Master Thesis in Finance

Do Managers Overreact to Nature Disaster? Evidence from Earthquake Events

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Abstract

This paper investigates the availability heuristic which inflates manager's perception of liquidity risk attributing to earthquake strikes. Employing the financial reporting data of Chinese listed firms, I estimate a fixed-effect model of severe earthquake events and corporate cash holding as proxy for a firm's self-insurance coverage. Since the probability of a future earthquake is exogenous to previous shocks, the optimal insurance decision is supposed to be irrelevant to strikes. Adversely, I find that firms incline to hold excess cash as liquidity buffer against seismic risk when a salient quake strikes area nearby. Driven by the availability heuristic, this pattern is transitory but persistent and perennial. Ultimately, the unduly extra cash holding casts considerable economic consequence as it retains the value of cash as well as the cash dividend to the shareholders.

Keyword: cash holding, managerial behavior, heuristic biases, earthquake

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1 Introduction

Availability describes the heuristic in which individuals form subjective estimation based on the most retrievable or vivid information rather than the most relevant clue. Driven by such a bias, people are prone to overestimate the likelihood of an unusual but memorable scenario and hence making suboptimal choices regarding probability. This paper investigates the availability heuristic which inflates manager's perceived liquidity risk attributing to earthquake by examining the cash holding of firms which are subject to minor seismic hazard. Since the probability of a future earthquake is exogenous to previous shocks, the optimal insurance decision for earthquake risk is supposed to be irrelevant to recent strikes. Adversely, the evidence from fixed-effect panel estimation reveals that firms incline to over insure against potential earthquakes with excess cash if a salient quake strikes area nearby. Driven by the availability heuristic, this pattern is transitory, but also persistent and perennial. Ultimately, the unduly extra cash holding casts considerable consequence as it retains the value of cash as well as the cash dividend to the shareholders.

Following the prominent experimental studies of Kahneman and Tversky in the early 1970s (e.g. Kahneman and Tversky, 1972; Tversky and Kahneman, 1973; Kahneman and Tversky, 1979), behavioral influences on decision making are attracting an increasing discussion. Recent developments in this topic have introduced a broader analysis method than a pure laboratory experiment, thus enable a more practical investigation in managerial decision making. As bounded-rational, managers indeed fall into traps of subjective judgment in corporate-level decision making. Among these studies, the most widely discussed factor is overconfidence which is widely observed in empirical phenomena (e.g. Malmendier and Tate, 2005; Adam, Fernando, and Golubeva, 2015; Hirshleifer, Low, and Teoh, 2012). The subjective judgment driven by availability, however, is far less investigated, although the it is well-documented in theoretical and experimental research.

Availability heuristic commonly serves as a shortcut to process information. To provide fast response, the brain unconsciously accesses the information which draws the most attention, and thus distorts focus from the most relevant one. As an illustration, the experiment conducted by Slovic, Fischhoff, and Lichtenstein (1980) uncovers that people tend to overestimate the annual morality of most rare or spicular hazards while underestimating the common ones with mostly unobervable fatality. Such a bias indeed has a remarkable impact on daily life. For instance, households are more likely to buy property insurance after a rare natural disaster, while underinsure themselves against car accident or diseases which are more likely to cause severe loss (Kunreuther and Pauly, 2014). Since managers prefer to apply the rule of thumb or intuition, rather than comprehensive analysis in corporate decision-making process (Baker and Wurgler, 2011, 2012), they can also commit similar mistake in risk assessment and risk management.

Existing research on managerial behavior provides inadequate empirical evidence on availability because retrievableness and managerial perception are not immediately observable. Dessaint and Matray (2016) address this concern by employing violent hurricanes as a treatment of retrievableness. In their natural experiment, they track cash holding level as proxy of perceived liquidity risks. Motivated by their experimental design, this paper proposes a similar framework to testify whether managers overestimate the probability of salient disaster and accordingly overinsure such risk. With a focus on the Chinese firms, this paper selects severe earthquake shocks instead of hurricane as the treatment. By examining the cash holding of 1303 listed firms over a 10-year period covering 16 severe earthquake events, this article supplements empirical evidence to managerial overreaction driven by availability bias.

Earthquake hazard is continuously considerable in China, whereas the catastrophe insurance product is insufficient. Firms thus rely on excess cash holding to manage liquidity risk attributing to earthquake strike. This specification is suitable for the in-the-field experiment design above discussed. For treatment assignment, I distinguish the firms into three categories according to the local shaking intensity, approximating by the distance to the epicenter. The treatment group consists of firms feeling minor shaking(hereafter "neighbor firms"), while the control group is unaffected by shaking (hereafter "faraway firms"). Stricken firms suffering extreme shaking are considered separately due to the severe impair. In the view of rational agent hypothesis, the cash holding for self-insurance purpose should not vary with previous earthquake shocks. The fixed-effect panel regression results, by contrast, reveal that the neighbor firms tend to increase their cash holding excessively after a shock.

Controlling the firm-level characteristics as well as the fixed effects of periods, firms, cities, and industrial sectors, the neighbor firms increase their cash holding by 0.8% of the total assets on average. Further investigations find the effect of availability heuristic robust to alternative sources of cash increase. In conformity with Dessaint and Matray (2016), this pattern is not unique to the firms assigned to the neighbor group. On the top of the domestic earthquake, an even stronger overreaction exists for both the neighbor and faraway firms when four salient earthquake events occurred in Japan (Tōhoku and Kumamoto), Nepal, and Chile. Although these quakes did not affect Chinese firms directly, the intensive media coverage enhances the salience of the strikes hence facilitating overestimation on the earthquake risk. Additionally, the overreaction pattern is transitory but persistent. As the memory of the last earthquake fading, the salience of the shock weakens. The empirical result implies that this pattern lingers for more than two years, which is close to the estimation of Dessaint and Matray (2016). In contradiction with the earlier finding, the overreaction is perennial, which indicates that the experience of earthquakes does not alleviate inflated estimation. More specifically, although the neighbor firms react most aggressively when they first time experience an earthquake, they repetitively overreact to subsequent shocks. Consistent with the availability heuristic, the finding suggests that the bias is systematic among both naive and sophisticated agents. Additionally, the evidence of a declining overreaction further mitigates alternative causal link between excess cash holding and extra earning due to the geographic spillover effect.

The estimation of the average excess cash buffer in anticipation of salient earthquake risk is 228,825 CNY. The effect is equivalent to 6% of median cash position and 0.56% of the standard deviation. This unduly excess buffer cuts down the revenue from cash and hence casting substantial opportunity costs for the shareholders. As such, I propose difference-in-difference comparison on the dividend policy of 377 neighbor firms with their matched pairs which are randomly selected from the control group firms based on their fundamental characteristics. After the earthquake, the payout ratio of neighbor firms strictly declines by 18%, and the neighbor firms pay 17.5% less dividend than the matched pairs. The eventual cost is strikingly more substantial comparing to the impact on cash holding.

This paper also seeks to validate the assumption that firms tend to self-insure rare natural disaster with extra cash instead of purchasing catastrophe insurance. Because catastrophe insurance is insufficiently developed during the last ten years, exogenous effect from cat insurance is not a concern in this specification. Nevertheless, to cement the evidence, I propose a preliminary test on above assumption with firm-level property and commercial insurance expenses data reported in the notes to the annual reports. Although the data omit considerable observations from the quarterly panel, the results demonstrate that property insurance expenses are rather fractional and stable over time. This evidence points to that insurance purchasing accounts for a negligible fraction in corporate risk management. Furthermore, the property insurance expenses do not eliminate the primary empirical evidence that neighbor firms hold more cash in anticipation of higher earthquake hazard and subsequent liquidity risk when an extreme earthquake strikes neighborhood area.

Overall, this paper provides evidence pointing to managerial heuristic bias which concurs with the survey of Baker and Wurgler (2011) as well as the natural experiment of Dessaint and Matray (2016). Employing the treatment design and difference-in-difference strategy of Dessaint and Matray (2016), I find that, when a severe earthquake occurs nearby, firms tend to hold excess cash as self-insurance buffer for a inflated perceived earthquake hazard. Further review demonstrates that, the small-sized and high-leveraged firms react more sensitively to the strike. The real probability of an earthquake, which remains independent with the previous shock, is however ignored in this heuristic. In consequence, the irrational decision leads to considerable opportunity costs to the shareholders. In good but not entirely agreement with the conclusion of Dessaint and Matray (2016) from hurricane landfalls in U.S., my analyses detect a comparable scale of managerial overreaction, a slightly longer period of temporary overreaction and a larger impair on cash dividend. Although Dessaint and Matray are correct to claim that managers learn the real risk from previous disasters, the quake experience does not necessarily lead to a faster calibration process in this case. Additionally, my initial survey on firm-level property insurance purchasing data further reinforces the assumption raised by Dessaint and Matray that self-insurance against natural disaster is prevailing. Finally, the overreaction towards earthquake by holding more cash is robust to property insurance purchasing and other alternative specifications.

2 Literature Review

Literature that motivates this paper includes empirical research on the distortion of managerial behavior, experimental studies on heuristic biases in decision making, and recent evidence on the link between managerial risk-taking associate to heuristics. As prior studies posit, behavioral biases and pattern of thinking serve as a critical part of the decision-making process of managers, who are far from fully rational. Regarding the scope of "irrational" managerial behavior, this paper limits the discussion to the behavior which the manager finds optimal for the interests of shareholders but actually not. The interest conflict issue, which is irrational from the perspective of the shareholders but might be rational for the manager, is not the primary consideration in this paper.

2.1 Managerial Behavioral

Current theoretical and empirical analyses in corporate finance report that managers are not entirely rational as described in traditional economic theory. The irrational managerial decision is widely observed in financing, investment, dividend policy as well as other detailed corporate decisions (e.g. Bertrand and Schoar, 2003; Malmendier and Tate, 2005; Baker and Wurgler, 2011; Adam, Fernando, and Golubeva, 2015). Managers deviate from the idea of maximizing firm value due to various factors documented in behavioral or psychological research, but only a fragment are covered in existing literature. In the survey of Baker and Wurgler (2011), managers admit accelerating decision making by applying the rule of thumb, previous experience or intuition rather than rigorous calculation. Another common behavior factor is overconfidence, which generates intense interest in the idiosyncratic distortion in corporate policy such as aggressive investment(Malmendier and Tate, 2005; Bertrand and Schoar, 2003) , and bold innovation Adam et al. (2015). Ben-David, Graham, and Harvey (2013), on the other hand, posit that the effect of overconfidence is systematic across managers on investment, leverage taking, and executive compensation. According to above research, overconfidence benefits the value growth by encouraging innovation in certain circumstances. Nonetheless, in most cases, the evidence points to the adverse effect in which the overconfident manager brings up value-destroy investment, leverages up risk, and exaggerates interest conflicts.

In addition to above endogenous behavior factors, recent research reports the distortion of managerial risk sentiment under rare events which are exogenous and economically irrelevant to the fundamental value. For instance, local terrorist attack or shooting drives a transitory conservative managerial decision (Antoniou et al., 2016). Bernile et al. (2017), on the contrary, find a persistent impact of early-age memory of natural disaster on managerial risk preference. In the two cases, managerial risk preference is mainly driven by the impression and the severity of previous shocks. Alternative to the overconfidence bias, this deviation conforms with the availability heuristic, which is less address in managerial behavior research.

2.2 Heuristic Biases

The first systematic study on heuristic biases was carried out in the early 1970s by Kahneman and Tversky (1972,1973). The prominent research notes the systematic error in decision making. One of the biases is due to the availability heuristic in which the most memorable and dramatic information serves as the primary clue for daily decision making (Tversky and Kahneman, 1973). The other is representativeness in which people ignore the principle of probability but form their estimation on a narrow sample (Kahneman and Tversky, 1972). Both biases exist for naive and sophisticated subjective. Under uncertainties, these heuristic biases hinder an agent from efficiently estimating the potential outcomes.

An illustration of heuristic biases from daily life is over insurance (Tversky and Kahneman, 1973; Johnson et al., 1993; Kunreuther and Pauly, 2014). Motivations behind insurance purchase behavior can be wholly inconsistent cross different hazards. People incline to insure against the rare, fatal hazard while ignoring the common risk, such as the aviation insurance, comparing with health insurance. The insurance preference for a specific risk also varies over time. In the case of natural disaster hazard, households express short-lived interests in buying property or disaster insurance immediately after an extreme disaster. The abrupt interests reflect the inflated perceived exposure to disaster and primarily increases with the severity and media coverage which draw the most attention. The real risk, on the other hand, is exogenous to recent occurrence or media coverage but is ignored by the agent. It is noteworthy that the perspective theory also addresses the puzzle of inconsistent preference under salient negative risk (Kahneman and Tversky, 1979; Bordalo et al., 2012). However, the perspective theory presumes that the agent is formed of the precise probability of each scenario and her "perceived risk" is identical to the real risk. Thereby, in this perspective, the behavioral pattern is different from the availability bias.

Regardless of its systematic impact in extensive phenomena, the availability heuristic remains less examined in empirical research on the managerial decision. Therefore, extending empirical research on availability heuristics will shed more light on the managerial behavior, in particularly the aforenamed over insurance pattern under salient natural disaster.

2.3 Natural Disaster and Firm's Response

Extreme natural disasters give rise to remarkable damage which includes not the direct economic loss to local firms but also the disruption of supply chains and infrastructure. Due to these shocks, stricken firms are subject to acute liquidity shortage. The worldwide survey across 53 countries and regions suggests that earthquake events negatively and persistently affect a firm's operating cash flow while insurance products can eliminate such impact (Ramirez and Altay, 2011). Meanwhile, Ramirez and Altay find that the negative impact in general on operating cash flow does not apply to all firms. Firms in the areas exposed to higher earthquake hazard, such as Asia and Latin America, hold more cash after local quake events. Associating their results to the perspective of "disruptive innovation", Ramírez and Altay interpret the increase of cash holding as a "blessing in disguise". This exposition, however, fails to separate the disrupted firms from unaffected firms in their analysis.

More recent evidence of Dessaint and Matray (2016) from US hurricane landfalls from 1989 to 2008 points to an alternative mechanism to such pattern. They conclude that increasing cash holding of a firm after a violent hurricane landfall nearby is the overreaction driven by availability heuristics. Their empirical results demonstrate that such overreaction is transitory and positively related to financial reporting concerning the hurricane. Almost identical to the aforenamed case of over-insurance, the manager' perception of liquidity risk attributing to hurricane surges shortly after the landfall and decays over periods. The perception is distorted as the actual risk remains unchanged conditional on recent hurricane events.

Alternative rationale of Bernile et al. (2017) asserts that disaster experience generates a persistent effect. In contradictory to the conclusion, Dessaint and Matray (2016) suggest that hurricane landfall causes a temporary distortion of managerial behavior. The overreaction diminishes along with the salient which decays over time due to old memory and so does the availability. Thereby, the managerial risk sentiment towards natural disaster is driven by availability bias.

Even though Dessaint and Matray provide evidence against potential explanations alternative to behavioral bias, few additional questions need to be raised. The most critical one pointing to their analysis is the primary assumption of self-insurance. As is customary in previous research, they presume that firms use cash buffer instead of catastrophe insurance to hedge against natural disaster risk. This assumption validates the method of proxying perceived risk with cash holding. Therefore, it is essential to assure this assumption and to eliminate the exogenous influence of insurance purchasing. Besides, contrast with Dessaint and Matray's claim, a hurricane is attractable and predictable. Meteorologists can track and predict the landfall 3-5 days ahead within a forecast error within 200 miles[1] (Cangialosi, 2017). A sound forecast can provoke cash holding increase out of rationality. They also ignore that hurricane is not widely distributed but occurs seasonally (usually July to November in U.S.) and concentrate in tropical and subtropical coastal. As such, the firms obtain a rough but rational estimation of hurricane hazard according to their locations. For a concrete evidence to behavioral motivation, a more suitable treatment should be harder to predict and affect broader regions hence enabling concrete evidence to heuristic biases in managerial decision-making. Under this view, I adjust Dessaint and Matray's design to fix the above gaps by employing a sample of China equity market. In this specification, catastrophe insurance remains at infancy stage. Moreover, I set the treatment as severe earthquake events, which widely occur in mainland China but hard to predict in advance.

3 Earthquakes: Hazard and Attention

This section briefly discusses the reason for selecting earthquakes rather than hurricanes as the treatment. Background information relates to the earthquake and the seismic hazard is also presented.

3.1 Earthquake distribution

Despite that around 90% earthquake activities concentrate along plate boundaries, earthquakes and subsequent destruction are not unique to the boundary zone. Because a violent

[1] Source: `http://www.nhc.noaa.gov/verification/verify5.shtml`

and deep-epicenter earthquake can affect areas tens of miles away, areas in the interior of the plate are also vulnerable to seismic hazard. The latest seismic hazard map created by the Global Seismic Hazard Assessment Program (GSHAP) presented in **Figure 1** demonstrates how the shaking intention distributes in last 50 years across China and the neighboring countries. The color marks the potential damage of the previous earthquake and illustrates the widespread of seismic hazard.

Unlike a hurricane which is trackable and predictable in advance, an earthquake is hard to predict or to observe accurate precursors early enough. According to the NOAA, the hurricane is mostly concentrated in tropical and subtropical coastal areas. Adversely, an earthquake is not seasonal either but random through the year. Thus, the time of a potential earthquake strike is also widely spread. Also, one seismic fault is unlike to change the risk level of the future earthquake[2]. The temporal and spatial distribution of earthquake provides a suitable exogenous treatment for the empirical analysis. The investigation distinguishes the mainshock from the aftershock for earthquake events, and exclusively focus on the mainshock since the severity of a aftershock is usually weaker than the mainshock. Furthermore, the mainshock is more intensively referred to in media coverage than the aftershock.

3.2 Earthquake Damage and Attention

The magnitude of an earthquake is commonly measured in Richter magnitude scale (also referred as M_L, the local magnitude), which quantifies the magnitude of the energy release equivalents. As in practice of USGS, an earthquake above 5 Richter scale is considered as damageable, and a quake above six is severe. Another widely used seismic scale in earthquake hazard assessment is the modified Mercalli intensity scale (hereafter MMI) which measures the severity of seismic shaking. **Table 6** in Appendix proposes the comparison between two magnitude scale. Based on the estimation of USGS, a 6 Richter scale earthquake roughly causes a VII Mercalli intensity shaking at the epicenter. A shock at the level is destructive to buildings and infrastructures. For earthquakes above 7 Richter scale, the level VIII shaking intensity is already too severe for ordinary substantial buildings.

In China, the earthquake is the most devastating natural disaster and accounts for 54% of total facilities loss caused by the natural disasters from 1950 to 1999. The annual

[2] If considering only the mainshock

economic loss due to the earthquake is the second to the loss from climate disaster[3]. **Table 7** in Appendix reports the annual earthquake faults, damage and losses. The most serious earthquake fault during the last ten years is the 7.8 Richter scale Wenchuan Earthquake in eastern Sichuan on May 12, 2008. The direct economic loss equals to more than 70% of Beijing's GDP in 2008. These faults caused mass casualties and economic loss because the regions are densely populated and highly industrialized. Moreover, considering the rapid industrial development as well as urbanization in China, the potential damage of a similar strike in more recent period can be even more damaging.

In the light of marked seismic damage, the public is concerned about earthquake strikes, especially the devastating strikes. The searching index on Baidu.com, the premier searching engine in China, detects continual searching popularity for the term earthquake and the names of previous strikes. The index of media coverage on earthquake is more transitory. The trend is in line with the availability heuristic in that the salience boosts with media coverage while severe strikes remain impressive persistently.

3.3 Earthquake Risk Management

As above discussed, China is continuously subject to earthquake hazard. The severe earthquake strikes in the last ten years have caused severe losses. Nevertheless, specific insurance against earthquake, such as catastrophe insurance, is not prevalent nor sufficiently developed. Thereby, households and firms can only cover a partial economic loss with property insurance. It was until July 1, 2016 that the first catastrophe insurance against earthquake was launched, targeting on residential housing specifically.

In addition to the direct economics loss discussed in the previous section, firms are also subject to liquidity risk caused by the ripple reaction following the shock that hinders the production, financing, or investment process. Under the assumption that firms self-insure against natural disaster, the anticipated risk from the future disaster will serve as the primary driver of cash holdings. Mechanistically, the probability of a future earthquake strike, or the seismic hazard, is exogenous to the previous faults, if considering only the mainshock. It is also straightforward to see that the seismic hazard is exogenous to of the media coverage of recent shock. Thereby, if a firm notices earthquake hazard threatening its business, its self-insurance coverage is supposed to relate only to the probability and

[3] Source: National Bureau of Statistics of China, 2017

expected loss. The optimal insurance level should also be exogenous to previous faults or media coverage. However, if the managerial overreaction discussed by Dessaint and Matray (2016) exists in this specification, then the real life scenario will be the opposite. Given the availability heuristic, firms will retain more cash for self-insurance buffer after salient quake event happens nearby, even though the future earthquake hazard will not increase afterward.

Accordingly, this paper asks the question whether firms close to earthquake hazard areas will increase their cash holding in anticipation of a higher earthquake threaten in the future. Based on the experimental and empirical research on heuristic biases, I expect the firms will temporarily raise their cash holding as their perceived seismic hazard boosts as the results mentioned by Dessaint and Matray (2016).

4 Data Description

The primary dataset for the empirical analysis consists of the profile and fundamental information of 3426 Chinese listed firms. More specifically, the dataset includes the date of listing, headquarter location, quarterly financial reporting data, and their industrial sector category. The data are derived from GTA China Stock Market & Accounting Research (CSMAR) database, which collects the data from public financial disclosures. The data of earthquake strikes are collected from the United States Geological Survey (USGS), which releases first hand global seismic data with other seismic programs such as the Global Seismographic Network. To achieve a balance between a larger sample of listed firms and earthquake events, I set the 10-year sample period from January 1, 2007 to December, 2016. It is notable that internet and social media are gradually taking a significant proportion of communication during this period hence further enabling a stronger availability effect. Considering the differences between the large firms and the small-to-medium enterprises, I excluded firms listed in the middle-to-small board market, leaving the 1303 firms listed on main board equity markets.

4.1 Corporate Fundamental Data

The profile of listed firms is obtained from the China Listed Firms Research Series data library under CSMAR. The raw data cover the profiles of firms listed in Shanghai Stock

Exchange and Shenzhen Stock Exchange, regardless of their size of market capitalizations, hence including all listed firms in mainland China. By the end of 2016, 3260 firms remain listed and 1303 of them in main board equity market (the A shares at Shenzhen Stock Exchange and Shanghai Stock Exchange). CSMAR reports the historical reporting information of delisted firms during their listing period. To obtain a more comprehensive sample free from survivorship bias, I keep the historical records of delisted firms. Due to the small size of delisted subsample, I suppose they will not affect the conclusion. The profile contains the name, registered location, stock code, industry, establishment date, listing date, and listing exchange of each firm. The data of registered headquarter location enable the calculation of the distance between the firm and the earthquake focus.

The quarterly financial reporting data from the China Listed Firms Research Series data library are available for all the quarters since the firm went listed. In connecting financial data with the corporate profile, this paper only considers the consolidated financial data, i.e. financial situation of the group rather than the parent company. The unbalanced panel contains the financial statement data of 1,303 firms and 49,911 quarter-firm observations after removing the missing value. The panel is unbalanced due to the recent listed (delisted) firms and the missing values. The panel data are adjusted by inflation. In proxy of the liquidity buffer against natural disaster, the cash holding level is calculated as total cash holding scaled by the total asset. The actual extra cash a firm holds can be less than its total amount of cash and cash equivalents. However, as mentioned in the worldwide survey conducted by Lins et al. (2010), the non-operational cash position is positively related to the total cash position. Thus, this approximation will not impair the empirical result.

$$Cash_{i,t} = \frac{\text{Total cash and cash equivalent}_{i,t}}{\text{Total assets}_{i,t}} \tag{1}$$

The leverage level is derived by dividing the total equity divided by the total liability as the credit risk indicator.

$$Leverage_{i,t} = \frac{\text{Total liabilities}_{i,t}}{\text{Total assets}_{i,t}} \tag{2}$$

Additionally, the empirical analyses review the data of expenses spent on the property or other similar commercial insurance as well as the dividend distribution data. Both data are collected from CSMAR. The insurance expenses are reported under the administrative expenses in the notes to annual financial statements, which is available in CSMAR but only in Chinese. To exclude ambiguous terms such as expenses on social insurance or unemployment insurance, I filter administrative expenses data to exclusively property and commercial insurance. No disclosure on catastrophe insurance is found in the selected sample. Due to the annual frequency and irregular disclosure, the filtering results in a loss of observations. The insurance panel has 2780 year-firm observations. Only 596 firms report their insurance expenses for limited years mainly in 2010 and 2011. The insurance expenses are scaled by the total operating income at the end of the year for the insurance purchase ratio.

$$Insurance_{i,t} = \frac{\text{Property insurance expenses}_{i,t}}{\text{Operating income}_{i,t}} \tag{3}$$

The dividend distribution data reports the retention ratio instead of payout ratio for each quarter. In this specification, the quarterly payout ratio is simply one minus the retention ratio. Meanwhile, the quarterly payout ratio is meaningless in cross-sectional comparison, as part of the firms pay dividend twice a year while the others only once a year. As a solution, the end-of-year payout ratio is generated as the share of total pre-tax cash dividend (in CNY) to the total net income during each financial year.

$$Payout_{i,t} = \frac{\sum_{i=1}^{I=4} \text{Pre tax cash dividend}_{i,t}}{\text{Operating income}_{i,t}} \tag{4}$$

in which t is the quarter of year-end, and i is the quarter in the same year of t. Statistic summary of the characteristics of these listed firms is presented in **Appendix. Table 8**.

Additional variables of interests are the pre-tax operating income and total assets which represent the firm-level characteristics. These two variables are relavent as mentioned by Anderson and Carverhill (2011) that operating cash flow is the primary driver of corporate optimal cash holding justifies the selection of revenue indicator. Also, the result of Nilolov and Whited (2014) that small firms hold more extra cash due to a higher uncertainty and expensive external financing motivates the selection of size indicator.

4.2 Earthquake Events

The earthquake information is collected from USGS[4,5] which monitors global seismic activities in partnership with other institutions worldwide. The data points include the date, time, geographic coordinates (latitude and longitude), Richter magnitude scale, and depth of epicenter of each earthquake fault. During the 10-year period, USGS has observed 266 natural earthquakes of 5.0-5.9 Richter scale and 19 of 6.0 Richter scale or above. Following the reference of USGS, I select the severe earthquake faults with magnitude is no less than 6.0 Richter scale happened in mainland China. The USGS also releases most recent estimation of earthquake magnitude. However, the dataset applies the original estimation to keep the measure consistent with the media coverage as well as the impression at the days when the earthquake struck,

Under the 10-year sample period, 19 earthquake faults satisfy the selection criteria. Among them, two earthquakes happened soon after faults in the same location. To consolidate the earthquake events into quarterly panel dataset, I combine the records with the more severe magnitude and early date. One 6.9 M earthquake occurred on February 18th, 2010 on China-Russia-North Korea border region but was located 577.7 km under the ground. Another two strikes happened in remote depopulated area. According to the USGS, these faults has no intensity data. Thus, these events are removed. Eventually, 16 events in the list of earthquakes provided in **Table 10**.

In measuring the managerial overreaction comparing with a benchmark, this paper introduces a treatment strategy as in the practice of Dessaint and Matray (2016). The treatment distinguishes the firms into three categories according to their distance to the epicenter.

According to the availability bias theory, the most memorable information serves the major clue in decision making. Under this view, feeling the shaking adds the vividness of earthquake memory, hence enhancing the salience. When the seismic wave spreads out, the shaking intensity decreases with distance to the epicenter, so does the salience. As such, the distance matters for the treatment of availability bias. More specifically, the treatment group represents the firms headquartered close enough to the seismic center but also distant

[4] Data index:`https://earthquake.usgs.gov/data/comcat/data-eventterms.php#nst`

[5] Catalog search:`https://earthquake.usgs.gov/earthquakes/search/`

enough to avoid direct damage. The controlled group consists of the distant firms which located further away to the stricken area than the neighbor firms. I assume that the firms located too close to the epicenter will be severely impaired. Therefore, this group is assumed to be significantly different with the two other group and hence being considered separately.

Although the shaking intensity and the distance to the epicenter is negatively correlated, it is hard for the seismologist to accurately estimate the distribution of seismic severity at a specific area. It is because that the seismic wave does not travel equal distance or cast equal shaking in all the direction (as illustrated in **Figure 2**). In practice, USGS reports the detected intensity distribution for each earthquake event. This empirical distance-intensity relation serves as an approximation for the "intensity radius" estimation for the treatment.

In the treatment, firms subject to shaking intensely no less than V MMI are classified into the stricken groupe. Although the "stronger shaking" intensity of VI MMI is more likely to cause a considerable loss, I think a threshold of V MMI shaking intensity is more suitable. In that it is hard to distinguish the affected and neighbor firms by location, a larger scope eliminates the possibility of mistakenly exclude a stricken firm from the stricken group. Since a shaking below V MMI causes minor effect, I distinguish the treatment group from unaffected with the distance corresponding to V MMI. In general, the treatment group located 50 km to 1200 km away to the epicenter. Among the earthquakes event, the Wenchuan Earthquake is M7.8 has the largest scope of treatment group extends to 1200 km to the epicenter. The threshold distances are consistent with the baseline observed by Atkinson and Wald (2007) on "Did you feel it" report date from California and East and Central US in **Figure 3**.

The distance between the headquarter and the epicenter is derived from the geographic coordinates data, i.e. the longitude and latitude. The method returns the great-circle distance which is the shortest distance between two points on the spherical surface. For example, one headquarter and one epicenter locate in point A and B respectively, then the great-circle distance between A and B is calculated as follow:

$$Distance_{A,B} = R \times \arccos[\sin(w_A)\sin(w_B) + \cos(w_A)\cos(w_B) \times \cos(j_A - j_B)] \tag{5}$$

in which: R=6371.004 km, notes the approximate Radius of the Earth, and

$$
\begin{aligned}
w_A &= lat_A \times \tfrac{\pi}{180} && \text{notes the radian of the latitude of A} \\
w_B &= lat_B \times \tfrac{\pi}{180} && \text{notes the radian of the latitude of B} \\
j_A &= lon_A \times \tfrac{\pi}{180} && \text{notes the radian of the latitude of A} \\
j_B &= lon_B \times \tfrac{\pi}{180} && \text{notes the radian of the latitude of B}
\end{aligned}
$$

The coorindates of earhtquakes are obtained from USGS and the coordindates of listed firms via Google map Geocoder service[6].

Ultimately, the firms are classified into three categories: the stricken group (hereafter stricken firm), the treatment groups (hereafter neighbor firm), and the control group (hereafter faraway firm). The map in **Figure 4** presents the headquarter of listing firms as well as the epicenter of earthquakes during the sample period. **Table 10** summarizes the number of struck and neighbor firms. The numbers of affected firms depend on the seismic magnitude as well as the population and industrial density of the faults' location. Eastern Sichuan Province is densely populated and highly industrialized. Thus, the serious earthquakes in 2008 and 2014 struck hundreds of firms. Xinjiang and Qinghai have much lower density. Hence fewer firms were affected.

5 Empirical Analyses and Results

The method of proxying perceived risk with cash holding enables empirical analysis to capture the relation between recent earthquake events and the managerial perception of future earthquake hazard. As in the practice of Dessaint and Matray (2016), this thesis proposes fixed-effect panel regression and difference-in-difference analysis to test following hypotheses:

H1: Firms increase their excess cash holding in response to a salient earthquake occurs nearby;

H2: The increase of cash holding, if any, is persistent;

H3: The temporary increase of cash holding tend to disappear over time;

H4: The increasing of extra cash, if any, leads to a lower payout ratio.

[6]Achieved with the online resolver: http://map.yanue.net/

The following models will be applied to test the first three hypotheses responsively:

$$Cash_{i,t} = \beta Neighbor_{i,t-1} \times Mag_{i,t-1} + \theta Strike_{i,t-1} \times Mag_{i,t-1} + \gamma X_{i,t-1} + FE_{i,t} + \varepsilon_{i,t} \quad (6)$$

$$\begin{aligned} Cash_{i,t} = &\beta Neighbor_{i,t-1} \times Mag_{i,t-1} + \sum_{q=1}^{q=N} \lambda closeq_{i,t-1} + \\ &\theta Strike_{i,t-1} \times Mag_{i,t-1} + \gamma X_{i,t-1} + FE_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (7)$$

$$\begin{aligned} Cash_{i,t} = &\beta Neighbor_{i,t-1} \times Mag_{i,t-1} + \phi Neighbor_{i,t-1} \times Mag_{i,t-1} \times Exp^{T}_{i,t-1} + \\ &\theta Strike_{i,t-1} \times Mag_{i,t-1} + \gamma X_{i,t-1} + FE_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (8)$$

in which i is the index of companies and t is the index of the quarter. $Cash_{i,t}$ notes the cash holdings in the percentage of total assets of company i in quarter t. $FE_{i,t}$ notes the fixed-effects which capture the cross-sectional heterogeneity of cities and quarters, locations and industrial sectors. $X_{i,t}$ stands for the controlled variables for firm's characteristics, including lagged cash holding level, log term of total assets and the leverage ratio of firm i at period t. Explanatory variable for the treatment $Neighbor_{i,t}$, as well as $Strike_{i,t}$, notes the neighborhood firms and the stricken firms at period t respectively. To eliminate the issue of collinearity, I use the the cross term of event dummy and the magnitude scale $Mag_{i,t}$ of earthquake event. The dummy close$q_{i,t}$ equals to 1 if a quake occurred in last q quarters. The quarter indicator q ranges from 1 to 12. In the regression, the value 1,2,4,8,and 12 is selected, to capture the persistent impact for one month, half year, one year and two years. The dummy variable $Exp_{i,t}$ denotes the previous experience. If a firm i has never be assigned to neighbor or stricken firm before quarter t, the dummy $Exp_{i,t}$ equal to 0, otherwise 1.

In the preliminary regression model, the load on Neighbor treatment, β , is the coefficient of major interest. If the managers do overreact to severe earthquake occurrence nearby, β is expected to be positive and significant. Model 2 includes the lag term of the treatment variables, $Neighbor_{i,t-1}$, and $Strike_{i,t-1}$, to detect if an earthquake event has a persistent impact on firm's cash holding level. In the light that the availability bias decays as the memory becomes less retrievable, hypothesis H2 assumes that the memory of earthquake in neighborhood area is short-lived. If the availability heuristic drives the cash holding after earthquake strikes neighborhood area, then the load on lagged neighbor treatment should be also positive but less aggressive than the unlagged. In model 3, the independent variable, $Exp_{i,t}$ forms the interaction terms of earthquake treatment and the historical quake experience. As aforementioned, no firm is stricken twice during the sample period. Thus, the experience variable notes only whether a firm witnesses a shock strikes nearby region before. If managers learn from the previous earthquake and calibrate their perceived risk to the real probability, the coefficient of experience term would be significantly detrimental.

Additionally, the analysis testifies hypothesis H4 by estimating the difference-in-difference of payout ratio between the treatment group and the control group. As revealed in the empirical results, the availability bias exists in managerial overreaction in response to severe earthquakes nearby. Moreover, such overreaction is transitory but persistent and perennial. Ultimately, such bias leads to higher extra cash holding level and lowers payout ratio comparing with the normal of neighbor firms and the controlled group.

5.1 Evidence for Self-insurance and Overreaction

The previous investigations on managerial overreaction on salient natural disaster assume that firms self-insure against the liquidity risk of natural disaster with extra cash. This hypothesis ignores the alternative hedging method of catastrophe or other commercial insurance. In confirmation of this presupposition, this paper reviews the property and commercial insurance expenses before processing the preliminary hypothesis.

Among the 1303 firms in the sample, only 596 of them report the expenses on property insurance in their annual reports. The rest 707 firms do not disclose considerable insurance expenses at all. Moreover, no firm reports expenses on catastrophe insurance. In fact, catastrophe insurance product is still not prevailed in China. The mainstream insurance products are still limited to property insurance, life insurance, health insurance, and accident insurance. It was until July 1, 2016 that the Insurance Regulation Committee (CIRC) and the Ministry of Finance released the first implementation program for catastrophe insurance, which targets only on residential buildings against earthquake[7].

Comparing with the full sample, which contains 287 neighbor firms and 133 stricken firms, only 88 neighbor firms and 77 stricken firms report property insurance expenses. Even among the firms reporting insurance expenses, the disclosure is inconsistent and dis-

[7] Source:`http://english.gov.cn/news/top_news/2016/07/03/content_281475385162162.htm`

continuous. In addition to the irregular reporting, the insurance coverage is quite insufficient. The median growth of insurance expenses is as negative as -1.6% after adjusting for inflation. The fixed-effect panel regression on property insurance coverage indicates that property insurance expenses have no significant relation to earthquake events.

The fixed-effect regression in model 1 conveys the logic of difference-in-difference method. The left-hand-side is the dependent variable: the cash holding level measured by the share of cash holding relate to the total assets. The right-hand-side is the the treatment variables and the controlling variables. More specifically, the firm characteristic measures in the previous quarter and fixed effects to control endogenous issues. The firm characteristic measures include logged total assets, leverage ratio, and operating income in the previous period. The characteristic measures are lagged since it takes time to adjust the financial structure. The fixed effects cover the idiosyncratic level of firms, headquarter locations, reporting periods, and industrial sectors. The dummy variables, neighbor and stricken, distinguish the firms affected by earthquake events from the far-away ones in quarter t with earthquake event(s). The dummy is similar to the interaction variable of treatment and post-earthquake in difference-in-difference (DiD) regression. The level of treatment effect pre-earthquake is already absorbed by location fixed-effect. Moreover, in the model the interaction of neighbor(stricken) dummy and magnitude of earthquake event is applied to avoid collinearity.

The fixed-effect regression results reject the null hypothesis of H1. The results in **Table 1** indicate that the neighbor firms increase the extra cash holding after a salient earthquake happens. Controlling firm's characteristics and fixed-effects, the coefficient on the neighbor-magnitude cross term is 0.12%. Scaled up with the magnitude of quake event, the impact will be 0.72% of the total assets or above. Thus, the estimated impact on neighbor firms equals to an extra cash position of 218,664 CNY for a sample firm with the median scale of 30.37 million CNY. The increase of cash holding is equivalent to 0.54% of the cash position standard deviation. The coefficient on struck treatment is insignificant but positive, probably because of the limited observation. Alternative rationale is that large scope for treatment selection misclassifies neighbor firms into the affected group.

A problem with the result is that the quake in May 2008 is extremely destructive, hence it may dominate the impact on managerial reaction. As such, estimation (4) excludes this event from the observations. The impact on the treatment group remains significant, thus this extreme event does not weaken the conclusion. As in the practice of previous studies, I also propose another two estimations which excludes (keeps) firms from cash-intensive sectors, i.e., finance, utilities and real estates, from the observation. The overreaction is even more aggressive for non-cash-intensive sectors, while no significant effect is detected in the cash-intensive sectors.

In addition to the regression on the full sample, I replicate the regression by the scale of total assets and by the leverage ratio. The results in **Table 2** find positive and significant impact on neighbor firms with small-to-medium scale or median-to-high leverage. The impact on large-scale firms and low-leverage firms is insignificant. The estimations for scale-by-leverage subgroup reported in **Appendix Table 12** also point to the same conclusion. This conclusion is in line with the research of Nilolov and Whited (2014) that the cash holding of small-scale firms is more sentimental to uncertainty. One possible explanation is that small size firms are more fragile to liquidity risk, making potential earthquake event more costly for them. The same vein goes to high leveraged firms, which are subject to higher liquidity risk as well as credit risk. On the other hand, firms with lower credit risk and larger scale is less sentimental to exogenous risks from earthquake.

Comparing with the domestic shocks, earthquake events abroad are more exogenous to firm's cash holding level and enable a more concrete investigation. The earthquakes in Tōhoku, Japan earthquake, Kumamoto, Japan earthquake, Gorkha, Nepal earthquake, and Chiloé, Chile are the most intensively reported strikes according to the searching trends on Google and Baidu. Information of these quakes are presented in **Appendix Table 13**. More particularly, the four events are exclusively mentioned in preannouncement of listed firms. Supposing that the overreact to severe earthquake is systematic, quake events abroad would cast positive impact on the average cash holding of all the firms. A domestic earthquake and an earthquake in foreign country can happen in the same quarter. To disentangle the impact from the coincidence, I introduce the dummy variable of the abroad quakes along with treatment variables in model 1.2. Another critical adjustment is required as the treatment of overseas quakes absorbs the original period effect in the same quarter. As a solution, in model 1.2 the quarterly period effect is replaced by the annual and seasonal effect. The model returns similar estimations as in a difference-in-difference-in-difference

Table 1: Impact Estimated with Full Sample

This table reports the impact of earthquake on the cash holding level of far-away, neighbor, and stricken firms. The categories of firm is assigned according to their distance to earthquake epicenter, the center of the shake. $Cash_{i,t}$ notes the quarterly cash holding level, which is calculated as the share of cash to the total assets in percentage. The firm characteristic variables include the lagged operating income, scaled by total assets, $OpIncome_{i,t-1}/TA_{i,t-1}$, the corresponding quarterly leverage ratio $Leverage_{i,t-1}$ and lagged log term of total asset scale $log(TA_{i,t-1})$. Dummy variable $Neighbor_{i,t-1}$ equals to 1 if a severe earthquake strikes in quarter t and the headquarter of firm i located in region exposed to I MMI - IV MMI intensity; it applies similarly to $Struck_{i,t-1}$ which equals to 1 if the headquarter located in regions subject to V MMI or above shaking intensity. $Mag_{i,t-1}$ notes the Richer degree magnitude of quake events and in our sample $Mag_{i,t-1} > 6$ because of the aforementioned definition of severe earthquake. The models use the cross term of firm category and earthquake magnitude to capture the impact of quake events. (1) is the estimation to total sample. Estimation (1) and (2) report the results for full sample. For estimations on the sub samples, (3) presents results for sample excluded the M7.9 Wenchuan earthquake. (4) and (5) reports the estimation for excluded cash-intensive sectors sub sample and cash-intensive sectors sub sample respectively.

	Dependent variable: $Cash_{i,t}$				
	Full sample		Sub-sample		
	(1)	(2)	(3)	(4)	(5)
$\text{Neighbor}_{t-1} \times \text{Mag}_{i,t-1}$	0.125**	0.122**	0.131**	0.135**	0.063
	(0.052)	(0.052)	(0.056)	(0.054)	(0.149)
$\text{Struck}_{i,t-1} \times \text{Mag}_{i,t-1}$	0.016	0.032	−0.042	−0.021	0.488
	(0.236)	(0.233)	(0.372)	(0.244)	(0.680)
$\text{OpIncome}_{i,t-1}/\text{TA}_{i,t-1}$		2.475***	2.451***	2.047***	8.382***
		(0.135)	(0.137)	(0.140)	(0.549)
$\text{Leverage}_{i,t-1}$		0.001	0.0005	0.0004	0.001
		(0.0004)	(0.0004)	(0.0004)	(0.001)
$\log(\text{TA}_{i,t-1})$		−1.116***	−1.138***	−0.730***	−2.162***
		(0.041)	(0.042)	(0.048)	(0.087)
FE	Yes	Yes	Yes	Yes	Yes
Observations	48,608	48,603	47,361	40,142	8,461
R^2	0.111	0.130	0.131	0.143	0.221
Adjusted R^2	0.105	0.124	0.125	0.136	0.211
F Statistic	22.252***	26.341***	25.853***	25.063***	34.904***

Standard errors in parentheses

*p<0.1; **p<0.05; ***p<0.01

Table 2: Impact from Domestic Earthquake Events by Scale and Leverage

This table reports the individual impact of earthquake on the cash holding level by leverage and scale of the firm. The categories of firm is assigned according to their distance to earthquake epicenter, the center of the shake. $Cash_{i,t}$ notes the quarterly cash holding level, which is calculated as the share of cash to the total assets in percentage. The firm characteristic variables include the lagged operating income, scaled by total assets, $OpIncome_{i,t-1}/TA_{i,t-1}$, the corresponding quarterly leverage ratio $Leverage_{i,t-1}$ and lagged log term of total asset scale $log(TA_{i,t-1})$. Dummy variable $Neighbor_{i,t-1}$ equals to 1 if a severe earthquake strikes in quarter t and the headquarter of firm i located in region exposed to I MMI - IV MMI intensity; it applies similarly to $Struck_{i,t-1}$ which equals to 1 if the headquarter located in regions subject to V MMI or above shaking intensity. $Mag_{i,t-1}$ notes the Richer degree magnitude of quake events and in our sample $Mag_{i,t-1} > 6$ because of the aforementioned definition of severe earthquake. The models use the cross term of firm category and earthquake magnitude to capture the impact of quake events. Panel A reports the estimation by leverage, where (1) notes the subgroup with lowest leverage. Panel B reports the estimation by scale of total assests, where (1) notes the subgroup with lowest scale.

	Dependent variable: $Cash_{i,t}$					
	Panel A: By leverage			Panel B: By scale		
	(1)	(2)	(3)	(1)	(2)	(3)
$\text{Neighbor}_{i,t-1} \times \text{Mag}_{i,t-1}$	0.036	0.126*	0.198**	0.173*	0.200***	−0.037
	(0.098)	(0.076)	(0.082)	(0.092)	(0.073)	(0.088)
$\text{Struck}_{i,t-1} \times \text{Mag}_{i,t-1}$	0.392	0.111	−0.353	0.103	0.096	−0.018
	(0.479)	(0.327)	(0.356)	(0.416)	(0.324)	(0.398)
$\text{OpIncome}_{i,t-1}/\text{TA}_{i,t-1}$	2.922***	3.523***	1.732***	3.356***	2.699***	1.315***
	(0.313)	(0.239)	(0.186)	(0.290)	(0.204)	(0.202)
$\text{Leverage}_{i,t-1}$	−0.001	−3.021***	0.004***	0.0004	−2.226***	−2.271***
	(0.001)	(0.352)	(0.001)	(0.0004)	(0.097)	(0.123)
$\log(\text{TA}_{i,t-1})$	−1.287***	−0.419***	−0.515***	−2.446***	−0.537**	−1.437***
	(0.099)	(0.069)	(0.066)	(0.152)	(0.259)	(0.107)
FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,207	16,190	16,206	16,203	16,192	16,208
R^2	0.201	0.191	0.190	0.184	0.239	0.264
Adjusted R^2	0.188	0.177	0.177	0.171	0.227	0.254
F Statistic	17.791***	14.983***	16.732***	17.189***	22.528***	30.552***

Standard errors in parentheses

*p<0.1; **p<0.05; ***p<0.01

(DDD) model which captures the impact from quake event abroad on top of the impact from the domestic quake. The results suggest that the quake events abroad does not change the explaining power nor positive impact of domestic quake events. The average cash holding level of full-sample firms increase attributing to domestic strikes is more significant after including the abroad quake events in the system. Moreover, the quake events abroad add 0.4% increase in the cash holding to total assets, additional to the 0.7% absolute change in reaction to domestic quakes.

5.2 Evidence for Reaction drifting

Model 2 testifies the hypothesis whether the overreaction is persistent over time. The model structure is much in line with model 1. The only difference is that the dummy variable denoting lagged treatment. In the model, the dummy close$q_{i,t}$ equals to 1 if a quake occurred in last q quarters. The quarter indicator q ranges from 1 to 12. If managerial overreaction diminishes as the salience of earthquake decays, the coefficients on lagged treatment should be positive but decrease over time. Otherwise, a constant overreaction in contrast to Dessaint and Matray will point to the "life-long" effect of salient risk as discussed by Bernile et al. (2017).

Although the coefficients on persistent terms are not statistically significant, the estimates are economically significant. Consistent with Dessaint and Matray (2016), the results in **Table 3** imply that, the firms tend to increase of cash holding continually but to a lower degree in each period onward after the salient strike in nearby area. The difference between close_8 and close_{12} is also interesting since it implies that the overreaction is persistent for as long as 8 quarters but not extends to previous 12 quarters. This systematic difference points to the argument that the cash holding is indeed an overreaction instead of rational calibration.

5.3 Impact from Experience

As demonstrated in Figure 4, a firm may experience more than one severe earthquake strike. During the 10-year period, 141 firms have witnessed more than once earthquake in the neighbor region, while no firm has experienced strikes more than once. To investigate if experience accounts for any difference in firms' behavior, I repeat the regression in model 1 including the treatment of previous earthquake experience in addition to the treatment

Table 3: Evidence on Persistent Overreaction

This table reports the persistent impact of earthquake on the cash holding level of the neighbor firms. Observations from finance, utilities and real estates are omitted from theregression. The categories of firm is assigned according to their distance to earthquake epicenter, the center of the shake. $Cash_{i,t}$ notes the quarterly cash holding level, which is calculated as the share of cash to the total assets in percentage. The firm characteristic variables include the lagged operating income, scaled by total assets, $OpIncome_{i,t-1}/TA_{i,t-1}$, the corresponding quarterly leverage ratio $Leverage_{i,t-1}$ and lagged log term of total asset scale $log(TA_{i,t-1})$. Dummy variable $Neighbor_{i,t-1}$ equals to 1 if a severe earthquake strikes in quarter t and the headquarter of firm $i$located in region exposed to I MMI - IV MMI intensity; it applies similarly to $Struck_{i,t-1}$ which equals to 1 if the headquarter located in regions subject to V MMI or above shaking intensity. $Mag_{i,t-1}$ notes the Richer degree magnitude of quake events and in our sample $Mag_{i,t-1} > 6$ because of the aforementioned definition of severe earthquake. The dummy close$q_{i,t-1}$ equals to 1 if a quake occurred in last q quarters. The quarter indicator q ranges from 1 to 12. The models use the cross term of firm category and earthquake magnitude to capture the impact of quake events. Each estimation denotes a regression for a lagged period, from 1 quarter to 12 quarters.

	Dependent variable: $Cash_{i,t}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{Neighbor}_{i,t-1} \times \text{Mag}_{i,t-1}$	0.132*	0.130*	0.136*	0.138*	0.197*	0.190*
	(0.076)	(0.076)	(0.077)	(0.077)	(0.108)	(0.108)
$\text{close1}_{i,t-1}$		0.354				
		(0.485)				
$\text{close2}_{i,t-1}$			0.430			
			(0.370)			
$\text{close4}_{i,t-1}$				0.381		
				(0.289)		
$\text{close8}_{i,t-1}$					0.320	
					(0.262)	
$\text{close12}_{i,t-1}$						−0.315
						(0.284)
$\text{Struck}_{i,t-1} \times \text{Mag}_{i,t-1}$	−0.026	−0.028	−0.037	−0.036	−0.078	−0.025
	(0.244)	(0.244)	(0.246)	(0.245)	(0.389)	(0.392)
Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
FE (incl. occurrence)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	40,142	39,068	37,995	35,855	31,575	27,318
R^2	0.143	0.145	0.146	0.150	0.189	0.198
Adjusted R^2	0.136	0.138	0.139	0.143	0.182	0.190
F Statistic	25.049***	24.673***	24.241***	23.529***	27.468***	25.217***

Standard errors in parentheses

*p<0.1; **p<0.05; ***p<0.01

of current earthquake event. The variables for earthquake experience are the interaction of previous experience with current treatment of neighbor firm. In the case that a firm was previously a stricken and neighbor firm, the most severe experience will be considered as a previously stricken firm. The experience treatment distinguishes the impact of the earthquake on the first-time neighbor from experienced firms as well as the far-away firms which have not experienced any earthquake during the sample period.

In contractionary with Dessaint and Matray's result, the regression result in **Table 4** suggests that firms perennially overreact to salient earthquakes even after they have experienced an earthquake before. It indicates that managers will not learn from the experience over time or correct their perception. Although the inexperienced neighbor firms increase the cash holding by only 0.2% in relative to their total assets, the experienced neighbor firms react more aggressively and significantly with a net reaction to the earthquake of 0.73%. By further decomposing the experienced subgroups, the regression finds that even the most experienced firm significantly overreacts to similar quake events. The research of Dessaint and Matray (2016), in contrast, finds that the experienced neighbor firms overreact less aggresively to a salient earthquake than the non-experienced treatment. It could be that managers are learning from previous neighbor earthquakes and calibrating their perceived hazard risk to a more "rational" level. Whereas, my results suggest an alternative case. A conceivable explanation is that new strike confirms the managerial perception that earthquake is more likely to happen after previous strikes. As shown in the estimation, a new strike in closer period is more like to cause significant overreaction. Accordingly, repetitive strikes indeed enforce the salience of earthquake and reinforce the managers' perception.

5.4 Impact on Dividend Payout Ratio

Although the increase of cash holding is transitory, it takes time for the cash holding to convert to pre-earthquake level. The suboptimal extra cash holding will not only constraints R&D investment and acquisition opportunities for future growth but also cash dividend. Eventually, the unduly cash buffer results in to substantial cost to the shareholders.

The difference-in-difference analysis reviews the dividend payout ratio of 287 neighbor firms. The results in **Table 5** reveals that the cost of the overreaction discussed above is both significant and pronounced. After severe earthquake events, the neighbor firms pay 7% less cash dividend out of their net income than the controlled group with similar

Table 4: Effect on Earthquake Experience

This table reports the persistent impact of earthquake on the cash holding level of the neighbor firms. Observations from finance, utilities and real estates are omitted from the regression. The categories of firm is assigned according to their distance to earthquake epicenter, the center of the shake. $Cash_{i,t}$ notes the quarterly cash holding level, which is calculated as the share of cash to the total assets in percentage. The firm characteristic variables include the lagged operating income, scaled by total assets, $OpIncome_{i,t-1}/TA_{i,t-1}$, the corresponding quarterly leverage ratio $Leverage_{i,t-1}$ and lagged log term of total asset scale $log(TA_{i,t-1})$. Dummy variable $Neighbor_{i,t-1}$ equals to 1 if a severe earthquake strikes in quarter t and the headquarter of firm $i$located in region exposed to I MMI - IV MMI intensity; it applies similarly to $Struck_{i,t-1}$ which equals to 1 if the headquarter located in regions subject to V MMI or above shaking intensity. $Mag_{i,t-1}$ notes the Richer degree magnitude of quake events and in our sample $Mag_{i,t-1} > 6$ because of the aforementioned definition of severe earthquake. The models use the cross term of firm category and earthquake magnitude to capture the impact of quake events. Estimation (1) is the primary model in Section 5.1. Estimation (2) decomposes the neighbor group into inexperienced $\text{Exp0}_{i,t-1}$ and experienced subgroups $\text{Exp}_{i,t-1}$. Estimation (3) further divides the experienced into those have only one experience $\text{Exp1}_{i,t-1}$ and the rest with more experience $\text{Exp2}_{i,t-1}$. Estimation (4) includes a persistent term close_8, which absorbs the lingering impact for experienced group.

	Dependent variable: $Cash_{i,t}$			
	(1)	(2)	(3)	(4)
$\text{Neighbor}_{i,t-1} \times \text{Mag}_{i,t-1}$	0.132*			
	(0.076)			
$\text{Neighbor}_{i,t-1} \times \text{Mag}_{i,t-1} \times \text{Exp0}_{i,t-1}$		0.035	0.035	0.162
		(0.118)	(0.118)	(0.435)
$\text{Neighbor}_{i,t-1} \times \text{Mag}_{i,t-1} \times \text{Exp}_{i,t-1}$		0.153		
		(0.104)		
$\text{Neighbor}_{i,t-1} \times \text{Mag}_{i,t-1} \times \text{Exp1}_{i,t-1}$			0.085	0.033
			(0.151)	(0.190)
$\text{Neighbor}_{i,t-1} \times \text{Mag}_{i,t-1} \times \text{Exp2}_{i,t-1}$			0.210	0.214
			(0.137)	(0.134)
$\text{Struck}_{i,t-1} \times \text{Mag}_{i,t-1}$	−0.026	−0.061	−0.063	−0.086
	(0.244)	(0.246)	(0.246)	(0.389)
$\text{close8}_{i,t-1}$				0.561**
				(0.280)
Characteristics	Yes	Yes	Yes	Yes
FE (incl. occurance)	Yes	Yes	Yes	Yes
Observations	40,142	40,142	40,142	31,575
R^2	0.143	0.143	0.143	0.190
Adjusted R^2	0.136	0.136	0.136	0.182
F Statistic	25.049***	24.455***	24.366***	26.739***

Standard errors in parentheses

*p<0.1; **p<0.05; ***p<0.01

characteristics. The difference is even more substantial within the treatment group. At the sight of a salient earthquake, the neighbor firms pay 18% less dividend than they normally pay. The decrease remains as substantial as 11%-16% of annual net income after deducted parallel effect without quake event. It is clear that salient earthquakes cast a negative impact on the dividend policy of neighbor firms, while such impact does not exist on matched far-away firms during the same period. The impact is notable and equals to a 2,983,200 CNY decrease in cash dividend, if measured by the median net income of 49,720,000 CNY for treatment group. It is even striking that the dividend decrease is more than 10 times larger than decrease in cash holding. It appears that the self-insurance buffer does not just subtract the same amount of cash from the dividend distribution. Instead, the impact spills over from a simple dividend deduct to a more conservative growth and lower performance results. The results indicate that the excess buffer against future earthquake events engenders extra costs far more than the self-insurance expenses to the shareholders. Furthermore, the extra cash holding increase is based on the overestimated future risk of severe earthquake shock and lack of rationale. Thereby, the irrational extra cash holding is not only unnecessary but also expensive.

Table 5: Difference in Difference on Payout Ratio

This table reports the results of difference-in-difference comparison on payout ratio. The treatment group is neighbor firms, the baseline is the matched pairs randomly selected from matched faraway firms. Employing paired t-test.

	Faraway firm	Neighbor firm	Neighbor - Faraway
Quake quarter	0.215	0.145	-0.07*
			(-2.21)
Quarter without quake	0.22	0.26	0.04
			(0.33)
Quake - Without quake	-0.005	-0.18*	-0.175*
	(-0.22)	(-1.75)	(-1.67)

t-value in parentheses

* indicates significance at $p < 0.05$

6 Discussion

This section provides additional discussions on the analyses methods as well as the results. The discussions mainly focus on the exogenous influence of insurance purchasing and the random sampling for difference-in-difference comparison. Besides these two issues, it could be argued that the cash increase is driven by rational motivations such as a geographic spillover effect or the "disruptive innovation" opportunity. Evidence from financial pre-announcement during the sample period, however, shows that negative forecasts overwhelms positive forecasts after earthquake strikes. Thus, such growth opportunity is indeed negligible. One may also argue that this paper fails to consider the potential impact from agency issue. Nevertheless, this concern will not weaken the conclusion. As mentioned by Nilolov and Whited (2014), agency issue is weakly linked with cash holding in small-sized firms. Thus, the significant evidence on small-scale subgroup has already eliminated the alternative causal link of agency issue.

6.1 Insurance Expenses

In model 1, the firm characteristic variables do not include the expenses for property and commercial insurance. It is mainly because that the annual insurance data, together with missing value, limit the observations. Also, the insurance expenses present the aggregate premium for all types of property insurance contracts. Thereby, it is hard to measure insurance coverage precisely with limited data. Meanwhile, as a direct hedge against property loss, the insurance expenses might still be an essential protection against perceived liquidity risk, at least for the firms which disclosure the insurance expenses. The robust test in **Appendix Table 14** confirms the validity of the self-insurance assumption. The regression includes the insurance purchase ratio as an independent variable in the system with an annual panel data as well as annual quake event treatment. The insurance purchase behavior does not diminish the influence of earthquake event on neighbor firms. Property insurance purchasing does not contribute significant scale of explanatory power to the original model either. Nonetheless, stricken firms with higher insurance expenses turn out to hold higher cash at the end of the year, which can result from the hedging benefit.

6.2 Match pair analysis

The analysis in Section 5.4 compares the payout ratio of 287 neighbor firms with 534 matched far-away firms. The matched pairs are randomly selected from the same subgroup of total assets, leverage, and lagged cash holding level during each event quarter. Despite the random sampling, the results from only one matched pair group might be not representative. For a more robust evidence, I repeat the difference-in-difference comparison with 500 random samplings to eliminate potential bias from coincidence. The difference-in-differences obtained from the samplings are in conformity with **Table 5** that neighbor firms pay out less cash dividend one quarter after the quake events than the case without an earthquake. In this specification, the payout ratio of neighbor firms is 7.3% less than the case of distant firms after earthquake events after subtracting parallel differences. Among the 500 samplings, 254 (50.7%) of them find such negative difference at a 5% significant level, and 402 (80.2%) of them at a 10% significant level. The decrease measured by difference-in-difference is -9.2% on condition of sampling at a 5% significant level, and -8.2% at a 10% significant level. Accordingly, the sample selection does not impair the conclusion from the matched pair comparison.

In further robustness test, I restructure the subgroups by shrinking the steps of two tails to avoid mismatching the outliers with general samples. The detailed intervals are set as percentiles of 10%, 30%, 50%, 70%, 90% and 100%. In this specification, among the 500 random samplings the treatment group pays 7.2% less dividend than the controlled group net of parallel effect attributing to earhtquake events. 213 (42.5%) of the samplings find a conditional average difference-in-difference of -9.5% at a 5% significant level, and 349 (70%) of them reports a conditional average of -8.4% at a 10% significant level. The numbers of significant evidences are fewer than the original specification. Whereas, a more strict matching criteria does not weaken the conclusion. Overall, the decrease of cash dividend payout remains strong and significant for the treatment group.

7 Conclusion

Previous research suggests that managers are not always rational. Instead, they build the financial decisions on biased estimations. In the context of earthquake strikes, the recent salient shock does not lead to a higher seismic risk in the future. Thus, a rational manager will not increase the cash holding as self-insurance buffer according to the rational agent hypothesis. By contrast, the exercises on 1303 China mainboard-listed firms provide strong evidence to that firms overreact to severe earthquakes in the neighbor areas by substantially increasing the cash holding. The overreaction is not unique towards domestic earthquakes but also exists for quake events abroad with intensively reports For the shareholders, it is costly to temporally increase extra cash for self-insurance because the extra cash holding not only deducts cash dividend but also constrains current performance and even future growth.

The evidence from the earthquake is consistent with the research of Dessaint and Matray (2016) on managerial behavior from hurricanes. They unearth that managers tend to overestimate the risk of liquidity linked to a natural disaster. Meanwhile, this paper contributes to previous research by providing evidence supporting the assumption of self-insurance practice which is critical to previous research design. Moreover, the results uncover that the overreaction costs shareholders far more than the self-insurance buffer. In this light, my finding calls for an economical way to manage the risk of salient natural disaster. with respect to firms located in hazard areas, the managers need to know more about disaster hazard and try to limit the exposure. It is worth stressing that catastrophe insurance may be a better option to hedge natural disaster risk and replace the expensive self-insurance.

Overall, this paper detects the average degree of managerial overreaction towards salient risk and the subsequent costs. In the case of earthquake risks, the mechanism remains blur that how the over self-insurance behavior erodes cash dividend. In anticipation, the extra cash for self-insurance will limit R&D investment and acquisition opportunities, while further analysis is needed to understand this causal link, especially for a long-run evolving. For further light on this biased decision, it is worth to investigate if over-insurance exists in managerial insurance purchasing decision generally with more specific data, especially the insurance coverage based on the contract rather than insurance expenses. Finally, regarding the learning process, repeating the research with earthquake intensive region, such as Japan, will allow further understanding about the link between managerial overreaction and sentiment to earthquakes.

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Appendix

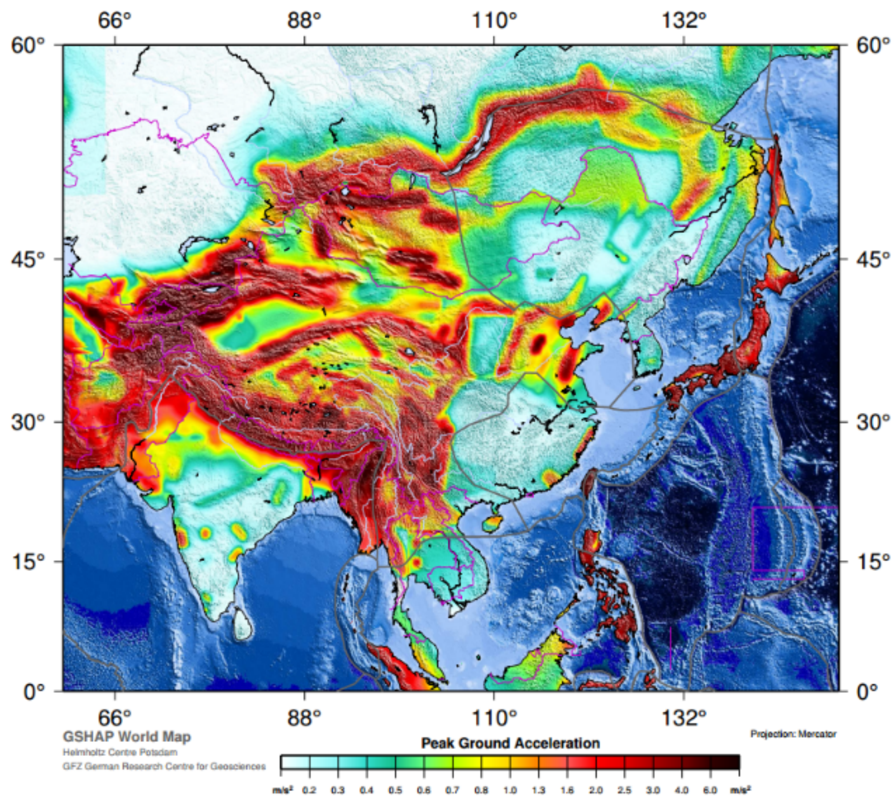

Figure 1: The Seismic Hazard Map

Source: created with Global Seismic Hazard Assessment Program (GSHAP) Data and Mapping tool
`http://gmo.gfz-potsdam.de/pub/GSHAP_Map_Online/gshap_map_online_frame.html`.
The pink lines show the political region border, and the gray lines show the plates boundaries. The hazard stands for shaking level, rather than the likelihood of earthquake fault, at a chance of 10% exceedance or 90% critical interval. The parameter in the map is peak ground acceleration (PGA), which notes how aggressively the earth shakes at a given geographic point.

Table 6: USGS Magnitude/Intensity Comparison Table

MMI	Description	M_L	Observations
I	Instrumental	1-2	Detected only by seismographs
II	Feeble	2-3	Noticed only by sensitive people
III	Slight	3-4	Resembling vibrations caused by heavy traffic
IV	Moderate	4	Felt by people walking; rocking of free standing objects
V	Rather strong	4-5	Sleepers awakened and bells ring
VI	Strong	5-6	Trees sway, some damage from overturning and falling object
VII	Very strong	6	General alarm, cracking of walls
VIII	Destructive	6-7	Chimneys fall and there is some damage to buildings
IX	Ruinous	7	Ground begins to crack, houses begin to collapse and pipes break
X	Disastrous	7-8	Ground badly cracked and many buildings are destroyed. There are some landslides
XI	Very disastrous	8	Few buildings remain standing; bridges and railways destroyed; water, gas, electricity and telephones damaged
XII	Catastrophic	8+	Total destruction; objects are thrown into the air, much heaving, shaking and distortion of the ground

Source: USGS.

M_L notes the local magnitude, i.e. the Richter magnitude scale, which is based on the energy release equivalents of the earthquake. MMI stands for the Mercalli intensity scale which gauges the shaking severity, thus is more direct measure of earthquake hazard. The comparison is rough and limited to the same location. In USGS' references, 6 Richter scale earthquake is serious and roughly causes a VII Mercalli intensity shaking severe enough to destroy normal buildings.

Table 7: Earthquake hazard and damage in China[1], 2007-2016

	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007
Earthquakes[2]										
M 5.0-5.9	8	13	14	10	8	11	4	5	6	1
M 6.0-6.9	4	1	4	3	3	2		2	4	1
M7.0+			1	1		1	1		2	
Casualties	51	813,000	3,666	15,965	1,279	540	13,795	407	446,293	422
Fatalities	2	30	623	294	86	32	2,705	3	69,283	3
Economic loss[3]	6.56	16.67	30.88	92.76	7.60	54.24	21.54	2.49	793.63	1.79

1 The data of Taiwan is not observed

2 M stands for Richter scale

3 Direct measure in billion CNY, adjusted to inflation

Source: National Bureau of Statistics of China, and China Earthquake Administration

The most serious earthquake fault during the latest 10 year is the 7.8 Richter scale Wenchuan Earthquake in eastern Sichuan in May, 2008. The direct economic loss equals to more than 70% of Beijing's GDP in 2008. In 2010, 2011, 2014, another three serious earthquakes struck Yushu County, Lushan County and Ludian County. These faulty caused severe casualties and economic loss due to the large population density and agriculture/industrial density.

Table 8: Descriptive Statistics of Fundamental Data

This table reports the statistic summary of the fundamental characteristic of the 1303 listed firms. The unit for each variable is million Chinese yuan except mentioned otherwise. The data are from the CSMAR database. The sample includes the records of delisted firms. Firm-level characteristics include total assets size, total debt, leverage ratio, total cash and equivalent Annual data include property insurance expenses and dividend payout ratio

Panel A: Descriptive Statistics of Full Sample

	Quarterly data					Annual data	
	Cash (%)	Leverage (%)	Total assets	Total cash	Total debt	Insurance expenses	Payout ratio(%)
Min.	7.121	-8.17	0.00	0.00	0.00	-0.22	-1838.58
1st Qu.	12.16	-0.47	13.52	1.43	0.00	0.00	0.00
Median	15.108	0.16	30.37	3.88	0.68	0.01	10.08
Mean	19.46	0.129	362.44	14.08	12.00	0.04	22.11
3rd Qu.	100	0.74	78.10	10.13	5.40	0.03	30.42
Max	100	8.14	182457.50	2142.33	1304.00	1.67	7927.27
SD	12.02	1.02	4978.08	50.57	52.64	0.10	108.89
N	49911	49911	49911	49911	49231	2780	12505

Panel B: Neighbor firms

	Quarterly data					Annual data	
	Cash (%)	Leverage (%)	Total assets	Total cash	Total debt	Insurance expenses	Payout ratio(%)
Min.	0.00	-816.86	0.00	0.00	0.00	0.00	-1838.58
1st Qu.	6.78	-41.14	11.97	1.27	0.00	0.41	0.00
Median	11.71	20.74	27.09	3.36	0.90	1.19	2.54
Mean	14.43	17.46	74.24	10.32	10.29	0.04	21.42
3rd Qu.	18.65	77.56	69.07	8.59	6.42	0.03	28.58
Max	100.00	813.69	2312.09	505.37	812.44	1.67	4636.17
SD	11.40	101.57	138.02	23.84	38.28	0.12	105.42
N	16890	16890	16890	16890	16890	1051	4234

Panel C: Unaffected firms

	Quarterly data					Annual data	
	Cash (%)	Leverage (%)	Total assets	Total cash	Total debt	Insurance expenses	Payout ratio(%)
Min.	0.00	-636.06	0.00	0.00	0.00	-0.22	-1743.64
1st Qu.	7.32	-50.62	14.65	1.53	0.00	0.00	0.00
Median	12.40	12.91	31.99	4.22	0.57	0.01	11.89
Mean	15.41	10.53	511.42	15.95	12.93	0.03	22.42
3rd Qu.	19.85	72.61	82.69	10.96	4.99	0.03	30.97
Max	100.00	767.72	182457.48	2142.33	1303.95	0.89	7927.27
SD	12.21	102.29	6125.26	59.73	58.77	0.08	110.80
N	32901	32901	32901	32901	32901	1729	8241

Table 9: Earthquake Event Records and Firms Struck, 2007-2016

More than one earthquake above 6 Richter degree can happen in one quarter. If a firm located close to one earthquake, it will be assigned to stricken group regardless whether the other earthquakes are in neighbor area.

Date	Latitude (°)	Longitude (°)	Depth (km)	Magnitude (Richter scale)	Stricken firms	Neighbor firms
2007/06/02	23.03	101.05	5	6.1	1	1
2008/05/12	31.00	103.32	19	7.9	40	355
2008/05/25	32.56	105.42	18	6.1	0	134
2008/08/05	32.76	105.49	6	6	0	105
2008/08/21	25.04	97.7	10	6	0	1
2008/08/30	26.24	101.89	11	6	0	16
2008/11/10	37.57	95.83	19	6.3	0	1
2009/08/28	37.7	95.72	13	6.3	0	1
2010/04/14	33.2	96.45	7.6	7.1	0	30
2012/06/29	43.43	84.7	18	6.3	23	3
2013/04/20	30.31	102.89	14	7	0	163
2014/02/12	35.91	82.59	10	6.9	0	4
2014/08/03	27.19	103.41	12	6.2	0	75
2014/10/07	23.38	100.47	8.5	6.1	0	15
2015/07/03	37.46	78.15	20	6.4	0	0
2016/12/08	43.82	86.35	17.6	6	0	19

Table 10: Industry Distribution of Selected Sample firms, 2007-2016

More than one earthquake above 6 Richter degree can happen in one quarter. If a firm located close to one earthquake, it will be assigned to stricken group regardless whether the other earthquakes are in neighbor area.

Industrial sector	Full sample	Unaffected	Stricken	Neighbor
Financials	12	10	1	1
Public utilities	143	112	1	30
Real estates	73	61	5	7
Conglomerate	109	80	8	21
Industry	866	526	43	297
Commerce	100	73	6	21
Total	1303	862	64	377

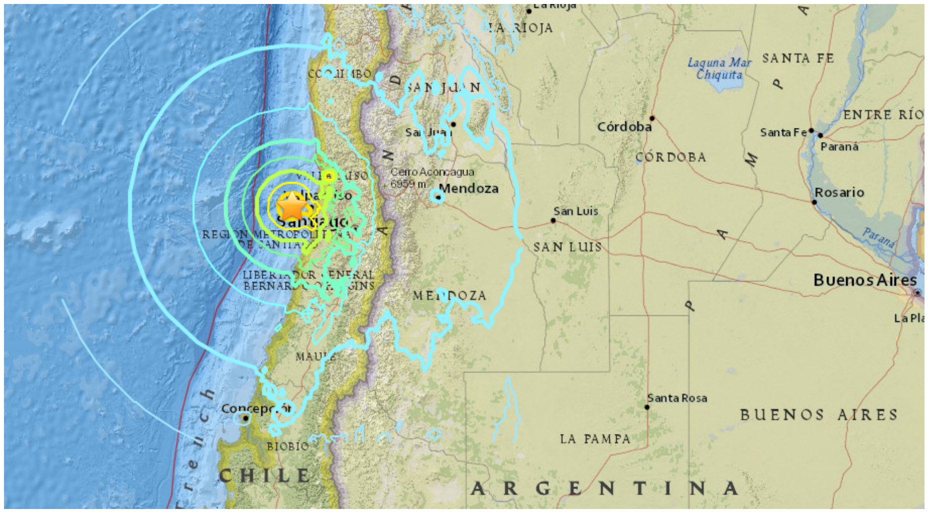

Figure 2: Earthquake Intensity, A Recent Example

Source: USGS.
Example of M 6.9 earthquake occurred on 39km W of Valparaiso, Chile at 2017-04-24 21:38:30 UTC. epicenter is 28.0 km deep. Highlighted lines in the map mark the Mercalli intensity caused by the fault in different locations: the brighter the color , the more intensive the shake. The route of seismic wave on land is not concentric radial pattern, which makes it difficult to estimate the "earthquake radius".

Table 11: Four Earthquake Events abroad

Events selected according to firms financial results forecast.

Location	Date	Latitude (°)	Longitude (°)	Depth (km)	Magnitude (M_L)
Tōhoku, Japan	2011/03/11	38.30	142.37	29	9.1
Kumamoto, Japan	2016/04/16	32.79	130.70	10	7
Gorkha, Nepal	2015/04/25	28.23	84.73	8.22	7.8
Chiloé, Chile	2016/12/25	43.41	73.94	38	7.6

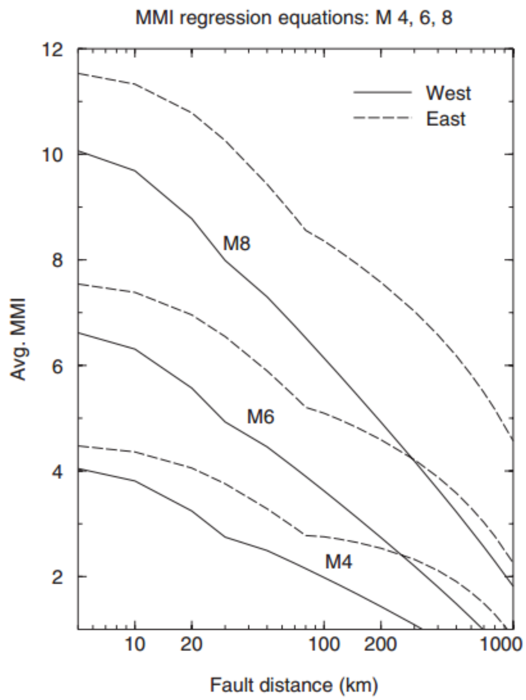

Figure 3: Seismic Intensity and Distance

Source: Atkinson and Wald (2007), and USGS.
The estimated relationship between modified Mercalli intensity (MMI) for earthquake events of M 4, 6, and 8 for California (CA, solid) and the Central-east US (CEUS, dashed), based on empirical regression. Atkinson and Wald note that at 300 km the intensity for a CEUS event of M = 4 is similar to that of a CA event of M = 6. At 400 km the intensity for a CEUS event of M = 6 is similar to that of a CA event of M = 8.

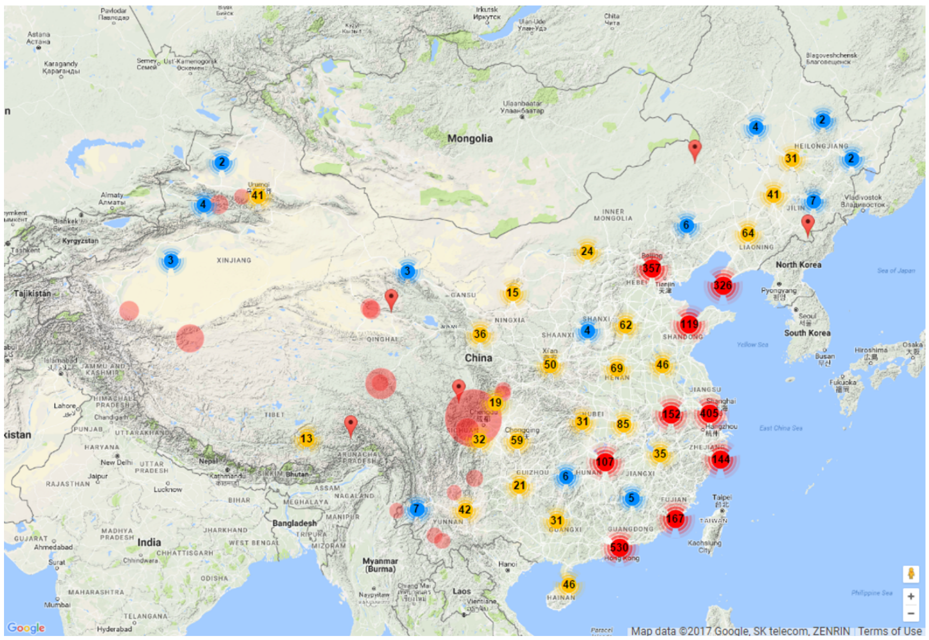

Figure 4: Listing Firms Location and Epicenters of Historical Earthquakes

Map created with Google developers based on data from CSMAR and USGS. The cycles with number mark the location of listing firms and the number of firms in a given region. The map consolidates the number as it rooms out the scope. For a more accurate location information, please refer to `http://jsfiddle.net/1c057d47/3/show/` and room in. The transparent red cycles mark the historical epicenter since 2007 to 2016. All earthquake events noted are M6 or above. Listed firms mainly headquartered in key cities; and severe earthquake mainly strikes western China. The Midwestern to Southwestern regions are population, agriculture and industry intense; while the Northwest has a far lower population density. The size of the cycle presents the Richter magnitude scale of the earthquake fault for comparison among earthquakes. If a region is covered by the cycle, it does not necessary mean that the region is struck by earthquake.

Table 12: Impact from Domestic Earthquake Events by Scale and Leverage (continue)

This table reports the individual impact of earthquake on the cash holding level by leverage and scale of the firm. The categories of firm is assigned according to their distance to earthquake epicenter, the center of the shake. $Cash_{i,t}$ notes the quarterly cash holding level, which is calculated as the share of cash to the total assets in percentage. The firm characteristic variables include the lagged operating income, scaled by total assets, $OpIncome_{i,t-1}/TA_{i,t-1}$, the corresponding quarterly leverage ratio $Leverage_{i,t-1}$ and lagged log term of total asset scale $log(TA_{i,t-1})$. Dummy variable $Neighbor_{i,t-1}$ equals to 1 if a severe earthquake strikes in quarter t and the headquarter of firm $i$located in region exposed to I MMI - IV MMI intensity; it applies similarly to $Struck_{i,t-1}$ which equals to 1 if the headquarter located in regions subject to V MMI or above shaking intensity. $Mag_{i,t-1}$ notes the Richer degree magnitude of quake events and in our sample $Mag_{i,t-1} > 6$ because of the aforementioned definition of severe earthquake. The models use the cross term of firm category and earthquake magnitude to capture the impact of quake events. Panel A to Panel C are ranked by the scale of total assets. In each panel, estimation (1) to (3) are ranked by the leverage ratio.

	Dependent variable: $Cash_{i,t-1}$								
	Panel A: Small scale			Panel B: Median scale			Panel C: Large scale		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$\text{Neighbor}_{i,t-1} \times \text{Mag}_{i,t-1}$	−0.0005	0.071	0.772***	0.106	0.168*	0.257**	−0.161	0.106	−0.081
	(0.138)	(0.140)	(0.176)	(0.142)	(0.101)	(0.117)	(0.229)	(0.140)	(0.116)
$\text{Struck}_{i,t-1} \times \text{Mag}_{i,t-1}$	0.710	0.269	0.118	0.023	0.170	0.014		−0.088	0.081
	(0.723)	(0.589)	(0.719)	(0.536)	(0.556)	(0.496)		(0.505)	(0.553)
Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Observations	8,082	4,696	3,425	5,501	6,043	4,648	2,624	5,451	8,133
R^2	0.240	0.249	0.268	0.333	0.351	0.324	0.519	0.286	0.316
Adjusted R^2	0.220	0.214	0.227	0.309	0.326	0.293	0.491	0.260	0.299
F Statistic	14.153***	8.658***	8.128***	17.122***	16.840***	13.150***	25.259***	13.666***	23.240***

Standard errors in parentheses

*p<0.1; **p<0.05; ***p<0.01

Table 13: Impact from Oversea Earthquake Events

This table reports the impact of oversea earthquake events on the cash holding level on Chinese listed firms. The oversea earthquake events including 4 salient earthquakes happened in Japan (Thoku and Kumamoto), Nepal, and Chile. The data are from two sub-sample respectively. The quake sub-sample compares only cash holding level in quarters when severe earthquake happens, and the non-stricken sub-sample excluded firms which are stricken by severe earthquake. The categories of firm is assigned according to their distance to earthquake epicenter, the center of the shake. $Cash_{i,t}$ notes the quarterly cash holding level, which is calculated as the share of cash to the total assets in percentage. The firm characteristic variables include the lagged cash holding level, $Cash_{i,t}$, the corresponding quarterly leverage ratio $Leverage_{i,t-1}$ and total asset scale $log(TA_{i,t-1})$. Dummy variable $Neighbor_{i,t-1}$ equals to 1 if a severe earthquake strikes in quarter t and the headquarter of firm i located more than 500 km but less than 1000 km to the epicenter; it applies similarly to $Struck_{i,t-1}$ which equals to 1 if the headquarter located less than 500 km to the epicenter. $Mag_{i,t-1}$ notes the Richer degree magnitude of quake events and in our sample $Mag_{i,t-1} > 6$ because of the aforementioned definition of severe earthquake. The models use the cross term of firm category and earthquake magnitude to capture the impact of quake events.

	Dependent variable: $Cash_{i,t}$	
	(1)	(2)
$\text{Neighbor}_{t-1} \times \text{Mag}_{i,t-1}$	0.093^{*}	0.098^{**}
	(0.049)	(0.049)
$\text{Strick}_{t-1} \times \text{Mag}_{i,t-1}$	-0.024	-0.016
	(0.166)	(0.166)
Overseas		0.403^{**}
		(0.164)
$\text{OpIncome}_{t-1}/\text{TA}_{t-1}$	0.290^{*}	0.293^{*}
	(0.152)	(0.152)
Leverage_{t-1}	-1.545^{***}	-1.545^{***}
	(0.066)	(0.066)
$\log(\text{TA}_{t-1})$	-0.971^{***}	-0.970^{***}
	(0.075)	(0.075)
FE	Yes	Yes
Observations	48,595	48,595
R^2	0.033	0.033
Adjusted R^2	0.006	0.006
F Statistic	95.233^{***}	90.289^{***}

Standard errors in parentheses

*p<0.1; **p<0.05; ***p<0.01

Table 14: Controlling Property and Commercial Insurance Effect

This table reports the impact of earthquake on the end of year cash holding level of far-away, neighbor, and stricken firms. Model 2 controls the effect of property and commercial insurance purchasing, which is measured as the property insurance coverage, i.e. the ratio of property insurance premium to total assets. In another regression on insurance coverage itself, the coverage ratio shows no change when earthquake happens in neighbor or local area. The categories of firm is assigned according to their distance to earthquake epicenter, the center of the shake. $Cash_{i,t}$ notes the quarterly cash holding level, which is calculated as the share of cash to the total assets in percentage. The firm characteristic variables include the lagged cash holding level, $Cash_{i,t}$, the corresponding quarterly leverage ratio $Leverage_{i,t-1}$ and total asset scale $log(TA_{i,t-1})$. Dummy variable $Neighbor_{i,t-1}$ equals to 1 if a severe earthquake strikes in quarter t and the headquarter of firm i located more than 500 km but less than 1000 km to the epicenter; it applies similarly to $Struck_{i,t-1}$ which equals to 1 if the headquarter located less than 500 km to the epicenter. $Mag_{i,t-1}$ notes the Richer degree magnitude of quake events and in our sample $Mag_{i,t-1} > 6$ because of the aforementioned definition of severe earthquake. The models use the cross term of firm category and earthquake magnitude to capture the impact of quake events.

	Dependent variable: $Cash_{i,t}$			
	Panel A: All sectors		Panel B: Selected sectors	
	(1)	(2)	(3)	(4)
$\text{Neighbor}_{i,t-1} \times \text{Mag}_{i,t-1}$	0.151	0.152*	0.191**	0.192**
	(0.092)	(0.092)	(0.097)	(0.097)
$\text{Struck}_{i,t-1} \times \text{Mag}_{i,t-1}$	0.084	0.086	0.085	0.086
	(0.085)	(0.085)	(0.090)	(0.089)
$\text{Ins\_p}_{i,t-1}$		0.00002***		0.00002***
		(0.00000)		(0.00000)
$\text{OpIncome}_{t-1}/\text{TA}_{t-1}$	2.100***	2.124***	1.657***	1.682***
	(0.191)	(0.190)	(0.197)	(0.196)
Leverage_{t-1}	−2.509***	−2.515***	−2.485***	−2.492***
	(0.121)	(0.121)	(0.133)	(0.133)
$\log(\text{TA}_{t-1})$	−0.481***	−0.439***	−0.096	−0.036
	(0.088)	(0.088)	(0.102)	(0.102)
FE	Yes	Yes	Yes	Yes
Observations	11,237	11,237	9,282	9,282
R^2	0.167	0.171	0.179	0.184
Adjusted R^2	0.146	0.150	0.154	0.159
F Statistic	8.036***	8.223***	7.402***	7.627***

Standard errors in parentheses

*p<0.1; **p<0.05; ***p<0.01