	(-7.67)	(-10.39)	(-6.30)
NetIssue	0.147	0.159	0.169	0.096	0.105	0.099	0.146	0.045	0.078
	(5.96)	(5.45)	(4.69)	(3.11)	(3.48)	(2.48)	(3.31)	(1.58)	(2.25)
Spill_Tech	0.007	0.008	0.018	0.000	0.007	0.006	0.005	0.001	0.005
	(2.47)	(1.33)	(1.54)	(0.12)	(5.88)	(2.33)	(0.82)	(1.24)	(1.43)
Spill_Sale	0.005	0.015	-0.001	0.001	0.005	0.012	-0.001	0.000	0.005
	(3.46)	(3.14)	(-0.07)	(0.56)	(7.27)	(5.00)	(-0.12)	(0.79)	(1.84)
ROA	0.060	0.046	-0.050	0.122	0.036	0.019	-0.104	0.127	-0.169
	(1.46)	(0.50)	(-0.38)	(3.04)	(0.96)	(0.27)	(-1.45)	(3.66)	(-3.64)
Sales growth	0.019	0.013	0.051	0.001	0.009	-0.007	0.067	-0.005	0.035
	(2.93)	(1.19)	(3.36)	(0.13)	(1.32)	(-0.62)	(2.55)	(-0.55)	(1.95)
Adjusted R^2	0.45	0.45	0.55	0.34	0.45	0.46	0.61	0.36	
No. of obs	28930	8197	2783	17950	28930	8197	2783	17950	

This table reports the estimates from the year fixed-effect and Fama and MacBeth (1973) (FM) regressions for cash holdings of technology (Tech), healthcare (Health), and other (Others) industries. The sample includes all common stocks on the NYSE, AMEX, and NASDAQ with positive cash-to-assets ratios, total assets, and sales. Financial firms (SIC codes 6000-6999), utilities (SIC codes 4900-4999), and non-classifiable firms (SIC codes 9900-9999) are excluded. The sample period is from 1980 to June 2015. t-statistics in parentheses are based on cluster-robust standard errors at the firm level.

Table 5
Determinants of the changes in cash holdings based on firm characteristics

	The year fixed-effect				The FM				
	All	Tech	Health	Others	All	Tech	Health	Others	Difference
_cons	0.008	0.017	0.009	0.009	0.012	0.019	0.015	0.011	0.006
	(14.21)	(10.37)	(3.93)	(14.70)	(14.75)	(9.45)	(5.96)	(14.90)	(3.69)
L.Cash	-0.101	-0.115	-0.090	-0.125	-0.109	-0.118	-0.117	-0.124	0.007
	(-20.62)	(-18.27)	(-11.99)	(-18.89)	(-22.26)	(-21.61)	(-8.90)	(-19.82)	(0.65)
dL.Cash	-0.044	0.014	-0.030	-0.057	-0.037	0.018	-0.017	-0.048	0.048
	(-5.32)	(1.14)	(-1.18)	(-5.99)	(-4.86)	(1.89)	(-0.78)	(-5.46)	(3.53)
dMB	0.003	0.003	0.002	0.003	0.003	0.004	-0.000	0.003	-0.001
	(2.84)	(2.19)	(1.01)	(2.46)	(3.23)	(3.53)	(-0.21)	(2.44)	(-0.89)
dSize	0.022	0.021	0.048	0.015	0.023	0.024	0.051	0.016	0.022
	(6.04)	(2.50)	(4.70)	(4.12)	(6.27)	(2.88)	(5.81)	(4.80)	(3.74)
dCF	0.051	0.078	0.060	0.030	0.053	0.079	0.090	0.031	0.054
	(6.42)	(5.73)	(3.26)	(3.01)	(8.09)	(5.24)	(4.98)	(3.59)	(3.52)
dCFR	0.036	0.017	-0.076	0.080	0.007	0.024	-0.062	0.055	-0.074
	(1.46)	(0.38)	(-1.51)	(2.37)	(0.22)	(0.47)	(-0.68)	(1.70)	(-1.42)
dNWC	-0.219	-0.257	-0.233	-0.198	-0.227	-0.269	-0.252	-0.212	-0.048
	(-26.81)	(-14.34)	(-12.83)	(-20.63)	(-30.91)	(-20.03)	(-12.41)	(-23.64)	(-3.32)
dCapex	-0.232	-0.355	-0.370	-0.178	-0.253	-0.404	-0.381	-0.200	-0.192
	(-15.32)	(-10.03)	(-9.01)	(-13.58)	(-15.86)	(-11.69)	(-8.73)	(-13.45)	(-6.82)
dLeverage	-0.118	-0.118	-0.123	-0.118	-0.109	-0.108	-0.126	-0.108	-0.009
	(-9.92)	(-5.61)	(-5.30)	(-10.93)	(-9.14)	(-5.33)	(-5.79)	(-9.45)	(-0.70)
dR&D	0.004	0.004	0.003	0.012	0.033	0.034	0.059	-0.001	0.048
	(2.16)	(1.68)	(2.05)	(1.63)	(2.54)	(1.58)	(1.49)	(-0.06)	(2.19)
dDivDummy	0.005	0.010	0.003	0.004	0.004	0.011	0.014	0.003	0.009
	(2.55)	(1.80)	(0.29)	(2.30)	(2.35)	(1.97)	(1.03)	(1.76)	(1.27)
dAcquisition	-0.209	-0.334	-0.342	-0.141	-0.226	-0.329	-0.373	-0.164	-0.187
	(-12.44)	(-12.91)	(-9.38)	(-10.90)	(-13.36)	(-15.84)	(-9.68)	(-10.97)	(-9.76)
dNetIssue	0.151	0.188	0.128	0.130	0.153	0.175	0.148	0.132	0.030
	(17.85)	(17.85)	(7.93)	(11.67)	(19.27)	(18.98)	(11.08)	(12.22)	(2.47)
Adjusted R^2	0.24	0.28	0.28	0.22	0.26	0.35	0.40	0.25	
No. of obs	67625	13758	6247	47620	67625	13758	6247	47620	

This table reports the estimates from the year fixed-effect and Fama and MacBeth (1973) (FM) regressions for the changes in cash holdings of technology (Tech), healthcare (Health), and other (Others) industries. The sample includes all common stocks on the NYSE, AMEX, and NASDAQ with positive cash-to-assets ratios, total assets, and sales. Financial firms (SIC codes 6000-6999), utilities (SIC codes 4900-4999), and non-classifiable firms (SIC codes 9900-9999) are excluded. The sample period is from 1980 to June 2015. t-statistics in parentheses are based on cluster-robust standard errors at the firm level.

Table 6
Effect of industry competition on cash holdings for three industry groups

	All	Tech	Health	Others	Difference
Panel A: The mean values of industry competition					
Compustat *HHI*	0.168	0.152	0.128	0.224	-0.084
	(32.49)	(20.09)	(19.51)	(64.03)	(-14.25)
Fitted *HHI*	0.056	0.054	0.053	0.062	-0.009
	(54.46)	(32.29)	(43.17)	(131.98)	(-6.68)
TNIC *HHI*	0.235	0.240	0.186	0.279	-0.066
	(78.15)	(45.06)	(50.21)	(70.24)	(-18.72)
Product fluidity	7.505	7.037	9.861	5.618	2.831
	(37.56)	(28.55)	(29.59)	(45.42)	(20.63)

Panel B: The cross-sectional regression									
	The year fixed-effect				The FM				
	All	Tech	Health	Others	All	Tech	Health	Others	Difference
Compustat *HHI*	-0.063	-0.161	-0.132	-0.008	-0.056	-0.136	-0.115	-0.005	-0.120
	(-4.82)	(-5.34)	(-2.59)	(-0.59)	(-10.49)	(-11.77)	(-3.35)	(-1.32)	(-5.51)
Adjusted R^2	0.45	0.46	0.56	0.34	0.46	0.47	0.62	0.36	
Fitted *HHI*	-0.461	-0.831	-1.210	-0.071	-0.359	-0.588	-1.504	-0.032	-1.014
	(-5.81)	(-4.31)	(-2.31)	(-0.93)	(-8.87)	(-4.95)	(-3.36)	(-0.90)	(-4.28)
Adjusted R^2	0.45	0.46	0.55	0.34	0.45	0.48	0.62	0.37	
TNIC *HHI*	-0.100	-0.132	-0.072	-0.038	-0.092	-0.117	-0.066	-0.032	-0.059
	(-8.39)	(-5.40)	(-1.99)	(-2.83)	(-16.38)	(-11.46)	(-2.65)	(-4.51)	(-3.51)
Adjusted R^2	0.49	0.43	0.59	0.36	0.50	0.49	0.66	0.38	
Product fluidity	0.010	0.010	0.009	0.004	0.010	0.009	0.006	0.004	0.003
	(6.96)	(4.13)	(2.90)	(2.60)	(13.27)	(6.76)	(3.59)	(6.74)	(2.57)
Adjusted R^2	0.49	0.43	0.60	0.36	0.50	0.48	0.67	0.38	

This table reports the means of the industry competition measures and the estimates from the year fixed-effect and Fama and MacBeth (1973) (FM) regressions for cash holdings of technology (Tech), healthcare (Health), and other (Others) industries. "All" represents all industries. "Others" represents an industry group comprising firms that are not in technology and healthcare industries. In Panel A, the measures of industry competition are Compustat HHI, Fitted HHI (Hoberg & Phillips, 2010a), TNIC HHI (Hoberg & Phillips, 2010a, b), and product market fluidity (Hoberg et al., 2014). "Difference" is the difference in means between the average of a measure of healthcare or technology industries and that of other industry group. In Panel B, the independent variables are industry competition plus the control variables that consist of all firm and industry characteristics in Table 4. "Difference" represents the coefficient on the difference in a variable between the average of healthcare or technology industries and other eight industries from FM regression. The sample includes all common stocks on the NYSE, AMEX, and NASDAQ with positive cash-to-assets ratios, total assets, and sales. Financial firms (SIC codes 6000-6999), utilities (SIC codes 4900-4999), and non-classifiable firms (SIC codes 9900-9999) are excluded. The sample period is from 1980 to June 2015. t-statistics in parentheses are based on cluster-robust standard errors at the firm level.

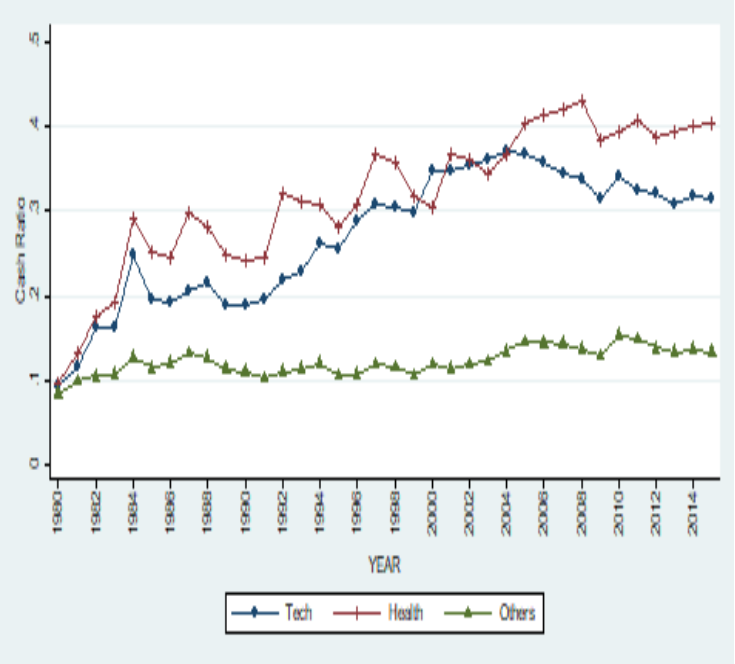
Table 7
Causal effect of the 2008 financial crisis on firm cash holdings: difference-in-differences analysis

Panel A: Balance tests				
	Treatment	Control	Diff.	t-statistics
MB	1.937	1.848	0.089	1.67
Size	6.588	6.511	0.076	0.74
CFR	0.063	0.065	-0.002	-0.34
Acquisition	0.027	0.028	-0.001	-0.47
NetIssue	-0.002	-0.006	0.004	1.04
Compustat *HHI*	0.172	0.179	-0.007	-0.87
Spill_Tech	14.405	14.399	0.006	0.14
Spill_Sale	13.396	13.427	-0.030	-0.45
ROA	0.113	0.114	-0.000	-0.04
Sales growth	1.105	1.092	0.013	1.06
Panel B: Difference-in-differences tests				
	Model (1)	Model (2)	Model (3)	Model (4)
Time	-0.002	0.002	0.007	0.008
	(-0.36)	(0.23)	(1.14)	(1.08)
Treat	0.040	0.060	0.040	0.060
	(3.31)	(3.32)	(3.30)	(3.26)
Time × *Treat*	0.025	0.021	0.025	0.022
	(3.01)	(1.98)	(3.12)	(2.10)
Adjusted R^2	0.41	0.45	0.41	0.45
Control	Yes	Yes	Yes	Yes
Industry FE	No	Yes	No	Yes
Year FE	No	No	Yes	Yes

This table reports the estimates of the difference-in-differences regressions on the effect of the 2008 financial crisis on firm cash holdings in the following model:

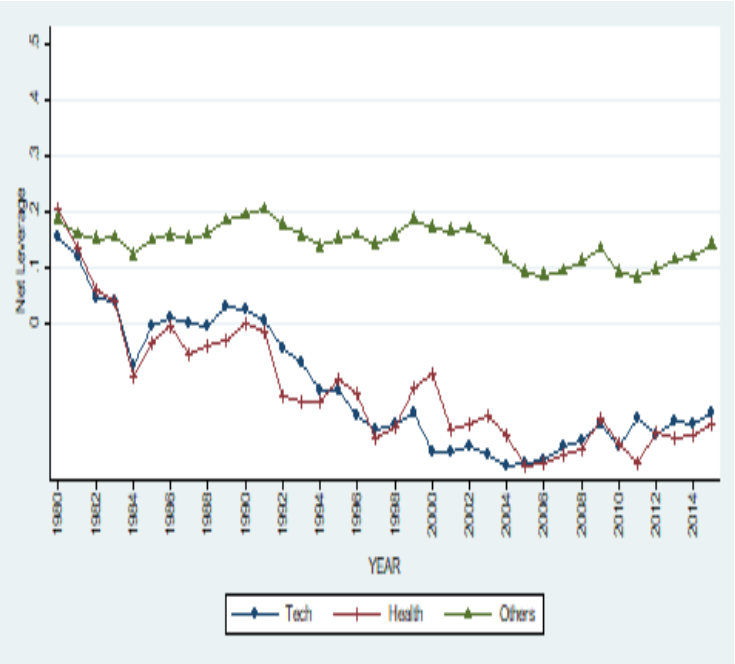
$$Cash_{i,t} = \alpha + \beta_0 Time_{i,t} + \beta_1 Treat_i + \beta_2 Time_{i,t} \times Treat_i + \beta_3 X_{i,t} + \varepsilon_{i,t} + \lambda_j + u_t,$$

The propensity scores are estimated from a logit model based on firm and industry characteristics of Panel A. The sample includes all common stocks on the NYSE, AMEX, and NASDAQ with positive cash-to-assets ratios, total assets, and sales. Financial firms (SIC codes 6000-6999), utilities (SIC codes 4900-4999), and non-classifiable firms (SIC codes 9900-9999) are excluded. The sample period is four years before the 2008 financial crisis to four years after the 2008 financial crisis. t-statistics in parentheses are based on cluster-robust standard errors at the firm level.



Average cash ratios of three industry groups from 1980 to 2015

Fig. 1. This figure plots the average cash-to-assets ratios for technology (Tech), healthcare (Health), and other (Others) industries. "Others" represents an industry group comprising firms that are not in technology and healthcare industries. The sample includes all common stocks on the NYSE, AMEX, and NASDAQ from 1980 to June 2015.



Average net leverage ratios of three industry groups from 1980 to 2015

Fig. 2. This figure plots the average net leverage ratios for technology (Tech), healthcare (Health), and other (Others) industries. "Others" represents an industry group comprising firms that are not in technology and healthcare industries. The sample includes all common stocks on the NYSE, AMEX, and NASDAQ from 1980 to June 2015.

APPENDIX A: Firm characteristics

Acquisition: acquisition-to-assets ratio calculated as the ratio of acquisition (data item AQC) to the book value of total assets.

Cash: cash-to-assets ratio calculated as the ratio of cash and marketable securities (data item CHE) to the book value of total assets (data item AT).

Capex: capital expenditures-to-assets ratio calculated as the ratio of capital expenditures (data item $CAPX$) to the book value of total assets.

CF: cash flow-to-assets ratio calculated as the ratio of operating income before depreciation (data item $OIBDP$) less the sum of interest expenses (data item $XINT$), income taxes (data item TXT), dividends of preferred shares (data item DVP), and dividends of common shares (data item DVC) to the book value of total assets.

CFR: cash flow risk calculated as the standard deviation of a ratio of operating income before depreciation less the sum of interest expenses, income taxes, dividends of preferred shares, and dividends of common shares to the book value of total assets over the previous 10 years.

DivDummy: dividend payout dummy, a dummy variable equals one in years in which a firm pays a common dividend (data item DVC). Otherwise, the dummy equals zero.

Leverage: leverage, the ratio of the sum of long-term debt (data item $DLTT$) and debt in current liabilities (data item DLC) to the book value of total assets.

MB: market-to-book ratio calculated as the ratio of the book value of total assets minus the book value of equity (data item CEQ) plus the market value of equity to the book value of total assets.

NetIssue: net equity issuance calculated as the ratio of net issuance to the book value of total assets. Net issuance is the sale of common and preferred stock

(data item $SSTK$) minus the purchase of common and preferred stocks (data item $PRSTKC$)

nLeverage: net leverage calculated as the ratio of the sum of long-term debt (data item $DLTT$) and debt in current liabilities (data item DLC) minus cash and marketable securities to the book value of total assets.

NWC: net working capital-to-assets ratio calculated as the ratio of net working capital to the book value of total assets. Net working capital is calculated as the working capital (data item $WCAP$) net of cash and marketable securities.

Payout: dividend payout ratio calculated as the total distributions including dividends paid to preferred stocks (data item DVP), common stocks (data item DVC), and share repurchases (data item $PRSTKC$) divided by the operating income before depreciation (data item $OIBDP$).

$R\&D$: research & development-to-sales ratio calculated as the ratio of research & development expense (data item XRD) to sales (data item $SALE$).

Size: firm size calculated as the logarithm of the book value of total assets.

APPENDIX B: Industry characteristics

ROA: return on assets, the ratio of operating income before depreciation to the book value of total assets.

Sales growth: the growth rate of total sales.

Spill_Tech: technology spillovers, is the weighted sum of all rivals' *R&D* stock (G), $Spill\_Tech_{it} = \sum_{j \neq i} \omega_{ij} G_{jt}$. $\omega_{ij} = \frac{T_i T_j'}{\sqrt{T_i T_i' \times T_j T_j'}}$ is the uncentered correlation between all firm ij pairings. $T_i = (T_{i,1}, T_{i,2}, ..., T_{i,426})$ is firm i's share of patents across 426 United States Patent and Trademark Office (USPTO) technology classes.

Spill_Sale: product market rivalry, is the weighted sum of all rivals' *R&D* stock (G), $Spill\_Sale_{it} = \sum_{j \neq i} \tau_{ij} G_{jt}$. $\tau_{ij} = \frac{S_i S_j'}{\sqrt{S_i S_i' \times S_j S_j'}}$. $S_i = (S_{i,1}, S_{i,2}, ...)$ is a row vector, in which the kth element, $S_{i,k}$, is firm i's share of sales in the four-digit SIC industry k.