The consequences of data breach disclosure laws and disclosed breaches on corporate cash holdings and performance

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Abstract

This paper investigates the effects of the staggered state-level data breach disclosure laws, and the subsequent disclosure of data breaches on the cash policies of corporations in the United States. We document a significant and positive relation between the state-level data breach disclosure laws and corporate cash policies, suggesting data security transparency laws influence firm behaviour. Further, we find firms that suffer data breaches: i) experience a decline in market value ii) report lower sales and ROA and iii) adjust financial policies by holding more cash. Finally, the effects of data breaches spill over within industries – firms in industries with high breach intensity increase their cash balances.

1 Introduction

In the wake of the rise in the frequency and severity of data breaches, corporate boards face mounting pressure to cope with cybersecurity risks. For example, in a recent publication in The Wall Street Journal, Fuhrmans (2017) asserts that "Cyber threats have zoomed to the top of chief executives' worry lists for fear a data breach could cost them their jobs and take down their businesses." Similarly, the Cambridge Analytica data privacy scandal, in 10 days after the news became public, wiped 18% off the market value of Facebook Inc. The Chief Executive Officer (CEO) of Facebook Inc., Mark Zuckerberg, pointed out in his first public response that "We have a responsibility to protect your data, and if we can't then we don't deserve to serve you."[1] Moreover, the fallout from other data breaches such as the attacks on Equifax Inc., Home Depot, Yahoo Inc., and Target Corporation provide compelling evidence that the risks to data security matter at the highest level of corporations.

Until 2002, US firms were not obligated to disclose data breaches. During the period of 2002-2017, state-level disclosure laws mandating firms disclose and notify authorities of data breach incidents that affect state residents were passed in almost all the US states.[2] In 2002, California became the first state to pass a data breach disclosure law.[3] Since the passage of the California law, all the other 49 states have passed similar laws as of April 2018.

These laws obligate firms to disclose breaches and thereby transform private information into public information. In effect, state-level data breach disclosure laws impose "disclosure costs" and inadvertently compel firms to account for the costs (including negative externalities such as identity theft and payment fraud) of their data insecurity (Laube and Bohme (2016)). In essence, exposure to, and disclosure of a data security breach has both direct and indirect cost implications for firms. Data breaches potentially subject firms to regulatory investigations and fines, litigation, media scrutiny and reputation damage, customer loss, revenue decline, increased cash flow risks (Kamiya, Kang, Kim, Milidonis, and Stulz (2018)), and possibly threaten a firm's bottomline as well as shareholder value, among others. For example, after suffering a data breach, Anthem Inc., reports in its 2015 10-K filing:

[1] See https://www.bloomberg.com/news/articles/2018-03-21/facebook-s-zuckerberg-outlines-steps-to-protect-data-after-leak.

[2] As of December 2017, only the states of Alabama and South Dakota were yet to pass a data breach disclosure law. However, the National Conference of State legislatures reports on its website that in the first quarter of 2018, both Alabama and South Dakota enacted disclosure laws.

[3] California Civil Code Section 1798.29 was passed in 2002 but went into effect on 1 July 2003.

> "We have incurred expenses to investigate and remediate this matter and expect to continue to incur expenses of this nature in the foreseeable future. Actions have been filed in various federal and state courts ... Further, we may be subject to additional litigation and government investigation which could divert the attention of management from the operation of our business, result in reputational damage, and have material adverse impact on our business, cash flows, financial condition and results of operations."[4]

Similarly, following the 2017 data breach at Equifax Inc., the company reports in its 2018 10-K filing that:

> "...disclosure or other loss of information could subject us to significant additional litigation, regulatory fines, penalties, losses of customers or reputational damage, any of which could have a significant negative impact on our cash flows, competitive position, financial condition or results of operations."[5]

These examples clearly demonstrate that a data breach could have significant cost implications for firms. However, despite the relevance of the state-level disclosure laws in establishing transparency on corporate data security reporting, and cyber risk being one of the most important sources of operational risk of firms (Kamiya, Kang, Kim, Milidonis, and Stulz (2018)), little is known about the effects on financial policies, if any, of mandatory data breach disclosure laws and actual data breaches. For instance, do corporations change their financial policies because of the passage of mandatory data breach disclosure laws? Do firms change their financial policies after exposure to actual data breaches? Do firms change their financial policies after within industry data breaches?

In practice, it is difficult (if not impossible) to hedge or insure the majority of the costs (especially the indirect costs such as reputation damage, litigation costs or customer loss) associated with a data breach incident.[6] In particular, a firm that discloses a data breach may have difficulty securing funds to settle the various costs resulting from the disclosed breach incident.

[4]The 2015 10-K filing can be retrieved from https://www.sec.gov/edgar/searchedgar/legacy/companysearch.html

[5]See the EDGAR website for the 2018 10-K filing

[6]The insurance firm, AON, explain that the cyber insurance market is not fully developed, and that for the direct costs of a data breach, no cyber insurance contract provides complete or full coverage. For examples of the different types of direct cost coverage, see https://www.aon.co.nz/Specialty-(1)/Cyber-Risk for some of the policy types

If access to capital markets is costly, Bates, Kahle, and Stulz (2009) posit that firms, in order to better cope with adverse events or shocks hold cash. Due to the limits of insurance and financial hedging, we advance that firms may ex-ante adjust cash policies to help hedge against the need to disclose data breaches following the enactment of disclosure laws, as well as against exposure to actual data breaches.

The literature devotes considerable attention to the high cash balances held by US corporations, and of the many explanations, some empirical evidence lends support to precautionary motives (See Bates, Kahle, and Stulz (2009), and Pinkowitz, Stulz, and Williamson (2015)). Cash represents a crucial liquid asset when access to external capital is costly, and profitable investment opportunities exist (Francis, Hasan, and Wang (2014)). Thus, the flexibility provided by holding cash gives it economic value. However, most of the explanations for holding high cash balances focus on firm-specific factors (Francis, Hasan, and Wang (2014)). It is therefore not clear whether firms respond to changing disclosure laws and exposure to actual data breaches, and adjust their financial policies accordingly. For this reason, we investigate firm financial policy changes by drawing a link between the cash levels, and the changes in state-level data breach disclosure laws and exposure to actual data breaches.

We first construct tests by exploiting the exogenous changes in the state-level data breach disclosure laws to examine changes in corporate cash holdings.[7] The staggered timing of the passage of the state-level disclosure laws plausibly provides a natural experiment framework to explore empirically how these regulatory changes affect corporate cash policies. This allows us to alleviate potential endogeneity concerns. Similar to previous studies (Francis, Hasan, and Wang (2014), Amore, Schneider, and Zaldokas (2013), and Cornaggia, Mao, Tian, and Wolfe (2015)), we use the difference-in-differences approach to examine how firms change their cash policies in response to changes in state-level data breach disclosure laws. We find evidence that firms respond with cash policy changes to changing disclosure laws. Ceteris paribus, in response to the enactment of data breach disclosure laws, firms increase *Cash* by 1.6%, which represents a 7.7% increase from the mean and a 14.7% increase from the median cash holdings.

While the staggered timing of the passage of the disclosure laws provide exogenous changes to data security reporting and transparency, it is possible that an omitted variable bias coinciding with the state-level data breach disclosure laws could be the primary cause of changes in cash

[7] We look at the various state disclosure laws passed from 2002 to 2016

holdings. If this is the case, then the changes in corporate cash holdings we attribute to the state-level disclosure laws reflect mere association rather than a causal effect. In our case of multiple shocks, it is unlikely that an omitted variable unrelated to the data breach disclosure laws would fluctuate every time a state-level disclosure law is passed. Therefore, our strategy of using multiple shocks helps isolate the impact of disclosure laws on cash holdings from other confounding factors, hence, mitigating the omitted variable concern. More so, the timing and passage of the state-level disclosure laws are out of the control of any individual firm. That is, firms have no influence or control over the years that disclosure laws are passed.

Nevertheless, we address this possibility by conducting placebo or falsification tests following an approach similar to Cornaggia, Mao, Tian, and Wolfe (2015). We randomly assign the states into the distribution of years when the various disclosure laws were passed.[8] This helps maintain the actual distribution of years in which the various states passed the disclosure laws; however, it disrupts the correct assignment of the states to the years in which the laws were passed. Therefore, an unobservable shock that occurs at approximately the same time as the passage of the state-level data breach disclosure laws would still reside in the baseline testing framework and hence, drive the cash results. In contrast, if no such unobservable shocks exist, then our expectation is that the incorrect assignments of the states to the disclosure law years should weaken our results for the re-estimated baseline specification. Thus, the falsely assumed disclosure law events should have no effect on cash holdings. Indeed, our randomized disclosure law estimation results show no effect on corporate cash holdings. The non-results in this test discounts omitted variable bias.

Also, we address potential simultaneity concern by following the dynamic effect specifications similar to Chava, Oettl, Subramanian, and Subramanian (2013), and Amore, Schneider, and Zaldokas (2013). If reverse causality is truly present, we expect to see increases in corporate cash holdings even prior to the passage of the state-level data breach disclosure laws. We examine the dynamics of cash holdings surrounding the state-level disclosure laws, and we find no prior positive change or trend in corporate cash holdings. That is, there were no effects prior to the passage of the various state-level data breach disclosure laws. Hence, the differential trend in cash holdings started only after the state-level data breach disclosure laws were passed and

[8] We randomly assign the states without replacement

became effective. This shows that reverse causality or prior trend in corporate cash holdings does not account for our findings.

Another intriguing issue that arises is that, it is plausible a corporation with strong cash flows can fully internalize the disclosure costs of a potential data breach and thus not change its cash policy in response to the enactment of disclosure laws. Therefore, testing the effects of the state-level data breach disclosure laws on cash policies requires the examination of the role of financial constraints. We find that the impact on cash holdings of the passage of the disclosure laws is more pronounced for the financially constrained subsample. Hence, the high cash holdings following the passage of the data breach disclosure laws is largely driven by constrained firms.[9]

After providing robust evidence that there is an aggregate increase in corporate cash holdings following the passage of the various state-level data breach disclosure laws, we probe the impact of actual data breaches on market value and corporate performance. Our findings, consistent with the findings of Kamiya, Kang, Kim, Milidonis, and Stulz (2018), reveals that the disclosure of data breaches is associated with a significant decline in market value. At the disclosure of a data breach, shareholder value declines by 1.2% during the three-day window surrounding the disclosure. Given the mean market value of about $30.56 billion for our sample of breached firms, this translates into an average loss of $367 million. This is consistent with Kamiya, Kang, Kim, Milidonis, and Stulz (2018) who find that the disclosure of a data breach is associated with a mean value loss of $439 million during the three-day window around the breach announcement. Similarly, Gatzlaff and McCullough (2010) find that data breaches negatively affect shareholder wealth.[10] Upon analysing the unconditional changes in the financial results of breached firms in a univariate setting, we find early evidence that data breaches are associated with a significant decline in sales and operating performance. This is consistent with Kamiya, Kang, Kim, Milidonis, and Stulz (2018), who find that firms experience a significant decline in sales growth for the three years following a data breach announcement. This confirms the effects cited by most of the firms that report data breaches in their 10-K filings. For in-

[9]We sort firms into constrained and unconstrained groups based on firm size, firm age and dividend payout ratio. We rank the firms and categorize firms in the top (bottom) 4 deciles of the distribution of the size and age measures as the unconstrained (financially constrained) group. For dividend payout ratio, we rank firms into dividend payers and non-payers, and classify dividend paying firms as the unconstrained group.

[10]The impact of data breaches on firm value is similar to the findings of Cline, Walkling, and Yore (2017), who find that the announcement of managerial indiscretions such as sexual misadventure result in an immediate 1.6% loss in shareholder value.

stance, following the breach disclosure by Equifax on 7 September 2017, its 2017 third quarter revenue, operating income, and net income declined by 2.6%, 42.1% and 41.8% respectively relative to that of the second quarter of the same year. Similarly, Target Corporation reported a weaker than estimated sales following the 2014 data security breach disclosure with net earnings declining by 46%. Given this early evidence, we turn to a multivariate approach to examine the impact of data breaches on firm operating performance. We find that data breach risk exposure leads to a decline in firm operating performance.

Next, we test the impact of exposure to, and disclosure of data breaches on corporate cash holdings. We find that firms increase their holdings of cash in response to a data breach incident, and that the positive effect of data breaches on cash holdings is stronger for firms that disclose multiple and or severe breaches over the sample period. Finally, we investigate whether the effects of data breaches spill over within industries. We do this by using actual data breaches to compute an *Industry Breach Intensity* variable which we measure as the ratio of the total breaches recorded in each of the Fama-French 10 industry classification to the total number of firms in each industry.[11] The *Industry Breach Intensity* variable is used as a measure of data breach risk exposure. It captures exogenous changes in the data breach risk exposure level of industry non-breached peers. Our results reveal that the effects of data breaches spillover within industries. We find that, on average, non-breached firms increase their cash holdings by 18.28% when industry peers disclose data breaches.

Our paper makes several key contributions to the corporate finance literature. First, we provide novel evidence on data breach reporting in the corporate finance literature by establishing a robust link between disclosure laws and data breaches, and cash policies of US corporations. Our paper, to the best of our knowledge, is the first to test the relation between state-level data breach disclosure laws and public firms' financial policy changes, and the impact of actual data breaches on corporate performance and corporate cash policy. Second, we add new evidence on how data security transparency influences firm financial policy behaviour. Third, we provide evidence on the shareholder wealth and accounting impact of data breaches. Fourth, we add novel evidence on the industry spillover effects of data breaches. Fifth, our paper contributes to the extensive literature on corporate cash holdings by identifying data breach disclosure reg-

[11] We use the Fama-French 10 industry classification because of the small data breach sample size. Our sample consist of 142 data breaches over the 2011-2016 period

ulatory changes and exposure to actual data breaches as important determinants of corporate cash holdings.

The remainder of the paper is structured as follows. Section 2 provides background information on the state-level disclosure laws, reviews the literature, and motivates and develops the various testable hypotheses. Section 3 describes the data and methodology. Section 4 and Section 5 discuss the empirical results. Section 6 concludes the paper.

2 Related Literature and Hypotheses Development

2.1 State-level data breach disclosure laws in the US

Prior to 2002, US firms were not obligated to disclose data breaches to authorities and affected state residents. Motivated by the data breach incident at the Stephen P. Teale Data Center; which affected the personally identifiable information of all 265,000 state employees (Skinner (2003)), California became the first state to enact a data breach disclosure law in the US in 2002.[12] The California data breach notification law was the first of its kind and has since been the model for many other state-level disclosure laws (Tom (2010)).[13]

As of 29 March 2018, all 50 US states, the District of Columbia, and the US territories of Virgin Islands, Puerto Rico, and Guam had enacted disclosure laws requiring business and non-business entities to disclose and notify affected state residents of data security breaches.[14] While details vary across states, the primary objective of all the state-level data security breach disclosure laws is to obligate firms to notify the appropriate authorities and affected state residents of data breaches involving personally identifiable information (Romanosky, Telang, and Acquisti (2011)). Therefore, the state-level disclosure laws force firms to account for the expected costs of breach disclosure (Romanosky, Telang, and Acquisti (2011)).

2.2 Case studies – effects of disclosed data breaches

In this section, we discuss three cases of disclosed data breach incidents. See Appendix A.1 for additional breach event cases.

[12] California Civil Code Section 1798.29 was passed in 2002 but went into effect on 1 July 2003.

[13] See the various state-level disclosure law years timeline in Table 2.

[14] See the various state disclosure laws from the National Conference of State Legislatures on http://www.ncsl.org/research/telecommunications-and-information-technology/security-breach-notification-laws.aspx

2.2.1 Stephen P. Teale Data Center

The 5 April 2002 data breach incident that occurred at the Stephen P. Teale Data Center led to the passage of the first state-level data breach disclosure law in California (Skinner (2003)).[15] The data breach incident affected confidential personally identifiable information (such as social security numbers and names) of all the 265,000 state employees who had their data stored at the Center. The affected employees were not notified of the breach incident until 21 May 2002. The delay in disclosure and the overall handling of the breach incident provoked criticisms (Skinner (2003)). In response to the concerns and issues arising out of the data breach incident at the Data Center, the state of California passed the first data breach disclosure law in 2002 which became effective on 1 July 2003 (Sullivan and Maniff (2016)).[16]

2.2.2 Equifax, Inc.

Equifax, one of the largest US consumer credit reporting agencies disclosed a data breach which affected 145.5 million American consumers on 7 September 2017. Following the disclosure on 7 September, the company's share price declined from $142.72 to $123.23 on 8 September, and as at the close of trading on 15 September the stock price had declined to $92.98, a loss of almost 34.5% in shareholder value. In its third quarter results released in November 2017, the company recorded initial data breach costs of $87.5 million and indicated it expects to incur significant data breach costs in future periods. The company's third quarter revenue, operating income, and net earnings declined by 2.6%, 42.1%, and 41.8% respectively relative to the previous quarter. As of 30 September 2017, more than 240 class action lawsuits relating to the data breach had been filed against the company. Equifax launched a credit freeze option for the affected customers at no cost, and key management personnel including the Board Chairman and Chief Executive Officer (CEO), Chief Information Officer (CIO), and Chief Security Officer (CSO) resigned from their respective positions.[17] Standard and Poor's (S&P) citing the substantial uncertainty of the impact of the breach incident, revised its outlook on Equifax's long-term

[15] The Stephen P. Teale Data Center is a state-operated data storage facility based in California.

[16] Civil Code Section 1798.29

[17] For detailed information on the key personnel changes at Equifax, see, https://www.equifaxsecurity2017.com/2017/09/15/equifax-releases-details-cybersecurity-incident-announces-personnel-changes/

issuer rating from a stable to a negative.[18] This is not surprising given that, in a recent study, Kamiya, Kang, Kim, Milidonis, and Stulz (2018) find that after a data breach, affected firms experience a decline in credit ratings.

2.2.3 Target Corporation

Target Corporation, one of the largest US general retailers, in 2014 disclosed in its 10-K filing that it had been a victim of two separate counts of data breaches. The breach incidents affected payment card details and personally identifiable information of about 110 million customers. Target recorded $61 million of data breach related expenses in 2014 and reported a weaker than estimated sales following the security breach disclosure with net earnings declining by 46% relative to the previous year. As of 28 January 2017, the company had incurred a gross expense of $292 million related to the data breach incidents. Over 80 civil lawsuits were filed against Target by different stakeholders, and the company has been a subject of investigations by the SEC, the Federal Trade Commission (FTC), and several other federal agencies. The data breach incident led to the resignation of the then CIO, Beth Jacob, and CEO, Gregg Steinhafel, and according to Ziabro and Lublin (2014), the Institutional Shareholder Services (ISS) recommended the expulsion of the firm's entire board of directors.

2.3 Corporate Cash Holdings

Despite the large payouts through dividends and repurchases made by US corporations, and the opportunity costs associated with holding cash, the cash levels on the balance sheets of US corporations have increased and continue to grow (Hoberg, Phillips, and Prabhala (2014), and Han and Qiu (2007)).[19] Pinkowitz, Stulz, and Williamson (2015) document US companies to be holding abnormally high levels of non-operational cash even after the recent global financial crisis.[20]

Many studies have sought to examine the reasons for the high cash holdings of US firms. Of the many findings, some empirical evidence lend support to precautionary motives. For

[18] See https://www.spratings.com (Research update: Equifax Inc. BBB+ rating outlook revised to negative following announcement of cybersecurity incident)

[19] Hoberg, Philips, and Prabhala (2014) provide that in 2008, US corporations paid cash dividends in excess of $450 billion, double the amount paid in 1997, and also doubled their cash balance to $1.3 trillion in 2008 relative to 1997

[20] Abnormally high levels of cash in this instance means cash levels above the amount needed to operate business

instance, Lins, Servaes, and Tufano (2010) survey chief financial officers (CFOs) across 29 different countries to investigate why firms choose to hold non-operational cash. Their findings, consistent with the precautionary motive for cash, and the findings of Campello, Giambona, Graham, and Harvey (2011) indicate that cash represents an unconditional liquidity that serves as a buffer against cash flow uncertainty and shocks. Thus, in the event of adverse cash flow shocks, firms will be incentivised to hold more cash as a buffer or hedge.

Also, in a situation where it is impossible to hedge or where firms face high hedging transaction costs for a particular type of risk, an alternative way to minimize risk exposure is to accumulate cash (Han and Qiu (2007), Riddick and Whited (2009), Brav, Graham, Harvey, and Michaely (2005), and Froot and Stein (1998)). Consistent with this argument, Arena and Julio (2015) find that firms involved in litigation significantly increase their holdings of cash.

Given that the state-level data breach disclosure laws obligate firms to disclose breaches, thereby transforming private information into public information, and invariably compel breached firms to internalize the expected costs (both direct and indirect costs) of breach disclosure, our expectation is that the passing of the disclosure laws, and exposure to actual data breaches should increase firm precaution. In a recent study, Kamiya, Kang, Kim, Milidonis, and Stulz (2018) find that after a data breach, affected firms experience an increase in cash flow risk, a decrease in sales growth, and a decrease in credit ratings. If a data breach affects executives' perception of a corporation's risk exposure and risk management ability, then, changes in financial policies post data breaches is highly expected (Kamiya, Kang, Kim, Milidonis, and Stulz (2018)). We therefore take a position consistent with the precautionary cash holding literature and formulate our hypotheses as follows.

Hypothesis 1. *Firms increase their cash balances in response to data breach disclosure laws, ceteris paribus.*

Hypothesis 2. *Firms hold more cash in response to a data breach incident and the positive effect of a data breach on cash holdings is stronger for firms that disclose multiple, and or severe breaches, ceteris paribus.*

3 Data and Methodology

3.1 Data Collection

Our initial sample consists of the entire universe of firms in the merged CRSP/Compustat database during the period 1990-2016. This period covers almost all the years in which the states passed the data breach disclosure laws.[21] Following prior literature (see Bates, Kahle, and Stulz (2009), and Opler, Pinkowitz, Stulz, and Williamson (1999)), we exclude all financial firms (SIC codes 6000-6999) because their cash holdings include inventories of marketable securities and they are also required to meet statutory capital requirements. Also, financial firms are subjected to the Gramm-Leach-Bliley Act (GLBA) which requires financial firms to update their primary federal regulator on data privacy breaches. We exclude utility companies (SIC codes 4900-4999) because of the possible subjection of their cash holdings to regulatory supervision in some states. Furthermore, we exclude medical and health service firms (SIC codes 8000-8734) because they are required by the Health Insurance Portability and Accountability Act (HIPAA) to disclose health information breaches to the affected individuals, and the Department of Health and Human Services. We further drop observations with negative or missing total book assets.

We construct our state-level disclosure law sample on the basis of the states in which firms are headquartered.[22] We provide reasons for focusing on the states in which firms are headquartered in the next section. We drop all firms incorporated in Alabama, South Dakota and New Mexico because they are the only three states that had no breach disclosure regulations during the 1990-2016 sample period. However, our results do not change when we include them in the analyses. The final state-level sample consists of 64,702 observations.

Next, we construct our data breach subsample over the period 2011-2016 in order to analyse the effect of actual data breaches on cash holdings. We obtain data on breached firms from a chronological listing of data breach disclosures available at the Privacy Rights Clearinghouse (PRC).[23] PRC is a consumer advocacy not-for-profit organisation that since 2005 has been publishing all disclosed data breaches in the US. The PRC data provides relevant disclosed

[21] With the exception of Alabama, South Dakota, and new Mexico

[22] For example, firms headquartered in say California are classified as California firms.

[23] (https://www.privacyrights.org/) PRC provides a comprehensive list of all disclosed data breaches since 2005 and it is the most cited source of information relating to data breaches in leading law and economics, and cybersecurity journals. For example, see Kamiya, Kang, Kim, Milidonis, and Stulz (2018) and Romanosky, Hoffman, and Acquisti (2014)

data breach information. We therefore collect information about the name of the breached firm, breach disclosure date, a description of the breach incident, and if available, the total number of records breached. We identify 142 breached firms (representing 0.85% of the data breach subsample) as having disclosed a data breach over the 2011-2016 sample period.[24] Our final data breach subsample following the merger of the PRC breach data with the CRSP/Compustat data consists of 16,797 firm-year observations.

We limit the actual data breach subsample to the period 2011-2016 because it was only from 2011 that firms began documenting data breaches in their 10-K filings following the issuance of the US Securities and Exchange Commission (SEC) cybersecurity risks and incidents disclosure guidance for public companies.[25] This permits us to document data breach severity since firms, as part of the SEC guidance, are recommended to document whether the breach is material to operations or not. Therefore, we manually review items 1A and 7 of the 10-K filings of the breached firms. Firms that document the breach as material or severe, or indicate that the breach is likely to have a significant impact on future operations and cash flows are classified into the severe data breach group. It must be noted that the SEC disclosure guidance is not a regulation; therefore, it is likely firms may not report a breach as severe or material even if it is in fact severe. However, this biases against finding strong results.

3.2 Estimation Technique

The staggered timing of the passage of the state-level disclosure laws enables us to use states that had not passed disclosure laws at a point in time to control for potential confounding effects. Therefore, we use the difference-in-differences approach to empirically explore the difference in cash holdings in a state before and after the enactment of the breach disclosure laws compared to the difference for firms located in a state that had not passed disclosure laws during the same period. Our model set-up mirrors Francis, Hasan, and Wang (2014) who test for the effects of banking deregulation on corporate cash holdings. We estimate

[24]This is after the data had been filtered of financial firms, health or medical firms, non-business entities such as educational institutions and non-governmental organisations (NGOs)

[25]The guidance recommends public companies to document and address in Items IA and 7 of their 10-K filings, both known and threatened cybersecurity risks and incidents that can materially affect their results, cash flows, liquidity, present as well as future financial condition. It must be noted that the state-level disclosure laws require disclosure to authorities and affected residents but not documentation in 10-K filings.

$$Cash_{i,k,t} = \alpha + \beta Disclosure\ Law(0/1)_{i,k,t} + \gamma X_{i,k,t-1} + \theta_k + \delta_t + \rho_j + \varepsilon_{i,k,t}, \quad (1)$$

where i indexes firms, k indexes headquarter state of the firm, and t indexes time. The dependent variable, *Cash*, is cash and marketable securities scaled by beginning year total book assets. $Disclosure\ Law(0/1)_{i,k,t}$ is a dummy variable that switches to one the year after the focal state passed the disclosure law. $Disclosure\ Law(0/1)_{i,k,t}$ captures the effect of state-level disclosure laws on cash holdings across states by comparing outcomes before and after the passing of each disclosure law in relation to disclosure laws passed later. $X_{i,k,t-1}$ is a vector of controls, all lagged by one year to reduce simultaneity concerns. θ_k represents a set of state dummies which results in the identification of β solely from within state variation across time. δ_t represents time dummies to control for secular shocks in cash holdings coinciding with the passage of the disclosure laws. ρ_j is a set of industry dummies to control for industry linear trends. The industry dummies are constructed based on the Fama and French (1997) 10 industry classification.[26] $\varepsilon_{i,k,t}$ is a random error term. We cluster standard errors by state because our disclosure law treatment is defined at the state level.

Our decision to focus on the states in which firms are headquartered for the state-level sample is based on the assumptions that firms will strictly comply with the disclosure laws of the states in which they are headquartered, firms make majority of their financial decisions at their headquarters (Francis, Hasan, and Wang (2014)), and that disclosure laws passed in states where firms are headquartered can significantly alter their internal operational practices. In essence, this decision to focus on the states in which firms are headquartered downward biases β in Eq.(1). For instance, following the passage of the California law in 2002, a firm in another state (without operations in California) might increase its cash level in response to the California law, which would minimize the difference between firms in California and other states.

3.3 Variable Definition

We use the most traditional measure of cash in the literature (See Bates, Kahle, and Stulz (2009), and Opler, Pinkowitz, Stulz, and Williamson (1999)) as our dependent variable. We

[26]The results do not change if we use the Fama and French (1997) 49 industry classification.

measure *Cash* as cash and marketable securities scaled by total book assets. In a robustness check, we follow Qiu and Wan (2015), and re-estimate the baseline cash regression with *Net Cash* as the dependent variable. *Net Cash* is total cash less debt and scaled by beginning year total book assets.

In addition to the dummies capturing disclosure laws, we construct variables to capture the impact of actual data breaches, severe breaches, and multiple breaches on cash holdings. *Breach(0/1)* is a dummy variable that equals one for breached firms in the year of the data breach. Otherwise, the dummy is set to zero. Over the 2011-2016 period, we identify 142 breaches, which represents 0.85% of the firm-year observations. To examine the effect of data breach severity on cash holdings, we construct a *Severe (0/1)* variable by manually reviewing 10-K filings of the breach sample to document those that disclose the breach as material to their operations and future cash flow. *Severe (0/1)* is a dummy variable that equals one in the year of the data breach incident which the firm recognized or disclosed as material or severe. Otherwise, the dummy is set to zero. We identify 20 severe breaches, which represents 0.12% of the firm-year observations.[27] Also, we investigate the effect of multiple breaches by constructing a *Multiple(0/1)* variable. *Multiple(0/1)* is a dummy variable set to one for any firm-year with cumulative breach frequency exceeding one. For example, if the cumulative breach frequency for company A in 2013 is two, we set the *Multiple(0/1)* dummy to one. Otherwise, the dummy is set to zero. Over the sample period, we identify 27 multiple breaches, which represents 0.16% of the firm-year observations. We treat multiple breaches in a particular year as a single breach. Table 3 presents the distribution of the data breach sample by year. The breaches are relatively evenly distributed over the sample period, reducing concerns that the data breaches are clustered in time.

We follow the existing literature (See Bates, Kahle, and Stulz (2009), and Opler, Pinkowitz, Stulz, and Williamson (1999)) and control for several variables that affect firm cash policy in our empirical testing. In all our *Cash* regressions, we control for *Firm Size*, *Firm Age*, *Book Leverage*, *Market-to-book*, *Cash Flow*, *Capital Expenditure*, *Acquisition Expenditure*, *Dividend Paying Firms (0/1)*, *R&D Expenditure*, *Net Working Capital*, and *Industry Cash Flow Volatility*. We control for *Firm Size* because large firms may have a lower cash-to-assets ratio compared

[27]Because the SEC guidance is not a disclosure regulation but a recommendation, firms are not obligated to report a data breach as severe, hence the small number of observations.

to small firms. We measure *Firm Size* as the natural logarithm of total book assets. Younger firms may have distinct cash policies from older firms. Therefore, we include *Firm Age* which we measure as the natural logarithm of the number of years a firm has been listed in the merged CRSP/Compustat database. We include *Book Leverage* because in a situation where debt is high, firms will opt to hold more cash to reduce leverage, and to be able to meet future debt repayments. *Book Leverage* is total book debt (sum of short and long-term debt) normalised by total book assets. Since firms with profitable investment opportunities may opt to hold more cash in order to capture future investment opportunities, we include *Market-to-book* to control for the impact of future investment opportunities. *Market-to-book* is the ratio of total book assets less the book value of common equity plus the total market value of equity all divided by the total book assets. Also, we include *Cash Flow* because firms with higher cash flow will accumulate or hold more cash, ceteris paribus. *Cash Flow* is earnings after interest, dividends and taxes, but before depreciation normalised by net book assets.

Capital Expenditure has the potential to consume cash and also increase a firm's debt capacity. *Capital Expenditure* is capital expenditure normalised by beginning year total book assets. Also, acquisition expenditure has an effect similar to that of capital expenditure. *Acquisition Expenditure* is acquisitions normalised by beginning year total book assets. Furthermore, in order to distinguish the effects of dividend payouts of firms, we construct the variable, *Dividend Paying Firms (0/1)*, that equals one in the year a firm pays a dividend. Otherwise, we set the dummy to zero. Dividend paying firms are less likely to be constrained. Moreover, dividend paying firms may choose to lower dividend payments or halt the payment of dividend to hold more cash if they anticipate an increase in future cash flow uncertainty. *R&D Expenditure* is a proxy for growth opportunities, and also consumes cash. *R&D Expenditure* is measured as research and development expense normalised by beginning year book assets. Also, *Net Working Capital* comprises assets that may substitute for cash. *Net Working Capital* is measured as net working capital normalised by net assets. Finally, because firms in industries with high cash flow risk will hold more cash balances than those in industries with low cash flow risk, we include *Industry Cash Flow Volatility* in our cash analyses. *Industry Cash Flow Volatility* is measured as the standard deviation of industry (Fama-French 10 industry classification) average of firms'

cash flows for the previous 10 years, we require at least 3 years of observations. We winsorize the variables at the 1st and 99th percentiles to minimize the influence of outliers.

3.4 Descriptive Statistics

Table 4 provides summary statistics of the key variables used in this study. We report mean, standard deviation, 25th percentile, median, and 75th percentile. Panel A presents information on the variables for the state-level disclosure law sample. On average, firms hold 21% of assets in cash. The mean book leverage and capital expenditure are 22% and 7% respectively, and on average 29% of the firms are dividend payers. In Panel B, breached firms comprise 0.85% of the data breach sample. Firms disclosing multiple breaches, and severe breaches respectively comprise 0.16% and 0.12% of the breach sample. The average firm in Panel B holds 24% of assets in cash.

4 State-level disclosure laws and corporate cash holdings

In this section, we test how firms cash holdings change with the passing of the state-level data breach disclosure laws.

4.1 Baseline regression results

Table 5 presents the estimation of Eq.(1). Column 1 is estimated with year fixed effects, Column 2 with year and industry fixed effects, Column 3 with year and state fixed effects, and Column 4 with year, industry and state fixed effects.[28] The coefficients on the *Disclosure Law(0/1)* variable are positive and statistically significant at less than the 1% level in all columns, revealing a positive relation between state-level disclosure laws and corporate cash holdings. We use the results in Column 4, which controls for year, industry, and state fixed effects to gauge the economic importance of state-level disclosure laws on corporate cash holdings. In Column 4, the coefficient associated with *Disclosure Law(0/1)* is 0.016, which implies, ceteris paribus, in response to the enactment of data breach disclosure laws, firms increase *Cash* by 1.6%, representing a 7.7% increase from the mean and a 14.7% increase from the median cash holdings.[29]

[28]The industry fixed effects are based on Fama-French 10 industry classification but the results remain unchanged if we use Fama-French 49 industry classification

[29]An increase in cash by 1.6% corresponds to 7.7% of mean cash holdings (0.2070) and 14.7% of median cash holdings (0.1090)

4.2 Placebo test

As discussed earlier, omitted variables coinciding with the timing of the passage of the state-level disclosure laws could be the primary driver of the baseline cash results. If this is the case, then the changes in corporate cash holdings we attribute to the state-level disclosure laws reflect mere association rather than a causal effect. However, the disclosure laws were enacted at different points in time, providing multiple exogenous shocks which affect the various states at different points in time. This enables us to overcome an obvious challenge facing single shock studies where the coincidence of a potential omitted variable and the single shock could possibly affect the economic outcomes of interest. While the staggered nature of the enactment of the state-level disclosure laws makes it unlikely for an omitted variable to coincide with the disclosure laws as explained earlier, we still address this concern by conducting a falsification test in a manner similar to Cornaggia, Mao, Tian, and Wolfe (2015). We randomly allocate the various states to the distribution of the data breach disclosure law years. Doing this preserves the correct distribution of the disclosure law years but disorders the proper assignment of the states to the disclosure law years. We expect our re-estimated results to weaken if unobservable shocks do not exist in our testing framework. Also, because the wrongly assigned states may not have passed disclosure laws in the distribution of years, data breach disclosure precaution will likely not exist so firms headquartered in those states do not make significant changes to their cash balances in those years, hence, the expectation of weaker results. Indeed, we do not find significant effects of the state-level disclosure laws on corporate cash holdings following the random assignment. As reported in Table 6, the coefficients on the *Disclosure Law(0/1)* variable in Columns 1-4 are all statistically insignificant, hence, not different from 0. The non-results show that our baseline cash holding results are not driven by an omitted variable.

4.3 Dynamic effects

It is possible the increasing cash holding trend began prior to the passage and enforcement of the state-level data breach disclosure laws. Therefore, we address potential reverse causality concerns by examining the dynamics of corporate cash holdings around the state-level disclosure law events.[30] In the case where reverse causality is present, we expect increases in corporate cash

[30]This endogeneity test examines pre-existing trends before the passage of the disclosure laws

holdings prior to the passage of the disclosure laws. We follow an approach similar to Chava, Oettl, Subramanian, and Subramanian (2013), and Amore, Schneider, and Zaldokas (2013) to examine the dynamics of corporate cash holdings by constructing a set of timing dummies. For instance, as shown in Table 7, for years 1-2 before disclosure law, we set the dummy to one for all the prior years (including the two years) before the passage of the state-level disclosure laws. For years 0-1 after disclosure law, the dummy is set to one in the year and the year after the disclosure law. For years 2-3 after disclosure law, the dummy is set to one in years 2 and 3 after the disclosure law. Finally, for years 4+ after disclosure law, the dummy is one for 4 or more years after the disclosure law.

As reported in Table 7, the coefficients for the years prior to the passage of the disclosure laws are negative in all columns. This indicates a decreasing trend of cash holdings for all firms prior to the passage of the disclosure laws. However, the post-disclosure-law coefficients are all positive and statistically significant, suggesting the pre-disclosure-law trends only diverge for affected state firms and non-affected state firms after the passage of the disclosure laws. The results therefore alleviate reverse causality concerns.

4.4 Role of financial constraints

So far, our findings strongly supports Hypothesis 1 that firms increase their cash holdings in response to the passage of data breach disclosure laws. However, it is plausible a corporation with strong cash flow and solid financial statements, fully internalizes the disclosure costs of a potential data breach and does not change its cash policy in response to the passage of the state-level data breach disclosure laws. Therefore, we examine the impact of the disclosure laws on cash policy of firms with different levels of financial constraints. Specifically, we sort firms into financially constrained and unconstrained groups based on firm size, firm age, and dividend payout ratio.[31] Following Francis, Hasan, and Wang (2014), we rank the firms over the sample period and categorize firms in the top (bottom) 4 deciles of the distribution of firm size and firm age as the unconstrained (financially constrained) group. For dividend payout ratio, we rank firms into dividend payers and non-payers, and classify dividend paying firms as the unconstrained group. Similar to Francis, Hasan, and Wang (2014), we perform the ranking

[31] Dividend payout ratio is measured as dividend per share scaled by earning per share.

on an annual basis, which enables firms in our sample to migrate between groups in different years.

Table 8 presents the findings for the relation between state-level data breach disclosure laws and corporate cash holdings for the financially constrained subsample (Columns 1, 3, and 5) and the unconstrained subsample (Columns 2, 4, and 6). In Columns 1-4 where the constraint measure is firm size and firm age, the coefficients associated with the constrained and unconstrained subsamples are both positive and statistically significant; however, the magnitude of the coefficients for the constrained group is larger than the unconstrained group. This indicates that the effect on cash holdings of the passage of disclosure laws is more pronounced for financially constrained firms than unconstrained firms. Across the specifications in Columns 5 and 6 where the sorting criteria is dividend payout ratio, disclosure law is positively and significantly associated with the constrained subsample (Column 5). In contrast, for the unconstrained subsample in Column 6, we find no evidence (statistically insignificant coefficients) of increased cash holdings. Since constrained firms face difficulty in accessing external markets, and that disclosing a data breach even makes it more unlikely to access external finance, resorting to high cash balance can help financially constrained firms to internalize the disclosure costs of a potential data breach.

4.5 Robustness – Exclusion of California

California is one of the largest and important state economies in the US, where some of the world's largest corporations (such as Apple, Google, and Facebook) are headquartered. Also, firms headquartered in California account for 18% of observations in our sample. Therefore, it is possible the results could be driven by the large representation of California firms. We exclude California and re-estimate Eq.(1) and compare against our baseline results. The exclusion of California does weaken our results. Using the results in Column 4 of Table 5 as reference, we observe that the coefficient drops from 0.16 to 0.1, and to the 5% level of significance. Therefore, even after excluding California the results still indicate that, on average, US corporations increase their holdings of cash in response to the enactment of state-level data breach disclosure laws.

4.6 Robustness – Alternative cash measure

Following Qiu and Wan (2015), we re-estimate Eq.(1) with *Net Cash* as the dependent variable. We measure *Net Cash* as total cash less debt (long-term debt plus short-term debt), and normalized by total book assets. This helps address the concern that the high corporate cash balances following the passage of the state-level disclosure are primarily due to aggressive corporate borrowings. As presented in Table 9, the baseline cash findings are fully retained.

4.7 Robustness – Exclusion of financial crisis period (2008-2010)

In a further robustness test as presented in Table 10, we purposely exclude the 2008-2010 financial crisis from the sample period. We do this because our aim is to isolate the effects of the state-level data breach disclosure laws. The results remain qualitatively unchanged; in Columns 1 and 2, the dependent variables are *Cash* and *Net Cash* respectively. The coefficients associated with *Disclosure Law(0/1)* in both columns are positive and statistically significant at the 1% level of significance. Therefore, even after excluding the financial crisis period, we find that firms increase their holdings of cash following the passage of state-level data breach disclosure law.

5 The effects of actual data breaches

We now turn to the analysis of actual data beaches. We begin by first examining the association between data breaches and certain observable firm characteristics.

5.1 Association between data breaches and observable firm characteristics

Data breach incidents may arguably be endogenously related to the observable firm characteristics in this paper. In particular, we are interested if cash policies are related to data breaches. Since there is no theoretical guidance from past research with regards to the determinants of data breaches, we consider the findings of this paper as suggestive or exploratory, and not definitive determinants of data breaches. We report the results of the logistic regressions in Table 11. The dependent variable, *Breach(0/1)*, is a dummy variable that equals 1 for breached firms in the year of the data breach. Otherwise, the dummy is set to 0. The observable firm characteristics lagged by one year include *Firm Size*, *Firm Age*, *Market-to-book*, *Book Leverage*,

Capital Expenditure, *Acquisition Expenditure*, *Dividend Paying Firms (0/1)*, *R&D Expenditure*, *Return on Assets*, and *Cash*. We include year fixed effects in Column 1, and year and industry fixed effects in Column 2.[32] Standard errors are clustered by firm in both specifications.

Columns 1 and 2 give similar results for all the observable firm characteristics. The results show that the coefficients of *Firm Size* are positive and statistically significant at less than the 1% level, suggesting that data breaches are more likely to occur at larger or visible firms. This reflects the view that larger firms may possess greater number of relevant records, data or proprietary information that may be attractive to data intruders. Also, the results show that data breaches are more likely for financially constrained firms (captured by firm dividend paying status), profitable firms (ROA), R&D intensive firms, and firms with high growth potential (Market-to-book). As Doyle, Ge, and McVay (2007) suggest, financially constrained firms may not have adequate resources (both money and time) to invest in effective data security systems since that may not be their priority. Also, the positive association between data breaches and growth opportunities (as measured by market-to-book and R&D) suggest that growth can stress the effectiveness of a firm's internal control system. That is, a rapid growing firm may outstrip its internal data security system and may require more time, personnel, and processes to keep up-to-date its internal data security systems (Doyle, Ge, and McVay (2007)).

The coefficient associated with *Cash* is negative and statistically insignificant in both Columns 1 and 2, suggesting that holding cash is not associated with the likelihood of experiencing a data breach. This suggests our later tests do not suffer from simultaneity bias.

5.2 The wealth and accounting impacts of data breaches

5.2.1 Data breaches and firm value

In Table 12, we report the event-study evidence of the market reaction to data breaches using three-day (−1, +1), five-day (−2, +2) and eleven-day (−5, +5) cumulative abnormal returns (CARs) surrounding the data breach announcement date. We compute market return using the CRSP value-weighted return.[33] Cumulative abnormal return (CAR) over the event window is the sum of the abnormal returns (For instance, for the three-day event window, cumulative abnormal return is computed as $CAR_{i(t-1,t+1)}=\sum_{T=t-1}^{T=t+1} AR_{i,t}$ where $AR_{i,t} = R_{i,t} - R_{CRSP,t}$). For

[32]The industry dummies are based on the Fama-French 10 industry classification

[33]We obtain almost identical results when we use the equally weighted return.

the disclosed data breaches, the average three-day CAR is −1.22% and significant at the 5% level of significance. Given the mean market value of about $30.56 billion for the breached firms, this translates into an average market capitalization loss of $367 million. The results are similar when we consider five-day and eleven-day windows. The mean five-day CAR is −1.91% and the mean eleven-day CAR is −2.16%; both values are significant at the 1% level of significance. Our finding is consistent with Kamiya, Kang, Kim, Milidonis, and Stulz (2018) who find that the disclosure of a data breach is associated with a mean market value loss of $439 million during the three-day window around the breach announcement. Similarly, Cline, Walkling, and Yore (2017) find that the announcement of managerial indiscretions results in an immediate 1.6% loss in shareholder value.

5.2.2 Univariate analysis - Unconditional changes in the financial of the breached firms

Next, we examine the impact of data breaches on the financial results of breached firms, first, in a univariate setting. Table 13 reports the unconditional median changes in *Total Revenue*, *Return on Assets*, and *Cash* of US firms that have experienced data breach incidents over the period 2011-2016. We report the median values in event time, where 0 represents the year of the data breach. We also calculate the median *Total Revenue*, *Return on Assets*, and *Cash* distribution for the year prior to, and the year following the data breach incident. Table 13 provides univariate evidence that data breaches impact firm financial performance. In particular, median *Total Revenue* declines from $23,114 million in the year before the breach to $17,902 million in the breach event year; similarly, median *Return on Assets* declines from 10.04% before the breach event to 9.69% after the breach event. In addition, Table 13 provides univariate evidence that firms adjust cash holdings after a breach event - median cash balances increase from 0.1285 before the event to 0.1654 after the event. Even though the univariate analysis does not control for firm characteristics, it provides preliminary evidence that data breaches impact financial performance and corporate cash policy.

5.2.3 Data breaches and firm operating performance

The univariate results suggest that breached firms experience a decline in market value, sales, and operating performance. In this section, we turn to a multivariate approach to examine

the impact of data breaches on firm performance. Table 14 presents estimation results for the impact of data breaches on firm operating performance. The dependent variable in all the specifications is *Return on Assets* measured as the ratio of earnings before interest and tax (EBIT) to total assets. In Columns 2, 4, and 6, the *Breach(0/1)*, *Multiple(0/1)*, and *Severe (0/1)* variables are lagged by one year to examine if the impact persist beyond the event year. We include several control variables in all specifications. The controls include *Firm Size*, *Firm Age*, *Book Leverage*, *Market-to-book*, *Cash Flow*, *Capital Expenditure*, *Acquisition Expenditure*, *Dividend Paying Firms (0/1)*, *R&D Expenditure*, *Net Working Capital*, and *Industry Cash Flow Volatility*. Year and industry fixed effects are included in all specifications. There are only 142 firm breaches, representing 0.85% of the firm-year observations.[34] Therefore, given the breach sample size, the industry dummies are constructed based on the Fama-French 10 industry classification.

The results in Columns 1 and 2 show that the coefficients associated with *Breach(0/1)* are negative and statistically significant at less than the 5% and 1% levels respectively. In Columns 3 and 4, the coefficients associated with *Multiple(0/1)* are negative but statistically insignificant.[35] In Columns 5 and 6, the coefficients associated with *Severe (0/1)* are negative and statistically significant at less than the 1% level. The magnitude of the coefficients associated with *Severe (0/1)* are twice that of *Breach(0/1)*, implying breaches reported as severe have even higher impact on firm operating performance. The results in Columns 2 and 6, where *Breach(0/1)* and *Severe (0/1)* are one-period lagged provide some evidence that the negative impact on *Return on Assets* of data breaches persist beyond the event year.

5.3 Data breaches and cash holdings

The univariate results presented in Table 13 suggest that firms increase their cash holdings following a data breach. In this section we use a multivariate approach to examine the impact of data breaches on corporate cash holdings. The dependent variable in all specifications is cash, measured as cash and marketable securities scaled by beginning year total book assets. While the direct costs of a data breach incident are mostly realized in the year of the incident, the more costly indirect costs (for instance, litigation) could persist beyond the event year.

[34] *Multiple(0/1)* and *Severe (0/1)* breaches respectively comprise 0.16% and 0.12% of the firm-year observations

[35] The insignificant results come as no surprise given the small sample size.

Therefore, to examine the persistent impact of data breach incidents on cash holdings, we lag the variables of interest, that is, *Breach(0/1)*, *Multiple(0/1)*, and *Severe (0/1)* by one-year in Columns 2, 4, and 6 of Table 15.[36] All specifications include the standard cash control variables described in Section 3, and they are all one-period lagged to address simultaneity concerns. Year and industry fixed effects are included in all specifications. Given the small breach sample size (0.85% of the total sample), the industry dummies are constructed based on the Fama-French 10 industry classification.[37]

Columns 1 and 2 of Table 15 show that the coefficients on the *Breach(0/1)* variable are positive and statistically significant at the 5% level of significance, revealing a positive relation between actual data breaches and corporate cash holdings. We use the results in Column 1 where the coefficient associated with *Breach(0/1)* is 0.0417 to gauge the economic importance of data breaches on corporate cash holdings. In response to a data breach exposure, firms increase *Cash* by 4.17%, which represents a 17.74% increase from the mean cash holdings.[38] In Columns 3, 4 and 5, the coefficients on the *Multiple(0/1)* and *Severe (0/1)* variables are positive and statistically significant. The magnitude of the coefficients are even higher than that of *Breach(0/1)*, implying a higher impact for firms that disclose multiple, and or severe breaches. Also, the positive and significant coefficients in Columns 2 and 4, where *Breach(0/1)* and *Multiple(0/1)* are one-period lagged provide some evidence that the impact persist beyond the event year.

5.4 Industry Spillover Effects

To further establish the causal link between data breaches and cash holdings, we examine the industry spill over effects of a data breach on non-breached peer firms. To do this, we compute an *Industry Breach Intensity* variable. We measure *Industry Breach Intensity* as the ratio of the total breaches recorded in each industry to the total number of firms in that industry. Due to the breach sample size, we use a coarse definition based on the Fama-French 10 industry classification to construct the *Industry Breach Intensity* variable. To insure we measure the spill over effect, we drop all firms that are actually involved in data breaches over the sample period. However, the results remain unchanged when we include firms actually involved in data

[36] This also helps mitigate potential simultaneity concerns.
[37] The results remain qualitatively unchanged when we use the Fama-French 49 industry classification.
[38] The mean *Cash* for the breach subsample is 23.50%.

breaches. The *Industry Breach Intensity* variable captures exogenous changes in data breach risk exposure level of non-breached peers. This helps to examine whether firms update their subjective probabilities of experiencing a data breach when industry peer firms disclose data breaches. In particular, this approach helps mitigate potential endogeneity concerns since it is unlikely that characteristics of non-breached firms could be driving the data intrusion of breached firms. Table 16 reports the results for the industry spill over effects. Table 16 shows positive and statistically significant coefficients associated with industry breach intensity in both Columns 1 and 2, suggesting that firms update their subjective probabilities of experiencing a data breach or reassess their risk when peer firms disclose data breaches. The coefficient associated with the *Industry Breach Intensity* variable in Column 1 shows that, on average, non-breached firms increase their cash holdings by 18.28% when industry peers disclose data breaches.

5.5 Robustness– Alternative cash measure

It is possible breached firms may intentionally delay disclosure in order to borrow from the external debt market before making public the data breach incident.[39] Therefore, to alleviate likely concerns that the high cash balances may be due to aggressive borrowing before actual disclosure, we follow Qiu and Wan (2015) and estimate *Net Cash* as total cash less debt (long-term debt plus short-term debt) and normalized by beginning year total book assets. As presented in Table 17, the previous cash findings are fully retained.

5.6 Robustness– Propensity score matching

We further test the robustness of our baseline cash results and use the propensity score matching approach in this section. Table 18 summarizes the propensity score matching estimation results and reports the Average Treatment Effect of the Treated (ATET) for the outcomes of interest. The outcomes of interest include either *Breach(0/1)*, *Multiple(0/1)*, or *Severe (0/1)*. The treatment assignment variables are *Firm Size*, *Book Leverage*, *Market-to-book*, *Cash Flow*, *Capital Expenditure*, *Acquisition Expenditure*, *Dividend Paying Firms (0/1)*, *Industry Cash Flow Volatility*, *R&D Expenditure*, *Industry*, and *Year*. Using robust standard errors, the ATET

[39]This can happen regardless of threat of fine. For instance, Yahoo Inc., only disclosed a 2014 data breach incident after it had entered into a merger agreement with Verizon in 2016. SEC fined Yahoo $35 million for misleading investors with the delay in disclosure

estimations for *Breach(0/1)*, *Multiple(0/1)*, or *Severe (0/1)* are all positive and statistically significant at less than the 5%, 1%, and 10% levels respectively. The results are similar to the baseline results in Table 15. The coefficient associated with *Breach(0/1)* is 0.0415 and statistically significant at the 5% level, and the magnitude of the coefficients associated with *Multiple(0/1)* and *Severe (0/1)* are twice that of *Breach(0/1)*.

6 Conclusion

Prior to 2002, US firms were not obligated to disclose data breaches. During the period of 2002-2017, state-level disclosure laws mandating firms to disclose have been passed in almost all the US states. These disclosure laws in effect, impose "disclosure costs" and inadvertently compel firms to internalize the costs (including negative externalities such as identity theft) of their data insecurity. Surprisingly, the impact of the passage of the state-level disclosure laws, and disclosure of actual data breaches has received little attention in the corporate finance literature. We fill this gap by investigating whether and to what extent data breach disclosure laws, and exposure to actual data breaches affect financial policies of publicly traded US corporations, using corporate cash policy as an example.

Our results show that firms increased their holdings of cash following the passage of the state-level data breach disclosure laws. In response to the enactment of data breach disclosure laws, firms increase *Cash* by 1.6%, which represents a 7.7% increase from the mean and a 14.7% increase from the median cash holdings. This finding is robust to a placebo test that addresses potential omitted variable bias, dynamic effect specification to address potential simultaneity concerns, the exclusion of California firms who comprise 18% of the total sample, an alternative cash measure, and exclusion of the 2008-2010 financial crisis period. Also, we examine the role of financial constraints by sorting firms into financially constrained and unconstrained groups based on firm size, firm age, and dividend payout ratio. We find that, the increase in cash balances following the passage of data breach disclosure laws are largely driven by financially constrained firms. Next, we probe the market value and corporate performance implications of exposure to data breaches. We find that disclosure of a data breach is associated with a significant decline in market value and corporate performance. Also, we find that firms increase

their cash balances following a data breach. Finally, we find that data breaches spillover within industries.

A Appendix

A.1 Additional case studies

A.1.1 Yahoo!, Inc.

Yahoo Inc, now renamed as Altaba Inc, disclosed in 2016 that it had been a victim of data breach incidents in 2013 and 2014 which affected 1 billion and 500 million customers respectively.[40] Yahoo made the data breach disclosure five days after it had entered into a merger agreement with Verizon Communications. The two companies, therefore, amended the original agreement to cut the original purchase price by $350 million. On 3 October 2017, Verizon communications revealed that the 2013 data breach incident affected 3 billion users of Yahoo and not 1 billion as initially disclosed. Yahoo, apart from being investigated by the SEC, state and federal regulatory agencies, was also hit with 43 class action lawsuits by consumers, 4 shareholder derivative class actions and a putative shareholder class action. An independent committee investigation found the board and audit committees guilty of not been fully briefed on the severity of the data security incident. The then CEO, Marissa Mayer, in response to the security incident, opted to forgo all her 2017 equity awards and the board also decided not to honour her 2016 cash bonus. On 24 April 2018, the SEC announced that Yahoo! has agreed to settle a $35 million fine for misleading investors when the company failed to disclose the 2013 and 2014 data breaches.[41]

A.1.2 Home Depot, Inc.

Home Depot, a US home improvement retailer, disclosed a data breach in the third quarter of 2014.[42] The data breach compromised access payment card information of 56 million customers between April and September of 2014. The company further disclosed on 6 November 2014, a separate breach that affected an additional 53 million customers. The company recorded $63 million pre-tax expense in relation to the data breach in the third quarter of 2014. A minimum of 57 class action lawsuits related to the data breach were filed against the company, and investigations related to the breach events were commenced by the US SEC, and other federal agencies. The company further disclosed that it expects the data breach to materially impact its cash flows, operations, and financial condition in the future. Other consequences of the breach cited in the company's 10-K filing include adverse effect on the firm's reputation, fines, and possible diversion of management's attention from the main operation of the business. As at the fiscal year ended January 29, 2017 the company had recorded $298 million gross expenses related to the 2014 security breach.

A.1.3 Sony Corporation

In 2011, Sony, a designer and manufacturer of various equipments, announced a data breach incident that compromised personally identifiable information of over 70 million customers. The

[40] For details see https://www.sec.gov/Archives/edgar/data/1011006/000119312517065791/d293630d10k.htm
[41] For details see https://www.sec.gov/news/press-release/2018-71
[42] See the company's 2015 10-K for details

incident compelled Sony to temporarily shut down its network services in order to conduct full-scale investigations into the data breach event. The company was subjected to inquiries from authorities and was named in various class action lawsuits in different jurisdictions. In November 2014, its pictures segment was also hit with another data breach incident which resulted in a disruption of its network, and unauthorized access to personally identifiable information of its employees. The company disclosed it had recorded significant costs in relation to the breach incidents. Class action lawsuits were filed against the company by several of its current and former employees.

A.1.4 Anthem Inc.

Anthem Inc, one of the largest health insurance companies in the US, disclosed in 2015, a data breach incident which affected personally identifiable information of 80 million Americans. The company acknowledged the data breach to be severe and that it expects the breach to adversely impact its cash flows, operations, reputation, and financial condition in future periods. The company has been subjected to state, federal and regulatory investigations. Several civil action lawsuits related to the data breach were filed against the company, and the company disclosed that a loss of any of the civil actions will adversely affect its operations.

A.2 Common effects of data breaches cited in 10-K filings

Table A.2.1 provides a summary of the common effects of data breaches cited in 10-K filings.

Table A.2.1: Common effects of data breaches cited in 10-K filings

This table provides examples of common effects of data breaches cited in 10-K filings.

Company name	Filing year	Description
Anthem Inc.,	2015	" We have incurred expenses to investigate and remediate this matter and expect to continue to incur expenses of this nature in the foreseeable future. Actions have been filed in various federal and state courts and other claims have been or may be asserted against us, allegedly arising out of the cyber attack. Further, we may be subject to additional litigation and government investigation which could divert the attention of management from the operation of our business, result in reputational damage, and have material adverse impact on our business, cash flows, financial condition and results of operations."
Aaron's Inc.,	2014	"Any significant compromise or breach of our data security, whether external or internal, or misuse of employee or customer data, could significantly damage our reputation, cause the disclosure of confidential customer, associate, supplier or company information, and result in significant costs, lost sales, fines and lawsuits."
Home Depot	2015	"We discovered a data breach in the third quarter of fiscal 2014 and are still in the process of determining the full extent of its impact and the impact of related government investigations and civil litigation on our results of operations, which could be material. As a result of the Data Breach, we are facing at least 57 civil lawsuits filed in the U.S. and Canada, and other claims may be asserted on behalf of customers, payment card brands, payment card issuing banks, shareholders, or others seeking damages or other related relief, allegedly arising out of the Data Breach. We are also facing investigations by a number of state and federal agencies. These claims and investigations may adversely affect how we operate our business, divert the attention of management from the operation of the business and result in additional costs and fines."
Target Corporation	2015	"In the fourth quarter of 2013, we experienced a data breach in which an intruder stole certain payment card and other guest information from our network (the Data Breach). In 2014, we recorded $191 million of pretax Data Breach-related expenses. Our losses could exceed the amounts we have recorded by material amounts, and these matters could have a material adverse impact on our results of operations. We experienced weaker than expected sales immediately following the announcement of the Data Breach, and we are currently facing litigation seeking damages or other related relief allegedly arising out of the Data Breach. In addition, state and federal agencies, including State Attorneys General, the Federal Trade Commission and the SEC, are investigating events related to the Data Breach, including how it occurred, its consequences and our responses."
Yahoo! Inc.,	2016	"Security breaches or other unauthorized data disclosure, acquisition or access (such as the Security Incidents) have resulted in, and may in the future result in, a combination of significant legal and financial exposure, increased remediation and other costs, damage to our reputation, and a loss of confidence in the security of our products, services, and networks that could have a significantly adverse effect on our business. In addition, various federal, state and foreign legislative or regulatory bodies may enact new or additional laws and regulations concerning privacy, data retention, data transfer and data protection issues, including laws or regulations mandating disclosure to domestic or international law enforcement bodies, which could adversely impact our business, our brand or our reputation with users."

A.3 Exclusion of California

Table A.3.1: Exclusion of California Firms

This table re-estimates the baseline regression by excluding firms headquartered in California. The dependent variable in all columns is *Cash* measured as cash and marketable securities scaled by beginning total book assets. Control variables are defined in Table 1. All controls are one year lagged to reduce simultaneity concerns. Standard errors clustered by state are reported in parentheses with less than 1%, 5%, and 10% levels of statistical significance denoted by ***, **, and *, respectively.

	Dependent Variable – *Cash*	
Explanatory Variables	(1)	(2)
Disclosure Law(0/1)	0.0100*	0.0102**
	(0.0050)	(0.0049)
Firm Size$_{t-1}$	-0.0124***	-0.0119***
	(0.0009)	(0.0009)
Market-to-book$_{t-1}$	0.0115***	0.0107***
	(0.0012)	(0.0011)
Firm Age$_{t-1}$	-0.0192***	-0.0186***
	(0.0030)	(0.0033)
Book Leverage$_{t-1}$	-0.1968***	-0.1869***
	(0.0126)	(0.0124)
Cash Flow$_{t-1}$	0.0017	0.0014
	(0.0017)	(0.0018)
Capital Expenditure$_{t-1}$	-0.0818***	-0.0689***
	(0.0158)	(0.0151)
Acquisition Expenditure$_{t-1}$	-0.0101	-0.0106
	(0.0070)	(0.0074)
Dividend Paying Firms (0/1)$_{t-1}$	-0.0220***	-0.0136***
	(0.0039)	(0.0035)
R&D Expenditure$_{t-1}$	0.2527***	0.2306***
	(0.0328)	(0.0306)
Net Working Capital$_{t-1}$	-0.0470***	-0.0461***
	(0.0093)	(0.0095)
Industry Cash Flow Volatility$_{t-1}$	0.0780***	0.0257***
	(0.0088)	(0.0065)
Year Fixed Effects	Yes	Yes
Industry Fixed Effects	No	Yes
State Fixed Effects	Yes	Yes
Observations	54,495	54,495
No. of States	46	46
R^2	0.4299	0.4431

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Table 1: Variable definitions

This table provides the definition of the key variables used. Accounting data are from Compustat and the breach data are obtained from the Privacy Rights Clearinghouse website (https://www.privacyrights.org/).

Variable	Definition
Cash	Cash and marketable securities scaled by beginning total book assets
Net Cash	Total cash less debt and scaled by beginning year total book assets
Net Assets	Total book assets less cash
Breach(0/1)	1 for breached firms in the year of the data breach and 0 otherwise
Multiple(0/1)	1 for any firm year with cumulative breach frequency exceeding 1 over the sample period and 0 otherwise
Severe (0/1)	1 for breaches disclosed in 10-K filings as material to the firm and 0 otherwise
Disclosure Law(0/1)	1 for periods after the enactment of the state-level data breach notification laws and 0 otherwise
Industry Breach Intensity	ratio of the sum of breaches recorded in each industry to the total number of firms in the industry
Firm Age	Natural Logarithm of the number of years a firm has been listed in the merged CRSP/Compustat database
Return on Assets	Earnings Before Interest and Tax (EBIT) scaled by total book assets
Market-to-book	Ratio of total book assets less the book value of common equity plus the total market value of equity all divided by the total book assets
Firm Size	Natural logarithm of total book assets
Book Leverage	Total book debt measured as sum of short and long-term debt normalised by total book assets
Cash Flow	Earnings after interest, dividends and taxes, but before depreciation normalised by net book assets
Capital Expenditure	Capital expenditure normalised by beginning year total book assets
Acquisition Expenditure	Acquisitions normalised by beginning year total book assets
Dividend Paying Firms (0/1)	1 in the year a firm pays dividend and 0 otherwise; set to zero if missing
R&D Expenditure	Research and development expense normalised by beginning year book assets
Net Working Capital	Net working capital normalised by net assets
Industry Cash Flow Volatility	Standard deviation of industry average cash flows for the previous 10 years, we require at least 3 years of observations

Table 2: Timing of data breach notification laws

This table provides the timing of the notification laws by state from the period 2002 to 2016. During this period, Alabama, South Dakota, and New Mexico were the only states without a data breach notification law. The distribution of years is by the year a state first enacted the disclosure law. Disclosure laws enactment years available at:
https://www.perkinscoie.com/en/news-insights/security-breach-notification-chart.html.

State	State code	Disclosure law
Alaska	AK	2008
Arizona	AZ	2006
Arkansas	AR	2005
California	CA	2002
Colorado	CO	2006
Connecticut	CT	2005
Delaware	DE	2005
Florida	FL	2005
Georgia	GA	2005
Hawaii	HI	2006
Idaho	ID	2006
Illinois	IL	2005
Indiana	IN	2005
Iowa	IA	2008
Kansas	KS	2006
Kentucky	KY	2014
Louisiana	LA	2005
Maine	ME	2005
Maryland	MD	2007
Massachusetts	MA	2007
Michigan	MI	2006
Minnesota	MN	2005
Mississippi	MS	2010
Missouri	MO	2009
Montana	MT	2006
Nebraska	NE	2006
Nevada	NV	2005
New Hampshire	NH	2006
New Jersey	NJ	2005
New York	NY	2005
North Carolina	NC	2005
North Dakota	ND	2005
Ohio	OH	2005
Oklahoma	OK	2008
Oregon	OR	2007
Pennsylvania	PA	2006
Rhode Island	RI	2005
South Carolina	SC	2008
Tennessee	TN	2005
Texas	TX	2007
Utah	UT	2006
Vermont	VT	2006
Virginia	VA	2008
Washington	WA	2005
West Virginia	WV	2008
Wisconsin	WI	2006
Wyoming	WY	2007

Table 3: Data Breach Distribution across Years

This table reports the distribution of the data breach sample across years. The data breach sample consists of breaches disclosed from 2011 to 2016 in which the breached firm is a US corporation with data available on Compustat. Financial and utility firms are excluded. The breach data are obtained from the Privacy Rights Clearinghouse website (https://www.privacyrights.org/), and the data spans from 2011 to 2016.

Year	Number of Breaches
2011	25
2012	29
2013	29
2014	26
2015	17
2016	16
Total	142

Table 4: Summary Statistics

This table reports the summary statistics of key variables. Panel A reports the summary statistics for the state-level disclosure law sample which covers the period 1990 to 2016. Panel B covers the data breach subsample, and the sample period is from 2011 to 2016. See Table 1 for variable definitions.

Panel A: Disclosure Law Sample (1990-2016)						
Variables	Obs	Mean	SD	25th	Median	75th
Cash	64,702	0.2070	0.2380	0.0304	0.1090	0.3030
Firm Size	64,702	5.3930	2.2260	3.7610	5.2440	6.9070
Firm Age	64,702	7.3003	0.9320	2.0179	5.0435	11.0918
Market-to-book	64,629	2.2980	8.7700	1.1060	1.5210	2.3960
Cash Flow	63,339	-0.3220	4.6470	-0.0150	0.0684	0.1210
Book Leverage	64,619	0.2280	0.2700	0.0186	0.1790	0.3490
Capital Expenditure	64,474	0.0723	0.2320	0.0184	0.0400	0.0802
Acquisition Expenditure	63,397	0.0391	0.3580	0	0	0.0099
R&D Expenditure	64,702	0.0635	0.1900	0	0	0.0636
Industry Cash Flow Volatility	64,702	0.3150	0.5310	0.0756	0.1300	0.2440
Net Working Capital	64,655	-0.0542	6.3470	-0.0670	0.0587	0.2240
Dividend Paying Firms (0/1)	64,702	0.2900	0.4540	0	0	1
Panel B: Data Breach subsample (2011-2016)						
Breach(0/1)	16,797	0.0085	0.0814	0	0	0
Multiple(0/1)	16,797	0.0016	0.0948	0	0	0
Severe (0/1)	16,797	0.0012	0.0307	0	0	0
Cash	16,797	0.2350	0.2530	0.0491	0.1370	0.3300
Firm Size	16,797	6.4570	2.1670	4.8910	6.4170	7.9580
Firm Age	16,797	2.0550	0.7520	1.8000	2.4060	2.5730
Market-to-book	16,776	1.6610	3.7100	0.5860	1.0410	1.9100
Cash Flow	16,531	-0.4635	5.9578	-0.0209	0.0674	0.1150
Book Leverage	16,775	0.2320	0.2610	0.00700	0.1840	0.3560
Capital Expenditure	16,778	0.0516	0.0704	0.0128	0.0299	0.0610
Acquisition Expenditure	16,567	0.0374	0.0660	0	0	0.0105
R&D Expenditure	16,797	4.1050	80.5300	0	0.0033	0.0884
Industry Cash Flow Volatility	16,531	0.5620	0.9200	0.0670	0.2090	0.3260
Net Working Capital	16,791	-0.2110	6.9800	-0.0930	0.0149	0.1540
Dividend Paying Firms (0/1)	16,797	0.3600	0.4800	0	0	1

Table 5: State-level disclosure laws and cash holdings: baseline results

This table reports estimation results of Equation (1) where the dependent variable is *Cash* and the functional form is linear. *Disclosure Law(0/1)* is a dummy variable that switches to 1 the year after the focal state passed the disclosure law; it captures the effect of state-level disclosure laws on cash holdings across states by comparing outcomes before and after the passing of each disclosure law in relation to disclosure laws passed later. Definition of control variables are in Table 1. All controls are one year lagged to reduce simultaneity concerns. Standard errors clustered by state are reported in parentheses with less than 1%, 5%, and 10% levels of statistical significance denoted by ***, **, and *, respectively.

	Dependent Variable – *Cash*			
Explanatory Variables	(1)	(2)	(3)	(4)
Disclosure Law(0/1)	0.0540***	0.0459***	0.0160***	0.0160***
	(0.0180)	(0.0142)	(0.0038)	(0.0036)
Firm Size$_{t-1}$	-0.0104***	-0.0099***	-0.0106***	-0.0103***
	(0.0020)	(0.0017)	(0.0018)	(0.0016)
Market-to-book$_{t-1}$	0.0115***	0.0104***	0.0110***	0.0101***
	(0.0009)	(0.0009)	(0.0009)	(0.0009)
Firm Age$_{t-1}$	-0.0242***	-0.0238***	-0.0225***	-0.0222***
	(0.0043)	(0.0045)	(0.0036)	(0.0040)
Book Leverage$_{t-1}$	-0.2284***	-0.2081***	-0.2106***	-0.1975***
	(0.0219)	(0.0175)	(0.0176)	(0.0155)
Cash Flow$_{t-1}$	0.0007	0.0003	0.0003	0.0000
	(0.0020)	(0.0022)	(0.0021)	(0.0022)
Capital Expenditure$_{t-1}$	-0.1179***	-0.0902***	-0.1001***	-0.0845***
	(0.0283)	(0.0243)	(0.0257)	(0.0232)
Acquisition Expenditure$_{t-1}$	-0.0133	-0.0140	-0.0126	-0.0132
	(0.0098)	(0.0105)	(0.0092)	(0.0099)
Dividend Paying Firms (0/1)$_{t-1}$	-0.0374***	-0.0231***	-0.0264***	-0.0161***
	(0.0089)	(0.0055)	(0.0055)	(0.0040)
R&D Expenditure$_{t-1}$	0.2910***	0.2521***	0.2586***	0.2301***
	(0.0281)	(0.0247)	(0.0245)	(0.0225)
Net Working Capital$_{t-1}$	-0.0417***	-0.0414***	-0.0404***	-0.0401***
	(0.0070)	(0.0070)	(0.0068)	(0.0067)
Industry Cash Flow Volatility$_{t-1}$	0.0884***	0.0309***	0.0833***	0.0297***
	(0.0085)	(0.0058)	(0.0077)	(0.0059)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	No	Yes	No	Yes
State Fixed Effects	No	No	Yes	Yes
Observations	64,667	64,667	64,667	64,667
No. of States	47	47	47	47
R^2	0.4318	0.4537	0.4553	0.4708

Table 6: Randomization of state-level data breach disclosure laws

This table reports estimation results of Equation (1) with randomized disclosure laws. The dependent variable in all columns is *Cash* measured as cash and marketable securities scaled by beginning total book assets. All controls are one year lagged to reduce simultaneity concerns. Standard errors clustered by state are reported in parentheses with less than 1%, 5%, and 10% levels of statistical significance denoted by ***, **, and *, respectively.

	Dependent Variable – *Cash*			
Explanatory Variables	(1)	(2)	(3)	(4)
Disclosure Law(0/1)	-0.0306	-0.0258	-0.0009	-0.0007
	(0.0218)	(0.0166)	(0.0041)	(0.0040)
Firm Size$_{t-1}$	-0.0105***	-0.0099***	-0.0106***	-0.0102***
	(0.0020)	(0.0017)	(0.0018)	(0.0016)
Market-to-book$_{t-1}$	0.0116***	0.0104***	0.0110***	0.0101***
	(0.0009)	(0.0009)	(0.0009)	(0.0009)
Firm Age$_{t-1}$	-0.0240***	-0.0236***	-0.0225***	-0.0222***
	(0.0043)	(0.0045)	(0.0037)	(0.0040)
Book Leverage$_{t-1}$	-0.2291***	-0.2085***	-0.2106***	-0.1975***
	(0.0220)	(0.0178)	(0.0176)	(0.0155)
Cash Flow$_{t-1}$	0.0007	0.0002	0.0003	-0.0000
	(0.0020)	(0.0022)	(0.0021)	(0.0022)
Capital Expenditure$_{t-1}$	-0.1201***	-0.0907***	-0.1002***	-0.0846***
	(0.0282)	(0.0241)	(0.0257)	(0.0232)
Acquisition Expenditure$_{t-1}$	-0.0132	-0.0139	-0.0125	-0.0132
	(0.0099)	(0.0106)	(0.0093)	(0.0099)
Dividend Paying Firms (0/1)$_{t-1}$	-0.0375***	-0.0232***	-0.0264***	-0.0161***
	(0.0087)	(0.0055)	(0.0055)	(0.0040)
R&D Expenditure$_{t-1}$	0.2917***	0.2523***	0.2586***	0.2301***
	(0.0283)	(0.0246)	(0.0245)	(0.0225)
Net Working Capital$_{t-1}$	-0.0415***	-0.0413***	-0.0404***	-0.0400***
	(0.0071)	(0.0070)	(0.0068)	(0.0067)
Industry Cash Flow Volatility$_{t-1}$	0.0884***	0.0307***	0.0833***	0.0298***
	(0.0084)	(0.0057)	(0.0077)	(0.0059)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	No	Yes	No	Yes
State Fixed Effects	No	No	Yes	Yes
Observations	64,667	64,667	64,667	64,667
No. of States	47	47	47	47
R^2	0.4306	0.4528	0.4552	0.4706

Table 7: Dynamic Effetcs

This table explores the dynamics of cash holdings around the disclosure laws. The dependent variable in all columns is *Cash* measured as cash and marketable securities scaled by beginning total book assets. The response to the state-level disclosure laws is modeled by lags and leads. Control variables are defined in Table 1. All controls are one year lagged to reduce simultaneity concerns. Standard errors clustered by state are reported in parentheses with less than 1%, 5%, and 10% levels of statistical significance denoted by ***, **, and *, respectively.

	Dependent Variable – *Cash*			
Explanatory Variables	(1)	(2)	(3)	(4)
Years 1-2 before disclosure law	-0.0305**	-0.0249**	-0.0057*	-0.0054*
	(0.0128)	(0.0104)	(0.0031)	(0.0029)
Years 0-1 after disclosure law	0.0193***	0.0164***	0.0075*	0.0071*
	(0.0057)	(0.0050)	(0.0040)	(0.0038)
Years 2-3 after disclosure law	0.0445***	0.0379***	0.0149***	0.0146***
	(0.0099)	(0.0083)	(0.0047)	(0.0046)
Years 4+ after disclosure law	0.0791***	0.0665***	0.0229***	0.0226***
	(0.0221)	(0.0177)	(0.0065)	(0.0062)
$Firm\ Size_{t-1}$	-0.0104***	-0.0099***	-0.0106***	-0.0103***
	(0.0019)	(0.0016)	(0.0018)	(0.0016)
$Market\text{-}to\text{-}book_{t-1}$	0.0115***	0.0104***	0.0110***	0.0101***
	(0.0009)	(0.0009)	(0.0009)	(0.0009)
$Firm\ Age_{t-1}$	-0.0239***	-0.0235***	-0.0225***	-0.0222***
	(0.0041)	(0.0043)	(0.0036)	(0.0040)
$Book\ Leverage_{t-1}$	-0.2267***	-0.2071***	-0.2106***	-0.1975***
	(0.0208)	(0.0170)	(0.0175)	(0.0154)
$Cash\ Flow_{t-1}$	0.0007	0.0002	0.0003	-0.0000
	(0.0021)	(0.0022)	(0.0021)	(0.0022)
$Capital\ Expenditure_{t-1}$	-0.1160***	-0.0900***	-0.1001***	-0.0845***
	(0.0279)	(0.0242)	(0.0257)	(0.0232)
$Acquisition\ Expenditure_{t-1}$	-0.0130	-0.0137	-0.0125	-0.0132
	(0.0098)	(0.0104)	(0.0092)	(0.0099)
$Dividend\ Paying\ Firms\ (0/1)_{t-1}$	-0.0365***	-0.0226***	-0.0264***	-0.0161***
	(0.0082)	(0.0052)	(0.0055)	(0.0039)
$R\&D\ Expenditure_{t-1}$	0.2890***	0.2510***	0.2587***	0.2302***
	(0.0275)	(0.0246)	(0.0246)	(0.0225)
$Net\ Working\ Capital_{t-1}$	-0.0414***	-0.0411***	-0.0404***	-0.0400***
	(0.0071)	(0.0070)	(0.0068)	(0.0067)
$Industry\ Cash\ Flow\ Volatility_{t-1}$	0.0880***	0.0306***	0.0833***	0.0296***
	(0.0086)	(0.0057)	(0.0077)	(0.0058)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	No	Yes	No	Yes
State Fixed Effects	No	No	Yes	Yes
Observations	64,667	64,667	64,667	64,667
No. of States	47	47	47	47
R^2	0.4338	0.4550	0.4554	0.4708

Table 8: Financially Constrained Firms versus Unconstrained Firms

State-level disclosure laws and cash holdings: financially constrained firms versus unconstrained firms. Standard errors clustered by state are reported in parentheses with less than 1%, 5%, and 10% levels of statistical significance denoted by ***, **, and *, respectively.

	Dependent Variable – *Cash*					
	Scheme #1: Firm Size		Scheme #2: Firm Age		Scheme #3: Payout Ratio	
	Constrained	Unconstrained	Constrained	Unconstrained	Constrained	Unconstrained
Disclosure Law(0/1)	0.0167***	0.0124**	0.0225***	0.0071*	0.0167***	0.0020
	(0.0062)	(0.0046)	(0.0041)	(0.0040)	(0.0035)	(0.0038)
$Firm\ Size_{t-1}$	0.0001	-0.0121***	-0.0114***	-0.0100***	-0.0085***	-0.0121***
	(0.0056)	(0.0017)	(0.0024)	(0.0017)	(0.0019)	(0.0021)
$Market\text{-}to\text{-}book_{t-1}$	0.0088***	0.0206***	0.0109***	0.0092***	0.0095***	0.0169***
	(0.0012)	(0.0020)	(0.0011)	(0.0011)	(0.0010)	(0.0023)
$Firm\ Age_{t-1}$	-0.0390***	0.0061*	-0.0165***	-0.0187	-0.0281***	0.0050*
	(0.0024)	(0.0032)	(0.0036)	(0.0332)	(0.0043)	(0.0030)
$Book\ Leverage_{t-1}$	-0.2293***	-0.1151***	-0.2106***	-0.1832***	-0.1953***	-0.1756***
	(0.0226)	(0.0088)	(0.0220)	(0.0231)	(0.0151)	(0.0136)
$Cash\ Flow_{t-1}$	-0.0003	-0.0329	0.0015	-0.0017	0.0006	-0.0031
	(0.0020)	(0.0256)	(0.0017)	(0.0028)	(0.0022)	(0.0024)
$Capital\ Expenditure_{t-1}$ -0.1933***	-0.0231	-0.0439**	-0.1877***	-0.0762***	-0.1222***	
	(0.0388)	(0.0145)	(0.0188)	(0.0452)	(0.0235)	(0.0277)
$Acquisition\ Expenditure_{t-1}$	-0.1009***	-0.0487***	-0.0585***	-0.0041	-0.0743***	-0.0030*
	(0.0211)	(0.0109)	(0.0206)	(0.0030)	(0.0181)	(0.0016)
$Dividend\ Paying\ Firms\ (0/1)_{t-1}$	-0.0067	-0.0237***	-0.0206***	-0.0096*	-0.0022	-0.0148***
	(0.0105)	(0.0039)	(0.0068)	(0.0048)	(0.0054)	(0.0043)
$R\&D\ Expenditure_{t-1}$	-0.0334***	-0.0403***	-0.0395***	-0.0375**	-0.0438***	-0.0222*
	(0.0061)	(0.0124)	(0.0075)	(0.0139)	(0.0086)	(0.0120)
$Net\ Working\ Capital_{t-1}$	-0.0307***	-0.0500***	-0.0362***	-0.0375***	-0.0438***	-0.0222*
	(0.0057)	(0.0179)	(0.0075)	(0.0096)	(0.0086)	(0.0120)
$Industry\ Cash\ Flow\ Volatility_{t-1}$	0.0456***	0.0002	0.0509***	0.0093	0.0302***	0.0236***
	(0.0069)	(0.0076)	(0.0115)	(0.0159)	(0.0065)	(0.0085)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	25,618	25,615	21,491	24,623	44,288	20,379
R^2	0.4524	0.4035	0.5171	0.3994	0.4663	0.3492

Table 9: Robustness – Alternative cash measure

This table reports the robustness results for the baseline model but with *Net Cash* as the dependent variable. *Net Cash* is measured as total cash less debt (long-term debt plus short-term debt), and normalized by beginning year total book assets. All estimations include one year lagged control variables to address potential simultaneity concerns. Standard errors clustered by state are shown in parentheses with less than 1%, 5%, and 10% levels of statistical significance denoted by ***, **, and *, respectively.

	Dependent Variable – *Net Cash*			
Explanatory Variables	(1)	(2)	(3)	(4)
Disclosure Law(0/1)	0.0657***	0.0547***	0.0172**	0.0172**
	(0.0199)	(0.0151)	(0.0075)	(0.0072)
$Firm\ Size_{t-1}$	-0.0190***	-0.0177***	-0.0191***	-0.0181***
	(0.0033)	(0.0029)	(0.0032)	(0.0029)
$Market\text{-}to\text{-}book_{t-1}$	0.0376***	0.0364***	0.0370***	0.0361***
	(0.0114)	(0.0112)	(0.0113)	(0.0111)
$Firm\ Age_{t-1}$	-0.0077	-0.0086	-0.0058	-0.0069
	(0.0071)	(0.0071)	(0.0061)	(0.0063)
$Book\ Leverage_{t-1}$	-1.1050***	-1.0729***	-1.0814***	-1.0586***
	(0.0862)	(0.0855)	(0.0849)	(0.0853)
$Cash\ Flow_{t-1}$	0.0002	-0.0003	-0.0002	-0.0006
	(0.0032)	(0.0034)	(0.0032)	(0.0034)
$Capital\ Expenditure_{t-1}$	-0.2541***	-0.2114***	-0.2303***	-0.2049***
	(0.0504)	(0.0495)	(0.0478)	(0.0480)
$Acquisition\ Expenditure_{t-1}$	-0.0216	-0.0223	-0.0206	-0.0212
	(0.0164)	(0.0172)	(0.0157)	(0.0163)
$Dividend\ Paying\ Firms\ (0/1)_{t-1}$	-0.0317**	-0.0147	-0.0195**	-0.0070
	(0.0124)	(0.0090)	(0.0088)	(0.0077)
$R\&D\ Expenditure_{t-1}$	0.4634***	0.4060***	0.4217***	0.3783***
	(0.0483)	(0.0470)	(0.0468)	(0.0463)
$Net\ Working\ Capital_{t-1}$	-0.0486***	-0.0491***	-0.0471***	-0.0475***
	(0.0070)	(0.0072)	(0.0068)	(0.0070)
$Industry\ Cash\ Flow\ Volatility_{t-1}$	0.0894***	0.0011	0.0819***	-0.0003
	(0.0109)	(0.0117)	(0.0100)	(0.0116)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	No	Yes	No	Yes
State Fixed Effects	No	No	Yes	Yes
Observations	64,586	64,586	64,586	64,586
R^2	0.3527	0.3579	0.3578	0.3616

Table 10: Robustness – Exclusion of financial crisis period

This table reports results for the exclusion of the financial crisis period. *Disclosure Law(0/1)* is a dummy variable that switches to 1 the year after the focal state passed the disclosure law. Definition of control variables are in Table 1. In Column 1, the dependent variable is *Cash* measured as cash and marketable securities scaled by beginning total book assets. The dependent variable in Column 2 is *Net Cash* measured as total cash less debt (long-term debt plus short-term debt) and scaled by beginning year total book assets. All controls are one year lagged to reduce simultaneity concerns. Standard errors clustered by state are reported in parentheses with less than 1%, 5%, and 10% levels of statistical significance denoted by ***, **, and *, respectively.

	Dependent Variable – *Cash*	
Explanatory Variables	(1)	(2)
Disclosure Law(0/1)	0.0175***	0.0177**
	(0.0037)	(0.0082)
$Firm\ Size_{t-1}$	-0.0100***	-0.0181***
	(0.0016)	(0.0030)
$Market\text{-}to\text{-}book_{t-1}$	0.0100***	0.0353***
	(0.0009)	(0.0114)
$Firm\ Age_{t-1}$	-0.0234***	-0.0077
	(0.0046)	(0.0078)
$Book\ Leverage_{t-1}$	-0.1996***	-1.0540***
	(0.0170)	(0.0978)
$Cash\ Flow_{t-1}$	0.0002	-0.0007
	(0.0021)	(0.0035)
$Capital\ Expenditure_{t-1}$	-0.0820***	-0.2034***
	(0.0242)	(0.0518)
$Acquisition\ Expenditure_{t-1}$	-0.0123	-0.0209
	(0.0092)	(0.0164)
$Dividend\ Paying\ Firms\ (0/1)_{t-1}$	-0.0166***	-0.0046
	(0.0039)	(0.0085)
$R\&D\ Expenditure_{t-1}$	0.2318***	0.3862***
	(0.0238)	(0.0519)
$Net\ Working\ Capital_{t-1}$	-0.0393***	-0.0452***
	(0.0071)	(0.0073)
$Industry\ Cash\ Flow\ Volatility_{t-1}$	0.0295***	0.0034
	(0.0062)	(0.0122)
Year Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
State Fixed Effects	Yes	Yes
Observations	57,376	57,308
R^2	0.4677	0.3546

Table 11: Association between data breaches and observable firm characteristics

This table presents results for the association between data breaches and firm characteristics. The dependent variable is *Breach(0/1)* and the functional form is logistic. All variables are defined in Table 1. The sample period is from 2011 through 2016. Standard errors clustered by firm are shown in parentheses with less than 1% and 5% levels of statistical significance denoted by *** and ** respectively.

	Dependent Variable – *Breach(0/1)*	
VARIABLES	(1)	(2)
Firm Size$_{t-1}$	0.6852***	0.7130***
	(0.0770)	(0.0775)
Firm Age$_{t-1}$	0.0959	0.0762
	(0.1800)	(0.1804)
Market-to-book$_{t-1}$	0.1215***	0.1542***
	(0.0409)	(0.0462)
Book Leverage$_{t-1}$	0.3839	0.2002
	(0.5566)	(0.4296)
Capital Expenditure$_{t-1}$	-2.1637	-0.7100
	(1.7404)	(1.6692)
Acquisition Expenditure$_{t-1}$	-1.2314	-0.9628
	(1.9326)	(1.8623)
Dividend Paying Firms (0/1)$_{t-1}$	-0.5884***	-0.4123**
	(0.2136)	(0.2041)
R&D Expenditure$_{t-1}$	1.4545**	2.3494***
	(0.7128)	(0.6559)
Return on Assets$_{t-1}$	2.1340***	2.1494***
	(0.4135)	(0.7923)
Cash$_{t-1}$	-0.1619	-0.3284
	(0.3424)	(0.2889)
Year fixed effects	Yes	Yes
Industry fixed effects	No	Yes
Observations	16,797	16,797
No. of Firms	3877	3877
No. of Breaches	142	142
$PseudoR^2$	0.1380	0.2050

Table 12: Data breaches and firm value

This table reports the impact of data breaches on firm value as indicated by the three-day, five-day, and eleven-day cumulative abnormal returns (CARs) at disclosure using standard event study methods. Abnormal return over the event window is computed as the difference between the realised returns and the expected returns. We compute the expected stock return using the CRSP value weighted return [43] Robust standard errors are reported in parentheses with less than 1% and 5% levels of statistical significance denoted by *** and ** respectively.

	(-1,+1)	(-2,+2)	(-5,+5)
CARs (Mean)	-0.0122**	-0.0191***	-0.0216***
	(0.0050)	(0.0068)	(0.0067)

Table 13: Unconditional Changes in Financials of Breached Firms

This table reports the distribution and median difference of *Total Revenue*, *Return on Assets*, and *Cash* in event time for breached firms. Year 0 is set as the year of the data breach. The sample period is from 2011 to 2016. The median equality test is conducted using the Wilcoxon test. See Table 1 for variable definitions.

Event Year	Median	Period	Test Statistic	Prob > |z|
Panel A: *Total Revenue* ($m) in Event Time				
-1	23,114	(1) versus (-1)	4.769	0.0000
0	17,902			
1	16,763			
Panel B: *Return on Assets* in Event Time				
-1	0.1004	(1) versus (-1)	3.069	0.0022
0	0.0969			
1	0.0962			
Panel A: *Cash* in Event Time				
-1	0.1285	(1) versus (-1)	2.371	0.0178
0	0.1654			
1	0.1706			

Table 14: Data breaches and firm operating performance

This table presents the results for the impact of data breaches on firm operating performance. The dependent variable in all columns is *Return on Assets* measured as earnings before interest and tax (EBIT) scaled by beginning year total book assets. In Columns 2, 4, and 6, *Breach(0/1)*, *Multiple(0/1)*, and *Severe (0/1)* variables are lagged by one-year to examine if the impact persist beyond the event year. Definition of control variables are in Table 1. All controls are one year lagged to reduce simultaneity concerns. The sample period is from 2011 through 2016. Standard errors clustered by firm are shown in parentheses with less than 1%, 5%, and 10% levels of statistical significance denoted by ***, **, and *, respectively.

	Dependent Variable – *Return on Assets*					
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Breach(0/1)	-0.0328**	-0.0371***				
	(0.0142)	(0.0143)				
Multiple(0/1)			-0.0310	-0.0329		
			(0.0304)	(0.0305)		
Severe (0/1)					-0.0702***	-0.0707***
					(0.0244)	(0.0236)
Firm Size$_{t-1}$	0.0351***	0.0352***	0.0352***	0.0352***	0.0351***	0.0351***
	(0.0021)	(0.0021)	(0.0022)	(0.0021)	(0.0021)	(0.0021)
Firm Age$_{t-1}$	0.0206***	0.0207***	0.0207***	0.0207***	0.0206***	0.0206***
	(0.0048)	(0.0048)	(0.0048)	(0.0048)	(0.0048)	(0.0048)
Book Leverage$_{t-1}$	-0.0210	-0.0210	-0.0207	-0.0208	-0.0212	-0.0211
	(0.0230)	(0.0230)	(0.0232)	(0.0232)	(0.0230)	(0.0230)
Market-to-book$_{t-1}$	-0.0048***	-0.0048***	-0.0048***	-0.0048***	-0.0048***	-0.0048***
	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)
Cash Flow$_{t-1}$	0.0147**	0.0147**	0.0147**	0.0147**	0.0147**	0.0147**
	(0.0059)	(0.0059)	(0.0059)	(0.0059)	(0.0059)	(0.0059)
Capital Expenditure$_{t-1}$	0.0028	0.0027	0.0028	0.0028	0.0028	0.0028
	(0.0038)	(0.0038)	(0.0038)	(0.0038)	(0.0038)	(0.0038)
Acquisition Expenditure$_{t-1}$	0.0451***	0.0450***	0.0448***	0.0448***	0.0452***	0.0451***
	(0.0124)	(0.0124)	(0.0124)	(0.0124)	(0.0125)	(0.0124)
Dividend Paying Firms (0/1)$_{t-1}$	0.0530***	0.0529***	0.0530***	0.0530***	0.0530***	0.0531***
	(0.0058)	(0.0058)	(0.0058)	(0.0058)	(0.0058)	(0.0058)
R&D Expenditure$_{t-1}$	-0.0003**	-0.0003**	-0.0003**	-0.0003**	-0.0003**	-0.0003**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Net Working Capital$_{t-1}$	0.0251	0.0251	0.0250	0.0250	0.0251	0.0251
	(0.0215)	(0.0215)	(0.0215)	(0.0215)	(0.0215)	(0.0215)
Industry Cash Flow Volatility$_{t-1}$	-0.0601***	-0.0601***	-0.0602***	-0.0602***	-0.0602***	-0.0602***
	(0.0180)	(0.0180)	(0.0180)	(0.0180)	(0.0180)	(0.0180)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,797	16,797	16,797	16,797	16,797	16,797
No. of Breach(0/1)	142	142	142	142	142	142
No. of Multiple(0/1)	27	27	27	27	27	27
No. of Severe (0/1)	20	20	20	20	20	20
R^2	0.2687	0.2687	0.2687	0.2687	0.2686	0.2686

Table 15: Data Breach Events and Cash Holdings

This table reports the estimation results for the impact of data breaches on corporate cash holdings. In all columns, the dependent variable, *Cash*, is measured as cash and marketable securities scaled by beginning year total book assets. The variables of interest are *Breach(0/1)*, *Multiple(0/1)*, and *Severe (0/1)*, and are lagged by one-year in Columns 2, 4, and 6. All estimations include one year lagged control variables to address potential simultaneity concerns. The sample period is from 2011 through 2016. Standard errors clustered by firm are shown in parentheses with less than 1%, 5%, and 10% levels of statistical significance denoted by ***, **, and *, respectively.

	Dependent Variable – *Cash*					
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Breach(0/1)	0.0417**	0.0389**				
	(0.0178)	(0.0163)				
Multiple(0/1)			0.0904***	0.0854***		
			(0.0263)	(0.0257)		
Severe (0/1)					0.0600*	0.0367
					(0.0341)	(0.0407)
Firm Size$_{t-1}$	-0.0187***	-0.0187***	-0.0192***	-0.0191***	-0.0185***	-0.0185***
	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)
Firm Age$_{t-1}$	-0.0223***	-0.0223***	-0.0225***	-0.0225***	-0.0223***	-0.0223***
	(0.0052)	(0.0052)	(0.0052)	(0.0052)	(0.0052)	(0.0052)
Book Leverage$_{t-1}$	-0.1459***	-0.1460***	-0.1467***	-0.1463***	-0.1458***	-0.1459***
	(0.0232)	(0.0232)	(0.0226)	(0.0227)	(0.0233)	(0.0233)
Market-to-book$_{t-1}$	0.0436***	0.0436***	0.0435***	0.0435***	0.0436***	0.0436***
	(0.0050)	(0.0050)	(0.0050)	(0.0050)	(0.0050)	(0.0050)
Cash Flow$_{t-1}$	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002
	(0.0030)	(0.0030)	(0.0030)	(0.0030)	(0.0030)	(0.0030)
Capital Expenditure$_{t-1}$	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091
	(0.0099)	(0.0099)	(0.0099)	(0.0099)	(0.0099)	(0.0099)
Acquisition Expenditure$_{t-1}$	-0.0645***	-0.0645***	-0.0635***	-0.0638***	-0.0648***	-0.0647***
	(0.0143)	(0.0143)	(0.0141)	(0.0141)	(0.0143)	(0.0143)
Dividend Paying Firms (0/1)$_{t-1}$	-0.0211***	-0.0211***	-0.0212***	-0.0212***	-0.0211***	-0.0212***
	(0.0061)	(0.0061)	(0.0060)	(0.0060)	(0.0061)	(0.0061)
R&D Expenditure$_{t-1}$	0.3984***	0.3984***	0.3981***	0.3983***	0.3986***	0.3987***
	(0.0801)	(0.0801)	(0.0800)	(0.0800)	(0.0801)	(0.0801)
Net Working Capital$_{t-1}$	-0.0303**	-0.0303**	-0.0301**	-0.0301**	-0.0303**	-0.0303**
	(0.0139)	(0.0139)	(0.0139)	(0.0139)	(0.0139)	(0.0139)
Industry Cash Flow Volatility$_{t-1}$	-0.0554*	-0.0554*	-0.0553*	-0.0552*	-0.0553*	-0.0554*
	(0.0283)	(0.0283)	(0.0283)	(0.0283)	(0.0283)	(0.0283)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,797	16,797	16,797	16,797	16,797	16,797
No. of Breach(0/1)	142	142	142	142	142	142
No. of Multiple(0/1)	27	27	27	27	27	27
No. of Severe (0/1)	20	20	20	20	20	20
R^2	0.2901	0.2901	0.2904	0.2903	0.2900	0.2900

Table 16: Industry spillover effects of data breaches

The table summarizes estimation results for the effects of data breaches on peer firms' cash holdings. The dependent variable is *Cash*, measured as cash and marketable securities scaled by beginning total book assets. *Industry Breach Intensity* is measured as the ratio of the total breaches recorded in each industry to the total number of firms in the industry. All controls are one year lagged to reduce simultaneity concerns. In Column 1, firms that are actually involved in data breaches are dropped. The breached firms are included in Column 2. The sample period is from 2011 to 2016. Standard errors clustered by firm are shown in parentheses with less than 1%, 5%, and 10% levels of statistical significance denoted by ***, **, and *, respectively.

	Dependent Variable – *Cash*	
Explanatory Variables	(1)	(2)
Industry Breach Intensity	0.1828**	0.1816**
	(0.0810)	(0.0816)
$Firm\ Size_{t-1}$	-0.0187***	-0.0191***
	(0.0027)	(0.0027)
$Firm\ Age_{t-1}$	-0.0221***	-0.0224***
	(0.0052)	(0.0052)
$Book\ Leverage_{t-1}$	-0.1461***	-0.1483***
	(0.0234)	(0.0229)
$Market\text{-}to\text{-}book_{t-1}$	0.0439***	0.0437***
	(0.0050)	(0.0050)
$Cash\ Flow_{t-1}$	-0.0002	-0.0002
	(0.0030)	(0.0030)
$Capital\ Expenditure_{t-1}$	-0.0090	-0.0090
	(0.0098)	(0.0098)
$Acquisition\ Expenditure_{t-1}$	-0.0650***	-0.0639***
	(0.0144)	(0.0142)
$Dividend\ Paying\ Firms\ (0/1)_{t-1}$	-0.0202***	-0.0195***
	(0.0061)	(0.0061)
$R\&D\ Expenditure_{t-1}$	0.3976***	0.3968***
	(0.0800)	(0.0801)
$Net\ Working\ Capital_{t-1}$	-0.0302**	-0.0300**
	(0.0139)	(0.0139)
$Industry\ Cash\ Flow\ Volatility_{t-1}$	-0.0553*	-0.0564**
	(0.0283)	(0.0283)
Year Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
Observations	16,797	16,586
R^2	0.2900	0.2896

Table 17: Robustness–alternative cash measure

This table reports the robustness results for the impact of data breaches on corporate cash holdings. The dependent variable, *Net Cash*, is measured as total cash less debt (long-term debt plus short-term debt), and normalized by beginning year total book assets. The variable of interest is *Breach(0/1)* and it is lagged by one-year in Column 2. All estimations include one year lagged control variables to address potential simultaneity concerns. The sample period is from 2011 through 2016. Standard errors clustered by firm are shown in parentheses with less than 1%, 5%, and 10% levels of statistical significance denoted by ***, **, and *, respectively.

	Dependent Variable – *Net Cash*	
Explanatory Variables	(1)	(2)
Breach(0/1)	0.0466**	0.0450**
	(0.0204)	(0.0176)
Firm Size$_{t-1}$	-0.0214***	-0.0214***
	(0.0058)	(0.0058)
Firm Age$_{t-1}$	-0.0080*	-0.0081*
	(0.0048)	(0.0048)
Book Leverage$_{t-1}$	-1.0746***	-1.0746***
	(0.0424)	(0.0424)
Market-to-book$_{t-1}$	0.0272***	0.0272***
	(0.0062)	(0.0062)
Cash Flow$_{t-1}$	0.0014	0.0014
	(0.0034)	(0.0034)
Capital Expenditure$_{t-1}$	-0.0122	-0.0122
	(0.0113)	(0.0113)
Acquisition Expenditure$_{t-1}$	-0.0979***	-0.0978***
	(0.0230)	(0.0230)
Dividend Paying Firms (0/1)$_{t-1}$	-0.0167**	-0.0167**
	(0.0076)	(0.0076)
R&D Expenditure$_{t-1}$	0.2903***	0.2902***
	(0.0892)	(0.0892)
Net Working Capital$_{t-1}$	-0.0528***	-0.0528***
	(0.0181)	(0.0181)
Industry Cash Flow Volatility$_{t-1}$	-0.0751**	-0.0751**
	(0.0336)	(0.0336)
Year Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
Observations	16,775	16,775
R^2	0.2832	0.2832

Table 18: Robustness–Propensity score matching

This table summarizes propensity score estimation results and reports the Average Treatment Effect of the Treated (ATET) for the outcomes of interest. The outcomes of interest include either *Breach(0/1)*, *Multiple(0/1)*, or *Severe (0/1)*. The treatment assignment variables are *Firm Size*, *Book Leverage*, *Market-to-book*, *Cash Flow*, *Capital Expenditure*, *Acquisition Expenditure*, *Dividend Paying Firms (0/1)*, *Industry Cash Flow Volatility*, *R&D Expenditure*, *Industry*, and *Year*. Using robust standard errors, the ATET estimations are statistically significant at less than the 1%, 5%, and 10% levels as denoted by ***, **, and *, respectively.

	Dependent Variable – *Cash*		
Outcome of Interest	Coefficient	z	P>|z|
Breach(0/1)	0.0415**	2.39	0.017
	(0.0174)		
Multiple(0/1)	0.0853***	6.21	0.000
	(0.0137)		
Severe (0/1)	0.0879*	1.82	0.068
	(0.0482)		
Observations	18,532		