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Abstract

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JEL Classification: G32, G35, G10

Keywords: corporate cash holdings, Stock liquidity, Repurchases

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Abstract

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We document that enhanced stock liquidity increases a firm's propensity to hold cash. Endogeneity is addressed using a difference-in-differences approach based on tick-size decimalization. Our finding is surprising in light of the view that improved stock liquidity reduces financial constraints. We propose that firms hold cash also to buy back shares and higher stock liquidity strengthens this incentive. Tests are supportive. Endogeneity is controlled for using the introduction of repurchase safe harbor rules. We conclude that with respect to the effect of stock liquidity on cash holdings, the repurchase motive dominates the real investments motive.

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1 Introduction

How stock liquidity affects corporate policies and valuations is an important issue in corporate finance, but still not fully understood. Increased liquidity may reduce the cost of equity and, thereby, improve firm value (Amihud and Mendelson, 1986; Diamond and Verrecchia, 1991; Fang, Noe, and Tice, 2009) and reduce leverage (Lipson and Mortal, 2009). In this paper, we argue and provide evidence that enhanced stock liquidity also increases a firm's propensity to hold cash. The logic we have in mind relates to stock repurchases and, in particular, to the ideas that firms may engage in this activity to take advantage of undervalued equity (Brav, Campbell, Harvey, and Michaely, 2005; Peyer and Vermaelen, 2009; Dittmar and Field, 2015) or to stabilize stock prices relative to fundamentals (Hong, Wang, and Yu, 2008). In turn, this may motivate cash accumulation. The repurchase motive for holding cash should be stronger for firms with more liquid stock. If the underlying motive is to benefit from undervalued shares, more dollars can be spent profitably the more liquid is the stock. If it is to move the stock price up to reflect fundamentals, more cash is needed for higher levels of liquidity. Thus, under either form of the repurchase motive, the prediction is that cash holdings are increasing in stock liquidity, ceteris paribus. The evidence is supportive. What we are saying in this paper, therefore, is that increased stock liquidity raises a firm's capacity to benefit from repurchases and, therefore, its incentive for holding cash.

To the best of our knowledge, this is the first paper to emphasize the repurchase motive for holding cash. Tax issues and disbursements apart, in the extant literature, identified motives for corporate cash holdings typically relate to real investments (Myers and Majluf, 1984; Huberman 1984; Jensen, 1986; Opler, Pinkowitz, Stulz, and Williamson, 1999; and Bates, Kahle, and Stulz, 2009). In particular, the precautionary motive says that firms hold cash as a hedge against excessive costs of external capital (financial constraints) in the future, while the agency motive says that entrenched manager may choose to build up cash reserves to spend or invest in ways that favor themselves, for example as discussed by Jensen and Meckling (1976). The precautionary perspective has substantial empirical support (Opler, Pinkowitz, Stulz and Williamson, 1999; Almeida, Campello, and Weisbach, 2004; Han and Qiu, 2007; Acharya, Almeida, and Campello, 2007; Bates, Kahle and Stulz, 2009; Sufi, 2009; Lins, Servaes, and Tufano 2010; Harford, Klasa, and Maxwell, 2014), and there is also support for the agency perspective (Jensen, 1986; Harford, 1999; Gao, Harford, and Li, 2013; Nikolov and Whited, 2014). In contrast, the repurchase motive for holding cash relates to financial rather than real investments. We will sometimes refer to it as the "cash as ammunition" hypothesis, which reflects the idea that firms may hold cash to buy back shares in response to market sell-offs.

The finding that enhanced stock liquidity increases the propensity to hold cash may seem at odds with the idea that firms with more liquid stocks are less financially constrained and, as a consequence, would be expected to hold less cash. Our explanation is that with respect to the effect of stock liquidity on cash holdings, the repurchase motive dominates the precautionary, real investments motive. Recent work by Warusawitharana and Whited (2016) shows that "misvaluation induces larger changes in financial policies than investment" (p. 603). Viewed in this light, our finding can be interpreted as saying that stock liquidity is more important with respect to addressing, or benefiting from, misvaluations through buybacks than with respect to raising funds for real investments.

We also explicitly examine share repurchases as a mechanism through which stock liquidity and cash holdings are related. Thus, the paper relates to the general literature on stock liquidity and payout policy (Barclay and Smith, 1988; Banerjee, Gatchev, and Spindt, 2007; Hillert, Maug, and Obernberger, 2016). Brockman, Howe, and Mortal (2008) find that firms with more liquid stocks have a relatively larger propensity to distribute cash through repurchases. We add to this by showing that the effect of stock liquidity on repurchase intensity is larger for firms that have a larger potential to time the market. This makes sense given the growing evidence that firms are able to buy on dips (Vermaelen, 1981; Comment and Jarrell, 1991; Stephens and Weisbach, 1998; Dittmar, 2000; Peyer and Vermaelen, 2009; Ben-Raphael, Oded, and Wohl, 2014; Dittmar and Field, 2015) and firms with more liquid stocks have more to gain from this, ceteris paribus. However, our main finding with respect to repurchases is that firms with more liquid stock increase their cash holdings relatively more when constraints to buying back shares are eased. In other words, firms accumulate cash to buy back stock in the future and the more so the more liquid is their stock.

Our empirical strategy has three parts. As a preliminary first step, we run panel regressions of US industrial firms' cash ratios on lagged measures of stock liquidity and a number of control variables, based for the most part on the standard references of Opler, Pinkowitz, Stulz, and Williamson (1999) and Bates, Kahle, and Stulz (2009). We use industry and year fixed effects and carry out robustness checks using firm fixed effects to address a potential within-firm time-invariant omitted variables problem. We employ two standard measures of stock liquidity, namely Amihud's (2002) *ILLIQ* measure of price impact and the relative effective bid-ask spread (Chordia, Roll, and Subrahmanyam, 2001). Because stock liquidity is highly correlated with size and because size has been shown in the literature to be an important explanatory variable with respect to cash holdings, we orthogonalize the stock liquidity measures to firm size in most specifications. The panel regressions are run over several different time periods, determined by the availability of the variables. Regardless of which time period, stock liquidity measure, or set of control variables we use, we find that firms' cash ratios are increasing in stock liquidity.

Second, to address endogeneity concerns, our main analysis employs a difference-in-differences methodology to test the effect on cash holding from an exogenous shock to liquidity. A potential source of endogeneity in our setting is reverse causality, since asset liquidity may affect stock liquidity (Gopalan, Kadan, and Pevzner, 2012). For identification, we follow Chordia, Roll, and Subrahmanyam (2008) and Fang, Noe, and Tice (2009) by using the introduction of tick-size decimalization on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and NASDAQ in 2001 as an exogenous improvement in stock liquidity. As in Fang et al., we construct a test using the insight that decimalization improves liquidity especially for more actively traded stocks (Bessembinder, 2003; Furfine, 2003). Stocks are classified based on their trading activity ex ante, i.e., the year prior to decimalization. Firm and year fixed effects are controlled for. Robustness is examined by including industry-times-year fixed effects, which addresses the potential issue of industry-level time-varying omitted variables. This could be a concern because of the dot-com crash and the recession in 2001. Our findings are consistent with the results from the panel regressions that cash holdings are increasing in stock liquidity.

The first two parts of our empirical analysis show that stock liquidity and cash holdings are positively correlated and support the specific hypothesis that enhanced stock liquidity strengthens the propensity for holding cash. In the third and final part, we examine the plausibility of the repurchase motive as an explanation for these findings.

Our primary test in the final part of the paper uses the Securities and Exchange Commission's (SEC) adoption of Rule 10b-18 in 1982, which eased regulatory constraints on stock repurchases by clarifying the circumstances under which firms can buy back shares without running the risk of being charged with market manipulation. This led to a significant increase in overall share buyback levels (Grullon and Michaely, 2002). We construct a difference-in-differences test around this event based on the idea that the treatment with respect to repurchases is stronger for firms with more liquid stock. The results show that firms with higher stock liquidity increased their cash holdings relatively more around the adoption of Rule 10b-18. This supports the view that the higher cash holdings of firms with more liquid stock relates to future stock buybacks.

We also explore the repurchase motive in three further sets of tests using panel regressions. First, running tobit regressions of stock repurchases on size-orthogonalized stock liquidity measures and a number of controls, we find that an increase in stock liquidity is associated with an increase in share repurchases. Furthermore, the effect is stronger for firms with higher potential to time the market (low market-to-book as in Dittmar, 2000). This suggests that the positive relation between repurchases and stock liquidity relates to the potential for profitable buyback opportunities. In a second set of tests, we examine current cash holdings of firms, with relatively good-market timing abilities, that carry out "large" repurchases in the near future. One might expect these firms to have abnormally large current cash ratios. However, benchmarked against other firms with good market-timing abilities, this holds only for firms with relatively high stock liquidity. Combined, these findings support the hypothesis that the ability to buy back undervalued shares is a reason as to why firms hold cash, especially for firms with more liquid stock.

Third, we look into the idea that firms may hold cash to allow them to carry out price-stabilizing buybacks. The specific idea we explore is that firms may face product market losses if their stock is undervalued (Subrahmanyam and Titman, 2001). Our tests are based on the idea that this is a relatively larger concern for firms with more short-term shareholders, that is, larger shareholder-base instability, or that face more product-market competition. These firms, therefore, have larger incentives to hold cash as ammunition against negative stock-product market spirals in the future. The regression evidence is supportive. The effect of stock liquidity on cash holdings is amplified by measures of high shareholder-base instability or product-market competition.

The rest of the paper is organized as follows: Section 2 describes the data and the variables. Section 3 contains preliminary panel regressions. Section 4 contains the difference-in-differences analysis around the start of tick-size decimalization. Section 5 examines the repurchase motive as the mechanism behind the link between stock liquidity and cash holdings. Section 6 concludes. The appendix contains detailed descriptions of all variables, including data sources, and an internet appendix with robustness checks is attached.

2 Data, variables, and descriptive statistics

Corporate accounting variables are collected from Compustat. Daily and monthly stock data are from CRSP. High-frequency intra-day stock data are from NYSE Trade and Quote (TAQ). Institutional investor holding data are from Thomson Reuters 13F. Financial analyst data are from the Institutional Brokers' Estimate System (IBES). Financials (SIC code between 6000 and 6999) and utilities (SIC code between 4900 and 4999) are excluded. We only keep firm-years with positive total assets, positive sales, a ratio of total debt (long term debt plus current liabilities) to total assets that is between 0 and 1, and a listing of common stock (CRSP share code 10 or 11) on NYSE, AMEX, or NASDAQ. Furthermore, stocks need to trade on no less than 100 days within the year, not change exchanges, and have prices not exceeding US$ 999 per share. In the case of two classes of common shares for a given firm-year, we take the one with the higher turnover. We delete firm-years with more than two classes of common shares. The sample period runs from 1964 to 2015, over which we have 95,351 firm-year observations. Non-CRSP/Compustat variables are available over shorter time periods, described below and in more detail in Appendix. The dependent variable in most of our analysis is the cash ratio, defined as cash and short-term investment (CHE) over total book assets (AT) [Compustat variable names in parentheses].

2.1 Liquidity measures

We use two stock liquidity measures, one using low frequency and one using high frequency data. The low frequency measure is Amihud's (2002) *ILLIQ*,[1] originally defined as

$$ILLIQ\_\text{Amihud}_{i,t} = \frac{1}{N_{i,t}} \sum_{d=1}^{N_{i,t}} \frac{|r_{i,t,d}|}{DVol_{i,t,d}},$$

where $r_{i,t,d}$ is stock i's rate of return on day d in year t, $DVol_{i,t,d}$ is the corresponding dollar volume (in USD millions), and $N_{i,t}$ is the number of trading days of stock i in year t. Returns and volume data are from CRSP.

Atkins and Dyl (1997) and Anderson and Dyl (2007) note that the dealer structure on NASDAQ leads to a double-counting problem of trading volume. As suggested by Atkins and Dyl (1997) and Nagel (2005), we address this double-counting problem by dividing the reported dollar volume of NASDAQ stocks by two. Furthermore, following Nyborg and Östberg (2014), we exclude daily CRSP observations with positive volume but no recorded closing price on either day d or $d-1$ and a zero return on day d, as this is highly suggestive of stale prices and spurious volume. Finally, following Acharya and Pedersen (2005), we adjust Amihud's *ILLIQ* by stock price "inflation", cap it to reduce the impact of extreme values, and bound it away from zero, leaving us with the following final measure:[2]

$$ILLIQ_{i,t} = \min\left(0.25 + 0.30 \times ILLIQ\_\text{Amihud}_{i,t} \times P^M_{t-1},\ 71.9\right), \tag{1}$$

where P^M_{t-1} is the ratio of the capitalizations of the CRSP market portfolio at the end of fiscal year $t-1$ and July 1962. *ILLIQ* is available for the full period.

The high frequency liquidity measure is the relative effective bid-ask spread (Chordia, Roll, and Subrahmanyam, 2001; Fang, Noe, and Tice, 2009). The effective spread is defined as the difference between the execution price and the mid-point of the prevailing

[1] In their tests of liquidity measures, Goyenko, Holden, and Trzcinka (2009) find that *ILLIQ* is the best performing low frequency price-impact measure.

[2] The cap of 71.9 is chosen to winsorize *ILLIQ* at the 90^{th} percentile in our sample. Acharya and Pedersen (2005) use a cap of 30, which would winsorize our sample approximately at the 85^{th} percentile. Our results are not qualitatively sensitive to which of these two bounds we use.

bid-ask quote. The relative effective bid-ask spread is the effective spread divided by the mid-point of the prevailing bid-ask quote. Using TAQ, we proceed in the usual way to compute this.

In particular, quotes established before the opening of the market or after the close of the market are excluded. Quotes are also discarded if the offer price is lower than the bid price. The trade record is excluded if it does not have a positive price or trading size. The Lee and Ready (1991) algorithm is then used to match trades and quotes: for a trade between 1993 and 1998, the five-second rule is used; for a trade between 1999 and 2015, the trade is matched to the first quote before the trade. The same matching methodology is used by Chordia, Roll, and Subrahmanyam (2008) and Fang, Noe, and Tice (2009). To eliminate potential errors in trades and quotes, following Chordia, Roll, and Subrahmanyam (2001), after the matching process, we exclude observations which satisfy the following four conditions: (i) Quoted spread > \$5, (ii) Effective spread/Quoted spread > 4.0, (iii) Relative effective spread/Relative quoted spread > 4.0, (iv) Quoted spread/Transaction price > 0.4, where quoted spread is the difference between the prevailing quoted bid and ask, and the relative quoted spread is the quoted spread divided by the mid-point of the corresponding quoted bid and ask.

The daily relative effective bid-ask spread is calculated by taking the arithmetic mean of the transaction-level relative effective bid-ask spreads over the day. The annual relative effective bid-ask spread is the average of daily relative effective bid-ask spreads within the relevant fiscal year. Following Fang, Noe, and Tice (2009), we use the logarithm of the annual relative effective bid-ask spread in our analysis, which we denote by Log_resprd. TAQ data, and therefore Log_resprd, is available from 1993.

2.2 Additional variables

For our control variables, we follow Opler, Pinkowitz, Stulz, and Williamson (1999) and use Firm size, MTB (market-to-book ratio), Leverage (debt over assets), Net working capital, a Dividend dummy, R&D, Capital expenditure, Acquisition expenditure, Cash flow, and Industry sigma. In addition, following Bates, Kahle, and Stulz (2009), we also include Net equity issuance, Net debt issuance, and dummies for the number of years that have passed since a firm's IPO. These variables are denoted IPON, where N runs from 2-5. IPON is 1 if the difference between the year of the fiscal year end and the year of the first occurrence in CRSP is N, and zero otherwise.[3] Dollar denominated variables such as R&D are normalized by total assets. Net equity and debt issuance and acquisition expenditures are available from 1971. See Appendix for further details on all variables.

We also use institutional turnover (Gaspar, Massa, and Matos, 2005; Yan and Zhang, 2009) and product-market fluidity (Hoberg, Phillips, and Prabhala, 2014). Data on institutional investors' stock holdings are from Thomson Reuters (13f), which is available from 1980. Fluidity is available from the Hoberg-Phillips data library over the period 1997-2015.[4] Both of these variables can be thought of as relating to the repurchase motive for holding cash. Firms that face more product-market competition may be more exposed to negative cascades from sliding stock prices, along the lines of Subrahmanyam and Titman (2001). To protect themselves from this, such firms may hold relatively more cash in order to support their stock price should the need arise. Similarly, larger institutional turnover indicates a less stable shareholder base and, therefore, a greater potential benefit from price-stabilizing share repurchases.

Other control variables are: (i) Analyst coverage, calculated from IBES with availability from 1976, which is shown by Chang (2012) to affect cash holdings. (ii) Blocks and Non-blocks, calculated using institutional ownership data from Thomson Reuters (13f). Blocks is the proportion of shares owned by institutional investors individually holding more than 5% of outstanding shares. This can be thought of as a proxy for corporate governance, as in Dittmar and Mahrt-Smith (2007). Better corporate governance can increase the value of cash holdings and thereby encourage more cash holdings (Dittmar and Mahrt-Smith, 2007; Harford, Mansi, and Maxwell, 2008). Non-blocks is the remaining institutional ownership. Smaller holdings may be less costly to unload, potentially making the stock price more vulnerable to negative news. Institutional ownership data is also used by Brown, Chen, and Shekhar (2011) to study cash holdings. (iii) Firm age, which we expect to have a negative effect on cash holdings because young firms have relatively weak

[3] We do not include IPO1 because liquidity measures are used with a lag of one year.

[4] http://hobergphillips.usc.edu/

connections with corporate stakeholders, such as customers, suppliers, employees, and investors. So we think of this variable as relating to the potential for negative feedback from falling stock prices. (iv) Equity beta, which can be regarded as a proxy for the systematic risk of a business and is therefore expected to have a positive impact on cash holdings, for precautionary reasons.

2.3 Descriptive statistics

Table 1 displays descriptive statistics of all variables. Panel A provides statistics for the main variables, namely, Cash ratio, *ILLIQ*, and Log_resprd. These are provided over different time periods, reflecting their availability over the different sub periods over which we run regressions in Section 3 and reflecting that the liquidity variables are used with a lag of one year. The average cash ratio ranges from 0.15 (1964-2015) to 0.20 (1998-2015). Over the same periods, average lagged *ILLIQ* is 12.46 and 12.88, respectively. For the main variables, standard deviations have the same order of magnitude as the respective means. Summary statistics for the other variables are in Panel B.

Insert Table 1 here.

2.4 Correlations and orthogonalization

Table 2 provides the correlation matrix of variables over the maximum overlapping availability time periods. The variables with the largest positive correlations with the cash ratio are R&D (0.49), MTB (0.39), Net equity issuance (0.35), and Fluidity (0.32). Those with the largest negative correlations are Leverage (−0.41), Cash flow (−0.32), Net working capital (−0.29), and Firm size (−0.24).

Insert Table 2 here.

Firm size is a key determinant of cash holdings (Opler, Pinkowitz, Stulz, and Williamson, 1999; Bates, Kahle and Stulz, 2009), but is highly correlated with some of the other variables, leading to a potential multicollinearity problem in our regressions. Its correlations with *ILLIQ*, Log_resprd, Analyst coverage, and Non-blocks are −0.57, −0.82, 0.72, and 0.75, respectively. To address this, for each year t, we orthogonalize these variables with respect to size by running OLS as follows for each firm i and year t:

$$X_{i,t} = \gamma_0 + \gamma_1 \text{Firm size}_{i,t} + \eta_{i,t}, \tag{2}$$

where X is one of the mentioned variables. In the analysis in subsequent sections, we typically replace the original variable, X, by the residual η from (2). But as a robustness check, we also run some regressions with the original liquidity measures. We denote the size-orthogonalized variable X by X_res; e.g., *ILLIQ* becomes ILLIQ_res and Log_resprd becomes Log_resprd_res.[5] The correlations of *ILLIQ* and Log_resprd with their respective size-orthogonalized versions are 0.59 and 0.49, respectively (over their respective full sample periods), showing that removing size from the liquidity measures leaves the liquidity measures reasonably well intact.

The correlations between the cash ratio and *ILLIQ* and Log_resprd are -0.01 and 0.03, respectively, showing that unconditionally, the relation between cash holdings and stock liquidity is weak. Yet, the correlations between ILLIQ_res and Log_resprd_res and the cash ratio are -0.19 and -0.27, respectively. Since higher values for both *ILLIQ* and Log_resprd reflect increased illiquidity, this means that controlling for size, more liquid stocks hold more cash. This is a first, simple piece of evidence for a positive relation between stock liquidity, adjusted for size, and cash holdings. It also points to measures of liquidity capturing an economic factor that is unrelated to, and different in substance from, size.

3 Preliminary panel regressions

In this section, we run panel regressions of the cash ratio on measures of stock liquidity and the control variables discussed in the previous section and listed in Appendix. We use the following basic specification over firm-years (i, t):

$$\text{Cash ratio}_{i,t} = \beta_0 + \beta_1 \text{Liquidity}_{i,t-1} + \mathbf{\Gamma}'\mathbf{Z}_{i,t} + \varepsilon_{i,t}, \tag{3}$$

[5] The standard deviations of ILLIQ_res over the time periods in Table 3 are: 1964-2015, 16.83; 1970-2015, 17.18; 1980-2015, 18.17; 1997-2015, 17.87. The standard deviation of Log_resprd_res over the 1998-2015 time period is 0.65.

where Liquidity is either *ILLIQ*, ILLIQ_res, Log_resprd, or Log_resprd_res, **Z** is a vector of control variables, and **Γ** is the corresponding vector of regression coefficients. The stock liquidity variables are lagged. We run variations of (3) over four time periods, namely, 1964-2015 (the full sample period), 1971-2015 (net equity and debt issuance and acquisition expenditures are available from 1971), 1981-2015 (analyst coverage and institutional holding data are available from 1976 and 1980, respectively), and 1998-2015 (Log_resprd is available from 1994 and Fluidity from 1997).[6] Industry and year fixed effects are used for all time periods. As a robustness check, some regressions are also run with firm instead of industry fixed effects. Standard errors are clustered at the firm level.

Insert Table 3 here.

We start by discussing the regressions with industry and year fixed effects, reported in Table 3, Columns 1-10. In all specifications and time periods, the coefficient on the liquidity variable, whether it is orthogonalized to size or not, is negative and statistically significant at the 1% level. Since stock liquidity is decreasing in *ILLIQ* and Log_resprd, this means that firms with more liquid stocks hold more cash, ceteris paribus. For each of the four liquidity measures, the regression coefficients are of similar magnitude across specifications. For ILLIQ_res, for example, the coefficient ranges from -0.042×10^{-2} (1998-2015 period) to -0.098×10^{-2} (1964-2015 period). In terms of economic magnitudes, over the 1964-2015 period, a one standard deviation decrease in ILLIQ_res increases the cash ratio by 1.65 percentage points (pps). This represents an increase of approximately 11% of the average cash ratio of 15% over this period. The corresponding numbers for Log_resprd_res, which is used over the 1998-2015 period (see Column 10 in Table 3), are similar, namely 1.69 pps and 11%.

The coefficients on the control variables are consistent with those in the extant literature, as summarized in Table 4. For example, as in Opler et al. (1999) and Bates et al. (2009), we find that larger firms, those with more volatile cash flows, and larger growth opportunities, as measured by either MTB or R&D, have higher cash ratios. The coefficients on Inst_turn and Fluidity are both positive (statistically significant at the 1% level),

[6] IPON is included in the last three time periods. This has no noteworthy effect on the results.

which may be viewed as supportive of the cash as ammunition hypothesis (as discussed in Subsection 2.2). With respect to the new control variables employed in this paper, the coefficient on Firm age is negative, whereas those on Blocks and Non-blocks_res are positive. All are highly statistically significant. These results are also in line with what we would expect under the cash as ammunition hypothesis (Firm age, Non-blocks_res) or that improved governance reduces the cost of holding cash (Blocks). The coefficient on Equity beta is also positive, consistent with the classical precautionary motive.

Insert Table 4 here.

The regressions in Table 3, Columns 1–10, use both year and industry fixed effects as well as a large and varied set of control variables. As an additional check on a potential time-invariant firm-specific omitted variables problem, we have also run the regressions in Table 3 with firm and year, instead of industry and year, fixed effects over the 1998-2015 time period with ILLIQ_res and Log_resprd_res as the liquidity variables. The results are in Table 3, Columns 11 and 12. For both liquidity variables, the coefficients remain negative and statistically significant at the 1% level. In conclusion, the results from our preliminary panel regression analysis supports the view that improved stock liquidity is associated with higher cash holdings.

4 Difference-in-differences analysis: tick-size decimalization

While the findings in the previous section consistently support the hypothesis that enhanced stock liquidity increases cash holdings, across different model specifications and subsamples of the data, it is also possible that causality flows the other way. Reverse causality can obscure both economic and statistical inference. If the variables are jointly determined, our regressions are subject to a simultaneity bias which is difficult to sign. To address this concern, in this section, we examine the effect of liquidity on cash holdings using a difference-in-differences (DiD) approach around the introduction of tick-size decimalization on the three major US exchanges in 2001, which is an exogenous shock to stock liquidity.

4.1 Empirical design

On January 29, 2001, the New York Stock Exchange (NYSE) and American Stock Exchange (AMEX) changed the minimal tick size from 1/16th of a dollar (6.25 cents) to 1 cent. NASDAQ decimalized on April 9, 2001. This event has been used previously in the literature to study the effect of liquidity in other contexts (Chordia, Roll, and Subrahmanyam, 2008; Fang, Noe, and Tice, 2009). As in Fang et al., we draw on the findings of Furfine (2003) and Bessembinder (2003) that more actively traded stocks improved their liquidity more than less actively traded stocks as a result of decimalization, in line with the prediction of Harris (1999). Thus, we want to test whether firms with more actively traded stocks increased their cash holdings relatively more after the introduction of decimalization.

Using TAQ, we measure how actively a stock is traded in the year prior to decimalization (2000) by the total number of trades. Based on this, stocks are divided into tercile groups. The indicator variable Treat is then set to one for stocks in the upper tercile group and zero for the lower tercile group. Stocks in the middle tercile group are dropped. We define the dummy variable Post to be one if a year is in or after the decimalization year, and zero otherwise. The baseline event window is from three years before decimalization to three years after, i.e., $[-3, +3]$. The specification of our DiD regression is

$$\text{Cash ratio}_i = \beta_0 + \beta_1 \cdot \text{Treat}_i \times \text{Post}_t + \beta_2 \cdot \text{Post}_t + \beta_3 \cdot \text{Treat}_i + \mathbf{\Gamma}'\mathbf{Z}_{it} + \varepsilon_{it}, \quad (4)$$

where i and t are firm and year indicators, respectively, $\mathbf{Z}$ is a vector of control variables (same as in the baseline regression in Column 7 of Table 3), and $\mathbf{\Gamma}$ is a vector of coefficients. Different fixed effects are included in different specifications, as reported below. The coefficient of the interaction term, β_1, is the difference-in-differences estimator. We expect β_1 to be positive as this would imply that treated firms (more actively traded) hold relatively more cash than control firms after decimalization.

4.2 Parallel trend condition

We first check if the parallel trend condition for a DiD analysis is satisfied. It is crucial that the treated group and the control group have similar trends before the treatment. We examine this using a graphical analysis as in, e.g., Autor, Donohue, and Schwab (2006), Acharya, Baghai, and Subramanian (2014), and Serfling (2016). Specifically, we first regress Cash ratio on individual yearly dummies and controls (same as in the baseline regression in Column 7 of Table 3) with firm and year fixed effects. The yearly dummies, D_j, are defined based on the timing relative to the decimalization year. In particular, D_j equals one if a year is j year(s) relative to the decimalization year and the firm is a treated firm, and zero otherwise, $j = -2, -1, \cdots, 3$. D_j is always zero for control firms. Year -3 is used as the base year and so there is no separate dummy for this year. The parallel trend condition would be satisfied if the coefficients of D_{-1} and D_{-2} are not statistically different from zero. The results are shown in Figure 1.

Insert Figure 1 here.

The figure plots the estimated coefficients for the yearly dummies over time relative to the decimalization year (Year 0). Ninety percent confidence intervals, based on standard errors clustered at the firm level, are drawn as dashed lines. The figure shows that the coefficients of D_{-1} and D_{-2} are not statistically different from zero at the 10% level. We conclude that the parallel trend condition is satisfied.

Figure 1 also shows a significant increase in cash holdings for treated firms in the decimalization and subsequent years. The effect peaks in the first year after decimalization.

4.3 Results of the DiD analysis

We carry out the DiD analysis using the general specification in Equation (4). Results are in Table 5. There are six different specifications. All (except the last) include year fixed effects. The specification in Column 1 also has industry fixed effects. This is replaced with firm fixed effects in the other columns. In these cases, we drop the Treat dummy.

Insert Table 5 here.

The baseline specification in Column 1 employs $[-3, +3]$ as the event window. The DiD estimator, β_1, is seen to be positive and statistically significant at the 1% level. In other words, our baseline result is that treated, or more actively traded, firms hold relatively more cash after decimalization. Specifically, more actively traded firms increase the cash ratio by 3.2 percentage points relative to controls. This represents 19% of the average cash ratio in the test sample. The results in the other columns discussed below show that our baseline finding is robust to alternative specifications and event windows.

The specification in Column 2 simply replaces the industry fixed effects of the specification in Column 1 with firm fixed effects. The coefficient on the DiD estimator drops to 0.019. So, the effect is economically weaker when using firm rather than industry fixed effects. But the coefficient remains statistically significant at the 1% level.

We also run robustness tests using the specification in Column 2 over alternative event windows. In Column 3, the event year, 2001, is dropped. Columns 4 and 5 use event windows of $[-2, +2]$ and $[-4, +4]$, respectively. The estimate of the DiD coefficient remains statistically significant at the 1% level and ranges from 0.018 (Column 4) to 0.021 (Columns 3 and 5). So the results are very similar to those in Column 2.

The specification in Column 6 includes industry-times-year fixed effects. Accordingly, the Post dummy is dropped. The event window is $[-3, +3]$. Including industry-year fixed effects addresses the potential issue of an industry-level time-varying omitted variable, such as the dot-com crash or differential industry reactions to the recession of 2001. The results in Column 6 show that our basic finding is robust to this possibility. The estimated DiD coefficient is 0.017 and statistically significant at the 1% level. Thus, the estimated relative increase in treated firms' cash ratios from decimalization is almost the same across Columns 2-6. In short, the baseline finding that enhanced stock liquidity increases cash holdings is robust to different specifications and event windows.

In an internet appendix, we carry out additional robustness checks. First, we address concerns that our results may relate to the recession of 2001. The main issue is that recessions may differentially affect firms' abilities to finance operations or new investments because they face different degrees of financial constraints. This could be an omitted variable. While the industry-year fixed effect in Column 6 should take care of this, we have also run the specification in Column 2 with different standard financial constraint measures. We find that this does not alter our basic findings; the estimated DiD coefficient remains statistically significant at the 1% level and ranges from 0.019 to 0.021 under the different financial constraint measures.[7] Second, we repeat the analysis in Table 5 with the median by number of trades in 2000 as the cutoff for treated firms. The results in the internet appendix show that our qualitative findings are unaffected.

5 Mechanism behind the effect of stock liquidity on cash holdings

In this section, we examine the idea that the mechanism behind the effect of stock liquidity on cash holdings involves share buybacks. We first run tests for the repurchase channel through an exogenous shock on repurchase activity, namely the SEC's adoption of Rule 10b-18 as a safe harbor for stock buybacks (Grullon and Michaely, 2002). This event is also used for identification by Hong, Wang, and Yu (2008). We then explore the specific idea that firms accumulate cash with a view to take advantage of undervaluations. Finally, we run tests related to the notion that firms hold cash to stabilize their stock prices.

5.1 Stock repurchases: SEC adoption of Rule 10b-18

In 1982, the SEC adopted Rule 10b-18, which is a guideline for firms with respect to share buybacks on the open market.[8] The rule provides a safe harbor for firms against charges of stock manipulation after share repurchases. Compliance requires firms to purchase all shares on the open market from a single broker or dealer on any single day, to purchase at a price not higher than the highest independent bid or the last sale price, to purchase no more than 25% of the average daily volume over the preceding four calendar weeks, and

[7] The financial constraint measures are the following widely used dummy variables: (i) Small, which equals one if book assets are below the median in a year and zero otherwise, (ii) SAI, which equals one if a firm's size-and-age index (Hadlock and Pierce, 2010) is above the median in a year and zero otherwise, (iii) WWI, which equals one if a firm's Whited and Wu index (Whited and Wu, 2006) is above the median in a year and zero otherwise, (iv) Bond rating, which equals one if a firm has S&P bond rating and zero otherwise, and (v) Paper rating, which equals one if a firm has S&P commercial paper rating (Denis and Sibikov, 2010).

[8] Securities Exchange Act Release No. 19244 (November 17, 1982) and 47 Fed. Reg. 53333 (November 26, 1982).

not to purchase during opening or the last thirty minutes before the closing of the market. Grullon and Michaely (2002) find that share repurchase activity increased significantly after the adoption of Rule 10b-18.

In this subsection, we carry out a difference-in-differences analysis based on the adoption of Rule 10b-18 to test whether firms with more liquid stock increase cash holdings relatively more when constraints to share buybacks are eased. We would expect this to be the case if firms hold cash to repurchase shares, either to profit from undervaluations or to stabilize their stock prices, since firms with more liquid stock have lower trading costs and price impact. Thus, we define the treated group as firms with more liquid stocks and the control group as those with less liquid stocks. Specifically, we define a dummy variable for the treated group, Treat, to be one (zero) for firms below (above) the bottom (top) tercile of ILLIQ_res in the previous year (Log_resprd_res is not available in this time window). Firms in the middle tercile group are excluded. We employ a time window from 1979 to 1985, three years before and three years after the event year, 1982. We also use alternative event windows as robustness tests. Treated firms are expected to increase cash holdings relatively more.

We first check if the parallel trend condition for a DiD analysis is satisfied using the same graphical procedure as in Section 4. Specifically, we first regress Cash ratio on individual yearly dummies and controls (same as in the baseline regression in Column 3 of Table 3) with firm and year fixed effects. The yearly dummies D_j are defined based on the timing relative to the adoption year: D_j equals one if a year is j year(s) relative to the adoption year and the firm is a treated firm, and zero otherwise. D_j is always zero for control firms. The parallel trend condition is met if the coefficients of D_{-1} and D_{-2} are not statistically different from zero.

Insert Figure 2 here.

Figure 2 plots the coefficients for the yearly dummies over time as well as ninety percent confidence intervals based on standard errors clustered at the firm level. Year 0 represents Rule 10b-18 adoption. As seen, the coefficients of D_{-1} and D_{-2} are not statistically different from zero at the 10% level. Firms with more liquid stocks do not increase cash holdings more than those with less liquid stocks prior to the event year. Thus, the parallel trend condition is satisfied.

Figure 2 also shows a significant increase in cash ratios in the first year after the adoption of Rule 10b-18 for firms with more liquid stocks. This is consistent with the repurchase motive for holding cash; looser regulation with respect to share buybacks increases incentives to hold cash relatively more for those firms that can benefit more from buybacks, namely those with more liquid stock.

We test this more generally using the same basic specification as before:

$$\text{Cash ratio}_{i,t} = \beta_0 + \beta_1 \text{Treat}_{i,t} \times \text{Post}_{i,t} + \beta_2 \text{Treat}_{i,t} + \beta_3 \text{Post}_{i,t} + \mathbf{\Gamma}'\mathbf{Z}_{i,t} + \varepsilon_{i,t}, \qquad (5)$$

where (i, t) denotes firm-years, Treat indicates relatively liquid firms (as defined above), Post is an indicator variable for years 1982 and later, $\mathbf{Z}$ is a vector of control variables (as in Column 3 of Table 3), and $\mathbf{\Gamma}$ is a vector of coefficients. The treatment effect is shown by the coefficient of the interaction term, β_1. Since enhanced stock liquidity should increase the net benefits from holding cash to buy back shares, we expect β_1 to be significantly positive. We run (5) with three different sets of fixed effects (see below). Standard errors are clustered at the firm level.

Insert Table 6 here.

Table 6 reports the results. The baseline specification in Column 1 uses $[-3, +3]$ as the event window and includes industry and year fixed effects. The results show that the DiD estimator, β_1, is positive (0.023) and statistically significant at the 1% level. Hence, more liquid (treated) firms increase the cash ratio relatively more than less liquid firms after the adoption of Rule 10b-18 by 2.3 percentage points. This represents 22% of the average cash ratio of 10.4% in the test sample. Since rule 10b-18 reduces potential costs to firms from buying back their own stock, the finding that firms with more liquid stock increase cash holdings relatively more gives support to the hypothesis that firms with more liquid stock hold relatively more cash because they can benefit more from buybacks.

The other columns in Table 6 represent robustness checks on the finding in Column 1. The specification in Column 2 employs firm rather than industry fixed effects. The coefficient on the DiD estimator drops to 0.014 but remains statistically significant at the 1% level. In terms of economic significance, the relative increase of 1.4 percentage points represents 13.5% of the average cash ratio in the sample.

For additional robustness, the specification in Column 2 is also run over alternative event windows. In Column 3, the event year, 1982, is dropped, while Columns 4 and 5 use event windows of $[-2, +2]$ and $[-4, +4]$, respectively. The DiD coefficient remains statistically significant at the 1% or 5% level and ranges from 0.010 (Column 4) to 0.019 (Column 5). Finally, the specification in Column 6 uses industry-times-year fixed effects with an event window of $[-3, +3]$. The estimated DiD coefficient is 0.010 and statistically significant at the 5% level. In short, the baseline finding in Column 1 is robust to alternative event windows and specifications.[9]

The results in this subsection show that firms with relatively more liquid stock increase cash holdings relatively more when restraints on repurchases are relaxed. This supports the empirical relevance of the repurchase motive for holding cash and, in particular, that elevated stock liquidity strengthens this motive because of a larger potential gain from stock buybacks.

5.2 Repurchases and market timing

According to the logic of the repurchase motive for holding cash to buy undervalued shares, firms that have a greater ability to time the market should hold relatively more cash, ceteris paribus. Furthermore, this effect should be stronger for firms with relatively high stock liquidity because such firms can put more "buyback cash" to profitable use due to the lower price impact. This is examined in this subsection.

We follow Dittmar (2000) and use MTB as a measure of market-timing potential. In a given year, a firm is classified as having high (low) market-timing potential if its MTB is below (above) the median. The following tobit regression is then run on the full sample of firms, high market-timing firms, and low market-timing firms:

$$\text{Rep}_{i,t} = \beta_0 + \beta_1 \text{Liquidity}_{i,t-1} + \mathbf{\Gamma}' \boldsymbol{Z}_{i,t-1} + \varepsilon_{i,t}, \tag{6}$$

[9] In the internet appendix, we rerun all tests using the median by stock liquidity as the cutoff for treated firms and find that the qualitative results are robust to this alternative as well.

where Rep is the ratio of repurchase amount over lagged market capitalization (repurchase ratio), Liquidity is ILLIQ_res or Log_resprd_res, $\boldsymbol{Z}$ is a vector of control variables, and $\boldsymbol{\Gamma}$ is a vector of coefficients. $\boldsymbol{Z}$ is comprised of firm size, MTB, market-adjusted stock returns, free cash flows, return on equity (ROE), industry-adjusted leverage, non-operating profit, and cash dividend. As in Dittmar (2000), we use a tobit approach since share repurchases are bounded below by zero. The control variables capture different motives of stock buybacks, for example, market timing, excess capital distribution, and optimal leverage. Industry and year fixed effects are included and inference is based on firm-clustered standard errors.

Insert Table 7 here.

The results are in Table 7. Panel A provides tobit coefficients and Panel B the marginal effects. In Panel A, Columns 1 and 2 display results for ILLIQ_res and Log_resprd_res, respectively, for the full sample of firms. In both cases, the tobit coefficients are statistically significantly negative at the 1% level. Columns 3–6 repeat the exercise for high and low market-timing firms. As seen, the coefficient of stock illiquidity remains statistically significantly negative in all four cases. Importantly, for either illiquidity measure, the coefficient is larger (in absolute value) for firms classified as having high market-timing potential, with the p-value of the coefficient equality test being 0.00 and 0.01 under ILLIQ_res and Log_resprd_res, respectively. So the impact of stock liquidity on share repurchases is statistically significantly larger for firms with more potential to time the market.

Tobit coefficients are difficult to interpret economically because they combine (in our case) the change in the probability of repurchasing shares and the change in the repurchase ratio conditional on repurchasing per unit change in the regressor (McDonald and Moffitt, 1980). Therefore, in Panel B we decompose the tobit coefficients into these two marginal effects. We report averages, keeping the values of the controls fixed at observed values. We also estimate unconditional marginal effects in the same way. In all cases, the marginal effects are statistically significantly negative at the 1% level, or, in the case of low-timing firms under ILLIQ_res, at the 10% level. In terms of economic magnitudes, a one-unit change in ILLIQ_res (Log_resprd_res) reduces the unconditional repurchase ratio by 1.12 pps (1.13 pps) on average. This represents 87% (88%) of the average repurchase ratio of 1.28%. Equivalently, a one-standard-deviation change in ILLIQ_res (Log_resprd_res) reduces the unconditional repurchase ratio by 0.19 pps (0.72 pps) on average. This represents 15% (56%) of the average repurchase ratio. For high market-timing firms, the unconditional marginal effect of ILLIQ_res (Log_resprd_res) on share repurchases is about three (one and a half) times as strong as for firms with low market-timing potential. So stock liquidity has a much bigger effect on buyback activity for firms that potentially can gain more from buying undervalued stock.

Our results in this subsection show that there is a positive relation between stock liquidity and share repurchases. Importantly, the effect is stronger for firms that can be said to have a relatively larger potential to time the market. This supports the view that firms with more liquid stock and high market-timing potential have more to gain from buying back undervalued shares. In turn, they have a larger incentive to hold cash. In short, the findings in Table 7 support the relevance of the repurchase motive for holding cash.

5.3 Stock liquidity, cash holdings, and future repurchases

In this subsection, we continue to investigate the link between stock liquidity, repurchases, and cash holdings. In particular, we ask whether firms that buy back "large" fractions of their shares in the near future have abnormally large cash ratios and whether this is related to stock liquidity. As we are interested in repurchases where market-timing may be a motivation, we focus on firms with low MTB. The idea is that firms with high market-timing potential may have an incentive to build up cash reserves to buy back stock in the near future, especially if their stock is highly liquid.

We proceed as follows. For each firm-year, we create a simple proxy for significant future buybacks. Specifically, we define the indicator variable Fut_Rep to be one in year t if the repurchase amount in the year $t+1$ is more than 1% of the firms' market capitalization, and zero otherwise. This may also be viewed as a simple proxy for firms with significant future buyback *plans*. In addition, we define two high liquidity indicator variables, Low_illiq and Low_spread, to be one (zero) for firms in the bottom (top) quartile of ILLIQ_res and Log_resprd_res in the previous year, respectively. Firms in the middle two quartiles are dropped. To focus on firms with relatively high market-timing potential, we drop those in the top tercile group by MTB. On the resulting sample, we run panel regressions on the Cash ratio along the same lines as in Section 3 as follows:

$$\text{Cash ratio}_{i,t} = \beta_0 + \beta_1 \text{Fut\_Rep}_{i,t} + \beta_2 \text{Fut\_Rep}_{i,t} \times \text{Dum\_Liq}_{i,t-1} + \beta_3 \text{Dum\_Liq}_{i,t-1} + \mathbf{\Gamma}'\mathbf{Z}_{i,t} + \varepsilon_{it}, \quad (7)$$

where Dum_Liq is either Low_illiq or Low_spread, $\boldsymbol{Z}$ is a vector of control variables (same as in Table 3, Column 7), and $\mathbf{\Gamma}$ is a vector of coefficients. Inference is based on firm-clustered standard errors.

As a baseline, we first run the specification in (7) without either liquidity variable, with and without controls. We then run the full specification using either Low_illiq or Low_spread. Firm and year fixed effects are included in all four specifications. The specifications with (without) controls are run over the period 1998 (1972) to 2015. The results are in Table 8.

Insert Table 8 here.

In the two baseline specifications without the liquidity variables (Columns 1 and 2), the coefficients on Fut_Rep are positive and statistically significant (1% level). However, the results under the full specification in Columns 3 and 4 show that this is driven by firms with the most liquid stock. In either column, the coefficient on Fut_Rep is insignificant, while that on the interaction term of Fut_Rep with the high-liquidity dummy is statistically significantly positive at the 5% level. The interaction term coefficients are 0.016 (Low_illiq) and 0.013 (Low_spread). This represents 15% and 12% of the sample firms' average cash holdings. In short, among firms that have current potential to time the market and end up doing large-scale repurchases next year, it is only firms with high stock liquidity that actually have abnormally large current cash ratios.

The evidence thus far in Section 5 shows that (i) cash holdings increase more for more liquid firms when constraints on repurchases are relaxed, (ii) there is a positive effect of stock liquidity on repurchase activity and this is stronger for firms that are better able to time the market, and (iii) cash ratios of firms that do large repurchases in the future are abnormally large only for firms with relatively high stock liquidity. Combined, these findings support the view that the potential to benefit from repurchasing undervalued stock is an important explanatory factor with respect to why firms with high stock liquidity hold more cash, as seen in Section 4.

5.4 Stock price stabilization

If firms buy back stock to stabilize stock prices (Hong, Wang, and Yu, 2008; Busch and Obernberger, 2017), then this also provides a motive for holding cash. Firms that are more susceptible to sharp downturns have a relatively greater incentive to hold cash for this reason. Furthermore, a higher level of stock liquidity should amplify this incentive because more cash would be required to bring the stock price up. Conversely, stock-price instability would be expected to amplify the effect of stock liquidity on cash holdings. In this subsection, we investigate this second dimension to the repurchase motive for holding cash.

Our approach is based on two simple ideas. The first is that firms with relatively more short-term investors have less stable stock prices because these investors are more likely to sell on negative news. This may be referred to as shareholder-base instability. Dudley and Manakyan (2011) provide evidence that firms that experience large selling by mutual funds are more likely to repurchase their shares. The second idea relates to product-market competition. Subrahmanyam and Titman (2001) argue that there may be a positive feedback loop between stock markets and product markets. A negative shock to a firm's stock price may lead to customers abandoning the firm's products, which, in turn, leads to further downward pressure on the stock price. We would expect such feedback to be stronger for firms that face more competition in the product markets. Thus, firms with more unstable shareholder bases or firms that face more product-market competition would be expected to hold more cash. The evidence in Table 3 already supports this. In this subsection, we ask whether there is a positive interaction effect between potential instability and stock liquidity.

To capture shareholder-base instability, we define a dummy variable, High_Inst_turn, which equals one if institutional turnover (Inst_turn) of a firm's stock is greater than the yearly median and zero otherwise. Similarly, we define high-competition dummies using three text-based network industry classification (TNIC) competition measures, Fluidity, Herfindahl-Hirschman Index (HHI), and Product Similarity, which are available in the Hoberg-Phillips data library. We refer to these dummy variables as HighComp_Fluid, HighComp_HHI, and HighComp_SIM, respectively. The respective dummy is one for firm-years with values larger than the median in that year and zero otherwise.

To test for an interaction, or amplification, effect between stock liquidity and instability, we run:

$$\begin{aligned}\text{Cash ratio}_{i,t} \quad = \quad & \beta_0 + \beta_1 \text{Liquidity}_{i,t-1} \times \text{Amplification}_{i,t-1} + \beta_2 \text{Liquidity}_{i,t-1} \\ & + \beta_3 \text{Amplification}_{i,t-1} + \mathbf{\Gamma}' \mathbf{Z}_{i,t} + \varepsilon_{i,t}, \end{aligned} \quad (8)$$

where Liquidity is *ILLIQ*_res or Log_resprd_res, Amplification is High_Inst_turn, HighComp_Fluid, HighComp_HHI, or HighComp_SIM, $\mathbf{Z}$ is a vector of control variables (same as in Table 3, Column 7), and $\mathbf{\Gamma}$ is a vector of coefficients. As we study cross-sectional variations, we include industry fixed effects and year fixed effects in all regressions. The sample period is 1998 to 2015. The results are reported in Table 9.

Insert Table 9 here.

Columns 1 and 2 present the results for shareholder-base instability. The results show that a relatively high institutional turnover increases cash holdings. Moreover, there is a statistically significant interaction (1% level) effect between high institutional turnover and stock liquidity. Using *ILLIQ_res* as the liquidity measure (Column 1), the effect of liquidity on cash holding is 2.5 times larger for high relative to low institutional turnover firms $((0.057 + 0.038)/0.038)$.

Columns 3 to 8 show the results for product-market competition. The coefficients of all interaction terms between the two liquidity measures and the high competition dummies are negative and statistically significant at the 1% or 5% level. Across the different liquidity and competition measures, the average effect of liquidity on cash holding is 1.96 times larger for high relative to low competition firms.

The results in Table 9 show that the effect of stock liquidity on cash holdings are stronger for firms with high institutional turnover and high product market competition. Because such firms may face larger losses from sell-offs, they may have more to gain from price-stabilizing repurchases. Thus, our findings in this subsection support the view that firms may also hold cash to buy back shares in order to stabilize their stock prices.

6 Concluding remarks

The main empirical point in this paper is that there is a positive relation between stock liquidity and the cash ratio. This may be surprising because liquidity is typically thought of as reducing financial constraints. So if firms hold cash for precautionary reasons related to real investments, firms with more liquid stock, ceteris paribus, should hold less cash. Yet, empirically, they hold more cash.

The positive relation between stock liquidity and the cash ratio is robust in the data across different empirical methods and different measures of stock liquidity. We first see it in the correlations between size-orthogonalized stock liquidity measures and the cash ratio. This carries over to panel regressions over different time periods and different control variables. Endogeneity concerns are addressed using a difference-in-differences approach based on the introduction of tick-size decimalization in 2001. The result holds up. It is robust to a wide range of controls and fixed effects. In short, cash holdings are increasing in stock liquidity, ceteris paribus.

The second key point of the paper is an explanation for this finding. In particular, we propose that firms hold cash not only to invest in real assets but also for financial reasons, namely to buy back stock. They may do this to profit from undervalued equity or to stabilize their stock prices. That stock liquidity is positively related to cash holdings may be interpreted as implying that for stock liquidity, the repurchase motive for holding cash dominates the real investments motive. This resonates with Warusawitharana and Whited's (2016) conclusion that misvaluation affects financial policy more than investments. That is, stock liquidity matters more to firms with respect to taking advantage of, or dealing with, misvaluations than with respect to funding real investments.

As a third dimension to this paper, we have examined the plausibility of the repurchase motive for holding cash as an explanation for the finding that stock liquidity and cash holdings are positively related. Our main approach uses the SEC's adoption of Rule 10b-18 in 1982, which eased regulatory constraints on stock repurchases, to construct a difference-in-differences test for the relative increase in cash holdings for firms with more liquid versus less liquid stock. Consistent with the logic of the repurchase motive for holding cash, we find that firms with more liquid stock increased their cash holdings significantly more. We also further explore different facets of the repurchase motive – profiting from undervalued shares and stabilizing the stock price – with supportive results.

Overall, our paper contributes to the cash holding literature by documenting that stock liquidity has a positive influence on corporate cash holdings. As an explanation, we suggest that firms with more liquid stock are better able to take advantage of undervaluations or need more cash to reverse slides in stock prices, ceteris paribus. As far as we know, this is the first paper to emphasize the repurchase motive for holding cash. In future work, it may be interesting to disentangle the relative importance of motives for cash holdings that relate to real versus financial investments. This could potentially help shed light on variations in corporate cash holdings over time.

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Appendix: Descriptions of variables

The names of variables in Compustat are shown in parentheses.

Variable	Data source	Description
Acquisition	Compustat	The ratio of acquisition expenditures (AQC) relative to total (book) assets (AT).
Analyst coverage	IBES	Take average of the number of estimates across months within a fiscal year. Then take logarithm of one plus the average. If a stock is not covered in IBES, set Analyst coverage to zero.
Blocks	Thomson Reuters (13f)	Total proportion of shares outstanding held by institutional investors with more than 5% of shares outstanding each.
Cash flow	Compustat	[EBITDA (OIBDP) − interest (XINT) − taxes (TXT) − common dividends (DVC)]/total assets (AT).
Capex	Compustat	The ratio of capital expenditures (CAPX) to the total assets (AT).
Cash ratio	Compustat	The ratio of cash and short-term investment (CHE) to total assets (AT).
Dividend	Compustat	The ratio of cash dividends to net income.
Dividend dummy	Compustat	A dummy equals 1 if a firm paid common dividends (DVC) in that year; 0 otherwise.
Equity beta	CRSP	Annual Scholes-Williams (1977) equity beta.
Fluidity	Hoberg-Phillips Data Library	Product market fluidity constructed by Hoberg, Phillips, Prabhala (2014) as a measure of competition in product market.
Firm age	CRSP	Calculate the number of months since a stock first appears in CRSP. Then take the logarithm of one plus the number of months.
Firm size	Compustat	Logarithm of total assets, where the total assets are deflated to 1962 dollars.

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Variable	Data source	Description
Free cash flow	Compustat	Operating income before depreciation minus interest expenses, preferred dividend, common dividend, and income taxes, plus deferred taxes, then divided by total assets.
HHI	Hoberg-Phillips Data Library	Herfindahl-Hirschman Index based on the text-based industry classifications (TNIC) in Hoberg and Phillips (2013).
HighComp_Fluid		Dummy variable which equals 1 if Fluidity in a year is above the median in that year, and 0 otherwise.
HighComp_HHI		Dummy variable which equals 1 if HHI in a year is below the median in that year, and 0 otherwise.
HighIlliq	CRSP	Dummy variable which equals 1 if *ILLIQ* is in the top quartile, and 0 if in bottom quartile.
High_Inst_turn	Thomson Reuters (13f)	Dummy variable which equals 1 if Inst_turn is greater than the yearly median, and 0 otherwise.
HighMTB	Compustat	Dummy variable which equals 1 if MTB is above the median in a year, and 0 otherwise.
HighSprd	TAQ	Dummy variable which equals 1 if Log_resprd is in the top quartile, and 0 if in bottom quartile.
Industry sigma	Compustat	The industry (2-digit SIC codes) mean of firm-level Cash flow standard deviations over 10 years (at least 3 firm-year observations required). Follows the definition in Bates, Kahle, and Stulz (2009).
ILLIQ	CRSP	Adjusted version of Amihud's (2002) original illiquidity measure. See equation (1) in the text.

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Variable	Data source	Description
Inst_turn	Thomson Reuters (13f)	First, calculate institutional churn ratio following Yan and Zhang (2009): $\text{Churn ratio}_{k,t} = \frac{\min(\text{Churn\_buy}_{k,t}, \text{Churn\_sell}_{k,t})}{\sum_{i=1}^{N_k}(S_{k,i,t}P_{i,t} + S_{k,i,t-1}P_{i,t-1})/2}$, where N_k is the total number of stocks in the portfolio of institution k, $S_{k,i,t}$ is the number of shares of stock i held by institution k in quarter t, $P_{i,t}$ is the price of stock i in quarter t, $\text{Churn\_buy}_{k,t} = \sum_{i=1,\ S_{k,i,t}>S_{k,i,t-1}}^{N_k} \lvert S_{k,i,t}P_{i,t} - S_{k,i,t-1}P_{i,t-1} - S_{k,i,t-1}\Delta P_{i,t}\rvert$, $\text{Churn\_sell}_{k,t} = \sum_{i=1,\ S_{k,i,t}\leq S_{k,i,t-1}}^{N_k} \lvert S_{k,i,t}P_{i,t} - S_{k,i,t-1}P_{i,t-1} - S_{k,i,t-1}\Delta P_{i,t}\rvert$, $\Delta P_{i,t}$ is the change in price, $P_{i,t} - P_{i,t-1}$. Second, following Gaspar, Massa, and Matos (2005), Inst. turnover is calculated as $\sum_{k\in\mathcal{S}} w_{i,k,t}\left(\frac{1}{4}\sum_{r=1}^{4}\text{Churn Ratio}_{k,t-r+1}\right)$, where $\mathcal{S}$ is the set of institutional shareholders of stock i, and $w_{i,k,t}$ is the weight of investor k in the total percentage held by institutional investors in year-quarter t. Then an annual Inst_turn is calculated as the average across a year.
IPO2-IPO5	CRSP	Dummy variables equal to one if the difference between the year of the fiscal year end and the year of the first occurrence in CRSP is 2 to 5 respectively, and zero otherwise.

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Appendix – continued from previous page

Variable	Data source	Description
Leverage	Compustat	Total debt divided by total assets (AT), where total debt is long-term debt (DLTT) plus debt in current liabilities (DLC).
Leverage_IA	Compustat	Market leverage minus the median market leverage in the same industry (2-digit SIC). The market leverage is the total debt divided by market value of total assets, where total debt is long-term debt (DLTT) plus debt in current liabilities (DLC), and market value of total assets is the book value of assets (AT) minus the book value of common shareholders' equity (CEQ) plus the multiplication of common shares outstanding (CSHO) and stock price at fiscal year end (PRCC_F).
Log_resprd	TAQ	Logarithm of relative effective bid-ask spread. Relative effective bid-ask spread is the difference between the execution price and the mid-point of the prevailing bid-ask quote divided by the mid-point of the prevailing bid-ask quote.
Market-adjusted return	CRSP	Annual cumulative stock return minus the annual cumulative CRSP value-weighted market return.
MTB	Compustat	[Total assets (AT) − book value of equity (CEQ) + market value of equity (PRCC_F× CSHO)]/total assets (AT).
Net debt issuance	Compustat	[Annual total debt issuance (DLTIS) − debt retirement (DLTR)]/total assets (AT).
Net equity issuance	Compustat	[Equity sales (SSTK)− equity purchases (PRSTKC)]/total assets (AT).

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Appendix – continued from previous page

Variable	Data source	Description
Net working capital	Compustat	[Net working capital (WCAP) − cash and short-term investment (CHE)]/total assets (AT)
Non-blocks	Thomson Reuters (13f)	Total proportion of shares outstanding held by institutional investors with less than 5% of shares outstanding each.
Non-operating profit	Compustat	The ratio of nonoperating income (NOPI) to total assets (AT).
Fut_Rep	Compustat	A dummy variable equals 1 if the repurchase in the next year is larger than 1 percent of market capitalization, and 0 otherwise.
R&D	Compustat	The ratio of research and development expense (XRD) to total assets (AT). If XRD is missing then set R&D to zero.
Rep	Compustat	The ratio of dollar volume of repurchase to the market capitalization at the previous year end. The repurchase is adjusted by the decrease in preferred stock.
ROE	Compustat	The ratio of net income (NI) to the book value of equity (SEQ).

Table 1
Descriptive statistics

This table displays summary statistics for the variables. *Panel A* is for the main variables. *Panel B* is for control variables. The column *Period* indicates the relevant sample period. The column *Unit* indicates the units of the corresponding variables (a blank in this column indicates that the variable is a digit, e.g. a ratio or a dummy). Observations are yearly. N denotes the number of firm-year observations. Definitions of the variables and the underlying data source are provided in the Appendix.

Name	Period	Unit	Mean	Median	Std. Dev.	Std. Err.	Min.	Max.	N
Panel A: Main Variables									
Cash ratio	'64-'15		0.15	0.08	0.19	0.0006	0.00	1.00	105,366
	'71-'15		0.16	0.08	0.19	0.0006	0.00	1.00	99,199
	'81-'15		0.17	0.09	0.20	0.0007	0.00	1.00	85,097
	'98-'15		0.20	0.11	0.22	0.0011	0.00	1.00	42,495
ILLIQ	'63-'15	1/Million$	12.46	1.06	22.63	0.0696	0.25	71.90	105,622
	'70-'15	1/Million$	13.03	1.21	23.02	0.0725	0.25	71.90	100,694
	'80-'15	1/Million$	14.32	1.32	24.09	0.0820	0.25	71.90	86,366
	'97-'15	1/Million$	12.88	0.76	23.42	0.1097	0.25	71.90	45,594
Log_resprd	'97-'15		-5.59	-5.61	1.35	0.0063	-9.17	-2.04	45,181
Panel B: Control Variables									
Firm size	'64-'15	log(Million$)	3.60	3.50	1.98	0.0061	-2.14	11.47	105,376
Leverage	'64-'15		0.23	0.21	0.19	0.0006	0.00	1.00	105,376
MTB	'64-'15		1.74	1.32	1.35	0.0042	0.12	36.24	105,359
Firm age	'64-'15	log(month)	4.71	4.89	1.05	0.0032	1.61	6.99	105,376
Net working capital	'64-'15		0.14	0.13	0.19	0.0006	-4.70	0.92	105,093
Dividend dummy	'64-'15		0.41	0	0.49	0.0015	0	1	105,376
R&D	'64-'15		0.04	0.00	0.09	0.0003	0.00	4.17	105,376
Capex	'64-'15		0.07	0.05	0.06	0.0002	0.00	1.29	105,348
Cash flow	'64-'15		0.03	0.07	0.17	0.0005	-9.65	1.63	104,419
Industry sigma	'64-'15		0.08	0.06	0.08	0.0003	0.01	1.10	105,376
Equity beta	'64-'15		0.90	0.87	0.62	0.0019	-2.00	3.49	104,029
IPO2	'64-'15		0.06	0	0.24	0.0007	0	1	105,376
IPO3	'64-'15		0.05	0	0.23	0.0007	0	1	105,376
IPO4	'64-'15		0.05	0	0.22	0.0007	0	1	105,376
IPO5	'64-'15		0.05	0	0.21	0.0007	0	1	105,376
Net equity issuance	'71-'15		0.04	0.00	0.16	0.0005	-2.11	3.07	98,194
Net debt issuance	'71-'15		0.01	0.00	0.11	0.0003	-5.27	1.22	98,765
Acquisition	'71-'15		0.02	0.00	0.05	0.0002	-0.60	0.83	98,775

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Table 1 – continued from previous page

Name	Period	Unit	Mean	Median	Std. Dev.	Std. Err.	Min.	Max.	N
Analyst coverage	'81-'15		1.23	1.16	1.03	0.0036	0.00	3.89	83,644
Blocks	'81-'15		0.12	0.09	0.13	0.0005	0.00	0.90	82,114
Non-blocks	'81-'15		0.26	0.20	0.21	0.0007	0.00	0.99	82,114
Fluidity	'97-'15		6.68	6.19	3.17	0.0153	0.02	22.79	42,991
Inst_turn	'80-'15		0.09	0.09	0.04	0.0001	0.00	0.58	83,689

Table 2
Correlations

Pair-wise correlations between selected variables. The sample period is from 1964 to 2015 for most variables, except Net equity issuance, Net debt issuance, and Acquisition (1971-2015); Inst_turn (1980-2015); Analyst coverage, Blocks, and Non-blocks (1981-2015), Log_resprd (1993-2015) and Fluidity (1997-2015). Correlations with these variables are calculated over their respective sample periods.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
(1) Cash ratio	1.00																					
(2) *ILLIQ*	-0.01	1.00																				
(3) Log_resprd	0.03	0.69	1.00																			
(4) Inst_turn	0.16	-0.15	-0.02	1.00																		
(5) Fluidity	0.32	-0.10	-0.03	0.18	1.00																	
(6) Firm size	-0.24	-0.57	-0.82	-0.01	-0.01	1.00																
(7) Leverage	-0.41	0.04	-0.03	-0.05	-0.02	0.18	1.00															
(8) MTB	0.39	-0.13	-0.14	0.12	0.18	-0.12	-0.20	1.00														
(9) Firm age	-0.19	-0.12	-0.31	-0.26	-0.26	0.38	0.00	-0.17	1.00													
(10) Net working capital	-0.29	-0.03	0.12	-0.09	-0.28	-0.09	-0.15	-0.19	0.07	1.00												
(11) Net equity issuance	0.35	0.02	0.19	0.18	0.21	-0.25	-0.11	0.31	-0.35	-0.12	1.00											
(12) Net debt issuance	-0.01	-0.07	-0.07	0.03	0.04	0.07	0.18	0.01	-0.01	0.01	-0.10	1.00										
(13) Dividend dummy	-0.23	-0.32	-0.37	-0.17	-0.25	0.44	-0.03	-0.13	0.35	0.17	-0.19	0.03	1.00									
(14) R&D	0.49	0.04	0.09	0.09	0.29	-0.22	-0.21	0.33	-0.10	-0.18	0.28	0.00	-0.23	1.00								
(15) Capex	-0.17	-0.09	-0.01	0.05	0.08	0.06	0.10	0.02	-0.11	-0.18	0.04	0.15	0.05	-0.12	1.00							
(16) Acquisition	-0.09	-0.09	-0.12	0.06	-0.01	0.11	0.10	0.00	-0.03	-0.06	0.01	0.26	-0.02	-0.05	-0.08	1.00						
(17) Cash flow	-0.32	-0.20	-0.25	-0.03	-0.20	0.31	-0.01	-0.18	0.15	0.24	-0.42	-0.03	0.20	-0.51	0.11	0.06	1.00					
(18) Industry sigma	0.22	0.02	-0.11	0.04	0.16	-0.02	-0.07	0.16	0.00	-0.21	0.09	0.03	-0.18	0.22	0.01	0.05	-0.15	1.00				
(19) Equity beta	0.07	-0.37	-0.41	0.17	0.12	0.27	0.02	0.11	0.01	-0.03	0.05	0.04	0.02	0.07	0.06	0.01	0.04	0.06	1.00			
(20) Analyst coverage	0.00	-0.53	-0.74	0.08	0.10	0.72	-0.03	0.12	0.23	-0.11	-0.14	0.06	0.28	0.01	0.07	0.09	0.21	0.14	0.33	1.00		
(21) Blocks	0.01	-0.24	-0.31	0.04	-0.01	0.28	0.01	-0.04	0.11	-0.05	-0.11	0.01	0.03	-0.01	-0.08	0.07	0.09	0.09	0.11	0.23	1.00	
(22) Non-blocks	-0.04	-0.53	-0.85	0.11	0.02	0.75	-0.03	0.09	0.30	-0.10	-0.18	0.05	0.29	-0.07	-0.01	0.14	0.25	0.09	0.34	0.72	0.34	1.00

Table 3

Preliminary regressions of Cash ratio on liquidity measures and controls over different time periods

This table presents the results from panel regressions with the general specification Cash $\text{ratio}_{i,t} = \beta_0 + \beta_1 \text{Liquidity}_{i,t-1} + \mathbf{\Gamma}'\mathbf{Z}_{i,t} + \varepsilon_{i,t}$, where Liquidity is *ILLIQ*_res, *ILLIQ*, Log_resprd_res, or Log_resprd, $\boldsymbol{Z}$ is a vector of control variables, and $\mathbf{\Gamma}$ is a vector of coefficients. The sample period varies with the availability of Liquidity and control variables, as indicated in the top row. Industry (Fama-French 48 sectors) fixed effects and year fixed effects are included in Columns 1 to 10. Firm fixed effects and year fixed effects are included in Columns 11 and 12. t-statistics are based on firm-clustered standard errors and displayed in parentheses. Statistical significance at the 1%, 5% and 10% level is indicated by $\boldsymbol{a}$, $\boldsymbol{b}$, and $\boldsymbol{c}$ respectively. A * indicates that the coefficient is multiplied by 100.

	1964-2015		1971-2015		1981-2015		1998-2015					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ILLIQ_res^*_{t-1}	-0.098^{a}		-0.093^{a}		-0.067^{a}		-0.066^{a}				-0.042^{a}	
	(-18.11)		(-17.19)		(-11.49)		(-7.51)				(-5.69)	
$ILLIQ^*_{t-1}$		-0.085^{a}		-0.086^{a}		-0.063^{a}		-0.064^{a}				
		(-16.78)		(-16.90)		(-11.21)		(-7.50)				
$\text{Log\_resprd\_res}_{t-1}$									-0.027^{a}			-0.011^{a}
									(-10.98)			(-5.79)
Log_resprd_{t-1}										-0.021^{a}		
										(-8.72)		
Firm size	-0.010^{a}	-0.014^{a}	-0.009^{a}	-0.013^{a}	-0.010^{a}	-0.014^{a}	-0.013^{a}	-0.017^{a}	-0.013^{a}	-0.024^{a}	-0.014^{a}	-0.015^{a}
	(-14.49)	(-18.85)	(-12.65)	(-17.52)	(-13.31)	(-15.83)	(-11.44)	(-12.95)	(-11.63)	(-13.75)	(-4.53)	(-4.88)
Leverage	-0.299^{a}	-0.304^{a}	-0.310^{a}	-0.316^{a}	-0.314^{a}	-0.319^{a}	-0.301^{a}	-0.303^{a}	-0.295^{a}	-0.300^{a}	-0.198^{a}	-0.193^{a}
	(-48.55)	(-50.37)	(-47.58)	(-49.22)	(-43.68)	(-45.18)	(-31.51)	(-32.17)	(-31.33)	(-31.72)	(-17.21)	(-16.94)
MTB	0.017^{a}	0.017^{a}	0.014^{a}	0.014^{a}	0.012^{a}	0.011^{a}	0.012^{a}	0.012^{a}	0.010^{a}	0.011^{a}	0.006^{a}	0.007^{a}
	(17.13)	(17.88)	(14.27)	(14.37)	(11.45)	(11.35)	(9.17)	(9.41)	(8.35)	(8.85)	(5.75)	(6.24)
Industry sigma	0.057^{a}	0.058^{a}	0.054^{a}	0.056^{a}	0.050^{a}	0.050^{a}	0.023^{b}	0.023^{b}	0.023^{b}	0.022^{b}	0.014^{c}	0.015^{b}
	(6.14)	(6.27)	(5.63)	(5.81)	(5.11)	(5.19)	(2.40)	(2.36)	(2.36)	(2.29)	(1.86)	(2.00)
Net Work. Cap.	-0.273^{a}	-0.271^{a}	-0.293^{a}	-0.292^{a}	-0.306^{a}	-0.305^{a}	-0.317^{a}	-0.316^{a}	-0.312^{a}	-0.313^{a}	-0.269^{a}	-0.269^{a}
	(-35.22)	(-35.63)	(-38.29)	(-38.69)	(-36.02)	(-36.52)	(-26.43)	(-26.79)	(-26.61)	(-26.60)	(-21.36)	(-21.55)
R&D	0.348^{a}	0.355^{a}	0.356^{a}	0.360^{a}	0.325^{a}	0.326^{a}	0.277^{a}	0.272^{a}	0.275^{a}	0.274^{a}	-0.165^{a}	-0.166^{a}
	(10.23)	(10.59)	(11.28)	(11.73)	(9.97)	(10.48)	(6.46)	(6.63)	(6.74)	(6.75)	(-6.02)	(-6.17)
Capex	-0.412^{a}	-0.398^{a}	-0.529^{a}	-0.521^{a}	-0.582^{a}	-0.576^{a}	-0.655^{a}	-0.653^{a}	-0.658^{a}	-0.655^{a}	-0.433^{a}	-0.429^{a}
	(-27.65)	(-27.72)	(-30.62)	(-31.04)	(-30.67)	(-31.33)	(-21.40)	(-21.77)	(-22.12)	(-21.96)	(-17.64)	(-17.11)
Div. dummy	-0.018^{a}	-0.019^{a}	-0.016^{a}	-0.017^{a}	-0.010^{a}	-0.011^{a}	-0.005	-0.006	-0.009^{b}	-0.008^{b}	0.008^{b}	0.008^{b}
	(-7.71)	(-8.21)	(-6.59)	(-7.11)	(-3.75)	(-4.04)	(-1.46)	(-1.54)	(-2.29)	(-2.11)	(2.37)	(2.20)
Cash flow	-0.037^{a}	-0.037^{a}	0.012	0.017^{c}	0.004	0.009	0.012	0.014	0.010	0.019	0.006	0.006
	(-3.94)	(-4.14)	(1.28)	(1.92)	(0.42)	(0.95)	(0.80)	(0.99)	(0.74)	(1.32)	(0.59)	(0.58)
Acquisition			-0.400^{a}	-0.395^{a}	-0.421^{a}	-0.419^{a}	-0.514^{a}	-0.512^{a}	-0.520^{a}	-0.508^{a}	-0.375^{a}	-0.379^{a}
			(-27.94)	(-28.29)	(-28.38)	(-29.02)	(-28.71)	(-29.29)	(-29.71)	(-29.30)	(-28.67)	(-28.97)

Continued on next page

Table 3 – continued from previous page

	1964-2015		1971-2015		1981-2015		1998-2015					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Net equity issu.			0.134[a]	0.142[a]	0.130[a]	0.137[a]	0.119[a]	0.123[a]	0.124[a]	0.135[a]	0.151[a]	0.153[a]
			(13.32)	(14.93)	(12.66)	(14.16)	(7.95)	(8.53)	(8.65)	(9.16)	(14.33)	(14.95)
Net debt issu.			0.198[a]	0.203[a]	0.209[a]	0.212[a]	0.275[a]	0.275[a]	0.259[a]	0.274[a]	0.216[a]	0.212[a]
			(12.80)	(13.51)	(13.13)	(13.81)	(17.76)	(18.43)	(17.57)	(18.40)	(17.44)	(17.38)
Firm age					-0.011[a]	-0.012[a]	-0.007[a]	-0.008[a]	-0.009[a]	-0.009[a]	-0.025[a]	-0.026[a]
					(-6.72)	(-7.58)	(-2.99)	(-3.46)	(-3.84)	(-3.88)	(-5.69)	(-6.27)
Equity beta					0.010[a]	0.010[a]	0.015[a]	0.016[a]	0.017[a]	0.018[a]	0.003[c]	0.004[b]
					(7.12)	(7.45)	(6.82)	(7.07)	(7.70)	(7.84)	(1.89)	(2.48)
Analyst coverage_res					0.007[a]	0.008[a]	0.012[a]	0.013[a]	0.010[a]	0.010[a]	0.004[c]	0.004[c]
					(5.16)	(5.69)	(5.53)	(6.17)	(4.49)	(4.91)	(1.92)	(1.83)
Blocks					0.047[a]	0.047[a]	0.057[a]	0.057[a]	0.063[a]	0.065[a]	0.040[a]	0.039[a]
					(5.36)	(5.45)	(5.14)	(5.15)	(5.80)	(5.99)	(3.66)	(3.60)
Non-blocks_res					0.035[a]	0.035[a]	0.052[a]	0.052[a]	0.019[c]	0.028[b]	0.086[a]	0.077[a]
					(4.18)	(4.17)	(4.68)	(4.70)	(1.68)	(2.49)	(7.96)	(7.12)
Inst_turn					0.160[a]	0.155[a]	0.183[a]	0.168[a]	0.222[a]	0.226[a]	0.121[a]	0.139[a]
					(6.24)	(6.24)	(4.07)	(3.85)	(5.06)	(5.14)	(3.45)	(4.03)
Fluidity							0.006[a]	0.007[a]	0.007[a]	0.007[a]	0.000	0.000
							(9.15)	(9.49)	(9.58)	(9.63)	(0.65)	(0.67)
IPO2			0.022[a]	0.020[a]	0.006[c]	0.003	0.020[a]	0.016[a]	0.018[a]	0.017[a]	0.006	0.008[c]
			(8.46)	(8.17)	(1.85)	(0.88)	(3.46)	(3.13)	(3.42)	(3.30)	(1.37)	(1.81)
IPO3			0.009[a]	0.007[a]	-0.005[c]	-0.008[a]	0.002	-0.002	-0.002	-0.002	-0.001	-0.002
			(3.58)	(2.88)	(-1.73)	(-3.00)	(0.46)	(-0.37)	(-0.35)	(-0.46)	(-0.18)	(-0.40)
IPO4			0.005[b]	0.004[c]	-0.005[b]	-0.007[a]	0.001	0.000	-0.000	-0.001	-0.000	0.001
			(2.11)	(1.90)	(-2.00)	(-2.77)	(0.32)	(0.01)	(-0.06)	(-0.22)	(-0.13)	(0.39)
IPO5			0.001	0.001	-0.008[a]	-0.009[a]	-0.003	-0.003	-0.004	-0.004	-0.005	-0.003
			(0.66)	(0.47)	(-3.05)	(-3.66)	(-0.69)	(-0.89)	(-0.96)	(-1.05)	(-1.52)	(-1.06)
N	92,238	95,351	85,743	88,223	69,970	72,174	31,731	32,624	32,679	32,679	31,787	32,735
R^2_{adj}	0.492	0.491	0.511	0.511	0.522	0.523	0.570	0.572	0.573	0.572	0.210	0.208

Table 4

The effect on cash holding of different variables: our paper vs. the literature

This table reports the signs of the regression coefficients in this paper as compared with the literature. The column labelled "Sign Us" lists the signs of coefficients in Column 9 of Table 3; the column labelled "Sign Lit." provides the signs in the relevant literature. NS stands for not significant at conventional levels (10% or better). The symbol + (−) indicates that the coefficient is positive (negative) and statistically significant at least at the 10% level.

Variable	Sign Us	Sign Lit.	Literature
Panel A: in the extant literature and this paper			
Firm size	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
Leverage	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
MTB	+	+	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
Industry sigma	+	+	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009), Han and Qiu (2007)
Net working capital	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
R&D	+	+	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009), Brown and Petersen (2011)
Capex	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
Acquisition	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
Dividend dummy	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
Cash flow	NS	mixed	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009), Riddick and Whited (2009)
Net equity issuance	+	+	Bates, Kahle, and Stulz (2009), McLean (2011)
Net debt issuance	+	+	Bates, Kahle, and Stulz (2009)
IPO2	+	+	Bates, Kahle, and Stulz (2009)
IPO3	NS	+	Bates, Kahle, and Stulz (2009)
IPO4	NS	+	Bates, Kahle, and Stulz (2009)
IPO5	NS	+	Bates, Kahle, and Stulz (2009)
Inst_turn	+	+	Brown, Chen and Shekhar (2011)
Fluidity	+	+	Hoberg, Phillips, and Prabhala (2014), Morellec, Nikolov, and Zucchi (2013)
Analyst coverage	+	+	Chang (2012)
Panel B: in this paper			
Stock liquidity	+		
Firm age	−		
Equity beta	+		
Blocks	+		
Non-blocks_res	+		

Table 5

Difference-in-differences tests using the introduction of tick-size decimalization in 2001

This table reports the results from the following regression

$$\text{Cash ratio}_{it} = \beta_0 + \beta_1 \cdot \text{Treat}_i \times \text{Post}_t + \beta_2 \cdot \text{Post}_t + \beta_3 \cdot \text{Treat}_i + \mathbf{\Gamma}'\mathbf{Z}_{it} + \varepsilon_{it},$$

where i refers to firm i, t refers to year t, the dummy variable Treat equals 1 (0) if the number of trades of a firm's stock is above (below) the top (bottom) tercile in 2000, the year before the event, and the middle tercile group is dropped, the dummy variable Post equals 1 if a year is in or after 2001, and 0 otherwise, $\mathbf{Z}$ is a vector of control variables (same as in Column 7, Table 3), $\mathbf{\Gamma}$ is a vector of coefficients. The coefficient β_1 is the difference-in-differences estimator. The event window of our main setting is $[-3, +3]$ as for Columns 1, 2, 3, and 6. Robustness tests for event windows $[-2, +2]$ and $[-4, +4]$ are reported in Columns 4 and 5, respectively. In the robustness test in Column 3 the event year 2001 is dropped. Industry (Fama-French, 48 sectors) fixed effects and year fixed effects are included in Column 1. Firm and year fixed effects are included in remaining columns. Industry×Year fixed effects are included in Column 6. t-statistics are based on firm-clustered standard errors and displayed in parentheses. Statistical significance at the 1%, 5% and 10% level is indicated by ***a***, ***b***, and ***c*** respectively.

	(1) Cash	(2) Cash	(3) Cash	(4) Cash	(5) Cash	(6) Cash
Treat×Post	0.032$^{\boldsymbol{a}}$	0.019$^{\boldsymbol{a}}$	0.021$^{\boldsymbol{a}}$	0.018$^{\boldsymbol{a}}$	0.021$^{\boldsymbol{a}}$	0.017$^{\boldsymbol{a}}$
	(4.68)	(3.66)	(3.37)	(3.63)	(3.84)	(3.08)
Post	-0.004	-0.003	-0.005	0.006	-0.002	
	(-0.56)	(-0.33)	(-0.62)	(0.93)	(-0.24)	
Treat	0.010					
	(0.87)					
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	No	No	No	No	No
Firm fixed effects	No	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	No
Industry×Year fixed effects	No	No	No	No	No	Yes
N	7,503	7,503	6,382	5,695	9,129	7,386
R^2_{adj}	0.576	0.206	0.222	0.198	0.212	0.872

Table 6
Cash holdings, stock liquidity, and SEC repurchase Rule 10b-18

This table presents the difference-in-differences analysis (DiD) for the repurchase mechanism of the stock liquidity effect on cash holdings. The DiD analysis is based on the SEC's adoption of Rule 10b-18 in 1982. The specification is Cash ratio$_{i,t}$ = $\beta_0 + \beta_1$Treat$_{i,t}$ × Post$_{i,t}$ + β_2Treat$_{i,t}$ + β_3Post$_{i,t}$ + $\mathbf{\Gamma}'\mathbf{Z}_{i,t} + \varepsilon_{i,t}$, where i is firm, t is year, Treat is the treated-firm dummy which equals one (zero) for firms below (above) the bottom (top) tercile of ILLIQ_res in the previous year, and the middle tercile group is dropped, Post is a dummy equal to one if the year is 1982 or later and zero otherwise, **Z** is a vector of control variables (same as in Column 3, Table 3), and **Γ** is a vector of coefficients. The coefficient β_1 is the difference-in-differences estimator. The event window of our main setting is $[-3, +3]$ as for Columns 1, 2, 3, and 6. Robustness tests for event windows $[-2, +2]$ and $[-4, +4]$ are reported in Columns 4 and 5, respectively. In the robustness test in Column 3 the event year 1982 is dropped. Industry (Fama-French, 48 sectors) fixed effects and year fixed effects are included in Column 1. Firm and year fixed effects are included in remaining columns. Industry×Year fixed effects are included in Column 6. t-statistics are based on firm-clustered standard errors and displayed in parentheses. Statistical significance at the 1%, 5% and 10% level is indicated by $\boldsymbol{a}$, $\boldsymbol{b}$, and $\boldsymbol{c}$ respectively..

	(1) Cash	(2) Cash	(3) Cash	(4) Cash	(5) Cash	(6) Cash
Treat × Post	0.023$^{\boldsymbol{a}}$	0.014$^{\boldsymbol{a}}$	0.014$^{\boldsymbol{b}}$	0.010$^{\boldsymbol{b}}$	0.019$^{\boldsymbol{a}}$	0.010$^{\boldsymbol{b}}$
	(4.28)	(3.04)	(2.25)	(2.15)	(4.16)	(2.21)
Post	-0.009$^{\boldsymbol{c}}$	-0.004	-0.004	-0.004	-0.010$^{\boldsymbol{c}}$	
	(-1.71)	(-0.75)	(-0.79)	(-0.85)	(-1.72)	
Treat	0.015$^{\boldsymbol{a}}$	-0.005	-0.004	-0.001	0.000	
	(2.74)	(-0.67)	(-0.47)	(-0.10)	(0.06)	
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	No	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	No	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	No
Industry × Year FE	No	No	No	No	No	Yes
N	6,757	6,757	6,004	4,477	9,058	5,732
R^2_{adj}	0.381	0.335	0.341	0.332	0.298	0.819

Table 7

Market timing, repurchases, and stock liquidity

This table presents results from the following tobit model: $\text{Rep}_{i,t} = \beta_0 + \beta_1 \text{Liquidity}_{i,t-1} + \mathbf{\Gamma}'\mathbf{Z}_{i,t-1} + \varepsilon_{i,t}$, where Liquidity is ILLIQ_res, or Log_resprd_res, $\mathbf{Z}$ is a vector of control variables, and $\mathbf{\Gamma}$ is a vector of coefficients. The lower bound of Rep is zero. Panel A reports the tobit coefficients and Panel B reports the average marginal effects of the stock illiquidity measures and the two components: i) the marginal effect of the repurchase ratio conditional on repurchasing, and ii) the marginal effect of the probability of repurchases. We calculate average marginal effects with observed values on the control variables. Industry (Fama-French, 48 sectors) fixed effects and year fixed effects are controlled. The sample period is from 1972 (1994) to 2015 for tests using ILLIQ_res (Log_resprd_res). The label Timing high (low) is for the sub-sample with high (low) potential to time the market (MTB below [above] median in a year). *p-value* is for the equality test of the stock illiquidity coefficients in the two sub-samples. t-statistics in Panel A are based on firm-clustered standard errors and shown in parentheses. z-statistics in Panel B are calculated based on standard errors using the delta method. Statistical significance at the 1%, 5% and 10% level is indicated by ***a***, ***b***, and ***c***, respectively.

Panel A: tobit regressions			High timing	Low timing	High timing	Low timing
	(1)	(2)	(3)	(4)	(5)	(6)
ILLIQ_res	-0.011[a]		-0.025[a]	-0.008[c]		
	(-3.37)		(-5.07)	(-1.93)		
Log_resprd_res		-0.011[a]			-0.014[a]	-0.010[a]
		(-11.66)			(-8.60)	(-8.52)
MTB	-0.005[a]	-0.005[a]	-0.010[b]	-0.003[a]	-0.009[b]	-0.004[a]
	(-9.08)	(-9.08)	(-2.34)	(-6.70)	(-2.21)	(-7.13)
Free cash flows	0.121[a]	0.098[a]	0.144[a]	0.099[a]	0.098[a]	0.088[a]
	(19.10)	(16.09)	(12.34)	(15.79)	(9.12)	(13.29)
ROE	0.006[a]	0.004[a]	0.008[a]	0.004[a]	0.004[b]	0.004[a]
	(5.40)	(4.24)	(3.90)	(3.28)	(2.23)	(3.29)
Firm size	0.007[a]	0.008[a]	0.007[a]	0.007[a]	0.008[a]	0.008[a]
	(22.08)	(23.62)	(13.15)	(19.36)	(14.87)	(21.28)
Leverage, industry adjusted	-0.048[a]	-0.044[a]	-0.069[a]	-0.019[a]	-0.050[a]	-0.038[a]
	(-11.51)	(-10.09)	(-11.91)	(-3.55)	(-8.59)	(-5.94)
Non-operating profit	0.381[a]	0.308[a]	0.409[a]	0.358[a]	0.289[a]	0.312[a]
	(11.82)	(8.70)	(7.85)	(9.85)	(5.16)	(7.50)
Stock return, market adjusted	-0.004[a]	-0.004[a]	0.005[a]	-0.006[a]	0.003[b]	-0.005[a]
	(-5.22)	(-4.68)	(3.16)	(-7.70)	(2.12)	(-5.64)
Dividend	0.002[a]	0.002[c]	0.000	0.003[a]	0.001	0.001
	(2.60)	(1.86)	(0.07)	(2.85)	(1.09)	(1.05)
p-value			*0.00*		*0.01*	
N	65,386	37,065	32,938	32,448	18,597	18,468

Panel B: Marginal effects		Unconditional	Conditional on repurchase	Probability of repurchase
Illiq_res	Full sample	-0.0112^{a}	-0.0032^{a}	-0.0534^{a}
		(-3.37)	(-3.37)	(-3.37)
	High timing	-0.0250^{a}	-0.0069^{a}	-0.0983^{a}
		(-5.07)	(-5.07)	(-5.08)
	Low timing	-0.0078^{c}	-0.0023^{c}	-0.0479^{c}
		(-1.93)	(-1.93)	(-1.93)
Log_resprd_res	Full sample	-0.0113^{a}	-0.0036^{a}	-0.0689^{a}
		(-11.66)	(-11.72)	(-11.87)
	High timing	-0.0137^{a}	-0.0041^{a}	-0.0703^{a}
		(-8.60)	(-8.67)	(-8.87)
	Low timing	-0.0099^{a}	-0.0035^{a}	-0.0715^{a}
		(-8.52)	(-8.47)	(-8.57)

Table 8

Stock liquidity, cash holdings, and future repurchases

This table shows the results from the following regression: Cash $\text{ratio}_{i,t} = \beta_0 + \beta_1 \text{Dum\_Liq}_{i,t-1} \times \text{Fut\_Rep}_{i,t} + \beta_2 \text{Dum\_Liq}_{i,t-1} + \beta_3 \text{Fut\_Rep}_{i,t} + \mathbf{\Gamma}' \mathbf{Z}_{i,t} + \varepsilon_{i,t}$, where Dum_Liq is Low_illiq or Low_spread, that is, is equal to 1 (0) if *ILLIQ*_res or Log_resprd_res is below (above) the bottom (top) quartile in a year (firms in the middle two quartile groups are excluded), **Z** is a vector of control variables (same as in Column 7, Table 3), and **Γ** is a vector of coefficients. Fut_Rep is a dummy variable equal to 1 if the repurchase in the next year is larger than 1 percent of market capitalization, and 0 otherwise. Only firms with market-to-book ratio below the top tercile are included in the regression. The sample period is from 1972 to 2015 when no controls are included and 1998 to 2015 when the controls are included (due to the availability of Fluidity). Firm and year fixed effects are included. *t*-statistics are based on firm-clustered standard errors and displayed in parentheses. Statistical significance at the 1%, 5% and 10% level is indicated by ***a***, ***b***, and ***c*** respectively.

	(1) Cash	(2) Cash	(3) Cash	(4) Cash
Fut_Rep	0.018[a]	0.012[a]	0.003	0.006
	(12.36)	(5.05)	(0.69)	(1.55)
Low_illiq×Fut_Rep			0.016[b]	
			(1.97)	
Low_spread×Fut_Rep				0.013[b]
				(2.00)
Low_illiq			0.024[a]	
			(2.99)	
Low_spread				0.004
				(0.44)
Controls	No	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	41,220	11,345	5,170	5,462
R^2_{adj}	0.008	0.190	0.216	0.185

Table 9

Stock price instability and stock liquidity amplification effects

This table presents the results from panel regressions with the following specification

$$\text{Cash ratio}_{i,t} = \beta_0 + \beta_1 \text{Liquidity}_{i,t-1} \times \text{Amplification}_{i,t-1} + \beta_2 \text{Liquidity}_{i,t-1} + \beta_3 \text{Amplification}_{i,t-1} + \mathbf{\Gamma}'\mathbf{Z}_{i,t} + \varepsilon_{i,t},$$

where Liquidity is *ILLIQ*_res or Log_resprd_res, Amplification is for High_Inst_turn, HighComp_Fluid, HighComp_HHI, or HighComp_SIM, High_Inst_turn is an indicator variable for high institutional turnover (Inst_turn) which equals one if Inst_turn is larger than the yearly median and zero otherwise, HighComp_Fluid (HighComp_HHI, HighComp_SIM) is an indicator variable which equals one if Fluidity (HHI, product similarity) is larger (smaller, larger) than the yearly median and zero otherwise, $\mathbf{Z}$ is a vector of control variables (same as in Column 7, Table 3), and $\mathbf{\Gamma}$ is a vector of coefficients. The sample period is 1998 to 2015. Industry (Fama-French, 48 sectors) and year fixed effects are included. t-statistics are based on firm-clustered standard errors and displayed in parentheses. Statistical significance at the 1%, 5% and 10% level is indicated by ***a***, ***b***, and ***c*** respectively. A * indicates that the coefficient is multiplied by 100.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ILLIQ_res$_{t-1}$ × High_Inst_turn$^*_{t-1}$	-0.057^{a}							
	(-4.62)							
Log_resprd_res$_{t-1}$ × High_Inst_turn$_{t-1}$		-0.018^{a}						
		(-5.41)						
ILLIQ_res$_{t-1}$ × HighComp_Fluid$^*_{t-1}$			-0.067^{a}					
			(-4.69)					
ILLIQ_res$_{t-1}$ × HighComp_HHI$^*_{t-1}$					-0.053^{a}			
					(-3.76)			
ILLIQ_res$_{t-1}$ × HighComp_SIM$^*_{t-1}$							-0.059^{a}	
							(-3.85)	
Log_resprd_res$_{t-1}$ × HighComp_Fluid$_{t-1}$				-0.013^{a}				
				(-3.51)				
Log_resprd_res$_{t-1}$ × HighComp_HHI $_{t-1}$						-0.008^{b}		
						(-2.32)		
Log_resprd_res$_{t-1}$ × HighComp_SIM $_{t-1}$								-0.014^{a}
								(-3.47)

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Table 9 – continued from previous page

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ILLIQ_res$^*_{t-1}$	-0.038$^{\boldsymbol{a}}$		-0.039$^{\boldsymbol{a}}$		-0.050$^{\boldsymbol{a}}$		-0.044$^{\boldsymbol{a}}$	
	(-4.02)		(-3.99)		(-4.84)		(-4.44)	
Log_resprd_res$_{t-1}$		-0.016$^{\boldsymbol{a}}$		-0.021$^{\boldsymbol{a}}$		-0.024$^{\boldsymbol{a}}$		-0.021$^{\boldsymbol{a}}$
		(-5.64)		(-7.33)		(-7.89)		(-6.86)
High_Inst_turn$_{t-1}$	0.012$^{\boldsymbol{a}}$	0.015$^{\boldsymbol{a}}$						
	(5.02)	(6.25)						
HighComp_Fluid$_{t-1}$			0.017$^{\boldsymbol{a}}$	0.018$^{\boldsymbol{a}}$				
			(5.45)	(6.04)				
HighComp_HHI$_{t-1}$					0.029$^{\boldsymbol{a}}$	0.029$^{\boldsymbol{a}}$		
					(10.02)	(10.27)		
HighComp_SIM$_{t-1}$							0.045$^{\boldsymbol{a}}$	0.046$^{\boldsymbol{a}}$
							(11.46)	(12.02)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	34,965	36,647	31,731	32,679	31,729	32,677	31,729	32,677
R^2_{adj}	0.567	0.572	0.567	0.569	0.569	0.572	0.573	0.576

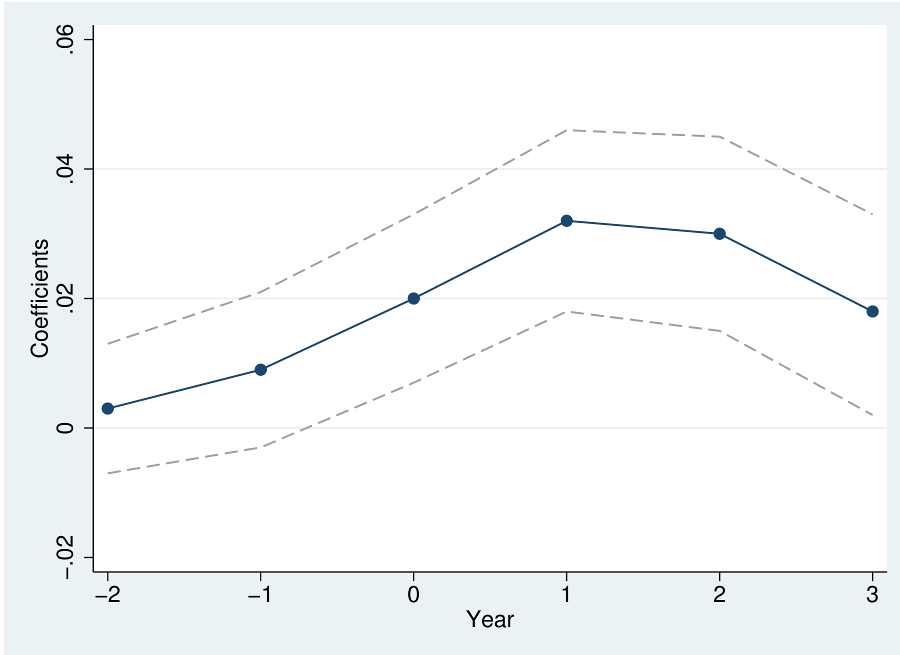

Figure 1. Graphical analysis for the DiD analysis using tick-size decimalization: parallel trend condition and the effect on cash holdings. This figure shows the graphical analysis for the effect of tick-size decimalization in 2001 on corporate cash holdings. The y-axis plots the coefficients β_j $(j = -2, \cdots, 3)$ from regressing Cash ratio on individual yearly dummies and controls (same as in the baseline regression in Column 7 of Table 3) with firm and year fixed effects: Cash ratio$_{i,t} = \beta_0 + \sum_{j=-2}^{3} \beta_j \cdot D_j + \Gamma' Z_{i,t} + \mu_i + \nu_t + \varepsilon_{i,t}$. The yearly dummy, D_j, equals one if a year is j year(s) relative to the decimalization year and the number of trades of the firm's stock is above the top tercile in the year before decimalization, and zero otherwise (the middle tercile group is dropped), $j = -2, -1, \cdots, 3$. D_j is always zero for control firms (number of trades below the bottom tercile in the year before decimalization). μ_i and ν_t are firm and year fixed effects, respectively. The x-axis shows the year relative to the decimalization year (year 0). The event window is $[-3, +3]$. Year -3 is used as the base year and so no yearly dummy for this year is included in the difference-in-differences regression. The dashed lines correspond to 90% confidence intervals of the coefficient estimates based on standard errors clustered at the firm level.

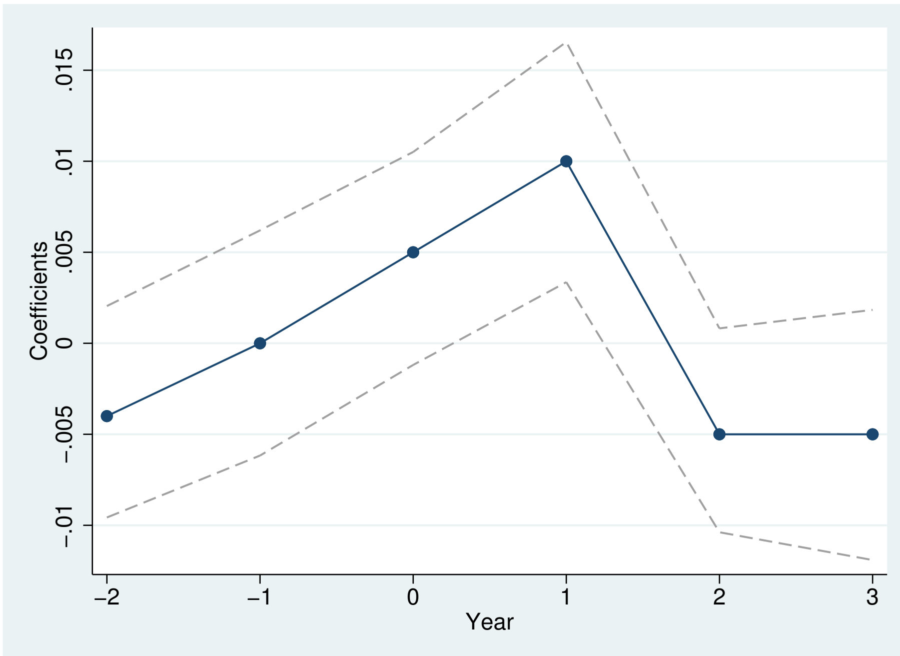

Figure 2. Graphical analysis for the DiD analysis using the adoption of SEC Rule 10b-18: parallel trend condition and the effect on cash holdings. This figure shows the graphical analysis for the effect of the adoption of SEC Rule 10b-18 in 1982 on corporate cash holdings. The y-axis plots the coefficients β_j $(j = -2, \cdots, 3)$ from regressing Cash ratio on individual yearly dummies and controls (same as in the baseline regression in Column 3 of Table 3) with firm and year fixed effects: Cash ratio$_{i,t} = \beta_0 + \sum_{j=-3}^{3} \beta_j \cdot D_j + \Gamma' Z_{i,t} + \mu_i + \nu_t + \varepsilon_{i,t}$. The yearly dummy, D_j, equals one if a year is j year(s) relative to the adoption year and ILLIQ_res in the previous year is below the bottom tercile, and zero otherwise (the middle tercile group is dropped). D_j is always zero for control firms (ILLIQ_res above the top tercile in the previous year). μ_i and ν_t are firm and year fixed effects, respectively. The x-axis shows the year relative to the adoption year (year 0). The sample period is from 1979 to 1985, where the year 1979 is the base year. The dashed lines correspond to 90% confidence intervals of the coefficient estimates based on standard errors clustered at the firm level.

Internet Appendix

Table 1A. Decimalization DiD tests controlling for financial constraints

This table presents the difference-in-differences analysis (DiD) for tick size decimalization controlling for financial constraints. The specification is Cash $\text{ratio}_{it} = \beta_0 + \beta_1 \cdot \text{Treat}_i \times \text{Post}_t + \beta_2 \cdot \text{Post}_t + \mathbf{\Gamma}'\mathbf{Z}_{it} + \varepsilon_{it}$, where i refers to firm i, t refers to year t, the dummy variable Treat equals 1 (0) if the number of trades of a firm's stock is above (below) the top (bottom) tercile in 2000, the year before the event, and the middle tercile group is dropped, the dummy variable Post equals 1 if a year is in or after 2001, and 0 otherwise, $\mathbf{Z}$ is a vector of financial constraint measures and other control variables (same as in Column 7, Table 3), $\mathbf{\Gamma}$ is a vector of coefficients. Financial constraint is measured by widely used dummy variables: i) Small, which equals one if book assets are below the median in a year and zero otherwise, ii) SAI, which equals one if a firm's size-and-age index (Hadlock and Pierce, 2010) is above the median in a year and zero otherwise, iii) WWI, which equals one if a firm's Whited and Wu index (Whited and Wu, 2006) is above the median in a year and zero otherwise, iv) Bond rating, which equals one if a firm has S&P bond rating and zero otherwise, and v) Paper rating, which equals one if a firm has S&P commercial paper rating (Denis and Sibikov, 2010). The coefficient β_1 is the difference-in-differences estimator. The event window is $[-3, +3]$. Firm and year fixed effects are included in all columns. t-statistics are based on firm-clustered standard errors and displayed in parentheses. Statistical significance at the 1%, 5% and 10% level is indicated by $\boldsymbol{a}$, $\boldsymbol{b}$, and $\boldsymbol{c}$, respectively.

	(1) Cash	(2) Cash	(3) Cash	(4) Cash	(5) Cash
Treat×Post	$0.020^{\boldsymbol{a}}$	$0.020^{\boldsymbol{a}}$	$0.019^{\boldsymbol{a}}$	$0.021^{\boldsymbol{a}}$	$0.021^{\boldsymbol{a}}$
	(3.67)	(3.66)	(3.63)	(4.15)	(4.18)
Post	-0.003	-0.003	-0.003	-0.004	-0.003
	(-0.39)	(-0.37)	(-0.38)	(-0.60)	(-0.39)
Fin. constr. dummy	Small	SAI	WWI	Bond rating	Paper rating
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	7,503	7,503	7,486	6,509	6,466
R^2_{adj}	0.206	0.206	0.204	0.204	0.201

Table 2A. **Decimalization DiD tests with the median trade number as cutoff**

This table reports the results from the following regression

$$\text{Cash ratio}_{it} = \beta_0 + \beta_1 \cdot \text{Treat}_i \times \text{Post}_t + \beta_2 \cdot \text{Post}_t + \beta_3 \cdot \text{Treat}_i + \mathbf{\Gamma}'\mathbf{Z}_{it} + \varepsilon_{it},$$

where i refers to firm i, t refers to year t, the dummy variable Treat equals 1 if the number of trades of a firm's stock is above the median in 2000 and 0 otherwise, the dummy variable Post equals 1 if a year is in or after 2001, and 0 otherwise, $\mathbf{Z}$ is a vector of control variables (same as in Column 7, Table 3), $\mathbf{\Gamma}$ is a vector of coefficients. The coefficient β_1 is the difference-in-differences estimator. The event window of our main setting is $[-3, +3]$ as for Columns 1, 2, 3, and 6. Robustness tests for event windows $[-2, +2]$ and $[-4, +4]$ are reported in Columns 4 and 5, respectively. In the robustness test in Column 3 the event year 2001 is dropped. Industry (Fama-French, 48 sectors) fixed effects and year fixed effects are included in Column 1. Firm and year fixed effects are included in remaining columns. Industry×Year fixed effects are included in Column 6. t-statistics are based on firm-clustered standard errors and displayed in parentheses. Statistical significance at the 1%, 5% and 10% level is indicated by ***a***, ***b***, and ***c*** respectively.

	(1) Cash	(2) Cash	(3) Cash	(4) Cash	(5) Cash	(6) Cash
Treat×Post	0.021[a]	0.012[a]	0.013[a]	0.011[a]	0.013[a]	0.010[b]
	(3.85)	(2.69)	(2.59)	(2.61)	(2.82)	(2.21)
Post	-0.003	0.002	0.001	0.008	-0.001	
	(-0.47)	(0.30)	(0.11)	(1.42)	(-0.12)	
Treat	0.003					
	(0.49)					
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	No	No	No	No	No
Firm fixed effects	No	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	No
Industry×Year fixed effects	No	No	No	No	No	Yes
N	11,421	11,421	9,725	8,657	13,873	11,258
R^2_{adj}	0.558	0.200	0.210	0.205	0.209	0.862

Table 3A. Robustness tests for the DiD analysis based on Rule 10b-18: median cutoff

This table presents the difference-in-differences analysis (DiD) for the repurchase mechanism of the stock liquidity effect on cash holdings. The DiD analysis is based on the SEC's adoption of Rule 10b-18 in 1982. The specification is $\text{Cash ratio}_{i,t} = \beta_0 + \beta_1 \text{Treat}_{i,t} \times \text{Post}_{i,t} + \beta_2 \text{Treat}_{i,t} + \beta_3 \text{Post}_{i,t} + \mathbf{\Gamma}'\mathbf{Z}_{i,t} + \varepsilon_{i,t}$, where i is firm, t is year, Treat is the treated-firm dummy which equals one for firms with ILLIQ_res in the previous year below the median and zero otherwise, Post is a dummy equal to one if the year is 1982 or later and zero otherwise, $\mathbf{Z}$ is a vector of control variables (same as in Column 3, Table 3), and $\mathbf{\Gamma}$ is a vector of coefficients. The coefficient β_1 is the difference-in-differences estimator. The event window of our main setting is $[-3, +3]$ as for Columns 1, 2, 3, and 6. Robustness tests for event windows $[-2, +2]$ and $[-4, +4]$ are reported in Columns 4 and 5, respectively. In the robustness test in Column 3 the event year 1982 is dropped. Industry (Fama-French, 48 sectors) fixed effects and year fixed effects are included in Column 1. Firm and year fixed effects are included in remaining columns. Industry×Year fixed effects are included in Column 6. t-statistics are based on firm-clustered standard errors and displayed in parentheses. Statistical significance at the 1%, 5% and 10% level is indicated by ***a***, ***b***, and ***c*** respectively.

	(1) Cash	(2) Cash	(3) Cash	(4) Cash	(5) Cash	(6) Cash
Treat × Post	0.016^{a}	0.013^{a}	0.014^{a}	0.010^{a}	0.015^{a}	0.007^{a}
	(4.02)	(3.93)	(3.43)	(2.87)	(4.70)	(2.65)
Post	-0.007	-0.007^{c}	-0.008^{b}	-0.007^{b}	-0.012^{a}	
	(-1.54)	(-1.95)	(-1.98)	(-2.10)	(-2.84)	
Treat	0.011^{a}	-0.006^{c}	-0.005	-0.005	-0.005	
	(2.78)	(-1.86)	(-1.49)	(-1.28)	(-1.51)	
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	No	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	No	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	No
Industry × Year FE	No	No	No	No	No	Yes
N	10,136	10,136	9,006	6,716	13,588	9,256
R^2_{adj}	0.374	0.317	0.323	0.329	0.291	0.806