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Corporate responses to stock price fragility ☆

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ABSTRACT

This study shows that firms regard stock price fragility - exposure to non-fundamental demand shocks stemming from the composition of equity ownership - as a salient corporate risk. We model ex ante corporate responses to higher potential for *future* stock market misvaluation and then empirically document that within firm variation in equity fragility has effects in line with the model: higher fragility raises cash holdings and lowers investment. Multiple natural experiments support a causal interpretation of the results. The results are shown to be more prominent in the face of high uncertainty and financial constraints. The evidence presents a new dimension of how managerial expectations affect corporate policies.

"The sharp reversal in some companies' share prices last week...came after Archegos Capital Management and its banks began unwinding large holdings in blue chip companies, capping a quarter of unusual trading activity. Such exaggerated stock moves, often without substantial changes to the business, have left corporate finance executives with a dilemma: They don't want to be led by their company's share price, but they can't afford to ignore it either." Wall Street Journal (2021).

1. Introduction

Firms rely on financial markets in different ways and so might be affected by shocks that originate in them. Rapid unwinding of positions, as in the introductory quote, or "meme stock" trading fueled by social media provide eye-catching examples of where stock prices appear to be moved by demand side shocks and trigger an effect on the corporation.[1] More systematically, whether non-fundamental mispricing shocks in the equity market affect firms' behavior also has been the focus of a large

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[1] See for instance testimony by the Chair of the U.S. Securities and Exchange Commission before the House Committee on Financial Services, (Securities and Exchange Commission (2021)).

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volume of research.[2] A common strategy has been to identify mispricing shocks and analyze their effect on various corporate-finance outcomes, such as corporate investment (e.g., Baker et al. (2003) or Hau and Lai (2013)) and takeovers (e.g. Dong et al. (2006) or Edmans et al. (2012)). The debate that often follows naturally centers on the extent to which shocks to prices indeed reflect non-fundamental changes.[3]

In this paper, we take a step back and ask whether firms change their financial behavior when they *anticipate* that their exposure to non-fundamental price movements - their stock price *fragility* - has increased. This can happen when firms' ownership base changes in a way that makes flows and price fluctuations more likely. Documenting that firms respond in a precautionary manner to an increased fragility sidesteps the controversy around identifying non-fundamental changes in prices, and offers a new way to understand the important relation between shocks in financial markets and corporate finance decisions. It also provides vastly new implications, pointing to the effect that financial market shocks have before they materialize, as corporations react directly to the increased threat of misvaluation.

Anecdotal evidence suggests that managers indeed pay significant attention to changes in ownership and executives have openly connected ownership composition to future price volatility for decades. In 2004, the Wall Street Journal reported: "We're looking for shareholders that aren't just going to flip the stock,' says Todd Bradley, chief executive of [palmOne]. 'We wanted to reduce the stock's volatility."[4] And in 2011, the WSJ discussed a new brokerage firm, Loyal3: "Barry Schneider, [Loyal3's] chief executive, also points to ... companies whose shares are now mainly held by hedge funds and institutions, a trend that he argues has increased price volatility."[5] The number of firms selling ownership information on a timely basis also indicates demand for such information.

We use the stock price fragility measure of Greenwood and Thesmar (2011) to capture the exposure to non-fundamental trading shocks based on ownership composition.[6] Higher fragility represents an increased exposure to non-fundamental risk. The logic behind their measure is that firms facing greater correlation in the liquidity needs of their stocks' owners are prone to higher idiosyncratic volatility in order flows and ultimately in stock prices.[7] Such firms are considered to be more exposed to stock price fragility. Greenwood and Thesmar (2011) build their measure based on the readily available data on mutual fund ownership and point to the dramatic increase in fragility due to changes in the landscape of the mutual fund industry, e.g., its concentration of holdings.[8] Following their approach, we examine whether stock price fragility affects important aspects of firms' behavior, such as their cash holding and investment.

We start the paper by providing a simple model to illustrate the channel. Firms choose how much cash buffer to keep in the business. The cost of an increased cash buffer is the forgone return on alternative illiquid investment opportunities. The benefit comes from the fact that the firm may face a future financing need if its cash balances fall below a certain level. The cost of raising cash in the future depends on the market price of the firm's securities, a feature that we take as given but is motivated by the feedback-effect literature and described in more detail below. While all firms face some risk that equity misvaluation increases their cost of raising capital in the future, changes in the degree of misvaluation risk should affect the benefit of precautionary cash holding. This implies that firms exposed to greater stock fragility will hold more cash and invest less in capital expenditure. The model is in the same tradition as in Baker et al. (2003) (building on Stein (1996)) in which a firm, after observing its current stock market valuation, decides on investment and whether to issue new equity. We differ from previous work on corporate responses to mispricing by modeling the *ex ante* decision of precautionary corporate behavior.

It is important to emphasize that the above mechanism does not rely on any asymmetry between underpricing and overpricing. A fragile stock price implies a higher probability of bigger overpricing just like it does for bigger underpricing. The key, however, is that the gains from overpricing do not play any role in the choice of cash buffer of the firm since the firm may always exploit these gains when they arise, regardless of its level of cash holding. However, it is only the loss from underpricing that is forced on the firm when it faces cash shortage, and this is why the firm will attempt to reduce cash shortages when it expects a higher likelihood of underpricing.

This model builds on the premise that stock prices affect firms' access to capital and thereby the cost of a cash shortfall (as, for example, in Goldstein et al. (2013)). In reviewing the literature on the real effects of financial markets, the feedback effect, Bond et al. (2012) argue that there are two types of effects to consider: a primary-market effect and a secondary-market effect. For a primary-market effect, the firm needs to actively use the stock market to raise more capital, i.e., by issuing new stocks at a price that is tied to market price. This happens when firms rely on secondary equity offerings (SEO; indeed, there is evidence that stock values and mispricing affect SEO policies, see e.g., Khan et al. (2012)) or other mechanisms such as Private Issuance of Public Equity (PIPE) and At-The-Market (ATM) offerings (Brown and Floros (2012), Billett et al. (2019)). These involve selling shares at par or at a discount to the current price (see e.g. Wruck (1989), Chaplinsky and Haushalter (2010)). The secondary-market effect arises even when firms are not actively issuing stocks. As Bond et al. (2012) explain, the mechanism goes through learning. Given that stock prices typically contain information about firms' prospects, many decision makers look at them for signal and base their actions on them. These may include creditors who choose to base the terms at which they lend to the firm on its stock price.[9] We think both the primary-market and the secondary-market channels are likely to be present and do not attempt to differentiate between them. They both have the same ex ante implication that our model and empirical evidence focus on: Firms would want to increase precautionary cash holding in response to a perceived higher chance of misvaluation.

[2] See Bakke and Whited (2010) for an overview.

[3] See recent critiques on the Edmans et al. (2012) fund-flows measure of mispricing by Berger (2019) and Wardlaw (2020), and, on the other hand, recent papers showing that the measure continues to work after addressing these critiques (Dessaint et al. (2021), Gredil et al. (2019), and Bian et al. (2018)).

[4] Wall Street Journal (2004).

[5] Wall Street Journal (2011).

[6] Greenwood and Thesmar (2011) builds on evidence – such as Coval and Stafford (2007) – that liquidity needs of mutual funds can drive stock prices of individual firms. There is also evidence by Anton and Polk (2014) and Koch et al. (2016) that ownership patterns matter for stock price fragility. To the best of our knowledge only one other paper brings this measure of fragility to a corporate finance context. Xiao (2020) documents a negative link between noise trading and firm performance as measured by returns on assets, cash flows and operating profits. This different set of results is based on a different channel than ours.

[7] See Gromb and Vayanos (2010) for in-depth discussion of how non-fundamental demand shocks can move asset prices away from fundamental values.

[8] See related evidence on fragility in Ben-David et al. (2021).

[9] This is recognized early on in the finance literature by Morck et al. (1990, p. 167), who write: "The stock market conveys information about how much a company is worth. Potential lenders presumably use this information in deciding how much to lend and on what terms. Therefore, stock price increases would increase debt capacity and reduce the costs of debt, and the reverse would be true for stock price decreases." In a recent review of the literature, Goldstein (2023) discusses the empirical literature on learning from prices, saying it has focused mostly on managers but should also apply to other decision makers such as creditors. In relation to that, it discusses the common view that credit rating agencies supplement their own information with market-based information and the fact that short-sale regulation is often justified on the concern that uncontrolled stock-price declines will depress the access of firms to credit. Finally, some models in the feedback-effect literature have also relied on creditors' learning from the stock price (see, e.g., Goldstein et al. (2013)).

After setting up the model to illustrate the mechanism, we first document the model's assumption that increased fragility associates with a higher likelihood of future misvaluation (at three different time horizons) using the Stambaugh et al. (2015a) proxy for mispricing. Next, we proceed to the main part of the paper – the empirical analysis based on the model's predictions. Our main set of results relate the measure of stock price fragility developed by Greenwood and Thesmar (2011) to cash holdings. In panel regressions, controlling for industry-time and firm fixed effects as well as a set of additional time varying firm characteristics, we document a strong positive relation between the changes in fragility and the firm's cash holdings. Across numerous robustness checks and controlling for potential current misvaluation, these within-firm specifications imply that firms respond to changing institutional ownership patterns and the resulting stock price fragility.

Additional important analysis in our paper demonstrates that fragility does not affect corporate policies equally across firms and over time. The expected cost of future misvaluation depends on the likelihood of future mispricing as well as on the probability of a shortfall in cash and on the severity of financial constraints. We show an elevated sensitivity of cash holdings to fragility across numerous proxies for uncertainty and financial constraint such as firms which are small, have more volatile earnings, and do not have a bond rating. This is a natural extension of Bakke and Whited (2010) which finds that large firms are unaffected by current mispricing. We document that the response to *future* misvaluation is likewise heterogeneous. These results lend further support to our interpretation about the mechanism via which stock fragility affects corporate policies.

Key to our model is the expectation of future misvaluation due to changing fragility. To explore the role of managerial expectations, we build on the rapidly growing literature on expectation biases (Afrouzi et al. (2020)). Overextrapolation is a well-established bias regarding future returns (Barrero (2022)) and would lead managers to overweight recent events. Indeed, we find that firms experiencing a share price increase in the prior quarter react less to changes in fragility. We also find a muted response to changes in fragility during periods of positive managerial sentiment using the measure from Jiang et al. (2019b), which captures "overly optimistic beliefs about future returns". Together, these lend support to the notion that it is managerial beliefs about the likelihood and cost of misvaluation which lead firms to respond to fragility.

Next we extend our analysis to other precautionary corporate decisions. Fragility has a negative impact on capital expenditures, R&D, repurchases, and short-term debt. The range of the precautionary outcomes is important to note. One alternative story is that fragility predicts lower future stock price informativeness and that the less informative price is what leads managers to reduce investment. Under those circumstances, it would be difficult to frame the increase in cash as precautionary. However, less informative prices do not predict the full range of corporate responses, including a reduction of repurchases and short-term debt. Firms engage in active liquidity management when they are subject to greater stock price fragility. These results emphasize how the real effect of financial markets extends beyond what happens when prices are shocked: anticipation of future shocks also causes firms to increase their precautionary behavior.

A potential concern regarding the previous results is whether they indeed indicate a causal effect of fragility on corporate policies. There is a possibility that investors expect a corporate policy change in the future (such as an announcement of a higher future cash holding target for a firm), which could change the ownership composition, and thereby the degree of financial fragility. Alternatively, potential endogeneity may be due to an omitted variable that is correlated with both shareholder composition and corporate cash policies. While there are no obvious alternative channels which could generate the results we obtain after controlling for both firm and industry-quarter fixed effects, we examine the effect of financial institution mergers which provide exogenous shocks to stock price fragility to buttress the panel regression evidence.

Our main natural experiment is the very prominent 2009 merger between Blackrock and Barclays Global Investors (BGI), which previously has been used as an exogenous shock to ownership concentration (Azar et al. (2018a), Massa et al. (2021)). As highlighted by Massa et al. (2021), the merger has several attractive features for identification purposes: It came as a surprise, it affected many stocks (stocks held by both BlackRock and BGI represent more than 60% of world market capitalization), and it was associated with a substantial change in ownership concentration for many affected stocks (concentration increased by 8.5% in the quintile of stocks with the highest overlap of portfolios). The results from a close examination of the BlackRock and BGI merger support the notion that the panel regressions capture a causal effect. With an exogenous change in ownership concentration and financial fragility, we again document that firms adjust their cash holding in the expected direction in response to fragility risk.

It is important to note that the fragility channel is distinct from any change in governance which might be attributed to increased blockholding resulting from the merger. In fact, the risk of fragility leads to novel empirical predictions. Blockholders prefer lower cash and more payout (Becker et al. (2011)) while fragility concerns resulting from the increased correlation of fund flows due to the merger predict higher cash and reduced payout.

While our focus is evaluating the merger-induced exogenous shift in stock price fragility on cash, let us note that the BlackRock-BGI merger has been widely debated in the context of the literature investigating the effect of common ownership on product market competition (see e.g. Dennis et al. (2022)). The distinct mechanism of interest in the current paper rests on the premise that a merger between asset managers is expected to raise the fragility of treated stocks. The salience and marked impact on stock price fragility of the BlackRock-BGI merger makes it particularly attractive in evaluating the mechanism that we propose. Yet, there could be a concern that common ownership affects profitability (Azar et al. (2018a)) and thus could lead to higher cash. While Dennis et al. (2022), Lewellen and Lowry (2021), and Koch et al. (2016) dispute this connection, we verify that our results are not driven by potential changes in the competitive landscape which could affect profitability.

Further, other asset management mergers in the sample period potentially allow us to confirm that our results are not unique to the BlackRock-BGI event or time period. We use the two largest asset manager mergers from Lewellen and Lowry (2021) which occur in our sample (Bank of America-Fleet and JPMorgan Chase-Bank One). We again establish that cash holdings increase in response to greater financial fragility.

Across the different specifications, we consistently document non-trivial effects. Using within firm variation in stock price fragility, a one standard deviation increase in stock price fragility raises cash holding by around 2.0% when evaluated at the mean. The corresponding effect for earnings volatility, a highly salient motivation for precautionary cash holding, is around 1.9%. We also note that treated firms raised their cash holdings by around 1.3 percentage points in response to the exogenous change in stock price fragility associated with the BlackRock-BGI merger.

By documenting that managers connect investor composition to mispricing risk, this paper relates to two broader streams beyond the feedback literature. First, we relate to extensive work on links from uncertainty to investment. Uncertainty can stem from firm or project risk - as is the focus of theory by Bernanke (1983) - and there is broad evidence that firms adjust investment and/or the propensity to save when facing such risks (see Baker et al. (2016) and Riddick and Whited (2009)). Our results highlight that uncertainty exists in external financing access or cost, regardless of project risk. To this end, we are similar in spirit to Pástor and Veronesi (2005), Ivashina and Scharfstein (2010), Massa et al. (2013), Mian and Santos (2018), and Favara

et al. (2021) which each document how particular forms of financing uncertainty affect corporate behavior.[10] Stock price fragility is a unique and economically important source of financing uncertainty. Moreover, increased consolidation in the asset management industry underscores the importance of understanding this risk. We are the first to provide evidence that managers identify increasing stock fragility – and the resulting potential exposure to non-fundamental shocks – as a salient risk. This finding also complements the investor horizon literature (Derrien et al. (2013), Cella et al. (2013)) with a new perspective on investor composition risk.

Second, we relate to work on precautionary cash holding and financial flexibility - using financial policies to ensure access to capital in a wide range of states of the world (see, e.g., Denis (2011)). A precautionary motive for cash holdings is supported by numerous studies, for instance Bates et al. (2009) or Faulkender et al. (2019). This paper expands this literature with the first evidence that the risk of misvaluation affects corporate cash, providing an important piece of evidence in support of the feedback-effect theory. Another implication is that the costs of market fragility are not just captured by the events following price changes, but rather that there is a non-trivial cost due to the need for firms to protect themselves against this risk. Indeed, it is possible that the growth of the asset management industry and the associated increase in equity fragility may be a force deterring firms from public markets.

The next section presents our model and then Section 3 presents the data and the measure of financial fragility. Section 4 presents the results from the panel analysis of fragility on our prime variable of interest, cash holding, but also on measures of investment and liquidity management. Section 5 uses asset management mergers to examine the causal impact of more concentrated institutional ownership on cash holding and the other variables of interest. Section 6 concludes.

2. Model

There are three dates, 0, 1, and 2. At date 0, the firm decides how much to invest in a long term illiquid project maturing at date 2, and how much cash (or liquid assets) to keep in the business. At date 1, the firm's intermediate earnings are realized, exposing it to potential financing needs. At that point, the firm can raise more cash in the capital markets, generating either a gain or loss, depending on the mispricing of its stock (or other securities), which is realized at the same time. Finally, at date 2, the long-term investment matures and all cash flows realize. Below, we start by describing the actions of the firm at date 1, and then go back to describe its choices at time 0.

2.1. Date 1: financing needs, mispricing, and the firm's interaction with capital markets

At date 1, the firm's cash balance is given by $c \equiv x + e$, where x is the initial cash balance the firm carried from date 0, and e is the realization of earnings generated during the period. We assume that e is distributed with a cumulative distribution function $F(e)$ and a density function $f(e)$ in the range $\left[\underline{e}, \overline{e}\right]$, where $\underline{e} < 0 < \overline{e}$.

At date 1, the firm can raise new cash $\Delta c \geq 0$ in the capital market, up to a ceiling of $\overline{\Delta c}$. The terms at which the firm is able to do this depend on the market price of its stock (or other securities). In particular, the terms of financing depend on the degree of mispricing. We use Δp to denote the level of mispricing. If the firm's stock is overpriced, then $\Delta p > 0$, and if it is underpriced, then $\Delta p < 0$. If $\Delta p > 0$, the firm generates a net profit from raising new cash, and if $\Delta p < 0$, it generates a net loss from doing so. We assume that the mispricing Δp is distributed with a cumulative distribution function $G(\Delta p)$ and a density function $g(\Delta p)$. We assume that the density function is symmetric around the mean of zero. That is, we do not want to have any asymmetry between overpricing and underpricing built into the model. For simplicity, we also keep the mispricing Δp independent of the earnings e.

We use Δp^+ to denote the positive realizations of Δp, and we use Δp^- to denote the absolute value of the negative realizations of Δp. Thus, both Δp^+ and Δp^- are positive. We use the function $G\left(\Delta c, \Delta p^+\right) \geq 0$ to denote the financing gain whenever $\Delta p > 0$ and $L\left(\Delta c, \Delta p^-\right) \geq 0$ to denote the financing loss whenever $\Delta p < 0$. Both $G(\cdot,\cdot)$ and $L(\cdot,\cdot)$ are increasing and weakly convex in the first element. They are increasing in the second element as well, and exhibit a positive cross-derivative. That is, $G_1 > 0,\ L_1 > 0,\ G_{11} \geq 0,\ L_{11} \geq 0,\ G_2 > 0,\ L_2 > 0,\ G_{12} > 0,\ L_{12} > 0$. We set $G(\cdot,\cdot)$ and $L(\cdot,\cdot)$ to be zero when $\Delta c = 0$ or $\Delta p = 0$.

For continuation of its operation, we assume that the firm's cash balances must stay at or above a threshold c^* between dates 1 and 2. Hence, if the firm finds itself with a lower cash balance c, it will need to go to the capital market and raise additional cash to bring it back at least to the threshold. We assume that the ceiling $\overline{\Delta c}$ faced by the firm for raising cash is sufficiently high to cover the firm's maximum potential cash shortfall, i.e., $\overline{\Delta c} > c^* - x - \underline{e}$.

Given the possibility of mispricing and the resulting financing gains and losses, and given the potential financing needs, the firm's optimal date 1 behavior will be as follows:

$$\Delta c = \begin{array}{ccc} \overline{\Delta c} & if & \Delta p > 0 \\ c^* - x - e & if & \Delta p \leq 0 \ and \ x + e < c^* \\ 0 & Otherwise & \end{array}. \tag{1}$$

Hence, whenever the firm experiences a positive mispricing Δp^+, it will get a financing gain of $G\left(\overline{\Delta c}, \Delta p^+\right)$. Whenever the firm experiences a negative mispricing Δp^- and faces a cash shortfall because $x + e$ is below the threshold c^*, it will incur a financing loss of $L\left(\left(c^* - x - e\right), \Delta p^-\right)$. Otherwise, if the firm has a negative mispricing and no cash shortfall, it will refrain from raising new cash and will have no financing gain or loss.

2.2. Date 0: the initial decision of the firm on cash holdings

At date 0, the firm has to choose its starting cash balance x. The firm faces an opportunity cost given by investment in a long-term project that matures at date 2. Hence, for a choice of cash x to be carried between date 0 and date 1, the firm is giving up return of $h(x)$ in the long-term project at date 2. We assume that the long-term project is completely illiquid and has no liquidation value at date 1. We assume that $h(x)$ is an increasing and convex function, i.e., $h'(x) > 0$ and $h''(x) > 0$.

For simplicity, we assume that there is no discounting in this environment. Then, given the description so far, and the choice of the firm in date 1, as given by Equation (1), the firm chooses cash balance x at date 0 to maximize the following objective function:

$$\begin{aligned} V = {} & x + E[e] - h(x) \\ & + \int_{\Delta p=0}^{\Delta p=\infty} G\left(\overline{\Delta c}, \Delta p^+\right) g(\Delta p)\, d\Delta p \\ & - \int_{e=\underline{e}}^{e=c^*-x} \left(\int_{\Delta p=-\infty}^{\Delta p=0} L\left(\left(c^* - x - e\right), \Delta p^-\right) g(\Delta p)\, d\Delta p \right) f(e)\, de. \end{aligned} \tag{2}$$

Here, the first line captures the direct payoff from cash balances minus the cost due to the forgone investment. The second line captures

[10] Pástor and Veronesi (2005) focuses on uncertainty in the IPO market. Ivashina and Scharfstein (2010) examines bank market access uncertainty following Lehman Brothers' failure. Massa et al. (2013) finds debt capital uncertainty leads firms to reduce leverage. Mian and Santos (2018) finds firms refinance early to limit refinancing uncertainty. Favara et al. (2021) documents how better access to debt markets reduces precautionary behavior.

the gains from additional financing whenever the firm finds itself in a situation of overpriced securities. The third line captures the losses from additional financing whenever the firm finds itself in a situation of cash shortfall and underpriced securities.

The first-order condition coming out of the maximization of V in Equation (2) is:

$$h'(x) = 1 + \int_{e=\underline{e}}^{e=c^*-x} \left(\int_{\Delta p=-\infty}^{\Delta p=0} L_1\left(\left(c^* - x - e\right), \Delta p^-\right) g(\Delta p)\, d\Delta p \right) f(e)\, de. \tag{3}$$

Essentially, the firm equates the marginal cost from increasing its cash buffer with the marginal benefit. On the left-hand side, the marginal cost is the marginal return lost from the alternative long-term project. On the right-hand side, the marginal benefit is the sum of the direct benefit from increasing the cash balance and the indirect benefit due to the decrease in financing losses incurred whenever the firm finds itself in an underpricing situation and a cash shortfall. By keeping a larger cash buffer, the firm can reduce those future financing losses because it does not need to raise as much cash in case of underpricing. Note that the financing gains in case of overpricing do not enter the first-order condition at all. This is because the firm will maximize these financing gains whenever the mispricing is positive and raise the maximum amount possible $\overline{\Delta c}$ irrespective of how much cash x it kept from date 0 to date 1.

There is a unique solution to (3) because the left-hand side is increasing in x and the right-hand side is decreasing in x. Hence, the level of cash buffer chosen by the firm is pinned down uniquely by this equation.

2.3. The effect of stock price fragility

Our main goal is to understand the effect that stock price fragility has on the choice of cash buffer made by the firm at date 0. Stock price fragility implies that higher levels of mispricing should be expected in the future both on the negative side and on the positive side. We capture this in the model by comparing two distributions of mispricing $g(\Delta p)$ and $g'(\Delta p)$; both are symmetric functions around the mean of Δp, i.e., around zero. We say that $g'(\Delta p)$ represents more fragility than $g(\Delta p)$ if there exists a value $\widehat{\Delta p} > 0$, such that:

$$\begin{array}{lll} g'(\Delta p) > g(\Delta p) & iff & \Delta p > \widehat{\Delta p} \quad or \quad \Delta p < -\widehat{\Delta p} \\ g'(\Delta p) < g(\Delta p) & iff & -\widehat{\Delta p} < \Delta p < \widehat{\Delta p} \end{array}. \tag{4}$$

Essentially, $g'(\Delta p)$ is a mean-preserving spread of $g(\Delta p)$.

Under the definition of fragility in Equation (4) and the first-order condition in Equation (3), it is clear that the firm chooses a higher level of cash buffer x when it faces mispricing distribution that represents more fragility $g'(\Delta p)$. Under the distribution $g'(\Delta p)$, weight is shifted from lower values of Δp^- to higher values of Δp^-. Then, because the cross derivative of the loss function $L(\Delta c, \Delta p^-)$ is positive ($L_{12} > 0$), the marginal benefit of cash buffer on the right-hand side of (3) increases for every level of x. Since the marginal cost on the left-hand side does not change for a given x, and since it is increasing in x, the solution to the equation then has to generate a higher x in equilibrium.

Intuitively, a more fragile stock price entails a higher probability of bigger underpricing. This increases any external financing cost when it needs to raise cash if it faces a shortfall in its cash balance.[11] The firm prepares for this in advance by increasing its cash buffer and reducing the likelihood and magnitude of cash shortfalls. It is important to emphasize again that we did not assume any asymmetry between underpricing and overpricing. The key, however, is that the gains from overpricing do not play any role in the choice of cash buffer of the firm, since the firm will always exploit these gains when they arise regardless of its level of cash. It is only the loss from underpricing that is forced on the firm when it faces a cash shortage, and this is why the firm will attempt to reduce cash shortages when it expects greater likelihoods of underpricing with greater magnitude.

In the model the firm makes a choice about one variable x, capturing greater cash buffer and lower long-term investment. In our empirical investigation, we hypothesize that firms facing greater fragility will increase cash and reduce other spending such as capital expenditures. However, following Bolton et al. (2011), we also investigate the scope of precautionary action and test for changes in capital structure.

3. Data and empirical model

Our sample construction begins with quarterly corporate data from Compustat starting with 2001 Q1 up to and including 2017 Q4. While precise variable definitions and some finer details of the data assembly are relegated to the Appendix, we provide an overview in this section. The dependent variables are scaled by total assets and we will consider cash and short-term investments (*Cash*), capital expenditures (*CapEx*), research and development expenditures (*R&D*), dividend payments (*Dividends*), repurchase of common equity (*Repurchase*), short-term debt (*ST Debt*), as well as equity issuance (*EquityIssue - Level and Indicator*) and debt levels (*LTDebt, Book Leverage*).

We control for a number of potentially confounding factors. The natural logarithm of total assets, $ln(Assets)$, acts as a proxy for firm size. *Earnings Volatility* is a common correlate of precautionary cash holding (as in e.g. Bates et al. (2009)) and we measure it as the 12 quarter rolling standard deviation of earnings. Our measure of stock price fragility depends on ownership patterns within the set of institutional owners and we control for *Inst Ownership* which is the sum of 13F owner shares scaled by total shares outstanding in a quarter. Additional potentially confounding variables that we control for are *Leverage*, operating cash flows (*Oper Cash Flow*), *Fixed Assets*, and *Inventory*.

We interact our measure of stock price fragility with indicator variables based on a set of measures that aim to capture variation in the potential expected cost of misvaluation. We start with three proxies for the likelihood of future misvaluation. To proxy for higher aggregate uncertainty regarding future stock prices, we use *High VIX Period*. (All indicator variables labeled by *High* take the value one for the top quartile of the respective measure and zero otherwise.) Also, the probability of a cash shortfall is likely to be higher in more volatile product markets which we proxy with *High Earnings Volatility* and *High Fluidity* (based on the Hoberg et al. (2014) measure of product market fluidity). Further, we note that the incentives to avoid costly cash shortfalls should be stronger for more financially constrained firms and we evaluate financial constraints with *Fin Constrain* (above median on the Hoberg and Maksimovic (2015b) text-based measure of financial constraints), *No Bond Rating*, *Small* (bottom three quartiles of $Assets$) and *Low Analyst Coverage* (bottom three quartiles in terms of number of analysts that cover the firm).

Lastly, tests use two additional external measures. In exploring managerial expectations, we use the textual tone-based manager sentiment index from Jiang et al. (2019b), which is a monthly time-series. Using every third quarter of the index as a proxy for the level of general managerial expectations, we generate an indicator for positive managerial sentiment periods. To examine the role of product market concentration, we rely on the text-based Herfindahl measure *Product Market HHI* which builds on Hoberg and Phillips (2010a) and Hoberg and Phillips (2016b).

In robustness exercises, we use seven proxies for current misvaluation: *Misprice*, is based on the Stambaugh et al. (2015a) firm-specific index of mispricing derived from a stock's association with 11 "anoma-

[11] As discussed in the Introduction, both primary-market (e.g. SEOs) and secondary-market effects imply that a more undervalued stock price makes it more costly to raise capital.

ly" variables. We also use the list of proxies of current misvaluation examined by Derrien et al. (2013): raw *Book-to-Market* as well as residual book-to-market following Pástor and Veronesi (2003), Hoberg and Phillips (2010b) and Rhodes-Kropf et al. (2005) respectively, in addition to *Mutual Fund Outflows* and *Future Excess Returns*.

3.1. Fragility

The measure of fragility is constructed following Greenwood and Thesmar (2011) for 2001 Q1-2017 Q4. Mutual fund holdings are collected from Thomson Reuters S12 database of 13F filings as of the filing data (FDATE).[12] For all mutual funds in the sample, total net assets are collected from the CRSP mutual fund file. Mutual funds with less than 5 million dollars in total net assets are excluded. Funds with missing data are excluded.[13] Stock level data is collected from the CRSP Stock File. To join data with the CRSP Stock File, a two-step process is used: stocks are first joined by CUSIP. When the CUSIP within the holdings data fails to match with the CRSP file, the NCUSIP within CRSP is matched to the CUSIP in the holdings file. This reflects how the two databases record CUSIPs: Thomson Reuters maintains the original CUSIP and CRSP uses the firm's most recent CUSIP and backfills through time. In CRSP, NCUSIP generally corresponds with the historical CUSIP.

As discussed below, we use stock price fragility to capture the sensitivity of stock price to non-fundamental demand from mutual funds. *Fragility G* is defined as:

$$G_{it} = \left(\frac{1}{\theta_{it}}\right)^2 W_{it}' \Omega_t W_{it}, \tag{5}$$

where W_{it} is a vector of each mutual fund investor's portfolio allocation weight to stock i, Ω_t is the covariance matrix of monthly dollar flows for the firm's mutual fund owners, and θ_{it} is the market capitalization of the firm's stock. Each element of W_i is equal to the number of shares of stock i held by fund j multiplied by the price of stock i, divided by the total net assets of fund j.

Holdings data is joined with the CRSP mutual fund file using MFLINKS. Holdings are aggregated to the portfolio level according to wficn, the unique portfolio identifier within MFLINKS. Monthly percentage flows are calculated for each fund from the CRSP mutual fund file:

$$f_{jt}^{\%} = \frac{TNA_{jt} - TNA_{jt-1}(1+R_{jt})}{TNA_{jt-1}} \tag{6}$$

where TNA_{jt} is the total net assets and R_{jt} is the return to fund j at time t. Each quarter t, a covariance matrix of percentage flows, $\Omega_t^{\%}$, is calculated using all available months since January 1990. *Fragility* requires the covariance matrix of dollar flows Ω_t, which is not estimated directly due to heteroskedasticity as discussed in Greenwood and Thesmar (2011). Instead, $\Omega_t^{\%}$ is transformed by the following equation:

$$\hat{\Omega}_t = diag(TNA_t)\Omega_t^{\%} diag(TNA_t) \tag{7}$$

where TNA_t is a matrix with values equal to each fund's total net assets on the diagonal elements and zero elsewhere. Finally, *Fragility* is estimated by the following equation:

[12] We use the Thomson Reuters regenerated data made available in June 2018, (WRDS (2018)).

[13] Although we follow Greenwood and Thesmar (2011), we recognize the potential for stale data in mutual fund filings (Pool et al. (2015)). In our context, this would introduce attenuation bias and bias the coefficient estimates towards zero. However, we rerun our baseline analysis excluding observations not updated within one year. These results are presented in the Online Appendix, Table IA.2. There is only a small change in the number of observations and no material change in economic or statistical significance.

Table 1
Summary Statistics.

	Mean	Sd	P50	N
Cash/Assets	0.192	0.218	0.105	136,191
CapEx/Assets	0.012	0.017	0.007	135,833
R&D/Assets	0.024	0.034	0.014	73,532
Repurchases/Assets	0.005	0.013	0.000	127,111
Dividends/Assets	0.002	0.005	0.000	135,585
ST Debt/Assets	0.040	0.077	0.008	135,255
$\sqrt{Fragility}$	0.004	0.004	0.003	136,191
Earnings volatility	0.025	0.048	0.010	136,191
Ln(Assets)	6.176	2.000	6.121	136,191
Inst Ownership	0.522	0.350	0.612	136,191
Leverage	0.196	0.207	0.135	136,191
Fixed Assets	0.246	0.224	0.170	136,191
Inventory	0.124	0.138	0.084	136,191
Oper Cash Flow	0.010	0.051	0.020	136,191

Summary statistics for variables as used in baseline regressions: Greenwood and Thesmar's stock price fragility measure as well as additional firm-level control variables. The data is quarterly from 2001 - 2017 and the sample excludes utilities, financial firms, and SIC 9000 codes. We require positive book equity and positive sales. Variables that are reported as year-to-date are transformed to quarterly flow variables based on the fiscal year-end and generally scaled by book value of assets. Variables used as explanatory variables are lagged one quarter in regressions. All variables are winsorized at the 1st and 99th percentiles.

$$G_{it} = \left(\frac{1}{\theta_{it}}\right)^2 W_{it}' \hat{\Omega}_t W_{it}, \tag{8}$$

In the main analysis, we follow Greenwood and Thesmar (2011) and examine stock price fragility at the fund level. When considering mergers between asset managers however, we expect that fragility at the level of family of funds responds rapidly, whereas fragility at the fund level will respond more gradually. To examine the effect of the merger on fragility, we therefore also calculate fragility at the level of family of funds (like Massa et al. (2020)). This replicates the Greenwood and Thesmar (2011) fund level fragility measure using firm level institutional holdings, often referred to as the S34 file. We return with a discussion of the impact of a merger on these two measures of fragility in connection with Fig. 1.

3.2. Summary statistics

We present summary statistics on the main variables used in regressions in Table 1. Unless otherwise noted, variables used as explanatory variables are lagged one quarter in regressions. All variables are winsorized at the 1st and 99th percentiles.

3.3. Empirical model

To investigate the relationship between changes in the exposure to non-fundamental price shocks, we pursue two distinct sets of analyses. First, we explore corporate responses to changing fragility within firms. We regress cash holdings and our measures of investment and liquidity management on the Greenwood and Thesmar (2011) fragility measure and other observable corporate factors such as firm size. We also include firm fixed effects and interacted time × industry fixed effects (where time is quarterly and industry measured at the SIC three-digit level), which we refer to as quarter-industry fixed effects, to control for developments over time at the industry level. Our main specifications estimate

$$\frac{DEP_{it}}{Assets_{it}} = \phi_i + \gamma_{qt-ind} + \alpha\sqrt{Fragility_{it-1}} + \beta X_{it-1} + \epsilon_{it}, \tag{9}$$

where DEP is our measure of cash holding ($Cash$), investment ($CapEx, R\&D$), liquidity management ($Repurchase$, $Dividends$,

$ST\,Debt$), or capital structure ($EquityIssue - Level$, $EquityIssue - Indicator$, $LT\,Debt$, $Book\,Leverage$) for firm i in quarter t. ϕ_i is a firm fixed effect, γ_{qt-ind} is a quarter-industry fixed effect, $Fragility_{it-1}$ is the Greenwood-Thesmar measure of fragility that varies by firm and quarter. Greenwood and Thesmar (2011) show that the volatility of returns is proportional to the square root of their fragility measure and we therefore follow their specification and include $\sqrt{Fragility}$ as a regressor. In line with common practice, we use one lag of the explanatory variables in the regressions to alleviate concerns related to that corporate policies are determined jointly and in the baseline specifications X_{it-1} contains $Earnings\ Volatility$, $Ln(Assets)$, $Inst\ Ownership$, $Leverage$, $OperCashFlow$, $Fixed\,Assets$ and $Inventory$ (with $Leverage$ omitted as a control in the capital structure regressions). The error term is denoted by ϵ_{it} and the standard errors are adjusted for clustering at the firm level.

Equation (9), with various dependent variables, represents the main estimating equations in the panel analysis that we perform in Section 4. To examine heterogeneity of responses we also estimate specifications where we include interaction between $\sqrt{Fragility_{it-1}}$ and indicator variables that take the value one for firms where we expect the effect of stock price fragility to be especially strong (for instance observations that are in the top quartile of earnings volatility). Such indicator variables, denoted $High_{it-1}$ in Equation (10), are interacted with $\sqrt{Fragility_{it-1}}$ in regressions of the following form, where we now use ξ_{it} to denote the error term:

$$\frac{DEP_{it}}{Assets_{it}} = \phi_i + \gamma_{qt-ind} + \alpha_H \sqrt{Fragility_{it-1}} \times High_{it-1} + \alpha \sqrt{Fragility_{it-1}} + High_{it-1} + \beta X_{it-1} + \xi_{it}. \quad (10)$$

The estimated coefficient on the interaction effect between the indicator variable of interest and stock price fragility, α_H, is used to evaluate whether we observe stronger effects of stock price fragility on cash holding in cases where we expect the importance of the precautionary cash holding mechanism to be particularly prominent. We again use firm and industry-quarter fixed effects to control for unobserved heterogeneity. These interaction results are reported in Tables 4 and 5.

To further evaluate the hypothesis that the results represent a causal effect, we present evidence on corporate responses to exogenous shocks to fragility stemming from mergers of financial institutions in Section 5. In each case, the regressions are estimated on a sample that is restricted to firms that are held by at least one of the merging financial institutions and the sample period is limited to a period surrounding the respective merger as detailed further below. The estimating equations in those cases take the following form:

$$\frac{DEP_{it}}{Assets_{it}} = \phi_i + \gamma_{qt-ind} + \delta Treatment_i \times Post_t + \beta X_{it-1} + \eta_{it}, \quad (11)$$

where $Treatment_i$ is an indicator variable that takes the value one for firms that were held by both the merging parties in the various mergers and zero for firms that were just held by one of the merging parties. $Post_t$ is an indicator variable that is one for periods after the announcement of the merger and zero otherwise. The error term is now denoted by η_{it} and the standard errors are adjusted for clustering at the firm level. The estimated coefficient δ is in these cases a difference-in-difference estimate of the effect of an exogeneous shock to fragility on the dependent variable.

4. The effect of stock price fragility

The key prediction of our model is that firms facing a greater risk of mispricing in the future, i.e. firms with a more fragile stock price, are likely to hold more cash in order to lower the probability of costly cash shortfalls. This relies on an assumption that higher stock price fragility is associated with a greater scope for misvaluation. Greenwood and Thesmar (2011) document that higher fragility is associated with higher future stock price volatility (see Greenwood and Thesmar (2011, Table 3)) and we confirm this relation for the current time period, reporting results in Table IA.1 in the Online Appendix.

We further examine direct evidence for whether higher fragility increases the potential for future misvaluation. Using the Stambaugh et al. (2015a) proxy for mispricing which ranges from 0 (highly undervalued) to 100 (highly overvalued), we generate two indicators of misvaluation. *Undervaluation Indicator* takes the value one when the stock is in the bottom quartile of the Stambaugh et al. (2015a) proxy while *Overvaluation Indicator* equals one when a stock is in the top quartile of the measure at three different time horizons (6 months, 1 year, and 18 months in the future). Using both OLS and logit estimations, Table 2 documents that an increase in fragility correlates with a higher likelihood of future undervaluation (Panel A) as well as future overvaluation (Panel B) at each of the time horizons. This is consistent with other evidence on the role of institutional investors on misvaluation (Ben-David et al. (2021); Anton and Polk (2014)).

4.1. Fragility and cash

Given this, we empirically test the model's prediction that the risk of mispricing affects precautionary corporate behavior. Table 3 examines this prediction and reports results from regressions with cash scaled by assets as the dependent variable and a set of controls in addition to firm and quarter-industry fixed effects.

Column (1) reports the estimation results for a specification that only controls for firm and industry-quarter fixed effects. As seen, fragility has a positive relation with cash holding in this "minimal" specification. Column (2) reports the results from a specification that controls for possible confounding factors and that we view as the baseline specification. The coefficient on fragility is again positive and statistically significant. While a precautionary motive for cash holdings has been documented in many other studies, see e.g. Bates et al. (2009) or Almeida et al. (2014), we identify a distinct channel of risk - the risk of equity misvaluation.

The point estimate on $\sqrt{Fragility}$ in Column (2) indicates that a one standard deviation increase in fragility is associated with an increase in *Cash* by 2.0% when set in relation to mean cash holdings (.22). To compare the magnitude of this effect to a well established source of variability we note that much of the literature uses the standard deviation of earnings to capture the motivation for precautionary cash holding (often averaged at the industry level as in Opler et al. (1999) or Bates et al. (2009)). In our sample a one standard deviation increase in earnings volatility is associated with increased cash holdings by 1.9% (when evaluated at the mean cash holding). Thus, the effect of stock price fragility on cash holding is of approximately the same magnitude as the effect of a leading motivation for precautionary cash holding. This underscores that the effect of within firm changes in fragility on cash holding is non-trivial and supports the notion that stock price fragility is salient.

The remaining columns in Table 3 explore robustness in various dimensions. As our focus is on precautionary cash, we recognize that our measure of cash may be distorted by the large levels of cash held by some multinational corporations for tax motivated reasons (see e.g. Faulkender et al. (2019)). Excluding firms which hold cash for both precautionary and tax reasons should provide a cleaner measure of precautionary cash responses. Column (3) therefore excludes multinational corporations and, as seen by a comparison with Column (2), the estimated association between fragility and cash holding is stronger for purely domestic firms. Column (4) reports results when the years of the financial crisis, 2008-2009, have been excluded and the estimated coefficient on $\sqrt{Fragility}$ is stable. While our baseline results follow Greenwood and Thesmar (2011) and use $\sqrt{Fragility}$, Column (5) presents $Fragility$ in levels for completeness. Again, there is a positive and statistically significant relationship between stock price

Table 2
Increase in Stock Fragility and Future Misvaluation.

Panel A	*Future Undervaluation Indicator*					
	OLS			Logit		
	(1) +2 qtr	(2) +4 qtr	(3) +6 qtr	(4) +2 qtr	(5) +4 qtr	(6) +6 qtr
Increase in $\sqrt{Fragility}$	0.010***	0.011***	0.006*	0.071***	0.077***	0.049**
	(0.003)	(0.003)	(0.003)	(0.019)	(0.019)	(0.019)
Quarter-Industry FE	YES	YES	YES	YES	YES	YES
Firm Controls	YES	YES	YES	YES	YES	YES
Adj. R2	0.165	0.153	0.150			
Pseudo R2				0.171	0.150	0.142
Observations	90,701	86,697	81,488	89,987	86,002	80,816
Panel B	*Future Overvaluation Indicator*					
	OLS			Logit		
	(1) +2 qtr	(2) +4 qtr	(3) +6 qtr	(4) +2 qtr	(5) +4 qtr	(6) +6 qtr
Increase in $\sqrt{Fragility}$	0.015***	0.012***	0.011***	0.121***	0.096***	0.094***
	(0.002)	(0.003)	(0.003)	(0.018)	(0.019)	(0.020)
Quarter-Industry FE	YES	YES	YES	YES	YES	YES
Firm Controls	YES	YES	YES	YES	YES	YES
Adj. R2	0.085	0.077	0.074			
Pseudo R2				0.089	0.079	0.075
Observations	127,692	119,142	111,130	120,087	111,809	104,061

Panel regression of *Undervaluation* (Panel A) and *Overvaluation* (Panel B) on firm-level control variables. *Undervaluation* is a dummy variable that takes the value 1 in the respective quarter for stocks that are in the bottom quartile of the Stambaugh et al. (2015a) measure of misvaluation. Analogously, *Overvaluation* takes the value 1 for stocks that are in the top quartile of the Stambaugh et al. (2015a) measure of misvaluation. The misvaluation measures are evaluated at 2, 4 and 6 quarters ahead (t+2, etc.). *Increase in* $\sqrt{Fragility}$ is a dummy variable that takes the value 1 for stocks whose $\sqrt{Fragility}$ has increased from t-1 until t. The regressions include quarter-year by industry (SIC3) fixed effects with OLS and both quarter-year FE and industry FEs with logit as well as additional (unreported) controls: *Earnings Volatility*, *Ln(Assets)*, *Inst. Ownership*, *Leverage*, *Oper Cash Flow*, *Fixed Assets*, and *Inventory*. Standard errors are adjusted for clustering at the firm level. Statistical significance at the 1, 5, or 10% levels is reported as ***, **, *, respectively.

Table 3
Stock Fragility and Cash Holding.

	(1) Cash/Assets: All	(2) Cash/Assets: All	(3) Cash/Assets: No MNC	(4) Cash/Assets: No Fin Crisis	(5) Cash/Assets: All	(6) Cash/Assets: All
$\sqrt{Fragility}$	0.692**	0.633**	0.938***	0.597**		
	(0.293)	(0.250)	(0.336)	(0.275)		
Fragility					39.190**	
					(16.041)	
$\sqrt{Fragility}$ (Current)						0.764***
						(0.250)
Earnings volatility		0.086***	0.065***	0.065***	0.085***	0.085***
		(0.019)	(0.023)	(0.020)	(0.018)	(0.019)
Ln(Assets)		-0.040***	-0.032***	-0.040***	-0.040***	-0.041***
		(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
Inst Ownership		0.015***	0.021***	0.017***	0.016***	0.014***
		(0.005)	(0.007)	(0.005)	(0.005)	(0.005)
Leverage		-0.092***	-0.079***	-0.102***	-0.092***	-0.092***
		(0.006)	(0.008)	(0.007)	(0.006)	(0.006)
Fixed Assets		-0.414***	-0.401***	-0.417***	-0.415***	-0.415***
		(0.017)	(0.022)	(0.018)	(0.017)	(0.017)
Inventory		-0.550***	-0.515***	-0.545***	-0.550***	-0.552***
		(0.024)	(0.033)	(0.025)	(0.025)	(0.025)
Oper Cash Flow		-0.045*	-0.052	-0.061**	-0.046*	-0.046*
		(0.026)	(0.032)	(0.028)	(0.026)	(0.027)
Quarter-Industry FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Adj. R2	0.836	0.862	0.882	0.865	0.862	0.863
Observations	136,191	136,191	66,990	119,524	136,449	135,908

Panel regression of cash on Greenwood and Thesmar's stock price fragility measure as well as additional firm-level control variables. The regressions include both firm and quarter-industry (SIC3) fixed effects and the standard errors are adjusted for clustering at the firm level. The data is quarterly from 2001 - 2017. Column (3) excludes multinational firms and Column (4) excludes 2008-2009. Statistical significance at the 1, 5, or 10% levels is reported as ***, **, *, respectively.

Table 4
Stock Fragility and Cash. The Expected Cost of Misvaluation.

	(1) Cash/Assets	(2) Cash/Assets	(3) Cash/Assets	(4) Cash/Assets	(5) Cash/Assets	(6) Cash/Assets	(7) Cash/Assets
High VIX period x $\sqrt{Frag.}$	0.916***						
	(0.240)						
High Earnings Vol. x $\sqrt{Frag.}$		0.907**					
		(0.428)					
High Fluidity x $\sqrt{Frag.}$			0.820				
			(0.567)				
Fin. Constrain x $\sqrt{Frag.}$				0.802**			
				(0.396)			
Small x $\sqrt{Frag.}$					1.301***		
					(0.447)		
No Bond Rating x $\sqrt{Frag.}$						1.169***	
						(0.440)	
Low Analyst Cov. x $\sqrt{Frag.}$							1.305**
							(0.521)
Quarter-Industry FE	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES
Adj. R2	0.862	0.862	0.864	0.870	0.862	0.862	0.876
Observations	136,191	136,191	130,473	98,662	136,191	136,191	103,105

Panel regression of cash on Greenwood and Thesmar's stock price fragility measure as well as additional firm-level control variables. The regressions include both firm and quarter-industry (SIC3) fixed effects as well as additional (unreported) controls: *Earnings Volatility*, *Ln(Assets)*, *Inst. Ownership*, *Leverage*, *Oper Cash Flow*, *Fixed Assets*, and *Inventory* as well as the reported interacted variables separately. Standard errors are adjusted for clustering at the firm level. *High VIX Period*, *High Earnings Volatility* and *High (Product Market) Fluidity* are dummy variables that take the value 1 for the top quartile. *Fin Constrain* is defined as firms above median of Hoberg and Maksimovic (2015b) measure of Financial Constraints, *Small* is defined as firms in the bottom three quartiles by assets and *No Bond Rating* is a dummy variable that takes the value 1 when a firm lacks a bond rating. *Low Analyst Coverage* is defined as firms in the bottom three quartiles in terms of the number of analysts that follow the firm. Statistical significance at the 1, 5, or 10% levels is reported as ***, **, *, respectively.

fragility and cash holding. Finally, given the inherently forward-looking nature of management responses to stock price fragility in our model, one could hypothesize that cash holdings might adjust in the same quarter that fragility changes. Thus, Column (6) includes the current level of fragility and the point estimate is essentially unchanged.

Across the specifications, the estimated effect of the control variables are in line with expectations. For instance, we confirm well established results that larger and more levered firms on average hold less cash (see e.g. Bates et al. (2009) and Faulkender et al. (2019)). We also find a negative relationship between inventory and cash as in Kulchania and Thomas (2017).

4.2. Heterogeneous effects of stock price fragility

In our model, a firm holds a cash buffer to avoid having to raise funds in a future situation when a cash shortfall coincides with an undervalued stock. Since the model's mechanism suggests some conditions under which the motivation to hold a cash buffer should be especially strong, we delve further into the heterogeneous effects of fragility. Table 4 reports how firms adjust cash when $\sqrt{Fragility}$ is interacted with proxies to capture differential effects of non-fundamental price shocks.

First, we consider the interaction between stock price fragility and variables that aim to capture *future price uncertainty*. Based on the key mechanism of our model, a higher sensitivity to non-fundamental price shocks should be more likely to raise precautionary cash holding in cases where stock prices are more uncertain (Zhang (2006)). In Column (1) *High VIX Period* is used to represent aggregate uncertainty and, in line with expectations based on our model, the interaction effect is positive and statistically significant.

Second, we evaluate interactions between stock price fragility and variables that aim to capture *need for capital*. The probability of a shortfall in cash holdings should be greater in more volatile product markets (Froot et al. (1993)). Column (2) establishes that if the firm observation is in the top quartile of prior quarter earnings volatility, as captured by *High Earnings Volatility*, this is associated with a stronger effect of fragility on cash holding. Column (3) examines whether firms competing in the most fluid product markets (Hoberg et al. (2014)) experience a stronger effect of fragility on cash holding. The coefficient on this interaction, *High Fluidity*, is not statistically significant at conventional levels however.

We also note that our modeling assumption of a lower bound on the cash balance hinges on financial constraints. Thus, we extend our exploration beyond the immediate predictions of the model and examine the role of financial constraint. Not only is the potential effect of financial constraint on investments well established (even if empirically measuring financial constraints remains a challenge (Hoberg and Maksimovic (2015b), Farre-Mensa and Ljungqvist (2016)), there also is evidence supporting an important role for financial constraints specifically in relation to misvaluation. Using fire sales during the financial crisis of 2008 to identify underpricing, Hau and Lai (2013) for instance show that the most undervalued firms lower investment, and that the effect is strongest among the most financially constrained firms (see also Lou and Wang (2018)). We build on these results but take an ex ante view where the decision of how much cash to hold depends on the probability distribution of the future stock market price.

As such, the ex ante precautionary measures taken in response to a more fragile stock price should be stronger for more financially constrained firms. The remaining columns of Table 4 therefore interact stock price fragility with variables that aim to capture *more constrained access to capital*. Column (4) uses the Hoberg and Maksimovic (2015b) text-based measure of *Fin Constrain*. Column (5) focuses on smaller firms (total assets in the bottom three quartiles) and, in the spirit of Gilchrist and Himmelberg (1995) and Almeida et al. (2004), Column (6) examines the impact of fragility for unrated firms. Finally, firms that exhibit a lower coverage by analysts are likely to face tighter financial constraints (Easley and O'Hara (2004), Whited and Wu (2006)) and Column (7) shows that the effect of stock price fragility on cash holding is stronger for firms that have a *Low Analyst Coverage*.

Let us expand somewhat on our last result, that low analyst coverage interacts with fragility to increase precautionary cash holding. As discussed in the Introduction, there are two channels through which a decrease in stock price can make it more difficult for the firm to ac-

Table 5
Managerial Expectations.

	(1) Cash/Assets: All	(2) Cash/Assets: No MNC	(3) Cash/Assets: All	(4) Cash/Assets: No MNC
Stock Price Increase x $\sqrt{Frag.}$	-0.388***	-0.527***		
	(0.133)	(0.178)		
Positive Manager Sent. x $\sqrt{Frag.}$			-0.215	-0.666**
			(0.209)	(0.287)
Stock Price Increase	0.003***	0.004***		
	(0.001)	(0.001)		
Positive Manager Sent.			-0.005***	-0.001
			(0.001)	(0.002)
$\sqrt{Fragility}$	0.832***	1.198***	0.608**	1.204***
	(0.261)	(0.349)	(0.295)	(0.396)
Earnings volatility	0.086***	0.065***	0.103***	0.094***
	(0.019)	(0.023)	(0.019)	(0.025)
Ln(Assets)	-0.040***	-0.031***	-0.042***	-0.033***
	(0.003)	(0.004)	(0.003)	(0.005)
Inst Ownership	0.015***	0.021***	0.017***	0.024***
	(0.005)	(0.007)	(0.005)	(0.007)
Leverage	-0.091***	-0.078***	-0.092***	-0.079***
	(0.006)	(0.008)	(0.007)	(0.008)
Fixed Assets	-0.414***	-0.402***	-0.415***	-0.398***
	(0.017)	(0.022)	(0.018)	(0.022)
Inventory	-0.549***	-0.515***	-0.556***	-0.510***
	(0.025)	(0.033)	(0.025)	(0.035)
Oper Cash Flow	-0.046*	-0.054*	-0.022	-0.026
	(0.026)	(0.032)	(0.028)	(0.032)
Quarter-Industry FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Adj. R2	0.862	0.882	0.867	0.887
Observations	136,191	66,990	120,201	56,541

Panel regression of cash on Greenwood and Thesmar's stock price fragility measure interacted with the reported dummy variables as well as additional controls. The regressions include both firm and quarter-industry (SIC3) fixed effects. *Stock Price Increase* is a dummy variable that takes the value 1 for stocks whose price has increased from t-2 until t-1. *Positive Manager Sentiment* is a dummy variable that takes the value 1 if the Jiang-Lee-Marti-Zhou measure of manager sentiment measure was positive in t-1. Statistical significance at the 1, 5, or 10% levels is reported as ***, **, *, respectively.

cess external funding: either because it makes it more expensive to rely on stock issuance (through SEO, PIPE, or ATM) or because it makes credit conditions less favorable as creditors update their view based on the stock price, an information channel. Our finding that firms with lower analyst coverage, where creditors have less alternative information, respond more strongly to increased fragility is consistent with the information channel playing some role for the precautionary behavior.

In sum, almost all the interaction effects are positive and statistically significant in line with the model and its implications for financial constrained firms. The magnitude of effects are non-trivial. For instance the specification in Column (1) implies that a one standard deviation increase in the stock price fragility is associated with an additional increase in cash holding of 2.4% for periods with the highest stock price volatility. The results in Table 4 thus support the notion that the model's mechanism plays an important role in generating the positive effect of stock price fragility on cash holding.

4.3. Expectations of future undervaluation

It is the expectations of future undervaluation which drives our model and this insight provides additional empirical predictions.[14] While a perfect proxy for the expectation of future undervaluation is difficult to imagine, there is a growing literature on expectation biases (see e.g. Afrouzi et al. (2020)) and we can build on the evidence of managerial biases regarding future returns. Barrero (2022) documents an overextrapolation bias which leads managers to overweight recent events. To the extent managers are subject to this bias, they may overextrapolate from recent stock price movements.[15] This is indeed what we see in Column (1) of Table 5 where we interact stock price fragility with an indicator for *Stock Price Increase*. The baseline coefficient estimate on $\sqrt{Fragility}$ remains positive and statistically significant but the interaction coefficient shows that the effect is attenuated in firms with recent stock price increases. Column (2), which excludes multinational firms, confirms that the effect holds in a sample where tax motivations for cash holding are less prominent.

Next, we use the text-based time-series index of managerial sentiment developed by Jiang et al. (2019b). This time series measure aims to capture periods of widespread overoptimism regarding future returns. In Columns (3) and (4), we interact fragility with *Positive Manager Sentiment*. Given this is an economy-wide index and not firm specific, it arguably makes effects harder to discern. The interaction effect is negative as predicted but not statistically significant when we consider all firms. However, we repeat the analysis excluding multinational firms to focus on a cleaner measure of precautionary cash (not affected by multinational tax motivations) and the coefficient estimate is negative and statistically significant for this sample (Column (4)). We conclude that the empirical evidence on heterogeneous effects aligns with the key mechanism in our model where precautionary cash holding today is increasing with managerial expectations of future undervaluation.

[14] We thank the referee for this suggestion.

[15] Given that stock price decreases could be correlated with more binding financial constraints, we focus on stock price increases rather than stock price decreases.

Table 6
Stock Fragility and Cash. Robust to Proxies for Current Misvaluation.

	(1) Cash/Assets	(2) Cash/Assets	(3) Cash/Assets	(4) Cash/Assets	(5) Cash/Assets	(6) Cash/Assets	(7) Cash/Assets	(8) Cash/Assets
$\sqrt{Fragility}$	0.687**	0.649**	0.706**	0.705**	0.633**	0.628*	0.626**	0.860**
	(0.316)	(0.291)	(0.295)	(0.295)	(0.291)	(0.325)	(0.301)	(0.349)
Misprice (SYY)/10	0.002**							0.002**
	(0.001)							(0.001)
Book-to-Market		-0.018***						-0.007**
		(0.001)						(0.003)
Residual Book-to-Market (PV)			-0.016***					-0.013***
			(0.002)					(0.005)
Residual Book-to-Market (HP)				-0.016***				-0.011**
				(0.002)				(0.004)
Residual Book-to-Market (RRV)					-0.009***			-0.020***
					(0.001)			(0.002)
Mutual Fund Outflows						0.013***		0.014***
						(0.002)		(0.003)
Future Excess Returns/10							-0.001**	-0.000
							(0.000)	(0.000)
Quarter-Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Adj. R2	0.840	0.842	0.843	0.843	0.842	0.847	0.843	0.851
Observations	94,198	133,332	131,374	131,374	133,167	112,488	123,743	79,692

Panel regression of cash on Greenwood and Thesmar's stock price fragility measure as well as mispricing proxies. Column (1) controls for current mispricing following Stambaugh et al. (2015a) and columns (2)-(8) use a set of mispricing proxies following Derrien et al. (2013) including Book-to-Market measures of Pástor-Veronesi (PV), Hoberg-Philips (HP) and Rhodes-Kropf-Robinson-Viswanathan (RRV). The regressions include both firm and quarter-industry (SIC3) fixed effects and the standard errors are adjusted for clustering at the firm level. The data is quarterly from 2001 - 2017. Statistical significance at the 1, 5, or 10% levels is reported as ***, **, *, respectively.

4.4. Current versus future misvaluation

The theory we present shows that the risk of future equity misvaluation affects precautionary cash decisions and Table 3 documents that firms adjust cash in response to changes in the Greenwood and Thesmar (2011) measure of fragility in regressions which include firm and time-industry fixed effects to control for unobserved heterogeneity. Nevertheless, one potential concern is that the results might merely reflect current misvaluation, rather than expectations of the scope for future misvaluation. To allay such concerns we first note that Greenwood and Thesmar (2011) and Ben-David et al. (2021) establish that greater stock fragility for a firm strongly predicts volatility and that the Greenwood and Thesmar (2011) measure of fragility is a measure of sensitivity to shocks, and not directly related to current over- or undervaluation.

However, we also control for the current level of misvaluation as a robustness exercise. While finding credible proxies for current misvaluation is challenging, Table 6 presents seven different proxies that have been proposed in the literature. In Column (1) we add a measure of mispricing based on Stambaugh et al. (2015a). As noted, this mispricing index ranges from 0 (highly undervalued) to 100 (highly overvalued) with 50 indicating that a stock is neither under- nor overvalued. We create the variable *Misprice (SYY)* defined as the absolute deviation of the index from 50. Next, we note that a particularly comprehensive examination of proxies for current misvaluation is conducted in Derrien et al. (2013) and the remaining columns control for all of these measures, first one-by-one and then collectively. Column (2) controls for raw *Book-to-Market* and Columns (3) to (5) for various measures of residual book-to-market that have been proposed: Column (3) follows Pástor and Veronesi (2003), Column (4) Hoberg and Phillips (2010b) and Column (5) Rhodes-Kropf et al. (2005). Column (6) controls for mutual fund outflows and Column (7) for future excess returns. Throughout these proxies for misvaluation show a statistically significant relation with cash holding. For instance, in line with e.g. Bates et al. (2009), higher book-to-market (both raw and the residuals examined) are associated with lower cash holdings.

The key finding for our investigation, however, is that the estimated coefficient on stock fragility sees little change across the columns and remains close to the benchmark estimate report in Column (1) of Table 3.[16] This holds true even in Column (8) which includes all potential proxies for current misvaluation. Thus, controlling for a set of measures that are highly likely to be correlated with current misvaluation does little to affect the economic significance of stock price fragility on cash holding. This provides further support for the notion that expectations of future stock price volatility, as captured by current fragility, impact corporate policy.

4.5. The effect of fragility on investment and liquidity choices

Our model focuses on precautionary cash holding in response to a more fragile stock price. The logic of the model also implies that greater fragility should be associated with less investment and more conservative liquidity management in line with Bolton et al. (2011). We explore these dimensions in Table 7 and Column (1) presents regression results of capital expenditure on the same explanatory variables as in the cash holding regressions. The point estimate indicates that higher stock price fragility is associated with less investment, even if the relation is only statistically significant at the 10% level. The estimated coefficient in Column (1) implies that if fragility increases by one standard deviation, capital expenditure/assets decreases by -.0003. While this may seem like a minuscule effect note that average investment rate is also low at .012 and a one standard deviation increase in fragility decreases capital investment by around 2.7%, when evaluated at the mean investment level.

Column (2) presents results from a regression with R&D expenditures as a measure of investment with quantitatively similar effects when set in relation to the mean level of R&D expenditures. Given the vast evidence that higher uncertainty lowers investment, the results

[16] Many of the proxies for current misvaluation partly build on our benchmark set of controls that we use in Columns (2) to (6) of Table 3 as well as in most other tables. For instance the measure in Column (3) of Table 6 uses the residual from a regression of the book-to-market value on variables including *Leverage* and *ln(Assets)*. To provide a clean comparison in Table 6 we therefore rely on the Column (1) Table 3 baseline specification with only firm and industry-quarter fixed effects.

Table 7
Stock Fragility, Investments and Liquidity Management.

	(1) CapEx/Assets	(2) R&D/Assets	(3) Repurch/Assets	(4) Dividends/Assets	(5) ST Debt/Assets
$\sqrt{Fragility}$	-0.050*	-0.086*	-0.072***	0.007	-0.356***
	(0.027)	(0.046)	(0.025)	(0.009)	(0.120)
Earnings volatility	-0.003*	-0.009**	-0.002***	0.000	-0.000
	(0.002)	(0.004)	(0.001)	(0.000)	(0.008)
Ln(Assets)	0.000	-0.009***	0.001***	0.000	-0.006***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Inst Ownership	0.002***	0.001	0.001**	-0.000	-0.004
	(0.000)	(0.001)	(0.000)	(0.000)	(0.003)
Leverage	-0.018***	-0.004***	-0.011***	-0.003***	0.122***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.005)
Fixed Assets	0.004*	0.013***	-0.002**	-0.001***	0.013*
	(0.002)	(0.003)	(0.001)	(0.000)	(0.007)
Inventory	0.002	-0.008**	-0.004***	-0.002***	0.093***
	(0.002)	(0.004)	(0.001)	(0.001)	(0.011)
Oper Cash Flow	0.012***	-0.109***	0.009***	0.003***	-0.057***
	(0.002)	(0.006)	(0.002)	(0.001)	(0.010)
Quarter-Industry FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES
Adj. R2	0.557	0.813	0.276	0.532	0.550
Observations	135,832	73,437	127,068	135,580	135,254

Panel regression of investment and liquidity decisions on Greenwood and Thesmar's stock price fragility measure as well as additional firm-level control variables. The regressions include both firm and quarter-industry (SIC3) fixed effects and the standard errors are adjusted for clustering at the firm level. The data is quarterly from 2001 - 2017. Statistical significance at the 1, 5, or 10% levels is reported as ***, **, *, respectively.

may not seem surprising. Note however that the source of uncertainty here is very specific and novel. Firms adjust investment in response to higher uncertainty regarding firm-specific, but non-fundamental, movements in the price of its stock.[17]

Columns (3) to (5) explore aspects of financial flexibility. Precautionary behavior leads us to expect that firms facing higher risk keep more financial muscle in the firm and therefore payout less - a prediction that is borne out for other sources of risk in e.g. Bonaimé et al. (2013) or Hoberg et al. (2014). We consider two ways of payouts separately, repurchases and dividend payments. In line with Massa et al. (2020), we find in Column (3) that higher financial fragility is associated with a lower repurchase rate. Column (4) indicates that there is no statistically significant relationship with, arguably less flexible, dividend payments.

Debt maturity is another aspect of liquidity management. As short term debt increases refinancing risk, our prior is that firms that are faced with a greater stock price fragility will try to reduce that exposure. Previous evidence consistent with an important role of refinancing risk come from e.g. Harford et al. (2014), who show that firms mitigate refinancing risk by holding more cash. In line with the hypothesis that a more fragile stock price again is associated with more cautious behavior, Column (5) shows that higher fragility associates with less short-term debt.

4.6. The (non-)effect of fragility on capital structure

The evidence suggests that firms engage in active liquidity management in response to stock price fragility but Bolton et al. (2011) notes that raising capital is an additional lever in that toolbox. Table 8 examines whether an increased risk of future non-fundamental price movement leads firms to preemptively seek external funds. The first two columns test whether within-firm changes in fragility associate with equity issuance – with equity issuance measured as the level scaled by assets in Column (1) and using an indicator in Column (2). The next two columns focus on debt, using long-term debt scaled by assets in Column (3) and book leverage in Column (4). Across all four columns, there is no evidence that firms adjust their capital structure in response to changes in fragility. This is consistent with the literature on the material cost of external financing (Hennessy and Whited (2007), Eisfeldt and Muir (2016)) as well as the resulting risk management preference to adjust internal liquidity management and even reduce investment to delay the need for external financing (Bolton et al. (2011)).

5. Asset management mergers

5.1. The BlackRock-BGI merger

The preceding analysis has shown that firms hold more cash and make other precautionary adjustments as the risk of future non-fundamental price shocks increases. The feedback effect creates a real cost to changes in ownership concentration and correlation. Combined, this supports the risk management hypothesis laid out in the model where managers recognize that greater fragility raises the probability of misvaluation and therefore adopt more cautious policies. In the analysis above, fixed effects at the level of the firm and industry-quarter level are likely to capture much potential unobserved heterogeneity. The fact that our results rely on within-firm variation, is stable across robustness specifications, and that the signs of interaction effects are in line with the logic that underlies our model buttress our confidence in the results.

Even so, one may be concerned that fragility is partly endogenous in the regressions above. To address this, we first use the merger of BlackRock and Barclays Global Investors (BGI) as an exogenous shock to stock price fragility. This event is advantageous relative to other ownership shocks, such as index reconstitutions, because the level of institutional ownership is unchanged by the event. Rather, the merger only affects the ownership concentration and correlation of flows – the key elements of the Greenwood and Thesmar (2011) measure of stock price fragility.

The Blackrock-BGI merger could increase price fragility in several ways. First, some individual funds were consolidated following the merger and this would have an immediate impact on the ownership con-

[17] Table IA.3 in the Online Appendix confirms that the magnitudes are similar if we consider CapEx and R&D expenditures jointly and if we examine investment in intangibles using the Peters and Taylor (2017) measure.

Table 8
Stock Fragility and Capital Structure.

	(1) Equity Issue (Levels)	(2) Equity Issue (Indicator)	(3) LT Debt/Assets	(4) Leverage (Book)
$\sqrt{Fragility}$	-0.076	-0.184	-0.025	-0.389
	(0.079)	(0.381)	(0.321)	(0.343)
Earnings volatility	0.002	-0.054*	0.046***	0.081***
	(0.009)	(0.031)	(0.016)	(0.018)
Ln(Assets)	-0.017***	-0.075***	0.048***	0.050***
	(0.001)	(0.004)	(0.003)	(0.003)
Inst Ownership	0.001	0.016**	-0.022***	-0.034***
	(0.001)	(0.007)	(0.007)	(0.007)
Fixed Assets	0.015***	0.009	0.134***	0.175***
	(0.004)	(0.021)	(0.018)	(0.019)
Inventory	0.010*	-0.044	-0.035	0.049*
	(0.006)	(0.028)	(0.026)	(0.027)
Oper Cash Flow	-0.195***	-0.073	-0.275***	-0.382***
	(0.016)	(0.047)	(0.020)	(0.022)
Quarter-Industry FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Adj. R2	0.175	0.170	0.744	0.758
Observations	128,046	128,046	139,175	139,175

Panel regression of equity issuance, leverage and long term debt on Greenwood and Thesmar's stock price fragility measure as well as additional firm-level control variables. Equity issuance in levels scaled by assets, and indicator variable of equity issuance equal to 1 if equity increase by at least 1%, otherwise set to 0. The regressions include both firm and quarter-industry (SIC3) fixed effects and the standard errors are adjusted for clustering at the firm level. The data is quarterly from 2001 - 2017. Statistical significance at the 1, 5, or 10% levels is reported as ***, **, *, respectively.

centration, thereby directly raising one element of fragility. Moreover, stock price fragility also can rise over time as Blackrock and BGI funds increase the similarity of their investments or experience more correlated investor flows. Nanda et al. (2004) and Sialm and Tham (2016) show that funds within the same fund management company have a higher correlation of inflows and Elton et al. (2007) show that they have more similar stock holdings. Lastly, since two families of funds merged, there is a direct effect on the ownership concentration at the family of funds (firm) level. We therefore recalculate stock price fragility at the fund family level to match the shock to ownership concentration provided by the merger using all the institutional investors included in the Thomson Reuters S34 (13F) file.[18]

5.1.1. Empirical design and assumptions

The two institutional investors merged in 2009 with the announcement in June and the deal completed in December. The merger followed an offer by CVC Capital to purchase the iShares piece of BGI earlier in 2009 which contained a 'go-shop' provision. Treated firms are identified as those held by both Blackrock and BGI at the end of 2008 (before the merger announcement, and preceding the CVC offer) and thus are exposed to an ownership concentration shock. As pre-merger ownership is not randomly assigned, we restrict our control group to firms that are held by either Blackrock or BGI in the pre-event period, thus mitigating the potential differences between the treated and control groups. Given our mechanism relies on expectations, the announcement is the natural event date and the variable *Merger Treatment* takes the value of 1 for treated firms from the second quarter of 2009 onward and 0 otherwise. We use difference-in-difference estimation for the years 2008-2010 to examine the effect of treatment by the merger on cash holding, investments and the measures of financial flexibility analyzed in the panel regressions.

Identification of the effect of the merger on cash holdings relies on two assumptions. The first key assumption in our difference-in-difference analysis is that the treated firms and control group would have followed the same developments if the merger had not occurred (the "parallel trends assumption"). Therefore, we examine developments of cash holding for the treated and control firms for the periods surrounding the merger and plot the estimated coefficient from a regression of cash holding on treatment before and after the merger (as well as firm fixed effects and the industry-quarter dummy variables incorporated in all the benchmark specifications) in the upper panel of Fig. 1. The absence of differential pre-trends supports our use of a difference-in-difference specification to evaluate the effects of exogeneous changes in stock price fragility on cash holding. As noted, we use the announcement date to determine the treatment indicator in regressions below. While the effect on fragility is likely to only materialize when the merger is completed, forward looking firms may respond preemptively at the date of announcement, as seen in Fig. 1.

The second key assumption is that the merger affects stock price fragility. To verify this, the lower panel of Fig. 1 plots the estimated coefficient from a regression of the square root of fragility (at the family of funds level) on treatment before and after the merger (as well as firm fixed effects and the industry-quarter dummy variables). There is clear evidence that the completion of the merger raises stock price fragility.[19]

5.1.2. Discussion of merger impact on fragility and volatility

While Fig. 1 shows that the merger raised fragility at the family of funds level, we also expect a higher fragility to be associated with higher future realized stock price volatility and indeed Columns (1) and (2) of Table 9 confirm that the BlackRock-BGI merger also associates positively with future stock price volatility. The positive effect on fragility and volatility from an ownership concentration differs from Massa et al. (2021), who use FactSet and Worldscope to explore shifts in the aggregate mix of institutional investors at the worldwide level. As the effect of the BlackRock-BGI merger on fragility is an identifying assumption in this section, it is important to discuss the different effects in Massa et al. (2021) and the current section. First, we note that, in line with our findings, their Table 7 documents that the BlackRock-BGI merger leads to higher fragility also in the global sample when fragility is measured using only open ended funds (OEFs). However, the coefficient flips when all FactSet fund types are used (OEF + non-OEFs)

[18] Details of this variable construction are provided in the Appendix.

[19] Table IA.4 in the Online Appendix show that the merger also increased fragility at the, more disaggregated, fund level.

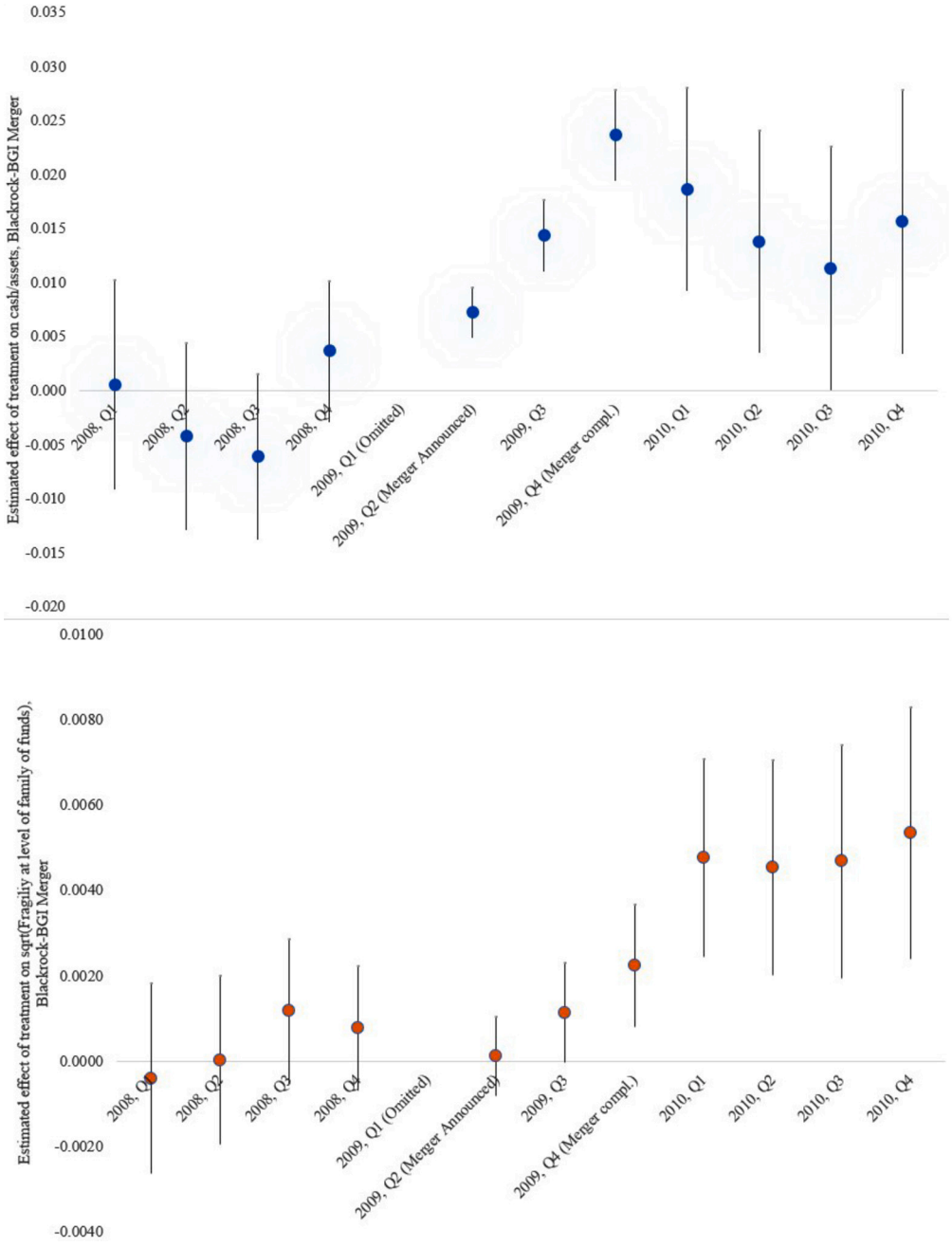

Fig. 1. The Estimated Effect of the BlackRock-BGI Merger on Cash Holding (upper panel) and on Square Root of Fragility at the Level of Family of Funds (lower panel). The figure shows the estimated coefficients on treatment (leads and lags) surrounding the BlackRock-BGI merger together with the 95% confidence intervals. The regressions include firm fixed effects as well as quarter-industry (SIC 3) fixed effects and are reported in Table IA.4 in the Online Appendix. Standard errors are adjusted for clustering at the firm level. The data is quarterly from 2008Q1-2010Q4. Merger Treatment equals one if the stock was jointly held by Blackrock and BGI in 2008 Q4 and 0 if the stock was held by only one of Blackrock and BGI in 2008Q4.

such that the mechanical effect of increased fragility from the merger is more than offset by responses of other institutional investors. Thus, the difference arises only when Massa et al. (2021) includes international non-OEFs. While FactSet has some nice advantages for the research question in Massa et al. (2021), Ferreira and Matos (2008) note that the FactSet data is quite incomplete in its coverage of non-OEFs and Koijen et al. (2020) highlight that the coverage is inconsistent across countries.

We therefore choose to focus on US equities and work with Compustat and 13F data that enables us to capture a more comprehensive view of US stocks. This feature is critical given the model's predictions as well as the panel regression evidence on the cross-sectional variation in the expected cost of misvaluation. As noted, using Fig. 1 (with 13F data which includes all institutional investors above the $100 million equity threshold - including both OEF and non-OEF funds) we document fragility increases around the Blackrock merger, consistent with what Massa et al. (2021) finds with OEFs where FactSet has more complete coverage.

So while Massa et al. (2021) provides evidence that a global sample of large firms treated by Blackrock-BGI merger saw decreasing fragility and volatility (due to flows from global institutional pension funds and other non-OEFs), we document that a comprehensive sample of US equities, including smaller firms, did not experience that decrease. The Blackrock-BGI merger, on average, lead to higher fragility as well as

Table 9
Mergers and Volatility.

	(1) Vol. of Returns	(2) Vol. of Excess Returns	(3) Vol. of Returns	(4) Vol. of Excess Returns
BlackRock-BGI Merger	0.004***	0.007***		
	(0.001)	(0.001)		
BofA-Fleet, JPM-Bank One Mergers			0.000	0.002***
			(0.001)	(0.001)
Earnings volatility	0.009**	0.009*	0.019***	0.020***
	(0.005)	(0.005)	(0.007)	(0.006)
Ln(Assets)	-0.006***	-0.006***	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Inst Ownership	0.001	-0.000	0.002	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Leverage	0.043***	0.043***	0.024***	0.025***
	(0.004)	(0.004)	(0.003)	(0.003)
Fixed Assets	0.005	0.007	0.014***	0.015***
	(0.005)	(0.005)	(0.005)	(0.005)
Inventory	0.008	0.006	-0.002	-0.001
	(0.008)	(0.007)	(0.007)	(0.007)
Oper Cash Flow	-0.029***	-0.032***	-0.026***	-0.026***
	(0.008)	(0.008)	(0.008)	(0.008)
Quarter-Industry FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Adj. R2	0.619	0.604	0.640	0.652
Observations	23,775	23,775	23,310	23,310

Panel regression of volatility of (excess) returns on merger treatment indicators as well as additional firm-level control variables. The regressions include both firm and quarter-industry (SIC3) fixed effects and the standard errors are adjusted for clustering at the firm level. In Columns (1)-(2) the data is quarterly from 2008Q1-2010Q4 and Merger Treatment equals one for firms treated by the Blackrock and BGI merger after its completion. In Columns (3)-(4) the data is quarterly from Q3 2002 until Q3 2005 and Merger Treatment equals one for firms treated by the Bank of America-Fleet and JP Morgan-Bank One mergers for the period after the merger. Statistical significance at the 1, 5, or 10% levels is reported as ***, **, *, respectively.

higher volatility for these firms. Columns (3) and (4) of Table 9 and Fig. IA.1 indicate that this pattern also holds for two additional mergers discussed below.

5.1.3. Baseline results and robustness

Let us now turn to the estimated effect of treatment on cash holding and other corporate variables using an indicator variable for treated firms in the post-merger period and controlling for the same variables as in the benchmark regression of Table 3. First, Table 10 presents the difference-in-difference estimates for cash holding. In Column (1) we see that increased stock price fragility as a result of the BlackRock-BGI merger leads to increased cash holding and the effect is statistically significant at the 1% level. Treated firms on average raise their mean cash holding by 1.3 percentage points - set in relation to the overall mean for these years the change implies that cash holding as a share of assets increases from around .20 to .213. For comparison, the seminal article Bates et al. (2009, p. 2011) states that "we infer that the average cash ratio increased by 2.1 percentage points from the 1980s to 2006 because of the increase in cash flow volatility [which more than doubled during this time, from 7% to 16.3%]." In light of this, our estimate of a 1.3 percentage points increase as a result of the BlackRock-BGI merger clearly points to a substantial effect of stock price fragility on cash holding.

The remaining columns of Table 10 examine robustness of the cash holding result. First, in their analysis of whether common ownership affects product market competition, Lewellen and Lowry (2021) note that firms treated by the BlackRock-BGI merger oversample certain industries and disproportionally represent high growth firms. We verify that our results are not driven by these concerns. Column (2) therefore excludes Drugs and Computer Service industries, Column (3) excludes book-to-market observations below median and Column (4) excludes firms with an above median R&D intensity. As seen, the estimated effect of the merger treatment is essentially unaffected relative to the benchmark in Column (1).

Further, numerous papers, such as Azar et al. (2018a), use BlackRock-BGI as an exogeneous shock to common ownership and examine whether this lead to weaker product market competition. While many of those papers raise doubts about the impact of common ownership on competition (Lewellen and Lowry (2021), Dennis et al. (2022)), there is the concern that *if* the BlackRock-BGI shock reduced competition for the treated firms, the resulting higher profits mechanically might increase cash. One counter-argument is that even if the shock lead to a direct effect on profits, it is far from clear that cash holding would naturally rise since we believe that cash holding reflects deliberate choices with respect to liquidity needs rather than just reflecting cash inflow. Nevertheless, it is important to verify that changes in product market competition do not drive our findings so we present three robustness tests. First, we control for the level of product market competition using the Hoberg and Phillips (2016b) textual-analysis based measure in Column (5) and, as seen, the coefficient on fragility is unchanged relative to the benchmark specification in Column (1). Next, we exclude firms experiencing a dramatic change in industry concentration. Column (6) excludes the top quartile of firms in terms of increase in product market concentration and the treatment effect is stable. Lastly, we drop those industries most affected by the Blackrock merger. Column (7) excludes firms in industries with an above median share of firms treated by the merger and the effect of merger treatment is again robust. Finally, for all our results in Table 10 note that the statistical significance of these cash results far exceeds any reasonable threshold applied to a test employing reused natural experiments (Heath et al. (2023)).

Moving beyond cash, we next investigate the effect of the exogeneous shock on fragility on investment, repurchases, dividends and short-term debt in Table 11. In Columns (1) and (2) we see that the results are consistent with a causal effect of higher fragility on investments (in capital expenditure and R&D). The effects are quantitatively non-trivial. For instance the coefficient on $CapEx/Assets$ of -0.002 can be set in relation to median $CapEx/Assets$ of 0.007. Finally, Columns (3) to (5) indicate that firms treated by the merger pursue more cautious financial policies relative to the control group: lowering repurchases,

Table 10
Effect of Exogenous Shock to Fragility (BlackRock-BGI Merger) on Cash Holding.

	All	Sample Robustness			Competition Robustness		
	(1) Cash/Assets: All	(2) Cash/Assets: Exclude Select Industries	(3) Cash/Assets: Exclude Low B/M	(4) Cash/Assets: Exclude High R&D	(5) Cash/Assets: All	(6) Cash/Assets: Exclude Largest Increase in P.M. Concentration	(7) Cash/Assets: Exclude More Treated Industries
Merger Treatment	0.013***	0.013***	0.012***	0.014***	0.013***	0.013***	0.015***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)
Prod. Market HHI/100					-0.008		
					(0.553)		
Earnings volatility	0.201***	0.174***	0.227***	0.216***	0.198***	0.200***	0.196***
	(0.028)	(0.033)	(0.033)	(0.043)	(0.028)	(0.029)	(0.039)
Ln(Assets)	-0.029***	-0.037***	-0.043***	-0.043***	-0.029***	-0.029***	-0.031***
	(0.007)	(0.007)	(0.010)	(0.012)	(0.007)	(0.007)	(0.010)
Inst Ownership	-0.003	-0.000	-0.007	-0.012	-0.004	-0.010	-0.011
	(0.009)	(0.009)	(0.011)	(0.015)	(0.009)	(0.009)	(0.016)
Leverage	-0.024***	-0.021***	-0.022***	-0.020	-0.023***	-0.027***	-0.019
	(0.008)	(0.007)	(0.008)	(0.013)	(0.008)	(0.008)	(0.014)
Fixed Assets	-0.404***	-0.376***	-0.330***	-0.381***	-0.404***	-0.395***	-0.525***
	(0.033)	(0.034)	(0.036)	(0.068)	(0.033)	(0.033)	(0.054)
Inventory	-0.438***	-0.449***	-0.423***	-0.376***	-0.438***	-0.450***	-0.489***
	(0.035)	(0.035)	(0.039)	(0.060)	(0.035)	(0.035)	(0.062)
Oper Cash Flow	0.098***	0.069***	0.073***	0.086	0.095***	0.107***	0.136***
	(0.022)	(0.022)	(0.026)	(0.053)	(0.022)	(0.025)	(0.038)
Quarter-Industry FE	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES
Adj. R2	0.930	0.913	0.929	0.901	0.930	0.932	0.935
Observations	22,178	18,581	10,832	6,311	21,868	18,655	9,933

Panel regression of cash on Blackrock-BGI treatment indicator as well as additional firm-level control variables. The regressions include firm fixed effects and quarter-industry (SIC3) fixed effects and the standard errors are adjusted for clustering at the firm level. The data is quarterly from 2008Q1-2010Q4. Merger Treatment equals one if the stock was jointly held by Blackrock and BGI in 2008 Q4 and 0 if the stock was held by only one of Blackrock and BGI in 2008Q4. Column (2) excludes Drugs and Computer Services Industries (SIC 283 and 737), Column (3) excludes below median Book to Market observations, Column (4) excludes above median observations on R&D/Assets. Column (5) includes the Hoberg-Phillips measure of product market concentration, Column (6) excludes the top quartile of observations in terms of change in product market concentration and Column (7) excludes industries above median in terms of the share of firms in the SIC 3-digit industry treated by the merger. Statistical significance at the 1, 5, or 10% levels is reported as ***, **, *, respectively.

Table 11
Effect of Exogenous Shock to Fragility (BlackRock-BGI Merger).

	(1) CapEx/Assets	(2) R&D/Assets	(3) Repurch/Assets	(4) Dividends/Assets	(5) ST Debt/Assets
Merger Treatment	-0.002***	-0.001**	-0.002***	-0.000**	-0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Earnings volatility	-0.005	-0.017*	0.003	0.001	0.018
	(0.004)	(0.009)	(0.002)	(0.001)	(0.016)
Ln(Assets)	-0.002	-0.013***	0.003***	0.001***	-0.001
	(0.001)	(0.003)	(0.001)	(0.000)	(0.003)
Inst Ownership	0.003**	0.001	-0.002	0.000	0.001
	(0.001)	(0.002)	(0.002)	(0.000)	(0.006)
Leverage	-0.017***	-0.000	-0.010***	-0.002***	0.084***
	(0.002)	(0.002)	(0.001)	(0.000)	(0.008)
Fixed Assets	-0.033***	-0.004	-0.014***	-0.004***	-0.040**
	(0.007)	(0.011)	(0.003)	(0.001)	(0.016)
Inventory	0.009**	-0.005	-0.012***	-0.001	0.089***
	(0.004)	(0.007)	(0.003)	(0.001)	(0.024)
Oper Cash Flow	0.013***	-0.054***	-0.000	0.000	-0.063***
	(0.004)	(0.012)	(0.002)	(0.001)	(0.017)
Quarter-Industry FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES
Adj. R2	0.619	0.881	0.316	0.639	0.648
Observations	22,148	11,976	20,931	22,127	21,995

Panel regression of investment and liquidity management decisions on Blackrock-BGI treatment indicator as well as additional firm-level control variables. The regressions include firm fixed effects and quarter-industry (SIC3) fixed effects and the standard errors are adjusted for clustering at the firm level. The data is quarterly from 2008Q1-2010Q4. Merger Treatment equals one if the stock was jointly held by Blackrock and BGI in 2008 Q4 and 0 if the stock was held by only one of Blackrock and BGI in 2008Q4. Statistical significance at the 1, 5, or 10% levels is reported as ***, **, *, respectively.

paying out less dividends and using less short term debt. In light of Heath et al. (2023), the t-statistics are above 7 for capital expenditures, above 10 for repurchases, and above 3.5 for short term debt. The coefficient estimates for both R&D and dividends have t-statistics just above 2.

In sum, we find that the causal effects of this merger between asset managers on cash holding, investment and precautionary liquidity management are in line with the predictions of our model. Cash holding is arguably the key variable of interest and the estimated effect of the merger on cash holding is large, which is likely to partly reflect

Table 12
Effect of Alternative Shocks (BoA-Fleet and JP Morgan-Bank One Mergers).

	(1) Cash/Assets	(2) CapEx/Assets	(3) Cash/Assets	(4) CapEx/Assets
Merger Treatment (both mergers)	0.005**	-0.000		
	(0.002)	(0.000)		
Merger Treatment (BoA-Fleet)			0.007***	-0.000
			(0.002)	(0.000)
Earnings volatility	0.053*	-0.009***	0.052	-0.008**
	(0.028)	(0.003)	(0.032)	(0.003)
Ln(Assets)	-0.035***	0.000	-0.045***	-0.000
	(0.008)	(0.001)	(0.009)	(0.001)
Inst Ownership	0.013	0.005***	0.015	0.006***
	(0.010)	(0.001)	(0.012)	(0.001)
Leverage	-0.062***	-0.013***	-0.061***	-0.013***
	(0.010)	(0.001)	(0.012)	(0.001)
Fixed Assets	-0.411***	-0.016***	-0.392***	-0.015***
	(0.031)	(0.004)	(0.037)	(0.004)
Inventory	-0.410***	0.006*	-0.443***	0.009**
	(0.040)	(0.003)	(0.048)	(0.004)
Oper Cash Flow	0.048	-0.002	0.004	-0.002
	(0.034)	(0.003)	(0.042)	(0.003)
Quarter-Industry FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Adj. R2	0.931	0.611	0.928	0.636
Observations	23,842	23,754	18,473	18,430

Panel regression of cash holding and investment for merger treatment as well as additional firm-level control variables. The regressions include firm fixed effects and quarter-industry (SIC3) fixed effects and the standard errors are adjusted for clustering at the firm level. The data is quarterly from Q3 2002 until Q3 2005. In Columns 1 and 2 Merger Treatment takes value 1 for treated firms in the BoA-Fleet merger 2003 Q4 onwards and the value 1 for treated firms in the JPM-Bank One merger from 2004 Q1 onwards. Merger treatment dummy is 0 for firms that were held by only one of the merging parties. Columns 3 and 4 exclude firms that were only treated or served as controls in the JP Morgan-Bank One merger. Statistical significance at the 1, 5, or 10% levels is reported as ***, **, *, respectively.

that the merger is large and salient. The large magnitude of the effects also may reflect that the merger occurred in a period of economic turbulence. The interaction effects reported in Table 4 indicated that the effect of stock price fragility on cash holding was especially marked in periods characterized by high VIX.

5.2. Other asset management mergers as natural experiments

The size of the BlackRock-BGI merger makes it an attractive candidate for examining the effect of exogenous changes in ownership concentration on company policies. However, the event occurred during the great recession and Lewellen and Lowry (2021) raise concerns that asset management mergers during this period may be unique. While Table 3 established that within firm changes in fragility affect cash even when the financial crisis period is excluded, we explore alternative asset management mergers to confirm our conclusions.

Starting with the Lewellen and Lowry (2021) list of financial institution mergers that occur between 1980 and 2015, we assemble data on the eight mergers which occur during our sample period but outside of the financial crisis years 2008 and 2009. Unlike BlackRock-BGI, which involved substantial increases in ownership concentration for the bulk of the treated firms, and treated more than 2,000 firms in the sample, these are mostly smaller mergers both in impact and scope. Two of the mergers, Bank of America-Fleet (BoA-Fleet), announced in October 2003, and JP Morgan-Bank One (JPM-BankOne), announced in January 2004, stand out as the largest with more than 1,000 firms treated in each of the mergers.[20] The Bank of America-Fleet merger created an approximately 470 billion combined assets under management and JP Morgan-Bank One created a domestic assets under management (AUM) pool of approximately 250 billion. For comparison, the Blackrock-BGI merger results in a combined 2.8 trillion AUM.

Since the BoA-Fleet and JPM-BankOne mergers are close in time and many of the treated firms are the same, we first create separate treatment variables for each of these two mergers based on the respective announcement quarter and then combine the treatment variables such that we use a dummy that takes the value of one if the firm is treated in at least one of these two mergers. Firms that are only held by one of the merging parties in each of the two mergers serve as controls.[21] Fig. IA.1 in the online appendix traces out the effect of the mergers on fragility at the level of family of funds and on cash holding over time. Similar to Blackrock-BGI, the cash starts to increase with the announcements and the fragility moves after the completion of the mergers. The patterns suggest that a difference-in-difference can be used to draw causal inference on the effect of changes in fragility.

Table 12 presents regression results for these mergers. The results in Column (1) show that merger treatment is associated with a .5 percentage point increase in cash holding, an effect that is statistically significant at the 5% level. For a firm with mean level of cash holding in this sample, the estimated effect corresponds to an increase in the cash/assets ratio from 22.2% to 22.7%. This again supports the notion that firms pay attention to fragility and respond to an exogenous change in stock price fragility by increasing precautionary cash holding. The effect is less than half the size of the effect for treatment by the BlackRock-BGI merger which plausibly reflects both that the merg-

[20] The other mergers identified by Lewellen and Lowry (2021) in our sample period treat fewer firms: Wells Fargo-Strong affected around 800 firms in sample, First Union-Wachovia and Morgan Stanley-Frontpoint around 300 and the remaining mergers each affected fewer than 100 firms.

[21] For instance a firm that is held by both Bank of America and Fleet Boston will be assigned the value one from Q4 2003 onward. Firms that were only held by one of the Bank of America and Fleet Boston but by both of JPMorgan Chase and Bank One will be assigned the value one from Q1 2004 onward.

ers occur during a period of relative financial stability and the much smaller scope of these mergers (as also indicated by the weaker effects on return volatility of these mergers seen in Table 9). Column (2) documents that we do not identify an economically or statistically significant effect on investment from these smaller mergers. That we find a significant effect on cash holding but not on investment for these smaller mergers is in line with Warusawitharana and Whited (2016), which finds that cash responds more than investment to misvaluation.

The estimated coefficient on treatment in a difference-in-difference analysis with time and group fixed effects, when the different groups are defined by varying time or intensity of treatment, can be seen as a weighted average of the treatment coefficients across these different groups. De Chaisemartin and d'Haultfoeuille (2020) highlight that the weights that go into that average can be negative and therefore the estimated treatment effect may not be a convex combination of the treatment effects in the different groups. They show that in many cases this is an important concern and in some prominent published papers more than half of weights are negative. In the regressions reported in Columns (1) and (2) of Table 12 less than one percent of the weights are negative, suggesting that such concerns are limited in the current case. The emerging literature on difference-in-difference estimation with heterogeneous treatment has paid particular attention to the fact that observations that are treated early in practice serve as controls for observations that are treated later (Goodman-Bacon (2021)). To avoid this concern Columns (3) and (4) excludes firms that were only involved in the later merger, that between JP Morgan and Bank One.[22] As seen, the effect of the exogenous shock to fragility on cash holding is economically and statistically significant also in this more limited sample.

Summing up, we find that exogenous changes in ownership concentration support the notion that there is a causal effect from stock price fragility on cash holding. The results are strongest for BlackRock-BGI, which is intuitively appealing since its size dwarfs the other asset management mergers. Yet, we also document a statistically significant, though less quantitatively important, effect on cash using the alternative smaller mergers.

6. Conclusions

As equity holdings are increasingly concentrated in a limited number of institutional investors (Ben-David et al., 2021), there is a question of whether the resulting stock price fragility documented by Greenwood and Thesmar (2011) creates a salient risk to corporations. This paper documents a link between the risk of non-fundamental price shocks and precautionary corporate behavior. In doing so, we document a novel cost to changes in the composition of institutional investors. We motivate the empirical analysis with a model which highlights the growing benefit of precautionary savings as stock fragility - the risk of future misvaluation - increases. The empirical evidence supports the predictions from the model. Broadly speaking, greater equity fragility leads firms to hold more cash and lowers investment. Not only are the findings both statistically and economically significant, the BlackRock-BGI merger also provides a natural experiment which supports a causal interpretation of the evidence. While that merger was a salient event, the finding of significant effects on cash holding in smaller mergers, as well as in panel regressions in the full sample, indicate that firms monitor their exposure to non-fundamental price shocks and adjust their liquidity management to hedge the risk of future misvaluation.

In the current paper, we examine the implications of one mechanism that makes a firm's stock more susceptible to future swings in valuation that are unrelated to firm fundamentals. There are also other such mechanisms that would be of interest to study in future work. For instance, while a larger share of foreign owners may bring additional capital or other benefits, it may also make a firm's stock more vulnerable to various global shocks. This is a concern in particular for developing markets and would be interesting to investigate, even if the evidence in Bena et al. (2017) suggests that the balance of effects from foreign ownership on investment is positive. It also would be valuable to investigate whether firms attempt to manage their stock fragility through PIPES or increasing inside ownership. We leave these topics for future research.

[22] The sample thus includes the 994 firms treated in both mergers and the 310 firms only treated in the BoA-Fleet merger but excludes the 118 firms only treated in the JP Morgan-Bank One merger as well as the 390 firms that only serve as controls in this latter merger.

CRediT authorship contribution statement

Richard Friberg: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Itay Goldstein:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Kristine W. Hankins:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

No conflicts to disclose.

Data availability

The replication package for the article is available as Friberg et al. (2023). It includes the code and description of the steps used to create the final data set. Several of the data sets used are proprietary (but readily accessible to researchers) and we are not at liberty to post these data. Therefore the replication package contains a pseudo data set.

Corporate Responses to Stock Price Fragility (Reference Data) (Mendeley Data)

Appendix A. Further details on data construction

We use quarterly corporate data from Compustat 2001 Q1 – 2017 Q4 and variables that are reported as year-to-date are transformed to quarterly flow variables based on the fiscal year-end. We exclude companies with primary SIC codes between 4900 and 4999, between 6000 and 6999, or greater than 9000. We also restrict the sample to firms with positive book equity (CEQQ), sales (SALEQ), and leverage.

We control for firm size using the natural logarithm of total assets (ATQ). *Cash* is cash and short-term investments (CHEQ). *CapEx* is capital expenditures (CAPXY) net of sales of property, plant, and equipment (SPPEY). *R&D* is research and development expenditures (XRDQ). *Dividends* is dividends (DIVQ) and *Repurchase* of common equity is measured by total stock repurchases (PRSTKQ) minus the book value of preferred stock (PSTKQ). Short-term debt (*ST Debt*) is debt in current liabilities (DLCQ) plus long term debt due in one year (DD1Q).

Debt is measured as current liabilities (DLCQ) plus long-term debt (DLTTQ). Market equity is the product of share price (PRC) and number of shares outstanding (CSHOQ). *Leverage* is defined as debt divided by debt plus market equity. *Oper Cash Flow* is operating income after depreciation (OIBDPQ) minus total interest and related expenses (XINTQ) minus total income taxes (TXTQ). *Fixed Assets* is total property plant and equipment (PPENTQ) scaled by total assets. *Inventory* is total inventories (INVTQ) scaled by total assets. We measure *Earnings Volatility* as the 12 quarter rolling standard deviation of income before extraordinary items (IBQ) after it has been scaled by total assets (ATQ). *Inst Ownership* is the sum of 13F owner shares scaled by total shares outstanding in a quarter.

Various robustness exercises use measures that capture aspects related to firms' stock market valuation. *Book-to-Market* is measured as

CEQQ/(PRCCQ×CSHOQ). The firm-specific index of mispricing developed by Stambaugh et al. (2015a) and Stambaugh et al. (2015b) can take on values from 0 to 100 with 50 indicating that a stock is neither under- nor overvalued and we create the variable *Misprice* defined as the absolute deviation of the index from 50. For the other measures of misvaluation in Table 6, we follow Derrien et al. (2013). Residual Book-to-Market measures following Pástor and Veronesi (2003) (residual from regression from quarterly cross-sectional regressions of book-to-market on age, a dividend dummy, leverage, size, return on equity and standard deviation of daily returns during the previous year), Hoberg and Phillips (2010b) (same specification as for Pástor and Veronesi (2003), but estimated separately for each industry (Fama-French 12) and Rhodes-Kropf et al. (2005) (residual from ln(market valuation) regressed on ln(book value), functions of net income and leverage estimated for each quarter and each Fama-French 12 industry). Future excess returns are raw returns (ret) minus the returns of the CRSP value-weighted index (vwretd), led by one year and expressed in %. Mutual fund price pressure measure as Edmans et al. (2012).

Data sources for the additional data capturing heterogeneity used in Tables 4 and 5 are, respectively, *Financial Constrain*: Hoberg and Maksimovic (2015a), *High Fluidity* and *Product Market HHI*: Hoberg and Phillips (2016a), and *Manager Sent*: Jiang et al. (2019a). *VIX* is based on monthly VIX data from Yahoo finance collapsed to the mean quarterly level, and bond ratings from Compustat are used to create a dummy variable that captures *No Bond Rating*.

Finally, in Section 5 we recalculate stock price fragility at the fund family (firm) level to match the shock to ownership concentration provided by the merger using all the institutional investors included in the Thomson Reuters S34 (13F) file where the number of shares held is calculated at the institution level, not the fund. The firm's shares outstanding is recorded from the CRSP Stock file at quarter end. In the S34 file, each institutional investor (manager) has a distinct manager number (mgrno). Following Azar et al. (2018a), holdings are aggregated to the parent company's manager number using a mapping key from Azar et al. (2018b). This combines several managers under BlackRock, for example.

To confirm the Blackrock-BGI evidence, we also examine the Lewellen and Lowry (2021) mergers which occur during our sample period but not during the financial crisis. For these eight mergers (First Union-Wachovia, Goldman Sachs-Ayco, Bank of America-Fleet Boston, JP Morgan-Bank One, Wells Fargo-Strong Capital, Transamerica-Westcap, MSDW-Frontpoint, and Goldman Sachs-Level Global), we follow the same procedure as with the Blackrock-BGI merger.

Appendix B. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jfineco.2024.103795.

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